PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

QUEENSLAND

FOR 1946

VOL. LVIII.

ISSUED 17th NOVEMBER, 1947.

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1. Each paper should be accompanied by the author's name, degrees and official address.

2. Papers must be complete and in a form suitable for publication when communicated to the Society and should be as concise as possible.

3. Papers must by accompanied by an abstract of not more than one hundred words.

4. Papers should be in double-spaced typescript on one side of the paper with ample margins.

5. The use of italics in the text should be restricted to generic and specific names, foreign words, and titles of periodicals.

6. The cost of author's corrections to proof above what the Council considers a reasonable amount, must be borne by the author.

7. Unless otherwise specified each author will be supplied with fifty separate copies of his paper. Any number exceeding this may be obtained at approximately cost price.

8. All references should be listed at the end of each paper and arranged alphabetically under authors' names, *e.g.*,

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Proceedings of the Royal Society of Queensland.

Presidential Address:

By H. J. Wilkinson, B.A., M.D., Ch.M.

(Delivered before the Royal Society of Queensland, 25th March, 1946.)

Ladies and Gentlemen,—

We have just passed through a very eventful year. After years of anxiety and turmoil, we have rejoiced in the cessation of hostilities and have been able to welcome back our relatives and friends who have been on active service. Among these are several members of the Society who during the war years contributed valuable service to the nation, and we especially welcome their return into our midst to play their part in the work of reconstruction which has already begun.

This year, too, we celebrated the jubilee of the discovery of X-rays, which stimulated research on radiant energy that has meant so much to the world and has resulted in the production of the atomic bomb. It is interesting to speculate on what effect these recent advances in the release of atomic energy will have on the future progress of the human race.

Since our last annual meeting, I regret to report the loss of some of our members. Mr. Pennington, late University Librarian, who acted on the Council as our librarian, has returned to England, and I would like to place on record our thanks for his services and wish him every success in his new sphere. We record the deaths of Dr. Sir David Hardy and Dr. Graham Brown, both of whom attained eminence in their profession and took an active part in the Society.

Mr. Longman, a past president of the Society, and for many years a very active member, has lately been unable to attend on account of continued ill-health. We miss his kindly and stimulating presence, and hope that it will not be long before we see him again at our meetings.

Recently we have been disturbed by the serious illness of Professor Richards, and trust he will soon be able to take his place again in our midst. Professor Richards is one of our oldest, most active, and prominent members, and has been a great influence in guiding the destiny of the Society.

Finally, I would like to take the opportunity of thanking the members of the Council for their help and co-operation during the year, and trust that my successor will enjoy his term of office as much as I have.

AN INTRODUCTION TO THE EVOLUTION OF THE BRAIN.

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INTRODUCTION.

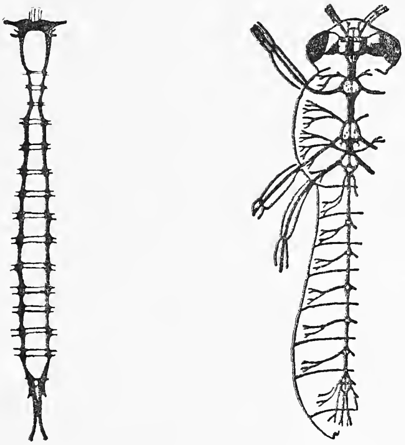
Man's pre-eminence in the animal world is indicated anatomically by the surpassing development of his brain; for it is the brain, the organ or instrument of the mind, which indicates an animal's status in the animal world, and the human brain is the instrument of the high powers of intelligence of man which distinguishes him from all other animals.

With these thoughts in mind, it occurred to me that to-night I might attempt to present to you in a simple way the main features and course of brain development, so that you might not only be able to understand better what is implied in the phrase "surpassing development of the human brain," but might gain some idea of the progress which has resulted in its production, and some idea also of those methods of approach which have been so fruitful in helping to solve the difficult problems connected with the structure and function of the human brain.

THE VERTEBRATE COMPARED WITH THE INVERTEBRATE NERVOUS SYSTEM.

First let us look at a series of brains. This will enable us better to define a few terms and clear away perhaps one or two preconceived notions you might have about the subject.

It will be observed from the labels that all the brains are from vertebrates. The invertebrates do not possess true brains. However, all but the lowest forms in the animal scale possess a nervous system, so that long before we come in evolution to the vertebrates we can trace the origin, gradual differentiation, and evolution of the nervous tissue and its organisation into a well-developed system. This system is found to consist of a central part, for the general control and co-ordination of the various parts of the body, and called the central nervous system, and the rest of the nervous system, which consists mostly of strands or bundles of nerve fibres or conductors that connect the central nervous system to all parts of the body, and which is called the peripheral nervous system.



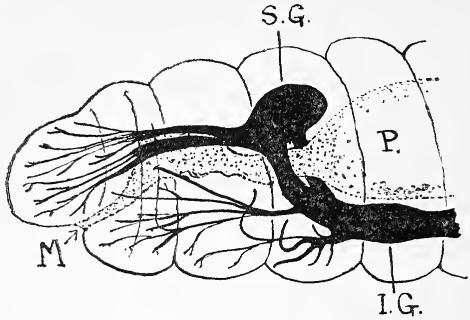
(*a*) (*b*)

TEXT FIGURE 1.

Types of ganglionated nervous system as seen in invertebrates. In "a," that of a simple crustacean, the central nervous system consists of a double chain of ganglia, and in "b," that of a species of fly, it consists of a single chain. ("a" after Hilton, and "b" after Brand, both from Herrick's Neurological Foundations.)

The central nervous system of all but the lowest forms of invertebrates consists merely of groups of cells or ganglia, united together by nerves, hence its name—ganglionated nervous system. At the head-end of this system (figures 1 and 2), we find an enlarged ganglion (or ganglia) in relation to the pharynx which dominates the activity of the rest of the nervous system, enabling the animal to react as a whole to external influences. This is sometimes called a brain, but many prefer to call it merely the head ganglion.

When we come to the vertebrates, however, we find that the central nervous system is built on an entirely different plan. Instead of a chain of solid ganglia, we have a hollow tube of nervous tissue, the head end of which develops primarily in relation to the special sense-organs of smell, sight, hearing, and taste, and becomes enlarged to form the brain, while the rest of the tube, which develops in relation to the segmented region of the body with its vertebrae, is called the spinal cord.



TEXT FIGURE 2.

The "brain" of the earthworm, consisting of SG and IG, superior and inferior oesophageal ganglia, respectively. M, mouth, and P, pharynx. (After Herrick.)

We may therefore define the brain as the enlarged or expanded part of the tubular central nervous system of a vertebrate, which develops primarily in relation to the special sense-organs of the head region, and is the organ which dominates the activity of the rest of the nervous system. In the higher vertebrates, however, it comes to be much more than this, especially in man.

SUPERFICIAL INSPECTION OF A SERIES OF BRAINS.

Returning again to our series of brains, it will be seen at once that they show considerable variation in size and shape, and on first consideration we might assume that the large brains are more highly developed than the small ones and grade them accordingly. We find, however, that the size of the brain varies in members of the same species merely according to the size of the animal, big animals of the species having larger brains than the smaller ones. A big dog, like a Newfoundland, for example, has a larger brain than a toy Pomeranian, and a big man has, on the average, a larger brain than a small man. This increase of brain which is directly due to increase in size of body gives, however, no increase in brain power. Among other things, it may be merely a matter of fineness or coarseness of the tissues.

Further, although man has the highest intelligence and stands far above all others in the animal scale, his brain is not the largest known, as it is exceeded in size both by that of the elephant and by that of the whale.

However, the significance of brain size or, more conveniently, brain weight, is more evident when it is compared with body weight. For example, the brain weight–body weight relations of the animals just mentioned are as follows:—

	Brain Weight.	Body Weight.	Ratio.
Man	50 oz.	140 lb.	1 : 46
Elephant	176 oz.	55 cwt.	1 : 500-560
Whale	71 oz.	120 cwt.	1 : 3,300

It is obvious that brain weight means more in the case of man than it does in the case of the elephant or the whale; but a further complication arises when we find that the ratio in the case of the rat is 1 : 31, so that the rat has a larger brain for its size than man. Are we to assume from this that the rat has more intelligence than man? Of course not! There must be other things to consider besides mere bulk. The fact is that the brain of the rat is different in architecture, texture, and organisation from that of man.

This point can perhaps be made clearer by the following demonstration. Let us compare, for instance, the brains of two mammals of obviously different status but of about equal weight such as those of the echidna, a monotreme, and the cat, a carnivore of about the same size. The brains of these two animals are of about equal size and weight, but the echidna belongs to the most primitive of the mammalian orders, and displays intelligence obviously inferior to that displayed by the cat. Although these animals are apparently endowed with the same amount of brain substance, the carnivore has advanced much further along the evolutionary scale than the monotreme. Examination of these brains reveals that the intrinsic structure of the carnivore's brain is far in advance of that of the monotreme. It displays more efficient organisation or arrangement of nervous tissue, or, in other words, the brain of the carnivore is more efficiently "wired," or is more complex in structure than that of the monotreme.

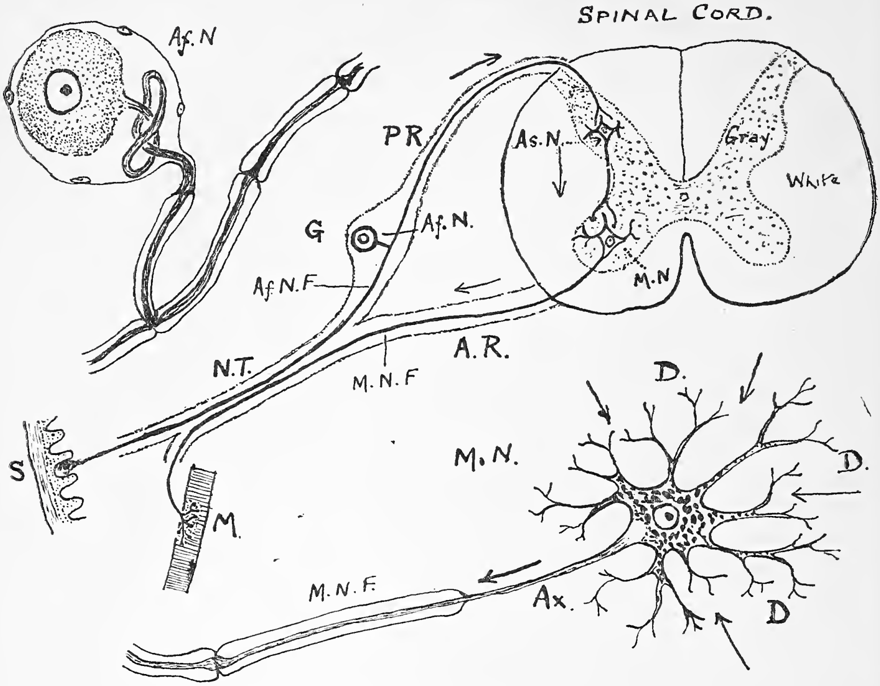
In tracing the evolution of the brain, then, we not only notice the gradual increase in the actual amount of brain substance, but pay particular attention to the gradually increasing complexity and efficiency in the organisation of the nervous elements.

It is obvious that on a subject so vast as this it is not possible in the short time at my disposal this evening to attempt more than a simple outline which might serve as an introduction to the subject of brain development. In thinking the matter over, I have come to the conclusion that this can perhaps best be accomplished by broadly sketching the main stages and comparing the one with the other as we proceed.

We have previously noted that before the evolution of animal organisms has advanced to the stage of the vertebrates, the structural elements of nervous tissue have already been differentiated, and we find also that nervous tissue already shows varying degrees of complexity and organisation in the different invertebrate phyla. The main structural problems connected with the building up of a nervous system have thus already been solved before we reach the vertebrates, and the development which we observe in the vertebrates can be regarded in many respects as a continuation of the process already observed in invertebrates. Nevertheless, although this is the case, the development in the vertebrates proceeds, as stated above, according to a different plan, and it will be seen that this makes possible the enormous expansion which eventually takes place in the vertebrate brain.

THE STRUCTURAL ELEMENTS OF THE NERVOUS SYSTEM.
(Figure 3.)

Before proceeding further, however, it is necessary to consider for a moment these structural elements, mentioned above, which go to form a nervous system. Nerve cells or neurons are differentiated as conducting elements or conductors which convey nervous impulses from affectors in all parts of the periphery to the central nervous system where they are then "switched" back to peripheral effectors, such as



TEXT FIGURE 3.

The sensori-motor arc consisting of an afferent nerve cell or neuron, AfN, an association neuron, AsN, and a motor neuron, MN. AfN is situated outside the C.N.S. in a ganglion, G, and AsN and MN are in the C.N.S. AfN and MN are drawn in greater detail above and below the central figure.

muscles and glands. Thus, in the central nervous system, provision is made for a certain amount of co-ordination, so that stimuli affecting the periphery can cause effector reactions such as movement in particular parts of the organism, or even in the organism as a whole. Obviously, the efficiency of this mechanism decides the survival value of an organism in its particular environment.

Nerve cells or neurons vary in structure according as they are afferent or efferent conductors to or from the central nervous system, respectively, or whether they are concerned with the function of association or correlation within the central nervous system itself. All, however, are provided with elongated processes which consist of prolongations of the cytoplasm from the region of the cell-body containing the cell-nucleus (see figure 3). All neurons, except those which provide the afferent conductors and a few others, have numerous processes which are of two kinds differing in structure and in function. All these processes except one are usually relatively short and extend out in the vicinity of the cell-body. These are the dendrons, D. Dendrons are identical in structure with the cytoplasm or neuroplasm surrounding the nucleus, and are the receivers of the impulses. One process, however, consists of especially differentiated nuroplasm, and is concerned with the discharge of the nervous impulses away from the cell-body. This is called the axon, Ax., and may extend for relatively long distances in the nervous system. In man, for instance, some axons may be over three feet in length. In many cases the axon is ensheathed in a fatty substance for insulation purposes, and those axons which course outside the central nervous system in the peripheral nerve trunks, NT, acquire another very thin cellular sheath called the neurolemma. The axon with its sheaths is called a nerve fibre. Nerve fibres run mostly in bundles which in the periphery are the nerve trunks and in the central nervous system, i.e., the brain and spinal cord, form the fibre tracts which constitute their white matter.

The bodies of the neurons with their cell-nuclei are usually found congregated or grouped together. Thus, in invertebrates they are found in the solid ganglia and in vertebrates they form the grey matter of the central nervous system and the ganglia which occur in the peripheral nervous system. In mammals the grey matter in the spinal cord region forms an internal central core surrounded by white matter. In the brain stem it is also mostly internal, forming masses called the brain stem nuclei; but in the brain hemispheres, both cerebral and cerebellar, although partly internal, it is for the most part external. This is an important feature of brain architecture, as it provides for the unlimited expansion of its hemispheres and the more ready connection and correlation of one part of the surface with another—such as is possible by internal lines of communication.

The nerve cells or neurons concerned with afferent conduction of impulses from the sense-organs in the periphery to the central nervous system are constructed differently, as seen in figure 3. The cell-bodies of these afferent neurons form ganglia which lie close to the central nervous system and their fibres are incorporated in the peripheral nerve trunks along with the fibres of the motor or efferent neurons.

In addition to these conducting elements which form the essential or specific structural elements of the nervous system there are others which comprise the framework which binds the true nervous tissue together, and there are, of course, the blood vessels. Needless to say, these tissues have importance, but they will not concern us this evening.

THE FUNCTIONAL UNIT OF THE NERVOUS SYSTEM.

Although the neurons are the essential structural elements or units of the nervous system, the functional unit consists of a chain of neurons forming a conduction path. One such conduction path extends from peripheral affectors, i.e., cells in the periphery affected by stimuli, to the central nervous system and back again to peripheral effectors. It thus provides a mechanism for conveying nervous impulses from the sense-organs to the central nervous system, where they are "switched" back again to cause some response such as contraction in muscle or secretion in glands. Such a conduction path is known as a sensori-motor or reflex arc. The shortest of these arcs consists in the lower vertebrates of two neurons—an afferent and an efferent (or motor) neuron; but in man it usually consists of three, a third or association neuron being interpolated into the chain to provide for the flow of impulses into more than one group of motor neurons.

In vertebrates the cell-bodies of the afferent neurons are situated mostly in ganglia found just outside the central nervous system, while those of the other two types of neurons are situated within the grey matter of the central nervous system itself as shown in figure 3. The association neurons, for example, lie just inside, near the point of entrance of the afferent fibres, and form the nuclei of reception of the afferent impulses. Close by these nuclei we find groups of motor neurons, which discharge the impulses back, for example, to muscles.

Each muscle of the body is represented in the brain stem or spinal cord by a group of motor neurons, and this group can be called a muscle nucleus. Each muscle nucleus gives rise to motor fibres which course in the peripheral nerves out to a particular muscle. The peripheral nerves therefore provide paths for both afferent and efferent fibres, and they are attached to the brain stem or cord in pairs, one for each side of the body. In the different vertebrates their number varies, but in man there are twelve pairs of cranial nerves attached to the brain stem and thirty-one pairs of spinal nerves attached to the cord, or roughly one for each vertebra.

The brain stem and spinal cord (or collectively the cerebro-spinal axis) therefore stand primarily in relation to the peripheral nerves, each segment of the axis showing a degree of development according to the volume and importance to the animal of the impulses which enter or leave it. This applies more particularly to the brain stem, as the spinal cord is fairly uniform in shape and structure.

The cerebro-spinal axis, however, in addition to the elements already mentioned, contains longitudinal interconnections, which bring its segments into relation with one another, but particularly with those in the brain, which early in evolution shows special enlargements which develop in relation with the special sense-organs in the head region.

In the cerebro-spinal axis, therefore, there are two kinds of centres. First there are the primary centres which stand in immediate relation to the peripheral nerves and provide the mechanism for the simple reflexes concerned with rapid local reactions. These are, of course, found all along the cerebro-spinal axis. In addition to these, however, there are others which provide for the more complicated responses involving correlation or co-ordination of activity in larger groups of muscles or in the body as a whole. These are found only in the brain and are called the higher correlation or integration centres.

Thus we find that superimposed on the simple segmental reflex conduction arcs which are concerned with local reactions there are others whose apices are found at various levels in the brain and provide the mechanism for a variety of more extensive responses, including the reaction of the body as a whole. The construction of the nervous system is sometimes compared to that of a telephone system, the centres in the central nervous system acting as switchboards or exchanges. The more numerous the switchboards and their interconnections the greater the number of connections possible between individual subscribers. Through the nervous system, however, all parts of the body tend to be connected with the brain, through which a dominating control can be exerted over the whole organism.

We are now in the position to state, in general terms, that the evolution of the brain is a process which results in the development of a mechanism of ever-increasing size and complexity of organisation, endowing the animal organism, as it ascends in the evolutionary scale, with an increasing efficiency in reacting to the influences of its environment and in a way which is in the best interests of survival. Also, at first behaviour is mostly involuntary, and automatic, but in the higher vertebrates it becomes more voluntary and affected by lessons learnt by individual experience.

We will now briefly describe the main stages in the development of the brain as exemplified in a series of actual brains of animals which belong to the various classes of living vertebrates, noting the main advances made at each stage. This is as near as we can get to the facts, for it is not possible to trace the actual process of development which has resulted in the production of any particular brain.

The following table indicates the stages chosen, together with a time scale to give some idea of the enormous periods of time involved in the process.

A TIME SCALE: VERTEBRATE PHYLUM.

The first vertebrates made their appearance in Ordovician times, or, maybe, in Cambrian times, about 400 or 500 million years ago.

Class.	Date back to the following times :—	Approximate Age in Millions of Years (?).
Fishes	Later Ordovician	350–400
Amphibia	Devonian	300
Reptilia	Upper Carboniferous	230
Mammals :—	Triassic	150–180
Primates :	Upper Cretaceous	70–100
Apes	Oligocene	40
Man (*Homo sapiens*)	Pleistocene	½

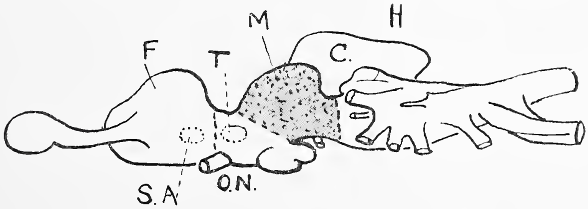
1. THE PRIMITIVE VERTEBRATE BRAIN: FISHES.

(FIGURE 4.)

It was stated earlier that the central nervous system of the vertebrate is fundamentally a tubular structure and is thus constructed according to a different pattern from that of the higher invertebrates with its chain of ganglia.

It should be stated that the tubular character is often difficult to make out in adult forms, but in the embryo, as seen in the models, it is a conspicuous feature in all vertebrates.

Therefore, it may be assumed that the central nervous system of the earliest vertebrate was probably merely a tube of nervous tissue which extended along the back of the organism and to which the peripheral nerves were attached in a segmental fashion. As far as the spinal cord region is concerned, this is the arrangement which persists in all vertebrates; but in the brain the development of the primary centres, both reflex and correlation, associated with the nerves from the special sense-organs progresses to such an extent that the tubular nature of its construction cannot always be readily seen.



TEXT FIGURE 4.

Brain of the dogfish, a small shark. F, fore-brain, M, mid-brain (shaded), and H, hind-brain. SA, somatic area, T, thalamus, ON, optic nerve and C, cerebellum.

In the fishes, the brain consists almost entirely of these enlarged primary centres (see figure 4). In the fore-brain, for instance, we see two enlargements, one on each side, which develop in relation to the sense-organs of smell; in the mid-brain also two, one on each side, for sight; and in the hind-brain there are various centres for hearing, general sensibility and visceral sensibility, i.e., taste and so on. These are sometimes referred to as the "smell brain," "sight brain," "hearing brain," "skin brain," and "visceral or taste brain," because they tend to work more or less independently of one another. These centres and their connections comprise the elementary segmental mechanism.

In the roof of the hind-brain, however, we see a special enlargement which does not stand in direct relation to any particular sense-organ. This is the cerebellum, a higher correlation or true integration centre. Its functions are wholly reflex and unconscious, and are concerned chiefly with the co-ordination of muscular activity and equilibrium, and the orientation of the body and its members in space, particularly in relation to gravity. In contrast with the segmental apparatus, the cerebellum is a supra-segmental or integration apparatus. In the fish brain, the cerebellum is the only true integration centre which is readily apparent on superficial inspection, but parts of the smell, sight, and taste brains may be regarded as such. The most important of these for us is that of the smell brain (fore-brain), for in later stages of evolution all the true integration centres for conscious activity become concentrated in the cortex of the fore-brain. The brains of fish, however, have no cerebral cortex.

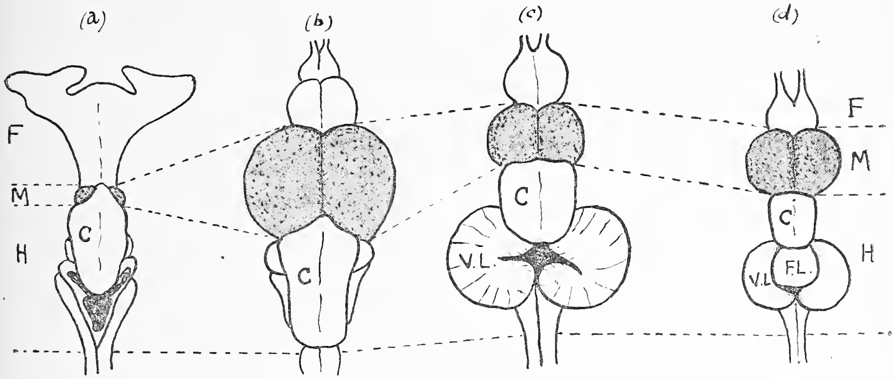
The Cerebellum.

Returning again to the cerebellum, we find that this appears very early in evolutionary history and is present in the brains of all fish. It receives impulses from all parts of the body; but the volume of these impulses entering it varies according to the variety and actual amount of movement exhibited by the organism. This accounts for considerable variation in size of the cerebellum. It is usually quite prominent in fish, and is very large in some species of shark, but in amphibia, such as the frog, it is quite insignificant. Then it increases again in reptiles, becomes quite large in birds; and, in mammals, with the increasing importance of the neck and limbs for posture, gait, and skilled movements, the cerebellum becomes very large.

Then again, although the cerebellum receives impulses from sense-organs in all parts of the body, the relative volume of impulses from the different sense-organs varies in the different species and accounts for a great variation in the actual form of the cerebellum. In mammals, for example, the increased importance, variety, and amount of movement of the limbs is indicated by its lateral expansion into the two cerebellar hemispheres. These reach their greatest development in man.

Although, however, we note such variation in size and form of the cerebellum in the various vertebrates, it is interesting to note that its intrinsic or cellular structure and organisation, once established, remains remarkably constant right up to man. The cerebellum, therefore, need not to-night detain us any longer.

Returning now to the brain of the fish, we have seen that the form of the brain depends almostly entirely on the development of the reflex centres associated with the various sense-organs. When we look at a series of fish brains, however, we note that they show great variation in shape according to the relative development of its various parts. This is associated with the relative dominance of one or other of its special sense-organs.



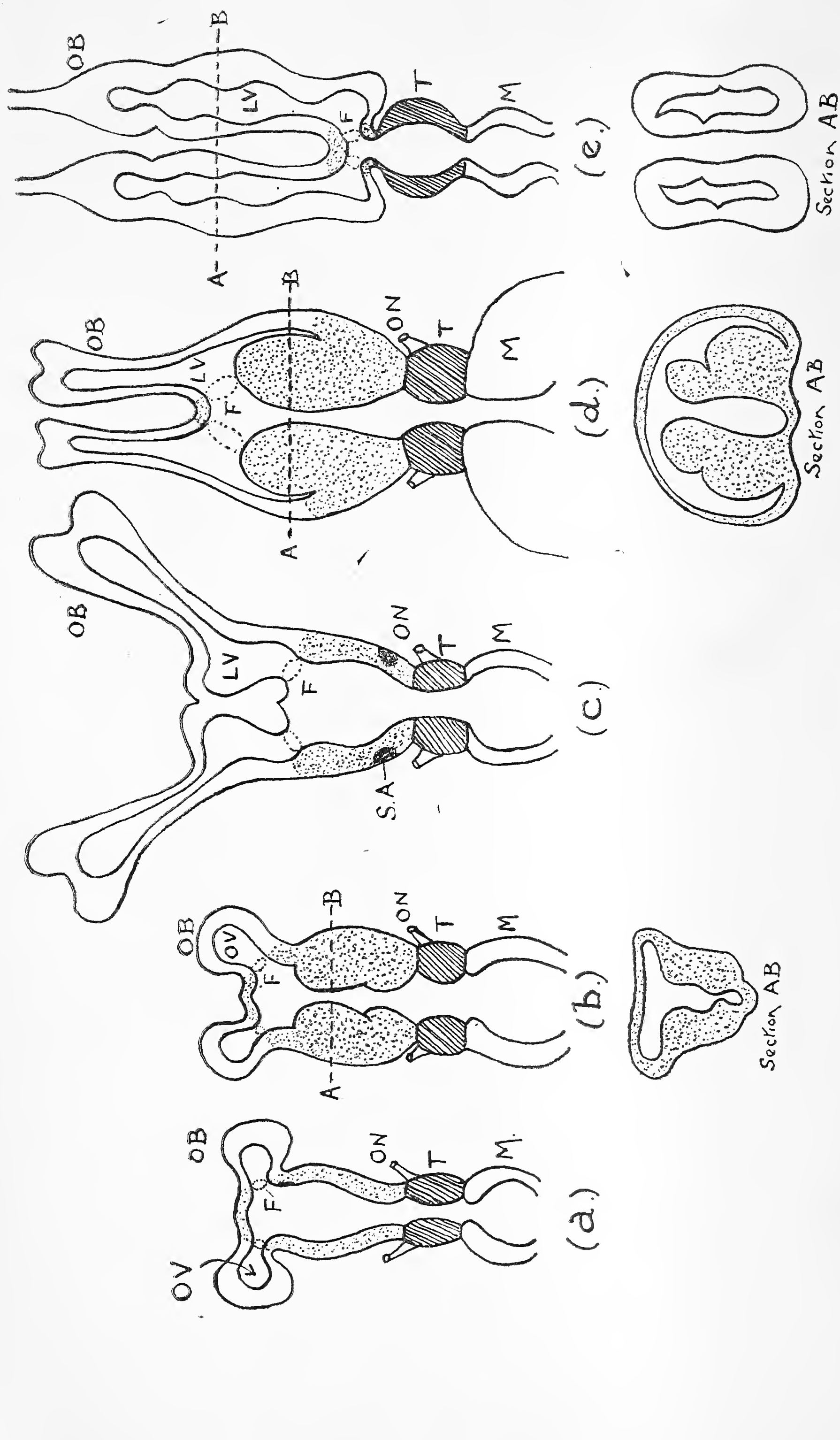
TEXT FIGURE 5.

Series of brains of different species of fish showing different development of fore-brain, mid-brain, and hind-brain, as described in the text. (*a*) Shark, (*b*) salmon, (*c*) carp, and (*d*) catfish.

Let us compare, for example, the brains of the shark, the salmon, the carp, and the catfish (see figure 5). In the shark, (*a*), the dominant sense-organ is that of smell, hence the fore-brain ("smell brain") is the largest part and develops two lateral bulgings; while the salmon, (*b*), whose dominant sense-organ is that of sight, has large optic lobes ("sight brain") in the roof of the mid-brain. In some fishes, however, the organs of taste are enormously increased in number and relative importance, so in the carp (mouth-tasters), (*c*), certain lobes in the hind-brain—the vagal lobes (VL)—are greatly enlarged, while in the hind-brain of the catfish (skin-tasters), (*d*), in which taste-buds are widely distributed over the entire skin surface, even in the fins and tail, there are enlarged lobes in the hind-brain called the facial lobes (FL).

What has been said will serve to show that, although the fish are all at a similar low stage of development, the different species show considerable variation in the shape of their brains depending on, and indicative, as it were, of their way of life.

With regard, however, to the enlargements seen in the different parts of the brain of the fish, the pair which in evolution is destined to play the most important part is that seen in the fore-brain ("smell brain"), for they eventually develop into the cerebral hemispheres, which are so prominent in the brains of the higher vertebrates. It will be of interest, therefore, to describe briefly their origin and development in the fishes.



TEXT FIGURE 6.

The evolution of the fore-brain in fishes. (*a*) Primitive fore-brain, (*b*) sturgeon, (*c*) shark, (*d*) buffalofish, and (*e*) lungfish. OB olfactory bulb, OV olfactory ventricle, LV lateral ventricle, T thalamus.

In the vertebrates more primitive than the fishes, the sense-organs of smell and sight had already acquired considerable importance, and so we find in their brains corresponding developments both in the fore-brain ("smell brain"), and in the mid-brain ("sight brain"). In the fore-brain of these primitive forms (see figure 6a), increase in the primary olfactory centres results in the development of two lateral bulgings or evaginations of the whole thickness of the brain wall, one on each side. These hollow evaginations are the olfactory bulbs and are the beginnings of the cerebral hemispheres.

Just behind the olfactory bulbs, in the unevaginated part of the fore-brain, we find on each side a small region, the so-called "somatic area" (S.A. in figure 4 and figure 6c), which is of particular interest and significance. This area not only receives olfactory impulses, but receives a variety of impulses which ultimately arise in the other sense-organs. It is thus a true correlation or integration centre. Later, in the fish, this somatic area becomes taken up into the evaginated olfactory lobe, and thus becomes part of the cerebral hemisphere. In the hind part of the fore-brain, just behind and continuous with the somatic area, there is on each side another correlation centre called the thalamus. This does not, like the somatic area, become taken up to form a part of the cerebral hemisphere, but remains in the unevaginated part of the fore-brain, so that in later stages the thalami come to lie in between the hemispheres.

Figure 6 shows successive stages in the evagination of the wall of the fore-brain as seen in the fishes. In the lungfishes (figure 6e) the larger part of the side wall of the fore-brain has on each side joined the olfactory bulbs in this lateral evagination, thus forming more extensive hemispheres. This is the definitive form of cerebral hemispheres as seen in all the vertebrates above the fishes.

From this stage onwards, as the higher correlation or integration centres found in the other regions of the brain of the fish tend to move forward and become concentrated in the cerebral hemispheres, we will note the gradual expansion and increased intrinsic structural elaboration of their walls, until they become the relatively large structures seen in mammals.

From now on we can recognise in the brain the following main parts. First of all, there is the fore-brain or prosencephalon, which is partly evaginated and partly unevaginated. The evaginated part, on account of its position at the front end of the brain, is called the end-brain or telencephalon and includes the cerebral hemispheres. These hemispheres at this stage consist of two parts, (1) the higher integration centres for smell, where later will appear the cerebral cortex, and (2) the basal thickenings, somatic areas, which later develop into the structure called the corpus striatum.

The unevaginated part of the fore-brain includes the thalamus, and as it later comes to lie between the expanded hemispheres, it is called the in-between or simply the tween-brain or diencephalon.

The mid-brain, in the roof of which are found the optic lobes, is called the mesencephalon, and the rest of the brain, which contains the cerebellum, "taste brain" and so on, is called the hind-brain or rhombencephalon.

For more ready reference, these facts are embodied in the following table:—

MAIN PARTS OF THE BRAIN IN HIGHEST FISHES.

I. Fore-brain or Prosencephalon.

END-BRAIN or TELENCEPHALON (Evaginated part) includes:—
The Cerebral Hemispheres:—
Olfactory Integration Centres (later CORTEX).
Somatic Area (later CORPUS STRIATUM).

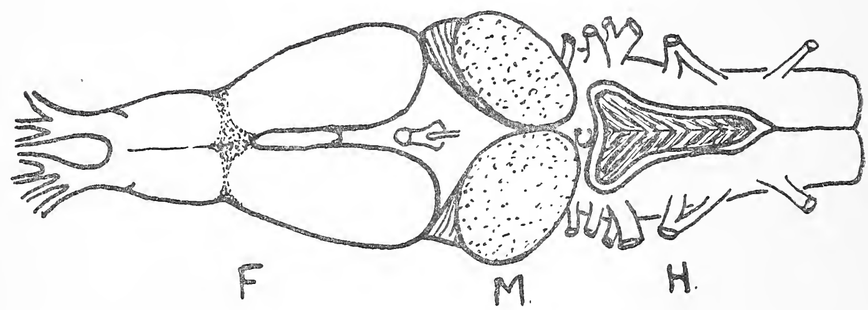
TWEEN-BRAIN or DIENCEPHALON (Unevaginated part) includes:—
THALAMUS.

II. Mid-brain or Mesencephalon includes:—
Optic Lobes.

III. Hind-brain or Rhombencephalon includes:—
CEREBELLUM.
"Taste Brain," &c.

2. AMPHIBIA. (FIGURE 7.)

As in the lungfishes, the entire end-brain of an ambphibian, such as the frog, is represented in the evaginated cerebral hemispheres. The walls of the hemispheres, however, are thicker and internally are more highly organised.



TEXT FIGURE 7.
Brain of the frog. Note insignificant cerebellum, C.

From this increased development of the hemispheres, we assume that olfactory impulses mean more to the frog than to the fishes, or in psychological terms, the olfactory sensations acquire more meaning and give rise to richer perception in the case of the frog than in that of a fish.

The further elaboration of the somatic areas is seen as basal thickenings which represent the beginnings of the corpus striatum; and in the convex dorsal walls, which are thin and undeveloped in the fishes, we now see a rudimentary cortex. Although the corpus striatum receives other than smell impulses, the rudimentary cortex is entirely concerned with smell.

We thus see in the brain of amphibia the beginnings of the two important structural mechanisms, quite different in structure and function, which together account for the whole of the cerebral hemispheres in all the higher vertebrates. These are the corpus striatum and the cerebral cortex.

The corpus striatum develops as a solid mass of grey matter in the base of the hemisphere and is a higher correlation centre for the inherited innate and fixed, that is, the reflex and instinctive types of behaviour.

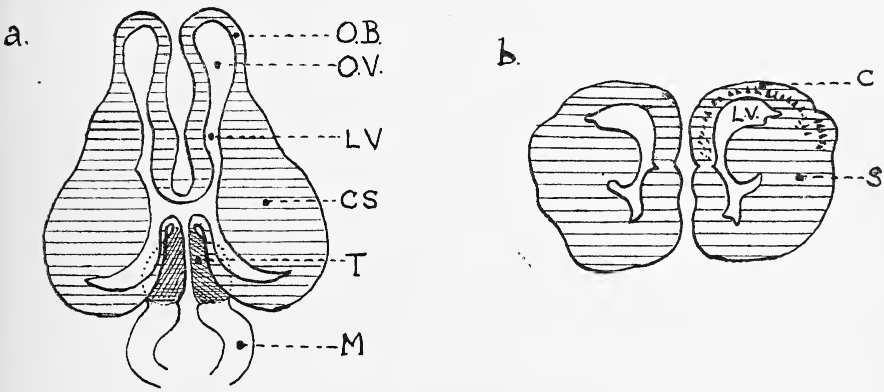
On the other hand, the cerebral cortex spreads out as a thin sheet on the surface of the hemisphere and forms the highest correlation centre concerned with the more modifiable individually acquired types of behaviour, and the capacity to learn by experience.

In the frog we also notice increased development and differentiation of the thalamus. This is due to the fact that it receives a greater volume of impulses from all types of sense-organs, and gives rise on the other hand to an increased number of connections with the rudimentary corpus striatum.

The frog, too, has large optic lobes, an indication of the fact that the integration of optic impulses is still effected in the roof of the mid-brain. The internal structure, however, of these lobes is more complex than that seen in the fishes, so that optic impulses, like smell impulses, mean more to the frog than they do to the fishes.

3. REPTILES AND BIRDS. (Figures 8, 9, and 12.)

In the cerebral hemispheres of reptiles, we note that its two main mechanisms, whose beginnings were noted in amphibia, are now developed as definite corpus striatum and true cortex. We recognise cortex, for example, when we see in the wall of the hemisphere a distinct lamination of the cells which is the characteristic structural feature of true cortex.



Text Figure 8.

Diagram of longitudinal and transverse sections of the brain of the tortoise. C.S., corpus striatum, C, cortex, and other letters as before. (After Herrick.)

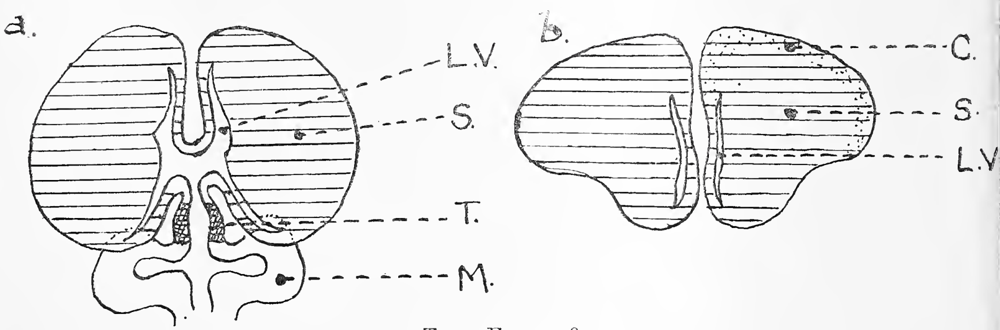
In the turtles, which are the most generalised and primitive of the existing reptiles, these structures show moderate development (see figure 8). It is also seen that, although the turtle's brain is constructed on much the same lines as that of the frog, its centres generally show increased elaboration and development as indicated by a relative increase in the number of neurons as well as an increase in the interconnections between the various cell groups or centres.

In turtles, however, a new feature is evident. Below reptiles, the cerebral cortex, what there is of it, is exclusively olfactory and receives fibres only from the olfactory bulbs. In reptiles, for the first time, there is seen in the cortex a small area (see figure 12) which receives fibres from the thalamus, which bring to it impulses other than olfactory. These thalamocortical connections are not conspicuous in reptiles, but their presence foreshadows an important advance in cerebral architecture which comes to full expression in the mammals.

This small new area of the cortex is called the somatic cortex to distinguish it from the olfactory cortex, and is also called neo-cortex (new cortex) to distinguish it from the more ancient olfactory cortex or palaeo-cortex.

From brains like that of the turtle, there are now two lines of development. In the one, there is development and elaboration of the corpus striatum leading to crocodiles, lizards, and finally to birds; and in the other, there is development of the cortex, leading to mammals.

The cerebral hemispheres of birds (see figure 9) are much larger than those of reptiles, but this increase is due to the relative enlargement of the corpus striatum. So great is this, that the cavity or ventricle of the hemisphere is reduced to a narrow slit, and the hemisphere itself is nearly solid. With these changes, we note a degradation and relative reduction of the cortex compared with reptiles. Visual, auditory, and tactual sensibility are very highly developed in birds, so we see, for example, large optic lobes in the mid-brain for the integration of the optic and the auditory impulses, and there is a noteworthy reduction in the sense of smell, so that the olfactory centres are considerably reduced.



TEXT FIGURE 9.

Diagram of longitudinal and transverse sections of the brain of a bird. S, corpus striatum, and other letters as before. (After Herrick.)

With this short note on the brain of birds, we will return to that of the turtle, and follow the other line of ascent, which leads to the mammals. The feature to watch in this connection is the small area to which we previously drew particular attention, viz., the small somatic or neo-cortex. The gap in the main line of evolution between the highest existing reptiles and the lowest existing mammal is apparently very wide; but examination of these two brains reveals that the most apparent difference between them is due to the relatively enormous expansion and development of the neo-cortex and its connections accompanied by the degradation and reduction of the optic lobes in the roof of the mid-brain.

Before leaving the pre-mammalian forms, however, it should be observed that the highest general integration mechanism for conscious activity, which in fish is in the thalamus, moves forward to the thalamus and corpus striatum in reptiles and birds, the so-called thalamo-striate brain, and finally to the cerebral cortex in mammals. As it moves forward from the brain stem, it becomes emancipated from the control of any particular reflex segmental system and comes to stand above them all as a supra-segmental or integration mechanism which is kept in touch with all sense-organs throughout the body, and can dominate, control, and regulate the activity of all its parts, as well as of the body as a whole.

The corpus striatum probably still remains a higher centre for the innate instinctive types of behaviour, but as we ascend in the mammals it becomes more and more under cortical control, until in man an individual can by effort learn to control his instincts.

The cerebral cortex, on the other hand, is a mechanism which endows the organism with the capacity to learn and profit by his own individual experience, so we see that the mammals show increased capacity in this connection, and that in man this capacity comes to its fullest expression.

INTRODUCTION TO THE BRAINS OF MAMMALS.

The brain of the lowest mammal looks quite different in external configuration from that of the reptile. This is due in the first place to the size of the cerebral hemispheres, which are so large that they extend back to the cerebellum. Thus when the brain is looked at from above, none of the brain stem parts are visible (see figure 11a).

The mammals emerge from more primitive vertebrates where activity was dominated by the sense of smell, so it is not surprising to find in the most primitive of existing mammals that a large part of the cortex is associated with this sense. In fact, all mammals, except the primates, have large smell brains, i.e., are macrosmatic.

The success of the mammals, however, depends in no small measure on the development and expansion of the new structure, the neo-cortex, which we saw had already made its appearance to a slight extent in reptiles. This expansion of the neo-cortex is due to the increasing importance in the life of the mammals of stimuli other than smell, viz., those of sight, sound, and touch. These gain marked cortical representation in the mammal and account for the expansion of the neo-cortex.

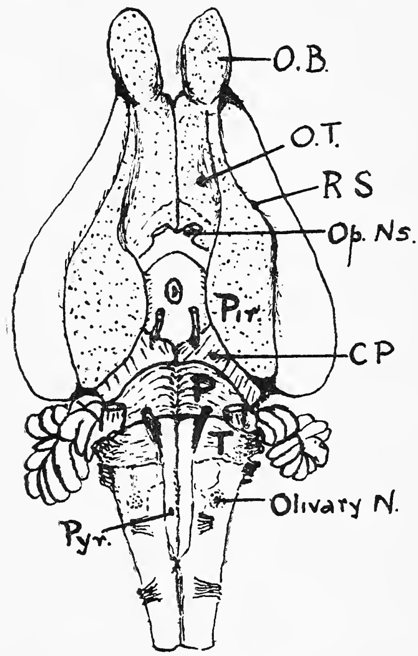
In the primates (figure 19) we note a gradual relative decrease in the size of the smell brain, until, in the human brain, it forms scarcely an hundredth part, and many of its constituent parts are distinguished only with difficulty. In contrast with the rest of the mammals, the primates have small smell brains and are therefore microsmatic.

Probably the most important factor which brought about the emancipation of our primate ancestors from the domination of the sense of smell was their adoption at one time of an arboreal habitat. Arboreal animals live in a sphere in which olfactory stimuli are relatively unimportant, so when once an animal leaves the earth to which the trail of a scent is able to cling, the sense of smell ceases to be dominant.

To become arboreal, however, is not enough—the animal must adapt itself to its new surroundings and must exploit the new channels of acquiring knowledge. We thus find in the most highly developed mammals—viz., the primates, increasing development of the neo-cortical areas of the brain associated with the senses of sight, hearing, and touch, and the elaboration of the areas associated with the initiation and control of muscular activity.

A very important factor in the integration of the nervous impulses from the various parts of the body into one complex whole is the functional correlation of the activities of the various cortical areas on the one side of the central nervous system with those of the other. This is effected through transverse connections called the commissures. When we compare the brains of the more primitive mammals, viz., the monotremes and marsupials (figure 14), with those of the more advanced true mammals (figure 16), we find that although the former have quite extensive cortical areas, their commissural bonds are relatively small. What commissural bonds they have, link mainly the olfactory areas, and the neo-cortical commissural connections are relatively scanty. In true mammals, i.e., all mammals except the primitive monotremes and marsupials, the neo-cortical commissural connections form a very large and prominent structure called the corpus callosum. The primitive mammals have no corpus callosum.

Apart from the cerebral hemispheres, however, there are several features which account for the difference seen in the external configuration, when the brain of the mammal is compared with that of a reptile.



Text Figure 10.

Ventral aspect of the brain of the rabbit. RS, rhinal sulcus, Pir, piriform area, CP, cerebral peduncle, P, pons, T, trapezoid body, and Pyr, pyramid. Neo-cortex unshaded.

If, therefore, we turn our attention for a moment from the cerebral hemispheres and look at the ventral aspect of a mammalian brain, such as that of the rabbit (figure 10), we will see several new formations not seen in reptiles. For example, there are the cerebral peduncles, C P, which contain the fibre connections which link the cerebral hemispheres with the rest of the brain, and in the forepart of the hind-brain we see the pons, P. In the pons, there are groups of cells (pontine nuclei), on which terminate fibres from the cerebral cortex (cortico-pontine fibres), and which themselves give rise to fibres (ponto-cerebellar fibres). These, as their name indicates, run into the cerebellar hemispheres, which in the lowest mammal have already made their appearance. The cortico-pontine neurons link with the ponto-cerebellar to form a conduction chain through which each cerebral hemisphere is able to influence or dominate the activity of the opposite cerebellar hemisphere. In fact, the establishment and development of these connections is closely associated with the development of the cerebellar hemispheres. It is interesting to note in this connection that, in cases where there is lack of development of a cerebral hemisphere, there is a corresponding absence of development of the opposite cerebellar hemisphere. It is obvious, then, that the latter are dependent for their existence on the influence of the former.

In the hind-brain, we also note a small bulge due to the olivary nucleus, which acts like the pontine nuclei as an intermediary nucleus, between the corpus striatum and certain brain stem centres on the one hand, and the cerebellum on the other. The cerebro-ponto-cerebellar path operates in voluntary activity and skilled activity voluntarily acquired, while the striato-olivo-cerebellar path is probably more concerned, although we do not know this for certain, with the control of cerebellar activity in the more innate instinctive type of behaviour.

Another structure seen in the hind-brain of the mammal is the so-called pyramid, Pyr, one on each side of the mid-line. This is a bundle of fibres which arise in the large pyramidal cells in the motor area in the cerebral cortex and pass down from the cortex through the brain stem into the cord to connect the cortex with the muscle nuclei in the brain stem and cord.

These structures are only a few of the more superficial and obvious of the mammalian acquisitions; but they will serve to indicate the profound alterations and development of internal organisation which have taken place in the evolution of the mammalian from the reptilian type of brain.

We are now in the position to recognise some of the main mammalian acquisitions and developments, viz.:—

(1) The rise and expansion of the Neo-cortex.
(2) The development of the Corpus Callosum in the true placental mammals.
(3) The continued expansion and elaboration of the Smell Brain in the macrosmatic mammals, and the fall of the Smell Brain in microsmatic primates.
(4) The development of the Cerebellar Hemispheres associated with—
  (*a*) the development of the cerebro-cerebellar connections and the Pons, and also
  (*b*) the further development of the striato-cerebellar connections and the Olivary Bodies.

The mammals, so far as their brain development is concerned, can therefore be arranged as follows:—

MAMMALS.

Primitive Mammals without a Corpus Callosum:
- (1) Prototheria: Monotremes.
- (2) Metatheria: Marsupials.

Placental (True) Mammals with a Corpus Callosum:
- (3) Lower Eutheria, i.e., all the orders of true mammals except primates.
- (4) Higher Eutheria or the Order Primates.

NOTE.—All mammalian orders except primates are macrosmatic. Primates are microsmatic.

There are thus in the mammals two lines of development, the one leading to greater elaboration of the brains of mammals still dominated by the sense of smell, and the other leading to the human brain, in which the smell brain forms such an insignificant part. We will therefore compare the brains of these two groups, that is, the brains of the macrosmatic mammals with those of the microsmatic.

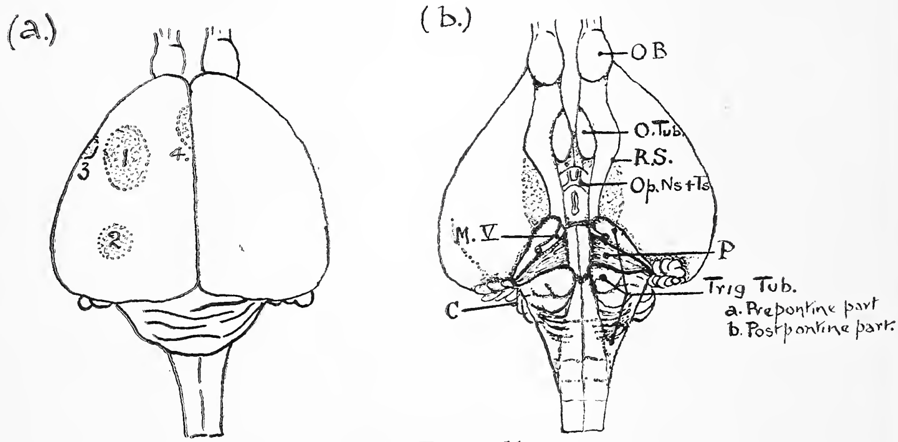
4. MACROSMATIC MAMMALS.

The macrosmatic mammals consist, as we said above, of three groups, which, according to the time of their appearance in evolutionary history, are arranged in the following order:—

- (*a*) Monotremes—the most primitive of existing mammals, which thus lie nearest to the reptiles. Found only in Australia.
- (*b*) The Marsupials—primitive pouched mammals. Except for one species, the American opossum, these are found only in Australia and the neighbouring islands.
- (*c*) The Lower Eutherian Orders, i.e., all true mammals except primates.

(*a*) The Monotremes. (Figures 11, 13, and 14.)

When compared with the brains of reptiles, those of the monotremes show great increase in the olfactory apparatus—olfactory lobes and tracts, olfactory cortex, and olfactory corpus striatum;



TEXT FIGURE 11.

The brain of the platypus, (*a*) from above, and (*b*) from below. Note the large trigeminal tubercle, Trig. Tub., associated with the large trigeminal nerve. MV, motor root of the trigeminal nerve. No pyramid is visible. Motor areas 1–4 after Martin.

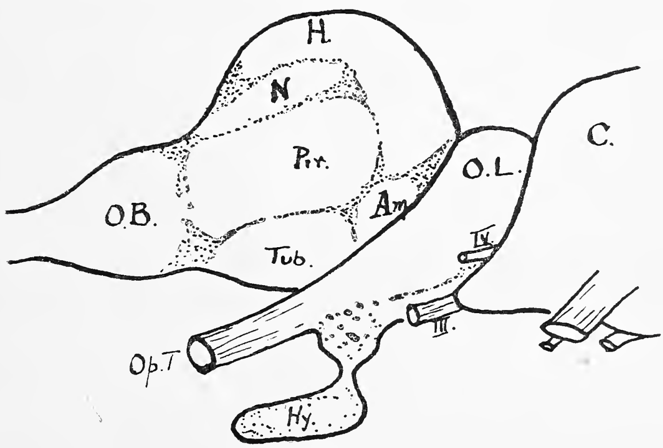
but the real difference is found in the greater size of the neo-cortex. Even in these lowly mammals, the neo-cortex can be readily recognised as it is separated from the older olfactory cortex by a groove, the rhinal sulcus (R.S., figure 11b). The increase in the neo-cortex is due to the great increase in the number of fibres which ascend to it from the thalamus. In monotremes the thalamus itself shows increased development, and its connections with the neo-cortex are not only increased in number, but there is a definite topographical relation between the thalamic nuclei and the regions which their fibres reach in the neo-cortex, as shown in the following table:—

	Thalamic Nuclei.	Neo-cortex.
Tactile fibres	Lemniscus nucleus	Parietal region
Optic fibres	Lateral geniculate body	Occipital region
Auditory fibres	Medial geniculate body	Temporal region

In addition to these ascending fibres, there are those which descend to connect the cortex with the muscle nuclei in the brain stem and spinal cord. In the monotreme, the motor areas, which give rise to these descending fibres, are not concentrated in one particular region of the cortex as in higher forms, but are more diffuse (figure 11a). It should be noted also, that the cerebral peduncles and the pyramidal tracts, which connect the neo-cortex with the brain stem and cord, are so insignificant that they do not give rise to projections on the surface as they do in higher forms (figure 11b).

As already mentioned above, the neo-cortical commissural connections, which link one hemisphere with the other, are relatively small in monotremes, and there is no corpus callosum (figure 16); but the development of the neo-cortex is already associated with that of the cortico-ponto-cerebellar connections, and with the development of the pons and cerebellar hemispheres, so that, although these structures are small, they have made their appearance.

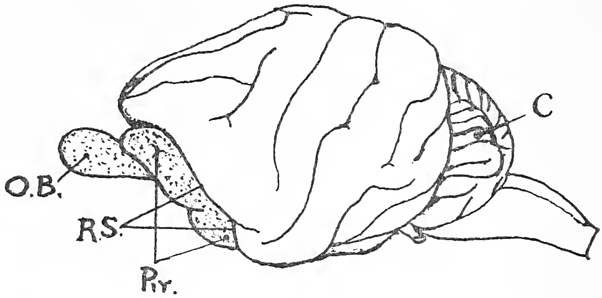
In monotremes, we notice also the increase in the size of the corpus striatum. This is due not only to the increase of that part which belongs to the olfactory apparatus, but to the rise of a new part, the neo-striatum, which is associated with non-olfactory functions.



TEXT FIGURE 12.

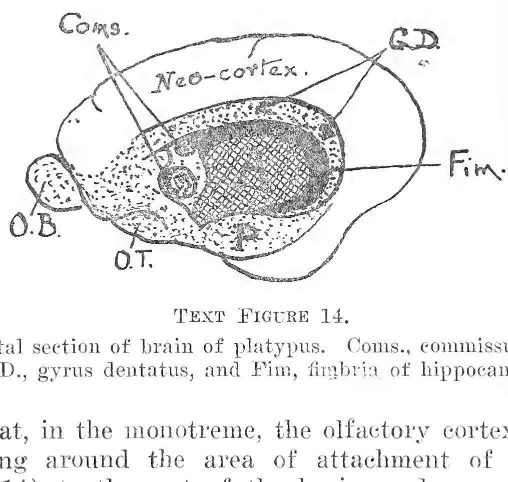
The brain of a reptile, the green turtle. H. hippocampus, Pir., piriform area, Tub., olfactory tubercle, OL, optic lobe, and N, neo-cortex. (After Papez.)

Before leaving the monotreme, it is interesting to notice what happens to the olfactory cortex during the great expansion of the neo-cortex which takes place between the stage of the reptile and that of the mammal. In the reptile, as shown in figure 12, the neo-cortex (N) forms only a small area seen towards the front of the hemisphere, the other parts shown being olfactory, viz., the hippocampal area (H), the piriform area (Pir), and olfactory tubercle (Tub.).



TEXT FIGURE 13.
Brain of echidna from the side. Letters as before.

However, in the monotreme, the neo-cortex has expanded to such an extent that, when the hemisphere is looked at from the side, very little of the olfactory cortex is seen at all (figure 13). The reason for this is that, as the neo-cortex expands, it pushes the hippocampus medially and backwards, and the piriform area is swung down first on to the ventral, and then on to the medial surface of the hemisphere. The final position taken up by the olfactory cortex in the monotreme can best be seen in the medial sagittal section as shown in figure 14.

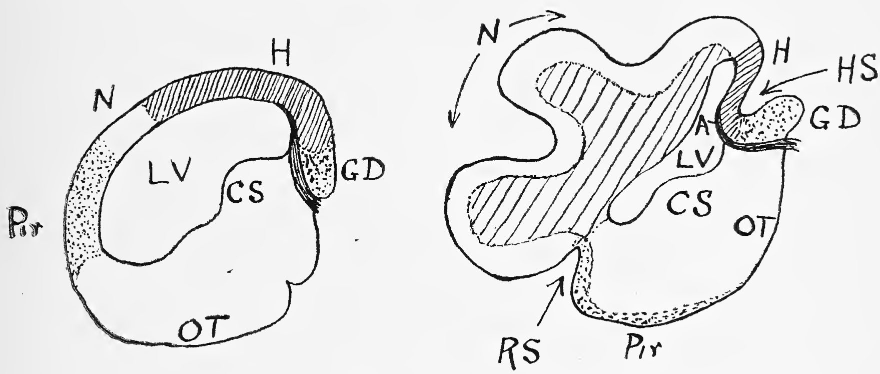


TEXT FIGURE 14.
Medial sagittal section of brain of platypus. Coms., commissures, A, attachment to brain stem, G.D., gyrus dentatus, and Fim, fimbria of hippocampus.

We see that, in the monotreme, the olfactory cortex comes to form a complete ring around the area of attachment of the hemisphere (A, in figure 14) to the rest of the brain, and can only be seen on the medial surface of the hemisphere.

(*b*) The Marsupials.

The superficial features of the marsupial brains are much the same as those of the monotremes, but many parts show amplification. We see, for example, that the relations of the olfactory cortex to the neo-cortex are much the same, but the expansion of the neo-cortex has caused an invagination of a part of the hippocampal area of the olfactory cortex so that it disappears from the surface and bulges into the ventricle. This bulge in the wall of the ventricle is called the hippocampus, and is a structural feature which will be seen in the brains of all the true mammals. Figure 15 will perhaps make this development a little clearer.



Text Figure 15.

Diagram showing results of expansion of the neo-cortex. The hippocampus, H, covered internally with white matter (alveus, A) projects into the ventricle. HS, hippocampal sulcus, and RS, rhinal sulcus. Other letters as before.

If we now look at the ventral surface of the kangaroo's brain, we will see further evidence of advance. For example, the pyramidal tracts are now larger, and appear as prominent strands, the so-called pyramids, on the surface of the medulla oblongata of the hind-brain. There is also a new feature, which is seen just below the pons. This is the trapezoid body, and it consists mostly of transverse fibres belonging to the central auditory path. This structure is associated with the increasing importance of the sense of hearing in marsupials. Later, as the pons increases in width, it comes to cover the trapezoid body, so that in the higher forms, viz., the higher primates, it does not appear on the surface.

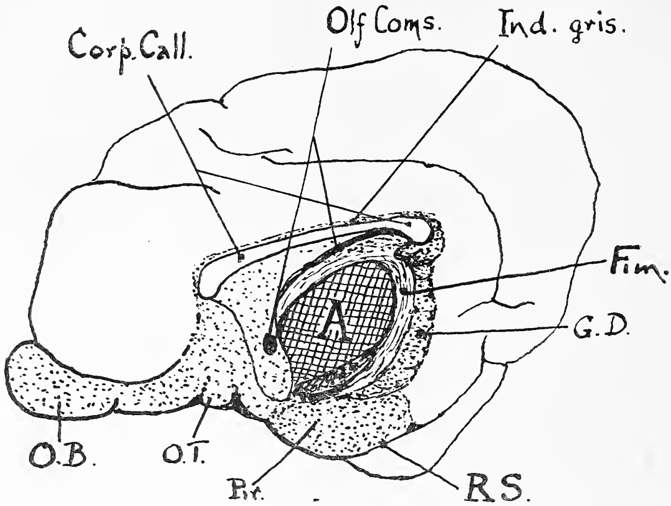
The brains of marsupials are in many ways very interesting objects of study, but they are specialised forms and so need not detain us any further this evening.

(*c*) The Lower Eutherian Orders. (Figures 10, 16, and 17.)

The brains of these mammals show yet further development of the olfactory apparatus, but there is, in addition to this, further expansion and elaboration of the neo-cortex, neo-striatum, and thalamus and their interconnections.

A special new feature, however, is the great increase in the neo-cortical commissural connections manifest in the corpus callosum (figure 16), a structure not previously seen in the lower forms.

The development of the corpus callosum has had an interesting effect on that ring of olfactory cortex which, as we have seen, forms such a distinctive feature on the medial surface of the brains of the monotremes and the marsupials.



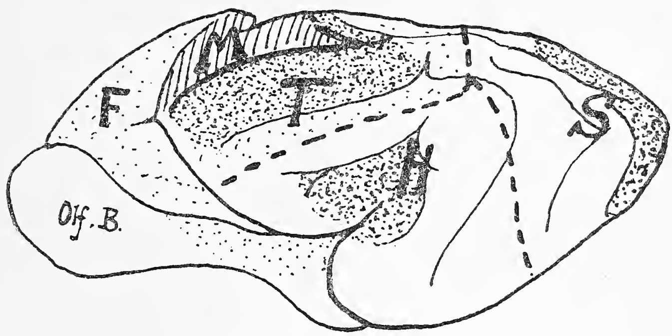
TEXT FIGURE 16.

Medial sagittal section of the brain of the cat. Corp. Call., corpus callosum; other letters as before. Note attenuated old olfactory cortex, Ind. gris., just above the corpus callosum.

The corpus callosum grows *pari passu* with the neo-cortex, and becomes so large that it attenuates parts of the old olfactory cortex, viz., a part of the hippocampal area and associated cortex. Thus, in a medial sagittal section of the brain of an eutherian mammal, that part of the hippocampal cortex which is dorsal to the corpus callosum is so thin that it forms only a thin sheet of grey matter (the indusium griseum), and its white matter is drawn out into fine strands (the longitudinal striae). This is shown in figure 16.

We will now look at the neo-cortex of a typical lower eutherian mammal more carefully to see what it reveals. Take, for example, the brain of the dog (figure 17). The various methods of neurological examination, such as dissection of the fibre tracts, microscopical examination of thin sections of the cortex, and so on, enable us to map out the neo-cortex into a number of areas, each of which differs from the others both in structure and connections. These are the so-called functional areas. The functional areas, as seen in the brain of the dog, are indicated in figure 17, showing the dog's hemisphere from the lateral aspect. The areas shown here extend over on to the medial side of the hemisphere up to the ring of olfactory cortex previously described.

In the dog, then, as shown in figure 17, we can distinguish the following areas. In the occipital region, at the back of the hemisphere, is the area marked S, which includes the optic projection area (darkly shaded) and the surrounding optic correlation or association area. Similarly, H and T indicate the projection and correlation areas for auditory and tactile (somaesthetic) sensibility, respectively. The projection areas receive the fibres conveying impulses from the appropriate nucleus in the thalamus, and the impulses are then radiated into the corresponding correlation area.



TEXT FIGURE 17.

Brain of dog showing cortical areas. T, somaesthetic or tactile area, S, optic area, H, auditory area, M, motor area, and F, pre-motor frontal areas. (After Campbell from Papez.)

Near the tactile area in the front of the hemisphere, we see the motor projection area (M), and, in front of this, the small frontal area (F), the pre-motor correlation or pattern area.

This arrangement is an advance on that shown in the platypus, where the motor areas are diffuse (see figure 11a). In mammals above the monotremes the motor area is concentrated in front of the so-called sensory areas, as shown in figure 17.

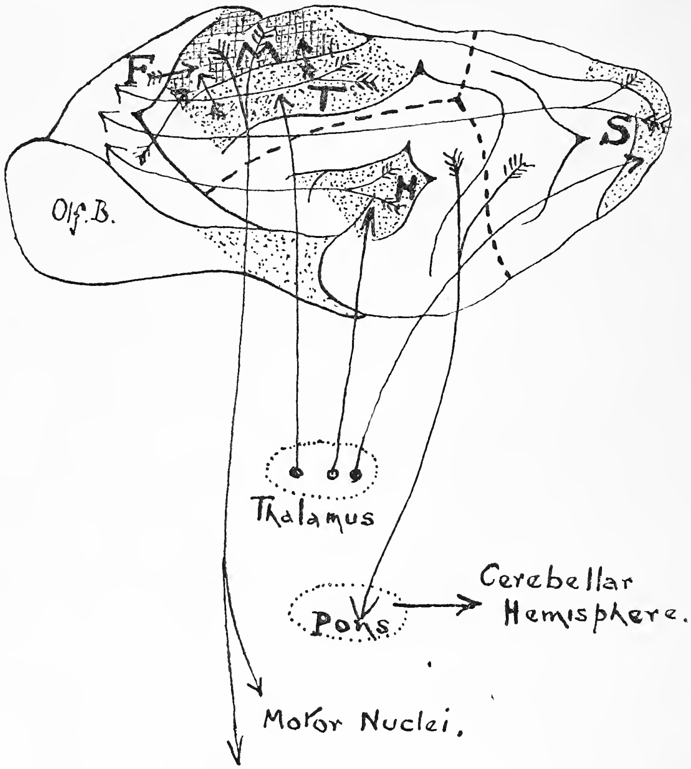
It is seen at once that most of the neo-cortex of this type of mammal is concerned with sensory reception and correlation.

From these sensory areas (figure 18), fibres pass forwards to the frontal cortex, F, that is, to the pre-motor correlation area, which, in turn, is connected with the motor area.

Some of these fibres from the sensory areas, however, connect directly with the motor area. The frontal area, as shown by its connections, is thus seen to be an intermediary centre interpolated between the various sensory and sensory correlation areas on the one hand, and the motor area on the other, and it provides a mechanism for ringing the changes, as it were, on the motor area according to the sensory impressions received. It thus decides the movement pattern, hence the pre-motor correlation area is sometimes known as the motor pattern area.

In addition, however, to these connections with the frontal cortex the sensory areas connect also with the underlying reflex systems through the pons and cerebellum, and in the interest of co-ordination. This connection is effected through the parieto-pontine bundle.

There are other neo-cortical areas with more obscure connections, but these will not detain us.



TEXT FIGURE 18.

Brain of dog showing some of the connections as described in the text.

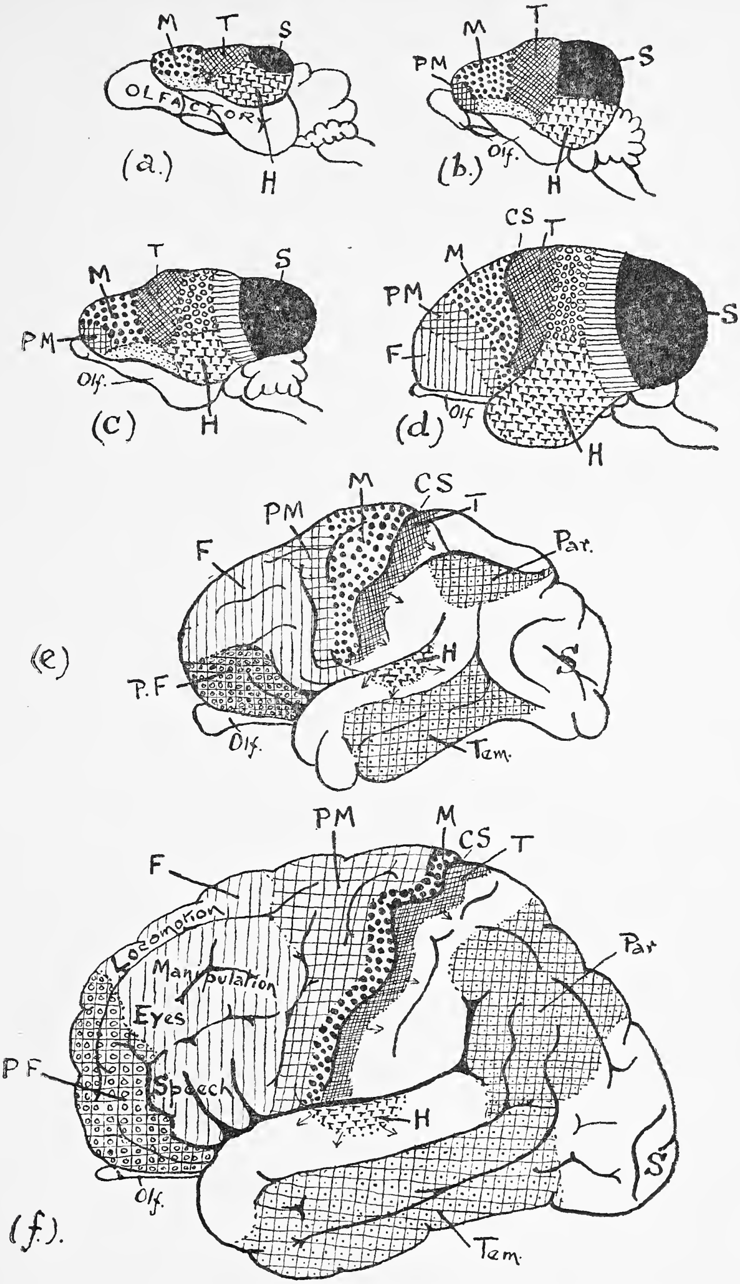
The above description of the neo-cortical areas in the dog applies on the whole to the brains of all the macrosmatic mammals, but the brain areas, of course, show different degrees of development and elaboration in the various orders.

The following table indicates the main neo-cortical areas as seen in the macrosmatic mammals, and will tend to facilitate comparison with conditions found later in the microsmatic primates.

MAIN NEO-CORTICAL AREAS IN MACROSMATIC MAMMALS.

Sensory Reception Areas *Sensory Correlation Areas*	for	Optic impulses: Occipital Region. Auditory impulses: Temporal Region. Tactile impulses: Parietal Region.
Pre-motor Correlation or Motor Pattern Area *Motor Projection Area*		in the Frontal Region.

Besides these developments in the cortex there are many other features which we could discuss at this stage, but what has been touched on is sufficient for our purpose this evening.



TEXT FIGURE 19.

Series of brains showing the fall of the smell brain and the development of the neo-cortex in the primates. (a) Jumping shrew, (b) Tree shrew, (c) Tarsius, (d) Marmoset, (e) Gorilla, and (f) Modern Man. (c) to (f) are primates. CS, central sulcus, Par, parietal, and Tem, temporal psycho-association areas, M, motor, PM, pre-motor, F, frontal, and PF, pre-frontal areas. Other letters as before. In (e) and (f) the optic sensory areas are unshaded and in (f), owing to the expansion of the neo-cortical areas on the lateral surface, most of the optic sensory area is found on the medial surface of the hemisphere. (Modified from Elliot Smith and Brodmann.)

5. MICROSMATIC MAMMALS: THE PRIMATES. (FIGURE 19.)

Primates show a new development in that further expansion and elaboration of the neo-cortex and its connections are associated now with a reduction and degradation of the olfactory mechanism. We thus see that in the higher primates the smell brain forms only an insignificant part of the fore-brain.

The expansion of the neo-cortex in the primates, however, has been due not only to the further elaboration of the pre-existing areas, but to the development of new ones with higher functions.

For example, the increase in the sensory areas provides for increased discrimination and richer perception, but as we ascend the primate scale we notice the origin and development of new areas between the three main sensory areas present in lower forms. These are shown in figures 19e and 19f, and it is seen that they do not stand in relation to any particular sense-organ.

These new areas reach their greatest development in man and provide for the closer correlation and more complete integration of all types of impulses, thus providing for a more unified consciousness of the external world. To distinguish them from the particular correlation areas which stand in relation to the sensory reception areas, these new higher general correlation areas can be called the psycho-association areas. Here it should be stated that the expansion of the sensory correlation areas and the rise of the psycho-association areas provide for the amplification of the mechanism of memory or recall of past experience.

In addition to these advances in the posterior "sensory" half of the neo-cortex, there is also great development in the anterior frontal region. Here we see the rise of new areas, the frontal and pre-frontal, which result from an extension of the pre-motor correlation or motor pattern area and are associated with new and higher functions. These new frontal areas are, perhaps, the most remarkable feature of the higher primate brain.

In the macrosmatic mammals the frontal areas generally are small (see figure 17), but in these mammals the lower motor systems situated in the corpus striatum and brain stem are highly organised on a reflex plane for the performance of various kinds of motor responses. Our early primate ancestors, however, became active arboreal animals, and so their way of life demanded a vastly greater accuracy and refinement in all kinds of movement, and involved special co-ordination of movement of the limbs and eyes, and thus we see an expansion of the motor areas, both correlation and projection. This, of course, was assisted by the increased powers of perception and the development of the memory functions, which were provided by the amplification and increased elaboration of the "sensory" mechanisms. In the higher primates, however, in addition to the increase of the pre-existing frontal areas, we have the differentiation and expansion of an entirely new one, the pre-frontal, which is most obvious and reaches its greatest development in modern man. Whereas the other areas of the frontal region apparently stand in relation to the motor systems of particular regions of the body, the pre-frontal cortex appears to have no such relations and develops as a centre which stands above them all.

In man, however, the special great advances in the cortical areas are associated with the development of the power of speech and the ability to write and execute other finer movements with the hands guided by the eyes. Also, the large pre-frontal area, which forms such a marked feature in the human brain, is associated with the higher human faculties of thought, attention and concentration, internal speech, and the higher psychic activity quite free from the actual use of the motor apparatus. This new pre-frontal area provides the mechanism for the more complete unification of the mind and for a more deliberate and concentrated effort based on experience. For this reason the pre-frontal region has been called the deliberative area, in contrast with the motor areas, association and projection, which can then be regarded as the executive area.

Along with the development in the frontal lobe, there arises in primates yet another new feature. This is the fronto-pontine bundle, through which connections are established between the motor pattern area and the lower reflex centres through the pons and cerebellum, so that in deliberative voluntary activity, provision is made for this suitable co-ordination.

We thus have in the human brain three great fibre bundles, which descend from the cortex. These are the pyramidal tract for the direct control of the muscle nuclei in the brain stem and cord, the parieto-pontine tract, which is associated perhaps with the co-ordination of the more automatic conscious responses, and finally, the fronto-pontine tract for the co-ordination of the more deliberative voluntary activity.

The following table indicates the main neo-cortical areas as seen in man, the highest of the microsmatic primates, to facilitate comparison with conditions formerly described in the macrosmatic mammals, and set out in the table on page 26. See also figure 19f.

MAIN NEO-CORTICAL AREAS IN MAN.

A. Areas behind the Central Sulcus.

Sensory Reception Areas *Sensory Correlation Areas*	for	Optic impulses: Occipital Region. Auditory impulses: Temporal Region. Tactile impulses: Parietal Region.

Psycho-association Areas, which do not stand in relation to any particular sense-organ, and provide for higher association functions and for the unification of consciousness.

B. Areas in Front of the Central Sulcus.

Pre-frontal Area, which does not stand in relation to any particular motor system.

Frontal Association Area. Divided into three parts which stand in relation to adjacent parts of the pre-motor area, viz.—

(1) that for the motor mechanism of the legs: for locomotion;

(2) that for the arms; for manipulation; and

(3) that for the head and neck; small in apes, and concerned with movements of the eyes; but large in man, for the additional functions of speech.

Pre-motor Association, Motor Correlation or Motor Pattern Area.

Motor Area.

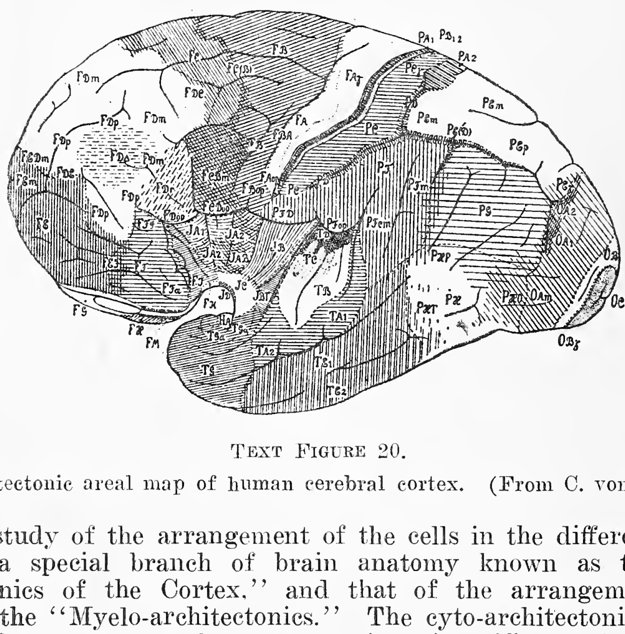
ADVANCES IN THE INTRINSIC STRUCTURE OF THE CEREBRAL CORTEX IN MAMMALS.

So far our attention has been mainly directed to such development or advances in brain structure as are distinguishable by the naked eye. It must be emphasised, however, that most of our knowledge of the comparative anatomy of the brain is due to the various methods of research involving the use of the microscope.

Many times to-night you have heard the words "development," "elaboration," "further differentiation in structure," and so on, and it now remains for me to give some idea of what these words imply. Obviously they mean much more than mere increase in size, for example, of brain centres or cortical areas, or mere increase in the number of their constituent nerve cells. True, the human brain has four times as many nerve cells as the next highest primate, namely 12,000 million as against the gorilla's 3,000 million, but the superiority expressed by these figures falls far short of the difference in performance of these two primates. However, we will see what the microscope reveals.

Take for example the cerebral cortex. The characteristic feature of the cortex as revealed by the microscope is the appearance of a distinct lamination, due not only to the variation in the size, shape, and number of the nerve cells seen from layer to layer, but to the arrangement of the fibres.

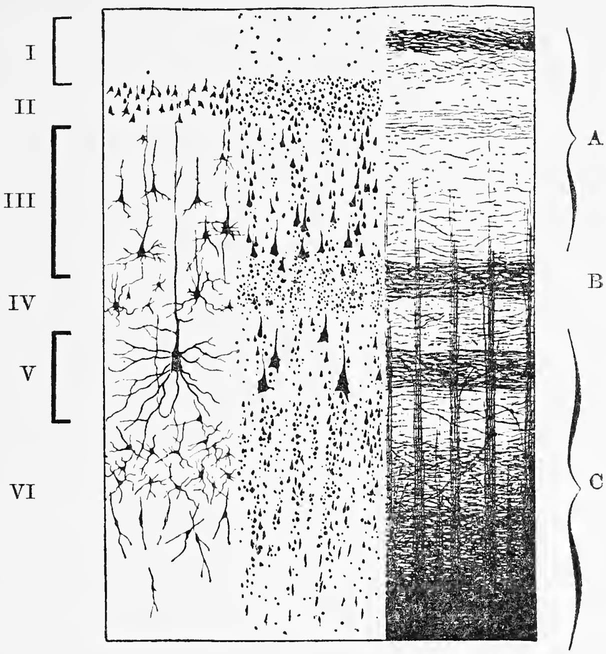
It is found that when different regions of the cortex are compared with one another they show recognisable differences in structure, and this makes it possible to map out the cortex into the more or less well-defined areas previously mentioned.



Text Figure 20.

Cyto-architectonic areal map of human cerebral cortex. (From C. von Economo.)

The study of the arrangement of the cells in the different cortical areas is a special branch of brain anatomy known as the "Cyto-architectonics of the Cortex," and that of the arrangement of the fibres, as the "Myelo-architectonics." The cyto-architectonic structure of the olfactory cortex, for example, is quite different from that of the neo-cortex, and that of the neo-cortex varies characteristically from area to area. In the human cortex (figure 20), 109 cyto-architectonic areas have been made out as against only 40 in the anthropoid ape (orang) and 32 in a lower monkey. This is a very striking indication of human advance.



TEXT FIGURE 21.
Diagram of the structure of the human cerebral cortex (Brodmann).

If we look now at a typical section of the neo-cortex (figure 21), we can distinguish three principal types of cells, viz., small granule or stellate cells, pyramidal-shaped cells of various sizes, and fusiform cells, and they are arranged in six layers. These layers are named and arranged as follows:—

I. *Molecular Layer.* Cells scanty. II. *External Granular Layer.* Small stellate cells and pyramids. III. *External Pyramidal Layer.* IIIA. Medium-sized pyramids. IIIB. Larger pyramids.	A. Supra-granular Cortex.
IV. *Internal Granular Layer.* Small stellate cells.	B. Granular Cortex.
V. *Internal Pyramidal Layer* (or Ganglionic Layer). Cells usually smaller than in IIIB., but very large in motor area. VI. *Fusiform Layer.* Irregular multipolar cells.	C. Infra-granular Cortex.

All layers are probably receptive and associative in function, but in the granular cortex (layer IV) the receptive function predominates, while in the supra-granular cortex (layers II and III) and in the infra-granular cortex (layers V and VI) the associative function predominates. Thus most afferent fibres to the cortex end in the granular and supra-granular layers, while the efferent fibres from a cortical area, namely the associational, commissural, and corticifugal fibres, arise in the infra-granular layer. Also the granular cortex (layer IV) is most marked in the sensory reception areas, and the internal pyramidal layer (V) is most conspicuous in the motor area, where very large pyramidal cells, the giant cells of Betz, give rise to the pyramidal tract, which contains the longest nerve fibres found in the central nervous system.

The granular and infra-granular layers are present in all mammals, but the supra-granular are better developed in the higher primates than in lower forms. It is therefore a later phylogenetic acquisition. Also the supra-granular cortex is the last to differentiate ontogenetically and is most conspicuous in the areas having many associative functions, such as the pre-frontal and frontal, and the higher sensory correlation and psycho-sensory areas. It is interesting to note that while the supra-granular cortex is, phylogenetically and ontogenetically, the last to appear, it is normally the first to show signs of degeneration in old age as we enter our dotage or second childhood.

Sufficient has now been said to give some idea of the process of brain development. As we pass from stage to stage, new features appear, which provide mechanisms for ever wider and higher mental function, until in man, we have the great development of the frontal areas and their connections, which more than any other mechanism accounts for "the surpassing development of the human brain," and establishes his pre-eminence in the animal world.

TIME FACTOR IN BRAIN DEVELOPMENT.

Before closing, I would like briefly to draw your attention to the time factor in the various stages in the evolution of the brain.

From the study of human palaeontology, it appears that there has been a marked acceleration in brain development over the past million years or so, for man's ape-like ancestors in late Tertiary (Pliocene) times had brains which were relatively less than half the size of those of modern man.

The earliest-known member of the human family, Java Man (*Pithecanthropus erectus*), who lived probably about 500,000 years ago, had a cranial capacity of about 850 ccs., corresponding to a brain weight of about 750 grams, while modern man has an average of about 1,500 ccs. (about 1,425 grams). Man has therefore evolved from his pre-human ancestors during the Pleistocene epoch, when the world experienced a series of ice-ages. It is thought, therefore, that the relatively recent acceleration in brain development has no doubt in great measure been due to the stimulus provided by the great environmental upheavals which occurred during this time.

In this connection, it is interesting to recall that attempts have been made to account for former relatively rapid advances in vertebrate evolution by their correlation with marked environmental changes. Former ice-ages in Permian and Upper Cretaceous time, for example, are thought by some to account for the emergence of amphibia from fish, and of mammals from reptiles, respectively. Reference, too, has already been made above to the environmental factor which probably resulted in the emergence of the primate microsmatic mammals from an earlier macrosmatic mammal, namely the adoption by our pre-primate ancestor of an arboreal habitat.

There are, of course, many other factors which direct and influence the evolutionary process, but it is beyond the scope of this talk this evening to enter into their discussion. Sufficient has been said, however, to draw your attention to this interesting topic and to anticipate, perhaps, some likely questions.

CONCLUSION.

We have now come to the end of our story. In such a wide subject it is most difficult to decide what to put in and what to leave out, and how to develop the subject for an audience, of whom many may be comparatively new to the subject and thus not very familiar with the terminology. It is hoped, however, that you have been able to get some idea of the development which has been effected through almost infinite periods of time in the organisation of nervous tissue. Evolution, however, has no beginning and no end; but what the continued development of the brain will bring forth in the future can only be an interesting subject for speculation. Nevertheless, we can be confident that the process will not cease and will no doubt result in the emergence of still higher faculties. We do not even know, however, whether man will continue to be dominant. Forms dominant in past world history have become extinct. To-day there are many who think that there is at present over-development of certain faculties in the human race at the expense of others of greater survival value. Unless the purely intellectual advance which has resulted in the emergence of modern civilisation and its atomic bomb is associated with a greater spiritual advance man may be doomed to extinction. The accent in modern education seems to be on skill and ''cleverness'' and the advancement of the individual, when it should be on character and the advancement of the human race.

NOTE.—The figures, with a few exceptions, have been copied or modified from well-known figures in the literature, and have been reduced to a minimum; but it is hoped that they will be sufficient to help out the argument. Needless to say, the address was illustrated with numerous lantern slides, models, and specimens. Also, it is thought unnecessary in an address of this kind to submit references; but I wish to take this opportunity of acknowledging fully the help derived from the works of Ariëns Kappers, Elliot Smith, Cajal, von Economo, Herrick, Ranson, Papez, Huber, Crosby, and many others too numerous to mention, whose labours have made it possible for us to acquire a clearer and more accurate conception of brain development.

NOTES ON AUSTRALIAN CYPERACEAE, VII.

By S. T. Blake, M.Sc., Queensland Herbarium, Botanic Gardens, Brisbane.

(*Received 29th April, 1946; read before the Royal Society of Queensland, 27th May, 1946; issued separately, 19th September, 1947.*)

In this paper three new species and one new section are described, one new name proposed, nine previously described species are recorded from Australia for the first time, and some other critical species are discussed. In 1937, through the courtesy of Dr. J. Mattfeld, I received on loan from the Berlin Herbarium the type-specimens of some species described by Boeckeler, and some of these are discussed in the paper.

The source of the specimens studied is indicated by the following abbreviations, which are those proposed for international use by Lanjouw in Chronica Botanica v, 142-150 (1939) :—

Tate Herbarium, University of Adelaide	AD
Botanisches Museum, Berlin-Dahlem (Berlin Herbarium)	B
Queensland Herbarium, Brisbane	BRI
National Herbarium of Victoria, Melbourne	MEL
National Herbarium of New South Wales, Sydney ..	NSW
Herbarium, Tasmanian Museum, Hobart	HO

Where no other indication of the herbarium occurs the specimens are in the Queensland Herbarium.

Cyperus L. (*sensu* Kükenthal in Pflanzenr. IV. 20, heft 101: 1935-6.)

Cyperus diffusus *Vahl,* Enum. ii, 321 (1806); Kükenth., l.c., 208 (1936).

Northern Territory.—North Australia: Cannon Hill, East Alligator R., 12° 24′ S., 132° 55′ E., in more or less shaded rock-crevices, October 2nd, 1946, *S. T. Blake* 17121.

Queensland.—Cook District: Daintree, in rain-forest, July 21st, 1945, *S. T. Blake* 14999; Cairns, on hillside in rain-forest, June 26th, 1935, *S. T. Blake* 9621; near Mourilyan, in swampy rain-forest, November 23rd, 1941, *S. T. Blake* 14421; Bingil Bay, near El Arish, in littoral rain-forest, September 14th, 1945, *S. T. Blake* 15295.

New for Australia. The species, as treated by Kükenthal, with 5 sub-species and 6 varieties, is cosmotropical; the typical form extends from Queensland to India and Formosa. Of the Australian specimens *Blake* 14999 shows an approach to var. *macrostachyus* Boeck. in Linnaea xxxv, 534 (1868), Kükenth., l.c., 209.

Cyperus ixiocarpus *F. Muell.* in Proc. Roy. Soc. Vict. xxiii, 53 (1887); Domin in Biblioth. Bot. xx, heft 85, 430 (1915).

This species was described from a single piece consisting of the inflorescence and upper part of the culm, collected by H. S. King between the Gascoyne and Fortescue Rivers, Western Australia, in

1885, and preserved in the Melbourne Herbarium. The species is not included in Clarke's list of world species in Kew Bull. Add. Ser. viii, 96–101 (1908) and is omitted from Kükenthal's monograph. Domin, l.c., mentions it only with the query "An *C. aristatus?*" It was again collected at Lander's Creek, Northern Territory, by G. F. Hill, in 1911, but Ewart and Davies misdetermined the specimen as *C. dactylotes* Benth, and cited it under this species in Fl. North. Territ. 55 (1917). Later collections have emphasised the distinctiveness of the species, and an amplified description is here given, based chiefly on my specimens from Mount Isa, Queensland, which are the only ones giving a really comprehensive idea of the plant.

Herba perennis, caespitosa, viridis, inflorescentia viscida inclusa 50–70 cm. alta. Culmi erecti vel obliqui, stricti, subteretes, compressibiles, profunde striati, apice 1·5–3 mm. crassi, striis exceptis laeves, glabri, haud viscidi, prope basin leviter incrassatam foliati. Folia pauca, 2–4 laminifera, haud viscida, glabra, summum culmo longius breviusque, inferiora gradatim breviora; vaginae laxiusculae, profunde striatae, antice marginibusque plus minusve hyalinae, brunneo-punctulatae, inferiores brunnescentes, imae paucae haud laminiferae; laminae rigidae, sursum attenuatae, conduplicatae vel convolutae, explanatae usque ad 5 mm. latae sed plerumque angustiores, marginibus parce scabrae, subtus striatae nec carinatae, inter nervis saepe leviter septatae, supra laevissimae haud striatae. Anthela explicata, laxa, subdecomposita. Radii circiter 10–14, inaequales, usque ad 10 cm. longi, setacei, subtrigoni, striatuli, e prophyllis subhyalinis ore oblique sectis orientes; radioli conferti, rigide setacei, patuli, usque ad 3 cm. longi. Bracteae inferiores 1–3 anthelam superantes foliiformes, superiores gradatim breviores, setaceae. Spiculae 2–4-nim confertae (haud vere digitatae), divergentes, conspicue resinosae, sub anthesi flavescentes, sub fructu nigricantes, lineares, compressae, pluri- vel multiflorae (pro more 11–21-florae), pro more 17–23 mm. longae, 2·5 mm. (sub anthesi) usque 4·5 mm. (sub fructu) latae. Rhachilla persistens, tenuis, flexuosa, angustissime alulata alulis persistentibus, internodis circiter 1·1–1·2 mm. longis. Glumae mox patulae, tenuiter membranaceae, valde carinatae carina crassa 1–3-nervi, utroque latere 2–3-nerves, marginibus late hyalinae, (explanatae) ovato-ellipticae apice rotunda mucronatae, 2·7–3 mm. longae (mucrone 0·3–0·5 mm. longo incluso), tandem cum nuce deciduae. Stamina 3; antherae lineares, minime apiculatae, 0·7–0·9 mm. longae. Stylus tenuissimus, infra stigmatibus 1 mm. longus; stigmata 3, stylo subaequilonga. Nux nigricans, nitidula, obovoidea, breviter acuminata, acutiuscule aequeque trigona angulis prominentibus nec costatis, lateribus mediis admodum concava cellulis extimis minimis conspicuis, 1·9–2·0 mm. longa, 1 mm. lata, glumae adhaerens.

WESTERN AUSTRALIA.—North-west Division: Gascoyne R., *Pollack* in 1882 (MEL), and *J. Forrest* in 1882 (MEL); between the Gascoyne and Fortescue Rivers, *H. S. King* in 1885 (TYPE in MEL).

NORTHERN TERRITORY.—North Australia: Settlement Creek, January, 1922, *L. J. Brass* 116. Central Australia: Lander's Creek, June 10th, 1911, *G. F. Hill* 318 (MEL); Coniston, on creek, August 8th, 1931. *J. B. Cleland* (hb. Cleland); Cockatoo Creek, August 14th, 1931, *J. B. Cleland* (hb. Cleland).

QUEENSLAND.—Burke District: Mount Isa, very common on sandy dry bed of Leichhardt R., 1,250 ft., April 25th, 1935, *S. T. Blake* 8755.

The affinities of this attractive and distinctive plant are obscure. Mueller suggested a position near the Tropical American *C. viscosus* Sw. (= *C. elegans* L.), probably on account of the viscid spikelets, but it differs from this species and its immediate allies (sect. *Glutinosi* Boeck.) in that it is the spikelets and not the vegetative parts which are viscid, the foliage is less evidently septate-nodulose, the spikelets are not densely capitate, the glumes are more distant, thinner, not bisulcate and have few nerves, the anthers are not crested, and the style is not thickened at the base. From *C. dactylotes* Benth., to which Ewart and Davies referred Hill's specimen, it differs in many respects, particularly in the viscid spikelets with rather widely spreading glumes with flat margins and the broad nut much shorter than the glume. It has very little in common with *C. aristatus* Rottb. to which Domin doubtfully referred the species from Mueller's description. The nearest affinity that I can suggest is *C. Zollingeri* Steud. which it more or less resembles in the arrangement of the spikelets, the rhachilla, the arrangement of the rather distant glumes, the scarcely apiculate anthers, and more or less in the form and relative size of the nut. It differs, however, in the more densely tufted subterete (not triquetrous) culms without stolons, the flatter spikelets, the more spreading glumes with flat margins, and the more symmetrical viscid nut. The differences are so marked that a new section is here proposed for the species.

Cyperus *L.* subgen. **Eucyperus** (*Griseb.*) *C. B. Clarke* sect. **Ixiocarpi** *S. T. Blake* sect. nov.

Herbae caespitosae rhizomate brevissimo. Culmi subteretes prope basin leviter incrassatam foliati. Bracteae inaequales, inferiores longae. Anthela explicata, laxa; radii graciles valde inaequales. Spiculae brevissime spicatae vel subdigitatae vel solitariae, lineares, acutae, compressae. Rhachilla persistens, tenuis, flexuosa, alulata alulis persistentibus. Glumae demum deciduae, tenuissime membranacae, remotiusculae, patulae, fere ellipticae, obtusae, carinatae, 7–9-nerves. Stamina 3, connectivum vix productum. Stylus longiusculus; stigmata 3. Nux viscida, $\frac{2}{3}$ glumae aequans, obovoidea, trigona, lateribus subconcava, glumae adhaerens et cum ea decidua. Typus: *C. ixiocarpus* F.Muell. Species adhuc nota unica.

Cyperus Cunninghamii (*C. B. Clarke*) *C. A. Gardner,* Enum. Pl. Austral. Occ. 12 (1930); Kükenth., l.c., 450 (1936).

C. fasciculigerus (F.Muell.)Domin in Biblioth. Bot. xx, heft 85, 445 in nota (1915).

C. aridicolus Domin, l.c., 445 in nota (1915).

C. umbellatus var. *fasciculigerus* F.Muell. in Horn Sci. Exp. Centr. Austr. iii, 181 (1896).

Mariscus Cunninghamii C. B. Clarke in Kew Bull. Add. Ser. viii, 18 (1908).

M. fasciculigerus (F.Muell.)Domin, l.c., 443 (1915).

M. aridicolus Domin, l.c., 439 (1915).

I agree with Kükenthal in regarding *C. umbellatus* var. *fasciculigerus* F.Muell. as being conspecific with *Mariscus Cunninghamii* C. B. Clarke. Mueller's type is a very young specimen and at first sight it looks very unlike well developed specimens of the species. I have not seen Domin's type of his *M. aridicolus*, but I have collected specimens at and near his type-locality which agree with his description. *M. xerophilus* Domin, l.c., 438, fig. 101, to judge from specimens from the same localities agreeing with Domin's description and figure, is not very different, and a larger suite of collections may show all to belong to one somewhat variable species. *C. Cunninghamii* extends from north-west Australia through the Northern Territory to north-west Queensland.

Cyperus flavus (*Vahl*) *Nees* in Linnaea xix, 698 (1847); Kükenth., l.c., 530.

Mariscus flavus Vahl Enum. Pl. ii, 374 (1806).

QUEENSLAND.—Moreton District: Sunnybank, near Brisbane, on roadside among grass on loose reddish sandy soil, January 20th, 1934, *S. T. Blake* 5106; Ipswich, Denmark Hill, on sandy loam, January, 1934, *H. G. Cribb;* Ipswich, Denmark Hill, on loamy soil with gravelly surface, February 16th, 1933, *H. G. Cribb;* Canungra, along roadside through *Eucalyptus* forest, ca. 300 ft., March 26th, 1937, *S. T. Blake* 12851.

Not previously recorded for Australia. Native to South America; naturalized in North America and in south-east Queensland. The determination of *Blake* 5106 has been confirmed by Kükenthal.

Cyperus Metzii (*Hochst.*) *Mattf. & Kükenth.* in Kükenth., l.c., 612 (1936).

Kyllinga squamulata Thonn. ex Vahl Enum. Pl. ii, 381 (1806), not *Cyperus squamulatus* Steud.

K. Metzii Hochst. ex Steud. Synops. Cyper. 70 (1855).

QUEENSLAND.—Maranoa District: 20 miles west of Mitchell, in open, damp, grassy places near tank, 1,600 ft., April 1st, 1936, *S. T. Blake* 10967.

New for Australia. Previously known from Africa, India and the West Indies.

Scirpus L.

Scirpus Merrillii (*Palla*) *Kükenth.*, ex Merr. Enum. Philip. Pl. i, 117 (1925).

Schoenoplectus Merrillii Palla in Kneucker, Cyperaceae (excl. Carices) et Juncaceae exsiccatae viii, nr. 223 (1911) et in Allgem. Bot. Zeitschr. xvii, Beil. 3 (1911).

QUEENSLAND.—Darling Downs District: Killarney, at shady edge of creek, ca. 2,600 ft., forming small green patches, January 31st, 1938, *S. T. Blake* 13238; near Killarney, on Spring Creek Plateau, in wet, swampy places in *Eucalyptus* forest, ca. 3,000 ft., May 1st, 1938, *S. T. Blake* 13802.

NEW SOUTH WALES.—Northern Tablelands: New England, *C. Stuart* 757 (MEL); Head of Bellinger R., April, 1873, *C. Moore* (NSW). North Coast: North Barrington, January, 1911, *J. L. Boorman* (NSW). Central Tablelands: Katoomba, wet places along tracks in deep gorges, 2,800-3,000 ft., January 22nd, 1939, *S. T. Blake* 13922

(BRI, NSW); Orange, January, 1908, *J. L. Boorman* (NSW). Southern Tablelands: Near Mt. Franklin, in peat swamps, 5,300 ft., January 19th, 1939, *S. T. Blake* 13895 (BRI, NSW); near Tharwa, on sandy river bank, ca. 2,000 ft., February 2nd, 1935, *S. T. Blake* 7553; Coree, Queanbeyan, December 11th, 1911, *R. H. Cambage* 3344 (NSW); Upper Gudgenby, Queanbeyan, January 16th, 1912, *R. H. Cambage* 3465 (NSW); Yarrangobilly Caves, February, 1897, *E. Betche* (NSW); Kiandra District, February, 1897, *E. Betche* (NSW); Pretty Point, Mt. Kosciusko, January, 1899, *Maiden & Forsyth* (NSW); Snowy Mountains, 6,000 ft., March, 1890, *W. Baüerlen* 134 (MEL, BRI).

VICTORIA.—North-East: Towanga, on bank of Kiewa R., January 27th, 1935, *S. T. Blake* 7409 (BRI, MEL); Mt. Buffalo, in morasses, ca. 4,500 ft., forming small green mats, January 25th, 1935, *S. T. Blake* 7377 (BRI, MEL); Mt. Buffalo, on mud, ca. 4,500 ft., January 25th, 1935, *S. T. Blake* 7379 (BRI, MEL). North-East or Gippsland: Mt. Cobberas, in alpine turfy meadows, *F. Mueller* (MEL, BRI); summit of Mt. Hotham, January, 1888, *C. Walter* (NSW). Central: Cement Creek, Dandenong Range, by the roadside in *Eucalyptus regnans-Nothofagus* forest, 2.200 ft., forming small, dense, light-green patches, January 19th, 1935, *S. T. Blake* 7251 (BRI, MEL).

TASMANIA.—King Island, *A. Neate* (MEL, BRI); Mt. Wellington, January, 1924, *A. H. S. Lucas* (NSW); Cascades, Hobart, *F. A. Rodway* (NSW, mixed with *S platycarpus* S. T. Blake); without definite locality, *hb. Archer* 37 (NSW, mixed with *S. calocarpus* S. T. Blake).

New for Australia. I have also seen specimens from New Zealand, New Guinea, and the Philippine Islands, including the type-collection (Caulon Volcano, Negros, Philippine Islands, *E. D. Merrill in Kneucker Cyperaceae et Juncaceae exsiccatae viii, nr.* 223).

The species has been confused with *S. inundatus* (R.Br.) Spreng., *S. aucklandicus* (Hook f.) Boeck. and *S. antarcticus* L. It is not very like *S. antarcticus*, differing in habit (particularly in having a creeping rhizome), the texture of the glumes and the pale-coloured prominently 3-ribbed nut. The affinities with the other species are indicated below.

Scirpus aucklandicus (*Hook. f.*) *Boeck.* in Linnaea xxxvi, 491 (1870).

Isolepis Aucklandica Hook. f. Fl. Antarct. i, 88, t. 50 (1844).

NEW SOUTH WALES.—Southern Tablelands: Near Mt. Franklin, in peat swamp, 5,300 ft., January 19th, 1939, *S. T. Blake* 13896 (BRI, NSW); Munyang Mtns., 5-6,000 ft., *F. Mueller* (MEL, BRI); Snowy Mtns., *F. Mueller* (MEL).

VICTORIA.—North-East: Mt. Buffalo, in morasses, ca. 4,500 ft., forming dense dark-green mats, January 25th, 1935, *S. T. Blake* 7374; Diamantina, under Mt. Hotham, 5,000 ft., December, 1914, *A. J. Tadgell* (BRI ex MEL). Gippsland: Snowy R., towards the Australian Alps, January, 1854, *F. Mueller* (MEL).

TASMANIA.—Arthur's Lakes, January 17th, 1845, *R. C. Gunn* 1420 in part (NSW); Hobart, December, 1923, *A. H. S. Lucas* (NSW); without definite locality, *hb. Archer* (NSW).

Not previously recorded for Australia except for the remark by Cheeseman in Handb. Fl. N. Zeal. 773 (1906); ed. ii, 221 (1925). The species is more widely spread in New Zealand and its outlying islands and in Amsterdam Island.

Mueller's specimens from the Snowy Mountains were referred by Bentham in Fl. Austral. vii, 328 (1878) to *S. cartilagineus* (R.Br.) Spreng. var. *alpina* (Hook f.) Benth., l.c., based on *Isolepis alpina* Hook. f., which is *Scirpus Gunnii* Boeck. The same specimens were referred to *S. antarcticus* L. var. *alpina* by Ewart in Fl. Vict. 219 (1930). Ewart's combination is probably based on Bentham's trinomial, but there is no direct evidence of this and it might be treated as a new variety.

Gunn 1420 (as to the specimens in herb. Sydney) is a mixture of *S. aucklandicus* and the terrestrial form of *S. fluitans* L. J. D. Hooker apparently examined only the latter plants, as this number is cited by him only under *Isolepis fluitans* var. *terrestris* in Fl. Tasm. ii, 86 (1860).

Scirpus Gunnii *Boeck.* in Linnaea xxxvi, 393 (1870).

Isolepis alpina Hook. f. Fl. Tasm. ii, 86, t. 143 B (1860), non *Scirpus alpinus* Schleich.

Scirpus cartilagineus Spreng. var. *alpina* (Hook f.) Benth. Fl. Austral. vii, 328 (1878).

TASMANIA.—Lake St. Clair, February 13th, 1845, *R. C. Gunn* 1409 (NSW) and January 7th, 1841, *R. C. Gunn* 1437 (NSW); Lake St. Clair, *Gulliver* (MEL, BRI); National Park, in tarn, moor at head of Broad R., ca. 3,500 ft., December, 1943, *W. M. Curtis* (HO); Cradle Valley, wet heath flora, 3,000 ft., Feb., 1911, *G. Weindorfer* (NSW, BRI); Tasmania, without definite locality, *R. C. Gunn* (B) and *Archer* 1584 (NSW).

In the original description of *Isolepis alpina*, J. D. Hooker, l.c., p. 87, cites *Gunn* 409, 1427, 1437. The specimen of 1427 in herb. Sydney is unsatisfactory, as the glumes and bracts have fallen away, but the shortly creeping rhizome and general appearance suggest that it is more likely *S. aucklandicus*. This may be the reason why Cheeseman (almost certainly on the authority of C. B. Clarke) has cited *Isolepis alpina* Hook.f. Fl. Tasm. ii (1860) 86 (*in part*) as a synonym of *Scirpus aucklandicus* in Handb. Fl. N. Zeal. 773 (1906); ed. ii, 221 (1925). The specimen in herb. Berlin is surely from one of these collections, though the number and exact locality do not appear on the label. It was on this specimen that Boeckeler based his description of *Scirpus Gunnii*.

Bentham, l.c., considered specimens of this species together with specimens of *S. aucklandicus* as representing a variety of the widespread *S. cartilagineus* (R.Br.)Spreng. (= *S. antarcticus* L.). Rodway, Tasm. Fl. 243 (1903), treats *Isolepis alpina* Hook.f. as a a synonym of *S. cartilagineus*. It differs from this species in foliage, less angled spikelets, larger glumes and nuts, glumes more oblong, less pointed, less incurved, fewer nerved, not or scarcely shining, and in the 3-ribbed slightly compressed nut. Actually the nut of *S. Gunnii* is slightly narrower than is shown by Hooker's figure, l.c.

Isolepis Gunnii Steud. Syn. Glum. ii, 94 (1855) was based on *Gunn* 420, which is a mixture of forms of the variable *S. inundatus* (R.Br.) Spreng. Since Steudel's epithet has not been transferred to *Scirpus* it does not affect the nomenclature of *Scirpus Gunnii* Boeck.

These species may be distinguished by the following key:—

Tufted annual, rarely branched below; spikelets prominently angled; glumes bright brown or chestnut, coriaceous; nut not ribbed, with nearly flat sides .. .. *S. antarcticus.*

Perennials; glumes pallid or more or less purplish-black (except in *S. aucklandicus*), membranous, with less stout keels; nuts with the angles rib-like:

Stamen 1; anther oblong, muticous, 0.5 mm. long or less; nut pale-coloured, somewhat convex between the 3 ribs, about 0.85–1 mm. long and 0.55–0.7 mm. wide:

Plant tufted, sometimes somewhat branched at the base but without a definite rhizome; leaves usually all reduced to their sheaths (upper one sometimes with a short, rarely long, blade); bract usually short; spikelets (except in very depauperate specimens) 3 or more; glumes more or less mucronate, not emarginate; nut distinctly shorter than the glumes .. .. *S. inundatus.*

Very slender usually quite short plants with filiform rhizomes and elongated leaves often overtopping the culm; bract frequently elongated; spikelets usually solitary, rarely 2 or even 3; glumes more or less emarginate, scarcely if at all mucronate, nearly as broad as long; nut nearly as long as the glume .. *S. Merrillii.*

Stamens 3; anthers linear, prominently apiculate, 0.7–1 mm. long; nut at maturity sometimes dark-coloured, about ⅔ as long as the glume, the sides rather concave between the ribs, about 1.5 mm. long and about 0.8–0.9 mm. wide; dwarf plants with short culms, relatively long frequently rigidly coriaceous leaves and bracts and usually solitary spikelets (up to 3 in. *S. Gunnii*):

Plant tufted, usually without a trace of a creeping rhizome; leaf-sheaths rather loose; spikelet lanceolate; glumes oblong-ovate, 2.5–3 mm. long, narrowly keeled; style below the branches 0.7 mm. long; nut finally dark-brown, nearly regularly triquetrous .. *S. Gunnii.*

Plant with slender firm creeping branched rhizomes; spikelet ovoid, small, partly hidden by the enlarged base of the bract; glumes ovate, stoutly keeled, 1.6–2.2 mm. long; style below the branches 0.3–0.4 mm. long; nut pale-coloured, somewhat compressed .. .. *S. aucklandicus.*

Scirpus Muelleri *Boeck.* Cyp. Nov. ii, 14 (1890).

Dr. J. Mattfeld kindly sent me a photograph of the type in herb. Berlin, and this with the original description (for a copy of which I am indebted to Mr. E. Nelmes, of the Royal Botanic Gardens, Kew) shows that the specimen is undoubtedly a young plant of the widely spread *S. nodosus* Rottb. and Boeckeler's name must be regarded as a synonym of this. The specimen is marked as having come from the Swan River and as having been sent by F. Mueller. I have not seen any specimens in herb. Melbourne labelled as from the Swan River, though there is a collection of Oldfield's from Freemantle and other collections from neighbouring areas. I know of no other member of the family from this region at all resembling *Scirpus nodosus.*

Scirpus hystrix *Thunb.* Prodr. Pl. Cap. 17 (1794-1800).

VICTORIA.—North-Central: Graytown, west of Nagambie, July 7th, 1939, *N. A. Wakefield* (BRI, MEL), and October 11th, 1939, *N. A. Wakefield* (BRI, MEL).

Apparently a recent introduction from South Africa. The species produces small leafy tufts with short culms, leafy bracts and a head of few spikelets with strongly squarrose glumes.

Eleocharis R.Br.

Eleocharis Chaetaria *R. & S.* Syst. ii, 154 (1817); Svenson in Rhodora xxxix, 250, pl. 461, fig. 10 (1937).

QUEENSLAND.—Cook District: Eubenangee swamp, north of Garradunga, very common in dried-out places, ca. 10 ft., December 1st, 1941, *S. T. Blake* 14491.

New for Australia; previously recorded from India, Ceylon, Indio-China, Malay Peninsula and the Philippine Islands.

The Australian specimens differ somewhat from Svenson's figure and description in the obscurely punctate culms and the less depressed style-base, and this suggested an approach to the corresponding American species *E. retroflexa* (Poir.) Urban. Specimens were accordingly sent to Dr. Svenson and he has reported that they undoubtedly represent *E. Chaetaria,* though the shape of the style-base is not quite characteristic of the species.

The species is recognized by its small slender annual habit (culms 5–15 cm. high), small few-flowered spikelets with the obtuse glumes spreading in fruit, 3-fid style, trigonous, tricostulate, urceolate, deeply cancellate nut and the 3-crested decurrent style-base. In my monograph of the Australian and New Zealand species in Proc. Roy. Soc. Queensl. l, 88–132 (1939) it would come between No. 11 and No. 12, and in the key on p. 94 it comes under the grouping "Style 3-fid, or if 2-fid," etc., and below this a separate group should be made: "Nuts tricostulate with prominently cancellate sides . . . . *E. Chaetaria.*"

Fimbristylis Vahl.

Fimbristylis pallida *S. T. Blake,* nomen novum.

F. leucostachya Boeck. in Linnaea xxxviii, 385 (1874), non R. & S. Syst. ii, 92 (1817).

F. nutans (Retz.) Vahl var. *leucostachya* C. B. Clarke ex Domin in Biblioth. Bot. xx, heft 85, 450 (1915).

The type sheet, *Schultz* 320 in herb. Berlin, bore four pieces of a distinctive plant closely allied to *F. nutans* (Retz.) Vahl, *F. rhyticarya* F.Muell. and *F. acuminata* Vahl. The specimens were collected by F. Schultz on May 15th, 1869, probably in the neighbourhood of Darwin, and certainly not near Adelaide, which is the locality given by Boeckeler, l.c. The specimens of *Schultz* 320 in herb. Melbourne are characteristic *F. acuminata* Vahl, and to judge from Bentham's description and remarks in Fl. Austral. vii, 302 (1878) Schultz mixed specimens of these two species under the same number. It differs from *F. nutans, F. rhyticarya* and *F. acuminata* in that the spikelet is more obtuse and the nut is narrowly and deeply furrowed (in the other species the transverse furrows are broad and shallow, and it is the ridges between the furrows which catch the eye); from *F. nutans* and *F. rhyticarya* it further differs in the pale-coloured erect spikelet (sometimes pale and suberect in *F. rhyticarya*), thinner fewer-nerved glumes and narrower nuts, while from *F. nutans* it differs still further in the presence of leaves and much less hardened base of the plant, and from *F. rhyticarya* in the smaller glumes and nuts. From *F. acuminata* it also differs in the broader and more obtuse glumes.

Fimbristylis adjuncta *S. T. Blake*; species nova, egregia, ob nucem obovatam cancellatam atque stylum persistem ab omnibus speciebus monostachyis distigmatosis distinguenda.

Herba annua, gracilis, caespitosa, basi foliata. Culmi fasciculati, stricti, obliqui vel erecti, setacei, subtetragoni, pluricostati, glabri laevesque, 7–15 cm. longi, circiter 0·25 mm. crassi. Folia plura, tertiam vel dimidiam partem culmi adaequantia; vaginae arctae, dorso conspicue nervosae sparse albo-pilosae pilis rigidis brevibus basi incrassatis, ceterum hyalinae eglandulosae glabrae vel glabrescentes; laminae setaceae, planae vel leviter incurvae, acutae, 0·3–0·5 mm. latae, subtus paucinerves nec carinatae, supra enerves vel uninerves ob cellulas distinctas reticulatae, marginibus incrassatae sursum scaberulae, ceterum glabrae laevesque; folia caulina 2–3, eorum laminae ceteris angustiores brevioresque saepe brevissimae. Inflorescentia unispiculata per glumas 2 vacuas apice setaceas quasi bracteata. Spicula erecta vel suberecta, pallida, lanceolata vel anguste ellipsoidea, acuta, 5–7·5 mm. longa, 1·4–1·6 mm. lata, multi- et densi-flora. Glumae spiraliter imbricatae, appressae, ovatae, obtuse rotundatae, prominule cuspidatae, tenuiter membranaceae, marginibus late hyalinae, dorso 3-nerves nervis viridibus confluentibus sursum crasse carinatae carina excurrente recta, omnino glabrae laevesque eglandulosae, cellulis elongatis, cuspide usque ad 0·5 mm. longa excepta 2·2–2·5 mm. longae, 1·4–1·5 mm. latae; 2 infimae vacuae angustiores cuspide longiore, ima interdum apicem attingens. Stamen 1; anther linearis minute rubro-apiculata, 0·75 mm. longa. Stylus complanatus manifeste fimbriatus, sursum tenuis basi dilatatus, 1–1·4 mm. longus, persistens; stigmata 2, tenuia, circiter 0·6 mm. longa. Nux albida, obovata late subcuneata, stipitata, apice obtusa vel obtusissima admodum umbonulata, marginibus anguste costulata acuta, lateribus nitidula tenuiter striata et cancellata cellulis extimis parvis transversim oblongis utrinque in seriebus circa 10–12 verticalibus regulariter dispositis, nec rugosa nec tuberculata, 0·75–0·85 mm. longa, 0·6–0·7 mm. lata.

QUEENSLAND.—Cook District: Eubenangee swamp, north of Garradunga, in dried-out places, ca. 10 ft., December 1st, 1941, *S. T. Blake* 14492 (TYPE).

This species differs from the other species with a single spikelet and 2 stigmas in the obovate striate and cancellate nut and the long persistent style which remains attached to the ripe nut. Some specimens of *F. annua* (All.)R. & S. and of *F. dichotoma* (L.)Vahl (species with striate and cancellate nuts) have the inflorescence reduced to a single spikelet, but in these species the spikelet is broader and brown-coloured, the glumes are broader and firmer, the style is readily deciduous, and the nut has coarser striations.

Fimbristylis recta *F. M. Bail.* 3rd Suppl. Syn. Queensl. Fl. 80 (1890).

F. xyridis R.Br. var. *rigidula* Benth. Fl. Austral. vii, 307 (1878).

F. stricticulmis Domin in Biblioth. Bot. xx, heft 85, 452 (1915).

NORTHERN TERRITORY.—North Australia: Darwin, *Giles* (?); Darwin, alongside drain, near sea-level, October 31st, 1946, *S. T. Blake* 17345; 5 miles south of Brock's Creek railway siding, with other annuals on disturbed soil in Eucalyptus forest, 480 ft., June 24th, 1946, *S. T. Blake* 16099.

QUEENSLAND.—Cook District: Hammond Island, June, 1897, *F. M. Bailey*; Cooktown, *Pollock* 24; near Northcote, February 20th, 1878, *R. C. Burton* (TYPE); Mareeba, in mixed open forest on yellowish-brown fine sandy loam, ca. 1,300 ft., June 18th, 1935, *S. T. Blake* 9481; Mareeba, in gently undulating *Eucalyptus* forest, ca. 1,400 ft., March 25th, 1938, *S. T. Blake* 13394; Herberton, January, 1912, *F. H. Kenny* (BRI, NSW), Stannary Hills, April, 1909, *T. L. Bancroft;* Fitzroy Island, *Walter* (MEL; TYPE of *F. xyridis* var. *rigidula*). North Kennedy District: Palm Island, in 1932, *T. L. Bancroft.*

The species also occurs in New Guinea. A very characteristic species which was not at all well described by Bailey, who placed it in sect. *Abildgaardia,* though it has densely spirally imbricated glumes. Probably because of the faulty description it was reduced to *F. monostachya* (L.)Haask. in Index Kewensis Suppl. i, 173 (1906). Domin did not see Bailey's type and redescribed the species as *F. stricticulmis* Domin from specimens collected by himself at Mareeba, not far from the type locality of *F. recta.* A few points in his description do not quite accord with Bailey's type, notably his description of a smaller not compressed nut and very short stigmas. My 9481 and 13394 were collected from Domin's type locality and, particularly among the numerous specimens with spikelets in various stages of development constituting 13394, spikelets were found which agreed closely with Domin's description, while others matched the type-specimens of *F. recta*; intermediate states occur. *F. xyridis* var. *rigidula* Benth. was based on a solitary immature specimen. *F. MacGillivrayi* C. B. Clarke in Kew Bull. Add. Ser. viii, 24 (1908) may be the same species, but until the type in the British Museum can be examined its identity must remain doubtful; from the description it appears to differ only in that the style is villous (not glabrous) below the stigmatic branches and in that the nut has subconcave (not convex) sides.

The outstanding characters of *F. recta* are its densely tufted perennial habit with rather numerous rigid rather broad leaves with broad white scarious margins to the sheaths, the solitary erect rather large ovoid or ellipsoid densely many-flowered spikelet, oblong obtusely rounded 1-nerved glumes 5–6 mm. long with the upper margin ciliate, and the more or less pyriform tricostate nut with the sides convex between the ribs and verrucose in the upper part. The material from the Northern Territory shows more slender plants than usual, flowering in the first year, with rather distinctly nerved leaves of thinner texture.

Fimbristylis spathacea Roth Nov. Sp. Pl. 24 (1821).

F. glomerata Nees in Linnaea ix, 290 (1834).

Scirpus glomeratus Retz. Obs. iv, 11 (1786), non L.

QUEENSLAND.—Cook District: Cooktown, near edge of salt-pan amongst *Sporobolus virginicus* and *Fimbristylis polytrichoides,* about sea-level, December 7th, 1941, *S. T. Blake* 14567; Cooktown, in crevices in sea-cliffs, ca. 50 ft., July 30th, 1943, *S. T. Blake* 15064.

New for Australia; known previously from Madagascar, Tropical Asia, Philippine Islands and some other parts of Malaysia. Other synonyms are quoted by C. B. Clarke in Hook.f. Fl. Brit. Ind. vi, 640 (1894). The plants are densely leafy mat-like tufts; the spikelets, relatively small for the genus, are solitary or more or less clustered on the rays of the umbelliform inflorescence with small obtuse or notched glumes with minutely ciliolate margins, bifid styles and obovate biconvex smooth or somewhat tuberculate dark-coloured nuts.

Fimbristylis schoenoides (*Retz.*) *Vahl* Enum ii, 286 (1806); Domin in Biblioth. Bot. xx, heft 85, 454 (1915).

Scirpus Schoenoides Retz. Obs. v, 14 (1789).

Fimbristylis inconstans Steud. Syn. Pl. Glum. ii, 107 (1885) (*fide* C. B. Clarke).

F. macrostachya Boeck. in Linnaea xxxviii, 386 (1874).

F. subbulbosa Benth. Fl. Austral. vii. 305 (1878).

I have seen the type of *F. macrostachya* (*Schultz* 664 in herb. Berlin) and a duplicate type of *F. subbulbosa* (Rockingham Bay. *Dallachy* in herb. Melbourne). The latter represents a common state of the species with only one spikelet. Schultz's specimen, however, represents an extreme rather abnormal form with 4–6 spikelets, 2 of which are on short rays up to 15 mm. long, and the others sessile or nearly so in a central cluster. The spikelets are in flower only, but the glumes, ovary, gynophore, style, anther and filaments agree well with characteristic *F. schoenoides*. The species is somewhat variable in regard to the number of spikelets in the inflorescence, 1 or 2 being the usual number on Australian specimens with 3 or 4 less common. It is a widely spread plant ranging from south-east Asia to south-east Queensland. The type of Retzius has been studied by C. E. C. Fischer and identified as indeed representing *F. schoenoides* as commonly interpreted (Kew Bull. 1932, 69:1932).

Fimbristylis Schultzii *Boeck.* in Linnaea xxxviii, 391 (1874); Benth. Fl. Austral. vii, 320 (1878).

F. platystachys Boeck., l.c. 390 (1874); Domin in Biblioth. Bot. xx, heft 85, 464 (1915).

F. platystachys Boeck. var. *Schultzii* (Boeck.) Domin, l.c.

WESTERN AUSTRALIA.—North-West Division: Native well between King Island and Exmouth Gulf, April, 1916, *H. Basedow* 81 (NSW). Kimberley Division: Kunmunya, May 30th, 1942, *G. W. Holmes* (herb. R. A. Black 1163.084-(3)); Sturt's Creek, in 1856, *F. Mueller* (MEL).

NORTHERN TERRITORY.—North Australia: Port Darwin, *Giles* (?) 31, 76; Port Darwin, *F. Schultz* 176 (MEL); probably Port Darwin, *F. Schultz* 96 (B; TYPE of *F. Schultzii*) and 792 (B; TYPE of *F. platystachys*); Cox's Peninsula, near Port Darwin, *Tate* 7 (MEL); Batchelor Farm, wet land, June, 1914, *C. E. F. Allen* 44 (NSW); 5 miles south of Brock's Creek railway siding, with other annuals on disturbed soil in *Eucalytus* forest, 480 ft., June 24th, 1946, *S. T. Blake* 16096A; near Daly River Police Station, at 13° 40′ S., 130° 42′ E., open ground, disturbed stony soil, 85 ft., July 19th, 1946, *S. T. Blake* 16515; near Edith R., Darwin-Katherine road, open places on granite sand, ca. 500 ft., June 24th, 1946, *S. T. Blake* 16096; about 9 miles north-west of Katherine, on Darwin road, in gravel-pit, on recently disturbed hard red stony soil, ca. 450 ft., June 20th, 1946, *S. T. Blake* 16037.

There is also a good collection in the Tate Herbarium ex Schomburgk Herbarium labelled "N. Australia," evidently collected by Schultz.

The type of *F. Schultzii* bears mature spikelets while that of *F. platystachys* has spikelets in flower only. I have no doubt that both represent the same species, as was first suggested by Bentham, l.c.; and his choice of name must accordingly be followed, since both names were published simultaneously (Art. 56 of the International Rules of Nomenclature). Domin apparently chose *F. platystachys* because of priority of page. Both the Berlin sheets were marked *Fimbristylis Schultzii* by C. B. Clarke in February, 1889.

The species is distinguished by its rather small annual leafy tufts, short leaf-sheaths, capitate inflorescence with short bracts and several sessile spikelets, the shortly ciliate to more or less glabrous glumes with stout keels, spreading points and hyaline sides, and the small shining black obovate-pyriform trigonous nut very obtuse to emarginate at the top. In *Blake* 16515 reduced spikelets with delicate glumes occur in some of the basal leaf-sheaths.

Fimbristylis stellata *S. T. Blake*; species nova, affinis *F. Schultzii* Boeck., a qua glumis crassius carinatis et longius robustiusque aristatis, nuce alba obovoidea nec pyriformi nec obcordata differt.

Herba annua, gracilis, plus minusve caespitosa, 10–50 cm. alta. Culmi saepe plures rarissime singuli, setacei, plus minusve tetraquetri sed compressi, pluricostati, sursum scaberuli, glabri, usque ad 0·6 mm. crassi. Folia dimidio culmo breviora vel longiora, flaccidula, acuta, plana, subtus 5-nervia costa nervis ceteris subsimili, supra saepe enervia, utrinque celluloso-reticulata, marginibus incrassatis sursum scabra ceterum glabra laeviaque, 0·7–1·6 mm. lata; vaginae rubido-punctatae glabrae, dorso reticulatae valde nervosae, antice hyalinae; folia caulina plerumque 2–4 eorum laminae bene evolutae. Inflorescentia capitata, 10–15 cm. diam. Bracteae plus minusve setaceae, 1–3 infimae inflorescentiam saepius aequilongae vel paullo longiores, reflexae. Spiculae pro more 5–12, stellatim patentes, brunneae, anguste oblongae, obtusae, angulatae, squarrosae, 5–7 mm. longae, circa 4 mm. latae, multi- et densi-florae. Rhachilla alulata. Glumae undique spiraliter imbricatae, oblongae, obtusissimae vel bilobae, sub apice aristulatae, dorso incurvo coriaceae obscure trinerves grosse obtuseque carinatae carina pallida sub apice in aristulam excurvam acutam plus minusve scabram 1–1·2 mm. longam excurrente, lateribus tenuissime membranaceae brunneo-tinctae vel -punctatae, minutissime parceque punctato-glandulosae, sursum marginibus vix hyalinis pilosulae, cellulis breviter oblongis, aristula exclusa 2·4–2·6 mm. longae. Stamina 3; antherae circa 1·5 mm. longae, apiculatae apiculo albosetoso. Stylus glaber triquetrus tenuis basi pyramidatus, circa 2 mm. longus; stigmata 3, stylo subaequilonga, tenuia, pilosula. Nux albida lucida fere vitrea, obovoidea, turgida, trigona interdum leviter compressa, tricostulata, apice obtusa umbonulata, basi plus minusve cuneata prominule stipitata, basi excepta dense verrucosa, cellulis extimis parvis transversim oblongis in seriebus verticalibus circa 6 utrinque regulariter dispositis sed ob verrucas indistinctis. 0·9–1·15 mm. longa (toro conspicuo rubido 0·1 mm. longo incluso), 0·7–0·75 mm. lata.

NORTHERN TERRITORY.—North Australia: Near Kathleen Falls, Flora R., in sparsely timbered grassy depressions with dark-grey hard soil, ca. 360 ft., October 16th, 1946, *S. T. Blake* 17241.

QUEENSLAND.—Cook District: On Wrotham Park, about 50 miles north-west of Mungana, on heavy soils in both forest and grassland, April 6th, 1938, *S. T. Blake* 13670 (TYPE).

Allied to *F. Schultzii* Boeck. and very similar to it in habit, foliage. anthers, style and shape of glumes; but differs in the broader more squarrose spikelets, the more coarsely and obtusely keeled glumes more densely hairy at the margins and with longer stouter awnlets, and in the white (not black) simply obovoid (neither pyriform nor obcordate) somewhat larger nut which also appears to be more densely and evenly verrucose.

Fimbristylis Brownii *Benth.* Fl. Austral. vii, 308 (1878).

F. leptoclada Benth. Fl. Austral. vii, 314 (1878), non Benth. Fl. Hongk. 393 (1861).

F. vaginata (R.Br.) Domin in Biblioth. Bot. xx, heft 85, 460 (1915) non Boiv. ex C. B. Clarke in Dur. & Schinz. Consp. Fl. Afr. v, 606 (1895).

Abildgaardia vaginata R.Br. Prodr. 229 (1810).

Brown's *Abildgaardia vaginata* was founded on immature specimens with 2–5 spikelets. Bentham transferred it to *Fimbristylis* sect. *Abildgaardia* and called it *F. Brownii.* Bentham founded his *F. leptoclada* chiefly on specimens with 1-3 spikelets collected by Dallachy and arranged it under sect. *Trichelostylis*; he entirely overlooked his previous use of this name for an entirely different Hong Kong plant. C. B. Clarke appears to have been the first to suggest that the Australian *F. leptoclada* was conspecific with *F. Brownii,* though his views were apparently not published before Domin, l.c., published them. Domin took up the earliest epithet for the species, but overlooked the fact that the resulting combination had already been published twenty years earlier for another species. Under the circumstances it appears that the combination *Fimbristylis Brownii* Benth. is now the legitimate name for the species, though it was illegitimate at the time of publication.

In the flowering state the glumes of this species appear to be distichous, though in the upper part of the fruiting spikelets they appear to be loosely spiral. The characters of the nut suggest a position closer to sect. *Abildgaardia* than to other sections. The spikelets vary in number from 1 to 10; commonly a culm bears 1–3 spikelets, the central spikelet sessile, the others pedunculate though when more numerous some are clustered.

The species appears to be restricted to the Northern Territory and Queensland, where it occurs on loose sandy soils usually not very far inland.

Mapania Aubl.

Mapania macrocephala (*Gaud.*) *K. Schum.* apud Warb. in Engl. Bot. Jahrb. xiii, 265 (1891).

Hypolytrum macrocephalum Gaud. in Freycin. Voy. 414 (1826).

Cephaloscirpus macrocephalus (Gaud.) Kurz in J. As. Soc. Beng. xxxvii (2), 83 (1869).

Lepironia macrocephala (Gaud.) Miq. Ill. Fl. l'Arch. Ind. 64 pl. xxvii (1871).

QUEENSLAND.—Cook District: Daintree R., in open gully in rain-forest, clumps 5–6 ft. high, September 24th, 1937, *L. J. Brass & C. T. White* 324; Cairns, at the foot of Edge Hill, in dense swampy rain-forest, about sea-level, abundant in undergrowth, December 1st, 1942, *S. T. Blake* 14770; Yarrabah, near Cairns, in swampy forest at about sea-level, June 28th, 1935, *S. T. Blake* 9645. North Kennedy District: Near Cardwell, in rain-forest near a creek, September 27th, 1935, *S. T. Blake* 9712.

New for Australia; previously known from the Moluccas, Admiralty Islands, New Guinea, New Ireland and the Solomon Islands.

A striking species belonging to the subgenus *Cephaloscirpus* (Kurz) Benth. & Hook. forming dense clumps resembling a small *Pandanus*. The very numerous bright green serrulate-margined and -keeled somewhat drooping leaves, not much narrowed towards the base but rather abruptly long-caudate at the tip, are from 2 to 3 metres long and 4–6 cm. wide. The culms are much shorter, usually less than 1 m., prominently triquetrous, usually 1-noded with a well-developed leaf about the middle. There are several bracts, the lower resembling the leaves but shorter (1–1·5 m. long), while the upper are gradually shorter and narrower. The inflorescence is a dense brown ovoid head 5–7·5 cm. in diameter. At Cairns and Yarrabah the plants were associated with *Scirpodendron Ghaeri* (Gaertn.) Merr. and *Hypolytrum latifolium* L. C. Rich.

This is the first record of the occurrence of a species of *Mapania* (sens. strict.) in Australia, for the previously recorded species, *Mapania hypolytroides* F.Muell., is now generally referred to the genus *Thoracostachyum* Kurz as *T. pandanophyllum* (F.Muell.) Domin.

Scleria Berg.

Scleria Novae-Hollandiae *Boeck.* in Flora lviii, 120 (1875).

QUEENSLAND.—Cook District: On Wrotham Park, about 50 miles north-west of Mungana, on sandy banks of creek, April 7th, 1938, *S. T. Blake* 13707; near Mareeba, wet places in *Eucalyptus* forest on sandy soil, ca. 1,400 ft., March 25th, 1938, *S. T. Blake* 13405; Cairns, in wet swampy forest about sea-level, June 15th, 1935, *S. T. Blake* 9380. North Kennedy District: Townsville, on wet sand on edge of small open gully, ca. 15 ft., March 20th, 1938, *S. T. Blake* 13335; Ravenswood, sandy creek bank, ca. 900 ft., March 31st, 1943, *S. T. Blake* 14881; Mt. Julian, *N. Michael*. South Kennedy District: Port Mackay, *Am. Dietrich* 725 (B; TYPE). Port Curtis District: Raspberry Vale Station, 22° 34½′ S., 150° 23′ E., at edge of waterhole in *Melaleuca* forest, ca. 150 ft., April 17th, 1945, *S. T. Blake & L. J. Webb* 15551. Moreton District: Alexandra Headland, on swampy cliffside, February 25th, 1934, *S. T. Blake* 5190; Geebung, Brisbane, in damp places, April 2nd, 1934; *S. T. Blake* 5310; Aspley, Brisbane, on damp open hillside, January 27th, 1934, *S. T. Blake* 5132.

A rather characteristic species distinguished from its closer allies by the oblong subcylindrical dull white (not shining) smooth nut with rounded scarcely lobed thin upper margin of the disc. Bentham, Fl. Austral. vii, 428 (1878) referred the species to *S. laxa* R.Br., and in this he was followed by F. M. Bailey in his various works and by Domin in Biblioth. Bot. xx, heft 85, 488 (1915). But *S. laxa* differs in having a nearly globular polished nut with a much thicker more distinctly 3-lobed disc, as well as in details of the inflorescence (see below).

Scleria filipendula *S. T. Blake;* species nova, affinis *S. rugosae* R.Br., sed planta fere glabra pedunculis filiformibus pendulis, nuce profundius tessellata, disco minus crasso profundius lobato differt.

Herba annua laxa humilis gracilis viridis, usque ad 22 cm. alta. Culmi dense fasciculati, obliqui sursum leviter excurvi, laeves, glabri, acute triquetri, lateribus concavi striati, infra inflorescentiam plerumque 1-nodes, raro 2-nodes. Folia pauca, basalia plerumque ad vaginas redacta; vaginae arctae, triquetrae, haud alatae, crebra brunneo-punctulatae, inferiores purpurascentes pubescentes, superiores virides glabrescentes; ligula brevissima, circa 0·3 mm. longa, late rotundata, ciliolata; laminae anguste lineares prope apicem obtusum leviter angustatae, culmo breviores, circa 1·2–1·3 mm. latae, marginibus atque nervis lateralibus supra parce scaberulae ceterum glabrae laevesque. Inflorescentia laxa foliosa paucispiculata, plantae partem majorem occupans, plerumque e duobus fasciculis pedunculorum constructa. Bracteae foliis similes, inflorescentiam subadaequantes vel superantes. Pedunculi 3–4-ni, plus minusve nutantes, tenuiter filiformes sub apice leviter incrassati 3-marginati marginibus scaberulis, usque ad 3 cm. longi, spiculos 5 vel 7 approximatos ferentes. Spiculae unisexuales; spicula mascula quemque pedunculum terminans, breviter pedicellata, linearis, 1·6–1·8 mm. longa, circiter 3-flora; glumae anguste ovatae, obtusae, membranaceae vel hyalinae, 1-nerves, glabrae, spiculae subaequilongae; stamen 1, anthera 1·1–1·2 mm. longa. Spiculae femineae uniflorae, circa 3·2 mm. longae; glumae ovatae, subobtusae, mucronulatae, carinatae, 1-nerves, glabrae. Nux subglobosa (vel disco incluso obovoidea), umbonulata, pluricostulata et leviter tricostata, inter costulas irregulariter trabeculata (hinc profunde sed irregulariter tessellata), apice plus minusve tuberculata, nitidula, alba vel albida raro demum nigrescens, glabra, disco incluso 2·2–2·3 mm. longa, 1·8–1·9 mm. lata; discus interior arcte appressus, haud glandulosus, fere 3-partitus lobis ovatis integris obtusissimis et sinubus valde incrassatus; discus exterior parvus cupularis.

QUEENSLAND.—Moreton District: Meridan Plains, near Buderim Mtn., on wallum flats, common, March 1st, 1934, *S. T. Blake* 5233 (TYPE).

Quite a large number of plants constitutes the type-collection. The species is allied to a group of small often pale-green annuals with unisexual monoecious spikelets which are rather widely spread in swampy places in north-east Australia, extending as far south as Brisbane, and are frequently found growing together. These are *S.*

Benthamii C. B. Clarke, *S. Novae-Hollandiae* Boeck., *S. laxa* R.Br. and *S. rugosa* R.Br. The five species may be distinguished by the following key:

Nut globular, polished; disc thickened, particularly at the sinuses, with 3 rounded lobes; terminal partial panicles not markedly different from the lower ones:

- Peduncles triquetrous, relatively stout, erect; disc shallowly lobed:
  - Plant glabrous; nut at maturity usually not tessellated except lightly so near the more or less tuberculate apex .. *S. laxa.*
  - Plant pubescent; nut at maturity conspicuously tessellate .. .. .. *S. rugosa.*
- Peduncles filiform, long, loose, and more or less nodding; nut deeply tessellate; disc deeply lobed .. .. *S. filipendula.*

Nut oblong to somewhat ellipsoid with nearly parallel sides, not polished and rather dull; inner disc rather thin though closely appressed to the nut, sinuately 3-lobed; terminal partial panicle markedly longer and denser than the others:

- Nut more or less distinctly tessellate at maturity, somewhat pubescent; lobes of disc with a short erect appressed point .. .. .. *S. Benthamii.*
- Nut smooth or nearly so at maturity though tessellate when young, glabrous; lobes of disc rounded, without any point .. .. .. *S. Novae-Hollandiae.*

THE LIGNEOUS GENUS ENDOSPERMUM Benth. (EUPHORBIACEAE) IN NEW GUINEA.

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(Plates I and II.)

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Pax (1912, pp. 33–39; 1914, p. 418) and Pax and Hoffmann (1919, p. 53), in the most complete account of the genus available, record only one species of Endospermum, *E. formicarum* Becc., from New Guinea. No descriptions of more recent additional species from this locality have been found. From observations made in the field it was suspected that at least three species occurred in those portions of the island visited. More critical examination of herbarium specimens has confirmed this belief. One of the three species proved referable to *E. formicarum*, but the remaining two did not agree with accounts of any of the Malaysian or Polynesian members of the genus and are here described as new. Type-specimens, illustrated in plates I and II, are deposited in the Queensland Herbarium, Brisbane. To complete the treatment of New Guinea species and to overcome the inadequacy in some respects of the original description, a full account of *E. formicarum* is also given. In addition a key is provided to distinguish the species dealt with.

E. formicarum and *E. myrmecophilum* sp. nov. most commonly occur as small to medium-sized trees on the rain-forest margin or in low regrowth forest. Each of them always possesses hollow branchlets, with neat circular outlets along them, which have been channelled out by and are inhabited by a species of blackish ant. This type of symbiosis, which is fairly common in the genus and has also been observed in several trees belonging to unrelated families, has been discussed in a paper by Docters van Leeuwin (1929) on *E. formicarum*. *E. medullosum* sp. nov., on the other hand, has been observed mainly within the rain forest. It normally develops into quite a tall tree and invariably has solid branchlets.

Approximately 600 ft. is the maximum altitude as yet recorded for any of the New Guinea specimens of *Endospermum*. A specimen from the Solomon Islands, tentatively placed under *E. medullosum*, was collected at approximately 2,700 ft., an altitude attained by many lowland rain-forest species.

The timbers of the three species of *Endospermum* dealt with are similar to one another. They are pale straw to pale yellow-brown in colour, moderately soft, straight-grained, and split cleanly on the "quarter." The timber from the smaller trees is inclined to be slightly softer. Cut transversely, moistened, and examined under the hand-lens, a piece of the wood shows a reticulum or a series of fine regular bands of soft tissue, narrow rays, and medium-sized pores commonly arranged in radial multiples. In these features the wood grossly resembles that of *Alstonia scholaris* (L.) R. Br., a widely distributed, unrelated tree belonging to the family Apocynaceae, and colloquially known in Queensland as Milky Pine. As the timber of the latter tree has approximately equivalent density and hardness, it seems probable that similar uses will be found for the wood of *Endospermum,* that is, general light indoor work, etc. (see Swain, 1928, p. 111). Like Milky Pine, the timber is also subject to borer attack and blue mould.

The letter "T," when placed within the brackets following the collection number of the specimens cited below, indicates that hand samples of the timber were collected from the same tree that provided the botanical material. A set of these is deposited with the Division of Forest Products Laboratory of the Council for Scientific and Industrial Research, Melbourne, and it is understood that an account of the wood anatomy will be published in due course.

The specimens cited are largely from a collection made by direction of Major J. B. McAdam, CRE New Guinea Forests, by responsible members of his unit headquarters and the two associated forest survey companies. This collection is indicated by the letters "NGF." preceding the collection number. Both of the specimens selected as types were collected in conjunction with Mr. C. T. White, Queensland Government Botanist, and Dr. H. E. Dadswell, Officer in Charge, Wood Structure Section of the C. S. & I. R. Division of Forest Products Laboratory, during a visit made by them to Lae for the purpose of conducting a forestry school for the instruction of members of the abovementioned units.

The districts used in grouping the localities of specimens cited throughout this paper, are those given by Bartholomew in "Joseph's Reference Atlas" (1936 Impression).

Endospermum Benth.

As pointed out by Corner (1940, p. 250) and others, the genus is difficult to distinguish satisfactorily from *Macaranga* Thou. It consists of about 16 species distributed from S.E. Asia through Malaysia to Polynesia with a single species in N.E. Queensland. Of these, 3 occur in New Guinea.

Pax (1912, p. 34) and Pax and Hoffmann (1931, p. 184) recognize two subgenera distinguished as follows:—

Folia non peltata. Ovarium 2-loculare .. *Euendospermum* Pax.

Folia peltata vel nonnulla epeltata. Ovarium 4-6-loculare .. .. *Capellenia* (Teijsm. et Binnend.) Pax.

Although *E. formicarum* clearly belongs to the second subgenus, both of the new species described below differ from the first in the ovary being 1-celled in all flowers examined. In addition, one new species has consistently peltate leaves, while the other normally has some peltate leaves mixed with the more typical cordate ones in the crown of all trees examined.

It does not seem desirable to create a new subgenus distinguished only by the 1-locular condition of the ovary, but rather to broaden the conception of the subgenus *Euendospermum*. It would then embrace those species with a reduction in the number of ovary-cells below the typical 3-locular condition in the family, this reduction being most commonly though not invariably associated with the development of non-peltate leaves. The description of this subgenus is therefore emended as follows:—

Euendospermum Pax emend. L. S. Smith. Folia non peltata vel interdum peltata. Ovarium 1–2-loculare.

KEY TO THE SPECIES.

Ovary and fruit 1-celled. Female inflorescence distinctly paniculate, the lower primary branches attaining 3-13 cm. Fruits less than 0.75 cm. diam.:

- Fruits 0.8-0.9 cm. long; branchlets containing pith; lower surface of leaf-blade distinctly tomentose to the naked eye and with conspicuous elevated reticulation of the veins; petiolar glands shortly cylindrical or subglobose and stipitate .. 1. *E. medullosum* L. S. Smith.
- Fruits up to 0.6 cm. long; branchlets hollow; lower surface of leaf-blade not tomentose to the naked eye (very minutely so under the lens), and with the reticulation of the veins neither conspicuous nor elevated; petiolar glands triangular or ovate in outline, appressed, convex or bluntly conical .. .. 2. *E. myrmecophilum* L. S. Smith.

Ovary and fruit (4-)6-celled. Female inflorescence racemose or with one or two short branches at the base less than 2 cm. long. Fruits approximately 2.0-2.5 cm. diam. (Branchlets hollow; lower surface of leaf-blade glabrous or almost so; petiolar glands depressed globular) .. .. 3. *E. formicarum* Beccari.

1. **Endospermum medullosum** L. S. Smith sp. nov.—Plate I.

Arbor unisexualis, ca. 35-45 m. alta; truncus ca. 0.75–1.0 m. diam., basi anteridibus saepe praeditus; cortex avellaneus vel cinereo-fuscus, tenuiter suberosus; lignum cremeum. *Ramuli* modice crassi, 0.5–1.2 cm. diam., medullosi, sursum pubescentes vel etiam pilis longioribus interspersis interdum ornati, deorsum cicatricibus ellipticis vel suborbicularibus foliorum delapsorum notati. *Stipulae* lanceolatae vel dentato-subulatae, usque ad 0·5 cm. longae, pubescentes, caducae. *Petioli* stellato-pubescentes, glabrescentes, 3–12 (–23 in foliis surculorum) cm. longi, 0.15–0.4 cm. diam., basi haud (vel raro) contracti, apice glandulis 2 (interdum 3–4 vel 0) 0.1–0.2 cm. diam. breviter cylindraceis vel subglobosis et ± stipitatis ornati, stipite minute pubescenti quam glandula saepe angustiore. *Foliorum laminae* firme coriaceae, ovatae vel ovato-oblongae vel orbiculari-ovatae, 8–25 (–33) cm. longae, 5.5–20 (–25) cm. latae, supra mox glabrae, subtus stellato-tomentosae, basi cordatae vel obtusae vel rotundatae vel truncatae vel interdum peltatae deinde lamina usque ad insertionem petioli interdum fissa, apice obtusae vel latissime recurvae deinde emarginatae, margine subtus incrassatae; nervi supra tenuiter canaliculati, subtus valde elevati, 5–7 (–9) e basi vel prope basin laminae orti; nervus medius nervis secundariis 6–9 utroque latere praeditus; rete venularum comparate intricatum, supra obscurum vel manifestum, subtus partim valde elevatum partim prominens; glandulae hypophyllae globosae, ca. 0.1 cm. diam., in axillis bifurcationum nervorum marginem versus sitae, plerumque nullae. *Inflorescentiae* in axillis foliorum superiorum ortae, pubescentes, paniculatae, usque ad 20 cm. longae pedunculo usque ad 6 cm. longo incluso; rami primarii panicularum ♂ usque ad 8 cm. longi, panicularum ♀ usque ad 5 cm. longi; bracteae ovatae vel lanceolatae, 0.15–0.4 cm. longae, basi late affixae, apice obtusae vel acuminatae incurvae, margine integrae vel utroque latere unidentatae, in axillis dentium interdum glanduliferae. *Flores* ♂ subsessiles, glomerulati, articulati; perianthium ca. 0.15 cm. longum, truncatum vel sparse irregulariterque obtuse dentatum, breviter stellato-pubescens; columna staminum demum exserta, usque ad 0.4 cm. longa, basi nuda angustata; stamina ca. 3 - 6, filamentis ca. 0.03 cm. longis, antheris peltatis (3–) 4–locularibus. *Flores* ♀ breviter pedicellati, pedicellis 0.05–0.1 (–0.2 sub fructu) cm. longis, singuli, articulati; perianthium ca. 0.2 cm. longum, extus breviter stellato-tomentosum, irregulariter obtuseque 3-5-dentatum vel subtruncatum; discus tubulatus, 0.02–0.05 cm. longus, glaber, integer vel sparse irregulariterque crenulatus; ovarium ellipsoideum vel globosum, 0.14–0.3 cm. longum, minute denseque tomentosum, 1-loculare, 1-ovulatum; stigma ± badium, sessile, semiglobosum vel late conicum, ca. 0.075–0.125 cm. diam. *Fructus* pallide viridus, drupaceus, ellipsoideus, 0.8–0.9 cm. longus, 0.5–0.6 cm. diam., apice stigmate ca. 0.15–0.2 cm. diam. coronatus, basi perianthium ca. 0.2 cm. diam. persistens ferens; epicarpium minute sparseque stellato-pubescens vel subglabrum; mesocarpium tenue, nonnihil oleagineum; endocarpium cartilagineum. *Semen* nigrescens, ca. 0.6 cm. longum, 0.4 cm. diam., irregulariter costatum, sparse verrucosum.

TERRITORY OF NEW GUINEA.—Aitape District: Aitape, a few miles south-east of Tadji airstrip, alt. ca. 25 ft., in rain forest, *L. S. Smith* NGF.1204 (fruits—T), January 1945 (A tree 110 ft. overall, the branches appearing whorled and very obliquely ascending. Bole 75 ft., narrowly buttressed to 4 ft., d.a.b. 1½ ft. Bark ¼ in. thick; outer—greyish or pale brown, marked by longitudinal lenticellate lines and often finely horizontally cracked, hard or somewhat corky; inner—green on the back, within a creamy colour with fine yellow-brown speckle. Sapwood not defined, wood whitish. Leaves glossy above, whitish or greyish beneath. Glands on petiole more frequently absent than present. Fruits pale green). Sepik District: Abunti (Middle Sepik) on hills 400-600 ft., *C. E. Lane-Poole* 787 (old ♀ inflorescences—fruits missing), 14th July 1923 (A medium to large tree. 6 ft. 6 in. in girth, with a 40-ft. bole and reaching 60 ft. overall. Medium buttresses to a height of 8 ft. Leaves . . . bent at right angles at junction with blade . . . generally cordate also peltate . . . Fruit on panicles up to 1 ft. long . . . Bark grey and brown, scaly—scales shed in small more or less round patches, leaving bole crocodile-skinned. Inner bark speckled yellow and orange. Wood yellow, sap undefined, axes firmly. Said to be used for canoes. Wood and bark have a turnip smell. Later, in Lavengai, I found this growing with a bole of 90 ft. Native name—Mabung (Lavengai)). Morobe District: Lae, alt. 25 ft. in rain forest, *J. Cavanaugh* NGF.2 (immature inflorescences—T), June 1944 (Notes at present unavailable); between Lae and Nadzab (9 mile post), alt. ca. 50 ft., in rain forest, *2 Aust. For. Svy. Coy.* NGF.215 (fruits—T), June 1944 (A tree 100 ft. overall with sparse crown. Bole 70 ft., buttressed to 6 ft., g.a.b. 78 in. Bark brown, ½ in. thick; outer—fairly smooth but roughened by prominent pustules and pocklike marks; inner—light brown. Wood cream in colour, light, easy to cut, splits freely to smooth surface. Leaves leathery, dark green and shiny above, pale green beneath. glands 2–4 at junction with petiole . . .); Lae, in rain forest, *CRE N. G. Forests* NGF.697 (♂ flowers—T), in 1944 (Notes at present unavailable); Lae, alt. ca. 25 ft. in rain forest, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1513 (fruits—T), July 1944 (A tree up to 130 ft. high with a short flattish crown. Bole unbuttressed, 90 ft., d.b.h. 2½ ft. Bark ½ in. thick; outer—pale grey, thin, fairly smooth; inner—greenish on the back, within pale yellow-brown, speckled, and somewhat granular. Wood pale, sapwood scarcely defined. Leaves . . . cordate or peltate . . . prominently veined beneath, with two shortly cylindrical prominent glands on the petiole . . . Fruits green); Lae, in rain forest, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1703 (♂ flowers—T), August 1944 (A tree 90 ft. overall. Bole 60 ft., buttressed to 3 ft., d.b.h. 1¼ ft. Bark ⅜ in. thick; outer—grey-brown, thin, corky, finely longitudinally cracked; inner—green on the back, orange-brown with fine white and yellowish speckle within. Wood pale straw, sapwood ill-defined. Leaves clustered . . .branchlets . . . solid . . . fairly hairy. Petiole 3–6 in., curved immediately beneath its peltate or cordate insertion and with 2 or more commonly 3 very shortly cylindric glands. Blade shiny green above, grey and hairy beneath where the reticulation of the veins is prominent. Yellow globular glands occur about ¾ in. in from the leaf-margin in the axils of the final forkings of the main lateral veins, i.e., approx. 5–8 on each side. Flowers greenish-yellow); Lae, in rain forest, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1738 (TYPE—♀ flowers and fruits—T), August 1944 (A tall tree, 130 ft. overall, with shallow umbrella-shaped crown. Bole 100 ft., buttressed to 6 ft., d.a.b. 2½ ft. bark ⅜–½ in. thick; outer—pustular and pitted in the grooves between the buttresses, finely longitudinally fissured and corky on the ends of the buttresses, pale greenish-brown above, corky, thin; inner—cream streaked with green on the back, cream within with orange-brown and yellow-brown flecks. Wood pale straw, sapwood not defined. Leaves clustered towards the ends of fairly stout branchlets. Petiole 2–3 in. long, curved upwards beneath its insertion on the blade where two shortly cylindrical glands occur. Blade dark glossy green above, veins yellowish-green, lower surface pale, shortly and densely pubescent and with veins elevated. Flowers in axillary panicles, ovary green. Fruits green, ¼ in. diam., mesocarp green, 1/16 in. thick, endocarp thin and cartilaginous, seed black, rugose).

PAPUA.—Northern District; Buna hinterland, Dobodura Plain, Popondetta area, alt. 600 ft., in rain forest on rich grey sandy loam, *J. Cavanaugh & D. Fryar* NGF.2075 (♂ flowers—T), March 1945 (A tree 110 ft. overall. Bole 70 ft., 38 in. diam. Bark ⅜ in. thick; outer—light brown, rough, somewhat scaly, with scattered fairly large pustules; inner—pink, yellow and green on the back, light brown (from indistinct layers of fibres) with little white patches within. Wood very light yellow. Leaves curled backwards at apex, dark green above, light green, hairy, and with conspicuous veins beneath . . . Flowers . . . in panicles up to 9 in. long).

SOLOMON ISLANDS.—Bougainville: Koniguru, Buin, alt. 900 m., common in rain forest, *S. F. Kajewski* 2107 (♂ flowers), 18 August 1930 (Native name—Manogo. A large sized tree up to 20 m. high. Leaves light green. Stamens white, numerous, stems of buds green. The natives say the wood is not very strong).

In the field, the umbrella-shaped crown with horizontal to obliquely ascending, somewhat whorled branches gives the tree a characteristic appearance when seen from the side. The buttresses are usually stout and rather narrow, and the bole comparatively long to the length of the crown.

NGF.215 and NGF.1705 have as many as 3-4 glands at the apex of the petiole, while in NGF.1204 these glands are very frequently absent. NGF.1703 possesses hypophyllous glands on the majority of leaves, whereas these appear to be absent from the remainder of the specimens. Although these features and the type of insertion of the petiole on the blade may vary, the tomentum and prominent venation on the under-surface of the blade appear to be constant.

Of those dealt with, this is the most important species from the timber utilization point of view. The bole is fairly straight and cylindrical with a basal diameter above the buttresses of up to 3 ft., and may be clear of branches for 100 ft. A slight curve throughout the length of the bole is probably associated with the occurrence of bands of tension wood which have been found in some of the logs (see Dadswell, 1944, pp. 20–21). The consequent woolliness in sawing has caused trouble in milling.

Kajewski 2107 is placed here with some reservation as it bears male flowers only.

Lane-Poole (1925, pp. 105-106) gives an account of this species under the name of *Macaranga* sp.

The specific epithet is derived from the Latin word "medulla," meaning marrow or pith, and refers to the branchlets containing pith in this species as opposed to being hollow.

2. **Endospermum myrmecophilum** L. S. Smith sp. nov.—Plate II.

Arbor unisexualis, saepe 10–20 m. alta sed usque ad 35 m. alta; truncus ca. 0.2–0.7 m. diam., cinereus vel ± avellaneus, lenticellatus, interdum anteridibus praeditus; lignum cremeum, comparate molle. *Ramuli* crassi, 1–1.5 cm. diam. cavi, a formicis pertusi, apice angustati, ± dense stellato-pubescentes, basin versus cicatricibus foliorum delapsorum notati. *Stipulae* anguste deltoideae, usque ad 0.3 cm. longae, pubescentes, caducae. *Petioli* minute stellato-tomentosi, demum glabrescentes, 6–22 cm. longi, 0.15–0.4 cm. diam., basi contracti, apice glandulis 2 appressis convexis vel latissime conicis ovatis vel oblique triangularibus ca. 0.2–0.3 cm. longis ornati. *Foliorum laminae* peltatae, firme chartaceae vel coriaceae, ovatae vel deltoideo- vel orbiculari-ovatae, 10–30 cm. longae, 9–24 cm. latae, minute stellato-tomentosae, supra mox glabrae, basi late rotundatae vel subtruncatae vel late cordatae, apice obtusae vel breviter acuminatae saepe mucronulatae, margine subtus incrassatae; nervi subtus prominentes, (7-) 9 e basi vel prope basin laminae orti; nervus medius nervis secundariis 4-7 utroque latere praeditus; rete venularum laxum, supra manifestum subtus prominulum;

glandulae hypophyllae parvae, globosae, in axillis bifurcationum nervorum marginem versus sitae, interdum nullae. *Inflorescentiae* ♂ ignotae, ♀ in axillis foliorum superiorum sitae, stellato-pubescentes, late pyramidatae vel ovoideae, usque ad 30 cm. longae, e basi ramosae vel pedunculo usque ad 8 cm. longo praeditae; rami primarii paniculorum usque ad 15 cm. longi; bracteae anguste ovatae vel lanceolatae, 0.1–0.3 cm. longae, integrae vel utroque latere unidentatae, apice obtusae. *Flores* ♀ pedicellati, pedicellis 0.15–0.2 (-0.4 sub fructu) cm. longis, singuli, articulati; perianthium ca. 0.15–0.2 cm. longum, extus breviter pubescens, minute irregulariterque 3-4-dentatum; discus angustus, minutus, glaber, saepe lobatus vel obliquus; ovarium ellipsoideum, ca. 0.2 cm. longum, minute denseque tomentosum, 1-loculare, 1-ovulatum, basi contractum; stigma badium, sessile, plano-convexum, ca. 0.1 cm. diam., margine interdum obscure lobatum. *Fructus* pallide viridus, drupaceus, late ellipsoideus vel subglobosus, ca. 0.6 cm. longus, 0.5 cm. diam., apice stigmate ca. 0.15 cm. diam. coronatus, basi perianthium persistens patulum undulatum 0.2–0.3 cm. diam. ferens; epicarpium minute stellato-tomentosum; mesocarpium tenue, parce oleagineum; endocarpium tenuiter cartilagineum. *Semen* ochraceum vel castaneo-notatum, ca. 0.45 cm. longum, 0.35 cm. diam., irregulariter costatum, sparse muricatum.

TERRITORY OF NEW GUINEA.—Morobe District: Yalu, between Lae and Nadzab, alt. ca. 100 ft., amongst regrowth in brown sandy loam on cleared alluvial flat near Munim Waters, *2 Aust. For. Svy. Coy.* NGF.274 (immature fruits—T), July 1944 (Tree 55 ft. high, bole 25 ft. high, with small spur roots, g.b.h. 35 in. Outer bark grey, smooth, covered with abundant insignificant brownish lenticels. Inner bark light brown 1/10 in. thick. Wood cream, easy to cut and split. Branchlets hollow and swarming with black ants. Leaves dark green above, greyish-green beneath, margins slightly undulate, veins amber coloured. Fruits green, somewhat wrinkled, stigma hard and brown, mesocarp thin, green and fleshy); Yalu, on rain-forest margin, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1640 (TYPE—fruit—T), July 1944 (A small tree, 30 ft. overall. Leaves dark green above, whitish beneath; glands 2, flat or convex, ovate in outline, yellowish, one each side of the petiole at its insertion. Branchlets hollow, inhabited by ants. Panicles semi-erect, fruits pale green, subglobular).

PAPUA.—Northern District: Embi Creek, Buna hinterland, alt. ca. 25 ft., in rain forest, *J. Cavanaugh & D. Fryar* NGF.2411 (old ♀ flowers and immature fruits), March 1945 (A tree 110 ft. overall, bole 90 ft., buttressed to 3 ft., d.a.b. 28 in. Outer bark grey and light brown, smooth but for very small fissures and small groups of pustules. Inner bark ⅜ in. thick, light pinkish-brown within, dark green on the back, composed mostly of thick dark brown fibres with a little white matter between. Wood pale yellow, light, soft, sapwood 3 in. thick. Leaves dark green above, light green beneath. Fruits round, light green, ¼ in. diam., immature, with brown stigma, in panicles up to 10 in. long). Central District: Vanapa, Veimauri, Aroa, *C. E. Lane-Poole* 21 (slightly immature fruits), June 1922 (A large tree 8 ft. by 70 ft. bole with narrow buttresses running up to 8 ft. Flowers in axillary panicles up to 6 in. long. Fruit . . . green . . . in panicles on hairy peduncles and pedicels, ¼ in. diam. containing one seed. Bark more or less smooth, grey brown. Inner bark streaked white and orange, ½ in. thick. Sapwood ill-defined, white, merging into yellow. Rays very fine indeed. Pores numerous, distinct. A light soft wood, rather nicely marked on the quarter. Suitable for indoor work. Native name—Kerea (Suku)).

Lane-Poole (1925, p. 105) gives an account of this species under the name of *E. formicarum.* To judge from the text (see p. 8), Veimauri is probably the locality in which the specimen cited was collected.

The larger flattened glands on the petiole readily distinguish the foliage of this species from that of both of the others, and thus serve as a useful field character.

The specific epithet is derived from the two Greek words *μύρμηξ*, ant, and *φιλέω*, I love.

3. **Endospermum formicarum** Beccari in Malesia ii, 44, t. ii (1884); Warburg in Engl. Bot. Jahrb. xiii, 348 (1891); Schum. & Lauterb. Fl. Deutsch. Schutzgeb. Südsee 406 (1901); Pax in Pflanzenr. IV. 147 iv, 36 (1912); Pax & Hoffmann in Engl. & Prantl Natürl. Pflanzenfam. 2 Aufl., Band 19 c, 184, fig. 97 (1931).

A unisexual tree, ca. 10–16 m. high; trunk ca. 0.15–0.3 m. diam.; bark greyish to light brown; wood cream-coloured. Branchlets thick, 1–1.5 cm. diam., hollow, the cavity inhabited by ants, the apex sometimes minutely stellate-pubescent, otherwise glabrous, the lower part marked by leaf-scars. Stipules deltoid, ca. 0.1 cm. long (so far as seen), caducous. Petioles soon glabrous, 6–19 cm. long, 0.15–0.4 cm. diam., contracted at the base, the apex with 2 depressed globular glands ca. 0.15–0.2 cm. diam. Leaf-blades peltate, chartaceous to thinly coriaceous, ovate to orbicular-ovate, 10–25 cm. long, 7.5–21 cm. wide, at length glabrous, the base broadly rounded, truncate, or very shallowly cordate, the apex acutely or obtusely acuminate, mucronulate, the margin slightly thickened; nerves 8–10 from at or near the base; mid-nerve with 4–7 lateral nerves on each side, all somewhat elevated beneath; reticulation of the veinlets lax, not prominent; hypophyllous glands present (in the type specimen, sec. Beccari, l.c.) in the axils of forkings of the lateral nerves near the leaf-margin, or absent (in all specimens cited). Inflorescences in the upper leaf axils, pubescent; male inflorescence a ± pyramidal panicle up to 20 cm. long including the peduncle which is up to 7 cm. long, lower branches up to 5.5 cm. long; female inflorescence a raceme or very narrow raceme-like panicle, up to 30 cm. long including the peduncle which is up to 11 cm. long, when paniculate then with the lower branches up to 1.25 cm. long; bracts lanceolate to deltoid, 0.3–0.7 cm. long, pubescent, shortly decurrent at the base, sometimes unidentate on each side, obtuse or acuminate at the apex. Male flowers subsessile, clustered, articulate; perianth 0.2–0.3 cm. long, irregularly and shortly 2–4 toothed, ± pubescent; staminal column at length exserted, up to 0.4 cm. long, bare at the base; stamens ca. 8–10, filaments 0.025–0.05 cm. long, anthers peltate (3–) 4-celled. Female flowers shortly pedicellate with the pedicels 0.05 (–0.15 beneath the fruit) cm. long, single or few in a cluster, articulate; perianth 0.3–0.6 cm. long, ± glabrescent, irregularly and sparsely toothed; disc annular, 0.02–0.04 cm. wide, thinly lining the base of the calyx-tube; ovary broadly oblong or depressed globular, ca. 0.3 cm. long, minutely and densely tomentose, (4–) 6-celled, with one ovule in each cell; stigma red-brown, sessile, discoid, 0.3–0.5 cm. diam. Fruit pale green to creamy green, drupaceous, depressed globular, ca. 2–2.5 cm. diam. (when living), the umbilicate stigma which is ca. 1 cm. diam. borne at the apex, the persistent, undulate, ± spreading perianth present at the base; epicarp thin, subglabrescent; mesocarp firmly fleshy, thick; pyrenes 4–6, free, compressed ellipsoid, thinly cartilaginous, 1-seeded. Seeds chestnut-coloured to blackish, 0.6–0.7 cm. long, 0.3–0.4 cm. diam., sparsely and irregularly ribbed and verrucose.

Territory of New Guinea.—Morobe District: Yalu, between Lae and Nadzab, alt. ca. 100 ft., amongst regrowth in grey-brown sandy loam on alluvial flats beside Munim Waters, *2 Aust. For. Svy. Coy.* NGF.273 (fruits—T), July 1944 (Tree 40 ft. high, with small open crown and horizontal branches. Bole 25 ft. clear, girth 30 in. Outer bark thin, light grey, smooth, with isolated corky pustules. Inner bark white to orange (intermingled). Wood creamy white, straight grained, soft, splits easily. Branchlets hollow and inhabited by ants, leaf scars prominent. Leaves . . . paler beneath, venation prominent on both surfaces. Racemes up to 6 in. long. Fruits depressed globular, ca. $\frac{1}{2}$–$\frac{3}{4}$ in. long, epicarp pale green, mesocarp greenish-white and fleshy, pyrenes 4–6, seeds with brittle black testa); Yalu, in regrowth area, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1639 (♀ flowers and fruits—T), July 1944 (A small tree 35 ft. overall. Bole 6 in. diam. Bark $\frac{1}{8}$–3/16 in. thick; outer—greyish; inner—green on the back, pale yellow-brown within and whitish against the sapwood. Wood pale straw. Leaves dark green above, slightly paler beneath, glands 2 slightly compressed-globular, punctate in centre and located at insertion of petiole. Branchlets hollow, inhabited by ants. Fruits creamy green, soft, depressed-globular, with yellow-brown stigma in a depression at the apex, arranged in pendulous spikes); Yalu, on rain-forest margin, *C. T. White, H. E. Dadswell & L. S. Smith* NGF.1641 (♂ flowers—T), July 1944 (A small tree, 20 ft. overall. Bole 5 in. diam. Bark 3/16 in. thick; outer—brownish; inner—green on back, cream within. Wood pale straw or whitish. Leaves dark green above, slightly paler beneath, glands 2, compressed-globular, punctate in centre, one on each side of petiole at its insertion on the blade. Flowers male, yellowish, paniculate). New Britain: Jacquinot Bay, *R. S. Haas* NGF.134 (fruits—T), December 1944 (A small tree 75 ft. overall, 40 in. g.b.h., slight ground swellings to 2 ft., scant foliage. Bark thin, grey, mottled, ca. $\frac{1}{2}$ in. thick, smooth with light horizontal ribbing. Wood white to light yellow, sapwood indistinguishable. Leaves . . . dying yellowish. Petiole 10–12 in. long. Branchlets hollow. Fruit round, green, 1–1$\frac{1}{2}$ in. diam.).

Papua.—Western District: Strickland River, *W. Bauerlen* (old ♀ inflorescences —fruits missing), in 1885.

All of the specimens examined differ from the description of the type and subsequent accounts in not possessing hypophyllous glands. As specimens of the two previous species occur both with and without these glands, their presence or absence appears to be of little taxonomic significance. A further difference is the normally 6-locular condition of the ovary. It was found, however, that 1–2 (or rarely more) loculi may soon become obscured through non-development of the ovules. Beccari has probably overlooked these rudimentary loculi and counted only the fertile cells. This seems even more likely in view of the fact that, to judge from his figure, the type is in young fruit. As the above cited specimens agreed in all other essentials with the original description and figure, particularly in the reduced female inflorescence, I have little hesitation in assigning them here, although the type-specimen (*Beccari* 648) collected at Andai in Dutch New Guinea in 1872 has not been seen.

It seems possible that, after decomposition of the fruit, the cartilaginous seed-cases may behave as cocci and dehisce along the top to free the seed.

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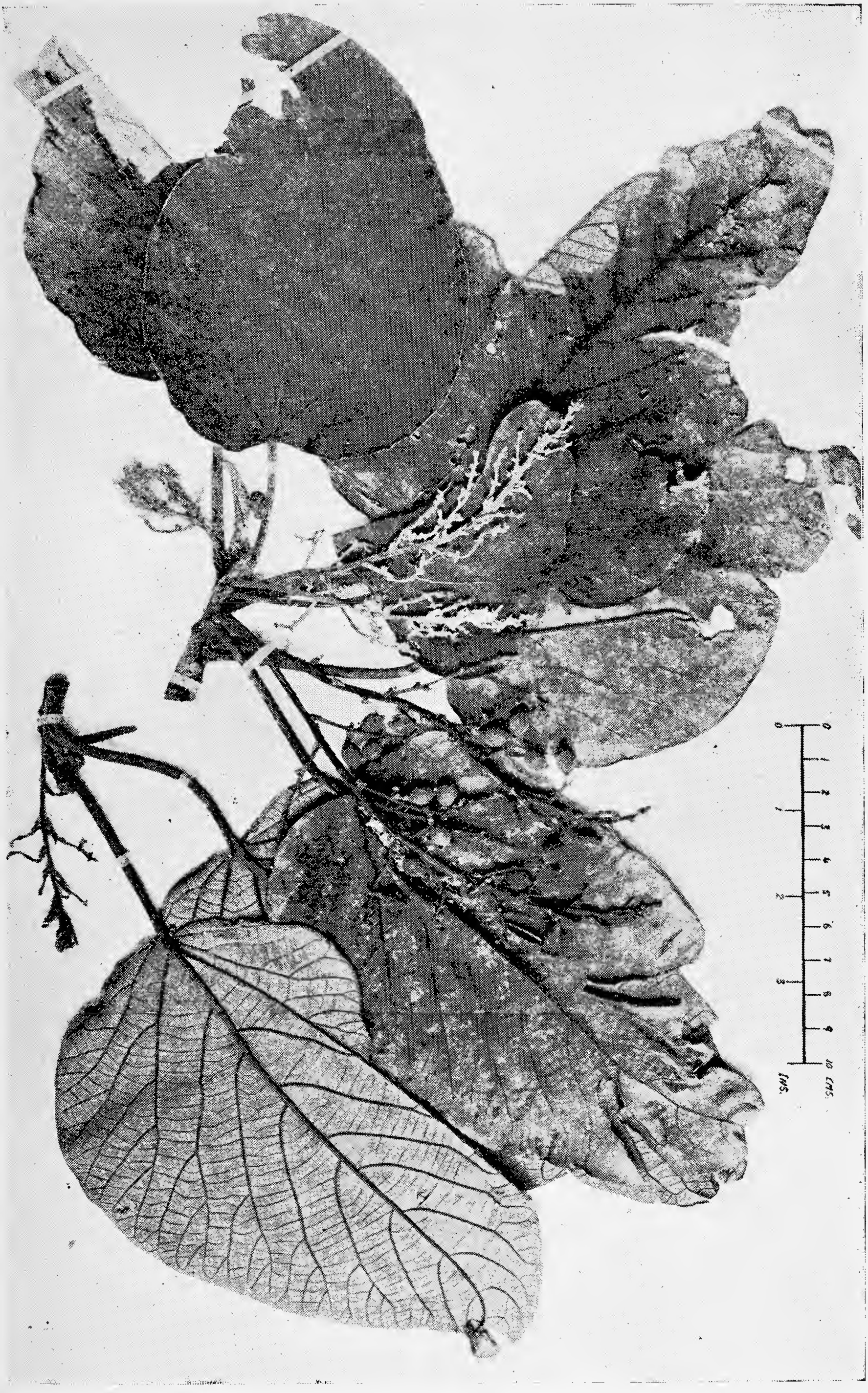
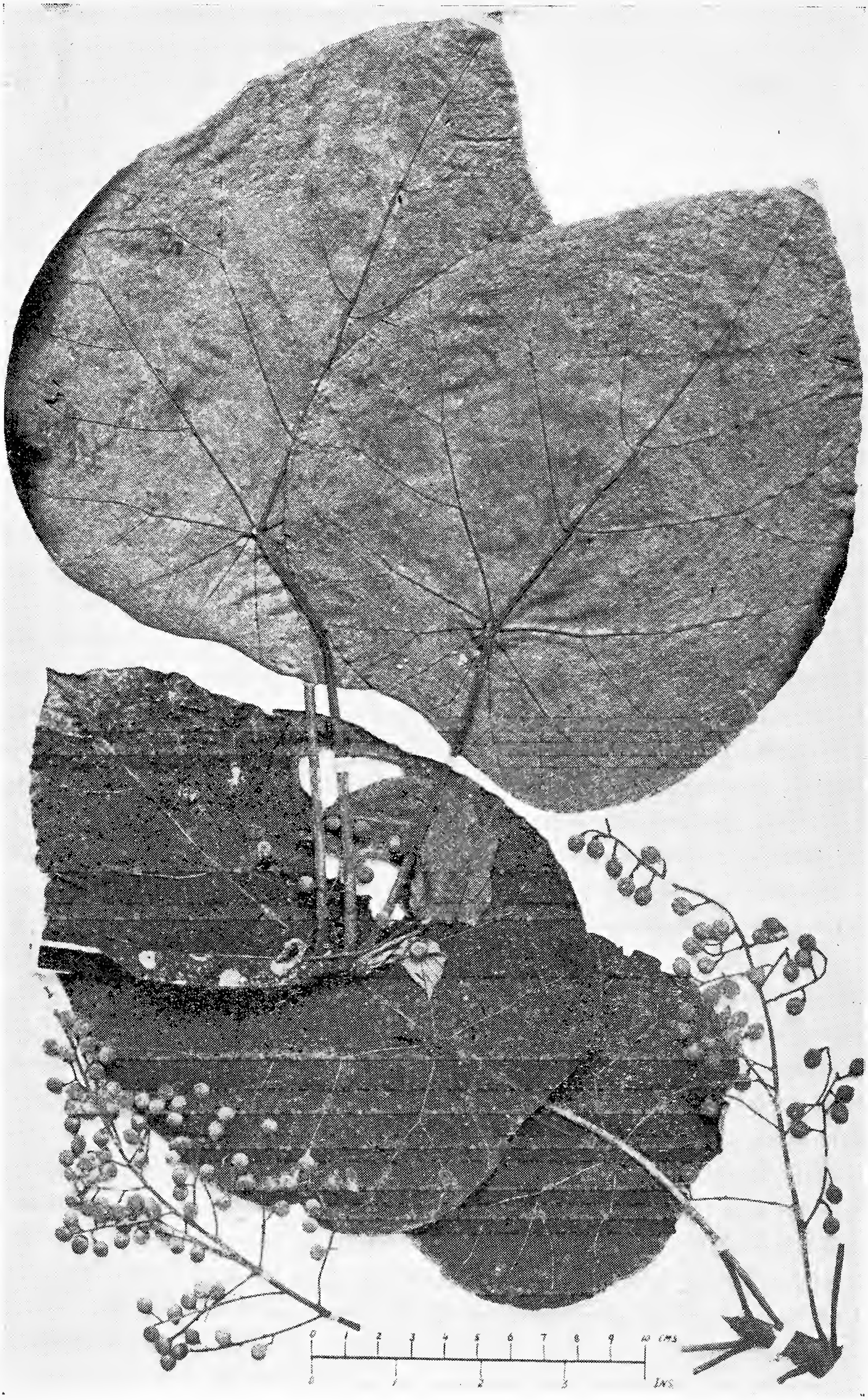


Endospermum medullosum L. S. Smith; type-specimen.

Photo. Dept. Agric. & Stock.



Endospermum myrmecophilum L. S. Smith; type-specimen.

Photo. Dept. Agric. & Stock.

SOME DEUTERIC CHANGES IN THE ENOGGERA GRANITE.

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(With two Text-Figures.)

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CONTENTS.

I. SUMMARY.

A small unusual part of the Enoggera Granite* was investigated to determine its origin. It is thought to have been formed by the action of gases or vapours on the main granite mass during a late stage of magmatic cooling. Other small differentiates are described, and direct evidence for the origin of some of the associated deuteric minerals is produced.

II. INTRODUCTION.

Quarrying operations in the granite quarry, Ashgrove, in portion 711, parish of Enoggera, on the central eastern side of the Enoggera Granite mass, not far from the eastern boundary, have revealed an interesting rock which appears to be directly related to deuteric minerals present in the quarry.

The Enoggera Granite has been described previously by Bryan (1914, 1922). Papers dealing with the deuteric phenomena associated with this mass have been written by Bryan (1923), and by Miss Whitehouse (1937).

As pointed out by Bryan (1922), there is very "wide variation of type" in the granitic rocks of the area, but rock types similar to those described in this paper have not been seen elsewhere in the area.

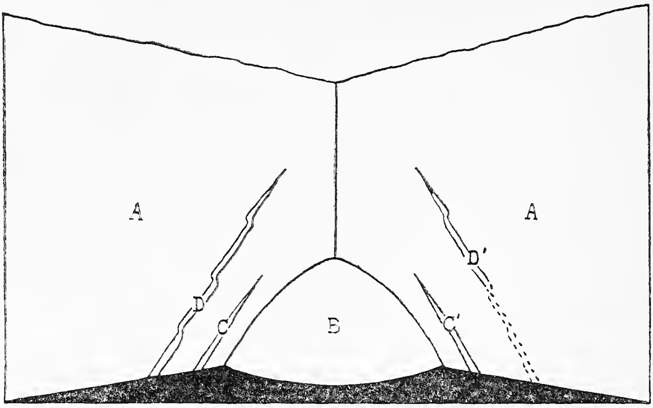
III. FIELD OCCURRENCE.

The larger mass is considered first, and the smaller differentiates are considered later.

The principal rock body described in this paper (see Figure 1, B) is made up of an unusual greenish-grey rock, which occurs in the

* Rock types of the Enoggera Granite vary from granite to quartz diorite, and even in this particular quarry there is wide variation of type.

southern end of the quarry, forming a marked contrast with the pink phase granitic material (see Figure 1, A) which surrounds it. The margins of this body, as at present exposed, slope downwards and outwards at about 30° from the horizontal, so that it appears to be dome-shaped.



TEXT FIGURE 1.

A diagrammatic view showing the relationships of the rocks discussed. "A" is the pink granite; "B" is the principal body; "C" is the lower vein; and "D" is the upper vein.

Two very prominent joint planes of the granite in this quarry converge at an angle of 50° towards the middle of the mass. Along these joint planes is a thin layer of kaolin heavily impregnated with pyrites. The margin of the body on closer inspection shows a layer of kaolin which grades into very altered granite and then into normal fresh pink granite.

Over a few small areas the rock shows well developed slickensiding where horizontal movement has occurred. The rock here is similar to the rest, but is softer and less coherent.

From this principal body are given off, near the present quarry floor, two dark veins, about 6 inches thick, but showing considerable pinching and swelling. The upper of these (see Figure 1, D) is almost black in colour, while the lower one (Figure 1, C) is of material very similar to that of the larger body.

IV. DESCRIPTION.

(i.) The Large Body (B).

Megascopic.—The rock is even-textured, greenish-grey, and porphyritic, with poorly defined phenocrysts of altered felspar, greenish- or pinkish-grey in colour, blebs of deep green chloritic material, and numerous patches of pyrites. The groundmass is of a uniform fine-grained greyish aggregate of the same material.

Pyrites is abundant throughout the whole of the rock mass, often occurring in patches several inches across. The pyrites almost invariably crystallises with the octahedron predominant, and with the striated cube only poorly developed. This is in contrast with the pyrites crystallising in the kaolin, where the striated cube is very well developed.

Calcite occurs sporadically in crystalline masses. It is associated in one specimen with pyrites, tourmaline, and quartz. The tourmaline occurs in small barrel-like aggregates, small ones being green and large ones being black. No epidote or fluorite has been seen in this rock.

Microscopic.—(The numbers refer to the numbers of the micro-sections in the collection of the Department of Geology, University of Queensland.)

Microscopic examinaton (859, 872) confirms the general impression of almost total alteration of the minerals originally present.

The phenocrysts of "felspar" still show in part a regular though not well-defined outline, but the original felspars have been all altered to kaolin, sericite, and quartz, so that their former composition is not known.

The quartz phenocrysts are rounded, generally smaller than the felspars, and have their margins corroded or surrounded by reaction rims. There is often a ring of small inclusions near the outer edge.

(It should be noted that rounded quartz crystals with rings of inclusions, and phenocrysts of felspar, are also present in the granite round about.)

The chlorite aggregates are fairly large, very irregular, and often have radiating crystals. They are pale yellowish-green to green in colour, and distinctly pleochroic. Many of them give the ultra blue interference colours, indicative of the variety penninite. Associated with the chlorite are small crystals of magnetite, and limonite stains. Often the chlorite includes hexagonal sections of quartz which have resulted from the reaction in which the chlorite was formed. Much of the chlorite is plainly due to alteration of biotite.

Pyrites is quite abundant, sometimes in well formed crystals but usually in shapeless grains. Some of the crystals have inclusions of quartz and altered felspar.

Calcite is present in one section as an aggregate of crystals abutting against quartz.

The groundmass is a fine-grained mass of quartz, kaolin, sericite, chlorite, and magnetite.

(ii.) The Lower Vein (C).

This penetrates the granite for only about 10 feet, parallel to the margin of the mass. It is similar in structure and composition to the rock of the main body, except that it shows evidence of chilling, as the rock becomes much finer grained and lighter in colour towards the edge. A linear orientation of the minerals is noticeable.

Microscopically (873) this rock is very similar to that forming the larger body, although it has a smaller grain size.

(iii.) The Upper Vein (D).

The upper vein is approximately parallel to the lower one, but it extends much further into the granite. It pinches and swells very markedly.

Megascopic.—In the hand specimen this rock is dark greenish-black with a pronounced flow structure and numerous dull black phenocrysts.

Microscopic. (874. 875).—The phenocrysts are all totally altered and usually have rounded, often indented, outlines. They are made up of quartz (sometimes to the exclusion of the other minerals), brownish kaolin, chlorite, and magnetite. The outer margin of each is usually a fine-grained aggregate of quartz. Many of these represent much altered, partially resorbed felspar crystals.

Other smaller phenocrysts have well defined angular outlines. These, although they are now pseudomorphic aggregates of chlorite, quartz and magnetite, appear to have been originally crystals of amphibole or biotite.

Quartz phenocrysts in this vein show prominent reaction rims. One such phenocryst has clear quartz in the middle, with brown non-crystalline inclusions, a ring of the same brown glass, and an outermost ring of granular quartz. The original quartz crystal appears to have been partially resorbed, and then a secondary ring of quartz deposited around its outer margin.

The groundmass is a greyish-brown glass with numerous small grains of quartz and magnetite.

V. CHEMICAL CONSIDERATIONS.

A quantitative chemical analysis of the rock of the main body was carried out by courtesy of the Government Analyst. The analysis gave the following results:—

	Per cent.		Per cent.		Per cent.
SiO_2 ..	.. 53.67	CaO ..	.. 5.50	CO_2 ..	.. 4.40
Al_2O_3 ..	.. 16.46	Na_2O ..	.. 1.30	TiO_2 ..	.. 0.80
Fe_2O_3 ..	.. —	K_2O ..	.. 2.58	P_2O_5 ..	.. 0.37
FeO ..	.. 3.92	H_2O $<105°$ C.	0.40	MnO ..	.. 0.28
MgO ..	.. 3.42	H_2O $>105°$ C.	4.33	FeS_2 ..	.. 2.22

The high content of water and carbon dioxide is notable, and is in contrast with the analysis of the pink phase granite given by Bryan (1922), which shows no carbon dioxide and only 0·44 per cent. of combined water. The amount of lime is not sufficient to use up all the carbon dioxide as calcite, so that some other carbonate appears to be present in small amount.

When referred to the C.I.P.W. system, these results do not lead to a satisfactory name for the rock. Referred to Shand's classification (1943), the symbol XOpL is arrived at. (The figure for the type of felspar present cannot, of course, be estimated.) This symbol, XOpL, indicates that the rock crystallised at a low temperature and under high pressure, in the water-rich late stages of the cooling of the magma.

VI. ASSOCIATED DEUTERIC AGGREGATES.

Attention will now be directed to the minerals occurring in small aggregates in various parts of the quarry. These deuteric masses are rounded, usually about 6 inches in diameter, and quite sharply marked off from the granite, though small pieces of the pink granite are sometimes intermingled with their outer parts.

On the whole the colour is greenish, although the centres often present beautiful aggregates of green chlorite, purple fluorite, white calcite, limpid quartz, black tourmaline, and brassy pyrites. Around this centre there are numerous small rounded groups of quartz with chlorite and epidote, set in a finer grained base.

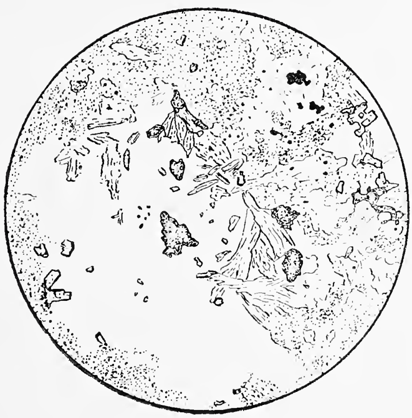
Further field work has shown that, contrary to the statement by Miss Whitehouse (1937), tourmaline and fluorite do form together, as evidenced by several specimens.

Microscopic.—Section 877 shows the junction of the granite and the deuteric aggregate material. The felspars of the granite are nearly all altered, although some still show fine lamellar twinning. The biotite present is in part altered to chlorite along the cleavages, and a grain of epidote is present beside one biotite crystal.

The deuteric material is mostly a fine-grained aggregate of quartz, altered felspar, patches of chlorite, and magnetite grains. Small acicular crystals of apatite are abundant. The grain size is smaller than that of the granite. Quartz is abundant, as is the felspar, some of which still shows twinning. Chlorite and magnetite are plentiful.

The small rounded groups seen in the hand specimen are:—

(*a*) Quartz-centred groups which have a single crystal of quartz including biotite and sphene. The biotite projecting into such quartz crystals is unaltered, whereas where the biotite projects out into the groundmass it has been chloritised (as shown in Fig. 2).



TEXT FIGURE 2.

Showing biotite unaltered where projecting into quartz, and elsewhere altered to chlorite and magnetite; also irregular crystals of sphene, columnar epidote crystals, and kaolinised felspar. (× 18.)

(*b*) An aggregate of quartz crystals. These also have biotite inclusions, unaltered inside the quartz, but altered outside to epidote and chlorite.

(*c*) Other green aggregates, with no fresh biotite, are made up largely of chlorite and epidote. Also present are quartz and calcite intergrown.

The epidote appears to have been derived from the biotite only, and none seems to have formed from the felspar.

VII. DISCUSSION.

The conclusions drawn from the evidence are as follows:—

The pressure developed by the volatiles as a result of the crystallisation, shown experimentally by Morey (1922), was sufficient to cause the injection of some material into the granite, and to effect the escape of some of the volatiles. The steam, carbon dioxide, boric acid, sulphides, and fluorides, moving along the joints in the granite, altered it to form the zeolites now present along the joint planes, the well developed crystals of pyrites in veins of kaolin, the tourmaline suns in the altered granite, and the fluorite in veins of calcite in the altered granite.

Those volatiles which were unable to escape formed the principal body described by chemically altering some of the already formed granite. This altering body suffered some movement, and the granite immediately surrounding was also attacked, giving kaolin merging into less altered granite.

With regard to the smaller differentiates, the cooling was similar, but the volatiles, not having reached a bursting pressure, were not able to escape. The calcite thus was not able to escape into the surrounding rock, as it did when the main body was cooling, so that the lime was available to form epidote from the altering ferromagnesian minerals. The fluoride present (it appears to have escaped from the main body) may have aided, as a flux, in the formation of the epidote.

The evidence derived from these investigations confirms Shand's opinion (1944) that these deuteric minerals "are not restricted to narrow temperature limits," and that they owe their "formation less to a particular physical condition than to a particular chemical condition."

In conclusion, I would like to thank Dr. W. H. Bryan for the helpful interest he has shown in the work.

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THE HEAVY MINERAL ASSEMBLAGES OF SOME BUNDAMBA AND WALLOON SANDSTONES.

By CLIVE W. BALL, D.F.C., M.Sc.

(*Received 29th July,* 1946; *read before the Royal Society of Queensland, 2nd September,* 1946; *issued separately, 19th September,* 1947.)

CONTENTS.

1. INTRODUCTION.

Whilst engaged in a Refresher Course in Geology under the Commonwealth Government Post-War Reconstruction Training Scheme at the University of Queensland, the writer has made a special study of the Heavy Mineral Assemblage of four specimens of Mesozoic Sandstones. It is hoped that these preliminary results may act as a guide to future workers in the local field, and form a reference for correlation purposes.

2. SEPARATION OF THE HEAVY MINERALS.

For the harder sandstones it was necessary to resort to light napping with a hammer to break up the rock fragments. The fragments thus obtained were digested with 30 per cent. hydrochloric acid. The argillaceous material was eliminated by panning with a prospector's dish. After drying and sieving, the minus 1 mm. fines were ready for separation with bromoform. In order to effect separation of the heavy minerals, the bromoform was used in an ordinary conical filter funnel with a rubber tube outlet fitted with a pinchcock. The heavy mineral crop was washed on the filter paper with toluene. The bromoform was subsequently recovered from the filtrate after distillation of the toluene.

3. PETROLOGICAL STUDY AND GRAIN COUNTS.

A standard set of Refractive Index liquids was used to assist in the determination of mineral species. After identification, a large number of grains—from 100 to 600—were counted in each slide to determine the relative percentages of the heavy mineral grains.

4. PETROLOGICAL DESCRIPTIONS.

(i.) Bundamba Sandstone.

Buff-coloured Sandstone—very fine grained. Location: An outcrop in the city of Ipswich, midway between Queen's Park and Denmark Hill.

The Light Minerals.—

Quartz: Sub-angular to rounded grains. Slightly dusty, with minute inclusions of magnetite.

Felspar: Sub-angular grains of tabular aspect.

Muscovite: *Slightly rounded plates. Very finely micro-crystalline. Inclusions: Magnetite.

The Heavy Minerals.—

The heavy mineral fraction is very fine grained. The average grain size of the heavy minerals is 0·02 mm.

Zircon: Colourless grains, mostly rounded. Some zircons are sub-hedral, and these are larger than the rounded grains.

Magnetite: Irregular, dusty grains.

Rutile: Rare, dark reddish brown, sub-angular to rounded.

Tourmaline: Very rare as short prisms; green, pleochroic, $E < O$.

Garnet: Rare, pink angular grains. Fairly large.

(ii.) Bundamba Sandstone.

Cream-coloured, medium grained, thin-bedded sandstone. Location: The specimen was obtained from a small quarry in the north-east corner of portion 219, parish of Ipswich. The site is ¼ mile south-east of Aberdare Extended No. 1 Colliery.

The Light Minerals.—

Quartz: Light brown and clear, colourless, sub-angular to rounded grains.

Felspar: Cloudy, white kaolinised grains, sub-angular generally, but some grains are well rounded.

The Heavy Minerals.—

The average grain size of the heavy minerals is 0·02 mm.

Muscovite: Clear, colourless plates, slightly cracked and showing a tendency to be well rounded. Biaxial negative.

Zircon: Colourless, doubly-terminated prisms and water-worn grains—sometimes yellow. Zoning is common. Possibly two generations of zircon.

Magnetite: Anhedral grains and tree-like growths. The latter are probably secondary.

Rutile: Very dark red, almost black, short prisms showing evidence of rounding.

Biotite: Very rare, brown plates. Anhedral.

Anatase: Indigo blue prisms, often with rounded corners and characteristic striations.

(iii.) Bundamba Sandstone.

White fine-grained sandstone. The cementing material is largely calcareous. Location: MacLean Bridge, Logan River. Collected by Dr. W. H. Bryan.

* The muscovite was removed in the panning process prior to separation of the heavy minerals with bromoform.

The Light Minerals.—

Quartz: Clear, colourless, sub-angular to rounded grains.

Felspar: Creamy, kaolinised, sub-angular to rounded grains.

The Heavy Minerals.—

The average grain size of the heavy minerals is 0·10 mm.

Garnet: Pink, angular crystals. High refractive index. Conchoidal fracture. Rarely amber coloured.

Muscovite: Colourless plates, irregular outlines, and tabular aspect. The outlines are sometimes rounded. Biaxial negative. The muscovite contains inclusions of zircon, with pleochroic haloes, and rarely magnetite anhedra.

Rutile: Reddish-brown prisms, and large angular grains.

Magnetite: Dusty grains, extremely fine. Anhedral.

Epidote: Sub-hedral, green prisms. Cleavage strongly developed. Pleochroic.

Anatase: Indigo blue. Faintly pleochroic. Refractive index very high. Euhedra, with slightly rounded corners.

Zircon: Clear, colourless. One doubly-terminated prism.

Tourmaline: Green, short prisms and rounded grains. Pleochroic, $E<O$.

Biotite: Anhedral plates. Brown. Rare.

Pyrites: One secondary aggregation of minute cubes.

(iv.) Walloon Sandstone.

Cream-coloured, fine-grained, ''pepper-and-salt'' sandstone. The cementing material is calcareous. Location: One and a-half miles west by south from Perry's Knob, Rosewood. The specimen was collected from a new coal mine dump in north-west corner of portion 476, parish of Rosewood.

The Light Minerals.—

Quartz: Sub-angular to rounded clear, colourless grains.

Felspar: Cloudy, white, sub-angular grains. One felspar grain showed quartz studs.

The Heavy Minerals.—

The average grain size of the heavy minerals is 0·10 mm.

Garnet: Angular crystals, pink. High refractive index.

Zircon: Colourless, rounded grains and prisms. The larger crystals are sub-hedral. The zircon is often zoned.

Rutile: As red and brown prisms and rounded grains.

Epidote: As green crystals. The larger grains are sub-hedral, but the small grains are perfectly rounded.

Magnetite: Rare, very small, dusty, angular grains.

Tourmaline: Pink, short prisms. Pleochroic, $E<O$. Rare.

Apatite: Sub-hedral prisms. Very rare.

Biotite: Very rare, red-brown plates, irregular rounded outlines.

5. TABLE OF RELATIVE PROPORTIONS OF THE HEAVY MINERALS.

Rock.	Locality.	Zircon.	Magnetite.	Garnet.	Rutile.	Epidote.	Tourmaline	Anatase.	Biotite.	Muscovite.	Pyrites.
Bundamba Sandstone	Mid-way between Queen's Park and Denmark Hill, Ipswich	*A*	*c*	*s*	*s*	..	*p*	..	..	*p*	..
Bundamba Sandstone	N. E. corner of Por. 219, Parish of Ipswich	*c*	*r*	..	*r*	..	..	*s*	*p*	*A*	..
Bundamba Sandstone	Maclean Bridge Logan River	*p*	*c*	*a*	*c*	*r*	*p*	*r*	*p*	*C*	*p*
Walloon Sandstone (Rosewood Stage)	N. W. corner of Por. 476, Parish of Rosewood	*C*	*s*	*a*	*c*	*r*	*p*	..	*p*	..	..

The symbols used in the above table represent the following percentages:—

A = Very abundant (>75%) *a* = Abundant (>45% but <75%)
C = Very common (>25% but <45%) *c* = Common (>5 but <25%)
r = Rare (>1% but <5%) *s* = Scarce (<1%)
p = Present but proportions not determined.

NEW AUSTRALIAN SPECIES OF BOARMIADAE (LEPIDOPTERA).

By A Jefferis Turner, M.D., F.R.E.S.

(*Received 2nd September*, 1946; *accepted for publication 30th September*, 1946; *issued separately 27th October*, 1947.)

Since Meyrick's valuable Revision of the Australian Boarmiadae (These Proceedings, 1891, p. 582) and his Classification of the European Geometrinae (Trans. Linn. Soc. N.S.W. 1892, p. 53) little has appeared dealing with the Australian species of this large and difficult family. Meanwhile many undescribed species have accumulated in our museums and collections. These I propose to describe in this paper. The more difficult task of a complete revision of the Australian species must await some future occasion.

1. Diastictis genialis n.sp.

genialis, pleasant.

♂ ♀, 28-32 mm. Head, palpi, and thorax grey. Antennae grey; ciliations in male two-thirds. Abdomen grey with a series of paired pale fuscous dots on dorsum. Legs fuscous with whitish rings; posterior pair except tarsi whitish sprinkled with grey. Forewings elongate-triangular, costa straight to near apex, apex pointed, termen straight, in male slightly angled in middle, in female with strong angular projection, oblique; 10 and 11 coincident anastomosing with 12 and 9; pale grey; costa strigulated with fuscous; a slightly waved slender fuscous line at one-fourth; a transversely elongate median discal mark, orange-brown outlined with dark fuscous; a slender fuscous vertical line from costa at three-fourths, bent inwards beneath costa and strongly inwardly curved to one-third dorsum; terminal area beyond this line and beneath its angle in male slaty-grey, in female orange-brown; a dark fuscous line edged anteriorly with orange-brown from costa near apex to the grey tornal blotch; a dark fuscous terminal line; cilia grey, bases whitish. Hindwings with termen sharply angled in middle; colour as forewings; sub-basal and median transverse lines with a discal dot between them; an orange-brown tornal mark edged white posteriorly; terminal line and cilia as forewings. Underside as above but clear white with dense fuscous strigulae and median line in both wings.

Queensland: Duaringa; Emerald in March; Milmerran in September; Talwood in November and April; Charleville. Ten specimens.

Gen. Peratodactyla nov.

περατοδακτυλος, with apical finger.

Tongue present. Face not projecting. Palpi short, porrect; second joint thickened with appressed hairs; terminal joint minute. Antennae bipectinate, towards apex simple. Thorax hairy beneath. Femora smooth. Forewings with 10 and 11 arising separately from cell, 11 anastomosing with 12 and 10, 10 anastomosing with 9. Hindwings with 12 anastomosing with cell. Probably allied to *Hyposidra*, but the neuration is distinctive.

2. Peratodactyla rutila n.sp.

rutilus, reddish.

♀, 42 mm. Head grey; face dark reddish, lower edge whitish. Palpi dark reddish. Antennae whitish, towards base reddish anteriorly; pectinations in female 1, apical sixth simple. Thorax pale ochreous-grey sprinkled with fuscous. Abdomen reddish-grey. Legs reddish; in posterior pair mixed with whitish. Forewings triangular, costa sinuate, apex with a short anterior finger-like process, termen rounded, with short teeth on veins 4 and 6; whitish sprinkled with fuscous, more densely towards costa; markings reddish; a sub-basal line angled outwards in middle; a broadly suffused line or shade from two-fifths costa to mid-dorsum, angled outwards above middle; a very oblique line from three-fourths costa, acutely angled inwards to three-fourths dorsum, followed by some grey suffusion; a reddish triangle on costa before apex; apical finger whitish; a terminal reddish suffusion; cilia reddish-fuscous. Hindwings with termen rounded and slightly dentate, colour as forewings; a sinuate antemedian line closely followed by a fuscus discal dot; slender postmedian and subterminal irregularly dentate lines partly connected by reddish blotches; cilia pale ochreous, towards tornus reddish-fuscous.

Queensland: Bunya Mts. in March; one specimen.

3. Ectropis dicranucha n.sp.

δικρανουχος, fork-bearing.

♂, 29 mm. Head, thorax and abdomen grey-whitish; face with median fuscous and inferior whitish bars. Palpi fuscous, apices whitish. Antennae grey-whitish; pectinations in male 3, slender, bifid at apices, fuscous. Legs whitish. Forewings triangular, costa straight to near apex, apex obtuse, termen slightly rounded, slightly oblique; grey-whitish slightly sprinkled with fuscous and brown; postmedian line from three-fourths costa, at first outwardly curved, then sinuate to two-thirds dorsum, slender, interrupted, followed by a narrow brown suffusion; a faint subterminal line; an oblique subterminal mark above middle; a terminal series of fuscous dots; cilia whitish. Hindwings with termen rounded, crenulate; a slender fuscous antemedian transverse line; a median discal dot; postmedian line slender, sinuate, fuscous, followed by a narrow brownish suffusion; a slender fuscous subterminal line; terminal dots and cilia as forewings.

New South Wales: Mt. Tomah near Mt. Wilson in February (G. M. Goldfinch); one specimen. Type in Australian Museum.

4. Ectropis fragilis n.sp.

fragilis, delicate.

♂, 28 mm. Head whitish; face and palpi fuscous. Antennae pale fuscous; pectinations in male 6, apical fourth simple. Thorax whitish sprinkled with fuscous-brown. Abdomen whitish with two fuscous-brown transverse basal bars. Legs pale fuscous; posterior pair whitish. Forewings triangular, costa straight to near apex, apex obtuse, termen slightly bowed, oblique; 10 and 11 stalked, 10 anastomosing with 9; whitish with many wavy or sinuate fuscous-brown transverse lines; four antemedian lines, of which the fourth runs from slightly before mid-costa to slightly beyond mid-dorsum; two closely parallel sinuate lines from three-fourths costa to three-fourths dorsum; a subterminal and a submarginal line; a terminal series of dots; cilia whitish. Hindwings with termen strongly rounded; colour as forewings; two lines from dorsum before middle; a discal dot; remaining lines and cilia as forewings.

NORTH QUEENSLAND: Atherton Tableland in January (F. P. Dodd); one specimen. Type in Queensland Museum.

5. ECTROPIS LOXOSCHEMA n.sp.

λοξοσχημος, with oblique pattern.

♂, 28 mm. Head and thorax grey-whitish sprinkled with fuscous. Palpi fuscous. Antennae fuscous; in male with two tufts of ciliations on each segment. Abdomen fuscous. Forewings rather narrowly triangular, costa straight, apex pointed; termen slightly bowed, oblique, crenulate; whitish heavily sprinkled with fuscous; markings dark fuscous; a double antemedian line from near base of dorsum to middle of costa; a slender median line from three-fourths costa to mid-dorsum, interrupted by a small annular subcostal discal dot; a slender postmedian line from two-thirds dorsum to costa before apex; a wavy subterminal line edged posteriorly whitish; a fine whitish line from just beneath apex to postmedian line beneath costa; a terminal line; cilia whitish with narrow fuscous bars. Hindwings with termen slightly rounded, crenulate; as forewings, but with a single transmedian line followed by a discal dot.

VICTORIA: Birchip in June; one specimen. Type in National Museum, Melbourne.

6. SYMMECTROCTENA MESOPSAMMA n.sp.

μεσοχαμμα, brownish in the middle.

♀, 30 mm. Head, thorax, and palpi dark fuscous. Antennae dark fuscous with whitish annulations. Abdomen dark fuscous; apical segments grey. Legs dark fuscous with whitish rings; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa straight, apex pointed, termen rounded, slightly oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; dark fuscous in parts sprinkled with white; markings blackish; central area of wing widely suffused with brownish, and basal area to a less extent; a crenulate outwardly curved line from one-fourth costa to one-fourth dorsum; a slightly rippled median line from two-fifths costa to mid-dorsum; postmedian line from three-fourths costa to three-fourths dorsum, posteriorly white-margined, interrupted; subterminal straight, coarsely dentate, slenderly margined posteriorly with white; a terminal series of dots; cilia fuscous with darker bars. Hindwings with termen slightly rounded, crenulate; whitish, dorsal margin and a terminal band suffused with fuscous; a whitish line from two-thirds dorsum lost in disc; a minute median fuscous discal mark; cilia whitish.

WEST AUSTRALIA: Perth in October; one specimen.

7. SYMMECTROCTENA LEUCOPROSOPA n.sp.

λευκοπροσωπος, white-faced.

♂ ♀, 30-35 mm. Head dark fuscous; face with upper half blackish, lower half white. Palpi dark fuscous, bases of hairs white. Antennae fuscous; pectinations in male 8 to 10, extreme apex simple. Thorax dark fuscous more or less mixed with white scales, sometimes forming a white posterior spot. Abdomen grey; basal segments dark fuscous. Legs dark fuscous with whitish rings; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa straight, apex pointed, termen slightly rounded, slightly oblique; 10 and 11 stalked or coincident, 10 sometimes anastomosing with 9; dark fuscous sparingly sprinkled with white; markings white and blackish; a white transverse line at one-sixth more or less developed, edged posteriorly with blackish; an obscure interrupted blackish antemedian transverse line at one-third; a narrow vertical median blackish discal mark; a white line from two-thirds costa, at first vertical, then angled and inwardly curved to two-thirds dorsum; a dentate blackish subterminal line edged posteriorly with white; a terminal series of blackish dots; cilia fuscous with white bars. Hindwings with termen rounded; grey-whitish; a median fuscous discal dot; very slender antemedian and postmedian transverse fuscous lines; a suffused fuscous terminal band; dorsal margin strigulated with dark fuscous and white; a fuscous terminal line; cilia as forewings.

QUEENSLAND: Milmerran in September, October, April, and May; seven specimens.

Gen. APHELOCEROS nov.

ἀφελοκερως, with smooth horns.

Face with smooth rounded prominence. Tongue present. Palpi smooth. Antennae of male simple, ciliated. Thorax with a moderate posterior crest; not hairy beneath. Femora not hairy. Posterior tibiae of male not dilated. Forewings in male with fovea; 10 and 11 stalked, their stalk sometimes connected with 12, 10 anastomosing with 9. Allied to *Symmectroctena*, differing in the palpi and the male antennae.

8. APHELOCEROS DASCIODES n.sp.

δασκιωδης, dark.

♂, 20-24 mm. Head, palpi, and thorax fuscous. Antennae fuscous; ciliations in male minute. Abdomen fuscous; tuft grey. Legs fuscous. Forewings triangular, costa straight, apex rounded, termen slightly rounded, slightly oblique; whitish sprinkled with fuscous, appearing grey; markings dark fuscous; a small suffused basal patch; a median fascia containing a central transverse line, its anterior margin incurved and indented, posterior margin with strong median projection; a finely dentate subterminal line indented in middle, sometimes obsolete in female; a terminal line; cilia whitish with fuscous bars. Hindwings with termen rounded; grey, more or less whitish towards base; a fine angular median transverse line; terminal line and cilia as forewings.

QUEENSLAND: Injune in January and February (W. B. Barnard); ten specimens. Type in Queensland Museum.

9. PSILOSTICHA ORESITROPHA n.sp.

ὀρεσιτροφος, mountain-bred.

♂, 33-34 mm. Head and thorax grey; face fuscous. Palpi fuscous; lower surface whitish. Antennae fuscous; in male minutely ciliated. Abdomen grey with fuscous bars or dots on dorsum. Legs fuscous with whitish rings; posterior pair whitish. Forewings triangular, costa nearly straight, apex obtuse, termen rounded, slightly crenulate, oblique; 10 and 11 stalked, their stalk sometimes connected with 12, 10 anastomosing with 9; whitish sprinkled with fuscous, appearing grey; lines fuscous; a line from one-third costa to one-fourth dorsum, slender or partly obsolete, thickened with three dots; a median subcostal dot; postmedian line from three-fourths costa to one-third dorsum, thickened by a series of dots; closely followed by a slender grey line; subterminal lines slightly dentate, grey; a subterminal series of dots united by a fine line; cilia grey with obscure pale fuscous bars. Hindwings slightly rounded, crenulate; colour as forewings; sub-basal and median transverse lines; between them a discal dot; a grey subterminal line edged partly with whitish posteriorly; terminal dots and cilia as forewings.

NEW SOUTH WALES: Mt. Kosciusko in November (G. M. Goldfinch); two specimens. Type in Australian Museum.

10. PSILOSTICHA BARYPASTA n.sp.

βαρυπαστος, heavily sprinkled.

♂, 25-28 mm. Head and thorax grey sprinkled with fuscous. Palpi dark fuscous, apices grey-whitish. Antennae grey; in male with moderately long ciliations (1 and a half). Abdomen grey sprinkled with fuscous, more heavily towards base. Legs grey; anterior pair fuscous with white rings. Forewings triangular, narrow, costa slightly arched, apex round-pointed, termen slightly rounded, oblique; 10 and 11 stalked, their stalk sometimes connected with 12, 10 anastomosing with 9; whitish heavily sprinkled and strigulated with fuscous; markings dark fuscous; a dot on one-fifth costa; a dot on midcosta with a median discal dot just beneath; both connected by a broken line with mid-dorsum; postmedian line from four-fifths costa to mid-dorsum, above which it anastomoses with median line; a whitish dentate subterminal line not reaching dorsum, broadly edged with fuscous posteriorly; a terminal series of dots; cilia whitish, apices fuscous. Hindwings with termen rounded, wavy; colour and markings as forewings; a transverse line at one-fourth; a median discal dot; a partly double curved transverse postmedian line; subterminal line indistinct.

QUEENSLAND: Childers in October; Mt. Tamborine in March; two specimens.

11. PSILOSTICHA ARGILLEA n.sp.

ἀργιλλεος, made of clay.

♂, 28 mm. Head and palpi greyish-brown sprinkled with fuscous. Antennae grey; ciliations in male 1 and a half. Thorax greyish-brown sprinkled with fuscous; a dark fuscous median bar. Abdomen greyish-brown with suffused fuscous transverse dorsal bars. Legs pale fuscous with white rings; posterior pair ochreous-whitish sprinkled with pale fuscous. Forewings elongate-triangular, costa slightly arched, apex pointed, termen nearly straight, oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; whitish heavily sprinkled with fuscous-brown, less so in median area above middle; markings fuscous, confused; costa with numerous spots and strigulae; lines mostly obsolete; two lines from one-third and two-fifths dorsum, anastomosing to form an irregular X mark, the limbs of which do not extend above middle; a slender slightly outwardly curved interrupted line from three-fourths costa to mid-dorsum; an indistinct whitish dentate subterminal line partly developed; a terminal series of dark fuscous dots; cilia whitish-ochreous mixed with fuscous. Hindwings with termen rounded; colour as forewings but more uniform; a discal dot and fine sub-basal, median, and subterminal lines; terminal dots and cilia as forewings.

QUEENSLAND: Gayndah in October; one specimen received from Dr. Hamilton Kenny.

12. BOARMIA METAPOLIA n.sp.

μεταπολιος, grey posteriorly.

♀, 28 mm. Head and thorax fuscous with a few whitish scales; thorax with a posterior crest. Palpi and antennae fuscous. Abdomen grey. Legs fuscous; posterior tibiae grey. Forewings triangular, rather narrow, costa slightly arched, apex rounded, termen rounded, oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; whitish uniformly sprinkled with fuscous, appearing grey; markings dark fuscous; a white spot on base of dorsum; a slender outwardly curved sub-basal line at one-fifth; antemedian line from one-third costa to two-fifths dorsum, slender, bisinuate; a discal dot beneath midcosta; postmedian line from two-thirds costa to two-thirds dorsum, slender, finely serrate; given off at right angles, but sharply bent above middle; subterminal line somewhat suffused, coarsely dentate, touching postmedian line in middle of wing; three short streaks running into termen above middle and another above tornus; a terminal line; cilia whitish sprinkled with fuscous and with a basal series of fuscous dots. Hindwings with termen rounded; pale grey; dorsal edge narrowly whitish intersected by dark fuscous; a darker grey terminal band obscurely margined with whitish; cilia grey. The colouring is suggestive of the genus *Symmectroctena*, but the face shows no rounded projection and the thoracic crest is only moderate.

WEST AUSTRALIA: Tammin in October; one specimen.

13. BOARMIA CATEPHES n.sp.

κατηφης, mournful.

♂, 20-23 mm. Head brownish-grey. Palpi fuscous. Antennae fuscous; pectinations in male 8 to 10, extreme apex simple. Thorax brown; posterior margin fuscous. Abdomen brown; apices of segments and tuft whitish; terminal segment dark fuscous. Legs fuscous; posterior pair whitish. Forewings narrowly triangular, costa slightly arched, apex obtuse, termen slightly rounded, oblique; 10 and 11 stalked, not anastomosing; brown with slender dark fuscous lines; sub-basal line faint or obsolete; antemedian line very faint or obsolete except for a dot on midcosta; postmedian commencing from a dot on three-fourths costa, indented beneath costa, bisinuate to three-fifths dorsum; subterminal similarly formed, edged whitish posteriorly; a terminal series of dots; cilia brown-whitish. Hindwings with termen rounded; colour as forewings; antemedian and postmedian lines very faint or obsolete; a median discal dot.

QUEENSLAND: Killarney in January and McPherson Rge. in October (W. B. Barnard); three specimens. Type in Queensland Museum.

14. Boarmia polysticta n.sp.

πολυστικτος, many-spotted.

♂, 29 mm. Head whitish; face blackish, lower edge white. Palpi dark fuscous, towards base white. Antennae fuscous; pectinations in male 3, apical fifth simple. Thorax and abdomen whitish-grey. Legs grey; posterior pair grey-whitish. Forewings narrowly triangular, costa straight, apex pointed, termen slightly rounded, oblique; 10 and 11 stalked, their stalk sometimes connected with 12, 10 anastomosing with 9; grey-whitish slightly sprinkled with fuscous and with many dark fuscous dots; a dot on one-fourth costa connected by a series of minute dots with dorsum near base; a dot on three-fifths costa, with a discal dot beneath it; a sinuate series of dots from three-fourths costa to three-fifths dorsum; a nearly straight subterminal series of dots; a series of elongate dots on termen between veins; cilia grey-whitish. Hindwings with termen rounded; colour and dots as forewings; sub-basal, median, and subterminal series of dots; a median discal dot; a terminal series of dots; cilia grey-whitish.

Queensland: Stradbroke I.; one specimen.

15. Boarmia odontosticha n.sp.

ὀδοντοστιχος, with toothed lines.

♂ ♀, 26-30 mm. Head, palpi, and thorax whitish-grey. Antennae fuscous; pectinations in male 8, extreme apex simple. Abdomen whitish-grey, sometimes with fuscous transverse lines on dorsum. Legs whitish; anterior pair pale fuscous or grey. Forewings triangular, narrow, costa straight to near apex, apex rounded, termen rounded, oblique; 10 and 11 stalked, 10 anastomosing with 9; brown-whitish with slight fuscous sprinkling; lines dark fuscous; sub-basal line obscure or obsolete; a faint line from costa beyond middle to dorsum near middle, sometimes obsolete; a wavy line from costa near apex to dorsum near middle, sometimes double below middle, in female reduced to a series of minute dots; subterminal line represented by two strong teeth beneath apex and a short outwardly oblique line from dorsum; a terminal series of dots connected by a fine line; cilia brown-whitish. Hindwings with termen slightly rounded, waved; colour as forewings; a distinct transverse sub-basal line not reaching costa; a discal dot; a slender transverse median line, sometimes double; subterminal line represented by a few teeth or obsolete; terminal dots and cilia as forewings. The fovea in the male is large.

Queensland: Emerald in September (W. B. Barnard); three specimens. Type in Queensland Museum.

16. Boarmia loxosticha n.sp.

λοξοστιχος, with oblique lines.

♂ ♀, 26-30 mm. Head white or grey; face and palpi fuscous. Antennae fuscous, near base white; pectinations in male 3, apical fifth simple. Thorax whitish or grey; sometimes with a dark fuscous bar near anterior margin. Abdomen whitish with grey and fuscous transverse lines on dorsum. Legs whitish; anterior tibiae and tarsi fuscous with whitish rings. Forewings triangular, narrow, costa straight almost to apex, apex obtuse, termen slightly rounded, very oblique; 10 and 11 coincident, not anastomosing; whitish with scanty fuscous irroration; markings dark fuscous; a slender line from one-third costa, indented beneath costa, thence very oblique to near base of dorsum; a very fine line from three-fifths costa to one-third dorsum; a discal dot beneath costa beyond middle; a finely serrate line from four-fifths costa to mid-dorsum; a slightly waved subterminal line; a terminal series of dots connected by a fine line; cilia whitish with fuscous bars. Hindwings with termen gently rounded; colour as forewings; a sub-basal transverse line; a discal dot; slightly waved postmedian and subterminal lines edged posteriorly with white; subterminal lines and cilia as forewings.

North Queensland: Prince of Wales I. in May and Cape York in June (W. B. Barnard); three specimens. Type in Queensland Museum.

17. Boarmia prionodes n.sp.

πριονοδης, serrate.

♂ ♀, 28-33 mm. Head white or grey; face and palpi fuscous. Antennae fuscous, at base white. Thorax white or grey mixed with fuscous. Abdomen grey with dark fuscous transverse lines on dorsum. Legs whitish; anterior tibiae and all tarsi fuscous. Forewings triangular, rather narrow, apex pointed, termen rounded, oblique; 10 and 11 coincident, not anastomosing; white, in male tinged with brown, sprinkled with fuscous, appearing grey; lines dark fuscous; short parallel costal and subcostal lines; longitudinal lines near base; a dot on one-third costa giving off a very fine curved line to base of dorsum; a second oblique line from costa about middle, bent inwards and anastomosing with previous line in middle of wing, thence separating and running to dorsum slightly beyond it at one-fourth; a slender bisinuate line from costa at three-fourths or four-fifths to about one-third dorsum; space between second and third lines whitish-grey; a sharply serrate white subterminal line; a slender terminal line; cilia white with pale fuscous bars. Hindwings with termen gently rounded; a sub-basal transverse line, followed by a median discal dot; a wavy postmedian line edged posteriorly with white; a sharply serrate subterminal line edged anteriorly by a dark fuscous line; colour, terminal line, and cilia as forewings.

Queensland: Tweed Hds. in September and Carnarvon Rge. in December (W. B. Barnard); three specimens, of which two, including the type, are females. The male, which is not in perfect condition, suggests that there is some sexual dimorphism.

18. Boarmia leucanthes n.sp.

λευκανθης, whitish.

♂, 37 mm. Head and palpi grey-whitish. Antennae grey; pectinations in male 4, apical fourth simple. Thorax whitish; apices of patagia grey. Abdomen whitish. Legs whitish; anterior and middle tarsi fuscous with whitish rings. Forewings narrowly triangular, costa straight, apex pointed, termen rounded, oblique; 10 and 11 coincident and free; whitish; a slender subcostal grey line from base to middle; a straight grey line from midcosta to one-fourth dorsum; a dark fuscous dot beneath midcosta; a slender subterminal line from beneath four-fifths costa to mid-dorsum, gently waved, fuscous in middle, grey towards costa and dorsum; a fine nearly straight parallel subterminal line from termen beneath apex; a series of minute blackish terminal dots; cilia whitish. Hindwings with termen very slightly rounded; colour as forewings; faint sub-basal, median, and subterminal transverse lines; a minute discal dot; terminal dots and cilia as forewings. Near *B. lithina* Warr.

WEST AUSTRALIA: Nornalup in November; one specimen.

19. BOARMIA ACCLINIS n.sp.

acclinis, leaning, converging.

♀, 31 mm. Head and thorax ochreous-whitish; face and palpi grey. Antennae fuscous, near base whitish. Abdomen ochreous-whitish with some transverse fuscous dorsal bars. Legs whitish. Forewings triangular, narrow, costa straight, apex pointed, termen slightly rounded, oblique; 10 and 11 stalked, 10 anastomosing with 9; ochreous-whitish with scanty fuscous irroration; lines slender, fuscous; sub-basal from one-third costa to near base of dorsum, wavy, antemedian straight from midcosta to two-fifths dorsum, so that these two lines converge; postmedian from three-fourths costa to mid-dorsum, straight, closely followed by a very fine parallel line; subterminal line obsolete except near dorsum; limited fuscous suffusions on termen beneath apex and between subterminal line and tornus; some minute terminal dots; cilia whitish. Hindwings with termen gently rounded, crenulate; colour as forewings; a transverse line at one-third; a discal dot just beyond; a double transverse line at three-fifths; subterminal represented by a short line from dorsum near tornus and a few dots towards apex.

QUEENSLAND: Maryborough in September; one specimen.

20. BOARMIA COLOBA n.sp.

κολοβος, curtailed.

♀, 34 mm. Head pale grey; face and palpi whitish. Antennae fuscous, near base pale grey. Thorax grey with a median fuscous transverse line. Abdomen grey with several transverse fuscous lines. Legs ochreous-whitish; anterior pair and middle tarsi fuscous with whitish rings. Forewings narrowly triangular, costa gently arched, apex pointed, termen slightly rounded, very oblique; slightly waved; 10 and 11 stalked, not anastomosing; whitish; markings dark fuscous and grey mixed with brownish; an elongate basal patch to two-fifths costa; a fine fuscous subcostal line from base to four-fifths; a fine brownish-grey line from apex of basal patch forming a long posterior loop, thence waved to one-fourth dorsum; within loop is a fuscous discal dot; a fine blackish line from termen beneath apex, gently waved to mid-dorsum, joined by an inwardly curved line from four-fifths costa, which passes through two blackish dots placed transversely; median area between this and sub-basal patch whitish; a dentate white subterminal line; cilia whitish with some fuscous bars. Hindwings rounded-triangular, termen straight, crenulate; colour as forewings, but with no central white area; a transverse fuscous line at one-third edged posteriorly by a whitish line containing a dark discal dot; a dark median line edged posteriorly by whitish; a wavy white subterminal line; terminal line and cilia as forewings. The shape of the hindwings is distinctive.

QUEENSLAND: Brisbane in June; one specimen.

21. Boarmia cymatomita n.sp.

κυματομιτος, with wavy threads.

♂, 32-34 mm. Head blackish or fuscous; with upper edge sometimes grey. Palpi grey-whitish mixed with fuscous. Antennae fuscous; pectinations in male 4, apical sixth simple. Thorax fuscous; anterior and posterior margins and tegulae grey. Abdomen whitish-grey. Legs whitish sprinkled with fuscous. Forewings triangular, rather narrow costa almost straight, apex round-pointed, termen slightly rounded, oblique; 10 and 11 stalked, 10 anastomosing with 9; grey-whitish partly suffused with fuscous; markings dark fuscous; a double sub-basal line, oblique from one-fourth costa to one-fourth dorsum; a straight suffused line from midcosta to one-third dorsum; a nearly straight line from just before apex to two-thirds dorsum, edged whitish posteriorly, preceded by two very slender closely parallel lines from just before postmedian line on costa to just beyond antemedian line on dorsum; an oblique shade from termen beneath apex; a terminal series of dots; cilia whitish with a light fuscous median line. Hindwings with termen rounded; with lines but without fuscous suffusion; a very short transverse line from one-fourth dorsum; a minute discal dot; a double slightly sinuate median line; terminal dots and cilia as forewings.

West Australia: Yanchep in September; two specimens.

22. Boarmia mesochra n.sp.

μεσωχρος, pale in the middle.

♀, 38 mm. Head and thorax fuscous. Palpi fuscous, beneath whitish. Antennae fuscous. Abdomen grey with a median series of dots. Legs fuscous with whitish rings; posterior pair whitish. Forewings triangular, costa straight, apex obtuse, termen scarcely rounded, moderately oblique; 10 and 11 stalked, 10 anastomosing with 9; whitish, basal and terminal areas fuscous; a sub-basal line from one-fourth costa to near base of dorsum; antemedian straight, from midcosta to two-fifths dorsum, below middle edged posteriorly with pale brownish; a discal dot beneath midcosta; subterminal line from just before apex to two-thirds dorsum; a terminal series of dots; cilia whitish with fuscous bars. Hindwings with termen slightly rounded, crenulate; whitish strigulated with fuscous towards termen and dorsum; a median discal dot; subterminal line suffused; terminal dots and cilia as forewings.

West Australia: Merredin in September; one specimen.

23. Boarmia pansticta n.sp.

πανστικτος, all-speckled.

♂, 30 mm. Head, palpi, and thorax fuscous. Antennae fuscous; pectinations in male 5, apical fifth simple. Abdomen grey sprinkled with fuscous; posterior pair ochreous-whitish. Forewings triangular, costa slightly arched, apex obtuse, termen slightly rounded, slightly oblique; 10 and 11 stalked, 10 anastomosing with 9; whitish sprinkled with fuscous and dotted with dark fuscous; a dark basal patch extending from one-third costa to near base of dorsum; a pale median area containing a discal dot beneath midcosta; a double postmedian line formed by confluent dots from three-fourths costa to two-thirds dorsum, slightly angled above middle, posteriorly somewhat dentate; a subterminal series of dots edged whitish posteriorly; a terminal series of large dots; cilia grey, bases whitish barred with dark fuscous. Hindwings with termen slightly rounded, crenulate; colour as forewings; a minute median discal dot preceding a double transverse median line; remaining markings as forewings.

VICTORIA: Melbourne in January (J. B. Thorne); one specimen. Type in Queensland Museum.

24. BOARMIA ATACTOPA n.sp.

ἀτακτωπος, disorderly.

♂ ♀, 32-34 mm. Head grey. Palpi grey; lower surface white. Antennae fuscous; pectinations in male 2 and a half, apical sixth simple. Thorax grey: a posterior spot and sometimes two slender transverse lines fuscous. Abdomen grey with a paired series of fuscous dots, in the female these may be confluent. Legs whitish sprinkled with fuscous; anterior pair mostly fuscous. Forewings triangular, narrow, costa straight, apex obtuse, termen rounded, oblique; 10 and 11 stalked, 10 anastomosing with 9, or 10 and 11 coincident and free; ochreous-whitish with confused variable fuscous markings and irroration; some minute costal dots before middle; sub-basal line from one-fourth costa to near base of dorsum, usually waved and double; a sinuate line from beneath midcosta to before mid-dorsum; after this a short line, sometimes dentate, not reaching margins; subterminal line from beneath three-fourths costa, variable, sometimes extending to three-fourths dorsum; a terminal dark fuscous line or series of dots; cilia whitish, in female with fuscous apices. Hindwings with termen slightly rounded, crenulate; colour and lines as forewings; sub-basal line at one-third, straight; a discal dot near middle; median line waved or sometimes sinuate; usually a subterminal line; terminal dots and cilia as forewings.

WEST AUSTRALIA: Yanchep in September; four specimens.

25. BOARMIA GRAVIS n.sp.

gravis, heavy.

♀, 60 mm. Head, thorax, and abdomen grey-whitish. Palpi fuscous. Antennae grey-whitish speckled with fuscous. Legs white sprinkled with fuscous; anterior pair dark fuscous with white rings. Forewings broadly triangular, costa gently arched, apex obtuse, termen rounded, oblique; 10 and 11 coincident and free; white heavily sprinkled with grey; costal edge strigulated with fuscous; sub-basal line indicated by three minute fuscous dots; a slender grey line from midcosta to two-fifths dorsum; a slender partly interrupted fuscous line from three-fourths costa to mid-dorsum, closely followed by a broad grey line; a fine interrupted fuscous terminal line; cilia whitish. Hindwings with termen rounded, crenulate; colour and lines as forewings; a slender wavy transverse fuscous median line; a slender irregularly dentate fuscous postmedian transverse line; a fuscous subterminal line; a series of fuscous terminal dots.

NEW SOUTH WALES: Tooloom in February; one specimen received from Mr. E. J. Dumigan.

26. Boarmia platyleuca n.sp.

πλατυλευκος, broadly white.

♂ ♀, 38-45 mm. Head, palpi, and thorax fuscous. Antennae fuscous sprinkled with white; pectinations in male 8, apical one-eighth to one-fifth simple. Abdomen with three basal segments fuscous, white-edged posteriorly, remaining segments grey edged whitish; tuft grey. Legs fuscous with tibial and tarsal white rings; posterior pair mostly whitish. Forewings triangular, costa almost straight; apex moderately pointed, termen evenly rounded, oblique; 11 and 12 stalked, their stalk connected at a point with 12; white with dense fuscous suffusion; markings blackish; a slender line from one-fourth costa to one-fourth dorsum; a broad line from midcosta to two-fifths dorsum, acutely angled outwards in middle; a triangular white blotch containing a few fuscous strigulae between these lines, its lower angle reaching middle of disc; a waved line from costa before apex, beneath costa dentate, preceded by a broad blackish band, which narrows to a line near dorsum; a terminal series of dots; cilia white with fuscous bars. Hindwings with termen rounded, slightly crenulate; a straight sub-basal line, followed by a broad white median band strigulated with fuscous and containing a minute central dot; beyond this as forewings.

Queensland: Bunya Mts. in November and February (W. B. Barnard); nine specimens. Type in Queensland Museum.

27. Boarmia phloeopa n.sp.

φλοιωπος, looking like bark.

♂ ♀, 40 mm. Head pale fuscous; face white with a dark fuscous transverse bar above middle. Palpi fuscous. Antennae fuscous; pectinations in male 8, apical eighth simple. Thorax grey with two wavy transverse fuscous lines. Abdomen grey, basal segments partly fuscous. Legs fuscous with white tibial and tarsal rings; posterior femora and tarsi whitish-grey. Forewings triangular, costa straight to three-fourths, thence arched, apex round-pointed, termen slightly rounded, slightly oblique; 10 and 11 stalked, their stalk anastomosing with 12 or connected with it by an oblique bar, 10 anastomosing with 9; grey strigulated with fuscous; markings blackish and brown; a curved crenulate line from two-fifths costa to one-fourth dorsum; a broader line from three-fifths costa to two-fifths dorsum, below middle partly brown; a blackish terminal line, posteriorly white-edged in middle of wing, obsolete below middle; sometimes represented on dorsum by a fuscous spot; a terminal series of dots; cilia pale fuscous with white bars. Hindwings with termen rounded, slightly crenulate; colour as forewings; a transverse sub-basal line; succeeded by a narrow discal mark; an irregular dentate postmedian line; a subterminal line thickened in middle, where it is edged posteriorly by a white spot; terminal line and cilia as forewings.

Queensland: Milmerran in September and October (J. Macqueen); two specimens. Type in Australian Museum.

28. Boarmia tessaramita n.sp.

τεσσαραμιτος, four-lined.

♂ ♀, 32-37 mm. Head grey or whitish; face dark fuscous. Palpi fuscous. Antennae fuscous, towards base grey or whitish; pectinations in male 10, apical tenth simple. Thorax grey-whitish, anterior and posterior margins fuscous. Abdomen grey, darker towards base. Legs fuscous; middle and posterior tibiae and tarsi grey. Forewings triangular, costa gently arched, apex round-pointed, termen slightly rounded, oblique; 10 and 11 stalked, their stalk sometimes connected with 12, 10 not anastomosing; whitish, densely strigulated with brownish-fuscous, appearing brownish-grey; four oblique dark fuscous lines sometimes thickened on costa; first from two-fifths costa to near base of dorsum, angled beneath costa; second from three-fifths costa to one-third dorsum, waved; third from four-fifths costa to two-fifths dorsum sharply indented beneath costa, thence straight or waved; fourth subterminal, partly edged with whitish posteriorly, irregularly waved; sometimes a white median terminal spot; a dark fuscous terminal line; cilia whitish with fuscous bars. Hindwings with termen rounded, slightly crenulate; colour as forewings; four nearly straight transverse lines; first line followed by a minute discal dot; second and third lines approximated. Underside of forewings grey-whitish sometimes suffused with fuscous; a large dark fuscous median spot; termen partly suffused with dark fuscous containing white apical and median spots; underside of hindwings similar, but spots smaller or obsolete.

QUEENSLAND: Duaringa in September; Clermont; Eidsvold in April; ten specimens. Type in Australian Museum.

29. BOARMIA ODONTOCROSSA n.sp.

ὀδοντοκροσσος, with toothed margin.

♀, 36 mm. Head brown. Palpi dark fuscous. Antennae grey annulated with fuscous. Thorax brown with slender dark fuscous median transverse line. (Abdomen missing.) Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings triangular, costa slightly arched, apex pointed, termen rounded, crenulate, oblique; 10 and 11 stalked, their stalk free, 10 not anastomosing; whitish sparsely sprinkled and partly suffused with brown; transverse lines slender, dark fuscous; a short streak from base of dorsum; a double wavy sub-basal line, angled outwards beneath costa; a dentate line from two-fifths costa, bent inwards beneath costa to end on mid-dorsum; a line from three-fifths costa, at first dentate, then bent inwards and sinuate, running to dorsum closely parallel to second line; a finely dentate subterminal line, edged posteriorly by a whitish line; terminal area brown traversed by dark fuscous lines on veins running into termen; an interrupted terminal line; cilia whitish mixed with fuscous. Hindwings with termen scarcely rounded, dentate; colour as forewings; a straight thick transverse line at two-fifths; second and third lines transverse, closely approximated, slightly waved; subterminal line dentate, edged posteriorly by a whitish line; terminal line and cilia as forewings.

TASMANIA: Russell Falls in February (G. M. Goldfinch); one specimen. Type in Australian Museum.

30. BOARMIA HARMODIA n.sp.

ἁρμοδιος, neatly arrayed.

♂ ♀, 26-32 mm. Head and thorax whitish or grey. Palpi clothed with long hairs; whitish mixed with dark fuscous. Antennae grey; pectinations 5, extreme apex simple. Abdomen pale ochreous-grey with a double row of fuscous dots. Legs fuscous; posterior pair whitish. Forewings triangular, costa slightly arched, apex pointed; termen rounded, oblique; 10 and 11 coincident and free; ochreous-whitish lightly sprinkled with fuscous; markings dark fuscous; a line from one-fourth costa, angled inwards beneath costa, to near base of dorsum; a second line from midcosta nearly straight to two-fifths dorsum; a line from three-fourths costa inwardly curved to mid-dorsum, edged posteriorly by a whitish line; a dentate subterminal line preceded by a median spot and edged posteriorly with whitish; a terminal series of dots; cilia whitish, bases barred with fuscous. Hindwings with termen rounded, crenulate; colour as forewings; a straight transverse sub-basal line; followed by a minute discal dot; an outwardly curved median line edged posteriorly with whitish; terminal dots and cilia as forewings.

QUEENSLAND: Toowoomba in September and December (W. B. Barnard); eight specimens. Type in Queensland Museum.

31. BOARMIA PHRICOMITA n.sp.

φρικομιτος, with rippled lines.

♂, 34 mm. Head whitish; face blackish, lower edge whitish. Palpi blackish, white beneath. Antennae grey; pectinations in male 2, apical fifth simple. Thorax whitish with a central fuscous spot defined anteriorly by a transverse blackish bar. Abdomen whitish with some dorsal fuscous bars. Legs whitish; anterior pair fuscous with whitish rings. Forewings narrowly triangular, costa slightly arched, apex obtuse, termen rounded, oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; whitish-grey with very slender fuscous lines and darker dots; sub-basal line from a dot just beneath costa at one-third to one-fifth dorsum; a postmedian line from three-fourths costa to mid-dorsum, double and rippled, its anterior component containing a blackish median streak and several dots; a finely rippled white subterminal line, edged anteriorly with some blackish dots and posteriorly by a fuscous line; a series of blackish terminal dots; cilia grey, apices whitish. Hindwings with termen gently rounded; colour as forewing; a transverse line at two-fifths, followed by a discal dot; a double rippled transverse line at three-fifths, its anterior component blackish and dotted; subterminal line similar; terminal dots and cilia as forewings.

NEW SOUTH WALES: Ebor in March; one specimen received from Dr. B. L. Middleton.

32. BOARMIA AELLOGRAPHA n.sp.

ἀελλογραφος, confusedly marked.

♂, 34-36 mm. Head, palpi, and thorax grey. Antennae fuscous; pectinations in male 8, apical eighth simple. Abdomen grey, ochreous-tinged towards apex. Legs fuscous with whitish rings; posterior pair whitish. Forewings triangular, costa straight to near apex, apex obtuse, termen rounded, crenulate, oblique; 10 and 11 stalked, their stalk connected with 12, or 11 from 12, 10 not anastomosing; whitish densely sprinked and strigulated with fuscous, appearing grey; markings fuscous, confused; sub-basal line indicated at margins or obsolete; a double median line slightly indicated; postmedian indicated by dots, edged posteriorly by a whitish line; sometimes a suffused median discal spot; an interrupted dark fuscous terminal line; cilia whitish, bases fuscous. Hindwings with termen rounded, sinuate; colour as forewings; a straight sub-basal transverse line; a discal mark or dot; postmedian represented by a series of dots; some dots representing subterminal line; terminal line and cilia as forewings. Underside of wings whitish with a fuscous median spot, and a subterminal series of dots preceding a broad fuscous terminal band, which in forewings contains a whitish submedian spot. Nearest *B. zascia* Meyr. It differs most in the underside of the wings.

QUEENSLAND: Carnarvon Rge. in December (W. B. Barnard); two specimens. Type in Queensland Museum.

33. BOARMIA VIRESCENS n.sp.

virescens, greenish.

♂, 38 mm. Head fuscous; face black, lower third white. Palpi dark fuscous. Antennae fuscous with white specks on dorsum of stalk; pectinations in male 10, apical sixth simple. Thorax fuscous, posteriorly mixed with grey-whitish. Abdomen grey mixed with fuscous; apices of segments whitish. Legs fuscous with tibial and tarsal white rings; (posterior pair absent). Forewings triangular, costa straight to near apex, thence arched, apex obtuse, termen slightly rounded, slightly oblique, slightly crenulate; 10 and 11 stalked, their stalk connected at a point with 12, 10 anastomosing with 9; whitish densely strigulated with fuscous, appearing grey with a greenish tinge; markings blackish; sub-basal line obsolete; a broad line from midcosta, at first transverse, angled inwards in middle, thence oblique to one-third dorsum; postmedian represented by a mark on three-fourths costa; a short dentate line in disc above middle, and a short line running into dorsum; subterminal line obsolete; a terminal series of dots; cilia whitish, bases barred with fuscous. Hindwings with termen rounded, slightly crenulate; colour as forewings; a transverse sub-basal line followed by a slender lineal discal mark; postmedian represented by dots and a short line running into dorsum above tornus; a slender terminal line thickened between crenulations; cilia as forewings.

NEW SOUTH WALES: Hillgrove in February (G. M. Goldfinch); one specimen. Type in Australian Museum.

34. BOARMIA CYMATIAS n.sp.

κυματιας, billowy.

♀, 36 mm. Head whitish; face with upper and lower thirds whitish, middle third blackish. Palpi fuscous. Antennae grey, near base whitish; thorax grey. Abdomen whitish-grey. Legs whitish; anterior pair fuscous. Forewings triangular, costa slightly arched, apex pointed, termen nearly straight, oblique; 10 and 11 stalked, not anastomosing; whitish sprinkled with fuscous, appearing whitish-grey, with dark fuscous and grey lines; a dot on one-third costa giving off a fine line at right angles, soon curved inwards and oblique to one-sixth dorsum; a dot on midcosta and another in disc beneath it, both connected by a faint line with one-third dorsum; postmedian line from three-fourths costa, sharply angled outwards beneath costa, thence bisinuate to mid-dorsum, posteriorly edged with grey; a grey dentate subterminal line sharply edged posteriorly with whitish; an interrupted terminal line; cilia whitish. Hindwings with termen nearly straight, crenulate; colour and lines as forewings; a median discal dot at one-third.

QUEENSLAND: McPherson Rge. in September (W. B. Barnard); one specimen. Type in Queensland Museum.

35. Boarmia spodochroa n.sp.

σποδοχροος, ash-coloured.

♂ ♀, 25-30 mm. Head grey-whitish; face and palpi pale fuscous. Antennae grey-whitish; pectinations in male 8, apical fifth simple. Thorax and abdomen grey-whitish often sprinkled with fuscous. Legs whitish; anterior pair grey or fuscous. Forewings triangular, costa slightly arched, apex pointed, termen slightly rounded, slightly oblique; 10 and 11 stalked, 11 free or anastomosing with 12, 10 anastomosing with 9, or 11 out of 12; grey-whitish more or less sprinkled with fuscous; without lines but with blackish dots; a subdorsal dot near base; usually one or two dots representing sub-basal line; sometimes a minute discal dot beneath midcosta; antemedian line obsolete or indicated by a short mark on dorsum; postmedian line obsolete; a subterminal series of dots edged with brown anteriorly, of these two subcostal and two median are most developed, but all may be absent; a terminal series of dots; cilia grey-whitish. Hindwings with termen rounded, slightly waved; colour and dots as forewings. Near *B. eremias* Meyr., but the apex of forewings is not so acute and the markings though similar differ in detail.

West Australia: Busselton in October and Yanchep in September; eight specimens.

36. Boarmia eucrypta n.sp.

εὐκρυπτος, well hidden.

♂, 38-40 mm. Head grey-whitish; face and palpi grey. Antennal stalk grey-whitish; pectinations in male 6, towards apex simple, fuscous. Thorax and abdomen grey. Legs whitish-ochreous; anterior pair fuscous. Forewings triangular, costa almost straight, apex rectangular, termen rounded, slightly oblique; 10 and 11 stalked, their stalk anastomosing with 12; whitish-ochreous or reddish densely sprinkled with fuscous; a dark fuscous discal dot beneath midcosta; a whitish-ochreous straight line from apex to three-fourths dorsum, broad at origin for a short distance, thence slender, interrupted below middle; a terminal series of fuscous dots; cilia fuscous, towards tornus whitish. Hindwings with termen rounded; colour as forewings; a fuscous discal dot before middle; a faint postmedian pale line edged posteriorly with some fuscous dots.

Tasmania: Coles Bay in February (G. M. Goldfinch); two specimens. Type in Australian Museum.

37. Boarmia conspersa n.sp.

conspersus, besprinkled.

♂, 30-34 mm. Head whitish-grey; face and palpi fuscous. Antennae fuscous; pectinations in male 4, extreme apex simple. Thorax fuscous mixed with whitish-grey. Abdomen grey or whitish-grey; apices of segments fuscous. Legs fuscous with whitish rings; posterior pair grey-whitish. Forewings triangular, rather narrow, costa slightly arched, apex obtuse, termen slightly rounded, oblique; 10 and 11 coincident and free; whitish uniformly sprinkled and strigulated with fuscous, in some the central area is more darkly sprinkled; markings blackish; a short slender longitudinal line from base of costa; a sub-basal transverse line very sharply angled outwards beneath costa, thence to near base of dorsum; subterminal line from four-fifths costa, sharply indented beneath costa, thence to before mid-dorsum, sometimes preceded by a parallel line, or these two lines may fuse; a short oblique mark from apex; a dentate line from beneath apex to three-fourths dorsum, at first broad, sometimes becoming slender or obsolete before dorsum; an interrupted terminal line; cilia whitish sometimes partly fuscous. Hindwings slightly rounded, crenulate; colour as forewings; a straight sub-basal line; a median discal dot; postmedian and subterminal lines straight; terminal line and cilia as forewings.

QUEENSLAND: Injune in November to March (W. B. Barnard); Milmerran in November (J. Macqueen); fourteen specimens. Type in Queensland Museum.

38. BOARMIA BARYSPILA n.sp.

βαρυσπιλος, heavily spotted.

♂ ♀, 36-44 mm. Head fuscous; face grey. Palpi fuscous; bases of second and third joints white beneath. Antennae with stalk whitish or fuscous; pectinations in male 6 to 8, apical eighth simple, fuscous. Thorax fuscous mixed with whitish. Abdomen grey with paired fuscous dots on three basal segments. Legs dark fuscous with broad white rings; posterior pair whitish. Forewings triangular, costa slightly arched, apex rounded-rectangular, termen rounded, oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; white heavily mottled with fuscous and grey dots and lines, some of which are narrowly edged with brownish; two sub-basal dots near base; two sub-basal transverse lines; two short transverse lines from midcosta narrowly separated by brownish, not reaching to middle of wing, connected by a crenulate line or series of dots with mid-dorsum; area between sub-basal and median lines white with a few fuscous strigulae; postmedian sinuate, composed of two closely parallel lines partly fused in middle, the anterior grey with dark fuscous dots, the posterior similar, but with dots closer together; a dentate subterminal line or more commonly a series of dots fused in middle of wing with postmedian; an oblong white mark on costa before postmedian, and another on midtermen; a terminal series of dark fuscous dots; cilia white with fuscous bars. Hindwings with termen rounded; colour and markings as forewings; a median fuscous discal mark; an oblong fuscous mark on termen near middle, between two white irregular marks. The female is similar but less heavily marked.

QUEENSLAND: McPherson Rge. in April; Killarney in January. NEW SOUTH WALES: Tooloom in January; Ebor in December; Mt. Wilson in March. Eight specimens.

39. BOARMIA PHAEOPASTA n.sp.

φαιοπαστος, darkly sprinkled.

♀, 30 mm. Head and thorax dark fuscous sprinkled with white; face dark fuscous. Palpi dark fuscous, extreme base white. (Antennae missing.) Abdomen grey; towards base dark fuscous; lateral margins, apices of segments, and tuft white. Legs fuscous with white rings; posterior tibiae white sprinkled with grey. Forewings triangular, costa gently arched, apex obtuse, termen slightly rounded, oblique, crenulate; 10 and 11 long-stalked and anastomosing with 9; white densely sprinkled with dark fuscous; a dark basal patch extending to one-third; an interrupted outwardly curved sharply dentate median line; a broad line from three-fourths costa, at first scarcely separate from median line, in middle bent outwards to apex; a terminal series of spots; a slender terminal line with triangular thickenings on veins; cilia white with fuscous bars, on tornus and dorsum grey. Hindwings similarly white densely sprinkled with dark fuscous; a median blackish dot at one-third; a narrow transverse line at one-fourth; three broader transverse lines beyond this; a terminal series of dots; cilia as forewings.

VICTORIA: Moe in February; one specimen.

40. SYNEORA SPECIOSA n.sp.

speciosus, handsome.

♂, 48 mm. Head whitish with fuscous central spot; face and palpi grey. Antennae fuscous; pectinations in male 10, apical fourth simple. Thorax grey-whitish; patagia fuscous. Abdomen grey-whitish; dorsum of second and third segments fuscous. Legs fuscous with whitish rings; posterior pair whitish. Forewings elongate-triangular, costa straight to three-fourths, thence arched, apex rounded, termen almost straight, oblique; 10 and 11 separate and free; fuscous with large whitish basal blotch, its upper edge outwardly curved from one-fifth costa to five-sixths dorsum; transverse lines slender, dark fuscous; basal white area sparsely sprinkled with fuscous; an oblique sub-basal line from one-fourth costa to near base of dorsum; an irregularly dentate line from two-thirds costa to two-thirds dorsum; subterminal line dentate, partly edged with white posteriorly; small white blotches beneath apex and on mid-termen; a terminal series of blackish dots; cilia fuscous, apices white, on blotches wholly white. Hindwings with termen slightly rounded; colour as forewings but paler except in apical area; a triangular white basal area; a slightly bent finely dentate transverse median line, followed by some white suffusion; a dentate white subterminal line; a white spot on middle of dorsum; terminal dots as forewings; cilia white.

NORTH QUEENSLAND: Cape York in November (W. B. Barnard); one specimen. Type in Queensland Museum.

41. SYNEORA SINUOSA n.sp.

sinuosus, with many curves.

♂, 35-36 mm. Head fuscous. Palpi fuscous; underside whitish. Antennae fuscous; pectinations in male four; apical fifth simple. Thorax fuscous; posterior margin and tegulae except bases whitish. Abdomen whitish with transverse bars on dorsum. Legs whitish sprinkled with fuscous; anterior and middle tibiae and all tarsi fuscous with whitish rings. Forewings triangular, rather narrow costa straight, apex obtuse, termen slightly rounded, slightly crenulate, oblique; 10 and 11 separate and free; whitish with fuscous markings and strigulae; an oblong basal spot extending on costa to one-fourth more or less developed; closely following this a fine bisinuate oblique line; a slightly curved line from one-third costa to one-fourth dorsum; a blackish median subcostal dot; a fine line from four-fifths costa to mid-dorsum, three times sinuate; a fascia from termen beneath apex, soon becoming submarginal, ending suffusedly above dorsum; sometimes followed by a closely parallel line; a terminal line or series of dots; cilia whitish; bases partly pale fuscous. Hindwings with termen gently rounded, slightly crenulate; colour as forewings but strigulae more numerous; a very short sub-basal line from dorsum; a discal dot; transverse lines very slender or composed of coincident strigulae; terminal dots and cilia as forewings.

QUEENSLAND: Stanthorpe in December and January (W. B. Barnard); two specimens. Type in Queensland Museum.

42. SYNEORA PIPERATA n.sp.

piperatus, peppered.

♀, 30 mm. Head fuscous; face whitish. Palpi whitish with long rough fuscous hairs beneath. (Antennae missing.) Abdomen pale grey. Legs blackish with white rings; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa straight, termen slightly rounded, slightly oblique, crenulate; white densely sprinkled with fuscous; a white transverse sub-basal fascia; a transversely elongate median discal mark; a slender sinuate white line from two-thirds costa to three-fourths dorsum; a narrow fuscous subterminal fascia; a terminal series of fuscous dots; cilia fuscous with whitish bars. Hindwings with termen rounded; whitish-grey becoming whitish towards costa; a median fuscous discal dot; a subdorsal fuscous streak with some white scales; an interrupted fuscous terminal line; cilia whitish with some fuscous bars.

QUEENSLAND: Milmerran in February (J. Macqueen); one specimen. Type in National Museum.

43. CLEORA HEMICHROMA n.sp.

ἡμιχροος, half-coloured.

♂ ♀, 34-38 mm. Head and thorax fuscous-brown. Palpi 2; fuscous-brown. Antennae fuscous; pectinations in male 3, extreme apex simple. Abdomen fuscous; tuft whitish-ochreous. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings elongate-triangular, costa slightly arched, apex round-pointed, termen slightly rounded, oblique; fuscous-brown, paler in female; numerous slender fuscous costal strigulae; a dark fuscous transverse sub-basal line, edged pale anteriorly; a pale subcostal discal dot ringed with fuscous beneath costa beyond middle; a postmedian line from three-fourths costa to three-fourths dorsum, edged pale posteriorly, with an obtuse posterior median prominence and curved inwards beneath; area between lines suffused with fuscous in male; a crenulate subterminal line with narrow pale edge posteriorly; cilia fuscous, in female with whitish bars. Hindwings with termen rounded; orange-ochreous; a minute discal and several subterminal fuscous dots; some fuscous suffusion on termen; cilia ochreous with fuscous bars.

NEW SOUTH WALES: Ebor in February and March; four specimens received from Dr. B. L. Middleton.

44. Cleora pachydesma n.sp.

παχυδεσμος, with thick chains.

♀, 28 mm. Head whitish; face, palpi, and antennae fuscous. Thorax fuscous mixed with whitish. Abdomen fuscous; two basal segments whitish. Legs fuscous; posterior pair whitish. Forewings narrowly triangular, costa slightly arched, apex rounded, termen rounded, oblique; 10 and 11 separate, 11 connected or anastomosing with 12, 10 free; white unevenly sprinkled with fuscous; markings blackish and dark fuscous; costa strigulated and suffused with fuscous; a thick blackish transverse line at one-fourth; a narrow oblique discal mark beneath midcosta; a finely dentate blackish line from three-fifths costa, at first transverse, curved above middle, thence straight to two-fifths dorsum; closely followed by a broadly suffused fuscous subterminal line, its posterior edge dentate; a broad bar connects this with termen above middle; a fine sharply dentate fuscous line from costa before apex as far as this bar; an interrupted terminal line; cilia whitish with fuscous bars. Hindwings with termen strongly rounded; white; a fine crenulate median transverse line and a broad pale fuscous terminal band; cilia white.

North Queensland: Dimbulah in September; one specimen.

45. Cleora chionospila n.sp.

χιονοσπιλος, with white blotches.

♂, 34 mm. Head fuscous; face white with interrupted median transverse line. Palpi fuscous. Antennae fuscous; pectinations in male 8, apical eighth simple. Thorax fuscous with some white scales on anterior and posterior margins. Abdomen grey, towards base fuscous. Legs fuscous with white tibial and tarsal rings; posterior tibiae whitish. Forewings triangular, costa gently arched, apex moderately pointed, termen evenly rounded, oblique; 10 and 11 separate, 7, 8, 9 stalked. Forewings fuscous mixed with blackish and with white blotches and strigulae; several white specks on basal fifth of costa, beyond this a series of white costal strigulae, those near middle longer, one reaching half across wing; a blackish line from midcosta, angled outwards below middle, thence broader and oblique inwards, extending on dorsum from one-sixth to one-third; two irregular white blotches beyond middle, one subcostal and elongate, nearly reaching apex, the other broader, extending from dorsum beyond middle obliquely outwards, connected with a small collection of white strigulae before midtermen; an interrupted terminal line; cilia fuscous with some white bars. Hindwings with termen rounded; slightly crenulate; fuscous with blackish lines and white strigulae; a straight line from mid-dorsum to middle of disc; a narrow median dark mark; a narrow irregular dentate line from dorsum beyond middle becoming indistinct towards costa; a similar subterminal line thickened in middle, where it is white-edged posteriorly; terminal line and cilia as forewings.

Queensland: Milmerran in May (J. Macqueen); one specimen. Type in Australian Museum.

46. Cleora phaeocala n.sp.

φαιοκαλος, dark but beautiful.

♂ ♀, 34-38 mm. Head grey-whitish; face fuscous. Palpi fuscous. Antennae fuscous; pectinations in male 4, extreme apex simple. Thorax dark fuscous. Abdomen pale grey. Legs blackish with white tibial and tarsal rings; posterior tibiae whitish. Forewings triangular, costa slightly arched, apex round-pointed, termen evenly rounded, crenulate, oblique; 10 and 11 arising separately and anastomosing, 10 connected with 9; dark fuscous with blackish and white markings; a sub-basal blackish line; a blackish dentate line from one-sixth costa to mid-dorsum, not defined posteriorly; a subcostal blackish line separated from costa by whitish; a white postmedian line from two-thirds costa strongly angled beneath costa, thence slender and dentate to three-fourths dorsum; a dentate white subterminal line indented above tornus, preceded by a brown line containing many longitudinal blackish streaks, of which those towards costa are stronger; cilia fuscous with some white bars. Hindwings with termen rounded, slightly crenulate; whitish-grey; a median blackish speck; a slender faint postmedian line; an interrupted fuscous terminal line; cilia whitish-grey with fuscous bars.

New South Wales: Ebor in March; two specimens (Dr. B. L. Middleton). Victoria: Moe in March.

47. Cleora gypsochroa n.sp.

γυψοχροος, chalk-coloured.

♂ ♀, 42 mm. Head whitish; fillet dark fuscous; face in female grey. Palpi whitish. Antennae in male fuscous, pectinations 4, apical one-sixth simple; in female whitish. Thorax whitish with a dark fuscous transverse bar before middle. Abdomen whitish. Legs whitish with fuscous rings; posterior pair mostly whitish. Forewings elongate-triangular, costa straight, apex pointed, termen slightly rounded, oblique; 10 and 11 separate, 10 sometimes anastomosing with 9; whitish scantily sprinkled with fuscous; lines slender, fuscous; sub-basal from one-third costa to dorsum near base; antemedian line from midcosta to one-fourth dorsum, slightly sinuate; waved; median line from one-third dorsum, sinuate, reaching more than half across wing; subterminal line, from just beneath apex to two-thirds dorsum, straight, preceded by a closely parallel line in costal part of disc; a terminal series of minute blackish dots; cilia whitish. Hindwings with termen rounded; colour and lines as forewings; five very fine transverse lines; terminal dots and cilia as forewings. Underside with a large circular subapical spot on both wings.

South Australia: Robe in March (F. M. Angel); Flinders Chase (Kangaroo I.) in December; two specimens.

48. Cleora dolichoptila n.sp.

δολιχοπτιλος, long-winged.

♂, 34-40 mm. Head, palpi, and thorax whitish densely sprinkled with fuscous, appearing grey. Antennae with stalk whitish; pectinations in male 4, extreme apex simple. Legs grey with dark fuscous rings; posterior pair whitish sprinkled with fuscous. Forewings narrowly elongate-triangular, apex rounded, termen obliquely rounded; 10 and 11 separate, 10 sometimes anastomosing with 9; whitish densely irrorated with fuscous, appearing grey; lines slender, dark fuscous; a small dark fuscous basal suffusion; sub-basal line from one-fifth costa to one-fourth dorsum, curved outwards beneath costa, indented above dorsum; a median transverse line, angled outwards above middle and inwards below; a narrow white dentate subterminal line preceded by some fuscous suffusion; a series of triangular terminal dots; cilia whitish. Hindwings much broader than forewings, termen rounded; pale grey with a pale fuscous terminal band; a fuscous discal dot; a fine pale fuscous slightly dentate postmedian line, incurved from costa near apex to middle, thence straight to tornus; cilia whitish.

NEW SOUTH WALES: Murrurundi in May. VICTORIA: Moe in April and May; three specimens. Type in Queensland Museum.

49. TIGRIDOPTERA LEUCOPLETHES n.sp.

λευκοπληθης, filled with white.

♀, 60-74 mm. Head and thorax bluish-grey; face, palpi and antennae fuscous. Abdomen ochreous-yellow. Legs fuscous. Forewings elongate-triangular, costa moderately arched, apex rounded, termen rounded, slightly oblique; bluish-grey with dark fuscous lines and spots; an ochreous-yellow basal blotch giving off two broad longitudinal lines, one along and the other above dorsum; these coalesce before reaching tornus; four transverse lines more or less enlarged by spots; the first near base outlines the basal blotch; second slightly beyond, outwardly curved; third from one-third costa to one-third dorsum, sinuate; fourth from three-fifths costa to three-fourths dorsum, slightly curved, interrupted by the ochreous dorsal lines; a large irregular white blotch succeeds fourth line and extends from beneath two-thirds costa to vein 3, above which it extends towards termen; two longitudinal oval fuscous spots between blotch and dorsum; five narrowly oval subterminal spots, of which the central one is followed by a small spot on termen; cilia bluish-grey. Hindwings with termen rounded; colour as forewings; a double transverse bluish-grey line followed by a dark fuscous discal spot; and this by a third transverse line; a large central white blotch between this line and terminal band and between veins one and seven; terminal band, dorsal, and subdorsal lines ochreous-yellow; cilia white, on dorsum grey.

NORTH QUEENSLAND: Cape York in November and April (W. B. Barnard); four specimens. Type in Queensland Museum.

50. EPIDESMA AETHERIA n.sp.

αἰθεριος, heavenly.

♂, 52-58 mm. Head peacock blue. Palpi blackish, anterior surface of second joint peacock blue. Antennae blackish; in male ciliated in fascicles (1). Thorax blackish; apices of patagia, a central spot, and posterior edge peacock blue. Abdomen fuscous; apices of segments and posterior part of dorsum peacock blue. Legs fuscous; anterior coxae and dorsal surface of femora and tibiae peacock blue. Forewings elongate-triangular, costa straight, apex round-pointed, termen slightly rounded, oblique; 10 and 11 coincident and free; base shot by brilliant peacock blue, which gives off three processes, a small and short costal streak, and broad median and dorsal streaks, the former reaching one-third of the length of wing, the latter three-fourths; an orange fascia from middle of costa to tornus, slightly outwardly curved, and with a short obtuse posterior process above dorsum; cilia blackish, on apex orange. Hindwings with termen strongly rounded; blackish; base and median and dorsal streaks as in forewings; cilia on upper third of termen orange, on lower two-thirds and on dorsum blackish.

North Queensland: Gordonvale near Cairns in November and December; two specimens. Type in Queensland Museum.

51. Metrocampa pyrrhophanes n.sp.

πυρῤοφανης, reddish.

♀, 32 mm. Head, palpi, and thorax reddish. Antennae pale grey. Abdomen grey. Legs ochreous-whitish sprinkled with fuscous; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa almost straight, apex acute, slightly produced, termen concave above middle, produced to a point on vein 4, thence nearly straight; 5 from middle of cell, 10 and 11 long-stalked, not anastomosing; reddish with scanty fuscous irroration; a very faint outwardly curved transverse line from one-fourth costa to one-third dorsum; a fuscous discal dot beneath mid-costa; a reddish-fuscous line outwardly curved from three-fifths costa to two-thirds dorsum, where it is joined by a slightly waved fuscous line from five-sixths costa; a series of minute fuscous terminal dots; cilia reddish. Hindwings angled on vein 4; pale ochreous with scanty fuscous irroration; cilia reddish.

South Australia: Adelaide in September; one specimen received from Mr. J. O. Wilson.

52. Lomographa sciara n.sp.

σκιαρος, shady.

♂, 28 mm. Head, palpi, thorax and abdomen grey. Antennae grey; pectinations in male 3. Legs grey; posterior pair whitish. Forewings triangular, costa slightly arched, apex rounded, termen slightly rounded, slightly oblique; grey lightly sprinkled with fuscous and white; a minute pale fuscous discal dot beneath midcosta; four pale fuscous transverse lines; first slightly sinuate from three-fifths costa to mid-dorsum; second from three-fourths costa to two-thirds dorsum, slightly dentate, obscurely edged with whitish posteriorly; third closely following, straight; fourth submarginal, interrupted; cilia grey, apices whitish. Hindwings with termen rounded; colour and markings as forewings, but with two lines only.

Queensland: Milmerran in June; one specimen received from Mr. J. Macqueen.

53. Casbia eutactopis n.sp.

εὐτακτωπις, neat.

♂, 22 mm. Head whitish-grey; collar brownish. Palpi 2; brownish, lower edge white. (Antennae missing.) Thorax and abdomen whitish-grey. Legs fuscous; posterior pair brown-whitish. Forewings triangular, costa gently arched, apex rounded, termen sightly rounded, slightly oblique; 10 out of 9, 11 separate, anastomosing with 12 and 10; whitish sprinkled with fuscous, appearing grey; a dark fuscous discal dot beneath midcosta; a slender outwardly oblique line from one-fourth dorsum; subterminal line broad and ill defined, posteriorly irregularly dentate, reddish mixed with dark fuscous, edged posteriorly with whitish; costal edge reddish and strigulated with fuscous from one-fourth to apex; a submarginal series of blackish dots; cilia grey with narrow white bars. Hindwings with termen rounded; colour and markings as forewings.

West Australia: Dongarra in October; one specimen.

54. Casbia didymosticta n.sp.

διδυμοστικτος, twin-spotted.

♂ ♀, 32-36 mm. Head fuscous, in female reddish-fuscous. Palpi 2, in female 1 and a half; grey, in female reddish; apex of third joint whitish. Antennae fuscous; pectinations in male 8, apical fourth simple. Thorax in male grey; patagia whitish sprinkled with purple-fuscous; in female reddish-grey. Legs fuscous; posterior pair grey-whitish. Forewings triangular, costa straight, apex round-pointed, termen rounded, oblique; in male grey with slight fuscous sprinkling; in female reddish-grey more heavily sprinkled; in male with three dark fuscous lines, first from one-sixth costa to dorsum near tornus; second from one-third costa to mid-dorsum, third from two-thirds costa to dorsum near tornus; in female these lines are obsolete; a minute subcostal blackish dot at two-fifths; in male a narrow costal line whitish tinged with pink, costal edge sprinkled with fuscous; no costal line in female; in male a pair of red dots ringed with fuscous placed transversely just posterior to middle of third line; in female these are replaced by a large round fuscous spot containing a few whitish scales; a terminal series of minute fuscous dots; larger in female; cilia grey. Hindwings with termen slightly rounded; colour as forewings; a median discal dot at two-fifths; in female a small irregular patch of fuscous irroration containing some whitish dots.

North Queensland: Lake Barrine (Atherton Tableland) in May; two specimens. Though these show marked differences, there can be no doubt that they are the same species, of which further material may show more variations.

55. Casbia idiocrossa n.sp.

ἰδιοκροσσος, with peculiar margin.

♀, 32 mm. Head and thorax grey-whitish; face and palpi grey. Antennae whitish. Abdomen whitish with a series of paired blackish dots. Legs whitish; anterior pair fuscous. Forewings elongate-triangular, costa straight, apex acutely projecting, termen sinuate, oblique; 10 and 11 stalked, 10 anastomosing with 9; grey-whitish with some fuscous sprinkling near base; antemedian line represented by three minute dots; a discal dot beneath costa at three-fifths; a postmedian line from three-fourths costa to three-fourths dorsum, outwardly bowed in middle, preceded near dorsum by a slight fuscous suffusion; cilia whitish. Hindwings with termen only slightly rounded; colour as forewings; a suffused transverse median line most distinct towards dorsum, followed by a discal dot, and this by a curved line of minute dots. The wing-shape of this species is distinctive.

West Australia: Albany in November; one specimen.

56. Casbia leptorrhoda n.sp.

λεπτορρόδος, faintly rosy.

♂ ♀, 26-30 mm. Head and thorax grey faintly rosy-tinged; face and palpi pale fuscous, dark fuscous in female. Antennae fuscous; pectinations in male 10, apical sixth simple. Abdomen pale grey. Legs fuscous; posterior pair whitish. Forewings triangular, costa slightly arched, apex pointed, termen rounded or slightly sinuate; 10 and 11 stalked, or 11 anastomosing with or arising out of 12, 10 anastomosing with 9; grey sprinkled with fuscous, in male faintly rosy-tinged; lines slender, fuscous; an outwardly curved slender line at one-fifth; sometimes obsolete; sometimes a minute discal dot beneath midcosta; sometimes an outwardly curved median line; a sinuate postmedian line at four-fifths; in female a submarginal series of dots; sometimes a subterminal series of minute dots; cilia grey. Hindwings with termen rounded; colour and markings as forewings.

West Australia: Bunbury in February; Yanchep in September; four specimens.

57. Casbia ammophila n.sp.

ἀμμοφιλος, sand-loving.

♂, 24-30 mm. Head, palpi, and thorax fuscous. Antennae fuscous; pectinations in male 10, apical eighth simple. Abdomen ochreous-grey. Legs whitish-ochreous sprinkled with fuscous; anterior pair fuscous with whitish rings. Forewings triangular, costa almost straight to near apex, apex round-pointed, termen rounded, oblique; 10 and 11 separate, 11 free or anastomosing with 12 or out of 12, 10 anastomosing with 9; grey lightly sprinkled with fuscous; from base to beyond middle often tinged with reddish; a darker transverse sub-basal line; a limiting darker transverse line from three-fourths costa, transverse to beneath middle of wing, then incurved to two-thirds dorsum, slightly dentate; sometimes preceding this line there may be a straight suffused dark line; usually a fuscous discal dot beneath middle of costa; a narrow fuscous or reddish subterminal line, sometimes preceded and followed by narrow belts of whitish-grey; sometimes a terminal series of fuscous dots; cilia grey or whitish. Hindwings with termen grey; cilia grey.

♀, 26-28 mm. Head and thorax grey or grey-whitish. Forewings grey or ochreous-whitish, often sprinkled with fuscous; markings fuscous, slender, or obsolete. Hindwings grey; in one example ochreous. Both sexes are very variable in coloration.

Queensland: Cunnamulla in April; locally abundant; a series taken.

58. Casbia ereutha n.sp.

ἐρευθος, blushing.

♂ ♀, 28-32 mm. Head, thorax, and abdomen pale grey; in female ochreous-tinged. Palpi 3; grey. Antennae grey; pectinations in male 12, extreme apex simple. Legs pale purple-fuscous; in female pale ochreous, pinkish-tinged. Forewings elongate-triangular, costa nearly straight, apex pointed, termen sinuate, oblique; pale grey more or less tinged with pink and lightly sprinkled with fuscous, in female pinkish-ochreous without irroration; three fuscous transverse lines, of which the first and third may be obsolete; first line from one-fourth costa to one-fourth dorsum, inwardly curved; second from mid-costa to mid-dorsum, inwardly curved; third subterminal wavy, sometimes conspicuously dark, sometimes reduced to a few dots or obsolete; cilia pale grey.

WEST AUSTRALIA: Bunbury in February (W. B. Barnard); six specimens. Type in Queensland Museum.

59. CASBIA ADOXA n.sp.

ἀδοξος, inglorious.

♂, 32 mm. Head and palpi brown. (Antennae missing.) Thorax and abdomen whitish-brown. Forewings triangular, costa slightly arched, apex rounded, termen rounded, scarcely oblique; whitish-brown; four slender pale fuscous transverse lines; first at one-fifth, nearly straight, second at two-fifths, straight; third at three-fifths, rippled; fourth subterminal, edged posteriorly with minute white dots, rippled; a terminal series of minute fuscous dots; a minute subcostal median discal dot; cilia whitish-brown. Hindwings with termen rounded, colour as forewings; a minute white antemedian discal dot; subterminal line, terminal dots, and cilia as forewings.

QUEENSLAND: Kuranda (F. P. Dodd); one specimen. Type in National Museum.

60. CASBIA PALLENS n.sp.

pallens, pale.

♂, 22-30 mm. ♀, 22-24 mm. Head whitish. Palpi 2 and a half; pale ochreous-brown. Antennal stalk whitish; pectinations in male 8, extreme apex simple. Thorax whitish; patagia pale ochreous-brown. Abdomen whitish. Legs whitish; anterior pair pale grey. Forewings triangular, costa straight to near apex, apex rounded in male, pointed in female, termen obliquely rounded, grey-whitish; extreme costal edge ochreous-brown strigulated with fuscous; sometimes traces of a sub-basal line; a median fuscous discal dot; a faint ochreous subterminal line, interrupted below middle by several ochreous dots edged posteriorly by dark fuscous; a terminal series of dark fuscous dots; cilia whitish with grey median line. Hindwings with termen rounded; colour as forewings; a median discal dot at one-third.

NORTH QUEENSLAND: Herberton (Atherton Tableland) in February. QUEENSLAND: Stanthorpe in October and February. Ten specimens.

61. CASBIA CELIDOSEMA n.sp.

κηλιδοσημος, blotched.

♀, Head and palpi fuscous-brown. (Antennae missing.) Thorax and abdomen pale grey. Forewings triangular, costa gently arched, apex pointed, termen slightly sinuate; pale grey sparsely sprinkled with fuscous; a pale fuscous slightly outwardly curved transverse line from two-fifths costa to mid-dorsum; a minute blackish discal dot above middle on this line; a similar dentate line from costa at three-fifths not reaching middle of wing, but prolonged by some minute fuscous dots; a large irregular-edged circular fuscous-brown spot above tornus;

a terminal series of minute blackish dots; cilia grey-whitish. Hindwings with termen rounded; as forewings, including a similar spot above tornus.

VICTORIA: Beaconsfield in December; one specimen. Type in National Museum.

62. CASBIA TANAOCTENA n.sp.

ταναοκτενος, long-combed.

♂, 26 mm. Head, thorax, and abdomen grey-whitish. Face and palpi brown. Antennae fuscous; pectinations in male 16. Legs whitish. Forewings triangular, costa gently arched, apex obtuse, termen rounded, oblique; grey-whitish with scanty fuscous sprinkling; markings fuscous; a subdorsal dot near base; an interrupted line from beneath one-third costa to one-fourth dorsum; a median subdorsal discal dot; an interrupted line from three-fourths costa to dorsum near tornus; a line of dots from costa near apex joining postmedian line below middle; cilia grey-whitish with minute blackish dots opposite ends of veins. Hindwings with termen rounded, crenulate; colour and markings as forewings.

VICTORIA: Moe in April; one specimen. Type in National Museum.

63. CASBIA CONIODES n.sp.

κονιωδης, dusty.

♂, 27 mm. Head and palpi dull reddish; fillet snow-white. Antennae white with blackish annulations; pectinations in male 5, apical one-fourth simple. Thorax grey-whitish; patagia pale reddish. Abdomen grey-whitish. Legs grey; posterior pair whitish. Forewings triangular, costa straight, apex pointed, termen slightly rounded, oblique; grey-whitish, ochreous-tinged; sprinkled and strigulated with fuscous; costal edge reddish; a median blackish subcostal discal dot; a terminal series of minute blackish dots; a faint interrupted subterminal line containing two or three minute white dots; a terminal series of minute blackish dots; cilia grey-whitish. Hindwings with termen rounded; colour and markings as forewings.

WEST AUSTRALIA: Northampton in October; one specimen.

64. CASBIA PLINTHODES n.sp.

πλινθωδης, brick-red.

♀, 34-36 mm. Head and palpi dull reddish. Antennae whitish with grey annulations. Thorax and abdomen pale reddish. Legs grey; posterior pair whitish. Forewings triangular, costa nearly straight, apex pointed, termen slightly rounded. slightly oblique; 11 out of 12; reddish-grey; a faint outwardly curved transverse line at one-third; a minute blackish median subcostal discal dot; a faint transverse median line; a sinuate subterminal line of fuscous dots; a terminal series of minute blackish dots; cilia pale reddish-grey. Hindwings with termen slightly rounded; colour and markings as forewings.

VICTORIA: Beaconsfield in October. TASMANIA: Hobart. Two specimens.

Gen. Hypochariessa nov.

ὑποχαριεις, ornate beneath.

Tongue well developed. Face smooth, not projecting. Palpi short, scarcely projecting beyond face, slender; second joint shortly rough-haired beneath; terminal joint minute. Antennae in male simple. Thorax smooth above and beneath. Femora smooth; posterior tibiae with middle spurs, in male swollen with long internal tuft of hairs. Forewings with 10 and 11 coincident, anastomosing with 12 and 9, or free. Hindwings with 7 from before angle, 12 approximated to cell as far as middle.

65. Hypochariessa ochrophara Turn.

♂ ♀, 30-35 mm. I have now a male of this species, which can no longer be referred to *Nadagarodes* Wlk. It belongs to a section of the *Boarmiadae* well represented in the Archipelago and India, and it is possible that it may ultimately be referred to some genus known from this region.

North Queensland: Ravenshoe (Atherton Tableland) in December; Mackay in August; three specimens.

66. Orsonoba diplodonta n.sp.

διπλοδοντος, with double teeth.

♀, 44 mm. Head reddish-brown; face with three white dots on each lateral margin. Palpi grey. Antennae whitish with fuscous annulations. Thorax white; patagia and bases of tegulae fuscous. Legs, anterior pair fuscous, tibiae and tarsi with whitish rings; posterior pair fuscous with white rings. Forewings triangular, costa straight to near apex, apex produced into a sharp tooth, a small tooth on vein 6, tornus obtusely produced; 10 and 11 separate, not anastomosing; pale grey; a white basal central dot; dorsum suffused with ferruginous; three fine oblique lines; first fuscous from one-fourth costa to one-fifth dorsum, angled outwards beneath costa; second whitish narrowly edged with fuscous, from beneath midcosta to mid-dorsum; third from a dot on two-thirds costa to five-sixths dorsum, angled outwards beneath costa; a faint submarginal line interrupted by a white, subcostal dot; slight fuscous sprinkling beneath costa near apex; cilia white apices partly dark fuscous. Hindwings with costa excavated before apex, apex produced into a sharp tooth on vein 7; a smaller tooth on vein six; termen produced into a sharp tooth on vein 4; pale grey with numerous fine transverse whitish lines; some fuscous suffusion on termen; dorsum strigulated with white and brown; cilia white.

Queensland: Injune in November (W. B. Barnard); one specimen. Type in Queensland Museum.

67. Orsonoba stramenticea n.sp.

stramenticeus, straw-coloured.

♂ ♀, 32-39 mm. Head whitish-ochreous; face brownish. Palpi brownish, beneath whitish-ochreous. Antennae whitish-ochreous sprinkled with fuscous; (male antennae missing). Thorax whitish-ochreous; patagia brownish. Abdomen whitish-ochreous with some brownish transverse bars towards apex. Legs fuscous with pale ochreous dots. Forewings elongate-triangular, costa straight to near apex, termen sinuate, more strongly in female, oblique; 10 and 11 separate, not anastomosing; in male ochreous-whitish, in female whitish-brown; markings fuscous; two slender transverse lines; sub-basal from one-third costa to one-fourth dorsum, in male angled inwards beneath costa, in female inwardly curved; postmedian from two-thirds costa to mid-dorsum or slightly beyond, acutely angled inwards beneath costa, in female preceded by some whitish suffusion above middle and brownish suffusion below middle; cilia concolorous. Hindwings with costa excavated before apex, apex produced in a strong acute tooth on vein 7; a similar tooth on vein 4; colour as forewings; a broad median transverse line edged posteriorly by a whitish band edged posteriorly by a slender dentate line.

QUEENSLAND: Emerald in August (W. B. Barnard); two specimens. Type in Queensland Museum.

68. ORSONOBA EUCTISTA n.sp.

εὔκτιστος, well-built.

♂ ♀, 35-39 mm. Head brownish-ochreous. Palpi brownish-ochreous or fuscous. Antennae brownish-ochreous. Thorax ochreous-grey; patagia fuscous-brown with white apices. Abdomen ochreous-grey. Legs pale ochreous sprinkled with fuscous. Forewings elongate triangular, costa straight to near apex, apex acute, termen sinuate, strongly oblique; 10 and 11 stalked, or coincident, free; pale brownish with a darker terminal band; markings fuscous; a broad interrupted costal line from base to one-third; a slender inwardly curved line from beneath three-fourths costa to two-thirds dorsum, its upper part double and filled in with white; cilia fuscous with a white dot on termen above tornus. Hindwings with costa excavated before apex, apex produced into a strong acute tooth on vein 7; a similar tooth on vein 4; colour as forewings; a minute discal dot; a slightly curved median line below middle, preceded by a broad fuscous line, which is prolonged on dorsum to base, and followed by a slender line.

QUEENSLAND: Cunnamulla in March; Quilpie in May; two specimens.

69. PICROPHYLLA RHABDUCHA n.sp.

ῥαβδοῦχος, carrying a wand.

♀, 36 mm. Head grey; face, palpi, and antennae pale fuscous. Thorax and abdomen pale ochreous. Legs fuscous; middle and posterior tibiae whitish sprinkled with fuscous. Forewings triangular, costa slightly arched, apex pointed, termen incurved beneath apex and with a tooth on vein 5; pale ochreous-grey sprinkled with fuscous; a slender fuscous outwardly curved line from one-third costa to two-fifths dorsum, edged white anteriorly; a fuscous discal dot beneath mid-costa; a slender straight fuscous line from costa shortly before apex to three-fifths dorsum, edged white posteriorly; a slender fuscous terminal line; cilia brown, apices white. Hindwings with termen scarcely rounded; colour as forewings; a median transverse fuscous line edged white posteriorly; cilia as forewings.

NEW SOUTH WALES: Allyn R. in December (G. M. Goldfinch); one specimen. Type in Australian Museum.

70. Picrophylla rubea n.sp.

rubeus, reddish.

♀, 25 mm. Head, palpi, and thorax dull reddish. (Antennae missing.) Abdomen pale reddish-grey. Forewings elongate-triangular, costa arched near base, thence straight, termen sharply angled on vein 4; 10 and 11 stalked not anastomosing, 10 sometimes connected by a bar with 9; dull reddish; markings pale fuscous; an ill-defined outwardly curved transverse line at one-fourth; a median subcostal discal dot; a slender slightly undulating outwardly curved subterminal line; some terminal dots; cilia dull reddish. Hindwings with termen slightly rounded; pale reddish-grey; a pale fuscous discal dot and slender interrupted subterminal line; cilia concolorous. Except in colour and shape of hindwings this species closely resembles *P. hyleora* Turn.

Tasmania: One specimen. Type in National Museum.

71. Idiodes rhacodes n.sp.

ῥαχωδης, ragged.

♂ ♀, 30-35 mm. Head and thorax brown; fillet and lower edge of face whitish. Palpi brownish. Antennae whitish. Abdomen pale brown. Legs ochreous-whitish sprinkled and ringed with fuscous. Forewings triangular, costa straight or slightly concave beyond middle, apex pointed, termen rounded, irregularly dentate; 10 and 11 arising separately, anastomosing together, 10 anastomosing with 9; brown with fine fuscous transverse lines, sometimes partly or mainly suffused with fuscous; costal edge more or less whitish with fuscous strigulae; sub-basal line from one-third costa to one-fourth dorsum or less, dark brown or fuscous, angled outwards in middle; submarginal line slender or rather broadly suffused, incurved above dorsum; an interrupted terminal line; cilia brown. Hindwings with termen dentate, rounded; pale ochreous with numerous fine parallel brown lines; cilia brown.

Queensland: Bunya Mts. in February; thirteen specimens of which one was from a larva beaten from the foliage of a rainforest tree.

72. Idiodes gerasphora n.sp.

γερασφορος, honourable.

♂, 42 mm. Head and palpi fuscous-brown; fillet white. Antennae grey becoming white towards base. Thorax and abdomen pale fuscous. Legs pale brown; anterior pair darker. Forewings triangular, costa gently arched, termen slightly rounded, slightly oblique; 10 and 11 stalked, their stalk anastomosing with 12, 10 anastomosing with 9; pale ochreous coarsely strigulated with pale fuscous; broad costal and dorsal stripes from base to apex, the former not extending to costal margin; a broad postmedian fascia; cilia pale fuscous. Hindwings with termen rounded; colour and markings as forewings.

Queensland: McPherson Rge. in January; one specimen received from Mr. E. J. Dumigan.

73. Planolocha hyposema n.sp.

ὑποσημος, marked beneath.

♂, 32 mm. Head brownish-grey; face fuscous-brown. Palpi 1; grey. Antennae grey. Thorax brownish-grey with a posterior pair of fuscous dots. Abdomen brownish-grey with a pair of fuscous dots on third segment. Forewings elongate-triangular, costa straight, apex pointed, slightly produced, termen oblique, strongly bowed on vein 4; grey with some fuscous scales mostly towards base; a series of fuscous dots on costa before middle; a short oblique ferruginous-fuscous mark on one-third costa, connected with one-fourth dorsum by a line of minute fuscous dots; an oblique ferruginous-fuscous mark beneath three-fifths costa; a nearly straight line of dots from near apex to three-fourths dorsum; cilia grey. Hindwings with termen slightly rounded, with a slight prominence on vein 4; grey with scanty fuscous sprinkling; a discal dot; a slender straight fuscous postmedian line preceded on dorsum by a ferruginous spot; cilia grey. Underside of hindwing with a broad patch of long appressed hairs mostly grey, but fuscous at terminal end, between veins 2 and 4. Closely similar to *P. autoptis* Meyr., but differentiated by the hairy patch on underside of hindwings in male.

New South Wales: Allyn R. in December; one specimen received from the late Mr. G. M. Goldfinch.

74. Planolocha lactea n.sp.

lacteus, milk-white.

♂ ♀, 18-22 mm. Head white; face smooth, pale brown. Palpi 2; pale brown. Antennae and abdomen white. Legs pale fuscous; posterior pair whitish. Forewings triangular, costa straight, apex pointed, termen slightly rounded, scarcely oblique; 10 and 11 arising separately, anastomosing together, 10 anastomosing with 9; white, sometimes sprinkled with brownish; a slender rounded transverse line at one-fourth; a fuscous discal dot beneath costa beyond middle; a broad oblique line from two-thirds dorsum towards but not reaching apex, brown with fuscous dots; a slender fuscous terminal line; cilia white. Hindwings with termen rounded; white; in female sprinkled with brownish, and with a slender brownish transverse line beyond middle; terminal line and cilia as forewings.

New South Wales: Murrurundi in November and December; three specimens received from Dr. B. L. Middleton.

Gen. Macqueenia nov.

Head smooth, rounded, somewhat prominent. Tongue well developed. Palpi short; second joint rough-scaled; terminal joint short. Antennae in male bipectinate to apex. Thorax not hairy beneath. Femora smooth; posterior pair in male not swollen. Forewings with 7, 8, 9, 10 stalked, 11 from cell, anastomosing or connected with 12 or 10 or both, or free. Hindwings with 12 approximated to cell as far as middle. Allied to *Thalaina* Wlk.

75. MACQUEENIA CHIONOPTILA n.sp.

χιονοπτιλος, with snow-white wings.

♂ ♀, 45-56 mm. Head orange; face brown. Palpi fuscous, lower edge white. Antennae fuscous; pectinations in male 2 and a half. Thorax white. Abdomen grey-whitish lightly sprinkled with fuscous. Legs pale fuscous; posterior pair white. Forewings triangular, costa straight, apex sharp-pointed, termen slightly rounded, oblique; shining white; dorsal margin and cilia orange. Hindwings with termen slightly rounded, oblique; white; two blackish blotches, first subapical, rounded, second on tornus, oval; cilia white.

QUEENSLAND: Milmerran in April and May; nine specimens received from Mr. J. Macqueen, who informs me that the larva feeds on Brigalow (*Acacia harpophylla*) and pupates underground.

76. STATHMORRHOPA APHOTISTA n.sp.

ἀφωτιστος, dark.

♂ ♀, 48-56 mm. Head, palpi and thorax fuscous. Antennal stalk in male whitish; pectinations 3, fuscous; in female serrate, fuscous. Abdomen pale fuscous. Legs fuscous with whitish rings; posterior tibiae grey-whitish sprinkled with fuscous. Forewings elongate, sub-oblong; costa slightly arched, apex rectangular, termen straight, rounded below middle, not oblique; fuscous with numerous irregular transverse darker lines, or mottled, or finely sprinkled; a small dark fuscous discal spot beyond middle; cilia fuscous. Hindwings with termen rounded, wavy; basal half grey-whitish; a slender median transverse fuscous lunule; a broad band of terminal fuscous suffusion; cilia grey-whitish.

VICTORIA: Moe in May. TASMANIA: Millbrook in April. Four specimens.

Gen. HAPLOCEROS nov.

ἁπλοκερας, with simple antennae.

Antennae in male simple. Thorax without crest; densely hairy beneath. Femora densely hairy. Forewings with 10 and 11 separate, 11 connected by a bar with 12, 10 by a bar with 11, 9 by a bar with 10, 7, 8, 9 stalked. Hindwings with 12 closely approximated to cell to three-fourths.

77. HAPLOCEROS SPHENOTYPA n.sp.

σφηνοτυπος, marked with wedges.

♂, 56 mm. Head, palpi, thorax and abdomen grey-whitish. Antennae grey. Legs fuscous with whitish rings; posterior pair grey-whitish. Forewings elongate, posteriorly dilated, apex rounded-rectangular, termen slightly rounded, slightly oblique; grey-whitish; markings fuscous; antemedian line slender, from one-fourth costa to two-fifths dorsum, obliquely curved outwards; a dot on middle of posterior edge of cell; postmedian from two-thirds costa, outwardly curved, angled inwards above dorsum, where it ends at three-fourths, consisting of minute wedges on veins; a terminal series of dots; cilia whitish. Hindwings with termen rounded; fuscous; cilia white.

NEW SOUTH WALES: Ebor in January; one specimen received from Dr. B. L. Middleton.

Gen. STINOPTILA nov.

στεινοπτιλος, with narrow wings.

Face smooth with rounded prominence. Tongue well developed. Palpi short, smooth-scaled; terminal joint minute. Thorax without crest; not hairy beneath. Forewings with 10 and 11 stalked, 11 connected by a bar with 12, 10 anastomosing with 9. Hindwings with 12 approximated to cell to two-fifths.

78. STINOPTILA ACONTISTICA n.sp.

ἀκοντιστικος, throwing darts.

♀, 30 mm. Head and palpi whitish; a blackish spot on vertex. Antennae white with pale fuscous annulations. Thorax brownish; patagia white sparsely sprinkled with fuscous. Abdomen and legs grey-brownish. Forewings elongate-triangular, costa straight, apex acute, termen sinuate, oblique; white sprinkled with fuscous; a broad brown costal streak from base to two-thirds; short sub-basal median and dorsal streaks, followed by a similar streak on fold; an acute brown and fuscous median wedge separating into two slender brown lines posteriorly; a short slender median line above this; a subterminal series of acute streaks separating into two slender brown lines anteriorly; a terminal series of blackish wedge-shaped dots forming apices of short pale fuscous longitudinal marks; cilia white. Hindwings narrow, termen rounded; white; veins tinged with brown; a small circular grey median discal spot; a subterminal series of minute grey marks on veins; cilia white.

SOUTH AUSTRALIA: Kangaroo I. in March; one specimen received from Mr. F. M. Angel.

79. CIAMPA STENOPTILA n.sp.

στενοπτιλος, narrow-winged.

♀, 38 mm. Head, palpi, and thorax fuscous. Antennae grey. Abdomen brownish-fuscous; terminal segments grey. Legs fuscous with whitish rings; posterior pair grey-whitish. Forewings elongate, narrow, costa gently arched, apex pointed, termen straight, oblique; 10 and 11 separate, 10 connected with 9; grey with fuscous suffusion and dark fuscous streaks; costal and median areas suffused; a slender median line in cell; posterior margin of cell dark fuscous; five longitudinal subterminal streaks suffusedly edged with whitish; a fine interrupted terminal line; cilia grey with whitish bars. Hindwings twice as broad as forewings, termen rounded; whitish; cilia whitish.

NEW SOUTH WALES: Murrurundi in May; one specimen.

80. CHLENIAS CHYTRINOPA n.sp.

χυτρινωπος, like earthenware.

♂, 36-38 mm. Head, palpi, and thorax fuscous. Antennal stalk whitish; pectinations in male 8, fuscous. Abdomen ochreous-grey. Legs fuscous with ochreous-whitish rings; posterior pair except tarsi ochreous-whitish. Forewings elongate-triangular, costa moderately arched, apex rounded, termen rounded, slightly oblique; 10 and 11 separate, not anastomosing; whitish-brown; markings fuscous; sometimes fine streaks on veins; antemedian line represented by three minute dots at one-fifth; a postmedian sinuate line of dots from three-fourths costa to two-thirds dorsum; a moderately broad median streak from first line to second and slightly beyond; a terminal series of dots; cilia whitish. Hindwings broad, termen rounded; pale fuscous; cilia whitish.

VICTORIA: Moe in May (C. G. L. Gooding); three specimens. Type in Queensland Museum.

81. CHLENIAS OCHROCRANA n.sp.

ὠχροκρανος, with pale head.

♀, 45 mm. Head and thorax whitish with some fuscous sprinkling. Palpi 2; fuscous mixed with whitish; terminal joint whitish. Antennae fuscous. Abdomen grey-whitish. Legs dark fuscous with white rings; posterior tibiae mostly whitish. Forewings elongate-triangular, costa rather strongly arched, apex rounded, termen rounded, oblique, crenulate; 10 and 11 separate, 11 anastomosing with 12; white sprinkled with grey; markings dark fuscous; a short slender line from base along fold; sub-basal line outwardly oblique, acutely bent inwards above dorsum; a broad irregular oblique line from one-third costa to one-third dorsum; a fine dentate line from three-fourths costa, closely approximated below middle to antemedian line; a short broad oblique streak from costa just before apex; an interrupted terminal line; cilia white with fuscous bars. Hindwings with termen slightly waved, rounded; grey; a faint fuscous straight antemedian line; followed by a small discal fuscous lunule.

NEW SOUTH WALES: Ebor in May; one specimen received from Dr. B. L. Middleton.

Gen. ALLOPHYLA nov.

ἀλλοφυλος, alien.

Tongue present. Face flat. Palpi moderate, obliquely ascending; second joint thickened with appressed scales; terminal joint short, obtuse. Abdomen not hairy beneath. Femora smooth. Posterior tibiae with long inner spurs. Forewings with 10 anastomosing with 9 to form an areole; 7 separate and 8 and 9 stalked from areole, 11 from cell anastomosing with 12. Hindwings with 6 and 7 connate, 12 diverging from cell at one-fourth.

82. ALLOPHYLA SPECIALIS n.sp.

specialis, peculiar.

♀, 22 mm. Head dull reddish, front of crown whitish; face dull reddish. Palpi 1 and a half; reddish, terminal joint whitish. Antennae fuscous. Abdomen dull reddish. Legs whitish-ochreous with fuscous rings; anterior pair fuscous. Forewings narrow-triangular, costa straight, apex rectangular, termen rounded, slightly oblique, crenulate; dull reddish; markings whitish; a broad costal streak from base to apex; a slender sub-basal transverse line; a shining white dot beneath costa at one-fourth; a slender finely dentate transverse line from three-fourths costa to three-fourths dorsum; a circular tornal patch, excavated posteriorly, containing some fuscous scales; a slender interrupted dentate submarginal line; cilia whitish with two dull reddish transverse lines. Hindwings with termen scarcely rounded, crenulate; colour and markings as forewings but without sub-basal line and discal dot.

NEW SOUTH WALES: Gosford in October (Moss Robinson); one specimen. Type in National Museum.

83. STIBAROMA HABROSTOLA n.sp.

ἁβροστολος, softly robed.

♂ ♀, 38-43 mm. Head, palpi, and thorax fuscous mixed with whitish. Antennal stalk whitish; pectinations in male 5, apical third simple, fuscous. Legs fuscous with whitish rings; middle and posterior femora whitish. Forewings elongate-triangular, costa straight to near apex, termen rounded, oblique; 10 and 11 separate, not anastomosing; fuscous densely sprinkled with whitish, appearing grey; a small white discal spot beneath middle of costa; a very slender crenate fuscous line from one-fifth costa to two-fifths dorsum; a slender bisinuate line from three-fourths costa to three-fourths dorsum; terminal veins slenderly outlined with fuscous; a faint whitish dentate subterminal line; cilia fuscous with a few whitish points. Hindwings with termen rounded; white; a well defined fuscous terminal band, containing a terminal series of whitish spots; cilia white with grey bars.

NEW SOUTH WALES: Ebor in March; five specimens received from Dr. B. L. Middleton.

84. STIBAROMA ASTREPTA n.sp.

ἀστρεπτος, unbending.

♂, 40 mm. Head, palpi, and thorax grey. Antennae fuscous; pectinations in male 2 and a half, apical sixth simple. Abdomen grey mixed with whitish; tuft whitish. Forewings elongate-triangular, costa straight to near apex, termen slightly rounded, slightly oblique; 10 and 11 stalked or separate, not anastomosing; grey with four dark fuscous transverse lines; first at one-fourth, straight; second parallel at one-third, slightly bisinuate; fifth from seven-eighths costa to tornus, straight; a discal dot beneath costa beyond middle; veins mostly finely outlined with dark fuscous; an interrupted terminal line; cilia grey. Hindwings with termen rounded; whitish with a broad terminal band not reaching costa, its margin suffused; cilia whitish.

NEW SOUTH WALES: Ebor in March and April; two specimens received from Dr. B. L. Middleton.

Gen. HETEROGENA nov.

ἑτερογενος, of different kind.

Face smooth, not projecting. Palpi moderate, slender, porrect. Antennae of male unipectinate, apex simple. Femora smooth. Forewings without areole; 10 and 11 arising separately from cell, 11 anastomosing with 12, 9 anastomosing with 10. Hindwings with 12 approximated to cell as far as middle. Of unusual structure and uncertain affinity.

85. HETEROGENA EXITELA n.sp.

ἐξιτηλος, faded.

♂, 40 mm. Head and palpi fuscous. Antennae pale fuscous; pectinations in male 5, apical sixth simple. Thorax and abdomen grey. Forewings elongate-triangular, costa almost straight, apex round-pointed, termen as long as dorsum, rounded; oblique; pale fuscous; a large dark fuscous discal spot beneath midcosta, surrounded by whitish suffusion; a broad dark fuscous line from two-thirds costa to tornus, at first gently outwardly curved, thence slightly sinuate; a series of white spots on termen; cilia very short, pale fuscous. Hindwings with termen rounded; colour and pattern as forewings.

QUEENSLAND: Jandowae near Dalby in March (R. Hamilton); one specimen. Type in Queensland Museum.

Gen. CRYPHAEA nov.

κρυφαιος, hidden.

Head smooth, not prominent. Tongue well developed. Palpi moderately long; second joint shortly rough-haired; terminal joint short. Antennae in male bipectinate, apex simple. Thorax with a posterior crest; densely hairy beneath. Femora smooth. Posterior tibiae of male swollen, with an internal tuft of long hairs. Forewings in male without fovea; 10 and 11 separate, 11 anastomosing with 12; 10 out of 9 or cell, 10 and 11 arising separately and usually anastomosing together, 10 anastomosing or connected with 9, or free. Hindwings normal. Type *C. xylina* Turn. (Proc. Linn. Soc. N.S.Wales 1917, p. 369).

86. AMELORA ANTHRACOCENTRA n.sp.

ἀνθρακοκεντρος, with coal-black centre.

♂, 33-38 mm. Head pale grey; upper part of face fuscous. Palpi fuscous. Antennae pale grey; pectinations in male 6. Thorax and abdomen pale grey. Legs fuscous with whitish rings; posterior pair whitish sprinkled with fuscous. Forewings elongate-triangular, costa slightly arched, apex obtuse, termen rounded, oblique; pale grey with or without scattered blackish scales; an outwardly curved transverse sub-basal line at one-fifth sometimes indicated; a transverse oval blackish discal spot beneath costa beyond middle; sometimes a few blackish terminal dots; cilia grey-whitish. Hindwings with termen slightly rounded; colour as forewings; a minute discal dot.

WEST AUSTRALIA: Merredin; two specimens.

87. AMELORA CONIA n.sp.

κονιος, dusty.

♂, 30-31 mm. Head whitish. Palpi grey; terminal joint sometimes white. Antennal stalk grey; pectinations in male five, fuscous. Thorax and abdomen grey. Legs grey; posterior tibiae swollen with an internal extrusible tuft of long hairs. Forewings elongate-triangular, costa slightly arched, apex acute, termen sinuate, oblique; pale grey finely dusted with fuscous or blackish scales; an outwardly rounded sub-basal transverse line at one-fifth, sometimes obsolete; a blackish or fuscous discal dot beneath costa beyond middle; a straight oblique line or series of dots from apex to two-thirds or three-fourths dorsum, edged posteriorly by a faint whitish line; cilia whitish. Hindwings with termen rounded; pale grey; a minute median discal dot; a postmedian series of dots faintly indicated; cilia whitish.

SOUTH AUSTRALIA: Mt. Lofty in April. WEST AUSTRALIA: Denmark in April (W. B. Barnard); four specimens. Type in Queensland Museum.

88. Amelora belemnophora n.sp.

βελεμνοφορος, carrying darts.

♂, 27 mm. Head, palpi, and thorax grey. Antennae fuscous; pectinations in male 5. (Abdomen missing.) Legs whitish sprinkled with fuscous; anterior pair fuscous with whitish rings. Forewings elongate-triangular, costa almost straight, apex pointed, termen slightly rounded, oblique; whitish densely sprinkled with fuscous, appearing grey; markings dark fuscous; fine streaks on veins; a stout longitudinal bar from base to one-fifth slightly beneath middle; a similar median bar from near base to middle of wing, its apex acute with a small upright projection above it; four elongate costal dots between middle and apex; an oblique streak from apex to near median bar, sharply defined and dentate anteriorly, posteriorly irregular in outline; three dart-shaped streaks on veins 2, 3, and 4; a subdorsal bar with suffused margins from about middle to termen; cilia white with a faint fuscous median line. Hindwings with termen rounded; white with slight grey suffusion towards termen; a fuscous terminal line; cilia white. Underside of both wings white with fuscous discal dot and a postmedian line of minute dots.

Queensland: Cunnamulla in April; one specimen.

89. Amelora ceraunia n.sp.

κεραυνιος, thunderstricken.

♂, 30-32 mm. Head, palpi, and thorax fuscous. Antennae grey; pectinations in male 6. Legs fuscous with whitish rings; posterior pair grey-whitish sprinkled with fuscous. Forewings triangular, costa gently arched, apex obtuse, termen rounded, oblique; uniform grey with some fuscous sprinkling near base; a fuscous discal dot beneath midcosta; a slender blackish line from apex inwardly oblique and slightly waved for a short distance, angled outwards above middle, thence strongly dentate to mid-dorsum, very slender or interrupted between dentations; cilia grey. Hindwings with termen rounded; grey-whitish; a minute pale fuscous median discal dot; cilia grey-whitish.

Queensland: Miles in March; three specimens.

90. Amelora anepiscepta n.sp.

ἀνεπισκεπτος, unconsidered.

♂ ♀, 28-34 mm. Head, palpi, thorax, and abdomen grey. Antennae pale fuscous; pectinations in male 3. Legs grey-whitish sprinkled with fuscous; anterior pair fuscous with whitish rings. Forewings triangular, costa slightly arched; apex pointed. termen sinuate, oblique; 10 and 11 stalked, their stalk anastomosing with 9; grey with slight fuscous sprinkling and dots; three or more minute dots representing sub-basal line; a minute discal dot beneath midcosta; a sub-marginal series of minute dots, indented in middle, above middle sometimes connected to form a sharply dentate line; sometimes a few terminal dots; cilia grey. Hindwings with termen strongly rounded, crenulate; colour as forewings; dots usually obsolete, but present on underside.

Victoria: Moe in February. West Australia: Denmark in March and April. Four specimens. In three of these the neuration is as stated; but in the type male it is so on only one side, on the other it is that normal in the genus. I have observed the same peculiar neuration in *A. crenulata* Turn.

91. Amelora thegalea n.sp.

θηγαλεος, sharp-pointed.

♂ ♀, 30-34 mm. Head, palpi, thorax and abdomen grey. Antennae grey with blackish annulations; pectinations in male 4; fuscous, extreme apex simple. Legs fuscous with whitish rings; posterior pair whitish with fuscous sprinkling. Forewings elongate-triangular, costa arched near base, thence straight, apex sharp-pointed, somewhat produced in female, termen sinuate, oblique; grey sprinkled with fuscous; markings fuscous; a few minute dots representing sub-basal line; a median subcostal discal dot; a sinuate series of dots from costa near apex, indented above middle; a terminal series of dots; cilia grey-whitish. Hindwings with termen rounded; grey; a median discal dot; a series of minute subterminal dots; cilia grey-whitish.

West Australia: Denmark in March and April; Perth; twelve specimens.

92. Amelora adusta n.sp.

adustus, sunburnt.

♂, 36 mm. Head fuscous-brown; face with a transverse median blackish line. Palpi pale brownish. Antennal stalk grey-whitish with some fuscous scales; pectinations in male 4, fuscous. Abdomen grey-whitish sprinkled with fuscous. Legs dark fuscous with whitish rings; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa slightly arched, apex rectangular, termen slightly rounded, slightly oblique, crenulate; fuscous partly suffused with whitish; costal edge brown with fuscous strigulae; dorsum irregularly suffused with brown; a broad fuscous costal line from base to sub-marginal fascia; an indefinite broad fuscous line from costa near base to one-fourth dorsum; a blackish discal dot edged posteriorly with brown beneath midcosta; a moderate fuscous fascia from costa before apex, its anterior edge irregularly dentate, much widened posteriorly to touch discal dot, then narrowing to end in three-fourths dorsum; pale areas on termen and around discal dot; a blackish terminal line dotted on veins; cilia ochreous-whitish with a median fuscous line. Hindwings with termen rounded; grey; a minute fuscous median discal dot; a very fine dentate subterminal fuscous line, dentate with minute whitish dots on apices of teeth; a terminal line, cilia as forewings.

New South Wales: Ebor in February; one specimen received from Dr. B. L. Middleton.

93. Authaemon poliophara Turn.

Proc. Linn. Soc. N.S.Wales 1919, p. 297.

A. stenonipha Turn. ibid. p. 297 is a synonym.

94. Mnesampela macroptila n.sp.

μακροπτιλος, long-winged.

♂, 55 mm. Head and thorax grey. Palpi whitish; terminal joint fuscous. Antennae pale grey; pectinations in male 1 and a half. Abdomen whitish-ochreous. Legs whitish-ochreous; anterior pair and all tarsi fuscous. Forewings elongate, costa moderately arched, apex rectangular, termen sinuate, oblique; 11 from cell, connected by a bar with 12 and anastomosing with 10; whitish; margins broadly suffused with grey; slender longitudinal blackish streaks between veins; a subcostal blackish discal dot at three-fifths; cilia white. Hindwings with termen rounded, wavy; whitish with a large grey terminal suffusion narrowing from apex to tornus; cilia white.

New South Wales: Mittagong in April (G. M. Goldfinch); one specimen.

95. Smyriodes idiograpta n.sp.

ἰδιογραπτος, with peculiar markings.

♂, 40 mm. Head and thorax grey. Palpi 1; fuscous, beneath ochreous-whitish. Antennae fuscous; pectinations in male 6. Abdomen greyish-ochreous. Legs dark fuscous; posterior pair mostly whitish. Forewings elongate-triangular, costa strongly arched, apex rounded, termen slightly oblique; 10 and 11 from cell, 10 anastomosing with 9; grey lightly strigulated with fuscous; markings blackish; a spot on one-fourth costa connected by a curved line with three-fourths costa, enclosing a space one-third breadth of wing, this line is thickened in disc and is connected by slender curved lines with a slender subdorsal line enclosing a rhomboidal median area; beneath this two curved lines enclose a narrower dorsal area; a dot on midcosta; a thick interrupted subcostal line from apex; a terminal line; cilia whitish with narrow fuscous bars. Hindwings with termen slightly rounded, wavy; white with a narrow undulating subterminal fuscous line; a fuscous terminal suffusion; a slender dark fuscous terminal line; cilia white.

South Australia: Ooldea in July (J. A. Kershaw); one specimen. Type in National Museum, Melbourne.

Gen. Liometopa nov.

λειομετωπος, smooth-faced.

Palpi moderate; second joint much thickened with appressed scales; terminal joint very short. Antennae fuscous; in male pectinate to apex. Thorax with a double posterior crest; beneath hairy. Femora hairy. Forewings with 10 and 11 from cell, 10 anastomosing with 9. Hindwings with neuration normal.

96. Liometopa rectilinea n.sp.

rectilineus, with straight lines.

♂, 42 mm. Head and thorax fuscous. Palpi 1 and a half; fuscous, terminal joint whitish. Antennae fuscous; pectinations in male 2. Abdomen grey, towards apex grey-whitish. Legs fuscous; posterior pair mostly whitish. Forewings elongate-triangular, costa straight, apex obtuse, termen slightly rounded, slightly oblique; fuscous with five blackish transverse lines; first from near base of costa to fold, on which it is prolonged; second and third approximated at about one-third, slightly waved; fourth from two-thirds costa to five-sixths dorsum, sinuate; fifth subterminal, nearly straight; some fine blackish lines on veins in disc; short whitish lines on veins running to termen; two or three blackish interneural lines running to upper part of termen; an interrupted terminal line; cilia whitish. Hindwings with termen rounded; whitish with a broad pale fuscous terminal band; cilia whitish.

New South Wales: Ebor in March (Dr. B. L. Middleton); one specimen. Type in National Museum, Melbourne.

Gen. MIDDLETONIA nov.

Face smooth, not prominent. Tongue well developed. Palpi moderately long; second joint shortly rough-haired above and beneath; terminal joint minute. Antennae in male bipectinate. Thorax with a small bifid posterior crest; beneath hairy. Femora smooth. Posterior tibiae in male not swollen. Forewings with 10 and 11 arising separately from cell, anastomosing together, 10 anastomosing with 9 or free. Hindwings with 12 approximated to cell to beyond middle. Allied to *Paurocoma* Low., with which it agrees in neuration.

97. MIDDLETONIA SUAVIS n.sp.

suavis, pleasing.

♂ ♀, 35-37 mm. Head and thorax fuscous sprinkled with white; face dark fuscous. Palpi 1 and a half; fuscous. Antennae fuscous; pectinations in male 3. Abdomen grey-whitish. Legs whitish; anterior pair fuscous with whitish rings. Forewings triangular, costa slightly arched, apex rounded, termen rounded, oblique; whitish or ochreous-whitish sprinkled with fuscous, in some parts densely, postmedian area sometimes largely suffused with whitish; markings dark fuscous; a sub-basal dentate line from one-fifth costa to two-fifths dorsum; a short outwardly oblique whitish mark from two-thirds costa; sometimes a whitish spot beneath three-fifths costa; apical area broadly fuscous, containing three or four short blackish longitudinal streaks; a small spot on tornus, a terminal series of blackish dots; cilia whitish with fuscous bars. Hindwings with termen rounded; whitish or ochreous-whitish with slight fuscous sprinkling towards termen; a fine interrupted blackish terminal line; cilia whitish or ochreous-whitish.

NEW SOUTH WALES: Ebor in February and March; two specimens received from Dr. B. L. Middleton.

Gen. CRYPSIPHILA nov.

κρυψιφιλος, loving concealment.

Face smooth, slightly prominent. Tongue well developed. Palpi short; second joint thickly scaled, rough beneath; terminal joint minute. Antennae in male bipectinate, apex simple. Thorax with posterior crest; densely hairy beneath. Femora smooth. Posterior tibiae in male swollen with internal tuft of long hairs. Forewings in male without fovea; 10 and 11 arising separately from cell, anastomosing together, 10 anastomosing with 9. Hindwings normal.

98. CRYPSIPHILA ATMOPHANES n.sp.

ἀτμοφανης, smoky.

♂, 20-22 mm. Head, palpi, and thorax fuscous. Antennae fuscous; pectinations in male 1 and a half, apical third simple. Abdomen fuscous; tuft grey-whitish. Legs fuscous with whitish rings; posterior pair whitish sprinkled with fuscous. Forewings triangular, costa straight, apex round-pointed, termen slightly rounded, slightly oblique, wavy; fuscous; a slender straight blackish line from one-fourth costa to one-fifth dorsum; a similar but irregularly waved line from four-fifths costa, straight from costa, thence concave to near dorsum, on which it ends at four-fifths; base before first line and area beyond second line tinged brownish; a fuscous terminal line; cilia grey-whitish with fuscous bars and apices. Hindwings with termen rounded, wavy; grey-whitish with some fuscous sprinkling; a minute discal dot; a slender postmedian transverse line, followed by brownish and fuscous suffusion; terminal line and cilia as forewings.

WEST AUSTRALIA: Coorow in October; one specimen.

Gen. THRENETA nov.

θρηνητος, most mournful.

Face with anterior tuft. Tongue well developed. Palpi obliquely ascending, rather slender, smooth-scaled; terminal joint short. Antennae in male simple. Thorax without crest; slightly hairy beneath. Femora smooth. Posterior tibiae in male swollen with internal tuft of long hairs. Forewings without fovea; 10 and 11 arising separately from cell, anastomosing together, 10 anastomosing with 9. Hindwings normal.

99. THRENETA PELLOPHANES n.sp.

πελλοφανης, grey.

♂, 35 mm. Head, thorax, and antennae grey. Palpi, 1 and a half; grey. Abdomen and legs grey. Forewings triangular, costa straight, apex pointed, termen rounded, slightly oblique; grey; markings fuscous; antemedian line slender, outwardly curved, from one-third costa to one-third dorsum; postmedian similar but nearly straight, from near apex to two-thirds dorsum; cilia grey. Hindwings with termen rounded; grey; a median discal dot; closely followed by a straight transverse line; cilia grey.

QUEENSLAND: Bunya Mts. in March; one specimen.

Gen. LACISTOPHANES nov.

λακιστοφανης, torn.

Head with central scaleless depression surrounded by raised scales. Tongue strong. Palpi moderate, porrect; second joint shortly rough-scaled; terminal joint short. Forewings elongate-triangular, costa straight, apex obtuse, termen deeply incised between apex and middle, produced into an obtuse tooth between veins 3 and 4, thence very oblique, dorsum short; 10 and 11 from cell, 9 out of 10, anastomosing with 8 to form a typical areole. Hindwings with 3 and 4 short-stalked, 12 diverging from cell at about one-third. An anomalous genus, not near any other.

100. LACISTOPHANES HACKERI n.sp.

♀, 31 mm. Head brown sprinkled with whitish. Palpi 1 and a half; dark fuscous. Antennae grey. Thorax brown; tegulae white. Abdomen whitish-ochreous sprinkled with fuscous. Forewings brown-whitish, central portion of terminal area brownish-grey; costal edge from middle to apex dark fuscous with whitish dots and a subcostal whitish line; dorsal edge fuscous-brown with long marginal scales and a small sub-basal tuft; terminal edge on base of incision dark fuscous; a narrow dark fuscous marginal line and whitish submarginal line between median tooth and tornus; cilia dark fuscous, on apex whitish, on terminal tooth whitish with fuscous bars. Hindwings with termen sinuate; grey; cilia whitish.

QUEENSLAND: Bunya Mts. in December (H. Hacker); one specimen. Type in Queensland Museum.

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ROBERT LOGAN JACK: A MEMORIAL ADDRESS.

By Dorothy Hill, D.Sc., Ph.D., A.N.C., F.G.S.

(Delivered before the Royal Society of Queensland, 28th October, 1946*; issued separately 27th October,* 1947.)

Robert Logan Jack was born in Scotland, at Irvine, Ayrshire, on 16th September, 1845. He was educated at the Irvine Academy and Edinburgh University. Details of his university career are not available, but his family was academically distinguished, his brother being a senior wrangler. He joined the staff of the Geological Survey of Scotland in 1867. Scottish geology at the time was very vital; the principles of the vigorous young science were being formulated and tested; and Jack was associated with such outstanding men as Sir Archibald Geikie, B. N. Peach and J. Horne, to his own and, later, Queensland's great benefit. When Robert Etheridge, Junior, also joined the survey staff in 1873 and remained for a year, he and Jack began an association founded on mutual respect for one another's qualities of sincerity and enthusiasm; an association of field geologist with palaeontologist that was to result in what still remains Queensland's outstanding geological work—"The Geology and Palaeontology of Queensland and New Guinea." Jack's chief contribution to Scottish geology was his mapping of coalfields; but he also worked on the older rocks, and in these particularly he must have felt the influence of those fathers of metamorphism, Peach and Horne. As with all enthusiasts, Jack's vacations were usually busman's holidays; he visited France, Austria and Germany whenever possible, expanding his geological knowledge and experience; and in his Queensland publications we often find comparisons with the European sections he visited during this period. One of the results of these visits was a paper published in collaboration with John Horne in the Quarterly Journal of the Geological Society of London, in 1877, on the glacial drift in the north-eastern Carpathians. It is unfortunate that Queensland offered no scope for his interest in glaciology.

Meanwhile, in Queensland, the position of Geological Surveyor for Northern Queensland had become vacant when Richard Daintree, in 1871, became Agent General for the colony in London. Jack was appointed to the vacancy on 29th March, 1876. On relinquishing his Surveyorship, Daintree had summarised what was known of the geology of Queensland in his remarkable "Notes on the Geology of Queensland" published in the Quarterly Journal of the Geological Society for 1872, with the first geological map of the State which had been attempted and this formed the foundation for Jack's work. The correspondence on the appointment shows Jack's desire to fit himself for his new work in a largely unmapped country. He asked for leave to spend a few months in Scotland, on a suitable allowance, to make himself familiar with the latest methods of topographic mapping, so that he as a geological surveyor could provide his own base maps, where these did not exist and could not be made in time by the map-making authority. This allowance was refused; but the time and his request for authority to spend £200 in purchasing surveying and geological instruments was granted.

He married Janet Simpson Love in 1877; they both arrived in Brisbane in 1877, and left for his office in Townsville almost immediately. Jack on his arrival was 32. He was fashionably moustached and bearded, and he remained so throughout his connection with Queensland. He was of average height, about 5 feet 9 inches is conjectured from his photographs, and spare in build, quiet, but of active habit, and correct in dress.

At this time A. C. Gregory was Geological Surveyor for Southern Queensland, and the two men reported independently to the Minister for Mines and Works. Two years later, in 1879, when Gregory retired, Jack was appointed Government Geologist for the whole of Queensland; and from this time the development of the Geological Survey, under a Chief Geologist in the Department of Mines, was assured.

Jack's special qualities as a scientist soon became apparent. His sound training in Edinburgh; his capacity to complete work begun; his ability to amass detail; his passion for accuracy; his courage to draw deductions from the available evidence; and above all his ability to synthesise masses of detail into a coherent whole and to present the results for the education of others all contributed to the value of his services to Queensland. His personal qualities of vigour, integrity, friendliness and respect for the rights of others, which naturally made him liked and respected by all with whom he came in contact, also paid dividends to the State; for they made his relations with prospectors, miners, officials, settlers, selectors and public harmonious and efficient, and no doubt contributed considerably to his success as an administrator.

Jack was a many-sided man, and his work as Government Geologist falls naturally into six divisions:—(i) Survey of coal and mineral fields; (ii) exploration of new country for metalliferous prospects and for suitability for railway lines; (iii) recognition and survey of the Great Artesian Basin; (iv) making the actual results of surveys and explorations known to officials and to the scientific and general public; (v) development of the Geological Survey; and (vi) assistance to academic institutions and scientific societies.

His numerous surveys of mineral fields kept pace with the demands of the day, while those of coalfields went ahead of them. Most of his reports deal with the northern divisions; and it is to Jack that we owe our early knowledge and appraisal of the Bowen River coalfield and of coal prospects near Cooktown, Townsville and the Flinders River. In the coal areas his field method was to define the boundaries of the field and then to examine minutely every creek and natural section. The outcrops of every seam were noted. Had the land maps of the time not been so niggardly of topographic detail, Jack's original surveys would have been of even greater value. As it was, he recognised the potentiality of the Bowen field with its drawback of expensive carriage to the coast. He regarded it as a possible source of petroleum also. Jack did much topographic mapping himself, and urged continually that surveyors should be sent ahead of geological parties. He made excellent collections of fossils, and, aware of the dangers of making palaeontological identifications with inadequte libraries, he prevailed upon his friend Robert Etheridge, Junior, then at the British Museum, to undertake these identifications and descriptions.

He reported on the Normanby, Marengo, Hodgkinson, Mt. Morgan (three reports), Mt. Leyshon, Charters Towers, Palmer, Taranganba, Moondilla, Grasstree, Russell River and Brovinia goldfields, the Wild River, Stanthorpe, Herberton, Watsonville and Kangaroo Hills tin mines, the Dry River, Argentine and Sellheim River silver mines, the Chillagoe and Koorboora mining districts, and the sapphire deposits of Withersfield. All his reports are characterised by geological as well as mining observation and inference; and while on visits to mines and mineral fields he made opportunities to investigate outcrops critical for an improved understanding of the relations between the geological formations of the State.

He liked to correct the proofs of his reports himself, declaring that the professional proof-readers evidently suffered from insomnia, and so were unable to pick up the errors in type-setting. He was fond of making literary quotations in his reports, and when one from Macbeth was cut out by the departmental censor he supposed, in retrospect, that this was because it was not couched in official language or because the Shakespearian lines fell below the departmental standard of literary merit.

Jack's conservatism of thought is visible in these reports. Although the theory of granitisation, the metamorphic process by which sediments are converted to granites, was falling into disrepute under the attack of the young vigorous magmatic school, he frequently referred to granites as derived from and grading into the sedimentary rocks of the district. In the present decade we see a reversion from the magmatists to the granitisation or migmatic school.

But he had also a certain hardy independence of thought; thus he ascribed the richly auriferous Mt. Morgan gossan to deposition on a pre-Desert-Sandstone landscape by a thermal spring; even after criticism he considered that the available evidence supported his interpretation that the sinter and ironstone were deposited on, and were not altered portions of, the pyritous quartzite country rock, although he remarked that Mt. Morgan was the only known instance of deposition of gold from geyser action.

He never traversed a route without recording its geological and topographical features; and the observations he made in going to and from the mineral fields were frequently made the subject of special reports. Whenever time was available he made journeys to little known areas to assess their geology and mineral prospects, and much of our knowledge of the district between Charters Towers and the coast, of the hinterland of Mackay, of North Queensland and of the Bunya Bunya Range was gained in this incidental manner. Some of these routes he traversed on Cobb and Co.'s coaches; but usually he travelled on horseback, when each member of his party took one horse to ride and one as a pack, carrying tents, provisions, etc.; and while he was stationed at Townsville his monthly returns included a statement of the condition of his six or eight horses.

He had a leaning towards exploration; and his method of extending his geological investigations into the lesser known and unknown country led to his exploring expeditions in the eastern half of Cape York Peninsula. While assessing coal prospects in the hinterland of Cooktown, he took the opportunity to proceed northward from the old Coen Goldfield with two white assistants and two blacks into the country at the head of what proved to be the Archer River, country that had never been mapped. He took obvious pleasure on this and on his subsequent trip in naming new topographic features after his friends, particularly after his colleagues in the Geological Survey of Scotland, Sir Archibald Geikie, B. N. Beach and J. Horne. Geikie gave his name to a range, as befitted his status as Murchison Professor of Geology at Edinburgh University and Director of the Geological Survey of Scotland. Peach, Horne and several others had rivers, creeks or peaks named after them. Jack noted metamorphic rocks and granites in the region, underneath the great ''Desert Sandstone'' dissected tableland forming the western fall from the Divide, and concluded the country was gold-bearing.

This report of gold prospects led to his second and main journey of exploration in Cape York Peninsula, which he made over the wet season, between November 1879 and April 1880. He was instructed to accompany a party of prospectors led by James Crosbie, a very able and experienced bushman, into Cape York Peninsula, and to indicate to them favourable areas for prospecting for alluvial gold. His own party included two assistants and one aborigine. One of his assistants had accompanied him on his previous trip, and the other was Jack's stepson, James Simpson Love, a lad of 16, who had newly arrived in the colony and insisted on making the trip, his strength of will overcoming Jack's misgivings.

Only two parties had previously attempted to traverse Cape York Peninsula from south to north. The Jardine brothers, in 1864-5, successfully drove 250 head of cattle and a number of horses up the Peninsula to Somerset at the tip; for the most part they kept on or to the west of the main divide, where the dissection of the capping of sandstone forming the western slope of the divide is least. To the east of the main divide the topography is much more irregular, with dissected areas of old rocks outcropping, easterly fronting scarps of Mesozoic sandstones and, in the more northerly region, a waste of sandy areas that has been called the wet desert, where the Mesozoic sandstones have been almost base-levelled. Kennedy in 1848 had attempted this eastern traverse; he had to leave the main body of his party near Cape Weymouth and travelled on with one aborigine, Jackey Jackey, as far as the mouth of the Escape River, where he was speared by blacks and died almost within sight of his objective. Jackey Jackey alone completed the trip; but the data so painfully collated by Kennedy were lost to Jack and all others who followed.

Jack and the prospecting party in 1879-80 had the same natural dangers to face as Kennedy—poison weed which killed the horses; hostile natives; festoons of mosquitoes and flies; heavy rain and heavy moist heat. The heavy rain ensured water and grass for the horses, and made the grass too green for the natives to apply their usual scorched earth policy, but it had its counterbalancing discomforts and dangers in flooded rivers and sodden ground. On more than one occasion a tree to which a hammock had been slung collapsed on the tent when one of the travellers got into it; while even Crosbie's knowledge and ingenuity was taxed at times in getting the two parties across the flooded rivers.

The chief danger was from the natives, who naturally resented the intrusion of the white man into their hunting areas and larders. Jack recognised this danger; nevertheless his attitude to them was always one of respect for their human rights. After his first expedition, he had made the sensible suggestion to the Minister that the party should be accompanied by an officer of native police with a few troopers, to protect the horses and take charge of the relationships between blacks and whites. This was shortsightedly refused; but Jack's subsequent experience led to later parties being so accompanied, and life and time were saved. Much to his regret his party had once to fire on the blacks to prevent an attack developing; and he himself later was speared through the neck near the shoulder during a surprise night attack on his camp. The wound was a painful one, and for some days he had to be lifted on and off his horse and have his head laid down for him when he went to rest and lifted when he wished to get up. But he completed his proposed journey by riding on to Somerset, the Jardines' place at the tip of the Peninsula, which he reached nearly four weeks later. The expedition discovered no payable auriferous field, but Jack made meticulous topographic and geological observations throughout. He charted his route in the field, day by day, on an outline map or "blank" of the coast line taken from the Admiralty charts as they stood in 1879. He checked his dead reckoning by star sights, and by bearings taken from view hills upon the coastal headlands of the charts.

Jack's written reports on the expedition were published almost immediately on his return; but the map which he drew showing his route and its topographic features was unaccountably omitted, although it was used by several departments, and its information was incorporated in the new 16-inch map. This initial failure to publish his map, in the end made Queensland geography greatly the richer. Jack had always disapproved of this omission, and about 1910 he decided to publish the map himself with an annotated reprint of his reports. He located a copy of a copy of his map, which itself could not be traced.

When he had completed his task of annotation, he concluded that in order to place his own exploratory work in its proper perspective he should publish also accounts of the work of earlier explorers. In order to make these as accurate as possible, he mastered the Dutch language so that he could read the Dutch accounts in originals, rather than in the possibly inaccurate translations. This is typical of his thoroughness and accuracy. Then he felt it would be well to complete the story, and outline the work of those who came after; and finally after twelve years of work, he published his book on Northmost Australia in two volumes. The work is a remarkable one; it sets out all the evidence of all the surveys, both land and sea. It covers not only the Peninsula, it takes in all Queensland north of about 22°S. Herein we find recorded the explorations of Leichhardt, Gregory, Daintree and Kennedy, of the naval men, the cattle men and the ubiquitous prospectors who left few or no written records behind. It is extremely well documented and its historical and geographical value will become greater and more obvious as time goes on. We are indeed a fortunate State to have such a careful and full account of the discovery and opening-up of our northern lands. Jack was a stickler for the etiquette of new place names; in other words for the application of the law of priority to place names; and he entered several vigorous protests against misuse, one being against the application of the name Jack to three different creeks and rivers all in the same area. He introduced a system of naming creeks "first," "second," "third" and "fourth" magnitude, so that some idea might be given of how far the point described was distant from the head of the watercourse. The suggestion, however, was not generally adopted.

Jack's exploratory work by no means ended with his Peninsula expedition. Wherever he went he filled in details in the maps, especially when based on Cloncurry in 1881 to study part of the district to be traversed by a proposed trans-continental railway.

His trip to Cloncurry from Townsville in 1881, undertaken in connection with this study, was destined to be responsible for his greatest service to Queensland—the development of the Great Artesian Basin as a source of water for the sheep that were to provide the bulk of Queensland's wealth at the beginning of the present century. Without the water, our wool cheque from the west would have been insignificant. Noting the geology in his usual careful way wherever he went, Jack realised that the Mesozoic strata crossed between Cloncurry and the western flanks of the granite divide which separates the Burdekin and the Flinders Rivers, were in the form of a great syncline with its axis crossing the Flinders near Marathon. "If this is correct," he says, in 1881, in his report to Major-General Fielding, who was in charge of the railway party, "we may expect to find the greater part of the drainage of the divide between the Flinders and the Burdekin, and of the McKinlay Ranges, lodged in the more porous beds of the series [the Mesozoic rocks] under conditions favourable for artesian water." His reports were presented to Parliament, and as a great drought affected the west during the early and middle 1880's, his remarks on possible artesian water created great interest. In 1885 he and J. B. Henderson, the hydraulic engineer, were sent to report on possible bore sites near Tambo, Blackall and Aramac. This was the beginning of the exploration of our great artesian supplies; the first successful bore was sunk at Barcaldine in 1886, and artesian water had arrived. Jack recognised the impervious nature of the marine Cretaceous cap, and that the chief porous strata were located near the base of the sequence; and he early recognised the importance of the intake areas along the divide to the east. His theory of artesian supply was correctly based on rain water supply; he gave no credence to the views that the water was plutonic or connate.

Jack's services to mining, to geography, and to the wool industry have thus been very great; but to the geologist his chief contributions have been the immense works of compilation he undertook and carried through. Just to read the titles of his works gives some indication of the labours involved. The first was, characteristically, a survey of the literature; it was undertaken in collaboration with that other tireless worker, Robert Etheridge, Junior, his erstwhile colleague in Edinburgh, and was entitled "A Catalogue of Works, Papers, Reports and Maps on the Geology, Palaeontology, Mineralogy, Mining and

Metallurgy etc. of the Australian Continent and Tasmania.'' It was published in 1881. Etheridge had earlier been an assistant on the Geological Survey of Victoria, and his liking for Jack and for Australian geology led him to agree to describe Jack's fossils for him. This marked the beginning of a collaboration that was to be of immense value to Queensland geology. The two men had a great appreciation of one another's qualities. They shared the habit of putting their best, almost their all, into their work. Both had the same passion for accuracy. But whereas Etheridge was usually content to state facts and draw only the very safest of deductions, Jack argued freely from his facts. As far as I can discover, Etheridge's palaeontological work for Queensland was honorary. In 1886 Jack produced ''A Handbook of Queensland Geology and a Map,'' which incorporated the changes he considered his work made necessary in Daintree's 1872 ''Notes on the Geology of Queensland with Map.'' This handbook was for the Colonial and Indian Exhibition in London, 1886, and was designed to make our mineral wealth known to the world. Interesting advances were noted in that the Gympie formation, previously regarded as Devonian, was now recognised to be younger and regarded as Carboniferous, while the Mesozoic facies of the Burrum coalfield was recognised, both of these changes being supported by Etheridge Junior; he introduced the Rolling Downs Formation, and discussed artesian water prospects.

Two years later, in 1888, he made another compilation, in a presidential address—he had been appointed president of the geological section for the first meeting of the Australasian Association for the Advancement of Science. There is an interesting letter from Jack to Etheridge, who was the secretary of the geological section. It runs, ''I am awfully glad it is you who are Secretary. I would as soon have been Secretary under your Presidentship, but perhaps I might not have got leave from my chief to attend in that case.'' He chose as his presidential address a review of the geology of Queensland; and advocated continuing to use local terms for formations—e.g. Burdekin Formation, until their relation to the English Devonian or Carboniferous, etc., could be proved. Once more considerable advance in knowledge and in interpretation was shown; and he regarded the Mt. Wyatt Beds as younger than the Silurian, in which they had been placed by Daintree and Etheridge, Senior, but older than Middle Devonian. The Lucky Valley Beds he, with Etheridge Junior, recognised as Permo-Carboniferous, and suggested with prophetic insight that the ''older Palaeozoics'' would have to be divided between Pre-Devonian and Permo-Carboniferous. ''Lithological resemblance,'' he said, ''is a broken reed.'' In this compilation also, he equated the Bowen beds to the Gympie formation. It seems, in retrospect, that in his general understanding of Queensland stratigraphy he was closer in this paper to what we now consider correct, than in his subsequent pronouncements. The chief error in this compilation now seems to have been his supposition that the Burrum coal beds underlay the Maryborough marine beds.

Another compilation for the same year was ''The Mineral Wealth of Queensland,'' in which he gave, for the Centennial Exhibition, Melbourne, and in illustration of his Index Map to the Mineral Wealth of Queensland, the then condition and value of the various mineral fields of Queensland, with an indication of localities where minerals awaited the attention of miner and capitalist.

At the meeting of the Australasian Association for the Advancement of Science in 1888, a committee had been appointed to complete a census of Australian minerals, and Jack became secretary of the Queensland sub-committee which produced a "Census of Queensland Minerals." This little-known work was published in 1890 in the second A.A.A.S. volume.

Ever since 1881, Jack and Etheridge had been in correspondence, and collaborating, to produce "The Geology and Palaeontology of Queensland," to which they added New Guinea. Etheridge was appointed to the New South Wales Survey and the Australian Museum in 1887, and visited Jack in Townsville in 1890. Most of his work of description had been done while he was still at the British Museum, a fact which is not generally realised. After this visit they completed their manuscript as far as possible; most of the plates had already been prepared in England, and in 1893 the great compilation was published. The amount of accurate fact packed into this work in two volumes with map is quite amazing, and it could only have been achieved by men with an extraordinary capacity for detail, allied with an equally remarkable capacity for compilation. The section of Jack's work which most calls for remark is the map; and, next, his treatment of Post-Tertiary time in Queensland, which remains almost without alteration to-day. But part of Jack's work (Jack being always the more venturesome) is marred by a serious error in deduction: because the Gympie and Lucky Valley fossils, with those from several other places in south-eastern Queensland, had been shown by Etheridge to be Permo-Carboniferous, Jack made the extraordinary error of deducing that all the "Older Palaeozoics" from Rockhampton southwards were "Gympie" or Permo-Carboniferous, quite failing to recognise that these fossiliferous Gympie Beds were downfaulted into and unconformable on Carboniferous, Devonian and older. Admittedly, lithology is a broken reed, but Jack neglected also the difference in degree of metamorphism in the rocks of his newly extended "Gympie." But so clearly did he differentiate between fact and inference, that his few wrong inferences hardly detract from the value of the book to-day. The map was a great advance on the earlier ones, with the exception of the unfortunate expansion of the "Gympie" Series; and a very interesting innovation was the mapping of volcanic foci—all of which are east of the main divide. The Royal Society of New South Wales recognised the great value of this book by the award of a Clarke Medal to each of the authors in 1895.

This was the high tide of Jack's geological compilations. During his remaining six years in Queensland he was concerned more and more with administration. But he prepared a "Catalogue of Exhibits" for the Mineral Court at the Queensland International Exhibition in 1897; and a new geological map of Queensland which he published in London in 1899, and which is a permanent record of the state of knowledge of Queensland geology when he left us. As his final crowning effort, however, we have his remarkable historical and geographical compilation, "Northmost Australia," mentioned above, which is packed with geological details.

Jack, being the first Government Geologist for the whole of Queensland, naturally became the head of the new Geological Survey when this was begun almost imperceptibly in 1883 by the appointment of

W. H. Rands as Assistant Geologist. Rands came straight from England. Jack continued in his office at Townsville, which at that time was a three-roomed house, while Rands was stationed at Maryborough. By 1887 there was such an increase in the demand for services and advice that Jack was asking for at least three more assistant geologists, a chemist and assayer, and two surveyors to prepare maps in advance of the geological parties. Coming as he did from the Geological Survey of Scotland, which had for its base maps fully contoured sheets prepared by the Ordnance Survey, Jack was painfully aware of the way in which geological work suffered from the absence of all but the most sketchy topographic detail on the early land maps of Queensland, and he continually urged the appointment of surveyors, to make his department as independent as possible. Also, much purely chemical and assaying work had to be done by men trained as geologists, and Jack's Scottish soul was continually fretted by this uneconomic waste; he was always pressing for the appointment of chemists and assayers to his staff—always, so far as I can gather, without success. A. Gibb Maitland was appointed an assistant geologist in 1888 and joined Jack at Townsville; and, by a minor arrangement, James Smith, of Rockhampton, was appointed collecter in 1889; but the latter died from the effects of exposure in 1891. In 1891 Jack was urging the advantages of locating all the officers of the Survey under one roof in the capital; and his plea was successful in 1892, when all were removed to Brisbane, to an office in Elizabeth Street. At the end of 1893 the office was removed to the old Treasury Building at the corner of George and Queen Streets. From 1892 to 1893 the Mineralogical Lecturer of the Charters Towers School of Mines was transferred to the Survey Staff for the preparation of a map of Charters Towers with contours and underground workings. Jack directed him to add to it buildings, mills, shafts, etc., stating characteristically that he had always held that landmarks were of more value than evanescent pegs and imaginary boundary lines—a view which has not yet received general acceptance by Queensland map making authorities, perhaps because of bush fires.

In 1894 he made an interesting recommendation, which was that one or two cadets should be attached to the staff, to give Queensland youths a chance to acquire a knowledge of economic and field geology; and in 1899 Mr. L. C. Green was appointed as a cadet. S. B. J. Skertchley had meanwhile been appointed an assistant geologist. In 1896 Jack's staff was reduced by the resignation of Gibb Maitland and Skertchley to take up other positions; but in 1897 W. E. Cameron, a Queensland man with a Cambridge education, and B. Dunstan, from Sydney Technical College, were appointed to the vacancies. Jack never saw his wish for a chemist or assayer fulfilled, but he did have a surveyor added to the staff in 1898, from the Defence Force; while in the same year two outside surveyors were used for special purposes. A lithographic draftsman was appointed in 1894, to prepare the now very numerous maps for official reports, whereby, says our Scot, a noteworthy economy of time and labour was effected.

Coming from Europe, where, in all but the most backward countries, sheet surveys were the long-term routine work of the Geological Surveys, Jack knew, as he said in 1892, "The highest function of a Geological Survey is to lay a basis for future scientific observations by accurately mapping the relations of the various formations met with in a given district. I cannot say that this ideal has been reached in Queensland. In every country, and especially in every new country, it becomes necessary in the first place to give attention to districts remarkable for the presence and prospect of mineral deposits.'' It was this latter type of work on which Jack was forced to concentrate. But he did his best to approach the sheet survey principle by observing geological details in travelling time, and by extending his observations wherever he could make the opportunity. No doubt his frequent requests for more staff were directed to this end. But they fell on deaf ears; and Queensland is still without even the beginnings of a sheet survey, although all her geologists desire it for its long-term wisdom. May the day soon come when we shall have our State systematically mapped, sheet by sheet, so that our resources will be known to the public and their development expedited!

For his untiring efforts to have all the geological information gathered during his regime published and accessible to the public, Queensland has special cause to be grateful to Jack. In Jack's early days his reports were made to the Minister for Mines and Works, presented to both Houses of Parliament by command, and published as Parliamentary Papers. The system had its irritations, and Jack, made impatient by the delays and inaccuracies in the printing of his reports, advised the Minister that ''If my work is worth paying for, my reports are worth printing promptly and printing correctly, and if not——.'' This, he remarks with moderate satisfaction, effected some improvement. He reminisces, in his ''Northmost Australia,'' about the ''slipshod old days when reports were pigeon-holed for years and laid upon the table at the caprice of a minister.'' Jack was a true democrat; he regarded his reports as reports to the people through their elected representatives, and he wrote for the information of everyman—a much more difficult type of report to write than one to a superior official.

But his chief vehicle to the common people was his Geological Survey Museum, which he fathered and tended carefully till it grew into an imposing building in Brisbane through which yearly more than 9,000 people passed to assimilate information about the State's mineral wealth. He was always a vigorous collector; and from all his trips he brought back specimens illustrating the geology, mineralogy, petrology and palaeontology of the route. These were in most cases very fine specimens. At first he housed them in his three-roomed office at Townsville, but they grew and grew, and finally he persuaded the Government to build a new home for them at Townsville, with a caretaker who should among other things prevent the gold specimens being stolen, although twice the museum was burgled. When the Survey moved to Elizabeth Street, Brisbane, the Museum took up two whole floors. Here the 1893 flood filled the ground floor; and although the specimens in the display cases were carried upstairs by the caretaker (Mr. Tom Sythers) and his wife, most of the palaeontological collection, which had not then been unpacked after the transfer from Townsville, was under water in the heavy cases for some days. This valuable collection included the types handled by Etheridge, and Jack immediately telegraphed to Rands and Maitland to return from the field to the more important task of salvaging it by decyphering the sodden labels. Towards the end of 1893 the Museum was moved to the old Treasury Building at the corner of George and Queen Streets, and

Jack himself spent the greater part of 1893-4 arranging the collections in it. He had copies of all the Survey's publications bound and placed on tables for the general reader, and all the maps mounted on the walls. The layout of the collection was designed to assist the common man to know the subject of geology, and to entice him to develop the mineral wealth of the State.

Throughout the whole of his 22 years in Queensland this many-sided man kept up a very large correspondence with miners, prospectors, station-owners and people interested in natural history—indeed, with all who wrote to him—answering even the most eccentric with the utmost courtesy; and the information he gleaned from their letters and from the specimens they sent him, he incorporated in his numerous maps. One cannot read his letter books without being struck by his generosity in making his knowledge, experience and time available to all who asked.

Jack was closely associated with the scientific and cultural life of the country. We have already spoken of his connection with the Australasian Association for the Advancement of Science and his recognition by the Royal Society of New South Wales.

He became a member of our own Royal Society of Queensland in 1891, just before his removal to Brisbane; he was elected Vice-President for 1893, and President for 1894. His Presidential Address delivered in January, 1895, was on "The Higher Utilitarianism" which was an explanation to the public of the value of the "purer" branches of geology to those with more immediate economic applications. He served on the Council in 1895 and 1896. He read six short papers to the Society in 1894 and 1895, on a varied set of subjects—palaeontology, Artesian Basin stratigraphy, aboriginal cave drawings and the meridional ant hills of Cape York Peninsula, all showing his sound common-sense observations and deductions.

He advised the Government on the foundation of the Charters Towers School of Mines in 1888; this was really a university to supply technical men for the development of the mining industry in Queensland. It is pleasing to a palaeontologist to note that he added as his own recommendations to those of the School of Mines committee that a lecturer in natural history and palaeontology should be appointed and a professor of metallurgy.

Jack's attitude to palaeontology was always that it was a necessary collaborator with field work in the science of geology; and he spared no pains to get good collections for Etheridge to describe, and to encourage naturalists to send in fossil specimens. He twice employed collectors. But it is almost to be regretted that he found such ready assistance from Etheridge since it meant that he took no steps to have a palaeontologist appointed to his own staff.

He was not above having a dig at palaeontologists, however, as the following quotation shows:—

> "The mistaken zeal of palaeontologists to settle horizons by fossil evidence has often led to great confusion, and to damage to the interests of both zoology and geology. I, therefore, state here, and without any prejudice whatever, that the stratigraphical evidence warrants the following order of

> succession, and no other, in the strata of the Lower Star Basin, whatever conclusions may be drawn from preconceived ideas regarding the range of the fossils—when these shall have been determined:—''

Jack was very successful at arranging specimens and maps for exhibition; so much so, that after the exhibit he prepared for the Queensland International Exhibition in 1897, he was made a Commissioner for Queensland at the Greater Britain Exhibition at Earl's Court in London in 1899; and at the end of 1898 he left Queensland with the specimens for display. While away in London he had the 1899 edition of his map published. His fame was now such that the University of Glasgow honoured him with an Honorary LL.D. in 1899, and he received an offer from an English company operating in the East to explore the metalliferous deposits of Szechuan. He resigned his position as Queensland Government Geologist to accept this offer.

He set off from Shanghai to Szechuan accompanied by his son Robert Lockhart Jack* who has since carried on the tradition of underground water geology in South Australia, and is now Chief Geologist for Broken Hill Proprietary. While they were in Szechuan the Boxer Rebellion broke out, and they had to make their way to Burma over 450 miles of uncharted country in the southern portion of the mountain region now so well known as ''the Hump.'' He made a route map of the journey, and described his journey from Shanghai to Rangoon in his book ''Backblocks of China,'' 1904. He also wrote an article for the Geographical Journal entitled ''From Shanghai to Bhamo'' published in 1902. He had been a member of the Royal Geographical Society since 1877. He arrived back in London in 1901, where for about two and a half years he carried on a consulting practice as a mining geologist. He was elected a member of the Institute of Mining and Metallurgy in 1901 and in 1903-4 was a member of the Council of the Geological Society of London which he had joined in 1870.

In 1904, he returned to Australia and carried on a practice in Western Australia as consulting engineer for five years. During this period he acted for the West Australian Government as Royal Commissioner on the Collie Coalfield and Chairman of a Royal Commission to report on the ventilation and sanitation of mines and the prevalence of lung diseases among miners.

In 1910, he was living in Sydney, and here, during the last years of his life he completed his historical work on Northmost Australia. He died in Sydney early in November, 1921, survived by his wife and son. Of Jack, one may indeed say he was a giant of the past, in his accomplishments as well as in his labours, while he covered so much country on horseback that one feels his horses must have worn seven-league shoes.

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* I am indebted to Dr. Lockhart Jack for details of his father's career, and to Mr. C. C. Morton (Acting Chief Government Geologist, Queensland) for access to certain of Jack's papers and maps.

THE GROUP ARRANGEMENT OF HAIR FOLLICLES IN THE MAMMALIAN SKIN.

PART I. NOTES ON FOLLICLE GROUP ARRANGEMENT IN THIRTEEN AUSTRALIAN MARSUPIALS.

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2 Tables, Plates III-IX.

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INTRODUCTION.

Among the main features which distinguish the mammals from all other classes of vertebrates are the nature of their skin and the production of a hairy coat. Because of this, but perhaps more by reason of convenience, pelage differences have been included among diagnostic features: they have even been made the major or sole basis for some specific or sub-specific distinctions. This only accentuates the need for a thorough biological study of the mammalian coat.

The growth of hair and the structure of hair fibres have been the subject of many studies. Karl Toldt junior and F. W. Dry have made outstanding contributions to the morphological description of fibres and their classification into types. The importance of cuticular scale patterns on hairs as diagnostic features has been emphasized by L. A. Hausman and others, who have studied this feature in a wide range of mammals. Patterns of hair direction on the skin have been described by F. Wood Jones and many others who advanced theories of their cause and significance. The genetic study of the pelage has not been neglected, and the work of F. B. Sumner with his associates on coat colour in *Peromyscus*, and of Dry on fibre type inheritance in sheep may be quoted as examples. There have even been a few physiological studies of the mammalian coat; for example, observations of the effects of temperature, light or hormones on the growth of hair.

The literature on the mammalian coat is thus considerable. As knowledge of the producing organ is an essential part of the background for experimental work with hair, it seems remarkable that so few people have made any detailed study of the microscopic structure of the skin which produces these hair fibres in their many varieties. Among those features which merit study are the micro-anatomical relations of hair follicles, their associated skin glands and muscles. Such information is necessary for distinguishing follicle types, which may differ not only in structure but also in function. This knowledge, which has been much neglected, is nevertheless of great importance both to the systematist and the experimental biologist.

De Meijere (1894) seems to be the only worker who has attempted a survey of the arrangement of hair follicles in the mammalian skin. His main aim was to examine the relation between the arrangement of reptilian scales and mammalian hairs, but his observations are of value for many other purposes. De Meijere collected much of the relevant literature on hair follicle arrangement by earlier writers (e.g. Leydig 1859, Harms 1868, Chodakowsky 1871, Weber 1886), and described systematically every species that was available to him in the Leiden Museum, the Amsterdam Zoological Society and smaller collections—221 species in all. In nearly every species examined the hair follicles, at least on some parts of the body, were arranged in groups of regular constitution, and within a group certain follicles were distinguished from the rest by such features as greater size, associated sudoriferous glands, or larger sebaceous glands. De Meijere was thus able to distinguish the "Mittelhaare" from "Gruppenhaare" and "Bundelhaare," and introduced other terms to denote special follicle types.

Only a few workers since de Meijere have followed his suggestive lines of investigation with certain species. Several (Spöttel and Tänzer 1923, Duerden and Ritchie 1924, Wildman 1932, Terentjeva 1939, Carter 1943) have studied sheep skin histologically, and found that the group arrangement and the distinction between two types of hair follicles were fruitful in interpreting some fleece characters such as fibre population density and fibre diameter variation. Other mammals in which the group structure has been noted are the platypus and echidna (Spencer and Sweet 1899), the armadillo (Cooper 1930), dog (Claushen 1933), cat (Höfer 1914) and pig (Höfliger 1931). Reference to hair follicle grouping in the marsupials is very rare, but studies have been made on *Notoryctes typhlops* (Sweet 1907), and *Trichosurus vulpecula* (Gibbs 1938, Bolliger and Hardy 1944).

The scarcity of published observations on the hair follicle arrangement in marsupial skin suggests that it is worth recording some preliminary findings on a limited amount of material. These observations on the adult skin are presented without detailed consideration of ontogentic or phylogenetic relationships, or of the relation between follicle types in the skin and fibre types in the pelage.

MATERIAL AND METHODS.

The skin snippings used in this study were accumulated during several years from a number of sources, chiefly museums, as material was made available. The skin was sampled where possible at several points, these being selected to indicate regional variations. The sampling positions were defined as follows:

Mid-back. On the dorsal mid-line of the trunk, half-way between the fore limbs and hind limbs.

Mid-belly. On the ventral mid-line of the trunk, half-way between the fore limbs and hind limbs.

Mid-side. A point on either the right or left side of the trunk, half-way between the mid-back and mid-belly positions.

Mid-dorsal cranial. A point on the mid-dorsal line on the head in the region of the parietal bones.

Mid-dorsal mid-caudal. A point on the mid-dorsal line on the tail half-way between the butt and the tip.

Radial. A point on the lateral surface of the fore limb over the radius and half-way along its shaft.

Tibial. A point on the lateral surface of the hind limb over the tibia and half-way along its shaft.

The details of the specimens and regions examined are set out in Table 1. In some cases the small size of the specimens limited the number of body regions which could be sampled; in some cases sampling was only permitted from certain regions of museum specimens; while in others unsatisfactory preservation or sectioning prevented the achievement of good serial sections from all regions. However, all areas from which an adequate picture of group arrangement could be obtained are recorded in the table.

The animals used in this study were either adults or else young animals which, although not fully grown, had well developed hair follicle groups differing only from those of the adult in the presence of a few immature hair follicles.

TABLE I.

LIST OF SPECIMENS AND BODY REGIONS EXAMINED HISTOLOGICALLY.

Species.	Animal No.	Source.	Sex.	Age.	Body Region. Mid-back.	Mid-side.	Mid-belly.	Mid-dorsal Cranial.	Mid-dorsal Mid-caudal.	Radial.	Tibial.
Antechinus flavipes . .	1	Australian Museum (M5960)	♂	Adult	+						
	2	Macleay Museum (MC8) . .	♂	Adult		+		+	+		
Dasyurops maculatus . .	1	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
	2	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
Sarcophilus harrisi . .	1	Australian Institute of Anatomy	♂	Adult	+			+	+		
Thylacinus cynocephalus . .	1	Australian Institute of Anatomy	♂	Adult					+	+	+
Notoryctes typhlops . .	1	Macleay Museum (MC21) . .	♂	Juvenile	+	+	+				
Isoodon torosus	1	Australian Museum (M6311)	♂	Juvenile	+						
Perameles nasuta	1	Veterinary Science School, Sydney	♀	Adult	+	+					
	2	Physiology Department, University of Queensland	♂	Adult	+	+	+	+	+ (Mid-ventral)		
	3	Australian Institute of Anatomy	. .	Adult	+						
Tarsipes spenserae . .	1	Australian Museum (M4514)	. .	Adult	+						
Acrobates pygmaeus . .	1	Australian Museum (M4241)	. .	Juvenile	+						

Pseudocheirus laniginosus	1	Australian Institute of Anatomy	♂	Adult	+	+		+		+	+
Trichosurus vulpecula ..	1	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
	2	Sydney Medical School (No 400)	♂	Adult	+		+				
	3	Sydney Medical School (No. 300)	♀	Adult	+						
	4	Sydney Medical School (No. 403)	♂	Adult			+				
	5	Sydney Medical School (No. 218)	♂	Adult			+				
Phascolarctos cinereus ..	1	Australian Institute of Anatomy	♂	Adult			+				
	2	Australian Institute of Anatomy	..	Adult						+	+
Macropus major	1	Australian Institute of Anatomy	♂	Adult				+			
	2	Gilruth Plains, Queensland	♀	Adult	+	+	+	+	+	+	+

TABLE 1.

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Species.	Animal No.	Source.	Sex.	Age.	Body Region.						
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	2	Macleay Museum (MC8) ..	♂	Adult		+		+	+		
Dasyurops maculatus ..	1	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
	2	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
Sarcophilus harrisi ..	1	Australian Institute of Anatomy	♂	Adult	+			+	+		
Thylacinus cynocephalus ..	1	Australian Institute of Anatomy	♂	Adult					+	+	+
Notoryctes typhlops ..	1	Macleay Museum (MC21) ..	♂	Juvenile	+	+	+				
Isoodon torosus	1	Australian Museum (M6311)	♂	Juvenile	+						
Perameles nasuta	1	Veterinary Science School, Sydney	♀	Adult	+	+					
	2	Physiology Department, University of Queensland	♂	Adult	+	+	+	+	+ (Mid-ventral)		
	3	Australian Institute of Anatomy	..	Adult	+						
Tarsipes spenserae ..	1	Australian Museum (M4514)	..	Adult	+						
Acrobates pygmaeus ..	1	Australian Museum (M4241)	..	Juvenile	+						
Pseudocheirus laniginosus	1	Australian Institute of Anatomy	♂	Adult	+	+		+		+	+
Trichosurus vulpecula ..	1	Australian Institute of Anatomy	♂	Adult	+	+	+	+	+	+	+
	2	Sydney Medical School (No 400)	♂	Adult	+		+				
	3	Sydney Medical School (No. 300)	♀	Adult	+						
	4	Sydney Medical School (No. 403)	♂	Adult			+				
	5	Sydney Medical School (No. 218)	♂	Adult			+				
Phascolarctos cinereus ..	1	Australian Institute of Anatomy	♂	Adult			+				
	2	Australian Institute of Anatomy	..	Adult						+	+
Macropus major	1	Australian Institute of Anatomy	♂	Adult				+			
	2	Gilruth Plains, Queensland	♀	Adult	+	+	+	+	+	+	+

Most of the skin samples were taken with a sharpened circular cork-borer, but some were square samples dissected off with a scalpel. The technique used for the preparation of paraffin skin sections was that described by Carter (1939). This followed general lines except for the introduction of two modifications. Before fixing in formalin, the square skin samples were impaled by pins attached to metal blocks to prevent shrinkage. At the time of embedding, the skin was flattened against a piece of glass to prevent curling. Sections were cut in series parallel to the skin surface, and stained with haematoxylin, eosin and picric acid.

The material available is obviously incomplete, and is in some cases not in the most satisfactory state of preservation for histological examination. Nevertheless, a detailed examination of animals such as the sheep (*Ovis aries*) and the possum (*Trichosurus vulpecula*) have suggested that even a single skin sample may provide a general picture of the pattern of fibre grouping over a large area of skin, and that regional and individual variations within species are concerned mainly with follicle density, group size, fibre thickness and other quantitative features. Thus there is some justification for the publication of a description based on a single skin section in the absence of any other published information on the subject.

HISTOLOGICAL DESCRIPTION.

In this section, group arrangement in the skin of each species will be described from the available material. The number of specimens and body regions examined is set out in Table I. Any marked deviation from the characteristic arrangement on a particular body region is noted. Finally, reference is made to any relevant literature on the species. The specific and popular names are from Iredale and Troughton (1934). In a few cases where a specimen had been mutilated, it was not possible to check the classification of specimens as indicated by museum labels and registers, but any errors in diagnosis are probably only between related species. Special attention is paid to the structure and arrangement of sudoriferous glands, and the distinction drawn by Schiefferdecker (1917) between apocrine and eccrine glands is used.

The smooth muscle fibres found in the dermis have been classified throughout this paper as "arrectores pilorum." This designation may be criticized on the grounds that the arrector pili muscle was originally described as having its origin in the superficial part of the dermis and being inserted on the outer root sheath of a single hair follicle. In some marsupials this is undoubtedly the case, but in other species, while the origin of the fibres is as described, the place of insertion is not definitely known, being probably either the root sheath of a central follicle or the connective tissue sheath surrounding a follicle group. This, however, does not interfere with the function of the muscles in raising hairs, either singly or in a group, and it is considered that the term "arrectores pilorum" may well be applied to this group of muscles.

Suborder POLYPROTODONTIA. Family DASYURIDAE.

1. ANTECHINUS FLAVIPES Waterhouse 1838.

(Yellow-footed Marsupial Mouse)

Pl. III, Figs. 1, 2.

General Description. The hair follicles are arranged in groups of irregular constitution. The most complete groups have the following components:

(*a*) A single central follicle standing alone, with a sebaceous gland and a sudoriferous gland opening into it. At skin level the central hair fibre is frequently but not always appreciably larger than other fibres.

(*b*) Two or more lateral clusters of follicles, each with one, two or three follicles. One sebaceous gland is associated with each lateral cluster, which has a shallow common follicle mouth. There are no sudoriferous glands with the lateral clusters.

(*c*) Traces of smooth muscle fibres scattered between the follicle groups, and probably representing small arrector pili muscles. Their mode of attachment to groups or follicles is not clear.

(*d*) The sudoriferous glands, found only in association with central follicles. They are very small, and the secretory portion consists of a saccular terminal expansion lined with cells of apocrine type.

This arrangement is, however, not always present. A central follicle, although otherwise typical, may have no sudoriferous gland attached to it. On the other hand, a central follicle may be replaced by a central cluster of two or three follicles, unaccompanied by a sudoriferous gland and generally similar to the lateral clusters.

To illustrate the relative frequency of the different kinds of groups, a series of follicle density counts was made on measured areas of skin from the mid-back of Specimen 1. Here, the average of several counts indicated that a typical area of 0.25 sq. mm. might have the following:

51 fibres arranged in
8 groups of which
3 groups have a single central follicle with an associated sudoriferous gland,
2 groups have a single central follicle but no sudoriferous gland,
3 groups have no single central follicle but a cluster of follicles, and no sudoriferous gland.

The eight groups might have the following numbers of clusters, counting the central follicle, where present, as a cluster:

1 group has 2 clusters of follicles,
4 groups have 3 clusters,
2 groups have 4 clusters,
1 group has 5 clusters.

Regional Variation. The above pattern was seen on all body regions examined. Grouping of follicles was most clear and uniform on the tail, where a large central and two smaller lateral follicles had a few still smaller follicles between them.

Notes on Literature. De Meijere (1894) described group arrangement on the back and tail of *A. flavipes.* The general arrangement described by de Meijere was confirmed by the present study, but his follicle groups were more regular in constitution and he found a greater distinction in thickness at skin level between central and lateral cluster fibres.

De Meijere did not remark on the presence of sudoriferous glands in this species.

Suborder POLYPROTODONTIA. Family DASYURIDAE.

2. Dasyurops maculatus Kerr 1792.

(Tiger Cat: Large Spotted-tailed Native Cat)

Pl. III, Figs. 3-5; Pl. VII, Fig. 22.

General Description. On all areas examined, hairs are arranged in groups of fairly regular form.

(*a*) There is one central follicle, generally standing alone, and with a sebaceous gland and a sudoriferous gland opening into it. At skin level the central fibre is generally larger than the lateral cluster fibres, and the follicle wall, particularly the connective tissue sheath, is larger than those of lateral follicles.

(*b*) There are several lateral follicle clusters (two to six, most frequently four), each having a variable number of follicles (average four) which open by a common follicle on to the skin surface. At least one sebaceous gland is associated with each lateral cluster, but there are no sudoriferous glands.

(*c*) Arrector pili muscles are conspicuous, but their arrangement is rather complex. They appear to be attached to the central follicle of each group.

(*d*) The sudoriferous gland duct, as with most animals, lies in the "obtuse dermal area," i.e., near the obtuse angle formed by the sloping central follicle and the skin surface. It is thus on the same side of the central follicle as the arrector pili muscle. But the deeper part of the duct moves around one side of the central follicle to the "acute dermal area" where the secretory part of the gland is situated. The muscle layer of the gland wall is thin by comparison with the high columnar epithelium which shows stages in apocrine secretion.

Regional Variation. The arrangement described above was found to exist on all the skin areas examined from both specimens. In one specimen, skin from the mid-dorsal cranial position contained numerous medullated fibres, with pigment granules in both cortex and medulla.

The mid-dorsal mid-caudal region of both specimens was characterized by larger fibres, fewer lateral cluster follicles and larger arrector pili muscles.

Notes on Literature. This species has not been described, but de Meijere (1894) reported generally similar groups in *Dasyurus quoll.*

Suborder POLYPROTODONTIA. Family DASYURIDAE.

3. SARCOPHILUS HARRISI Boitard 1841.

(Tasmanian Devil)

Pl. IV, Figs. 6-8.

General Description. The hairs on all areas examined are arranged in small but fairly well defined groups.

(*a*) There is a single central follicle standing alone, with a sebaceous gland and frequently a sudoriferous gland opening into it. At skin level the central fibre is frequently thicker than the lateral cluster fibres.

(*b*) The central follicle is surrounded by several lateral follicle clusters (most frequently two), each with several follicles (one to three, most frequently two) which open by a common follicle to the skin surface. One or more sebaceous glands is associated with each lateral cluster, but no sudoriferous glands are present.

(*c*) Arrector pili muscles are conspicuous, and their arrangement appears complex. A muscle is probably attached to the central follicle of each group.

(*d*) The sudoriferous glands are of the apocrine type, and the appearance of the secretory cells is similar to that found in *Dasyurops maculatus.*

Regional Variation. The mid-dorsal mid-caudal region showed rows of groups each consisting of three thick fibres. The central fibre of each trio was thicker than the two lateral fibres. A small sebaceous gland opened into each follicle, but no sudoriferous glands were seen. Large quantities of smooth muscle tissue were present in the dermis. Elsewhere the grouping conformed with the general description above.

Suborder POLYPROTODONTIA. Family DASYURIDAE.

4. THYLACINUS CYNOCEPHALUS Harris 1808.

(Tasmanian Wolf or Tiger)

Pl. IV, Fig. 9.

General Description. Hairs on all areas examined are arranged in groups which vary in size and in the number of follicles present. Two or three groups are frequently situated in a row close to one another. The following is the general arrangement of a typical group.

(*a*) There is one central follicle standing alone, with a sebaceous gland and a sudoriferous gland opening into it. At skin level the central fibre is generally thicker than the lateral cluster fibres, and the follicle wall is frequently also thicker in central follicles. A second (new) fibre growing from the central follicle has been observed in several groups.

(*b*) There are one to six lateral clusters of follicles, each with one to four follicles which open by a common follicle mouth to the skin surface. At least one sebaceous gland is associated with each lateral cluster, but no sudoriferous glands are present.

(*c*) Arrector pili muscles are conspicuous and are associated with each group. It seems probable that all follicles with sweat glands (i.e. central follicles) and a few other large follicles without sweat glands (i.e. large lateral follicles) have their own arrector pili muscles or a branch of one.

(*d*) The sudoriferous glands are apocrine in form, and are arranged in loose coils in the obtuse dermal area. The high columnar epithelium is similar to that of *Dasyurops maculatus* and *Sarcophilus harrisi*.

Regional Variation. There was considerable variation in the appearance of the groups in the three regions examined. The number of lateral cluster follicles in a group was less on the radial area than on the tibial area. On the tail the arrangement was quite different from that on the other two areas. Here the characteristic group arrangement was replaced by aggregations of about six to twelve follicles of rather uniform size; all of these had large sebaceous glands and one third to half of them had sudoriferous glands.

Suborder POLYPROTODONTIA. Family NOTORYCTIDAE.

5. Notoryctes typhlops Stirling 1889.

(Marsupial Mole)

Pl. IV, Figs. 10, 11; Pl. VII, Fig. 23.

General Description. Hairs on all areas examined are arranged in groups of regular form.

(*a*) One central cluster of follicles contains a very large follicle with a stout fibre and a number of smaller follicles (average 17) closely packed together beside the large (central) follicle. The follicles open near the surface by a common follicle mouth, into which opens the duct of a sudoriferous gland. There is at least one sebaceous gland accompanying each central cluster.

(*b*) There are on the average two lateral clusters of follicles, each consisting of a number of small follicles (average 17) of which one is generally conspicuously larger than the rest, although not as large as the central follicle. At least one sebaceous gland accompanies each lateral cluster, but there are no sudoriferous glands. The follicles of a lateral cluster open by a common follicle mouth to the skin surface.

(*c*) Strands of arrector pili muscle are seen, and it appears that there is at least one such muscle to each follicle group.

(*d*) The sudoriferous glands are apocrine in form. The terminal portion is a small expanded slightly coiled sac with a tall secretory epithelium.

Notes on Literature. Sweet (1907) gave a good general description of the arrangement of hairs in groups and clusters on the general body surface of *N. typhlops*. Her observations on the grouping of large and small hairs and the presence of arrector muscles are confirmed in the present study, but the specialized areas which she described have not yet been examined. It appears that sebaceous and sudoriferous glands were not distinguished by Sweet, who regarded the long narrow (sweat gland) ducts as ducts of the sebaceous glands. This interpretation is found also in the description of the skin and hairs of Monotremes by Spencer and Sweet (1899).

Suborder POLYPROTODONTIA. Family PERAMELIDAE.

6. Isoodon torosus Ramsay 1877.

(Giant Brindled Bandicoot)

Pl. V, Fig. 12.

General Description (from juvenile specimen only). Hairs on back are arranged in groups of the following constitution:

(*a*) One large central follicle has a bilobed sebaceous gland opening into it. Generally a small sudoriferous gland duct can be made out opening into the central follicle. (In most central follicles in this specimen a new and second large hair fibre is associated with the original large central fibre. The follicle papilla is quite separate, and is more deeply implanted than that of the original fibre, but the root sheaths of the two fibres are connected over most of their length and the two fibres have a common follicle opening at the surface. It seems probable that this specimen is in the process of shedding one coat of thick fibres and replacing it by a second.)

(*b*) A variable number of lateral follicles is situated on either side of the central follicle (average 18 per central follicle). Among these follicles two or three may have a common follicle opening but the clearly defined common follicles of certain Marsupials are not present. Many lateral follicles have small sebaceous glands opening into them, but there are no associated sudoriferous glands. (In this specimen a number of lateral follicles are still at an early undifferentiated stage, and have not yet produced fibres. Probably these would be functional by the time the animal reached maturity.) The fibres of the lateral follicles are finer than those of central follicles.

(*c*) Fragments of smooth muscle in the dermis suggest that arrector pili muscles are present, although their mode of attachment to follicles is not clear.

(*d*) The sudoriferous glands are very rudimentary, and each consists of a short narrow duct with a very small sac-like terminal expansion. The structure of the glandular wall is apocrine as far as it can be made out in these sections; but it is doubtful whether these glands are functional.

Notes on Literature. De Meijere (1894) described the general arrangement on the back and tail of *Isoodon obesulus.* He remarked that the thickest hairs were arranged in rows, and that the finer hairs were much more numerous on the back than on the tail. De Meijere found sebaceous glands accompanying the tail hairs, but no sudoriferous glands, so that sudoriferous glands in the genus *Isoodon* are here recorded for the first time.

Suborder POLYPROTODONTIA. Family PERAMELIDAE.

7. Perameles nasuta Geoffroy 1804.

(Long-nosed Bandicoot)

Pl. V, Figs. 13, 14.

General Description. Hairs are generally arranged in groups of the following constitution:

(*a*) The single central follicle contains a large fibre and has a sebaceous gland and a sudoriferous gland opening into it. This follicle opens separately on to the skin surface.

(*b*) Several lateral follicle clusters (average four) surround the central follicle. Each cluster has a common follicle opening near the skin surface and is provided with a sebaceous gland. The fibres are distinctly smaller than those in the central follicles.

(*c*) Strands of smooth muscle indicate that arrector pili muscles are present, but their mode of attachment is not clear.

(*d*) The sudoriferous glands, which are apocrine, are less rudimentary than those of the *Isoodon torosus* specimen, and there is a slight degree of terminal expansion and coiling. Unfortunately this comparison is only between the juvenile *I. torosus* and adult specimens of *P. nasuta.*

Regional and Individual Variation. The most marked variation in the appearance of skin sections was due to differences in the development and apparent activity of the sudoriferous glands in the three animals. Specimen 1 had very small glands which may not have been functional. Specimen 3 had somewhat larger sudoriferous glands which were more probably functional. Specimen 2 (Fig. 14), however, had well developed apocrine glands whose long slender terminal portion appeared to be actively secreting. Moreover these glands in the last specimen were associated not only with the central follicle of each group but generally also with two large lateral follicles. These lateral follicle sudoriferous glands were generally present in at least four of the five skin areas examined. The fifth, mid-side region, was not in sufficiently good condition to determine this point.

The greater activity of sudoriferous glands in Specimen 2 might be explained by its warmer habitat (it was captured in Queensland) or by its subjection to very high temperatures in the course of experiments before the skin sections were taken. It is, however, more difficult to explain the development of three sudoriferous glands to each group, unless this is a feature of the northern variety of *P. nasuta*.

The general arrangement of follicle groups was otherwise the same on all regions examined except the mid-ventral mid-caudal region. Here the follicle clusters were absent, and all the follicles were arranged in groups of three. Each follicle resembled the central follicles of other areas in having a large sebaceous gland and a sudoriferous gland attached. The sudoriferous glands were large and active, as on other parts of this animal (Specimen 2), and secreted material was seen in the lumen. The hair fibres were very large, and follicles showed that shedding and replacement were taking place.

Notes on Literature. De Meijere (1894) described the group arrangement on the back of *Perameles gunnii* which was similar to that described here for *P. nasuta*. On the tail of *P. gunnii* the hairs were arranged in groups of five or six, of which three were frequently larger than the others. There was no mention of sudoriferous glands on either the back or the tail.

Suborder DIPROTODONTIA. Family PHALANGERIDAE.

8. Tarsipes spenserae Gray 1842.

(Honey Possum)

Pl. V, Figs. 15, 16.

General Description. Hairs are arranged in groups, each group containing (generally) three clusters of fibres. In most groups the following arrangement is present:

(*a*) One central follicle stands alone, with a sebaceous gland and a sudoriferous gland opening into it. At skin level the central fibre and the central follicle sheaths are generally thicker than those of the lateral cluster follicles.

(*b*) There are two lateral clusters of follicles each having about two to four follicles which open by a common follicle mouth to the skin surface. A sebaceous gland is associated with each lateral cluster, but no sudoriferous glands.

(*c*) Arrector pili muscles are distinguished only as fragments of smooth muscle in the dermis near each follicle group.

(*d*) The sudoriferous glands are apocrine in form. The narrow duct opens sharply into a small expanded secretory portion which is not coiled or only slightly coiled. The appearance of the glands suggests that they are active.

The arrangement is not invariably present. In some groups the central follicle is replaced by a central cluster similar to the lateral clusters of follicles, and having a sebaceous gland associated with it. Whether a sudoriferous gland is associated with such central clusters is not clear from the present material.

Notes on Literature. De Meijere (1894) described only the arrangements of hairs in groups of three on the tail of *T. spenserae*.

Suborder DIPROTODONTIA. Family PHALANGERIDAE.

9. Acrobates pygmaeus Shaw 1793.

(Pigmy Glider)

Pl. V, Fig. 17.

General Description (from juvenile specimen only). The hair follicles are arranged in clusters of from one to four fibres which are generally arranged in parallel rows. Three clusters are sometimes grouped together, but this group arrangement is not the general rule, as it is in other species. There are two types of arrangement present.

(*a*) Here and there a single follicle opens separately to the skin surface, and has a sebaceous gland and a sudoriferous gland opening into it. The fibres in such follicles are not conspicuously larger than those of other clusters at skin level.

(*b*) The majority of clusters have 2, 3 or 4 follicles (most commonly 3) lying close together throughout their whole length and opening to the skin surface by a common follicle mouth. Each cluster is accompanied by a sebaceous gland but no sudoriferous gland. Each type (*a*) follicle is flanked on either side by a type (*b*) cluster making a complete group of 3 clusters. The rest of the type (*b*) clusters are, however, scattered about without obvious arrangement.

(*c*) The arrector pili muscles are represented by scattered vertical strands of smooth muscle fibres, whose attachment is not known.

(*d*) The sudoriferous glands in the juvenile specimen examined have the appearance of apocrine glands but are very undeveloped. The secretory portion is short and not coiled, and its diameter is only slightly greater than that of the duct.

Notes on Literature. De Meijere (1894) described the arrangement of hairs on the back of *A. pygmaeus* as being in "numerous isolated bundles of 3, 4 or 5." He indicated the presence of a few hairs standing singly which were similar to the cluster hairs, but did not mention the existence of sudoriferous glands opening into them. De Meijere also noted the arrangement of hairs on the tail in groups of three.

Suborder DIPROTODONTIA. Family PHALANGERIDAE.

10. Pseudocheirus laniginosus Gould 1858.

(South-eastern or Common Ring-tail Possum)

Pl. VI, Fig. 18; Pl. VIII, Fig. 24.

General Description. In this specimen the hair follicles are arranged in clusters and only some of the clusters are arranged in groups of three. There are two types of follicles.

(*a*) Some large follicles stand alone, each having a separate opening to the skin surface and having a sebaceous and a sudoriferous gland opening into it. At skin level the hair fibres in these follicles are conspicuously larger than those in the follicle clusters.

(*b*) Most of the follicles are arranged in clusters of three, four or five, lying close together and having a sebaceous gland but no sudoriferous gland associated with each cluster. One such cluster lies on either side of each type (*a*) follicle, and the others lie scattered in the skin without obvious arrangement. Each cluster has a common follicle mouth at the skin surface.

(*c*) The arrector pili muscles are represented by fragments of smooth muscle scattered in the dermis, but their attachment is not known.

(*d*) The apocrine sudoriferous glands associated with the single follicles are small, and the expanded terminal sac is not coiled.

Suborder DIPROTODONTIA. Family PHALANGERIDAE.

11. Trichosurus vulpecula Kerr 1792.

(Common Brush-tailed Possum)

Pl. VI, Fig. 19.

General Description. Hairs on all areas examined are arranged in groups.

(*a*) The central follicle contains a large fibre and has a sebaceous gland and a sudoriferous gland opening into it. This follicle generally opens separately on to the skin surface, but occasionally one or two finer hair follicles unite with it near the surface.

(*b*) Several lateral follicle clusters (generally two to four) are beside the central follicle. Each cluster has a common follicle opening near the skin surface, and is provided with a sebaceous gland. The hair fibres are finer than those in the central follicles. No sudoriferous glands are associated with the lateral clusters.

(*c*) There are a few traces of smooth muscle fibres in the dermis, but their attachment to follicles or connective tissue sheaths has not been seen.

(*d*) The sudoriferous glands are well developed coiled glands of apocrine type, showing various signs of activity.

Regional Variation. The arrangement described above was found on all the regions examined, but there were variations in the hair fibre diameter, number of follicles per cluster, number of clusters per group, and so on.

Notes on Literature. The arrangement of hairs in groups and bundles on the back and tail of *T. vulpecula* was mentioned by de Meijere (1894), who did not, however, refer to the associated skin glands. Gibbs (1938) described the arrangement of hair follicles in pouch young only. The general descriptions of de Meijere and Gibbs have been confirmed in the present study, and further details have been added. A fuller histological description of the skin and of the special features of the sternal area was given by Bolliger and Hardy (1944).

Suborder DIPROTODONTIA. Family PHASCOLARCTIDAE.

12. Phascolarctos cinereus Goldfuss 1817.

(Koala)

Pl. VI, Fig. 20; Pl. VIII, Fig. 25.

General Description. On the areas examined, the hairs are arranged in groups.

(*a*) One central follicle is generally standing alone, with both a large multilobular sebaceous gland and a sudoriferous gland opening into it. At skin level the central fibre is generally thicker than the lateral cluster fibres. Occasionally a distinct central follicle of this type appears to be absent from a group.

(*b*) There are two to eight lateral clusters each consisting of a number of hair follicles with a common opening on the skin surface. One or two sebaceous gland lobes are associated with each lateral cluster, but there are no sudoriferous glands.

(*c*) No arrector pili muscles have been seen in the material examined.

(*d*) The apocrine sudoriferous glands have a rather small secretory portion which is only slightly coiled.

Regional Variation. While the number of lateral follicle clusters on the mid-belly region was two or three per group, the radial and tibial regions showed as many as seven or eight clusters in each group. Groups on the mid-belly were separated by particularly wide bands of connective tissue.

Notes on Literature. Hausman (1920) figured a typical fur hair from *P. cinereus,* but no literature on skin structure has been found.

Suborder DIPROTODONTIA. Family MACROPODIDAE.

13. Macropus major Shaw 1800.

(Grey Kangaroo)

Pl. VI, Fig. 21; Pl. IX, Fig. 26.

General Description. The hairs are arranged in groups of the following constitution:

(*a*) There is one central follicle standing alone, with a sebaceous gland and a sudoriferous gland opening into it. The fibre is frequently but not always thicker at skin level than the fibres of the lateral follicles surrounding it.

(*b*) The small number of lateral follicles (average two to five) generally stand alone. In the most superficial parts of the skin, two or more lateral follicles sometimes have a common opening, but the typical follicle cluster openings are not present. Each lateral follicle has generally a sebaceous gland but no sudoriferous gland.

(*c*) Strands of smooth muscle fibres are seen beside most follicle groups. These probably represent arrector pili muscles which are attached to the connective tissue around a follicle group rather than to any individual follicle.

(*d*) The sudoriferous glands are apocrine, and have a small but distinct, slightly coiled secretory portion.

Regional Variation. There was no appreciable variation from the arrangement described above on the body regions examined. Differences between regions included differences in follicle density, group size and fibre diameter.

Notes on Literature. Megaleia rufa and *Wallabia rufogrisea* were described by de Meijere (1894). He found the fibres arranged in groups of a kind similar to those described above for *M. major.* Duerden (1939) figured the arrangement of hairs in groups in a "wallaby," similar to those described above, but did not indicate the presence of any skin glands. Semichon (1926) examined the skin on the ventral surface of the tail of *Megaleia rufa,* finding the hair follicles arranged in groups. He noted the associated sebaceous glands but did not mention the presence of sudoriferous glands.

DISCUSSION.

This histological study of the marsupial skin has added confirmatory evidence to de Meijere's statement that, in mammals, there is a universal and regular grouping of hair follicles. The present observations permit a more precise definition of this grouping for the Marsupialia.

Before making generalizations about the follicle group in marsupials, it will be necessary to recapitulate the evidence for the existence of two distinct types of follicles. The structure of the group is built up around the distinction between "central" follicles and "lateral" follicles. Table II sets out the main features of the central follicles as found in each species examined.

From this table it will be seen that eight of the thirteen species had a single hair follicle to each group. In five species the central follicle was not always present, although a number of groups had a central follicle between lateral clusters. In one of these species (*Phascolarctos cinereus*) the absence of a well-defined central follicle was of unusual occurrence.

Nine species had central follicles which stood alone in the dermis and were not associated with any smaller lateral follicles in a common follicle mouth. In three other cases some lateral follicles occasionally shared a common follicle mouth with a central follicle but were clearly distinguished from the latter in deeper parts of the dermis by size and lack of accessory structures. Only in the case of *Notoryctes typhlops* was the central follicle of a group regularly associated in a common follicle mouth with a cluster of lateral follicles.

The central follicles of nine species were distinguished by having obviously thicker fibres at skin section level than the lateral follicles. Three other species had some central follicles with thicker fibres. It was not possible to detect a difference in fibre thickness in *Acrobates pygmaeus* by general observation, although actual measurement may still show a difference in mean thickness.

TABLE II.

The Properties of "Central" Hair Follicles in Different Species.

Species.	Central Follicle Present with Each Group.	Central Follicle Opening Separately to Skin Surface.	Central Follicle Relatively Large.	Sudoriferous Gland Opening into Central Follicle.	Sebaceous Gland Opening into Central Follicle.	Arrector Pili Muscle Present.	Arrector Pili Muscles Attached to Central Follicle.
Antechinus flavipes	+/−	+	+/−	+/−	+	+	+
Dasyurops maculatus	+	+/−	+	+	+	+	+
Sarcophilus harrisi	+	+	+	+/−	+	+	+
Thylacinus cynocephalus ..	+	+	+	+	+	+	(probably) +
Notoryctes typhlops	+	−	+	+	+	+	(also to some lateral follicles) ?
Isoodon torosus	+	+	+	+/−	+	+	?
Perameles nasuta	+	+	+	+	+	+	?
Tarsipes spenserae	+/−	+	+	+	+	+	?
Acrobates pygmaeus	+/−	+	−	+	+	+	?
Pseudocheirus laniginosus ..	+/−	+	+	+	+	+	?
Trichosurus vulpecula	+	+/−	+/−	+	+	+	?
Phascolarctos cinereus	+/−	+/−	+	+	+	−	−
Macropus major	+	+	+/−	+	+	+	?

All the sudoriferous glands found in these skin samples opened into hair follicles. They were all of apocrine type on the body regions studied, although eccrine glands have been observed on the foot-pads of one or two species. These glands were found in all the species examined, in every case opening into hair follicles, and with one exception associated only with the central follicles. (In one of the specimens of *Perameles nasuta* some of the lateral follicles as well as all the central follicles had sudoriferous glands.) In ten species every central follicle had an associated sudoriferous gland. In the remaining three species many but not all of the central follicles had a sudoriferous gland. It should be remembered, however, that two of the species (*Antechinus flavipes* and *Isoodon torosus*) had such small glands that some might easily escape notice in an imperfect skin section.

A sebaceous gland was associated with every central follicle in all species. While the presence of sebaceous glands did not distinguish central from lateral follicles, the glands opening into central follicles were often distinguished by their greater size and by having two lobes. Furthermore, while a sebaceous gland accompanied each central follicle, many lateral follicles had only one gland to each cluster.

Twelve species had strips of smooth muscle tissue in the dermis representing arrector pili muscles. The mode of attachment of these muscles was generally not clear, but in at least three cases attachment was to the central follicle of the group. In *Thylacinus cynocephalus*, however, parts of the muscle were attached also to some of the largest lateral follicles. It is probable that in many of the smaller fine-haired animals the muscle is attached to the connective tissue surrounding a group of follicles rather than to the central follicle alone. The use of this muscle in the distinction between follicle types is therefore more limited than in some placental mammals.

It is considered on the evidence presented above that there is justification for distinguishing two categories of follicles—central and lateral —in each species. While the distinction between the two types did not depend on exactly the same combination of characters in each species, it was nevertheless well marked in most cases. The separate follicle openings, greater fibre thickness, and presence of sudoriferous glands were the most useful diagnostic features.

Among the lateral clusters of follicles, it was most usual for each cluster to have a common follicle opening on to the skin surface. This was the case in eleven of the species examined, and common follicle openings were sometimes present in a twelfth (*Macropus major*). The exception was *Isoodon torosus,* in which each follicle had its own opening. The diagnostic features of lateral follicles included fineness of fibre and absence of sudoriferous glands.

Returning now to the question of group constitution, it was noted that there were groups with both central and lateral follicle types in all species, but five of these species had some follicle aggregations without central follicles. In the case of *Acrobates pygmaeus* and *Pseudocheirus laniginosus* the extra follicle aggregations were merely single clusters of "lateral" follicles scattered in the dermis, which may or may not have been originally associated with one of the typical groups. The position was rather different in *Antechinus flavipes, Tarsipes spenserae* and *Phascolarctos cinereus,* where some otherwise typical groups had a central follicle cluster with fine fibres in place of a single central follicle. In this connection it is worth noting that on the tail of *Antechinus flavipes,* a region which according to de Meijere often shows a more primitive follicle arrangement, there was a well defined central follicle in each group.

The illustrations show that the orientation of lateral follicles about the central follicle in a group and the position of the sudoriferous glands and sebaceous glands relative to central and lateral follicles show many variations. It must be emphasized that in this respect there are variations at different depths in the skin and even between adjacent groups at the same skin level. Such differences between the single follicle groups here depicted do not therefore necessarily represent differential characteristics of species or even body regions.

Differences between body regions in a single specimen have not been emphasized in this study, but there is abundant evidence that the group pattern of a species is repeated over most of the body. The differences that do exist are mainly concerned with the follicle population density, number of clusters in a group, number of fibres in a cluster, fibre thickness and size of skin glands. Among the regions examined, the tail was the only one showing a difference in group pattern from the rest of the body. Skin from the tail was examined in only six species, but in four of these the groups were differently constituted, and showed generally a simpler arrangement than on other skin areas.

There is insufficient material to discuss the intraspecific variation for any animal in this study. The most that can be said is that where more than one specimen has been examined, the intraspecific differences were of the same nature as the regional differences. Only in the case of *Perameles nasuta* was a difference in group constitution found between two specimens.

Family and generic characteristics cannot yet be discussed for similar reasons. No clear distinction could be drawn between the Polyprotodontia and Diprotodontia. The two members of the Peramelidae (*Isoodon torosus* and *Perameles nasuta*) were very similar both in general arrangement and in the nature of the sudoriferous glands. Follicle groups were not very well developed in two small representatives of the Phalangeridae, *Tarsipes spenserae* and *Acrobates pygmaeus,* but they resembled in this respect also the unrelated *Antechinus flavipes,* a small member of the Dasyuridae.

The above observations enable a provisional description of a "typical" hair follicle group arrangement in the skin of the adult marsupial.

A typical marsupial follicle group consists of a central hair follicle with one to four lateral clusters on either side of it. Each central follicle is provided with an apocrine sudoriferous gland and a sebaceus gland, and opens separately to the skin surface. The central fibre is thick in comparison with the lateral fibres. Each lateral cluster has separate follicle papillae but a common follicle opening to the skin surface. There is at least one sebaceous gland to each lateral cluster, but no sudoriferous glands. Each group has an arrector pili muscle attached either to the central follicle or to the connective tissue sheath surrounding the whole follicle group.

The variations from the typical arrangement have already been discussed and this description is intended merely for comparison of the marsupials as a whole with other groups of mammals.

It will be noted that the terms "central follicle" and "lateral follicle" have been used in these descriptions in preference to any of the many terms used in the literature. The reason is not a desire to add to the confusion that already exists in terminology, but rather to reserve judgment on the equation of follicle types until a greater range of mammals has been studied. In a general way the "Mittelhaare" of de Meijere (1894) correspond to the central follicles; but this author distinguished the Mittelhaare by position and, sometimes, size without always referring to the associated glands and muscles. Similarly the lateral clusters with a common follicle opening and those without such common opening correspond roughly to "Bundelhaare" and "Gruppenhaare" respectively.

The central follicles described here may also be compared with the earliest developing "primary" follicles as defined for sheep by Wildman and Carter (1939), and lateral follicles may be compared with "secondary" follicles. In the absence of definite evidence about the order of development of central and lateral follicles, it is not possible to define them as primary and secondary follicles respectively. Furthermore the accessory structures invariably associated with primary follicles in the sheep (bilobed sebaceous glands, sudoriferous glands and arrector pili muscles) are characteristic of but not universally present with the marsupial central follicles, so that the latter term is retained here for the present. It will also be noted that while the sheep and a number of other placental mammals have groups with three "primary" follicles, most marsupials have only one follicle in each group, which is distinguished by size or accessory structures. Occasionally, as in *Thylacinus cynocephalus* and *Notoryctes typhlops,* there is one lateral fibre on each side of the central follicle which is intermediate in thickness between the central fibre and the rest of the lateral fibres. In one case (*T. cynocephalus*), an arrector pili muscle was sometimes seen with a large lateral follicle, but there were no sudoriferous glands. These large lateral follicles represent an intermediate type between central and lateral cluster follicles, and may be related to the lateral primary follicles in those placental mammals possessing trio groups.

The present limited study has made very clear the need for examining the development of follicle groups in the pouch young of marsupials in order to interpret the adult structure. The existence of intermediate follicle types emphasizes this point, for a complete classification will need to be supported by embryology. Developmental stages in hair follicle group formation in a few species have been examined and will be described elsewhere. For the present it is sufficient to state that there is some embryological evidence for regarding the central follicles in marsupials and the central primary follicles in sheep and other placental mammals as homologous.

Another important relationship to be studied is that between follicle types in the skin and hair types in the pelage. Nearly all the animals examined have at least two hair types—the long, thick, straight "guard hairs" and the shorter, fine, wavy "fur hairs." These types are more obvious by reason of length and thickness differences in the bandicoots, and less obvious in animals like the koala. It is evident that the large central fibre of most marsupial groups is a "guard hair" and that the fine fibres of lateral clusters represent "fur hairs," but the relation between intermediate follicle types and intermediate hair types is less easy to determine. It is interesting to note that *Acrobates pygmaeus,* the only species not showing any difference in fibre thickness between central and lateral fibres at skin level, was also the species in which two hair types above the skin were most difficult to detect. Here the "guard hairs," though longer and straighter than the "fur hairs," were only slightly thicker over a small portion of their length. The relation of hair types to follicle types merits closer study and it would be preferable to use the technique of microdissection to establish the facts conclusively.

SUMMARY.

A study was made of the skin of thirteen adult marsupial species representing the families Dasyuridae, Notoryctidae, Peramelidae, Phalangeridae, Phascolarctidae and Macropodidae. Skin samples from one to seven points on the body were cut in series parallel to the skin surface in order to study the arrangement of hair follicle groups.

The main features of follicle group arrangement in each species were described. Evidence was given for the presence of two distinct categories of follicles, called here the central and lateral follicles. A description was given of a "typical" marsupial hair follicle group, and variations from this type were discussed. On the available material, differences between body regions on a single specimen were generally quantitative differences not affecting the characteristic group pattern of the species. Sometimes the tail showed special features.

Typically, the hair follicle group in the marsupial consisted of one large central follicle with a sudoriferous gland attached and flanked by from two to eight lateral clusters of smaller follicles. Each lateral cluster had a common follicle opening at the skin surface, and had no sudoriferous glands. There was an arrector pili muscle associated with each group and attached either to the central follicle or to the connective tissue sheath surrounding the follicle group.

The interpretation of follicle types and variations in follicle group composition will depend on embryological studies. For this reason the terms "central" and "lateral" follicles were not identified with any of the follicle types proposed by other workers. No attempt was made in this study to establish relationship between follicle types in the skin and fibre types in the pelage; but some evidence was produced for associating the thick "guard" hairs with the central follicles, and the "underfur" fibres with the lateral clusters of follicles.

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EXPLANATION OF PLATES.

(Key to shading of Plates III-VI shown on Plate III.)

Plate III.

Fig. 1.—*Antechinus flavipes.* Mid-back at sebaceous gland level. Two groups, one with a distinct central follicle and one without. SN1399 × 300.

Fig. 2.—*Antechinus flavipes.* Mid-back at superficial skin level showing common follicle openings. Two groups, one with a distinct central follicle and one without. SN 1399 × 300.

Fig. 3.—*Dasyurops maculatus.* A group on the mid-back region at a deep level in the skin. SN1508 × 141.

Fig. 4.—*Dasyurops maculatus.* A group on the mid-back region at sebaceous gland level. See also Pl. VII, fig. 22. SN1508 × 141.

Fig. 5.—*Dasyurops maculatus.* A group on the mid-back at a superficial skin level showing the common openings of lateral follicle groups and the enlarged sudoriferous gland opening. SN1508 × 141.

Plate IV.

(All figures × 141.)

Fig. 6.—*Sarcophilus harrisi.* A group at a deep skin level on the cranium. SN1506.

Fig. 7.—*Sarcophilus harrisi.* A group at an intermediate skin level on the cranium. SN1506.

Fig. 8.—*Sarcophilus harrisi.* A group at a superficial skin level on the cranium. SN1506.

Fig. 9.—*Thylacinus cynocephalus.* A single group. Note the well developed arrector pili muscles and the two relatively thick lateral hair fibres. SN1480.

Fig. 10.—*Notoryctes typhlops.* A typical group at sebaceous gland level. See also Pl. VII, Fig. 23. SN1806.

Fig. 11.—*Notoryctes typhlops.* A group at a superficial skin level showing the common follicle openings. Note especially the common opening of the central follicle with a cluster of ''lateral'' follicles, and the sudoriferous gland opening. SN1806.

Plate V.

(All figures × 141.)

Fig. 12.—*Isoodon torosus.* A group on the mid-back region. Note the two central fibres, of which the uppermost is a new fibre replacing the lower one. The cross-hatched areas represent developing follicles that have not yet produced fibres in this juvenile specimen. SN1395A.

Fig. 13.—*Perameles nasuta.* A group on the mid-back region with one sudoriferous gland. SN1377.

Fig. 14.—*Perameles nasuta.* A group from the cranium of the Queensland specimen, showing the presence of three sudoriferous glands. SN2166.

Fig. 15.—*Tarsipes spenserae.* A group on the mid-back having a large central follicle with a sudoriferous gland attached. SN1397.

Fig. 16.—*Tarsipes spenserae.* A group on the mid-back having no distinct central follicle and no sudoriferous gland. SN1397.

Fig. 17.—*Acrobates pygmaeus.* A skin area on the mid-back, showing on the right one typical group with a central follicle and two lateral clusters. Elsewhere the clusters are scattered irregularly. SN1396.

Plate VI.

(All figures × 141.)

Fig. 18.—*Pseudocheirus laniginosus.* An area on the mid-back showing two typical groups in the upper centre and lower right, and a number of clusters scattered irregularly. See also Plate VIII, fig. 24. SN1497.

Fig. 19.—*Trichosurus vulpecula.* A group on the mid-back region. SN1652.

Fig. 20.—*Phascolarctos cinereus.* A group on the mid-belly. See also Pl. VIII, fig. 25. SN1553.

Fig. 21.—*Macropus major.* A group on the mid-back. Compare with the two other groups illustrated in Pl. IX, fig. 26. SN1582.

Plate VII.

Fig. 22.—Tangential skin section from *Dasyurops maculatus*, mid-back region, showing one follicle group. Note the large central follicle with sebaceous and sudoriferous glands. This group is sketched in Fig. 4. Skin specimen No. 1508. × 176.

Fig. 23.—Skin section from *Notoryctes typhlops*, mid-back region, showing one follicle group. The smaller fibres have been cut obliquely. Compare Fig. 10. Skin specimen No. 1806. × 235.

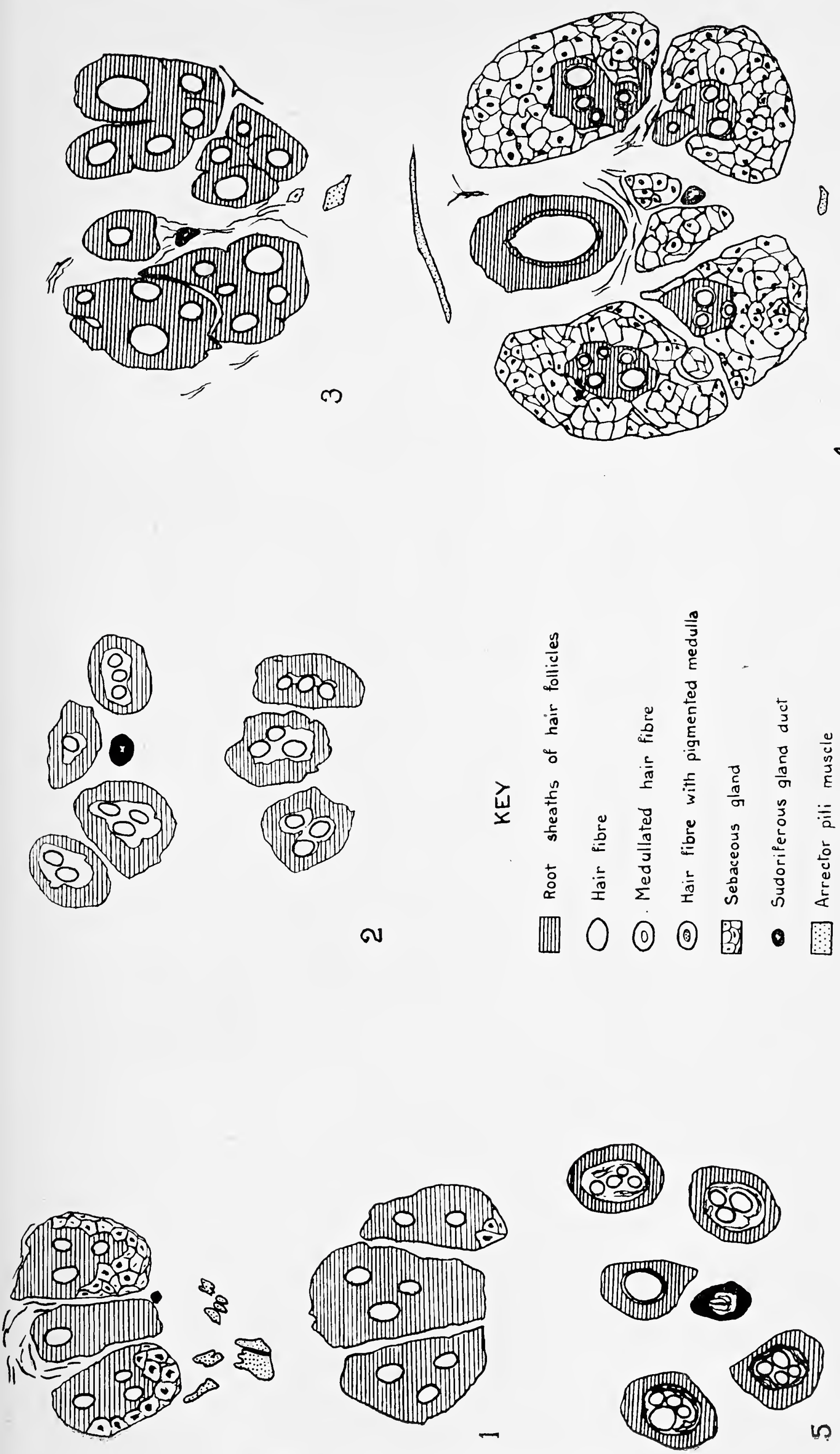
Plate VIII.

Fig. 24.—Skin section from *Pseudocheirus laniginosus*, mid-back region, showing two ''groups'' and a number of clusters scattered in the skin without obvious grouping. Compare Fig. 18. Skin specimen No. 1497. × 176.

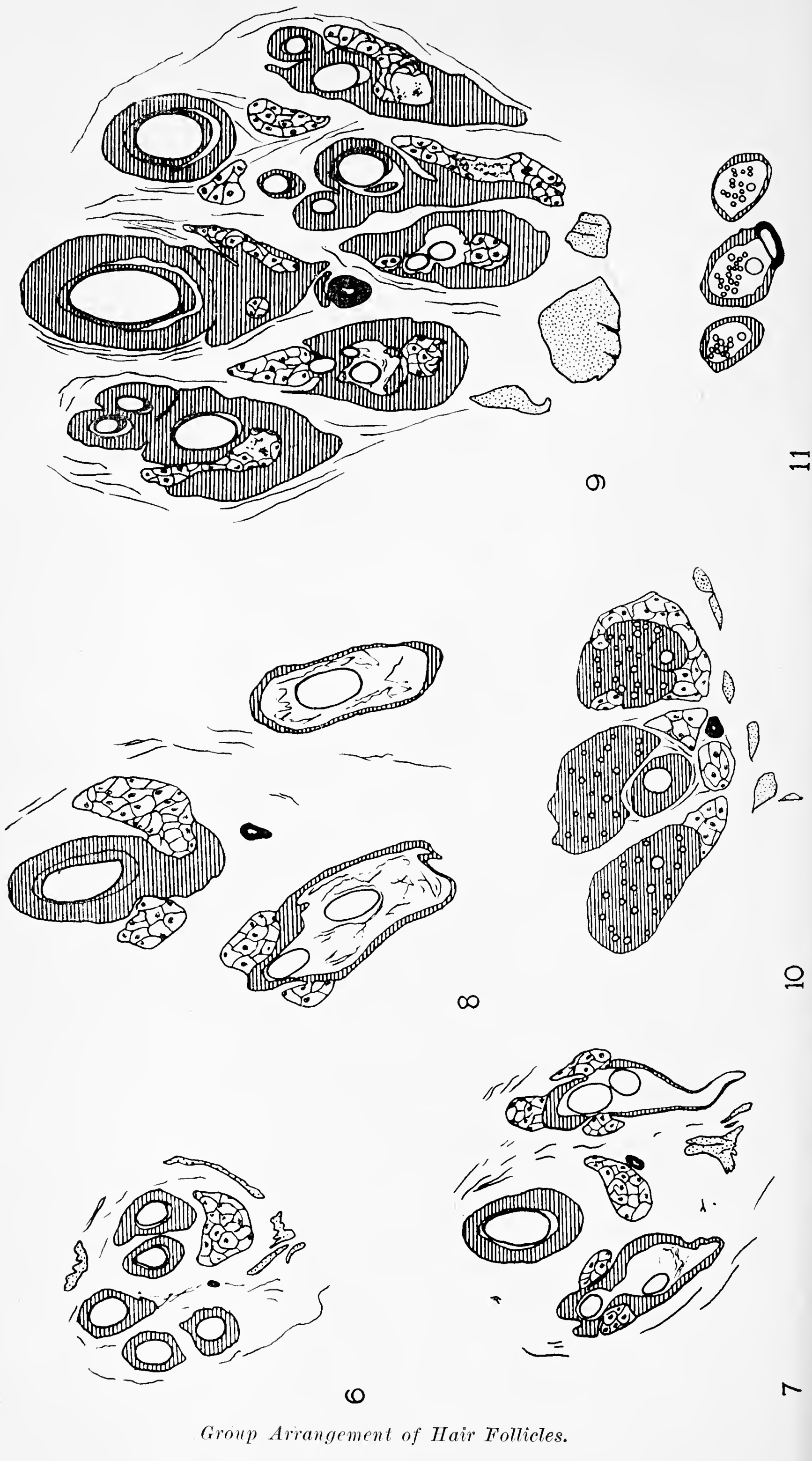
Fig. 25.—Skin section from *Phascolarctos cinereus*, mid-belly region, showing one follicle group. Compare Fig. 20. Skin specimen No. 1553. × 176.

Plate IX.

Fig. 26.—Skin of *Macropus major*, mid-back region, showing two follicle groups. Note the central follicles with their sudoriferous glands, and the pigmented cortex of most hair fibres. Another group is sketched in Fig. 21. Skin specimen No. 1582. × 176.



Group Arrangement of Hair Follicles.



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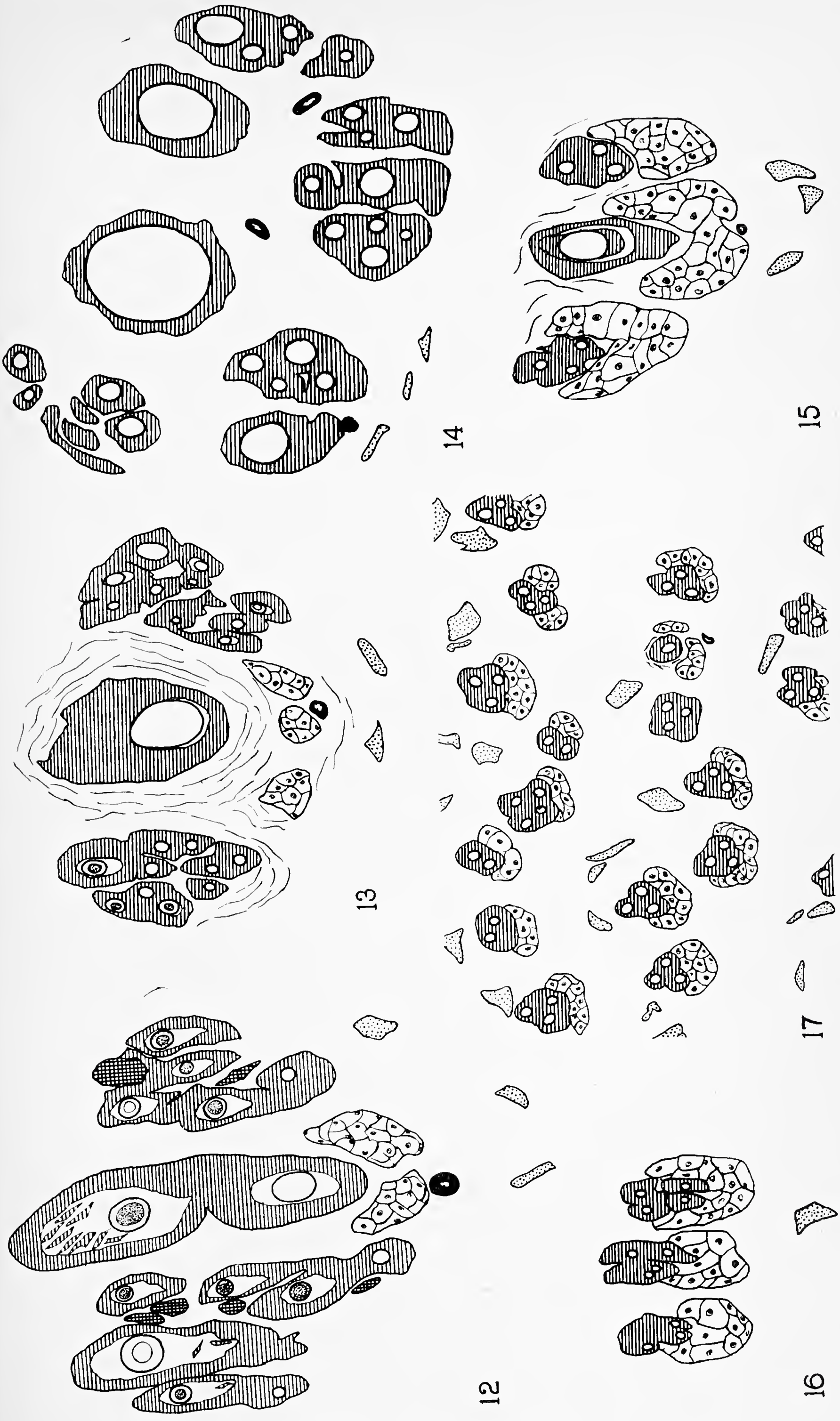

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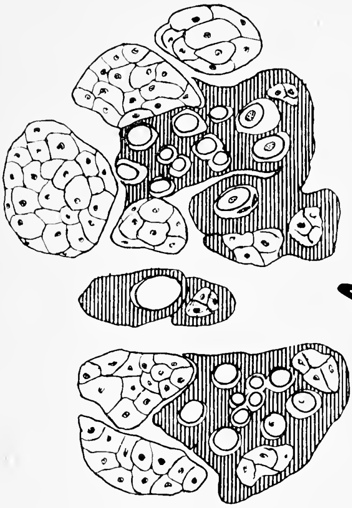

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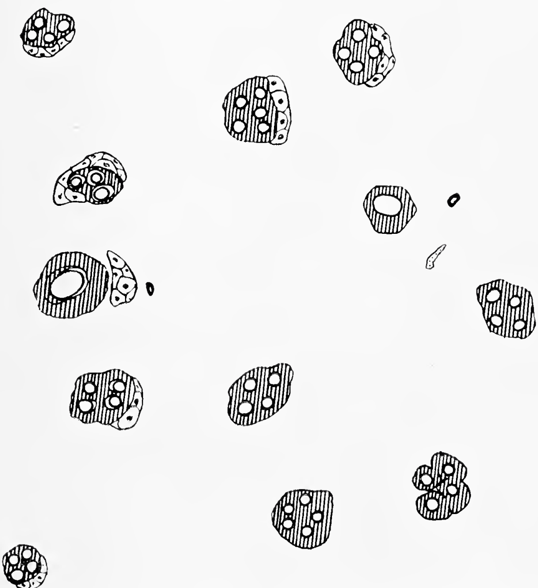

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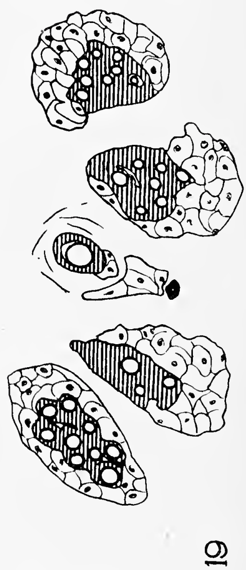

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Group Arrangement of Hair Follicles.

Fig. 22.

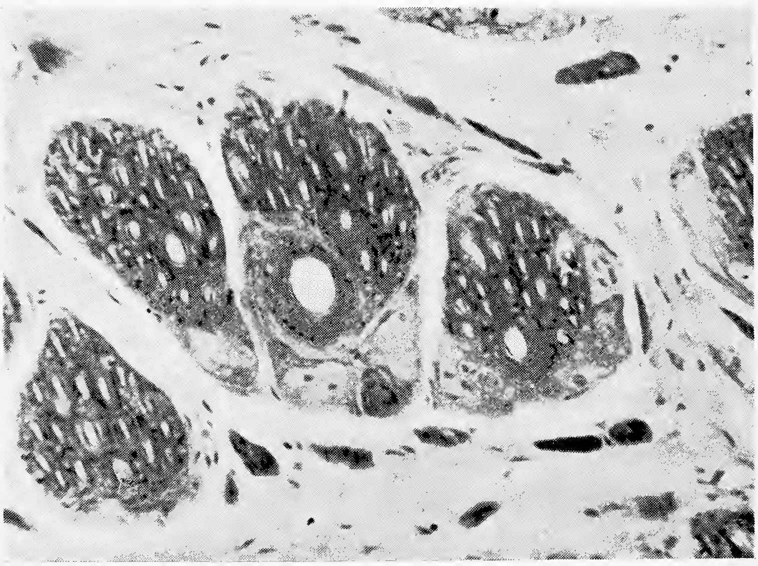

Fig. 23.

Group Arrangement of Hair Follicles.

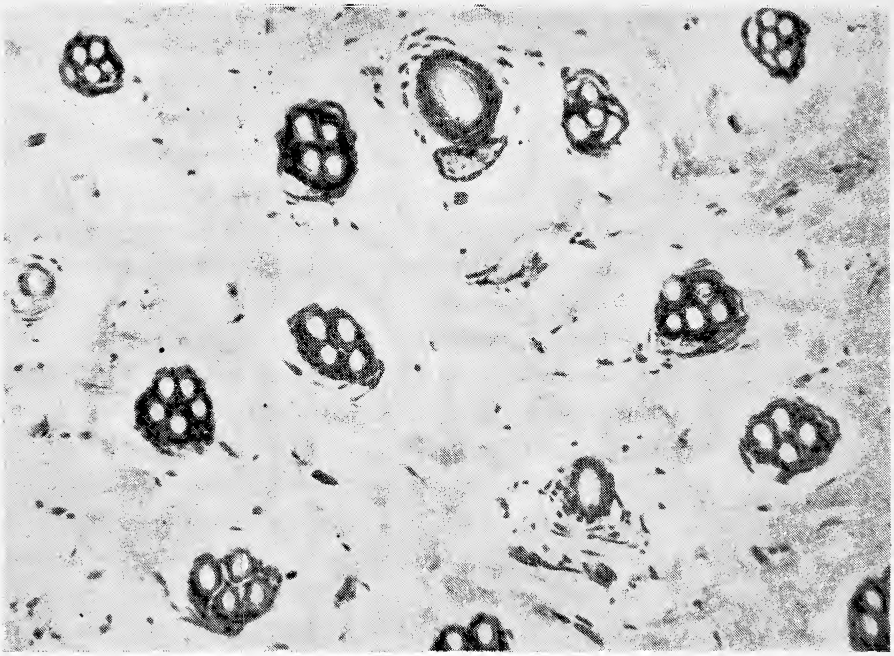

Fig. 24.

Fig. 25.

Group Arrangement of Hair Follicles.

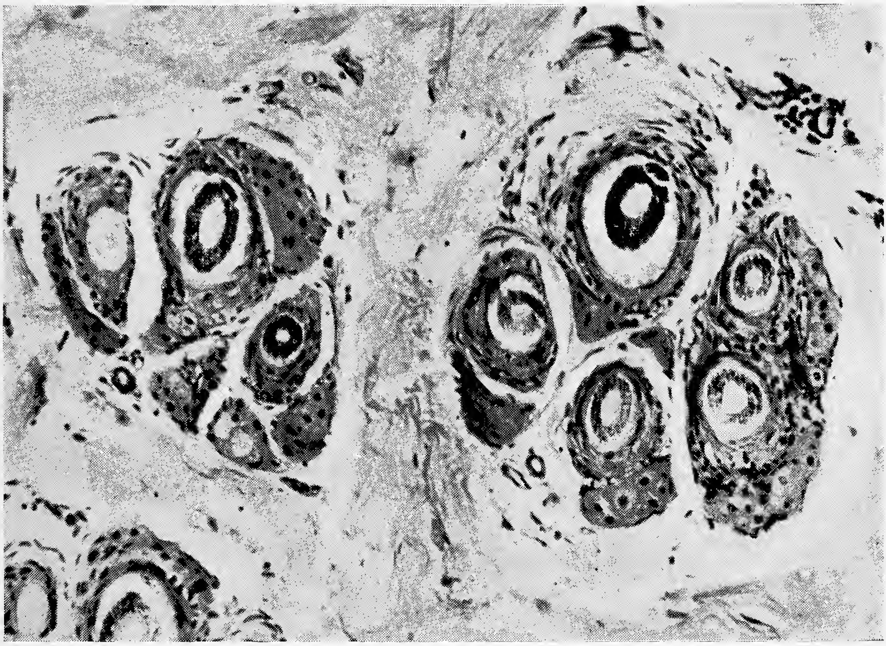

Fig. 26.

Group Arrangement of Hair Follicles.

PSEUDOMICROCOTYLE, A NEW MONOGENETIC TREMATODE.

By Dorothea F. Sandars, M.Sc., Assistant Lecturer in Zoology, The University of Queensland.

(With Plate X.)

(*Received 18th November,* 1946; *accepted for publication 25th November,* 1946; *issued separately 27th October,* 1947.)

INTRODUCTION.

In April 1946 an unusually large shoal of *Elagatis bipinnulatus* (Stead), commonly called the Runner, was caught just off the Queensland coast, near Moreton Bay. This fish, which is apparently common in American waters, is not abundant around the coast of Australia. One of these fish was obtained intact as a museum specimen for the Biology Department of the University of Queensland. The author thus had the opportunity only to examine, in an inadequate manner, the gills of this one fish for ectoparasitic Trematodes. Four Monogenetic forms (Microcotylidae) were obtained and of these one specimen was too badly damaged to be of value, while another was partly damaged.

From a study of the literature obtainable, these Microcotylids appear to belong to a new genus which has been named *Pseudomicrocotyle*. The following description has been based on only three of the specimens obtained. The lengths given on each occasion are averages, the corresponding length in the type specimen being given in brackets.

The specimens were fixed in Kleinenberg's Picric Acid, stained with Acetic Acid Alum Carmine, and mounted in Canada Balsam. The type specimen is lodged in the Queensland Museum.

Appreciation is expressed for the encouragement by Professor Goddard and the co-operation of the Staff of the Brisbane Fish Markets. The work was done under a grant from the Council for Scientific and Industrial Research.

Pseudomicrocotyle elagatis n.g.; n.sp.

Pseudomicrocotyle elagatis (fig. 1) has a typical Microcotylid appearance, the body tapering both anteriorly and posteriorly. The total body length is 3.75 mm. (3.45) and the maximum body width is 0.49 mm. (0.50) across approximately the middle of the whole body length. The body width across the oral suckers is 0.13 mm. (0.14); across the genital atrium 0.19 mm. (0.18). The cotylophore is 1.08 mm. (1.05) long and so occupies approximately two-sevenths of the total body length; the anterior margin is 0.48 mm. (0.48) wide.

The cotylophore is not sharply demarcated from the rest of the body and bears from 38 to 65 pairs (48) of stalked suckers, each with a characteristic skeletal support. The suckers vary in size from the anterior to the posterior of the cotylophore, being largest in the middle. The anterior suckers have a length from 0.024 mm. and width from 0.032 mm. The largest suckers have a maximum length of 0.084 mm. (0.092) and a maximum width of 0.048 mm. (0.048). The skeletal support for each sucker appears to be composed of 8 pieces, variously hinged together, there being 3 major pieces which are terminally hooked. To one of the latter of these are attached 8 closely set small hooklets which give a comb-like appearance (figs. 3, 4). In the anterior and posterior suckers these hooklets measure 0.004 mm., while in the suckers of the middle region they are 0.008 mm. long. At the extreme posterior end of the cotylophore is a pair of closely set solid hooks of maximum length 0.30 mm. (0.30) (fig. 5).

The buccal cavity has a subterminal ventral aperture and within this lies a pair of oral suckers of width 0.05 mm. (0.05) and length 0.03 mm. (0.03), each having a small transverse septum. The pharynx lies close to the oral suckers, being 0.03 mm. (0.03) long and 0.020 mm. (0.02) wide. The oesophagus of length 0.07 mm. (0.06) has lateral diverticula, there being usually only 1 pair (each sub-branched) present in each specimen. The intestinal bifurcation occurs anteriorly to the genital atrium and 0.17 mm. (0.18) from the extreme anterior end of the body. There are 2 main longitudinal ducts in the digestive system, one along each side of the body and each having numerous lateral branched diverticula both internally and externally. The main ducts extend into the cotylophore, apparently not uniting posteriorly.

The testicular follicles are extremely numerous, closely packed and occupying an intervitelline field, approximately one quarter of the total body length. The follicles are round and of varying diameter (from 0.02 to 0.03 mm.). The total field occupied by these follicles is of maximum length 0.90 mm. (0.68) and of maximum width 0.26 mm. (0.27). The vas deferens passes anteriorly to the genital atrium, situated 0.24 mm. (0.24) from the anterior end of the body, and heavily armed with approximately uniform hooks 0.012 mm. (0.012) long. The maximum length of the genital armature is 0.03 mm. (0.03) and the maximum width 0.02 mm. (0.02) (fig. 2).

The ovary is conspicuous, occupying the middle region of the body. It commences immediately in front of the testicular field loops and passes anteriorly to the right and then to the left and once again passes posteriorly. The ovary is unusual in that it extends relatively a long way forwards, even anteriorly to the commencement of the paired vitelline ducts. The maximum length of the field occupied by the ovary is 0.47 mm. (0.42). The two lateral fields of the vitellarium, which commence 0.52 mm. (0.53) from the extreme anterior end of the body, are quite distinct both anteriorly and posteriorly. The two vitelline fields, 1.83 mm. (1.65) long, extend posteriorly only approximately halfway along the testicular field, and hence do not pass into the cotylophore. Paired vitelline ducts arise from the vitelline fields, 1.69 mm. (1.65) from the anterior end of the body. The left vitelline duct, 0.09 mm. (0.09) long, and the right vitelline duct, 0.05 mm. (0.05), unite to form the common vitelline duct of length 0.11 mm. (0.11). This is joined by the oviduct, and the genito-intestinal canal passes to the left. The thin walled uterus passes anteriorly to open into the genital atrium.

One complete egg, seen within the uterus, is too misshapen for accurate measurements to be made from it, but it has short, stout appendages at both poles, the anterior measuring 0.12 mm. and posterior 0.08 mm.

GENERIC DIAGNOSIS: PSEUDOMICROCOTYLE: n.g.

Fam. *Microcotylidae.* Medium sized body; mouth aperture subterminal; buccal cavity with paired oral suckers. Genital atrium ventral and heavily armed with hooks. Ovary large, extending further forwards beyond the origin of the paired vitelline ducts; cotylophore with numerous small suckers each with a typical complex skeletal support bearing a series of small hooklets; cotylophore bearing also one pair of small hooks at its posterior extremity.

Pseudomicrocotyle: Very closely resembles *Microcotyle* (van Beneden & Hesse), from which it may be distinguished by the following features. The cotylophore of *Pseudomicrocotyle* besides possessing paired posterior hooks, not present in *Microcotyle,* has suckers with skeletal supports of much greater complexity than the corresponding structures in the latter; each of these suckers also possesses a series of small hooks (which give a comb-like appearance) which are not present in *Microcotyle.* The testicular follicles in *Pseudomicrocotyle* are much more numerous and smaller than in *Microcotyle* and the ovary extends relatively over a much greater length than in the latter.

Pseudomicrocotyle shows some resemblance to *Microcotyloides* (Fujii) but differs in that it possesses hooks on the cotylophore, in the greater complexity in the skeletal supports of the suckers of the cotylophore, and in the arrangement and size of the ovary. In *Microcotyloïdes* also the genital atrium is unspined, and it possesses complex terminal male genitalia not present in *Pseudomicrocotyle.*

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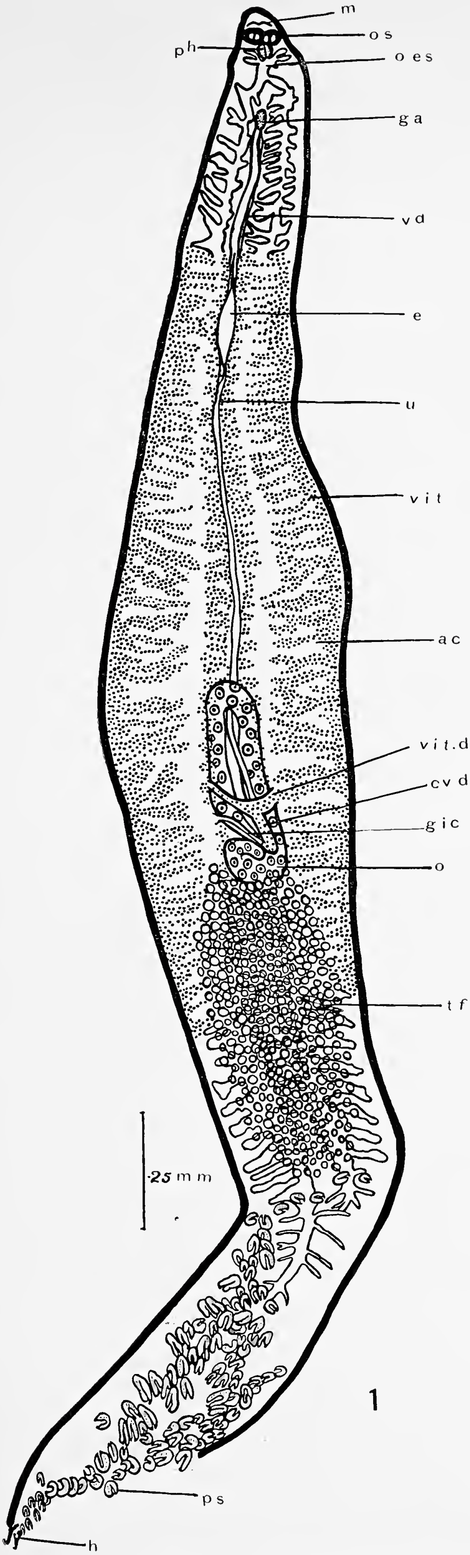
EXPLANATION TO PLATE X.

FIGS. 1-5.—PSEUDOMICROTYLE ELAGATIS: 1, whole specimen, dorsal view; 2, genital armature; 3, 4, two views skeleton of posterior sucker; 5, posterior hooks on cotylophore.

ABBREVIATIONS.

a.c., alimentary canal; c.v.d., common vitelline duct; e., egg; g.a., genital atrium; g.i.c., genito-intestinal canal; h., hooks on cotylophore; m., mouth; o., ovary; oes., oesophagus; o.s., oral sucker; ph., pharynx; ps., posterior sucker; t.f., testicular follicles; v.d., vas deferens; vit., vitellarium; vit.d., vitelline duct; u., uterus.



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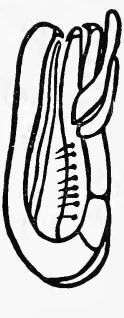

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Pseudomicrocotyle elagatis n.g., n.sp.

The Royal Society of Queensland.

Report of Council for 1945.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting the Annual Report of the Society for the year 1945.

At Ordinary Meetings one address was given, one exhibit evening and three symposia were held. Two Memorial lectures were given, one dealing with the work of the late Mr. T. L. Bancroft, and the other to commemorate the birth of Dr. W. C. Röntgen, the discoverer of X-ray. Eight original papers were accepted for publication in the Proceedings.

The Chief Secretary's Department has agreed to pay a £1 for £1 subsidy for printing on papers 1-11 published in Volume LVI of the Proceedings and judged of value from a governmental point of view. The Council acknowledges this subsidy with gratitude.

The recataloguing of the library was continued, largely owing to the efforts of Mr. Pennington, whose resignation from the Society and departure abroad will be a definite loss to the Society.

With considerable regret the deaths are recorded of two members of the Society—Dr. Graham Brown and Sir David Hardy. Both were members of the Society for many years.

There are 5 honorary life members, 4 life members, 3 corresponding members, 204 ordinary members, and 16 associate members in the Society.

Attendance at Council meetings was as follows:—H. J. Wilkinson, 10; O. A. Jones, 8; F. A. Perkins, 5; E. W. Bick, 10; M. I. Scott, 9; R. Pennington, 7; M. White, 4; S. T. Blake, 7; S. B. Watkins, 7; H. J. Hines, 7; M. F. Hickey, 5; E. M. Shepherd, 8; J. Bostock, 7.

H. J. WILKINSON, President.

MARGARET I. R. SCOTT, Hon. Secretary.

THE ROYAL SOCIETY OF QUEENSLAND.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDED 31st DECEMBER, 1945.

Cr. — RECEIPTS.

Receipts	£	s.	d.
Balance in Commonwealth Bank, 31st December, 1944	129	19	1
Subscriptions	152	5	0
Sale of Reprints	1	9	4
Interest on Commonwealth Loan	4	11	3
Savings Bank Interest	2	18	6
Refreshments Account, Collections	5	7	9
Exchanges	0	9	11
	£297	0	10

Dr. — EXPENDITURE.

Expenditure	£	s.	d.	£	s.	d.
Government Printer, Abstracts and Report				12	1	8
Government Printer—						
Volume, Proceedings	208	9	10			
Less Government Subsidy	86	14	9			
				121	15	1
State Government Insurance (Library)				1	3	1
Hon. Secretary, Postages, etc.				12	9	5
Refreshments				6	0	7
Lanternist				1	10	0
Stationery, Envelopes (Besley and Pike)				5	4	6
Hon. Treasurer, Postages and Duty				1	5	0
Balance in Commonwealth Bank				135	11	6
				£297	0	10

Examined and found correct.

L. P. HERDSMAN, Hon. Auditor.

E. W. BICK, Hon. Treasurer.

26th February, 1946.

Abstract of Proceedings, 25th March, 1946.

The Annual Meeting of the Society was held in the Geology Lecture Theatre of the University on Monday, 25th March, 1946.

The President, Professor H. J. Wilkinson, occupied the chair, and about 60 visitors and members were present. Apologies were received from Professor Richards, Dr. Hill, Dr. Meyers and Miss Scott.

The minutes of the previous Annual Meeting were read and confirmed.

The following were proposed for ordinary membership:—Messrs. G. Mack, G. Naylor, and Dr. C. B. Mann.

The annual report was adopted and the balance-sheet received.

The following officers and Council were elected for 1946:—

President: Mr. O. A Jones.

Vice-Presidents: Professor H. J. Wilkinson, Mr. E. M. Shepherd.

Hon. Treasurer: Mr. E. W. Bick.

Hon. Secretary: Miss Scott.

Hon. Editors: Dr. Hickey, Mr. Blake.

Hon. Librarian: Miss Baird.

Members of Council: Mr. Watkins, Mr. Hines, Mr. Ogilvie, Mr. Boardman, Dr. Webster.

The retiring President delivered an address entitled "The Evolution of the Brain." A vote of thanks moved by Dr. Webster, seconded by Dr. E. O. Marks, was carried by acclamation.

Abstract of Proceedings, 29th April, 1946.

The Monthly Meeting was held in the Geology Lecture Theatre on Monday, April 29th, 1946.

The President, Mr. O. A. Jones, M.Sc. in the Chair. He announced that the Council proposed Mr. H. A. Longman for Life Membership and that the proposal would be submitted to the next Ordinary Meeting.

The following were elected to ordinary membership.—Messrs. G. Mack, B.Sc., G. Naylor, M.A., B.Sc., and Dr. C. B. Mann.

The following were nominated for ordinary membership:—Messrs. E. L. Richard, H. G. Brameld, and R. de V. Gipps.

Dr. W. H. Bryan exhibited photographs of the mouths of the Nerang and Maroochy Rivers on behalf of Dr. F. W. Whitehouse. They were discussed by Messrs. L. C. Ball, H. J. T. Bake and O. A. Jones.

Professor H. J. Wilkinson exhibited a specimen of a newborn opossum (*Trichosurus vulpecula*) collected before it had reached the pouch.

Mr. L. C. Ball exhibited:—

1. Specimen from head of Haves Gully, North Brookfield.

Cast reminiscent of Archaeocyathinae in volcanic agglomerate, associated with the phyllitic shales in which Dr. W. H. Bryan and Mr. O. A. Jones last year found *Diplograptus*.

2. Polished specimens of limestone.

Blocks up to 2 ft. in diameter in agglomerates on the northern slope of Mt. Elphinstone overlooking Brookfield. When polished the rocks exhibit structures reminiscent of fragmentary Archaeocyathinae.

3. Manganese dioxide and jasperoid from head of Moggill Creek. This comes from an area of Brisbane Schist, a clay phyllite, quartzite, greywacke and andesitic volcanics, having a general N.W.-S.E. strike. The occurrence is aligned with others for several miles to the south-east.

4. Turquoise from Jolly's Lookout.

This quartzite is associated with phyllites and greywacke lying to the SW of the andesitic agglomerates of Jolly's Lookout.

It is not yet possible to say that the turquoise characterises a particular horizon, but it falls within a belt having a N.W.-S.E. trend and lying between the volcanics (on the north-east) and a manganese belt (on the south-west).

Mr. R. Gradwell exhibited turquoise and wavellite in quartzite collected at Mt. Elphinstone. Such minerals have been found at several other localities in Eastern Queensland and appear to form a horizon near the base of the Neranleigh Series.

Mr. J. T. Woods exhibited several specimens of banded chert from Rockhampton showing intricate intraformational contortions produced by subaqueous slumping while the sediments were unconsolidated and in a plastic condition.

The geological exhibits were discussed by Dr. Bryan, Dr. Marks, Mr. Ball, Mr. Denmead, Mr. Robinson, Mr. Jones, Dr. Herbert, and Mr. Bake.

Mr. S. B. Watkins, M.Sc. exhibited a feather taken from the cheek of a child.

Mr. S. T. Blake, M.Sc. exhibited specimens of three plants recently recorded from Queensland:—*Lepidosperma canescens, Marsdenia suaveolens, Parsonsia induplicata.*

Abstract of Proceedings, 27th May, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 27th May, at 8 p.m. with the Vice-President (Prof. H. J. Wilkinson) in the chair. About thirty members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. H. A. Longman was elected to Honorary Life Membership. Mr. G. Mack, Mr. G. Naylor and Dr. C. B. Mann were elected to Ordinary Membership. Mr. G. L. Wilson, Mr. M. D. Sutherland, Miss D. Vincent, Dr. E. Fisher, Mr. G. Lahey, Miss B. V. Cawley, Miss D. Coote and Mr. J. A. Lamberton were nominated for Ordinary Membership and Miss D. England, Mr. J. S. Hynd and Mr. L. J. Webb for Associate Membership.

Mr. L. S. Smith read a paper entitled "The Ligneous Genus Endospermum Benth. (Euphorbiaceae) in New Guinea," which gave a systematic account of the three species so far known to occur in New Guinea. Two of these, *E. medullosum* and *E. myrmecophilum* are described as new. Brief reference was made to the ecology of the species and possible utility of the timber.

Mr. S. T. Blake read a paper entitled "Notes on Australian Cyperaceae, VII." Three new species and one new section are described, nine previously described species are recorded from Australia for the first time, and some critical species are discussed.

Mr. C. W. Ball exhibited a photograph of a Dinosaur footprint from Lanefield Extended Colliery, Rosewood. Cast of a mould made by dinosaur treading in substance from which coal was derived. Length 18 in., width 15in., relief 1 in. Location—near bottom of No. 2 adit at vertical depth of less than 70 ft. from surface. Notification by Mr. John Clark, Manager, and visit to mine in company with Chief Government Geologist.

Mr. C. T. White gave an address entitled "Plants of the South West Pacific." Using New Guinea as a basis, the different primary types of vegetation were discussed and the altitudinal range of each type indicated. Reference was made to a number of the timber trees and other economic plants, particularly those of use to the native. A comparison between the forests of New Guinea and those of the Solomon Islands was made, the frequent predominance of a single species in the latter being noted. Mr. White mentioned a number of his experiences during a recent timber survey of the Solomon Is. with which he was associated. At the conclusion of the lecture a series of interesting photographs were shown by means of the epidiascope.

Abstract of Proceedings, 24th June, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 24th June, at 8 p.m., with the President (Mr. O. A. Jones) in the chair. About fifty members and friends were present. The minutes of the previous meeting were read and confirmed. The following people were elected to Ordinary Membership:—Mr. J. A. Lamberton, Mr. G. L. Wilson, Mr. M. D. Sutherland, Miss P. Vincent, Dr. E. Fisher, Mr. G. Lahey, Miss B. V. Cawley, Miss D. Coote, Mr. J. S. Hynd, Miss D. England, and Mr. L. J. Webb. The following were proposed for Ordinary Membership:— Mr. D. F. Robertson, Mr. G. F. Cardno, Miss E. Furlonger, and Miss D. Sandars.

Members of the Science Students' Association of the University gave an account of their recent expedition to Myora on Stradbroke Island. The reports were geological (Palaeozoic greenstones, Mesozoic sandstones, red soils, recent sand dunes, and emergence), chemical (chemistry of the oceanic water in the Rainbow channel and of the water over the Myora flat), botanical (marine algae), zoological (ecology of the Myora flat, some habits of the chief species, and descriptions of the species of carid prawns and cephalochordates), and entomological (distribution of mosquitoes and their larvae). The speakers were Dr. D. Hill, Messrs. D. Traves, J. Cuthbert, G. Lahey, W. Boardman, Miss D. England, Mr. N. Haysom, Miss T. Gritching, and Messrs. J. S. Hynd and J. T. Bake. Mr. J. B. Davenport outlined the aims of the association's expeditions.

Dr. E. O. Marks, Mr. L. C. Ball, and Mr. E. F. Riek contributed to the discussion.

Mr. L. C. Ball exhibited yellow and white sublimates occurring around vents from which hot gases are escaping due to underground gasification of the Aberdare coal seam near Blackstone on the Ipswich Coalfield. Collected by L. C. Ball 11th June, 1946. Identification by H. G. S. Cribb, of the Geological Survey of Queensland. Yellow = sulphur. White = ammonium chloride.

Abstract of Proceedings, 29th July, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 29th July, at 8 p.m. with the President (Mr. O. A. Jones) in the Chair. About sixty members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. D. F. Robertson, Mr. G. F. Cardno, Miss E. Furlonger and Miss D. Sandars were elected to Ordinary Membership.

The following motion for submission to the Commonwealth Government was placed before the Society:—"The Royal Society is of the opinion that all fundamental research, including that into atomic power, should be entirely free, but that the production of atomic power should be under international control. The Society therefore urges the Commonwealth Government to exert all its influence in these directions." An amendment that the last sentence be deleted was put forward and passed. An amendment that the words "of Queensland" be inserted after "Royal Society" was put forward and passed. The President asked leave to amend the motion replacing the word "free" by "unrestricted and uncensored throughout the world." The motion was then put to the meeting and defeated.

A symposium on "Agriculture in Low Rainfall Areas" was held. Dr. Bryan in opening the discussion emphasized the complementary nature of soil and water. He pointed out that the soils of low-rainfall areas are intrinsically of far more worth than those of the luxuriant tropics, but that if they are to be used to their maximum advantage it will be necessary to develop a new agricultural technique (with the particular purpose of obviating wind erosion) and new drought resistant types will need to be evolved by the plant breeders. Where however water may be conveyed to the low-rainfall areas by irrigation (although this has its own peculiar problems), the change over from pastoral to agricultural pursuits will be more readily accomplished.

Mr. W. H. R. Nimmo said that in agriculture under irrigation it is the function of the engineer to develop the source of water supply, convey the water and deliver it in a manner suited to the method of watering to be adopted. He may also have to provide a drainage system to remove excess water and thereby prevent water logging and destruction of land by salting. The wide flat plains of the Murray basin, parched during the dry summer, will carry only a sparse pastoral population but, watered with the winter rains from storage reservoirs in the mountains, they support thriving communities under ideal conditions. Water is conveyed some hundreds of miles in large canals and is applied by allowing it to run by gravitation between check banks from head ditch to a drain. By careful grading of the shallow top soil, a uniform application of water is obtained. In south-eastern Queensland rainfall, if well distributed and reliable, would be adequate for agriculture but supplemental irrigation is required to stabilise production. The rolling topography is less suited to construction of canals or grading of the land. The deep soils make uniform watering by flooding difficult. The lesser quantity of water required can frequently be obtained from small storages created by weirs or from underground sources. Such water must be pumped through pipes and consequently conditions are favourable to the application of water by spraying, but cheap electric power is an essential factor.

Mr. E. C. Tommerup spoke on the actual farming processes in low or erratic rainfall areas and illustrated his remarks by lantern slides and epidiascope pictures. Dry farming includes a study of crop in relation to climate and soil, but it is mainly concerned with methods of conserving water in soil, by hindering run off and evaporation, and by preventing removal of water from the soil by transpiring weeds. These actions are performed by cultivating the soil to provide a rain-absorbing surface; by contour cultivation if the land is sloping, and by use of basin listing machines. The cultivating machinery is of various types, mainly shallow draught multiple disc ploughs which plough under the stubble from the last crop and any weeds which grow, and at the same time prepare the seed bed for the crop. The dry surface soil should not be left in a fine dusty condition because it is too susceptible to wind erosion. The surface should be slightly cloddy or should be compacted by use of the ribbed cultipacker roller. The prevention of weed growth is one of the main means of conserving moisture. The moist soil readily nitrifies and so provides a store of available nitrogen for the subsequent crop. Every effort should be made to conserve organic matter because this sustains the colloidal status of the soil, and provides the source of the nitrate.

The main crops grown in the dry farming areas are wheat, oats, barley, sorghum, cotton, grapes, lucerne and a few minor economic plants. Some of these are grown in wide spacings to allow of interrow culture with a view to moisture conservation. Fodder production in these zones is of great importance, the ultimate products being beef, lambs, cheese, butter, etc. The preeminent fodder for this purpose, besides the winter cereals, is thinly spaced lucerne.

Abstract of Proceedings, 2nd September, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 2nd September, at 8 p.m. with the President (Mr. O. A. Jones) in the chair. About twenty members and friends were present. The minutes of the previous meeting were read and confirmed.

Mr. R. Gradwell presented a paper entitled, "Some Deuteric Changes in the Enoggera Granite." He said that a small unusual part of the Enoggera Granite was investigated to determine its origin. It is thought to have been formed by the action of gases or vapours on the main granite mass during a late stage of magmatic cooling. Other small differentiates were described, and direct evidence for the origin of some of the associated deuteric minerals was produced.

Mr. Clive W. Ball presented a paper entitled "The Heavy Mineral Assemblages of some Bundamba and Walloon Sandstones." The paper gives an account of the petrological features and relative proportions of the heavy minerals present in four Mesozoic Sandstones from South-Eastern Queensland. The method of separation of the heavy minerals with bromoform is also described. Three of the rocks selected were of Bundamba Sandstone (Triassic) and the fourth is a sandstone from the Rosewood Stage of the Walloon Series (Jurassic). The Table of Relative Proportions of the heavy minerals is based on extensive grain counts. Zircon, magnetite and rutile are present in all four of the rocks. Additional heavy minerals are garnet, epidote, tourmaline, anatase, biotite, muscovite, and pyrites. The average grain size of the heavy minerals from one Bundamba sandstone and the Walloon sandstone is of the order of 0·10 m.m. However, in the case of two of the former sandstones, it is only 0·02 m.m. These studies were made whilst undergoing a 3 months' Refresher Course in Geology at the University of Queensland under the Commonwealth Government Post-War Reconstruction Training Scheme.

Mr. C. Ogilvie exhibited a specimen of sandy clay from the base of a sand dune on the Cooper, and explained that the popular conception of these sandhills was rather in error, since they were really composed of about 90 per cent. sandy clay, with a cover of dune sand. The latter acted as a mulch and protected the stored rainfall in the former from evaporation. Consequently crotalarias grew with their roots in wet sandy clay.

Mr. G. F. Whitten exhibited specimens of greenstone from outcrops not previously reported at Royston and Villeneuve (Woodford–Kilcoy Railway) and extended westward the area of greenstones south of Woodford. From Villeneuve were also recorded manganiferous and banded cherts.

A number of designs for a Royal Society building were exhibited and described by Mr. R. P. Cummings. The designs, executed as class-work, were the work of Senior Students in the University Architectural Course. The programme of requirements included a large Library, a Science type Lecture Room, Board Room, provision for minor research and general offices and services. Most of the five solutions exhibited showed an openness of planning well suited to Queensland climatic conditions with ample circulation space between the different sections of the building. A feature common to all schemes was the spacious Lecture Room foyer for use as an after-meeting supper lounge. A particular requirement of the programme was that the main sections of the building such as Lecture Room and Library be able to function as distinct units without interference to each other. The Library was designed to house 25,000 books with plenty of space for reading tables. Easy supervision of the whole Library by the Librarian was taken as an important point in planning. The outward expression of all the designs was modern in character, the best solutions expressing a feeling of dignity and restraint suited to the purpose of the building.

Abstract of Proceedings, 30th September, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 30th September, with the President (Mr. O. A. Jones) in the chair. About sixty members and friends were present. The minutes of the previous meeting were read and confirmed. Miss P. Shann was proposed for Ordinary Membership.

Mr. R. Gradwell exhibited specimens of malachite and azurite in weathered granite from a quarry about half a mile west of The Gap, a new locality for copper minerals in the Enoggera Granite. Such traces of copper within the granite are rare.

Mr. Arthur Groom gave an illustrated lantern lecture on the Centre of Australia. He pointed out that mountains mapped as 5,000 feet high had indicated rugged country which might be of such a high scenic quality that they should be protected from possible vandalism. With this in view, and also to survey native mission work, he travelled 6,000 miles by air, 600 miles by motor truck, and over 500 miles on foot into the more inaccessible regions. He gave an account of foot excursions of several days duration into the little known Ormiston Gorge at the head of the Finke River, the ascent of Mount Sonder, visits to Standly Chasm and the surrounding country, a visit accompanied by Missionaries from the Hermannsburg Mission to Areyonga and Haast's Bluff Native Depots in the large aboriginal reserve. It was pointed out that the work of the Lutheran Mission at Hermannsburg was bearing fruit, in that, since 1935, native births had exceeded deaths. Some excellent photographs of rock formations were secured during the trip. In conclusion it was stressed that there should be two, if not more, large National Parks in Central Australia; one of them to include much of the Macdonnell Range system westward from Jay Creek Aboriginal Reserve and ending at the Haast's Bluff Reserve; the other to run westward from the Ellery and Finke Rivers, along the Krichauff and George Gill Ranges to the Aboriginal Reserve.

A motion that the Society would do all in its power to encourage the creation of National Parks in the area spoken of by Mr. Groom was proposed and carried.

Abstract of Proceedings, 28th October, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 28th October, at 8 p.m., with the President (Mr. O. A. Jones) in the chair. About thirty-five members and friends were present. The minutes of the previous meeting were read and confirmed. Miss P. Shann was elected to Ordinary Membership. Mr. P. J. Skerman, Mr. M. C. Bleakly, and Dr. R. Hawker were nominated for Ordinary Membership.

Mr. S. L. Everist exhibited specimens of a ferruginous sandstone from an outcrop on the beach at Coochiemudlo Island. The island shows marked evidence of emergence in the presence of inland sea cliffs, raised sea floors and beaches, and a raised alluvial fan. The main mass of the island is red-brown loam to sandy loam.

Dr. F. W. Whitehouse exhibited specimens of gymnosperm wood from the Bundamba Sandstones (? Jurassic), south of Grantham, showing destruction of tissues similar to that occurring in modern woods afflicted with White Pocket Rot, a fungus disease.

Dr. Dorothy Hill delivered the Robert Logan Jack Memorial Lecture. She said that Robert Logan Jack was born in Scotland in 1845 and was educated at Edinburgh University. He joined the Geological Survey of Scotland in 1867 and in 1877 resigned to become Geological Surveyor for Northern Queensland. In 1879 he became Government Geologist for Queensland, and there built up the Geological Survey of Queensland. He surveyed and reported on all the northern coal and mineral fields and in 1879-80 led the first expedition to successfully traverse the eastern fall of Cape York Peninsula from south to north. Then he explored the western parts of the colony, and recognised that the structure was suitable for the occurrence of artesian water; this led to the successful supply of water to the West from bores. In 1899 he resigned to report on the metalliferous deposits of Szechwan. His party was cut off from the coast by the Boxer Rebellion, and he escaped over "The Hump" to Rangoon. In 1904 he returned to Australia as a consulting geologist, first in Western Australia and then in Sydney. During the last ten years of his life he wrote his important documentary book as Northmost Australia. He died in Sydney early in November, 1927.

In conclusion Dr. F. W. Whitehouse, Mr. C. C. Morton, Mr. F. Gipps, and Mr. L. C. Ball all paid tribute to Dr. Jack.

Abstract of Proceedings, 25th November, 1946.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 25th November, at 8 p.m., with Prof. H. J. Wilkinson (Vice-President) in the chair. Forty-seven members and friends were present. Minutes of the previous meeting were read and confirmed. Dr. R. Hawker, Mr. M. C. Bleakly and Mr. P. J. Skerman were elected to Ordinary Membership. Mr. J. B. Davenport was nominated for Ordinary Membership. The Mueller Medal for Researches in Natural Sciences was presented to Mr. C. T. White, on behalf of the Australian and New Zealand Association for the Advancement of Science.

Mr. E. T. Holdaway delivered an address entitled "Centenaries of Early Astronomers."

As an introduction to the subject matter of the address, he gave points from early Chinese, Egyptian, Babylonian and Greek astronomy.

Nine astronomers were listed and this year we celebrate anniversaries from 100 to 400 years. Tycho Brahé, 1546-1601, lived before the development of the telescope, but his ingenuity in carrying out observations and recording star positions left much that assisted later astronomers to delve into the unknown depths of space. His early life was in the home of his uncle who had planned the career of a statesman but the call of astronomy proved too strong. Although a special tutor was engaged to keep him in the paths his uncle desired, Tycho waited till his tutor was asleep and then put into action plans he had built during the day. Instruments were designed and improved and even with these instruments, crude as they were, he calculated the movements of the planets, the times of eclipses and even attempted a determination of the distance of stars. After Tycho's marriage, the King of Denmark established him in Uraniborg where the greater part of his work of recording celestial positions was carried out.

Leibnitz, 1646-1716, German astronomer and mathematician, was four years younger than Newton. Both played important parts in the development of the Calculus. Leibnitz may be remembered by the theorem in the calculus which bears his name and by the lunar mountains which rise near lunar south pole to heights of 26,000 to 33,000 feet. Much of his work was carried out at Hanover, but on the accession, in 1714, of his master, George I, to the throne of England, Leibnitz was forbidden to come to England. He died in Hanover two years later.

Flamsteed, 1646-1719, was born in Derbyshire, England, and suffered ill-health in his early years. By the age of 20 he had completed a catalogue of 70 of the fixed stars, investigated the obliquity of the ecliptic, the sun's distance from the earth and the length of the tropical year. He obtained his M.A. degree at Cambridge in 1674. About this time a paper on lunar occultations prepared for the Royal Society brought him into prominence and he was appointed King's Astronomer at £100 per annum. A building site was chosen on Greenwich Hill by Sir Christopher Wren and the foundation of the Royal Observatory was laid in 1675. At the commencement of Flamsteed's career the only available star catalogue was that prepared by Tycho Brahé with 1,000 stars. With the advent of the telescope Flamsteed not only improved the position numerically but raised the standard of the work. Flamsteed's catalogue may be regarded as the foundation of all subsequent star catalogues.

Piazzi, 1746-1826, a Sicilian astronomer, discovered the first asteroid which he called Ceres. The discovery created a great stir, for the object, although small, occupies a place in the solar system that gives a more satisfactory interpretation of Bode's Law. Ceres is now known to be the largest of the asteroids, but its diameter is only 480 miles. There are 1,500 known asteroids, all small bodies, occupying a position in space which may at one time have held a planet comparable with the others of the solar system.

Backland, 1846-1916, a Swedish astronomer, did much to develop astrophysical and astrophotographic work in Russia. He was director of Pulkova for 21 years, and before his death had opened the third branch. Each of these branch observatories had special work to carry out. Simeis, in Crimea, was opened and equipped with one of the finest photographic refractors built by a British firm.

Holden, 1836-1914, an American, was the first director of the Lick Observatory, a contemporary of Chandler, Boss and the Pickerings. He laid down a sound policy which has made Lick so notable throughout the Astronomical world.

Chandler, 1846-1912, an American noted for his work on latitude determinations which showed a movement of the terrestrial poles. His research led to an International programme for latitude determinations. Adelaide has now joined in this work.

Boss, 1846-1912, an American, noted for his Preliminary General Catalogue of Stars published in 1910. This catalogue contained the proper motions and spectral type of 6,188 stars. The study of proper motion, spectral type, parallase and radial velocities has helped the human mind to understand something of the grandeur of space.

E. C. Pickering, 1846-1919, an American, carried out an extensive programme of analytical spectroscopic work by photographic records. His classification of variables is well known:—(1) Cepheid, (2) Long period, (3) Irregular, (4) Novae or temporary stars, and (5) Eclipsing; all helped in the study of the universe.

Outstanding in the life of each is that sacrifice of self, that co-operative work which marks the true scientific mind and urges so many to follow step by step in the paths of these great men, always hoping to understand the architecture of the universe.

PUBLICATIONS RECEIVED.

The following Institutions and Societies are on our Exchange List, and their publications are hereby gratefully acknowledged.

ARGENTINE—

Dereccion general de Estadistica, Buenos Aires.
Observatorio M. Lasagna.
Universidad de Buenos Aires.
Universidad National de La Plata.

AUSTRALIA—

General—

A.W.A.
Australasian Association for the Advancement of Science.
Australasian Institute of Mining Engineers.
Australian Chemical Institute.
Australian Institute of Mining and Metallurgy.
Australian Journal of Experimental Biology and Medical Science.
Australian Science Abstracts.
Australian Veterinary Society.
Council for Scientific and Industrial Research.
Standards Association of Australia.

Federal Government—

Commonwealth Bureau of Census and Statistics, Canberra.
Department of Health.
Forestry Bureau.

New South Wales—

Australian Museum, Sydney.
Botanic Gardens, Sydney.
Department of Agriculture, Sydney.
Department of Fisheries, Sydney.
Department of Mines, Sydney.
Geological Survey.
Linnean Society of New South Wales.
Naturalists' Society of New South Wales.
N.S.W. National Herbarium.
Public Library, Sydney.
Royal Society of New South Wales.
Technological Museum, Sydney.
University of Sydney.

Queensland—

Crohamhurst Observatory.
Department of Agriculture, Brisbane.
Department of Mines, Brisbane.
Government Statistician, Queensland
North Queensland Naturalists' Club.
Queensland Museum, Brisbane.
Queensland Naturalists' Club, Brisbane.
Queensland, University of.
Royal Geographical Society of Australasia (Queensland), Brisbane.

South Australia—

Adelaide, University of.
Department of Mines, Adelaide.
Geological Survey, Adelaide.
Public Library, Museum and Art Gallery, Adelaide.
Royal Geographical Society of Australasia, Adelaide.
Royal Society of South Australia.
Royal Society of South Australia, Field Naturalists' Section.
Waite Agricultural Research Institute.

Tasmania—

Geological Survey.
Mines Department.
Queen Victoria Museum, Launceston.
Royal Society of Tasmania.
Tasmania, University of.

Victoria—

Department of Agriculture, Melbourne.
Department of Mines, Melbourne.
Field Naturalists' Club of Victoria.
Geological Survey.
McCoy Society, Melbourne.
National Museum, Melbourne.
Royal Society of Victoria.

Western Australia—

Geological Survey.
Mines Department, Perth.
Royal Society of Western Australia.

AUSTRIA—

Naturhistorisches Museum, Vienna.

BELGIUM—

Académie Royale de Belgique.
Société Royale de Botanique de Belgique.
Société Royale Zoologique de Belgique.

Brazil—
- Instituto de Biologia Vegetal, Rio de Janeiro.
- Instituto Oswaldo Cruz, Rio de Janeiro.
- Government. Departmento Nacionale da Produccao Animal.
- Government. Servico Geologico e Mineralogico.
- Ministerio de Agricultura Industria y Commercio, Rio de Janeiro.
- Museu Paulista, Sao Paulo.
- Universidade de Sao Paulo.

Canada—
- Department of Agriculture, Ottawa.
- Department of Mines, Ottawa.
- Geological Survey, Ottawa.
- Nova Scotian Institute of Science.
- Royal Astronomical Society of Canada.
- Royal Canadian Institute.
- Royal Society of Canada.

Ceylon—
- Ceylon Journal of Science.
- Colombo Museum.

Chile—
- Sociedad de biologia de Conception.

Cuba—
- Sociedad Geografica de Cuba, Habana.
- Universidad de Habana.

Czechoslovakia—
- Acta botannica Bohemica.
- Charles University, Prague.
- Czechoslovakian Entomological Society.
- Masarykova Universita, Brno.

Denmark—
- The University, Copenhagen.

Estonia—
- Tartu University.

Finland—
- Societas pro fauna et flora fennica.

France—
- Marseille Faculté des Sciences.
- Montpellier, University of.
- Museum National d'Histoire naturelle, Paris.
- Société botanique de France.
- Société des Sciences naturelles de l'Ouest, Nantes.
- Société entomologique de France.
- Société française de microscopie.
- Société géologique et mineralogique de Bretagne, Rennes.
- Société scientifique de Bretagne, Rennes.
- Station Zoologique de Cette.

Formosa—
- Taihoku Imperial University.

Germany—
- Akademie der Wissenschaften, Leipzig.
- Badische Landsverein für Naturkunde.
- Bayerische Akademie der Wissenschaften, Munich.
- Botanische Garten u. Museum, Berlin.
- Deutsche Entomologische Institut.
- Deutsche Geologische Gesellschaft, Berlin.
- Deutsche Kolonial- und Uebersee Museum, Bremen.
- Gesellschaft für Erdkunde, Berlin.
- K. Leopoldinisch-Carolinische deutsche Akademie der Naturforscher, Halle.
- Museum für Naturkunde, Berlin.
- Naturhistorisch-medizinischer Vereins, Heidelberg.
- Naturhistorischer Verein der preus. Rheinland und Westfalens, Bonn.
- Naturwissenschaftlicher Verein zu Bremen.
- Reichsamt für Wetterdienst, Berlin.
- Sächsische Akademie der Wissenschaften, Leipzig.
- Senckenbergische Bibliothek, Frankfurt a. Main.
- Zentralblatt für Bakteriologie, *etc.*
- Zoologisches Museum, Berlin.
- Zoologisches Museum, Hamburg.

Gold Coast—
- Geological Survey.

Great Britain—
- Botanical Society of Edinburgh.
- Bristol Museum and Art Gallery.
- British Museum (Natural History), London.
- Cambridge Philosophical Society.
- Conchological Society of Great Britain and Ireland, Manchester.
- Imperial Agricultural Bureaux.
- Imperial Bureau of Plant Genetics, Aberystwyth.
- Imperial Institute of Entomology, London.
- Leeds Philosophical and Literary Society.
- Manchester Literary and Philosophical Society.
- Rothamsted Experimental Station.
- Royal Botanic Gardens, Kew.
- Royal Empire Society, London.
- Royal Society of Edinburgh.
- Royal Society of London.
- Wales, University College of.

HAWAII—
Bernice Pauahi Bishop Museum, Honolulu.

HOLLAND—
K. Akademie van Wetenschappen te Amsterdam.
Royal Netherlands Academy.
Technische Hoogeschool, Delft.
University of Amsterdam.

INDIA—
Geological Survey of India.
Imperial Agricultural Research Institute, New Delhi.

IRELAND—
Royal Dublin Society.
Royal Irish Academy, Dublin.

ITALY—
R. Accademia delle Scienze dell' Instituto di Bologna.
R. Instituto superiore agrario di Bologna.
Museo civico di storia naturale, Genoa.
R. Scuola superiore d'agricoltura in Portici.
Societa Toscana di Scienze Naturali, Pisa.

JAPAN—
Agricultural Chemical Society of Japan.
Japanese Journal of Zoology.
Kyoto Imperial University.
National Research Council of Japan, Tokyo.
Ohara Institut, Kurashiki.
Tokyo Bunrika Daigaku.
Tokyo Imperial University.

MEXICO—
Academia nacional de ciencias Antonio Alzate.
Instituto Geologico de Mexico.
Observatorio Meteorologico Central, Tacubaya.
Secretario de Agriculture y Fomento.

NETHERLANDS INDIES—
Jardin Botanique, Buitenzorg.
K. Naturkundige Vereeniging in Ned.-Indië.

NEW ZEALAND—
Auckland Institute and Museum.
Department of Scientific and Industrial Research, Wellington.
Dominion Laboratory, Wellington.
Dominion Museum, Wellington.
Geological Survey of New Zealand.
Royal Society of New Zealand.

PERU—
Sociedad Geologica del Peru.

PHILIPPINES—
Bureau of Science, Manila.

POLAND—
Geological Institute, Warsaw.
Panstwowe museum zoologiczne.
Polskie Towarzystwo Przyrodnikow im. Kopernika, Lwow.
Sociétés Savantes Polonaises.
University of Lwow.

PORTUGAL—
Academia Polytechnicada, Oporto.
Instituto Botanico, Coimbra.
Sociedade Broterniana, Coimbra.

RUSSIA—
Academy of Sciences, Leningrad.
Bureau of Applied Entomology, Leningrad.
Laboratory of Palaeontology, Moscow University.
Lenin Academy of Agriculture Sciences, Leningrad.

SOUTH AFRICA—
Durban Museum, Natal.
Geological Society of South Africa, Johannesburg.
Natal Government Museum, Pietermaritzburg.
National Museum, Bloemfontein.
South African Museum, Capetown.
Transvaal Museum, Pretoria.

SPAIN—
Real Academia de Ciencias, Madrid.
Academia de Ciencias de Zaragoza.
Real Academia de Ciencias y Artes de Barcelona.
Museo de Historia Natural, Valencia.

SWEDEN—
Göteborgs K. Vetenskaps-och Vitterhets Samhället.
K. Fysiografiska Sällskapet, Lund.
Uppsala University.

SWITZERLAND—
Naturforschende Gesellschaft, Zurich.
Société de Physique et d'histoire naturelle, Genève.

TRINIDAD—
Imperial College of Tropical Agriculture.

URAGUAY—

Museo de historia natural, Montevideo.

UNITED STATES—

Academy of Natural Sciences, Philadelphia.

Academy of Science, St. Louis.

American Academy of Arts and Sciences, Boston.

American Geographical Society, New York.

American Museum of Natural History, New York.

American Philosophical Society, Philadelphia.

Arnold Arboretum, Jamaica Plain.

Boston Society of Natural Sciences.

Buffalo Society of Natural History.

California Academy of Sciences.

California, University of.

California, University of, Los Angeles.

Carnegie Institution, Washington.

Cornell University.

Federal Government—

Bureau of Standards.

Department of Agriculture.

Geological Survey.

Library of Congress.

Public Health Service.

Field Museum of Natural History, Chicago. (Now under new name.)

Florida State Geological Survey.

Harvard University.

Illinois Natural History Survey.

Illinois, University of.

Indiana Academy of Science.

Institute of Biological Research, Baltimore.

Iowa, University of.

John Crerar Library, Chicago.

Johns Hopkins University.

Kansas Academy of Science, Lawrence.

Kansas, University of.

Lloyd Library, Cincinnati.

Michigan Academy of Arts, Science, and Letters.

Michigan, University of.

Minnesota Geological Survey.

Minnesota, University of.

Missouri Botanic Garden, St. Louis.

Museum of Comparative Zoology, Harvard.

National Academy of Science, Washington.

National Research Council, Washington.

New York Academy of Sciences.

New York Zoological Society.

Ohio State University.

Portland Society of Natural History.

Puget Sound Biological Station, Seattle.

Rochester Academy of Science.

San Diego Society of Natural History.

Smithsonian Institution, Washington.

State College of Washington, Pullman.

United States National Museum, Washington.

Vanderbilt Marine Museum, Huntington.

Western Society of Engineers, Chicago.

Wisconsin Academy of Arts, Science, and Letters, Madison.

Wistar Institute of Anatomy and Biology, Philadelphia.

Yale University—

Bingham Oceanographic Laboratory.

Peabody Museum of Natural History.

List of Members.

Honorary Life Members.

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Corresponding Members.

*Domin, Dr. K.	Czech University, Prague.
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*Skeats, Prof. E. W., D.Sc.	The University, Melbourne, Victoria.

Ordinary Members.

Archibald, Dr. L., M.Sc., M.B., B.S.	Health Department, Brisbane.
Atherton, D. O., M.Agr.Sc.	Department of Agriculture and Stock, Brisbane.
Avery, Mrs. R. H.	Physiology Department, University, Brisbane.
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Barker, G. H	Adelaide Street, Brisbane.
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*Blake, S. T., M.Sc.	Botanic Gardens, Brisbane.
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Boardman, W., M.Sc.	Biology Department, University, Brisbane.
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* Members who have contributed papers to the Society.

Brameld, H. G.	"Green Gables," Highland Terrace, St. Lucia Heights.
*Briggs, Mrs. C.	First Avenue, Eagle Junction, Brisbane.
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Browne, H. V.	Cavendish Road, Coorparoo.
*Bryan, W. H., M.C., D.Sc.	The University, Brisbane.
*Bryan, W. W., M.Agr.Sc.	Agricultural High School and College, Lawes.
Buzacott, J. H., M.Sc.	Sugar Experiment Station, Meringa, *via* Gordonvale.
Caldwell, N. E. H., M.Agr.Sc. ..	Department of Agriculture and Stock, Toowoomba.
Callaghan, J. P., M.Sc.	Royal North Shore Hospital, Sydney.
Campbell, Miss B., B.Sc.	The University, Brisbane.
Cardno, G. F.	Fletcher Parade, Bardon, W.4.
Carson-Cooling, Geo., M.Sc.	Boys' Grammar School, Brisbane.
Carter, S. B.Sc.	187 Waterworks Road Ashgrove, W. 3.
Cary, J. G.	9, Macaulay Street, Coorparoo.
Cawley, Miss B. V., B.Sc.	Chemistry Department, University, Brisbane.
Chamberlain, W. J., D.Sc.	City Chemist, City Hall, Brisbane.
Chapman, C. C.	Coronation Drive, St. Lucia, Brisbane.
Chippendale, F., M.Agr.Sc.	Agricultural Experiment Station, Biloela.
Christian, C. S., M.Sc.	Division of Plant Industry, C.S.I.R., Canberra.
Cilento, Sir R. W., M.D., B.S. ..	Department of Health, Brisbane.
Clark, C., M.A...	Bureau of Industry, Brisbane.
Clarke, Miss H.	c/- W. Peterman, Box 194C, G.P.O., Brisbane.
Collins, Mrs. E., B.Sc.	4 Pearl Avenue, Chatswood, Sydney.
Coleman, F. B.	Department of Agriculture and Stock, Brisbane.
Common, I. F. B., B.Agr.Sc. ..	Cotton Research Station, Biloela.
Connah, T. H., M.Sc.	Geological Survey Office, Brisbane.
Coote, Miss D., B.Sc.	Chemistry Department, University, Brisbane.
Cottrell-Dormer, W., M.Agr.Sc. ..	Department of Agriculture, New Guinea Administration, Port Moresby, New Guinea.
Cribb, H. G., B.Sc.	Geological Survey Office, Brisbane.
Croll, Gifford, M.B.	Sherwood, Brisbane.
Cummings, R. P., M.A.	University of Queensland, Brisbane.
Daniels, C. L.	Mount Isa Mines Ltd., Mount Isa.
de Jersey, N. J., M.Sc.	Durack Street, Moorooka, Brisbane.
*Denmead, A. K., M.Sc.	Geological Survey, Brisbane.
Dimmock, T. D., B.Sc.	Department of Supply and Shipping, Canberra.
Dixon, G. P., C.B.E., M.B., Ch.M. ..	Wickham Terrace, Brisbane.
*Dodd, Alan P., O.B.E.	Prickly-pear Laboratory, Sherwood, Brisbane.
Donaldson, R. J.	care of Gibbs, Bright, and Co., Queen Street, Brisbane.
Earnshaw, P. A., M.B., Ch.M., F.R.A.C.P.	Ballow Chambers, Wickham Terrace, Brisbane.

* Members who have contributed papers to the Society.

East, J. D., B.Sc.	District Geologist's Office, Rockhampton.
Edmiston, E. S., M.Sc.	The University, Brisbane.
Elliott, T. M. B.	Stanford X-ray Co. Pty., Ltd., Wickham Terrace, Brisbane.
Ellis, C., B.E.	Co-ordinator-General's Department, Brisbane.
England, Miss D., B.Sc.	Biology Department, University, Brisbane.
Erskine, T. W., T.T.S.C.	Brisbane Boys' College, Toowong
Evans, C. K., M.Sc.	Fifer Street, Ipswich.
Everist, S. L., B.Sc.	Botanic Gardens, Brisbane.
Fenwick, O. T., M.E.	c/- W. J. Reinfold, Equitable Life Building, Queen Street, Brisbane.
Ferguson, Miss G., B.Sc.	Rode Road, Nundah.
Ferguson, J. A., B.Sc.	Geology Department, University, Brisbane.
Fisher, Eileen D., Ph.D.	Biology Department, University, Brisbane.
*Fisher, N. H., D.Sc.	Department of Shipping and Supply, Canberra, A.C.T.
Fison, D. G., M.Sc., M.B., B.S.	Children's Hospital, Brisbane.
Fogarty, H. C.	Hillside Crescent, Hamilton.
Fraser, C. S.	246 Queen Street, Brisbane.
Fraser, K. M., B.Sc., B.Sc.App., B.E.	Central Technical College, Brisbane.
Frew, A. E. Harding, B.E.	Los Angeles, 456 St. Kilda Road, Melbourne.
Furlonger, Miss E.	Physiology Department, University, Brisbane.
Gaffney, T.	Engineer in Charge, Pumping Station, Pinkenba.
Gasking, D. A. T.	Canberra University College, Canberra.
Gipps, F.	"Corymbosa," Eagle Heights.
Gipps, R. deV., B.E.	c/o Stanley River Works Board, Bayard's Building, Melbourne Street, South bane.
*Goddard, Prof. E. J., B.A., D.Sc.	The University, Brisbane.
*Gradwell, R., B.Sc.	Geology Department, University, Brisbane.
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Ore Genesis of Queensland

By
O. A. JONES, M.Sc., Department of Geology,
University of Queensland.

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PRESIDENTIAL ADDRESS:

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(*Delivered before the Royal Society of Queensland*, 31*st March*, 1947.)

Mr. President, ladies and gentlemen, before turning to the main part of my address I would like to refer to a few points mentioned in your Council's report.

First, during the past year two important awards have been made to members of the society—the Mueller Medal was awarded by the Australasian and New Zealand Association for the Advancement of Science to Mr. C. T. White, for his botanical researches, and the Australian Natural History Medallion was awarded by the Victorian Scientific Societies to Mr. H. A. Longman for his researches in vertebrate palæontology and for the leading part he has played in scientific societies and on scientific committees. I heartily congratulate them both.

During the year the society took an important step in joining with the Institute of Engineers and other Queensland societies in forming a committee to formulate a plan to erect a building, suitable in size and dignity, to house those societies. I am glad to say considerable progress was made and probably sometime this year a concrete plan will be laid before you. The thanks of the society is due to Professor Wilkinson, who with myself represented your society on the committee and who is also a member of the Ways and Means Sub-committee, for the time and energy he has devoted to the project.

I must also refer to the long delay in the printing of the Society's Proceedings. Not only is the volume for 1946 not yet in print but that for 1945 has not yet been received. I assure members that this delay is not due to any inefficiency on the part of the editors, but solely to the difficulties attending all printing work during the war and in the immediate post-war period. The Council is making every effort to improve the position. To obviate the late distribution of the Abstracts of Proceedings, which occurred several times in the past year, your Council is recommending to the incoming Council that they be distributed in roneoed form until the printing position improves.

ORE GENESIS OF QUEENSLAND.

CONTENTS.

INTRODUCTION.

In every science there is need of a periodic survey of accumulated facts in order to weave them into useful generalizations, to endeavour to reconcile conflicting opinions and apparently conflicting facts and to form a firm basis to which further detail and new facts may be added.

That the time is ripe for such a stock-taking of the periods and methods of formation of ores in Queensland is shown by the fact that, in spite of the great volume of detailed descriptive work done over a long period of years by officers of the Geological Survey of Queensland and others, it has not up to the present been attempted. Much of the earlier work in particular was of high calibre and the later work, although unfortunately more restricted in scope, has in many instances added valuable facts. I mention no names here, the bibliography appended to the paper and the references to it in the text being sufficient to speak for themselves.

Although no paper dealing directly and solely with ore genesis in the State as a whole has been published, there are a few which touch upon it to a greater or lesser extent. Of these the most important are those of Andrews (1923), Stillwell (1923), and Edwards (1943). Andrews (Geographical Distribution of Ore Deposits in Australia, 1923) suggested that south-western Australia was the old nucleus of the continent, that there was probably another great belt of Archæozoic rocks through the Northern Territory, Western Queensland and New South Wales and the eastern portion of South Australia; that after denudation so prolonged that rocks which had been within the zone of rock flowage were exposed over wide areas, Proterozoic rocks were deposited upon both these areas; that Cambrian to Devonian sediments were deposited between these two belts and beyond the outer one to the east, and by implication that later rocks were more widely distributed. He concluded further that the Ordovician was a time of intense folding and metamorphism; that no folding movement of note has taken place in Australia since the Palaeozoic and no ore deposits younger than the Palaeozoic have been recorded. He found that the ore deposits assume forms and mineral compositions appropriate to the depth below the surface at which they were formed.

Some of Andrews' generalizations still stand, though as a whole they were an over-simplification. In particular as far as Queensland is concerned large areas of rocks almost certainly of Pre-Cambrian age are now known to the east of Andrews' nucleus and outer belt; the Ordovician was not, in Queensland, a time of folding and metamorphism, for, apart from the small area in which the Toko Series outcrops, rocks of that age are known only in the Tasman geosyncline where they are conformable with and grade gradually into both Cambrian and Silurian rocks; that we had both folding and ore deposition in post-Palaeozoic time will be demonstrated later in this address when the evidence for an upper Cretaceous orogeny of considerable intensity, though it affected only a small part of the state, and accompanying metallogenesis is set out.

Even his generalization that particular forms of ore bodies and mineral associations are characteristics of the depth at which those ore bodies were formed must, as far as Queensland is concerned, be modified. The Mt. Isa deposits, little known at the time Andrews wrote, but which lie within Andrews' outer belt of very deeply eroded Pre-Cambrian rocks, the same belt in which Broken Hill lies, contain minerals which have led several workers (see below) to argue that they were formed at relatively low temperatures, thus presenting a marked contrast to the deposits of the Barrier Ranges. Similarly the ore deposits of the Pre-Cambrian areas further east, Etheridge and Einasleigh, and Woolgar goldfields, etc., show depth and form characteristics—fissure fillings and replacements along fissure and little evidence of very high temperatures—more like those of Andrews' Middle and Late Palaeozoic deposits. His generalizations concerning these latter and those concerning ores of tin, tungsten, molybdenum, etc. (formation at lesser depths than the zone of rock flowage, but invariably associated with intrusions of siliceous granite) in the main still stand.

Stillwell (Correlation of Ore Deposits in Australia, 1923) was concerned mainly with metallogenetic epochs, of which for Australia as a whole he distinguished three which he characterized as broad and important. These were 1. Pre-Cambrian, in which, of Queensland deposits he placed only, and then doubtfully, the Cloncurry region, the importance and age of the Mt. Isa ores and the probable Pre-Cambrian age of many of the Etheridge, Einasleigh, Cape River, and Woolgar ores not having yet been recognized; 2 Middle Palaeozoic, in which no Queensland deposits were placed; 3. Closing Palaeozoic, in which he included the coastal strip of Queensland with such fields as Stanthorpe, Gympie, Mt. Morgan, Charters Towers, Herberton, Chillagoe and possibly also the Etheridge mineral field. As will be seen below these conclusions of Stillwell must be radically modified in view of our later knowledge.

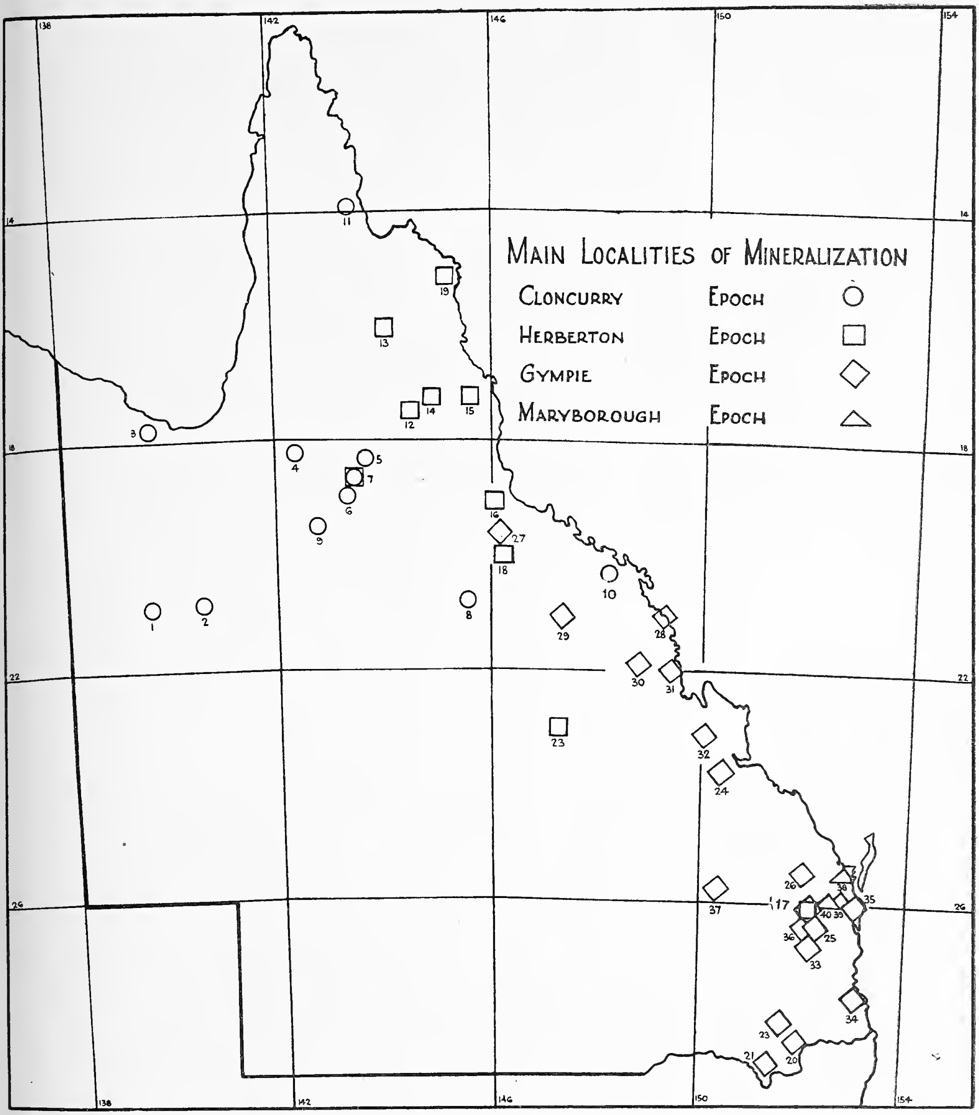
Edwards (The Copper Deposits of Australia, 1943) gave an excellent, well illustrated summary of the history, geological features and production of the main copper deposits of Australia and little can be added to this aspect of his paper. He touched only briefly on the age of the deposits, giving a map in which he distinguished only between Pre-Cambrian and Palaeozoic ores. I hope in the course of this address to define the ages of these copper and of other ores much more closely.

Other papers which should be mentioned here include the following:

Andrews (1916) argued that Australia, New Guinea and New Zealand constitute three distinct geological provinces both structurally and in ore genesis.

Ball (1923a) contributed a short discussion of the Ore Provinces of Queensland.

Andrews (1925) again put forward his view that the ore deposits of the Cloncurry–Mt. Isa area (among others in other states) were formed in the lower portion of the "Zone of Fracture" and the upper portion of the "Zone of Flowage" and suggested that "ore deposition travelled generally to the north-east and east with progressive passage of time." This latter appears to be an over-simplification, for, as will be shown later in this paper, there was late Pre-Cambrian or early Cambrian mineralization not only in north-western Queensland but also in the central north, and further, the deposits close to the present coast line, such as those of Coen and Batavia River in the north and of the Normanby field to the south, may well, in spite of a lack of definite evidence, belong to this epoch also. Nevertheless his generalization is correct in so far as ore deposits later than the close of Pre-Cambrian times do not occur in Western Queensland while our youngest ores, those of the Cretaceous (which Andrews did not recognize as of this age), are confined to areas quite close to the coast.



KEY TO LOCALITIES.

1. Mt. Isa, 2. Cloncurry, 3. Burketown, 4. Croydon, 5. Einasleigh, 6. Gilberton, 7. Percyville, 8. Cape River, 9. Woolgar, 10. Normanby, 11. Coen (Wenlock), 12. Chillagoe, 13. Palmer R., 14. Bamford and Wolfram Camp, 15. Herberton-Irvinebank, 16. Kangaroo Hills, 17. Kilkivan and Black Snake, 18. Charters Towers, 19. Cooktown District, 20. Copperfield, 21. Stanthorpe, 22. Silverspur, 23. Thane's Creek and Talgai, 24. Mt. Morgan and Moonmera, 25. Gympie, 26. Mt. Shamrock-Mt. Biggenden, 27. Argentine, 28. Mackay, 29. Sellheim, 30. Mt. Flora, 31. Collaroy and Carmila, 32. Rosewood, 33. Monsildale, 34. Indooroopilly, 35. North Arm, 36. Tansey, 37. Cracow, 38. Maryborough, 39. Neardie, 40. Yorkeys and Marodian.

Bryan's presidential address to this society in 1926, while it did not deal directly with ore deposits, greatly increased our knowledge of the periods of intrusive activity and consequently of the ages of associated ore deposits.

Skeats (1931), dealing with the age, etc., of the granites of Eastern Australia, placed those of the Einasleigh, Croydon and Cloncurry districts in the Pre-Cambrian, the Newellton granite in the Upper Devonian or Lower Carboniferous, and many granites in the Permo-Carboniferous. The recognition of late-Devonian activity was an advance on earlier work; but on the other hand Skeats over-emphasized the importance of the Permo-Carboniferous intrusions, under-emphasized that of the late Devonian, suggested a Triassic granitic intrusion to account for the Kilkivan cinnabar and placed those of the Maryborough area only as post-Walloon.

Morton (1930) gave excellent descriptions of the Charters Towers, Mt. Morgan and Gympie fields. He stated that there was insufficient evidence to date the fault fissures of Charters Towers or their filling, but that both were definitely Pre-Tertiary, and he tentatively assigned them to the late-Permian.

Browne (1933) tentatively suggested the close of the Archaeozoic as the age of the intrusion of the igneous rocks which were to be metamorphosed to the orthogneisses of Croydon, Cloncurry, Chillagoe and elsewhere. He also suggested a second series of intrusions with different petrological characters and mineralogical associations in Proterozoic times, but he was unable on the information then available to definitely place any Queensland granites in this period.

Reid (1933b) in an able summary of the copper resources of Queensland gave brief descriptions of the more important deposits and placed them as follows:

LATE PRE-CAMBRIAN: Cloncurry district.

LATE DEVONIAN OR EARLY CARBONIFEROUS: Chillagoe, Herberton, Peak Downs.

LATE PERMIAN: Most coastal deposits, as Mt. Morgan, Mt. Perry, Mt. Chalmers, Many Peaks, etc.

Reid's generalizations are largely borne out by this present work.

In an address of this kind, longer than usual though this one is, it is obviously impossible to deal with all ore occurrences of the State. Being forced to make a selection I have endeavoured first to treat areas rather than individual mines or even fields, second to select those areas which show interesting ore associations, forms of deposits or good evidence of their age of formation, and third I have included most of the major fields, though a number of small and economically unimportant deposits are included also because of particularly interesting features.

Throughout the paper I have used the term late Pre-Cambrian in the sense of the close of Mosquito Creek time, deposits equivalent to the Nullagine of Western Australia being referred to as Lipalian. Permian is used for those deposits which in the past were usually classed as Permo-Carboniferous, though some of these may eventually be found to be of Carboniferous age.

The following table summarizes the more detailed conclusions reached in the body of the address.

SUMMARY OF METALLOGENESIS IN QUEENSLAND.

Area.	Age of Mineralization.	Main Metals Introduced.	Form and Type of Deposits.	Remarks.
Mt. Isa	Cloncurry Epoch . .	Silver-lead, zinc, copper	Tabular, usually lenticular replacements of sheared and usually brecciated metamorphics. Some fissure fillings	The ores were formed at considerable depths–about the upper limits of the zone of flow, but some, being distant from their igneous source, do not show evidence of especially high temperatures
Cloncurry	Cloncurry Epoch . .	Gold, copper and cobalt	Tabular lodes on fissures and replacements along shears	High temperature of some deposits indicated by association with pegmatites and tourmaline ; others similar to Mt. Isa
Burketown Mineral Field	Cloncurry Epoch . .	Silver-lead, zinc, copper and cadmium (traces)	Tabular and lenticular veins. Brecciation due to tension faulting of arched strata, filling of faults and replacement of breccia	Formed at lesser depth than the above, within the zone of fracture and brecciation. No igneous rocks closely associated
Croydon-Stanhills . .	Cloncurry Epoch . .	Gold and tin, some lead, copper and zinc	Tabular veins and stockworks, mainly on shears, partly on tension faults at Croydon. On faults and joints at Stanhills	Formation at high temperatures indicated by development of graphite. The reefs are in granite or felsites invaded by the granite
Etheridge-Einasleigh	Cloncurry Epoch . .	Copper and gold . .	Tabular veins and lenticular masses filling faults	Close association with granite shown by gradation of veins into granitic dykes and by occurrence of felspar in veins. Formed above zone of flow but soon after elevation from that zone and at high temperature since the granite is in places gneissic and was injected "lit par lit," and graphite occurs in many of the lodes
Probably others as Woolgar, Normanby &c.	Cloncurry Epoch . .	. .	. .	. .

SUMMARY OF METALLOGENESIS IN QUEENSLAND—*continued.*

Area.	Age of Mineralization.	Main Metals Introduced.	Form and Type of Deposits.	Remarks.
Etheridge-Einasleigh	Herberton Epoch ..	Tin, molybdenum, tungsten and silver-lead	Tabular veins and lenticular masses filling faults and joints	Associated with the younger, the orthophyric granite. Pneumatolytic deposits in the zone of fracture
		Gold, bismuth, tin and tungsten	Tabular veins and lenticular masses filling faults and joints	Associated with or occurring in pegmatites—the last phase of the younger granite. Interesting association of gold and scheelite in pneumatolytic deposits
Chillagoe-Mungana ..	Herberton Epoch ..	Copper and silver-lead	Fissure lodes and large irregular replacements of limestone	Association of garnet indicates relatively high temperature
The Palmer Goldfield	Herberton Epoch ..	Gold	Small fissure fillings	Reefs occur in Pre-Cambrian, Silurian and Devonian rocks
Bamford - Wolfram Camp	Herberton Epoch ..	Tungsten, molybdenum, bismuth	Pipes	High temperature. Pneumatolytic deposition. Association with greisen
		Silver-lead	Fissure veins, and veins on bedding planes	Mineralization from pegmatite dykes
Herberton-Irvinebank	Herberton Epoch ..	Tin, tungsten and silver-lead	Fissure lodes, lenses and pipes in fissures and joints	Pneumatolytic deposits in association with greisen and topaz. Tin shows preference for chloritic rocks. Type 2 tin deposits
		Copper	Tabular on shear zone ..	
Kangaroo Hills ..	Herberton Epoch ..	Tin, silver-lead, copper and zinc	Tabular lodes filling fissures and joints	Two groups (*a*) in granite-quartz chlorite lodes with tin and subsidiary copper ores; (*b*) in metamorphics—quartz lodes with manganese, iron and garnets, silver-lead, copper and zinc
Kilkivan, Black Snake and The Serpentine Belt	Herberton Epoch ..	Gold, silver, copper, manganese, cobalt, arsenic, lead, nickel, antimony	Tabular lodes and complex replacements of quartzites and slates	Associated with intrusion of serpentine
		Chromium	..	Magmatic segregation from serpentine

Cooktown	Herberton Epoch ..	Tin	Tabular or pipe-like deposits on fissures or joint planes	Chief associates are quartz, tourmaline and mica closely associated with siliceous granites (Type 1 tin deposits)
Charters Towers ..	Herberton Epoch ..	Gold	Tabular fillings of N-S and E-W fault fissures	Mineralization was brought about by solutions from diorite-porphyrite dykes, late differentiates of granodiorite
Copperfield	Herberton Epoch ..	Copper and gold ..	Lodes on shears in mica and talc schists	Probably genetically connected with quartz porphyry and porphyry intrusions
Stanthorpe - Silverspur (including Thane's Creek, Talgai, &c.)	Gympie Epoch ..	Tin, tungsten, molybdenum, bismuth Gold, silver, lead, zinc, copper	Greisenised veins and stockworks Tabular and lenticular veins	Largely removed by erosion, thus giving rise to alluvial deposits Replacement of acid dykes and, at Silverspur, of fractured zone in metamorphics. Gold deposits are fissure veins
Indooroopilly	Gympie Epoch (more closely Early Middle Triassic)	Silver-lead	Irregular deposit in association with fissures and rhyolitic dykes	Only deposit considered to be related to the dykes. The small gold deposits of the Brisbane area are probably related to the Enoggera "granite".
North Arm	Gympie Epoch (more closely Middle Triassic)	Gold with high silver content	Tabular veins in trachytes and rhyolites	..
Tansey (near Goomeri)	Gympie Epoch (more closely Upper Triassic)	Gold	Quartz vein associated with a diorite dyke and stockworks in felsite dykes	..
Cracow	Gympie Epoch (more closely Middle Triassic)	Gold	Massive quartz lenses and mineralized volcanics in shear zones; smaller lodes in fissures and on joints	Mineralization took place at a considerable depth, near the lower limit of the zone of fracture and was genetically connected with the intrusion of felsite dykes
Mt. Morgan-Moonmera	Gympie Epoch ..	Gold and copper ..	Funnel-shaped deposit formed by replacement of sediments and igneous rocks	Probably the result of a rather deepseated explosive expansion of gases in a late stage of the intrusion of granodiorites

Area.	Age of Mineralization.	Main Metals Introduced.	Form and Type of Deposits.	Remarks.
Etheridge-Einasleigh	Herberton Epoch ..	Tin, molybdenum, tungsten and silver-lead	Tabular veins and lenticular masses filling faults and joints	Associated with the younger, the orthophyric granite. Pneumatolytic deposits in the zone of fracture
		Gold, bismuth, tin and tungsten	Tabular veins and lenticular masses filling faults and joints	Associated with or occurring in pegmatites—the last phase of the younger granite. Interesting association of gold and scheelite in pneumatolytic deposits
Chillagoe-Mungana ..	Herberton Epoch ..	Copper and silver-lead	Fissure lodes and large irregular replacements of limestone	Association of garnet indicates relatively high temperature
The Palmer Geldfield	Herberton Epoch ..	Gold	Small fissure fillings	Reefs occur in Pre-Cambrian, Silurian and Devonian rocks
Bamford - Wolfram Camp	Herberton Epoch ..	Tungsten, molybdenum, bismuth	Pipes	High temperature. Pneumatolytic deposition. Association with greisen
		Silver-lead	Fissure veins, and veins on bedding planes	Mineralization from pegmatite dykes
Herberton-Irvinebank	Herberton Epoch ..	Tin, tungsten and silver-lead	Fissure lodes, lenses and pipes in fissures and joints	Pneumatolytic deposits in association with greisen and topaz. Tin shows preference for chloritic rocks. Type 2 tin deposits
		Copper	Tabular on shear zone ..	
Kangaroo Hills ..	Herberton Epoch ..	Tin, silver-lead, copper and zinc	Tabular lodes filling fissures and joints	Two groups (*a*) in granite-quartz chlorito lodes with tin and subsidiary copper ores; (*b*) in metamorphics—quartz lodes with manganese, iron and garnets, silver-lead, copper and zinc
Kilkivan, Black Snake and The Serpentine Bolt	Herberton Epoch ..	Gold, silver, copper, manganese, cobalt, arsenic, load, nickol, antimony	Tabular lodes and complex replacements of quartzites and slates	Associated with intrusion of serpentine
		Chromium	..	Magmatic segregation from serpentino
Cooktown	Herberton Epoch ..	Tin	Tabular or pipe-like deposits on fissures or joint planes	Chief associates are quartz, tourmaline and mica closely associated with siliceous granites (Type 1 tin deposits)
Charters Towers ..	Herberton Epoch ..	Gold	Tabular fillings of N-S and E-W fault fissures	Mineralization was brought about by solutions from diorite-porphyrite dykes, late differentiates of granodiorite
Copperfield	Herberton Epoch ..	Copper and gold ..	Lodes on shears in mica and talc schists	Probably genetically connected with quartz porphyry and porphyry intrusions
Stanthorpe - Silverspur (including Thane's Creek, Talgai, &c.)	Gympie Epoch ..	Tin, tungsten, molybdenum, bismuth	Greisenised veins and stockworks	Largely removed by erosion, thus giving rise to alluvial deposits
		Gold, silver, lead, zinc, copper	Tabular and lenticular veins	Replacement of acid dykes and, at Silverspur, of fractured zone in metamorphics. Gold deposits are fissure veins
Indooroopilly.. ..	Gympie Epoch (more closely Early Middle Triassic)	Silver-lead	Irregular deposit in association with fissures and rhyolitic dykes	Only deposit considered to be related to the dykes. Tho small gold deposits of the Brisbane area are probably related to the Eneggera "granite".
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Cracow	Gympie Epoch (more closely Middle Triassic)	Gold	Massive quartz lenses and mineralized volcanics in shear zones; smaller lodes in fissures and on joints	Mineralization took place at a considerable depth, near the lower limit of the zone of fracture and was genetically connected with tho intrusion of felsite dykes
Mt. Morgan-Moonmera	Gympie Epoch ..	Gold and copper ..	Funnel-shaped deposit formed by replacement of sediments and igneous rocks	Probably the result of a rather deepseated explosive expansion of gases in a late stage of the intrusion of granodiorites

SUMMARY OF METALLOGENESIS IN QUEENSLAND—*continued.*

Area.	Age of Mineralization.	Main Metals Introduced.	Form and Type of Deposits.	Remarks.
Gympie	Gympie Epoch ..	Gold	Tabular reefs on fissures with great enrichment at intersection with carbonaceous strata	Gold precipitated by carbonaceous material. No obvious connection with igneous rocks
Mt. Shamrock - Mt. Biggenden	Gympie Epoch ..	Gold, silver, iron, manganese, cobalt and bismuth	Pipes (Mt. Shamrock and Mt. Biggenden). Fissure veins (Old Chowey, Gebangle, &c.)	Breccia-filled pipes are the result of explosive expansion on intrusion of granite and fissures were filled by deposits from liquids from same source
Argentine	Gympie Epoch ..	Silver-lead	Tabular veins	Veins occur in beds of the Star Series and older rocks. No clear connection with igneous rocks
Kilkivan	Gympie Epoch (more closely Lower Triassic)	Mercury	Tabular lodes, the gangue being most commonly siderite, sometimes quartz and rarely calcite	Associated with volcanics of the Neara Series
Monsildale	Gympie Epoch (more closely Lower Triassic)	Gold, silver-lead, mercury	Disseminated in clay at contact with andesite and in shales	Gold and silver lead lodes occur both in the Neara Series and older rocks and are associated with granitic intrusions; the mercury is associated with andesite of the Neara Series
Mackay district, Sellheim River, Mt. Flora, Collaroy and Carmila and Rosewood	Gympie Epoch ..	Gold, silver, lead, bismuth and copper	..	..
Maryborough District (Teebar &c.)	Maryborough Epoch	Copper and gold ..	Tabular veins in granite ..	The mineralization at all these places was connected with the late Cretaceous orogeny and the intrusion of the granites which accompanied that orogeny. It was confined to the south-east coastal region
Neardie Antimony Mine	Maryborough Epoch	Antimony	Tabular lode in metamorphics close to granite	
Yorkeys and Marodian gold and mineral field	Maryborough Epoch	Gold	Tabular veins in granite ..	

MINERALIZATION OF THE CLONCURRY EPOCH (LATE PRE-CAMBRIAN).

This period was one of the more important metallogenetic epochs in Queensland. In the north-west the great silver-lead, zinc and copper deposits of Mt. Isa were formed, while around Cloncurry important copper, gold, and cobalt ores were produced. All these must have been formed at considerable depth, for heavy shearing is characteristic of nearly all. Nevertheless, the Mt. Isa lodes do not show evidence of particularly high temperatures, perhaps due to their distance from their igneous source. In contrast, some at least of the Cloncurry deposits, in their close association with pegmatites and the occurrence of tourmaline, suggest higher temperatures.

To the north-west, the mineralization of the Burketown mineral field, while similar in the silver:lead ratio, differs in that copper is of minor importance, in that the lodes occupy tension faults and in the complete absence of igneous rocks.

To the north-east the gold ores of Croydon show evidence of high temperatures in their occurrence mainly on shears in granite and the abundance of graphite in the granite. The nearby tin ores of Stanhills, however, while closely associated with and often within the same granite (but non-graphitic), seldom show evidence of shearing.

Further east many though not all of the ore deposits of the Etheridge and Einasleigh fields, especially those of copper and some of gold, belong to this epoch and the ores of many other fields such as the Cape River, Woolgar, Hamilton, Coen, and Normanby probably belong here though definite evidence is lacking.

The best evidence for the age of these deposits comes from the Mt. Isa district, where almost undisturbed fossiliferous Cambrian rocks overlie the highly disturbed metalliferous strata. This indicates an age prior to Middle Cambrian and it is more exactly fixed in that it is related to the diastrophism of the late Pre-Cambrian times. I propose to term this important epoch the Cloncurry Epoch.

The Mt. Isa—Cloncurry District.

This district is of course best known for the silver-lead-zinc-copper deposits of Mt. Isa, but there are also many other important copper ore bodies such as that at Mt. Elliot and Mt. Oxide, gold producers as at Top Camp, the Gilded Rose, etc., and also cobalt near Selwyn, and iron deposits, although the latter have not as yet been exploited. The silver-lead deposits of Lawn Hill, although 140 miles to the north-north-west, will be considered here as they provide important evidence on the age of mineralization at Mt. Isa.

The work of Roland Blanchard, Graham Hall and their staff in the field aided by laboratory studies such as that by Grondijs and Schouten has produced detailed and comprehensive studies seldom equalled in Queensland Mining Geology and might well serve as a model for such enterprises. For these reasons the area is treated at length here.

The rocks of this region comprise ancient highly metamorphosed types many of which may be almost exactly matched among the Pre-Cambrian rocks about Broken Hill, 800 miles to the south. Overlying these highly disturbed Pre-Cambrians are only slightly dipping fossiliferous Cambrian limestones, sandstones, shales, and cherts.

The Pre-Cambrian rocks are grouped as follows:

THE PRE-CAMBRIAN SEQUENCE IN THE CLONCURRY-MT. ISA AREA.

Palaeozoic.	Cambrian.	Templeton Series.	——
Proterozoic ..	Newer (Lipalian)	Mount Quamby Series	Gently dipping beds of arkose and auriferous conglomerates
	Older ..	Mt. Isa Series — Upper	Limestones
		Middle	Quartzites and shales with silver, lead, zinc and copper
		Lower	Greenstones
Archaeozoic..	Newer ..	Soldier's Cap Series	Schists, greenstones, slates and quartzites
	Older ..	Kalkadoon - Argylla Series	Gneisses, schists and amphibolites

Honman (1937, p. 60) has, however, tentatively expressed the view that the Soldier's Cap Series is but a more highly metamorphosed lateral equivalent of the Mt. Isa Series and the Mt. Quamby Series may well be younger than Lipalian as it is unfossiliferous and nowhere overlain by younger rocks. Shepherd (1946, p. 146) has proposed a somewhat different grouping as follows:

Proterozoic	Upper	Templeton and Cloncurry granites Spring Creek basalts Mt. Isa Series, shales and quartzites Corella Series, mostly altered limestone
Archaeozoic	Middle	Wonga Series, gneissic granites Argylla Series, amphibolites, schists, gneisses, etc.
	Lower	Kalkadoon Series, gneissic granites Leichhardt Series, hornblende schists (probably originally igneous)

In this classification the Leichhardt and Kalkadoon Series are separated and the Soldier's Cap Series regarded as the equivalent of the Argylla Series; the Mt. Quamby Series is not discussed. Serial names are introduced for gneisses regarded as metamorphosed granites. The important items for the purpose of this paper—the age of the Mount Isa Series and the Templeton granite and the succeeding angular unconformity—are the same in both classifications.

The extensive ore deposits of Mt. Isa occur in the middle division of the Mt. Isa Series. In the vicinity of Mt. Isa itself replacement occurred in part of a belt of shales about 9,000 ft. thick, dipping west at about 60° and conformably over- and under-lain by quartzites.

A bibliography of papers describing the deposit and the genesis of the ore is given by Blanchard and Hall (1942). To this should be added papers by Blanchard (1942, 1943). These papers are the source of the brief description which follows.

Mineralization took place in the shales by replacement on a north-south line 1700—3,700 feet east of the western quartzite contact, over a length of 5 miles and with maximum width of 2,000 feet. The replacement was associated with three major movements: 1. a major overthrust accompanied by brecciation and followed by invasion by silica; 2. crushing and fracturing followed by invasion by calcium, magnesium and iron carbonates; and 3. the main shearing movement with deposition of three generations of sulphides.

As a result of the overthrusting movement from the south-south-west the incompetent shale beds, between the competent quartzites, were folded and sheared into an intricate pattern and thus became permeable to the ore-bearing solutions.

The overthrust movement produced all the major folding and faulting of the district, widespread crenulation in the thinner strata and in its late stages brecciation in particular zones. Much silica was introduced into the breccia, partly replacing the shale fragments and cementing the whole of individual zones into rigid masses, some of which to-day stand up several hundred feet above the general surface level.

The crushing and fracturing was caused by renewal of the thrust. This movement affected the now silicified breccia zones, the fractures formed being filled, and much breccia replaced, by "dolomite" (a coarse intergrowth of lime, magnesia and iron carbonates). In places this replacement occurred outside the breccia zones and produced massive "dolomite" bodies, sometimes of over 1,000,000 tons. Nevertheless, the bulk of the "dolomite" occurs in strata other than the massive bodies, mainly in the breccia zones. Some chalcopyrite was deposited at this stage.

The thrust was again renewed but with much decreased force, and produced mainly gentle (often microscopic), but widespread shearing along the bedding planes of strata which had escaped silification or "dolomitization." This thrust may be subdivided into three stages, with each of which a generation of sulphides was associated. The first generation consisted of huge quantities of very fine-grained pyrite. Replacement was mainly along the sheared bedding planes and adjacent shale, but it penetrated also along the numerous minute fractures in the breccia and massive "dolomite." Associated with the later ståges was fine-grained sphalerite. With renewed gentle shearing came deposition of the second generation of sulphides—pyrite, sphalerite, pyrrhotite, galena, and chalcopyrite.

The locus of the thrust now shifted gradually from a point to the south-south-west to a point more or less directly beneath the footwall of the ore bodies. This change in the direction of pressure produced, towards the end of the second generation, and during the third, innumerable minute fractures across the bedding; galena and chalcopyrite were deposited and other sulphides in minor quantities.

The chalcopyrite throughout was deposited in the "dolomite" (massive and otherwise) rather than in the shales.

The sequence of events is summarized in the accompanying table.

SUMMARY OF EARTH MOVEMENTS AND THE FORMATION OF THE MORE IMPORTANT GANGUE AND ORE MINERALS AT MT. ISA.

		Events.	Main Minerals Introduced.	
			Gangue.	Ore.
1	. .	Major overthrust and brecciation	Silica . .	. .
2	. .	Crushing and fracturing movement	" Dolomite "	Chalcopyrite (small quantities)
3a	Main Shearing Movement	Shearing; first generation of sulphides	Pyrite Silica Pyrrhotite	Sphalerite
3b		Shearing; second generation of sulphides	" Dolomite " Pyrrhotite Pyrite	Sphalerite (probable age) Galena Chalcopyrite
3c		Cross fracturing; third generation of sulphides	Pyrite " Dolomite " Silica	Galena Sphalerite Chalcopyrite

The origin of the mineralizing solutions is by no means clear. Both Grondijs and Schouten (1937) and Blanchard and Hall (1937) have dismissed a syngenetic origin even for the earliest pyrite generation, which preceded the economic minerals. The evidence for metasomatic replacement is in fact conclusive for most of the minerals.

The occurrence of abundant pyrrhotite was taken by Schwartz (1937) to indicate high temperature deposition. Graphite, usually indicative of high temperature, is also present, but both Grondijs and Schouten (1937) and Blanchard (1938) argue for a relatively low temperature, the latter pointing in particular to the distance of the deposit from outcrops of igneous rocks and the fact that deposition of carbonates continued during the introduction of the pyrrhotite. All, however, agree on an igneous origin for the solutions, although proof has not been established, nor has the channel along which the ore fluid found its way from below been located.

Just where the solutions originated is not clear. The nearest outcrop of intrusive rock of any kind to the deposit is a pegmatite dyke two miles distant. No intrusive rock has been met in the mine even in drill holes to 4,400 feet. Disregarding the gneissic granite to the west which is older than the ore, the nearest igneous rock of consequence is the Templeton granite batholith outcropping about eight miles to the west.

The first and major overthrust movement seems to have originated some miles south-south-west of the ore bodies and later pressure came from approximately the same area (Blanchard and Hall, 1942, pp. 7, 14, 35), so that this is a profitable area in which to search for the parent igneous rock. In this area are the Mica Creek pegmatites outcropping over a length of 2½ miles, and with a maximum width of one mile, the nearest outcrop to Mt. Isa being five miles south-south-west

(Denmead, 1937a, Shepherd, 1938). Blanchard and Hall (1942, p. 35) consider the overthrusting and faulting of the Mt. Isa area, the earliest of their three periods of deformation, to be "a minor feature of a comprehensive deformational event which produced much more extensive folding in the quartzite, schist and Archaean rocks to the south-south-west," and that the "related but subsequent brecciation, crushing and shearing of the ore areas (with which the ore deposition was associated) may have been more closely tied up with the less dynamic pegmatite intrusion . . . . . ." It is possible however, that the pegmatites are but the summit of a much larger intrusion, an intrusion sufficiently large to have produced forces great enough to account for all the phenomena.

The exact age of the mineralization is also in doubt. In the Mt. Isa area the mineralization appears to be earlier than the Mt. Quamby Series, which has been placed as late Proterozoic (Honman, 1936b, p. 49 and pl. 4), but this almost undisturbed series is of very limited extent, is found in contact only with the upper division of the Mt. Isa Series and may indeed be considerably younger than suggested. The only conclusive evidence is that about Mt. Isa itself the mineralization took place prior to the deposition of the Templeton Series. The lowest fossiliferous horizon of this series contains, about 100 feet above the base, the trilobite *Redlichia*, indicating the very top of the Lower Cambrian. The lower time limit is fixed by the fact that the movements which overthrust, folded and sheared the sediments and allowed their mineralization affected the whole of the Mt. Isa Series which is placed as lower Proterozoic. Thus this evidence shows the age of mineralization to be Lipalian (newer Proterozoic) or slightly later.

Going further afield, some evidence is to be found at Lawn Hill, 140 miles to the north-north-west, and at Little Tott's Creek, 85 miles to the north-west. At the former, a suite of ores closely similar to those of Mt. Isa is found in the Pre-Cambrian Lawn Hill Series (possibly equivalent to the Mt. Isa Series) (Blanchard 1931, Shepherd, 1931). The occurrence differs from that of Mt. Isa in that the ore bodies are not replacement bodies but fissure fillings, copper ores are comparatively rare, shearing is absent and the mineralization, though not the ores, passes upward a short distance into the overlying Middle Cambrian Limestone. Ball (1911, p. 16; 1923, p. 790) has emphasized the slight alteration and the freedom from igneous activity. At Little Tott's Creek, thin lodes in Middle Cambrian limestones carry silver, lead and zinc sulphides, the ratios of the three metals being similar to that at Mt. Isa.

On the evidence from these three areas, then, three interpretations are possible.

1. The whole mineralization was post Lower Cambrian; or
2. The main mineralization was late Proterozoic, with renewal producing slight effects in Middle Cambrian times; or
3. There were two separate periods of mineralization, that at Mt. Isa being pre-Middle Cambrian and those at Lawn Hill and Little Tott's Creek post-Lower Cambrian.

The third interpretation appears unlikely in view of the many similar features in the three deposits. As the Cambrian limestones are almost undisturbed—almost unfolded, and were not affected by the shearing in evidence at Mt. Isa or other faulting as at Lawn Hill, and as the mineralization was closely associated with these movements which took place in pre-Lipalian times, the second interpretation appears the most probable.

That the diastrophism occurred long before the Middle Pre-Cambrian is shown by the fact that the topography of the area is largely a rediscovered one, a Lower Cambrian topography, and a long erosion interval must have elapsed after the diastrophism and before the deposition of the Middle Cambrian sediments.

The length of the erosion interval is also indicated by the form of the Mt. Isa ore bodies which suggests formation at considerable depths though probably not as deep as at Broken Hill. The brecciation of the strata at Mt. Isa shows that it fractured rather than flowed under the heavy thrusting pressure.

In the Cloncurry district gold, copper and cobalt ores with lesser amounts of scheelite, wolfram, manganese, bismuth and molybdenite, occur in rocks of the Kalkadoon–Argylla Series, the Mt. Isa Series and the Soldier's Cap Series; but most are in the older series, though the Mt. Oxide copper-gold ores occur, like the Mt. Isa ores, in the Mt. Isa Series. Most of these probably belong to the same metallogenetic epoch as the Mt. Isa ores, but some may belong to an earlier period, for example, the Bower Bird auriferous reefs occur in the Kalkadoon–Argylla Series and may be related to a granite outcropping on the field and thought to be Archaeozoic (Honman, 1938, p. 5). Some are close to outcrops of igneous rocks, as are the Bower Bird lodes, and the Gilded Rose which is close to pegmatite and aplite (Honman, 1936a, p. 4); others are remote from igneous outcrops, though igneous rocks may be close beneath though not outcropping.

Some of the ore bodies, e.g., the Bower Bird reefs close to pegmatite and the Comstock reef (Jones, 1934, p. 337) in which gold occurs in a gangue of quartz and tourmaline, in contrast to those of Mt. Isa, show evidence of formation at high temperatures, and it appears that the formation of high temperature minerals depends rather on proximity to an igneous source than on depth *per se*.

The most important cobalt deposits are those at Mt. Cobalt, 18 miles south of Selwyn. The lode occurs in a fault or shear zone approximating to the contact of mica-schist and amphibolite of the Soldier's Cap Series. Granite, intrusive into this series and the Mt. Isa Series, outcrops three miles to the south and three miles to the north-east.

The rocks of the Mt. Isa–Cloncurry–Lawn Hill area are the only ones in the State of which we have as yet definite evidence of their Pre-Cambrian age. Elsewhere, there are known many series of such a high degree of metamorphism that it seems probable that they are Pre-Cambrian. In some cases an upper limit is fixed by the occurrence of overlying fossiliferous rocks of Silurian or Devonian age.

These probable Pre-Cambrian series are set out in the table below. The oldest group may possibly be Archaeozoic, the next Proterozoic and the youngest possibly Lipalian, though definitely assigning them to periods is little more than speculation. Of these series all contain mineral deposits except the two youngest, and all except those of Charters Towers and the Etheridge–Gilbert area are probably of Late Cambrian age.

PROBABLE PRE-CAMBRIAN DEVELOPMENTS ELSEWHERE.

Grouping According to Degree of Metamorphism.	Central Area.	Northern Area.	Coastal Area.	Tasman Geosyncline.	
				North.	South.
Slates and schists	..	..	..	Barron River Series (in part)	Greenstone Series
Mainly schists some gneisses	Cape Riv. (younger), Charters Towers, Etheridge (younger), Gilbert & Woolgar	..	Coastal Series (including Gatcombe Head Series, Stannage Point, Normanby, Dunk Is., Barnard Is., High Is.)	..	..
Mainly gneisses some schists	Dargalong Gneisses, Einasleigh Gneisses, Cape Riv. (Older), and Etheridge (Older)	Frome Series, Coen, Hamilton, and Pascoe Riv.			

The Etheridge—Einasleigh Area.

This area, together with adjacent areas to the north and east, is one of the greatest importance in deciphering Queensland's metallogenetic epochs, and it also contains a number of ore deposits presenting unusually interesting features. Unfortunately, detailed mapping and intensive study has as yet been carried out only in limited areas. There are divergent views on problems of much importance—how many granites are there? how many series of porphyries? what are their ages? is any or all the granite metamorphic? Consequently it is difficult or impossible to arrive at conclusions acceptable to all workers and the conclusions which follow must be regarded as tentative only.

The area, or parts of it, has been described by Daintree (1870b), Jack (1892b), Cameron (1900a), Marks (1911), Ball (1914a, 1915a) and Jensen (1923). The oldest rocks consist of old metamorphics—gneisses, mica and talc schists found mainly in the Einasleigh area, and slates, quartzites, limestones and shales in the Etheridge district. Daintree, Jensen, Bryan (1926), and Bryan and Jones (1946) distinguished in age between these two groups, but the other workers regarded them as one series, more highly metamorphosed in the Einasleigh than in the Etheridge area. Hills (1946, p. 74) urged the latter interpretation. Intrusive into these are diorite dykes and granites, overlain by porphyries and Mesozoic or Tertiary sediments. The metalliferous deposits, which include gold, silver-lead, copper, zinc, tin, tungsten, bismuth, molybdenum and tantalum, are found in both groups of metamorphics and in granite.

Jensen (1923, p. 32 et seq.[1]) distinguished two series of metamorphics—an older or Etheridgean[2] Series of gneisses and schists and a younger group of slates, chlorite schists and greywackes which he equated with his Herberton[3] Series further east. Younger sediments include somewhat metamorphosed sandstones placed by Jensen as Permo-Carboniferous but now known to be Devonian (see below). Intrusive rocks include granite, diorites, gabbros, pegmatites and aplites, and porphyries in part interbedded but in part intrusive are widespread.

The slates, chlorite schists and greywackes which Jensen equated with his Herberton Series appear to be those placed by Bryan and Jones (1946) as the younger of the two probably Pre-Cambrian groups.

There have been divergent views expressed both as to the origin and the age of the granites. Daintree (1870b) considered them to be very highly metamorphosed sediments—"metamorphic granite," the schists and gneisses being highly crystalline and the granite often foliated; but Cameron (1900 a, p. 2, p. 4), Marks (1911, p. 6), Ball 1915 a, p. 12) and Jensen (1923, p. 33) regard them as intrusive, but intimately associated with the metamorphics and injected in a *lit par lit* manner, and point to those places in which the tongues of granite cut across the strike of the metamorphics, as evidence of its intrusive nature.

All the writers but Jensen regarded the granites as of one age. Jensen distinguished alaskite granite, older than the "Herbertonian" but intrusive into the "Etheridgean" and a newer orthophyric granite of late Devonian or early Carboniferous age. The latter, unlike the former, has not undergone metamorphism and is correlated (on lithological grounds) with the Mareeba and Chillagoe granites to the north, which are intrusive into the Hodgkinson Series regarded as of Devonian age (1923, p. 19) and with the Herberton granite which is not intrusive into the Silver Valley Beds of Carboniferous age.

The porphyries, in part intrusive, in part extrusive, similarly present a problem. The earlier writers regarded them as of one age, post-granite ("older granite" of Jensen), and pre-Cretaceous. Ball (1915a, pp. 12-14) correlated them with those of the Featherbed Range to the north-east; similar porphyries occur at the base of the Mt. Mulligan coal measures, which further contain pebbles of the porphyries (Ball 1912, pp. 9, 10). He traced these porphyries to Kooboora, 30 miles to the south, where he found thin seams of impure coal interbedded. This

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[1] Jensen's paper is exceedingly difficult to interpret since *inter alia* he assigns the one series to several different ages in the course of the paper.

[2] The name Etheridge Series has however usually been applied to the other, probably younger, group of metamorphics.

[3] This should not be confused with the Herberton Series of Dunstan, which, while including Jensen's Herberton Series in the type area, also embraced many other rock types and is approximately equivalent to the Hodgkinson Beds of Jack. It included also the Silver Valley Beds and was assigned by Dunstan to the Carboniferous. For further details see Bryan and Jones 1944, p. 39.

coal he took to be of the same age as that at Mt. Mulligan (1912, p. 10, 1919-20, p. 510). He consequently regarded all the porphyries as of Permo-Carboniferous age.

Jensen (1923, pp. 3, 4, 19, 20, 21) distinguished at least two and probably three series of porphyries. The oldest he regarded as Silurian since it nowhere cuts the Hodgkinson Series and because lavas of this type are apparently interbedded with the Chillagoe Series [Upper Silurian and Lower Devonian]. His "middle porphyries" include those described by Ball at Mt. Mulligan and the red porphyries of the Etheridge–Einasleigh area; and since in places dyke off-shoots from them cut granite considered to be the "orthophyric granite," he thought them to be early Permo-Carboniferous in age. The Newcastle Range porphyries might, in part, be Jurassic in age.

Since publication of the above papers additional evidence bearing on the age of some of these formations has been found by Mr. F. G. de V. Gipps. In 1932 he found, to the south and south-west of Gilberton, a suite of beautifully preserved fossil plants. These have not as yet been described, but they include *Lepidodendron australe,* new species of *Lepidodendron* and several species of the primitive Psilophytales. There can therefore be little doubt that they are of Devonian age. A fossil fish has also been recorded from the same bed (Hills 1936, p. 163). The rocks in which this fauna and flora were found were described by Gipps as conglomerates, slates, schists and arkose, but examination of the specimens shows that schistosity is not highly developed and they appear to be those rocks described by Cameron (1900a, p. 3) from this locality as conglomerates and sandstones and placed beneath the Desert Sandstone as doubtfully Lower Cretaceous. Ball (1915a, p. 14) included them with the Desert Sandstone, but Jensen (1923, p. 3) showed them on his map as "sandstone, age uncertain, probably Permo-Carboniferous." The areas shown under this caption correspond exactly with those described by Cameron and include the seven localities from which the plants came. The sum total of the outcrops makes but a relatively small area but they show no evidence of mineralization and in comparison to the older rocks they are not highly metamorphosed—from the descriptions and examination of the available specimens, to about the same extent as the Hodgkinson Series.

Thus the gneisses and the schists are definitely pre-Devonian and their very much stronger metamorphism lends support to their being of Pre-Cambrian age.

Daintree (1870b, p.7) considered that in the slate areas the mineralizing agent was the diorite and he noted the presence of elvanite dykes in the auriferous portion of the field. Marks (1911, pp. 12, 13) dealing with the Oaks and Eastern portions of the Etheridge field, considered that the porphyry dykes, much crushed and brecciated and traversed by innumerable veins, had "some indirect genetic connection with deposition of the gold and other minerals, to which deposition the dykes are certainly antecedent." He noted that the brecciated dyke material as well as the quartz veins, in places, carries gold. With regard to the copper deposits he found it impossible to trace anything more than a chance association between the majority of them and the porphyry dykes.

Ball (1915a, p. 11) says only "In both slate and schist the intimate relationship between mineralization and igneous action is witnessed by the numerous porphyry and diorite dykes in the vicinity of the lodes."

Jensen (1923, pp. 38, 39) considered that there were three periods of mineralization: one connected with the older, the alaskite granites—pre-Silurian; a second with the younger, the orthophyric granite—Carboniferous; and a third with abundant aplites and pegmatites which are intrusive into the metamorphics and both granites—Permo-Carboniferous. He found that mainly copper and gold were introduced by the first, cassiterite, molybdenite, wolfram, scheelite and fluorspar by the second, and cassiterite, wolfram, molybdenite, gold, bismuth and scheelite by the third. Jensen considered that the alaskite granites, as those at the Einasleigh Copper Mine, and the porphyritic granites and tonalites of the Georgetown district were injected *lit par lit* into the old metamorphics and have been metamorphosed, almost certainly at the same time as the sediments into which they were intruded. He concluded that their age is therefore probably that of the metamorphism, which is known to be definitely pre-Silurian.

Amid these varied differences of interpretation it is difficult to reach a conclusion, but in support of Jensen's analysis can be added the argument set out by Bryan and Jones (1946, p. 14) that the degree of metamorphism and folding of the series, in comparison with that of the Kalkadoon-Argylla and the Mt. Isa series which are of Archaeozoic and Proterozoic age, suggest that the two metamorphic series in the Etheridge area are also probably Pre-Cambrian and possibly Archaeozoic and Proterozoic respectively. Further, the metamorphism in the Cloncurry area took place in late Pre-Cambrian or in Lower Cambrian times and the mineralization at the same time; by analogy the injection of the older granites and the mineralization in the Etheridge area may be regarded as late Pre-Cambrian.

The later or orthophyric granites were correlated by Jensen with the Mareeba and Chillagoe granite which are intrusive into the Hodgkinson Series. This series is regarded as Devonian, though the evidence is not conclusive. Jack (1899a, p. 200) pointed out that the series is "highly inclined, a good deal altered, and charged with auriferous reefs" and probably older than the Star Series and the Dotswood Beds. The fossil evidence is also inconclusive, consisting of *Lepidodendron australe*, *Pachypora* sp. and *Cyathophyllum* sp., and indeed Jack had earlier (1892, p. 113) included the series in his Gympie Formation. However, *L. australe* is certainly characteristic of, and may be confined to, Devonian rocks, so that the series is best regarded as tentatively Devonian. Jensen placed the granite as Carboniferous rather than late Devonian, for he considered that its intrusion was coincident with folding which he thought took place in late Carboniferous times (p. 75). Later in this paper evidence is set out showing that the folding cannot be dated as exactly as this. Elsewhere in the same paper however (p. 19) Jensen pointed out that the granite did not invade the Silver Valley (Newellton) Beds with *Rhacopteris*, certainly Carboniferous, possibly Lower Carboniferous in age—conclusive evidence that the granite in that area is at least pre-Middle Carboniferous.

These granites are therefore on present evidence best regarded as late Devonian or early Carboniferous.

Jensen's evidence that the alaskite granite introduced copper and gold is that he could find no constant relation of the copper lodes to the porphyry dykes (Silurian) and, further, gold occurs in large mineralized quartz reefs in granite country. The reefs are fissure lodes and ''are taken to have emanated from the mother liquor of the granite mass in which they occur'' (1923, pp. 36, 38, 45). This reasonable conclusion is supported by the observation by Gipps of pink felspars in some of these reefs in the Gilberton area (verbal communication). Jensen found that aplite dykes traversing the orthophyric granite (and presumably a late phase of it) carry wolfram, molybdenite, tin, etc. frequently in small amounts and sometimes in payable amounts (p. 39).

The evidence for the pegmatites being the mineralizing agents for some of the gold, bismuth, tin, wolfram and molybdenite is similar—actual occurrence as primary minerals in some of the dykes and close association in other places. (pp. 37, 40, 45).

Summing up, one may say that while the expressed views are very divergent and the data very incomplete, one may tentatively assign mineralization to three epochs—late Pre-Cambrian, the period of intrusion of the alaskite granite; late Devonian or early Carboniferous, the period of intrusion of the orthophyric granite; and a period, when aplites and pegmatites were intruded, possibly Permian; but these dykes are probably more reasonably to be regarded as the final stage of the orthophyric granite and but little later than the granite itself.

Croydon—Stanhills District.

The most recent reports on this area are those of Clappison and Dickinson (1937a, b), Clappison (1940) and Jensen (1940). Those of Clappison and Dickinson (1937b) and Clappison (1940) contain bibliographies of earlier reports.

The rocks of the field are granite, felsite and quartz felsite; overlying these are horizontal fossiliferous marine Cretaceous sediments; near the Golden Gate reef is a small area of sediments, with dips from 35° to 80°, surrounded by the felsites. Dunstan (1905, pp. 13, 14) regarded these sediments as part of the Cretaceous beds but considered that the upper part of the sediments, ferruginous sandstones and conglomerates, might be Tertiary. No other worker has made this distinction. There is no closer evidence than pre-Cretaceous for the age of the granites and felsites, and opinions differ as to the relative age of these two groups. Rands (1896, p. 5) and apparently Dunstan (1905, p. 9) regarded the felsites as younger. Jensen (1923, p. 35), referring to them as porphyries, thought that there may be two series, one older and one younger than the granite, but both regionally metamorphosed, and possibly a third series (p. 74) of Silurian age. Jensen regarded the granite as an extension of the Etheridge granite and of Pre-Silurian [Pre-Cambrian] age. Clappison and Dickinson (1937b) placed them as simply Pre-Cretaceous. Clappison (1940, pp. 7, 8) and Jensen (1940, p. 22) gave conclusive reasons for regarding the granite as intrusive into the older felsites. The age of mineralization is therefore very doubtful but is possibly late Pre-Cambrian.

The felsites everywhere contain small quantities of disseminated graphite. Certain parts of the granite likewise contain blebs of graphite in much greater quantity than in the felsites. Rands (1896, pp. 5, 6) thought two granites were present, an older graphitic granite, the result of extreme metamorphism of sediments, which was invaded by the younger non-graphitic granite. Dunstan (1906, p. 10) regarded coarse and fine-textured granite, graphitic and non-graphitic types as simply alternating belts of the one mass. Jensen, as the result of extensive investigations in 1919, also concluded that there is only one granite and in 1926 published the results of a microscopical investigation in support of his conclusions. Reid (1935, p. 77) said Jensen's conclusion that only one granite was present cannot be seriously challenged. Clappison and Dickinson (1937b, pl. 1) showed the graphitic granite as occurring in narrow belts running north-west and approximating to the trend of most of the reefs. Dunstan (1906, p. 10) suggested that the graphitic granite sheared more easily than the non-graphitic and for this reason the reefs in the former had low dips while in the latter they are nearly vertical (but (see below) many reefs in the felsites have low dips).

Jensen (1923, p. 34, 1926, p. 88) suggested that graphite was formed by the reduction of carbon dioxide by iron or iron sulphide "at a time when the rocks were in the zone of partial recrystallization." Clappison and Dickinson (1937a. pp. 57, 58; 1937b, p. 5) pointed out that the reefs are of two types—those in graphitic granite, occupying shear zones striking N.W.–S.E., not simple reefs but formations of graphitic granite up to thirty feet in width with numerous veins and narrow reefs of quartz, and those in felsite striking N.–S., mostly on thrusts of low dip and up to 15 feet in width, but some almost vertical filling tension faults and with a maximum width of only 3 feet.

The two distinct types of reef suggest the possibility of two periods of ore formation, one connected with the shearing and perhaps coincident with the intrusion of the granite and with the steep anticlinal and synclinal folding which is indicated in two places on Clappison and Dickinson's map, and another connected with tension developed perhaps only slightly later and with the final phases of the granite intrusion.

Some thirty miles to the south-east in the Stanhills area, the same granite, continuous in the field, but not graphitic, is found. Here an aplitic granite, possibly from the same magma (Jensen, 1940, p. 22) introduced mainly cassiterite, but also some ores of lead, copper and zinc, into fissures and joints in both granites and the felsites; greisenized masses of granite also carry cassiterite.

Thus in the Croydon and Stanhills area the picture is of a huge ancient granite mass which has been subjected to both shearing and tensional forces. Auriferous veins were formed along the fault planes probably during the Cloncurry Epoch, and at the same time at the margins of the granite mass stanniferous ore bodies were developed. The prevalence of shearing and the abundance of graphite suggest ore formation at considerable depths. The possibility of two periods of ore formation should not be overlooked.

MINERALIZATION DURING THE HERBERTON EPOCH (LATE DEVONIAN OR EARLY CARBONIFEROUS).

Ore genesis next became important at a time which on present evidence can only be placed as somewhere between late Devonian times and the middle of the Carboniferous. This epoch I propose to call the Herberton Epoch.

Its importance has never been fully recognized although Jensen has stressed its importance in north Queensland. Tin was the most important metal introduced and in the past the tendency has been to lump all the tin ores together as having been derived from a particular type of granite, "the tin granite" which was injected throughout Eastern Australia at the one time—late Permian (e.g., Skeats 1931). Certainly the tin ores of Queensland, as throughout the rest of the world, are genetically connected with exceptionally siliceous granites, but at least three different types of deposits are found in Queensland (see below) and three different ages represented. Of these three the Herberton Epoch seems to be at least as important as the Gympie, both being more important than the Cloncurry Epoch. Besides tin ores, ores of molybdenum, tungsten, copper, silver, lead, zinc, bismuth, gold, silver, cobalt, nickel, manganese and chromium were formed, though in the case of some of the metals only in small amount.

Besides the ores introduced by the orthophyric granite of the Etheridge-Einasleigh area, probably to be referred to this epoch (see above, p. 17), the tin, silver-lead, copper and zinc ores of Chillagoe, Mungana, O.K. and Kangaroo Hills; the tin ores of the Cooktown district; the tin, tungsten, copper and silver-lead of the Herberton-Irvinebank district; the tungsten, molybdenum, bismuth and silver-lead of Bamford and Wolfram Camp; the gold of Charters Towers; the gold, cobalt, copper, and manganese of the Kilkivan area, and the chromium and gold of the serpentine belt are placed in this epoch.

The ores of this epoch may be subdivided as follows:

A. The granite phase. Ores of tin, tungsten, silver-lead, copper, zinc, gold and bismuth genetically related to highly siliceous or to normal granites, and

B. The serpentine phase. Chromium and gold ores genetically related to the serpentine intrusion.

The age of the serpentine and its associated ores is shown to be Late Devonian and it is suggested that the continuation of the Great Serpentine Belt in New South Wales may also be of this age, rather than Carboniferous or later. But the age of the ores associated with granitic intrusions in North Queensland cannot as yet be fixed so closely and it may be that these were formed as late as the end of Lower Carboniferous times.

The Tin Deposits.

Most of the more important tin mines of Queensland are found within the following four districts: (1) Cooktown to Bloomfield River, (2) Stanthorpe, (3) Herberton–Irvinebank–Watsonville area and (4) Kangaroo Hills. Certain characteristics are common to all. All were formed within the zone of fracture, not shear, and at high temperatures within or close to the margins of acid granites. Beyond this, three distinct types, each with a different gangue and ore-mineral association, may be made out.

1. Lodes usually tabular but sometimes pipe-like in form, sometimes filling fissures, but often on joint planes, usually within acid granite or aplite but sometimes in the invaded metamorphics close to the granite contact; also occurring sometimes in irregular marginal modifications of granite. The chief gangue minerals are quartz and tourmaline which may be black or brown, or sometimes a light-coloured mica (greisen). Fluorite is sometimes, though not usually, present. Wolfram, molybdenite and arsenical pyrites are the most common associates.

This is the type of the Cooktown field (Mt. Leswell, Lion's Den, Mt. Hartley, Mt. Browning, Lode Hill) and the Stanthorpe field (Stanthorpe, Ballandean, Redrock, Sundown). To the south the Stanthorpe field merges into class 2 around Emmaville and Torrington in New South Wales.

2. Lodes tabular or pipe-like in form, filling fissures or joints, or impregnating the country rock on either side. The country is of acid granitic types or metamorphics close to the contact. The gangue may be largely quartz but chlorite is usually present and frequently makes up ninety per cent. of the gangue. Tourmaline is absent. Fluorite occurs but is not common though more so than in the previous class. Jack mentions hornblende in several lodes. Copper ores and wolfram are the most common associates, the wolfram being earlier than the cassiterite since in several places the latter occurs as pseudomorphs after wolfram.

This is the type of the Herberton–Irvinebank–Watsonville area.

3. Lodes tabular, filling fissures or joints (or shears?) in both granite and metamorphics. Two groups of associates are found in the one area:

(*a*) Usually in granite, a few in metamorphics—quartz-chlorite lodes with cassiterite and subsidiary amounts of copper ores.

(*b*) Usually in the metamorphics, rarely in the granite—quartz lodes rarely with chlorite but usually with much manganese and iron and with garnets in both lodes and country rock. The ores are silver-lead, copper and zinc.

Tourmaline and wolfram are absent from both types and fluorite is rare. Calcite occurs in places as a veinstone.

This is the type of the Kangaroo Hills field where an area of metamorphics about 8 miles across is almost surrounded by granite (see map, Reid, 1931, p. 264). The type of lode (*a*) occurs mainly in the granite but is found also in the metamorphics, as, for example at Mt. Brown. On the other hand type (*b*) is rare outside the metamorphics.

Type 1 tends to grade into type 2; for example, going south-west from the Stanthorpe field lodes of type 2, introduced by the same granitic complex, are found on the fringes of the Mole tableland. Type 2 tends to grade into type 3. Silver, silver-lead and copper ores occur to the south and west of the Herberton area, the nearest being the silver mines of the Dry River; but these, while within the tin-bearing area, are nine miles distant from Herberton and about eight from Mt. Garnet, in contrast to the much closer association on the Kangaroo Hills field. The silver-lead and copper ores of Chillagoe are nearly sixty miles to the west-north-west of Herberton.

None of the three types shows any likeness to the Bolivian silver-tin deposits, the latter having been introduced in late Tertiary times and relatively close to the surface by hypabyssal intrusions or quartz porphyry stocks (see Turneaure, 1935).

Type 1 is associated with late Permian granites (or early Mesozoic) as at Stanthorpe, and with Late Devonian (or Lower Carboniferous) granite to the south of Cooktown. Types 2 and 3 are known in Queensland only with the late Devonian granites of the Herberton district and

Kangaroo Hills, but type 2 is late Permian (or early Mesozoic) in the New England district of New South Wales. Further work is needed in the South to substantiate this generalization.

The Queensland types seem to bear some relation to the zoning found in the Cornish deposits, although zoning is not apparent in any one lode in Queensland. Davison and Cronshaw, both in 1921, made microscopic studies of the Cornwall lodes and Rastall (1923, p. 192) combined their data into the following generalization.

Stages (Cronshaw).	Main Gangue Mineral.	Ores.	
10. Calcite	Calcite ..	Iron Ores	
9. Pyrite, hematite, chalybite, quartz, fluorite	Quartz .. (stages 9, 8, 7)		
8. Galena, blende, chalcopyrite, quartz, fluorite			
7. Chalcopyrite, quartz, fluorite, accessory tourmaline, chlorite and cassiterite		Zinc blende, galena and chalcopyrite	
6. Chlorite, accessory tourmaline, cassiterite, arsenical pyrite, quartz, fluorite	Chlorite	Cassiterite / Arsenical pyrites (stages 6 to 1)	
5. Fluorite, accessory tourmaline, cassiterite, arsenical pyrite, quartz, chlorite	Fluorite		
4. Blue tourmaline, cassiterite, arsenical pyrite, accessory quartz and fluorite	Tourmaline (stages 4, 3)		
3. Brown tourmaline with accessory quartz ..			
2. Quartz and cassiterite with tourmaline and arsenical pyrite	Quartz (stages 2, 1)		
1. Quartz with wolframite, arsenical pyrite, felspar and local tourmaline, cassiterite and topaz			Wolfram and chalcopyrite

Of the three Queensland types, type 1 corresponds approximately to stages 3 and 4; type 2 to stage 6, and type 3 to stages 7, 8, 9. A study of the mineral associations in the Herberton, Watsonville and Irvinebank districts (type 2), suggests that with increase of quartz in the gangue, i.e. approach to stages 1 and 2, wolfram becomes more common, but copper becomes less common, the limited amounts of copper present being that of stage 7, not of stages 1 and 2, while the silver ores found at Silver Valley (Dry River) and Montalbion also suggest the coming in of stage 7. On the Kangaroo Hills field (type 3) we have ores of stage 6 in some lodes and of 7, 8, 9 in others, while the approach to stage 10 shows itself in the abundance of iron and manganese ores.

The main developments of wolfram and molybdenite have a quartz, and locally, topaz association, and rare fluorite, but very rare tourmaline, or a greisen association. Such associations, which correspond approximately to stages 1 and 2, except for the absence of cassiterite, occur at Almaden, Bamford and Wolfram about forty miles to the west of Herberton. In the New England district of New South Wales the main development of wolfram is much more closely associated with the tin ores; this main area is within a roof pendant of metamorphics, forming the higher parts of the Mole Tableland, and the tin lodes occur on the lower parts and flanks of the tableland where the metamorphics give place to granite.

The comparison of the Queensland types with Cornish stages suggests that they might be regarded as a very incomplete expression of metallogenetic zoning, though as no two types occur together such a suggestion is only tentative.

The tin ores of Stanhills are difficult to place, for very diverse opinions have been expressed as to the mineral associations in the lodes.

The Wolfram—Molybdenite—Bismuth Pipes.

Long pipe-like deposits largely of quartz but containing patches of rich ores occur at Wolfram Camp and Bamford in the Cairns Hinterland, at Wonbah near Mt. Perry and an exceptionally large pipe (about 220 feet in diameter) without ore at Bajool near Rockhampton, while some of the cassiterite ore bodies of the Herberton district are pipe-like in form. The numerous pipes of the Wolfram Camp—Bamford area (Ball 1913, 1915b, 1919-1920; Morton 1944, 1945) carry deposits of wolfram, molybdenite and bismuth ores, sometimes wolfram, sometimes molybdenite being the predominating ore. The Wonbah pipe (Ball 1915d, Reid 1919, Cribb 1937a, Shepherd 1943) contains molybdenite only, while that at Bajool is worked for quartz and has shown only small flakes of molybdenite.

The pipes of the Wolfram–Bamford district have an interesting history. Mining was on a relatively small scale until 1914 when the great war-time demand for molybdenite caused a great expansion of operations; the collapse of wolfram and molybdenite prices soon after the end of the war brought about the cessation of operations, but a number of the mines were re-opened during the recent war partly for the production of wolfram but also in search for rock crystal for use in radar installations.

I have elsewhere (1943, p. 2-6) discussed the formation of pipes and have nothing to add to that discussion, except to draw attention to a paper by Kennedy (1944) in which he points out that at very high pressures, such as would be found at depths at which ore formation takes place, the density of the vapour phase of a silica-water system approaches that of the liquid and the solubility of silica in the former also approaches the solubility in the liquid phase. Thus the available silica (that in the vapour phase) is relatively high and this may in part account for the very high proportion of quartz in these pipes, in the case of that at Bajool virtually to the exclusion of all other minerals.*

The pipes of the Bamford–Wolfram district occur in an acid granite which invaded porphyries (flows, tuffs and intrusions) at Bamford and porphyries and sedimentaries at Wolfram. The sedimentaries belong to the Hodgkinson Series and may be regarded provisionally as Devonian in age. Ball (1915b, p. 11, 1919-20, p. 510) and Morton (1944, p. 119) considered the porphyries to be Permo-Carboniferous, but Jensen (1923, p. 21) placed them and the Featherbed Range porphyries in the Silurian. This problem of age can be solved only by detailed mapping. On the former view the ores would belong to the Gympie Epoch; but, on the latter, to the Herberton.

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* Reference should also be made to a very important paper by Roland Blanchard—"Some Pipe Deposits of Eastern Australia." Ec. Geol., 42, pp. 265-304, 11 figs., 4 tables—which appeared while this address was in the press.

The Etheridge—Einasleigh District.

The mineralization of this district belongs in part to the Cloncurry Epoch, in part to the Herberton. The geology has been outlined above (p. 17).

Chillagoe—Mungana District.

The main ores formed in this district were those of copper, but ores of silver-lead and sometimes zinc are also important.

The more important reports are those of Jack (1891, 1898), Skertchly (1897), Jensen 1920c, 1923) and Morton (1926, 1938).

Jack and Skertchly regarded the cupriferous-lead deposits of the Mungana district as having been formed in open solution caves in the limestones of the Chillagoe Series, but Jensen (1923, pp. 46,54) pointed out that the lodes are contact and fissure lodes and that the huge "carbonas" are metasomatic replacements of the limestones by magmatic waters rather than fillings of open caves, and that the production of extensive garnet indicates high temperature deposition.

All writers agree that the Chillagoe granite and its differentiates were the source of the mineralizing solutions, and Jensen (1920, p. 150) gave the sequence of events at Mungana as follows:

1. Injection of a huge igneous mass into Silurian strata.
2. Injection of acid dykes.
3. Assimilation of calcareous beds and differentiation.
4. Cooling and consolidation of acid differentiates.
5. Formation of fissures.
6. Rise of siliceous solutions from aplitic differentiates along the fissures and formation of cherts and garnet rock.
7. Rise of metallic solutions accompanying cooling of basic differentiates.
8. Intrusion of Monzonite dykes.
9. Rise of further metallic solutions.

The age of the mineralization is therefore that of the Chillagoe granite. It is post-Lower Devonian, for it invaded the Chillagoe Series, the upper part of which is probably Lower Devonian (see Bryan and Jones, 1946, pp. 23, 27, tables H, J, and K). Jensen (1923, p. 28) correlated the Chillagoe granite with the Mareeba granite to the east which is intrusive into the Hodgkinson Series, and he therefore (pp. 28, 75) placed it in the Carboniferous. The age of the Hodgkinson Series has been discussed above (p. 20) and reasons set out for regarding the granitic intrusions of the Herberton. Bamford, Mareeba area as late Devonian rather than Carboniferous.

The mineralization of the Chillagoe–Mungana–O.K. area may therefore be tentatively assigned to the Herberton epoch, a course which was followed by Reid (1933b).

The Palmer Goldfield.

The Palmer Goldfield, one of the richest alluvial fields of Queensland, has never been a big field for reef mining, although, in addition to gold, small amounts of copper, silver-lead and antimony occur, as well as tin at Cannibal Creek. Much attention was given to the field, and especially to the occurrence of pre-Cretaceous alluvial deposits, by officers of the Geological Survey in the early days, but the predominately alluvial nature of the field is reflected in the lack of any subdivision of the old Palaeozoic complex. References to these early reports can be found in Jack (1899c). It has remained for the broad features of the geological structure to be worked out by officers of the Aerial, Geological and Geophysical Survey of Northern Australia. The results, together with a geological map, are contained in a report by Jensen, Clappison, Keid and Cleverly (1940).

They distinguished an old Pre-Cambrian group of gneisses, the Frome Series, followed by the Palmerville Series of schists, quartzites and limestones with interbedded andesites. The limestones contain Upper Silurian corals. The Maytown Series of slates and quartzites is continuous in the field with the Hodgkinson Series and therefore probably of Devonian age. Younger still, and strongly unconformable, are Jurassic or Cretaceous sandstones. There are two groups of granites, the Frome granites, probably of Pre-Cambrian age and the Mt. Windsor granites which are post-Devonian and pre-Jurassic. The Palmerville Series is thrust over the Maytown Series, their junction being a broad zone containing crushed strata of both series.

The reefs, mostly less than two feet in thickness, are not associated with the zones of shearing and overthrusting, but occupy fissures in all three metamorphic series. Change in the strike of reefs was an important factor in the localization of ore shoots.

The age of mineralization was clearly pre-Cretaceous and later than the deposition of the Maytown Series, but the only evidence to fix the age more closely is that the field is well beyond the area affected by Permian diastrophism, which suggests that the deposits should be placed in the Herberton Epoch.

The Herberton—Irvinebank District.

The latest stratigraphical work (including a detailed map) on this district is that by Jensen, Keid and Hassler (1939). The succession as worked out by them differs only slightly from that given by Jensen (1920, 1923).

They recognized two series of metamorphics, the older, crystalline quartzites, etc., of early Palaeozoic age, and a younger series, Silurian and Devonian in age and including interbedded volcanics—the Featherbed Range porphyries. In ? Late Devonian times these were invaded by granite with aplite and greisen dykes, syenite and diorite. Later rocks are Carboniferous conglomerates, sandstones, etc., [the Silver Valley Beds] and Tertiary volcanics.

The older metamorphics Jensen correlated with his Etheridge Series. Skertchly (1897) had included these with Jensen's Herberton Series, placing them as Permo-Carboniferous or Devonian. However, as pointed out by Bryan and Jones (1946, p. 19), a consideration of their lithology, degree of metamorphism, etc., suggests an age at least as old as Cambrian.

The rocks which Jensen in 1923 included in his Herberton Series as ? Ordovician and older than the Featherbed Range porphyries were, in 1939, placed by him in part above and in part below the latter, the whole being regarded as Silurian–Devonian.

The "porphyry problem" in this area and further west is very complex. Most workers have thought all the porphyries to be of one age and they have been placed as young as Jurassic. Ball (1915b, p. 11) regarded them as lower Permo-Carboniferous or possibly Carboniferous, thus making the granite which is intrusive into them Permian or later. But Jensen (1923, pp. 19, 75) distinguished two groups, the Featherbed Range porphyries and most of those of the Newcastle Range of Silurian age, and a younger group of Permo-Carboniferous age and later than the granites. In the Herberton area only the former occur.

We thus find a great variety of opinions on the age of the granite responsible for the extensive mineralization—introduction mainly of cassiterite but also of wolfram, copper and silver-lead ores.

Skertchly (1896, 1897) placed it as post-Devonian and (1899) as Permian, Cameron (1904) as simply post-metamorphic. Stirling (1905, p. 14) placed the granites as Lower Devonian on the grounds that they are not intrusive into the Silver Valley Beds with *Rhacopteris,* thus being pre-Carboniferous, and that they "correspond in age with the Lower Devonian plutonic masses of South-East Australia." Jensen (1923, p. 19) placed it as Devono-Carboniferous or early Carboniferous since similar granites invade the Hodgkinson Series; David (1932, p. 139) as Permian and Jensen, Keid and Hassler (1939) as late Devonian.

As far as the upper limit of age is concerned the critical area is Silver Valley, where both the granite and sediments with *Rhacopteris* are found. The granite did not invade the latter.

The Silver Valley Beds have generally been regarded as Upper Carboniferous in spite of *Rhacopteris* being characteristic of the lower portion of that period in the Northern Hemisphere (Seward 1931, pp. 193, 267).

This view was based on these facts:—(1) *Rhacopteris,* although found associated with *Lepidodendron velthcimianum,* occurs only in beds younger than those with *L. australe,* e.g., in the Drummond Range (see, for example, Whitehouse 1930, p. 31), and (2) *L. australe,* inter alia, occurs in the Star Series, regarded as Lower Carboniferous. Reid (1930, pp. 16-19, 27-28) has, however, advanced reasons for regarding the lower part of the Star Series as Upper Devonian, and Bryan and Jones (1946, pp. 31-32) also place it there. The Silver Valley Beds may therefore well be middle or lower Carboniferous, as suggested by Bryan and Jones (1946, pp. 34. 37). A Middle Carboniferous age was suggested for the upper Kutung Series of New South Wales with its *Rhacopteris* flora, by Carey and Browne (1938, p. 592).

The lower limit of age can be fixed only by turning to the area further north where the similar Mareeba granite invaded the Hodgkinson Series.

The age of the Hodgkinson Series is less certain than that of the Silver Valley Beds; the palaeontological evidence is meagre (though it includes *Lepidodendron australe*) and the series has been assigned to all ages from Upper Silurian to Permo-Carboniferous (for details see Bryan and Jones 1944, p. 40, and Whitehouse, 1930, p. 30). Jensen (1923, pp. 5, 6, 8, 22, 75), on the grounds of lithological differences from the Chillagoe Series and the occurrence of *L. australe,* regarded it as Devonian. Bryan and Jones (1946, p. 31) placed it in the Upper Devonian. Much further investigation is needed, but this last conclusion seems the best on the available evidence.

In that case the Herberton granite must be regarded as late Devonian or early Carboniferous, a view which was expressed by Reid (1933). Ball (1933), however, considered that there are two granites though he did not discuss their age.

The age of intrusion and metallogenesis may be assumed to correspond with that of the orogeny which folded and metamorphosed the pre-Carboniferous strata. To determine this it is necessary to survey the evidence from a much wider field than that to which the mineral fields are restricted.

In New South Wales Carey and Browne (1938) found evidence for a considerable orogeny at the end of Lower Carboniferous times, and in Queensland Reid (1929) considered that the Drummond movement was of that age and that it affected most of the State. In southern Queensland there is abundant evidence of the folding of the Middle Devonian Silverwood Series; Carboniferous rocks occur further west, but the details of their relationship to the Devonian strata are unknown. In Central Queensland in the coastal area Reid and Morton (1928) postulated a considerable disconformity between the Rockhampton and the Neerkol Series, thus suggesting the possibility of movement at the end of Lower Carboniferous times; but Whitehouse (1928) strongly disagreed. The Rockhampton district has not been mapped in detail, but the Devonian strata are more strongly folded and more highly metamorphosed than are the Lower Carboniferous rocks; further, serpentine invaded the former but not the latter. But further west in the Drummond Range area there was continuous and unbroken sedimentation from Devonian times well into the Carboniferous. Thus in Central Queensland there appear to have been Late Devonian movements accompanied by the intrusion of serpentine, which affected the coastal, but not the inland areas.

In North Queensland the movements pre-dated the Silver Valley Beds which may be Lower or even Middle Carboniferous; they post-dated the Star Series and the Hodgkinson Series.

The Star fauna needs revision before a choice can be made between an Upper Devonian and a Lower Carboniferous age, and the Hodgkinson Series can be regarded as only provisionally Devonian. It is attractive to correlate the North Queensland movements with those of the Rockhampton area; but they were accompanied by intrusions and ores of a very different type and the diastrophism appears to have been greater, for the Hodgkinson Series includes rocks of as high a grade of metamorphism as schists. It is safer on the present evidence to regard them as possibly distinct from the Central Queensland movements and as not definitely Late Devonian, but as Late Devonian or Lower Carboniferous.

The genesis of the tin ores was a matter of some difference of opinion in the early days of the field. Jack (1883, 1892b) considered that the ores had an intimate connection with dykes intruded into fissures, that they probably were an original constitutent of the dykes and were dissolved and redeposited as veins and pipes on the joint planes of the dykes (that is, a modified and restricted lateral secretion theory); nevertheless in 1887a he considered some at least of the deposits at Watsonville to be lodes, not dykes, and others to be mineralized sediments. Maitland (1891b), reporting on the Coolgarra mines to the south, followed Jack. Munday (1895) disagreed with Jack, pointing out that at depth "the veins develop more quartz and present a greater resemblance to ordinary lode veins, the enclosed mineral being in a more banded form and parallel with the walls of the enclosing fissure." Skertchly (1896, 1897) followed Jack's theory, but in 1899 he classified the deposits of the Herberton, Watsonville and Chillagoe districts as (1) true fissure lodes, tin bearing; (2) dyke lodes, tin bearing; (3) carbonas, copper and silver bearing; (4) impregnations from faults, tin bearing; (5) bedded or cleavage deposits, tin bearing; and (6) cave deposits, copper bearing, thus recognizing other types than those discussed by Jack. Maclaren (1900) referred to the Stannary Hills deposits as impregnations, although in the same year Cameron included irregular pipes and fissure lodes as well as impregnations.

Cameron (1904), in a comprehensive report on the Herberton field, disagreed strongly with Jack and emphasized that the irregularly distributed lode material is, in almost all cases, evidently a product of the alteration of the country rock by the action of mineralizing agents, which have changed its constitution by chemical action, and have at the same time deposited tin and other minerals within its interstices. Later workers have all agreed with Cameron.

The discontinuity of the ore bodies, their occurrence in apparently unrelated ore shoots, has always been a source of difficulty in their mining and of great expense in prospecting for new shoots; thus some mines have been abandoned as worked out and reopened several times. All workers have emphasized this difficulty, though, as noted above, there was early divergence of opinion as to whether the ore bodies occupy faults or joints. This difference of opinion has persisted, for in 1933 Reid described the Herberton area as an "intense fault complex," while in a foreword to the same report Ball pointed out that the "faults" may also be interpreted as joints. An examination of a limited number of specimens showing the junction of ore and country leads me to support Ball's view. Several attempts have been made to determine the factors which controlled ore deposition, but, so far, with little success. Ball (1923b,c,d) mapped with great care the joint systems in the lower levels of three of the mines, but was unable to discern any structural control. Broadhurst and Wade (1939) and Broadhurst (1942) put forward the suggestion that the location of the shoots depends on a complex structural control—the intersection of three planes, two joint planes and a pitch. However, later mining work has not so far substantiated this.

The problem would probably be capable of comparatively quick solution were it not for the absence of data, in almost all cases, of the faults and joint systems in the older workings of the mines, workings usually now inaccessible.

Kangaroo Hills.

This field is interesting in its association of tin and silver ores. The oldest rocks of the field form a thick series of metamorphosed sediments—garnetiferous mica and talc schists, greywackes, grits, and conglomerates, rhyolites and a thick limestone. This series has been considerably metamorphosed and, according to Saint-Smith (1922), heavily sheared, the shearing producing extensive crush zones, though Reid (1931, p. 267) says that "the metalliferous belt does not seem to constitute a specially crushed or sheared zone." The limestones contain fossils recognizable only as corals (Jack, 1893a, p. 1). To the west this series, which Saint-Smith called the Kangaroo Hills Series (1922, p. 312) and Reid (1931, p. 265) the Metalliferous Series, is unconformably overlain by sandstones with thin coal seams and *Lepidodendron* (called by Saint-Smith the Clarke River Series (1922, p. 312)) which both Saint-Smith and Reid regarded as equivalent to the Star Series. The metalliferous series was invaded by huge granite and porphyry intrusions. The overlying sandstones immediately to the west of the field were not intruded by these igneous rocks, but Saint-Smith (1922, p. 312) mentions granites intrusive into the Clarke River Series near Wando Vale, which, however, is over sixty miles to the south-west.

Gibb Maitland (1891a, p. 5) doubtfully equated the Kangaroo Hills Series to the Burdekin Series (Middle Devonian); Saint-Smith (1922, p. 312) regarded it as continuous laterally with a less metamorphosed series with interbedded rhyolites, underlying the Clarke River Series to the west. This latter he considered overlies the Burdekin Limestones and is equivalent to the Star Series, and he therefore placed the Kangaroo Hills Series in the Upper Devonian and suggested that its high degree of metamorphism is due to its intrusion by granite. Jensen (1923, p. 14) correlated it with the "Devonian (Lower Burdekin)" on lithological grounds. Reid however (1931, p. 265) argued strongly that it is older and equated it with the Silurian [Silurian-Lower Devonian] Chillagoe Series on the grounds of its strong unconformity with the Star Series, its general lithological similarity to the Chillagoe Series, its much stronger folding than that of the Burdekin Series and the similarity of the ore deposits to those of the Herberton-Chillagoe area.

This problem can be solved only by further field work and by detailed mapping. It is unfortunate that the details of Saint-Smith's reconnaissance from Wando Vale to the Burdekin River, which Saint-Smith said (p. 312) would be published in a later paper, was not published, for such a traverse would probably yield conclusive evidence.

Without having seen the series in the field and judging purely by the published descriptions, I incline to Reid's view, for the lithological resemblance to the Chillagoe Series is striking. The similarity of the ore deposits is, however, not as striking as suggested by Reid, for he compared them with the ores of a very wide district, Chillagoe to Herberton, apparently regarding the Herberton Series as of the same age as the Chillagoe. The age of this series was discussed above (p. 18), and it may be that it is older, possibly considerably older, than the Chillagoe Series.

Jensen (1923, p. 14) described a series of sandstones, very friable and frequently conglomeratic at the base, but indurated and cemented into quartzite towards the top, capping the Kangaroo Hills ranges. He placed this series in the Jurassic or Cretaceous though definite evidence is lacking. It is at any rate much younger than the Kangaroo Hills Series. The granite and porphyry did not invade the latter series near the field, indicating a pre-Mesozoic age; Saint-Smith's implied suggestion that the granite is of the same age as that at Wando Vale cannot carry much weight as the latter is over sixy miles distant. This and the similarity of rock types and the silver-lead mineralization to those of Chillagoe* suggest a similar age for the metallogenesis, i.e., late Devonian.

* Jack (1892c, p. 11) suggested a similarity to Broken Hill, but Reid (1931, p. 267) has shown that this comparison breaks down in detail.

The interesting ore association is treated elsewhere in this paper (p. 23).

The Kilkivan—Black Snake Area.

Mineralization in this area was widespread and varied. Metals found include gold, silver, copper, manganese, cobalt, arsenic, lead, zinc, and mercury with small amounts of nickel and antimony. Asbestos also occurs in small veins.

There are numerous references in literature to this area but the most comprehensive reports are those of Rands (1886c, 1892) and Denmead (1945a,b). Other references are given by Denmead (1945a).

The succession as determined by Denmead is:

Lower Esk Series = Kinbombi Boulder Beds [Neara Series], andesitic boulder beds, tuffs, lavas, sandstones, shales and conglomerates.

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Granite

Serpentine and diorite [? including porphyrite of Rands].

Metamorphics, phyllite, jasperoid and chert.

A basalt at Black Snake mapped by Rands as Miocene is regarded by Denmead as at least as old as Neara but probably older still and part of the metamorphics.

Evidence of the age of the metamorphics is scanty but they resemble generally the Brisbane schists; and judging from the rock types present, at least the upper part of that group—the Fernvale Series—and probably more is represented.

The age of the Fernvale Series is Upper Silurian (see Bryan and Jones, 1946, pp. 26, 85, table H), so that the age of the metamorphics may be stated tentatively as Silurian and older. The serpentine may be regarded as Late Devonian in age in conformity with that of the Rockhampton district; of the granite it can only be said definitely that it is post-Devonian and pre-Triassic, but as granites are not known to have been intruded at the same time as the serpentine it is probably of late Permian age.

It is difficult to reconcile the mapping of Rands with that of Denmead, and the former failed to recognize the sandstones, etc., of the Neara Series, as a series distinct from the metamorphics, but careful reading of his and Denmead's reports makes it clear that the ores can be divided into two groups—ores of gold, silver, copper,* manganese, cobalt, arsenic, lead, zinc, nickel and antimony which occur only in the metamorphics, serpentine or diorite (or in the case of copper, in basalt); and mercury ores which occur in phyllite, chlorite schist, serpentine, granite, andesitic rocks, sandstone, shale and conglomerate, in fact in strata of all the series present. This division immediately suggests at least two periods of mineralization of which the earlier was pre-Neara Series.

The manganese and cobalt at Mt. Coora and Mt. Cobalt near Black Snake occur as small irregular masses and nodules of cobaltiferous wad in a lode traversing serpentine. The ore is rich in both cobalt and manganese, but quantities available are small (Dunstan, 1917, p. 704;

* Mercurial tetrahedrite was recorded in small quantities from one lode, but this does not materially affect the general division into two groups.
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Jackson 1901b, p. 16). But Rands (1886, p. 5; 1887) and Dunstan (1913, p. 763) described a cobalt-bearing lode at Mt. Coora (possibly identical with the one above) as being interlaminated with brownish jasperoid quartzites and slates. If the latter description is correct, it together with the manganese lode in slates, quartzites, cherts and jaspers, noted by Denmead (1944b, p. 98), strengthens the correlation of the metamorphics with the upper part of the Brisbane schists, for manganiferous horizons (probably replacements) are common in the lower part of the Fernvale Series and upper part of the Neranleigh Series. Denmead (1944a) speaks only of the serpentine being superficially silicified and stained with manganese oxide.

The cobalt-manganese lode is closely associated with a well defined lode of low grade garnierite and this recalls the abundant occurrence of garnierite in serpentine and peridotites in the Thio district of New Caledonia. It is probable therefore that the nickel, cobalt and manganese of Black Snake were introduced at the same time as the serpentine.

The gold, silver, copper, lead, etc., ores occur in all rocks older than the granite and it is possible that they originated with the intrusion of the latter; but the close association of some of the lodes with serpentine and the occurrence of the metals in serpentine in the Rockhampton district (see below), where no granite is associated and their genetic connection with the serpentine is quite clear, suggest a similar relationship here.

As pointed out by Denmead (1946a, p. 15), most of the mercury deposits of the world occur in association with Tertiary volcanics or, more rarely, intrusives. The main exceptions are the great deposits of Almaden, Spain, which occur as replacements in sandy beds in Silurian slates, and those of New Almaden in California where they occur at the contact of serpentine with cherts and sandstone (? Jurassic). This immediately raises the question whether the Kilkivan deposits were introduced by the serpentine, by tertiary volcanics now removed by erosion, or by the volcanics of the Neara Series.

The fact that the cinnabar-bearing lodes occur not only in the serpentine, but in almost all the considerable variety of rocks in the area, often some distance from the serpentine and in some cases in rocks of later age than the serpentine, rules out the latter as the parent rock.

The nearest tertiary volcanics are those at Goomeri, about 15 miles to the south-west. Reid (1925, p. 90) points out that these occur at high levels, and are the almost unbroken continuation of those of the Darling Downs and therefore of late Tertiary age (Lamington Series of Pliocene age, see Bryan and Jones, 1946, p. 73). At first sight volcanic rocks of this age seem preferable as the parent rock to the only alternative—volcanics of the Neara Series. Denmead (1946a, p. 15) supports this view but points out the objection that it is in areas not only of Tertiary vulcanicity but also of Tertiary orogeny that most mercury deposits are found, whereas the basalts of the Lamington Series were poured out mainly on the peneplained surface which was developed following the Miocene orogeny. The small mercury deposits of Monsildale are discussed below (p. 50). Reference to that section will show that ore again occurs in volcanics of the Neara Series. It is surely more than a coincidence that these two mercury deposits, the most noteworthy in the State, occur in or in association with basic volcanics of different developments of the same series. It is better to regard them as having a genetic connection with these old but still existing volcanics than with Tertiary volcanics that may have existed in the past but which have since vanished.

Ball (1914b) recorded twelve reported occurrences of cinnabar (lode and alluvial) in Queensland. Of the records of lodes he regarded only two besides Kilkivan as not open to doubt: those of the Little River and of O.K. in the Mitchell River district. One other—Monsildale—has since been confirmed.

Ball (1910b) reported on the occurrence at Little River showing that small quantities of cinnabar occur in andesitic lavas interbedded in metamorphics of unknown age but presumably older than the Permo-Carboniferous coal measures. Little is known of the occurrence at O.K., but Ball (1914b, p. 629) quoted a letter from Mr. H. G. Stokes as saying that the cinnabar occurred along a crush zone in a basic dyke, but no clue as to the age of the dyke is given.

Neither of these falls into line with those at Kilkivan and Monsildale, but both occurrences are very small and that at Little River in particular would appear to need further investigation in the light of our more recent knowledge.

The Serpentine Belt.

The intrusion of the serpentine, which is found intermittently from north of Rockhampton to Ipswich, brought with it several minerals of economic importance—chromite, asbestos and gold, and probably also copper, cobalt, nickel and manganese, though in few cases is both the quality high enough and the quantity large enough for the deposits to be of importance.

The gold, cobalt, nickel, copper and manganese of the Kilkivan area have already been mentioned above. Chromite also occurs in this area (Dunstan, 1916, p. 421) in the form of small irregular masses in the serpentine, as is also the case at Pine Mountain, north of Ipswich. In the Rockhampton district the serpentine outcrops north and south of Cawarral, at Canoona and northwards, to the south of Princhester and the west of Marlborough. Chromite occurs in all these outcrops, in some cases as irregular masses through the serpentine, in other cases as lodes. The most important occurrence is at Elgalla, 3½ miles south-east of Tungamull. Here (as is also the case at Balnagowan) the lode has a porphyrite dyke as one wall and in one place chromite occurs in the dyke itself. Ridgway (1943, p. 37) considers that the chromite is a magmatic segregation and that the dyke was intruded along a line of weakness between the chromite and the serpentine. In the same area, the serpentine also contains asbestos, as is the case too at Pine Mountain near Ipswich, at Mt. Pring near Bowen, and many other localities.

The first discovery of gold in payable quantities in Queensland was at Canoona. Of this Daintree (1870a) said "it is proved that the gold exists in the rock mass [serpentine] itself," and Dunstan (1913, p. 178) described the gold at Oaks View, 45 miles north-west of Rockhampton, as being finely disseminated in belts or zones of the serpentine; while the country is mainly quartzites and schists, all the shafts are in an auriferous, quartz-veined, decomposed serpentine (Ball 1905). Serpentine is also the country rock of the auriferous lodes at Mt. Wheeler on the Cawarral gold field (Jack, 1886b, p. 59).

It is clear, then, that the serpentine was responsible for quite extensive though not very rich mineralization by means of hydro-thermal solutions, in addition to the magmatic segregation of chromite.

The age of the intrusion of the serpentine was suggested by Ridgway (1943, p. 37) to be Carboniferous or later, as it is intrusive into fossiliferous calcareous grits near Balnagowan. The fossils—gastropods and lamellibranchs—are, however, indeterminable and the age appears to be fixed as earlier than suggested by Ridgway by the fact that it is intrusive into the Middle Devonian (Etna Series) at Mt. Etna and Upper Devonian Sediments at Canoona (Bryan and Jones 1946, p. 4 and table K), while it does not disturb the Rockhampton Series of Lower Carboniferous age.

The serpentine of the Great Serpentine Belt of New South Wales has usually been regarded as at least as young as Carboniferous (Benson 1915, p. 620; 1917, p. 227; David, 1932, p. 63), but in view of the evidence in favour of a Late Devonian age in Queensland the possibility of a similar age for the New South Wales occurrences should be considered. The serpentine, with very few exceptions, follows the line of faulting which separates the highly disturbed lower Palaeozoic rocks on the east from the less folded Devonian and younger rocks on the west (Benson, 1915, p. 585; 1917, p. 233 and map). There is abundant evidence of faulting of the Carboniferous strata, and the fault which the serpentine follows has been classed with these, and the further deduction drawn that the serpentine was forced up the fault and is thus at least as young as the fault.

But two other possibilities should be considered: first, that the serpentine was faulted down, with the older palaeozoic rocks, against the Carboniferous strata, and second, that the serpentine was intruded along a pre-Carboniferous fault and that there was renewed movement along the fault in Carboniferous times. In either case the serpentine could be of Late Devonian age.

The serpentine invaded the Devonian Limestones and other sediments but in only a few doubtful cases has intrusion into Carboniferous rocks (for example, Benson, 1917, p. 241) been described. Such occurrences need re-examination in the light of the Queensland evidence.

Charters Towers.

It was felt that a short description of this field, in the past one of the major gold producers of the State, should be included in this paper, though little can be added to the comprehensive report by Reid (1917) and the excellent summary by Morton (1930, pp. 281–284): the former includes a complete bibliography.

Briefly, the rocks consist of pre-Devonian, unfossiliferous schists, slates, phyllites, quartzites and altered limestone. Jack (1879, p. 15) showed these and their metamorphism to be pre-Devonian, since pebbles and grains of the already metamorphosed rocks form the material of Devonian conglomerates and sandstones about eight miles to the north.

Reid (1917, p. 53), judging by the degree of metamorphism, suggested that they are at youngest of Cambrian age. Bryan (1926) and Bryan and Jones (1946, p. 14 and table E) regarded them as Pre-Cambrian. The metamorphics were invaded by granodiorite and dykes ranging from porphyrite to aplite. Lying on the granodiorite and made up of its debris are small areas of ? Tertiary lacustrine sediments.

Two sets of fault fissures, an earlier N.-S. set and a later E.-W. set, in the granodiorite, were filled by the auriferous quartz reefs. The mineralization is thought to have been connected with the intrusion of two series of diorite-porphyrite dykes, late members of the intrusive complex, formation of which began with invasion by granodiorite. The age of the dykes and consequently of the mineralization cannot be definitely fixed more closely than as post-metamorphics and earlier than ?Tertiary. Sixty miles to the north-east, near Townsville, Ball (1906b) found pebbles of granite in the Permian coal measures, while on Magnetic Island Gibb Maitland (1892) found the granite to be later than the Permian volcanics, indicating two granites, one pre-Permian, the other as young as at least Late Permian. A pre-Permian age is supported for the Charters Towers igneous complex by the fact that it lies well to the west of Reid's (1930b) and Carey and Browne's (1938) Hunter-Bowen overthrust, that is, to the west of the area of Late Permian diastrophism. The only certain evidence of post-Lower Carboniferous mineralization to the west of this area is that at Argentine, forty-five miles to the north of Charters Towers. Here the only granite (and the only plutonic rocks) is pre-Devonian. It differs from Charters Towers and from all the Late Permian-Middle Triassic mineralization, in apparently being genetically connected with a basic hypabyssal intrusive. Charters Towers is therefore placed in the Herberton Epoch.

The Cooktown District Tinfields.

The most comprehensive report on these fields (Annan River Tinfield and China Camp) is that of Saint-Smith (1916). This work contains a full bibliography.

Metamorphosed sediments, slates, shales, tuffs, agglomerates, quartzites, sandstones, etc., were invaded by granite and acid dykes and by diorite, quartz diorite and associated dykes. Much later, basalt flows of limited extent were poured out and later still stanniferous alluvial deposits were formed from weathering products of the earlier rocks. These latter were, and are, the most important source of tin ore, but lodes, carrying in places rich tin ore, were formed, either within the granite, or in the metamorphics close to the granite, at several localities. These lodes and their mineral association have been briefly discussed above (p. 23).

There is no fossil evidence of the age of the metamorphics, and Cameron (1907) and earlier writers did not assign them or the granites to any particular age. Ball's sections (1910a, p. 9) show similar stanniferous granite intrusive into metamorphics but not into the Jurassic Laura Series. Saint-Smith (1916, p. 10) placed the metamorphics as ? Permo-Carboniferous on lithological resemblance to the metamorphics of the New England District of New South Wales, and placed the granite in the same period, but slightly later than the metamorphics. Jensen (1923, p. 15, map p. 72) equated the metamorphics with his very much older Etheridge Series.

Correlation on lithological grounds of areas so widely separated as Cooktown and the New England district is extremely unsafe, and although such a correlation is supported by the similarity of the lodes and mineral association, the view is here put forward that, as the Cooktown fields, like the Charters Towers field, lie well outside the area affected by the Late Permian folding, the mineralization probably took place during the Herberton Epoch, when diastrophism affected a greater part of the state.

Copperfield.

At Copperfield, five miles south-south-west of Clermont, and in the belt of country running north-west and south-east, copper- and gold-bearing lodes, some of which were very rich, occur in micaceous schists. These dip to the south and south-west beneath a number of lenses of limestones with Middle Devonian corals, on Douglas and Drummond Creeks. Rands (1886d) gave a good description and plan of the reefs. Reid (1944) referred to the old appearance of the schists but regarded them as an extension of the less metamorphosed Clermont slates, the bedrock of the Clermont auriferous leads. Dunstan (1901, pl. 1) regarded them as unconformable with the overlying Devonian.

Without further evidence it is difficult to determine the age of mineralization; but if Reid's view is correct, as seems probable, the age is post Pre-Cambrian, and, as the reefs lie far to the west of the limit of Permian diastrophism, the mineralization may reasonably be referred to the Herberton Epoch, as suggested by Reid (1933).

The source of the mineralizing solutions appears to have been the limited number of quartz porphyry and porphyry dykes which invaded the schists.

MINERALIZATION DURING THE GYMPIE EPOCH (LATE PERMIAN—TRIASSIC).

Late Permian (or Late Permo-Carboniferous) time has for long been regarded as the greatest metallogenetic epoch in the geological history of Queensland. But from what has been written above it is clear that of the North Queensland deposits formerly assigned to this epoch some are to be placed definitely and others tentatively in the Herberton Epoch. It is proposed to call this Permian-Triassic epoch, which remains of great importance, the Gympie Epoch.

An examination of the evidence bearing on the age of the remainder of the North Queensland ore deposits and others elsewhere in Queensland, which are usually placed as Late Permian, shows that, while it is usually possible to fix Permian as a lower limit to the age of mineralization, it is rarely that an upper limit can be fixed with certainty, on account of absence or limited development of younger rocks in the particular area.

On the other hand Andrews (1908) suggested that the mineralization extended into the Triassic period, a view which is supported by the mineralization in the Neara Series (which is probably as old as Lower Triassic) at Monsildale, mineralization in rocks which in one characteristic at least—the abundance of andesitic types—are more akin to those of the Tasman geosyncline than to the succeeding deposits of the Mesozoic lakes. Further, the silver-lead mineralization at Indooroopilly is connected with dykes which are probably Middle Triassic in age, and the gold mineralization at Cracow, Tansey near Goomeri, and North Arm presents a close parallelism with mineralization at Indooroopilly, so that these deposits appear to represent the last flickers of activity of this long metallogenetic epoch.

While the earth movements which marked the close of the Palaeozoic era in Queensland have been regarded by some (Bryan, 1926, p. 30) as epeirogenic rather than orogenic, Reid (1930b) has shown that a broad coastal belt was involved in late Palaeozoic folding. Richards and Bryan (1925) showed that extensive block faulting also occurred, so that compressive forces were followed by tension.

This orogeny, that with which the mineralizing intrusions of the epoch were associated, did not affect the whole area of the Tasman geosyncline, but was confined to the coastal part of it. The line which marks the western limit of the orogeny was suggested by Carey and Browne (1938, fig. 1) to be a continuation of the line, defined by overthrusting, marking the western limit of diastrophism of Permian sediments in New South Wales. While overthrusting has not been demonstrated in Queensland, the line in this State is that shown by Reid (1930b; map facing p. 96) as the western limit of folding of Permian strata. This most important line may also be taken as the western limit of mineralization of the Gympie Epoch. Mineral fields to the east of it may be either older or younger than "Gympie," but fields to the west are unlikely to be younger than "Herberton," for no orogeny and hence little intrusive activity occurred to the west after "Herberton" times.

As the orogeny with which the late Cretaceous granites and their attendant mineralization were associated was confined to the south-east portion of Queensland, mineralization produced by igneous rocks to the west of this area, which are intrusive into Permian rocks, but which do not come into contact with younger series, may reasonably be regarded as Late Permian.

The mineralization at Monsildale is of two types—gold and silver-lead ores associated with the granitic intrusions and small quantities of mercury associated with andesites. The lodes of the first type occur both in Palaeozoic rocks and in the Neara Series, showing that the granitic phase of the Gympie Epoch continued at least to the end of Lower Triassic times.

This long epoch may be divided into three phases each characterized by association with a different type of igneous activity:

A. Mineralization genetically connected with granitic intrusions in Late Permian or Triassic times, which in turn were related to the diastrophism of that time. This phase is the most important of the three and I therefore suggest for it the same name as for the epoch—the Gympie phase.

Included here are the Stanthorpe–Silverspur area, the Mt. Morgan–Moonmera area, Gympie, the Mt. Shamrock–Mt. Biggenden Area, Argentine, the mines of the Mackay hinterland, Sellheim, Mt. Flora, Collaroy and Carmila, and Monsildale (in part). All these, with the exception of Argentine, are within the area to the east of Carey and Browne's (1938) Hunter-Bowen overthrust and the area of Late Permian–Early Triassic diastrophism. Granitic intrusions were as late as Middle Triassic (as at Monsildale).

The metals introduced included gold, silver, copper, lead, zinc, tin, cobalt, bismuth and manganese.

B. Mineralization genetically connected with the Lower Triassic andesitic volcanics of the Neara Series or its equivalents—the Kilkivan phase. The areas placed here are Kilkivan and Monsildale (in part) and the metal introduced was mercury.

C. Mineralization genetically connected with acid dykes whose source was common also to acid tuffs and volcanics of Middle or Upper Triassic age. For this I propose the name Indooroopilly phase.

Areas included here are Indooroopilly, Cracow, Tansey near Goomeri, and North Arm. Metals introduced included gold, silver and lead.

The Stanthorpe District.

In this area a complex granitic batholith invaded Palaeozoic sediments and the later phases of the intrusion introduced ores of tin, wolfram, molybdenite, gold, silver, zinc, copper and arsenic. Around Stanthorpe itself the ores are predominately those of tin, molybdenum and tungsten, the first of these being largely alluvial and probably derived from the breaking down of innumerable cassiterite-bearing veinlets and stockworks, as few lodes of consequence have been found. The batholith is, however, of great extent (extending indeed to the south over a large part of the New England plateau); and at and near its junction with the metamorphics to the west lodes were developed carrying cassiterite and copper, as at Sundown and Redrock, gold, silver, copper, lead and zinc, as at Talgai, Pikedale and Thane's Creek, and silver-lead-zinc ores, as at Silverspur. To the north-east rich alluvial gold was found on the Lucky Valley goldfield but few reefs of value have ever come to light. The area included here under the heading, The Stanthorpe District, stretches therefore from a little south of Warwick, southwards to the New South Wales border and westwards almost to Texas.

The most comprehensive report on this area is that by Saint-Smith (1914). Within the batholith Saint-Smith distinguished six plutonic types, of which two were earlier than the Permo-Carboniferous sediments. The sequence of intrusion was in general in order of increasing acidity culminating in rhyolite, quartz-felspar-porphyry, quartz porphyry and aplitic dykes and greisen seams. There are also dykes of diorite, mica lamprophyre, basalt and dolerite which Saint-Smith provisionally referred to the Tertiary.

Saint-Smith (1914, pp. 26-27) found that the lode tin, the tungsten, molybdenite and bismuth ores are in the main confined to the greisenized veins, late members of the sequence, and that the silver-lead-copper veins occur in association with quartz-felspar-porphyry dykes of about the same stage, while Ball (1904, pp. 21-24) described the latter as impregnation and replacement of the dykes. Ball (1918, pp. 24-26) agreed with Skertchly (1898, pp. 89, 90) that the ores at Silverspur were formed in fracture zones produced in the final stages of the intrusion of the Stanthorpe granite, which, although it does not outcrop within some miles, is probably not far below the surface, and that they are the result of replacement; but he did not regard the ore bodies as concordant with the bedding, as did Skertchly.

All workers agree that the ores originated from the last phases of the granite batholith. Skertchly (1898, p. 7) regarded the granite as all of one age, younger than the Gympie Beds (Permian) and older than the "Ipswich Beds." Saint-Smith (1914, pp. 17-18), in part as the result of field work in the New England district, while an officer of the Geological Survey of that state was able to subdivide the granite into five phases, all of which he regarded as probably Mesozoic in age; and the last two phases, those most concerned with ore genesis, he placed as probably late Mesozoic (pp. 26, 34). Bryan (1915, p. 158) concluded that the coarse-grained acid granite—the "Stanthorpe granite"—was probably late Permo-Carboniferous. Ball (1904, 1918) considered the whole batholith simply as Post-Permo-Carboniferous. Richards and Bryan (1925, p. 76) referred the Stanthorpe granite to the Permian.

But in considering the age of the batholith it is necessary to consider also that larger part which lies in New South Wales. Discussing that area David (1914, p. 257) placed the intrusion as Permo-Carboniferous and (1932, p. 139) as late-Permian, Andrews (1914, p. 510) as Permo-Carboniferous and (1905, p. 113; 1908, p. 6) as early Mesozoic, Carne (1911, map) as early Mesozoic (?).

The lower limit of the age is not difficult to fix approximately. In the Silverwood–Lucky Valley area, while the Fault Block Series (Permian, possibly Lower Permian; see Bryan and Jones 1946, p. 42 and table N) is nowhere intruded by the granite, the Stanthorpe Road Block contains small veins of tourmaline and quartz very similar to one phase of the marginal modifications of the granite; at Silverspur the metalliferous sediments contain Permian (probably Lower Permian) fossils* and in the New England district the granite invaded "strata high up in the Permo-Carboniferous" and appears also "to cut clear across the folding of the series" (Andrews 1905, p. 113). All this evidence points to Late Permian as the oldest possible age.

The determination of the upper limit is more difficult. In the Silverwood–Lucky Valley area the evidence is in favour of the granite being pre-Walloon Series and possibly pre-Triassic, for while fossiliferous Walloon strata nowhere rest on the granite, patches near the granite show no heat effects and in the Cherry Gully area unfossiliferous beds which may be Walloon (but may be younger) rest on an eroded surface of the granite (see also Andrews 1908, sections facing p. 11), while just to the north of Silverwood railway station there are sediments, which, while not in actual contact with the granite, are from their attitude and structural characters almost certainly post-granite, and which Dr. A. H. Voisey stated, on a recent trip through the area, to be, in his opinion (on lithological grounds), equivalent to the Narrabeen (Lower Triassic) of New South Wales.

Further south, in the Drake–Tabulum area, Andrews (1908, p. 5) regarded the Clarence Series (Jurassic) as resting on old granite surfaces. Richards, Bryan and Whitehouse considered that the road sections at Kettle's Lift (between Tabulum and Drake) showed the granite as intrusive into the Clarence Series. Later Madigan and Aldermann (in letters) urged that the Clarence Series rests unconformably on the eroded granite surface. After a further visit Richards

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* Reid (1930, p. 58), however, suggested an Upper Carboniferous age for these rocks.

and Bryan considered the evidence inconclusive. At a later date I had the opportunity of examining the old sections and also some new ones. I summarized the evidence as follows:

In favour of the granite being intrusive into the Clarence:

1. It sometimes cuts conglomerate, sometimes shales and sometimes sandstone.
2. In several places the Clarence strata show quite sharp dips towards the granite and end abruptly against it, while away from the granite the beds are horizontal.
3. The shales in contact with the granite appear slightly baked.

Against the granite being intrusive:

1. Granite pebbles occur in the conglomerate.
2. The granite in contact with the Clarence Series is quite coarse-grained.
3. In several places the granite clearly consists of boulders, suggesting an eroded surface.

Thus the evidence, as it stands at present, is conflicting, but, I think, rather favours the view that the Clarence Series rests on the eroded granite surface. Due weight must, however, be given to Andrews' argument (1908, p. 6) that, as the early phases of the batholith are intrusive into the Permo-Carboniferous and as there are several phases, the late phases must be at least extremely late Permo-Carboniferous, possibly early Mesozoic.

While the evidence regarding this huge batholith is inconclusive, there is conclusive evidence in the Monsildale area of Queensland that plutonic intrusion and metallogenesis continued into at least Lower Triassic times. This will be referred to in detail below. There are also a number of granitic intrusions along the western margin of the D'Aguilar horst which may repay study, for this is an area within which the Lower Triassic Neara Series is known to occur.

Saint-Smith (1914, pp. 18, 22, 134-135) emphasized the association of some of the gold, silver, lead, zinc and copper deposits with dykes of diorite, mica-lamprophyre, basalt, dolerite, etc., e.g., the silver-lead-zinc ores at Silverspur. He considered that the genesis of the ores was in many cases connected with the intrusion of these dykes. He regarded the granitic intrusions as continuing throughout the Mesozoic and the dykes as their final stage and also as probably related to the Tertiary basaltic effusions of northern New South Wales; he therefore placed them and the associated ore deposits as ?Tertiary.

If, however, the intrusion of the batholith was complete soon after the close of the Palaeozoic, its final phase, the intermediate dykes and associated ores, could not have been much later; a view shared by Andrews (1905, p. 119; 1908, p. 6).

The Mt. Morgan—Moonmera District.

The succession and age of the strata, the genesis of the rich gold and copper ore of this district and the period at which they were formed have all been subjects of great differences of opinion.

Jack (1884, p. 3; 1889b; 1892b, p. 598; 1898b, pp. 17-20) described the succession as metamorphic rocks (quartzites with dolerite and rhyolite dykes, shales, greywacke and limestone) with Permo-Carboniferous fossils, overlain by horizontal "Desert Sandstone." Gregory (1885) said that the general geological features are those of a granitic anticlinal axis, with thick beds of serpentinous rocks and altered slates of the Devonian period resting on the flanks, while horizontal sandstones of Mesozoic age are found capping some of the hills and ranges. J. M. Cameron (1887; quoted in Jack 1889b, p. 5) described the mountain as a network of quartz veins traversing a metamorphosed matrix of somewhat argillo-arenaceous composition and what appears to be a felspathic tuffaceous igneous rock. Wilson (1908) followed Jack. Newman and Campbell-Brown (1910, pp. 268-9) set out the following as the succession of events: (1) The oldest rocks are quartz porphyries, felsites and associated limestones. (2) Intrusion of numerous basic dykes and laccoliths. (3) Intrusion of hornblende granite and mineralization of 1 and 2. (4) Intrusion of 1, 2 and 3 by dykes of andesite, dolerite and diabase. (5) Denudation and deposition of lower Mesozoic conglomerates, fire clays, sandstones and ? volcanic ash and enrichment of the ore by descending waters. (6) Denudation, oxidation of the surface ores and secondary enrichment of the underlying ore. (7) Faulting at some time subsequent to the ore formation. Hart (1912), in a paper with the best published geological map, dealt with a wider area than Newman and Campbell-Brown and considered the rocks of the area to be: granite, porphyries, "blue older basic rock," banded jasper and allied rocks, andesitic and volcanic ash, metamorphics, limestones, dykes, and lower Mesozoic sedimentaries. He was uncertain of the age of several of the groups but showed the porphyries to be intruded by the granite and both these together with some of the limestones he placed as older than the volcanic ash, which he regarded as Carboniferous on the evidence of a few poorly preserved fossils from Struck Oil about 5½ miles to the north-east. He regarded most of the dykes as younger than these but older than the "lower Mesozoic" sandstone. He pointed out that at Struck Oil, the mineralization was later than the volcanic ash while at Mt. Morgan it is earlier than the "lower Mesozoic" sandstone.

Fraser (about 1931) said the sedimentary rocks are: (*a*) felspathic grits and shales; (*b*) close-grained cherty rocks; (*c*) agglomerate with fragments of (*a*) and (*b*); (*d*) crystalline limestones and quartzitic replacements after limestones; (*e*) laminated fine-grained sediments, probably volcanic ash laid down in water; (*f*) fire clay of Mesozoic age. The igneous rocks in order of age from oldest are: (*a*) andesite intrusions, flows and breccia (younger than the bulk of the felspathic grits); (*b*) older dolerite, etc.; (*c*) granodiorite (quartz-augite-diorite); (*d*) younger quartz andesites, quartz dolerites and dolerites forming masses and dykes.

Fraser's sedimentary groups (*a*), (*b*), and (*c*) are the porphyries of Hart and of Newman and Brown and were included in the metamorphics of Jack and of Cameron. Fraser definitely asserts they are of sedimentary origin and considers that the limestones demonstrate them to be of marine origin. Jack regarded all the igneous rocks as later than all the metamorphics as did Newman and Campbell-Brown though the latter split them into three successive groups. Colin Fraser places exactly only his first group, which he regarded as intrusive into his sedimentary groups (*a*), (*b*), and (*c*). His granodiorite is presumably the hornblende granite of Newman and Campbell-Brown.

In 1930 (pp. 284–289) Morton gave an excellent summary of the available information, pointing out that the oldest rocks are felspathic grits, shales, cherts and breccias, called quartz porphyry tuffs by Fraser, greywackes and quartzites by early workers, and quartz porphyry and felsite by Newman and Brown. These were invaded first by basic laccoliths and dykes and then by hornblende granites (diorite to granite) which introduced the ore. All were in turn invaded by basic dykes, faulted, uplifted, eroded and followed by deposition of Mesozoic sediments. Morton regarded the oldest rocks as Lower Carboniferous or possibly Devonian, the lacustrine sediments as Lower Mesozoic, and the age of the mineralization as between these two times.

It is clear from the above that the area is one of considerable complexity, that there has been no agreement on the succession or even on the rock types represented, and that detailed mapping is an essential to the understanding of the geology of the area.

The determination of the exact age of the strata containing the deposit is also a matter of difficulty. Jack (1889b, 1892b, 1898b) referred to the country rock as containing abundant Permo-Carboniferous fossils. Gregory (1885) suggested Devonian. Others refrained from assigning them to any particular period.

The fauna has been described by Etheridge (1892) and Mitchell (1918). Etheridge described *Phillipsia dubia* Eth., *Spirifera* sp. ind., *Productus ?longispinus* J. Sby., *Naticopsis ?harpaeformis* Eth. and *Murchisonia carinata* Eth. from the Don River. Etheridge and Dun (1909, p. 303) described *Productus ?solida* from the Darr (Don ?) River.

Mitchell, dealing only with trilobites, placed *P. dubia* Eth. from the Don River in *Griffithides dubius* Eth. Senr. From Crow's Nest near Mt. Morgan he described *Phillipsia grandis* Eth., and *P. woodwardi* Eth. and from Trilobite Ridge, Mt. Morgan, *P. woodwardi* and *P. morganensis.*

This list is short and not conclusive. *Phillipsia,* for long regarded as a typical Carboniferous genus, is now known in the Permian. The locality of *Productus ?solida* is doubtful, but Dr. Dorothy Hill, who has examined the specimen, states that it is identical with *Terrakea solida* from the Permian of Mantuan Downs. Reid (1930, p. 33) considered it unsafe to use the list from the Don River in compiling faunal lists, as the locality is somewhat doubtful. From our present knowledge of the fauna it may be either Carboniferous or Permian.

Hart (1912, p. 5) referred to a small collection of fossils from Struck Oil, determined by Etheridge as Carboniferous. The exact locality is uncertain and the list quite inconclusive as to age. Devonian limestones are known at Struck Oil, but rocks of Carboniferous and possibly Permian age also occur as well, as shown by recent collections by officers of the Geological Survey. Thus the surrounding country is a Palaeozoic complex containing rocks ranging from Devonian to Carboniferous and possibly to Permian.

The upper limit of age is equally difficult to fix. Overlying the older formations and not intruded by any of the igneous rocks is a series of almost horizontal sandstones, fire clays and ? volcanic tuff. Jack (1884, p. 3; 1889) included this in the "Desert Sandstone" and placed it as Tertiary and (1898b, pp. 17, 18) as Cretaceous. Gregory (1885) regarded it as Mesozoic. Newman and Campbell-Brown (1910, p. 276) refer to fossil plants in it, identified "by various writers" as *Alethopteris australis* [*Cladophlebis australis*], *Thinnfeldia indica* [*T. lancifolia*] and *Vertebraria media.* The last is almost certainly incorrect, probably simply woody tissue. Of the two former I can find no record in the literature unless they be those recorded by Dunstan (1904, p. 15) from white tuffs interbedded with Mesozoic Coal Measures about a mile N.W. of Moonmera railway station. These coal measures Dunstan regarded as being on the edge of the basin of the Stanwell coal measures and equivalent in age to them. The age of the latter has recently been shown to be early Cretaceous (Bryan and Jones, 1946, p. 60 and table S; Whitehouse 1947). Dunstan (1898a, section, pl. 1) showed the Stanwell coal measures as capped by ''Desert Sandstone,'' the latter extending as far south as the Razorback Mountains just to the north of Mt. Morgan, but in his report on Moonmera (1904, pp. 9, 15) he definitely included the ''Desert Sandstone'' as part of the coal measures. It seems likely, therefore, that the sandstones, etc., overlying the metalliferous rocks at Mt. Morgan, which are lithologically similar and not far distant, are also early Cretaceous.

On the present evidence, therefore, the age of the ore formation at Mt. Morgan and Moonmera lies between Carboniferous and early Cretaceous. The only known metallogenetic epoch within these time limits is the Gympie Epoch, and it is, therefore, probable that the Mt. Morgan deposits are of that age.

Several different theories of the origin of the ores have been put forward at various times. Jack (1884), seeing at that time only the botryoidal and stallactitic auriferous ironstone and the siliceous ''sinter,'' considered it to be a deposit from a huge thermal spring. Gregory (1885) thought the deposit to be a ''true metalliferous vein.'' Cameron (quoted in Jack, 1889b) considered that the gold occurred in groups of quartz veins formed before the metamorphism of the slaty rocks into quartzites. Jack (1889b, 1898b) criticized Cameron's view and restated his theory of formation from a geyser. Wilkinson (1892, p. 211) supported Jack, but thought that the deposit accumulated in cavities and cracks rather than as the direct overflow of a geyser. Dun (1905, pp. 344–5–6, 353) writing when the sulphide ore had been exposed, arrived at no conclusion on the ultimate origin of the ore but thought that the secondary ores, and the ''sinter,'' the ironstone and the kaolin ore, could all be accounted for by deep oxidation and leaching of the original surface ore. Wilson (1908) considered it to have none of the features of a lode formation—a deposit formed along a fissure—but thought its origin to be from ascending mineral-bearing solutions which silicified the sedimentaries into quartzites and replaced the original constituents by iron sulphides and associated copper sulphides and gold, followed by oxidation and leaching of the outcrop. He was, however, unable to account for the sharp boundary between the primary ore and the country rock. Newman and Campbell-Brown (1910, p. 269) thought the mineralization was produced by solutions from the hornblendic granites which were intruded into the older rocks, followed by enrichment by descending solutions, surface oxidation and leaching. Hart (1912, p. 9) considered that further work was needed to determine the origin of the ores. Emmons (1940, p. 229, fig. 171 on p. 225) considered the form of the ore body to be that of an inverted cone and classed it as a pipe occupying or replacing the walls of an opening probably formed by expanding gases which blew out a hole in the cover of an underlying cooling mass; but Bateman (1942, p. 449) described it as ''a pyritic stockwork in tuffs.''

This brief historical review illustrates the divergence of opinion as to form and origin of the deposit, the present position being that the theory of origin from a geyser is completely discarded and that most agree that the deposit was formed by hydrothermal solutions of one type or another originating from an igneous magma.

Emmons, however, ascribes a greater part to gases than to hydrothermal solutions and thus suggests formation at higher temperatures. The exact form of the deposit and the mechanism of deposition is still a matter of discussion, but it has recently been confirmed by Mr. G. Whitten and myself that the siliceous "sinter" of the upper levels is in fact a leached outcrop, for careful microscopic examination of the "sinter" shows some of the cavities in the boxwork to have the pyritohedral form of iron pyrites crystals.

Gympie.

The rocks of the Gympie goldfield consist of sandstones, conglomerates, carbonaceous shales, and limestones with interbedded tuffs and diabase. These are the Middle Gympie of Dunstan (1911) which, on the evidence of two fossiliferous horizons, he placed as Permo-Carboniferous; Reid (1930) referred to them as the Monkland Series, the upper part of his "Gympie Formation," and placed them in the Upper Carboniferous. Bryan and Jones (1946, p. 43 and table N) placed them in the Lower Permian.

Although many reports, the more important of which are Rands' (1889a, 1891b, 1895, 1901) and Dunstan's map (1911), deal with this field, little has been written concerning either the genesis of the ore or the period of its formation. An aspect which has, however, been given prominence is that the carbon of the carbonaceous shales, the so-called "beds of slate," precipitated the gold from solution and thus caused the rich ore to be localized where the reefs are in contact with the "slates." There has been difference of opinion whether there are three of four groups of slate beds, but the latest mapping (Dunstan, 1911), shows only three.

The reefs occupy well defined parallel fissures striking approximately N.W.–S.E., with another set of barren fissures at about right angles. The best values were associated with a white opaque quartz with or without crystalline calcite.

Jack (1889a, p. 4) wrote "The presence of sheets of intrusive rocks among the strata perhaps gives the key to the nature of the causes which operated in producing the auriferous reefs," and in 1905 (p. 21) he suggested that the forces which tilted the sediments also produced fissures and that at the same time, or slightly later, magma from a plutonic mass was forced into the bedding planes of the strata and also gave rise to the solutions from which the auriferous quartz reefs were formed. He thus regarded the "greenstones" as intrusive.

There is little evidence to support this view, for apart from a few diorite, dolerite and andesite dykes, most of which occupy N.E.–S.W. fissures, and mostly later in age than the reefs, all the igneous rocks, including the greenstones, are interbedded and in the main tuffaceous (Bryan: unpublished examination of many thin sections). As pointed out by Morton (1930, p. 291) intrusive diorite, dykes and sills are rare within the main productive area. The nearest granite which outcrops is $3\frac{1}{2}$ miles distant, but of course may be much nearer underground, and such a granite or granitic rock is a much more likely source than that suggested by Jack.

At some time after the completion of Permian deposition, tension faults developed to the east and south-east of the Great Bowen syncline, possibly on the crest of a median anticline within the remnants of the Tasman geosyncline of which the Great Bowen syncline was but a part; this faulting was at least pre-Jurassic, for Walloon Sediments overlie the faults in places, and probably pre-Middle Triassic, for neither the Ipswich nor the Esk Series seems to have been affected. It is reasonable to relate plutonic intrusions which invaded Upper Palaeozoic rocks, but not the post-Lower Triassic rocks, to these tensional forces, or to the compressional forces which immediately preceded them; and its seems likely that the Gympie mineralization can be ascribed to a plutonic mass of this age.

''Gympie'' has been chosen to designate the metallogenetic epoch, Late Permian to Upper Triassic, because it is a very well known field and in the past a very rich field, on which the reefs occur in fossiliferous Permian rocks.

Mt. Shamrock—Mt. Biggenden Area.

Reports dealing with this and adjacent areas comprise those of Rands (1886a, 1890b, 1891c) and Ball (1901, 1902b, 1903). The district is a highly mineralized one, mines worked including the Commonwealth Mine near Degilbo, the Mt. Biggenden Gold and Bismuth Mine, the Young Australia Gold Mine and the Mt. Shamrock Gold Mine, with the Old Chowey reefs 5 miles to the north and Gebangle 6 miles north-north-west, while about 8 miles to the north-west is the Paradise goldfield and eleven miles to the north the Stanton–Harcourt field. In these areas mineralization has produced ores of gold (including tellurides), silver, iron, manganese, cobalt and bismuth and a little copper.

The basement rocks of the area are hardened mudstones and slates with interbedded limestone lenses. Permian fossils have been found in limestone $1\frac{1}{2}$ miles east of Mt. Shamrock, between Biggenden and Degilbo; and while, as was pointed out by Ball (1902b, p. 1), this does not prove the whole of the slates to be of that age, the generally similar lithology throughout and the similarity of the mineralization (e.g. bismuth ores (not common associates of gold) occur in the Commonwealth mine, as well as at Mt. Shamrock and Stanton–Harcourt, and gold tellurides occur at Mt. Shamrock, Mt. Ophir, Old Chowey[1] and Mt. Hastings), strongly suggest that the slates are of the one age and were mineralized throughout at the one period.

Granite invaded the slates at Mt. Hastings, Paradise, Stanton–Harcourt, Woowonga Creek, Mt. Biggenden, Havilah and Chowey Reefs, and syenite dykes at Mt. Shamrock. Both Rands and Ball agree that the mineralizing solutions came from the granite. Some of the deposits are pipes, others fill fissures near the junction of granite and slate. The syenite at Mt. Shamrock is older than the mineralization, because in places it is veined with ore (Ball 1901, p. 5). The lower limit of the

[1] Rands (1886a, pp. 3, 4) refers to ''molybdenite'' at both Mt. Ophir and Old Chowey. That at the former is now known to have been one or more of the tellurides and that at the latter was probably telluride also.

age of the granite and thus of the mineralization is fixed as Permian by the age of the intruded slates, but there is no evidence whatever to assist in fixing an upper limit, for the only later rocks are alluvium and Recent basalt flows.[2]

The mineralization can therefore only be placed tentatively as ? Late Permian.

Unusual points of interest about the Mt. Shamrock deposit are that it is a breccia-filled pipe (auriferous pipe deposits are uncommon in Queensland) and the occurrence of tetradymite, the telluride and sulphide of bismuth, as well as gold tellurides in considerable quantity (also rare in Queensland). Such pipes are considered to be formed by the increase in vapour pressure in the early stages of crystallization of a magma rich in volatiles. This sudden great increase in pressure blows out a hole in the cover rocks, usually at the intersection of fractures or incipient fractures. On the thickness of the cover rock and the pressure developed depends whether the diatreme (i.e. the opening formed) will reach the surface and thus become a volcanic vent. A filled diatreme is a pipe. The filling may be brecciated country rocks, acid differentiates from the underlying magma, or igneous rock which in some cases may reach the surface as volcanic flows.

Emmons (1940, pp. 226-227) divided pipes into four classes:

1. Pipes and circles with closely spaced fractures but with little rotation of fragments in the pipes, e.g., Kidston, on the Oaks Goldfield (see Marks 1911 and Jensen 1920).
2. Pipes in which there has been considerable rotation and rounding of the brecciated fragments.
3. Cylindrical shells of ore surrounding brecciated material.
4. Mineralized craters and vents.

The Mt. Shamrock pipe is approximately oval in shape with the longer diameter about 120 feet and the lesser about 70 feet. Ball (1901, p. 5) wrote "The material of the pipe consists of slickensided agglomerate or breccia of the country rocks cemented by silicates, calcite, quartz and powdered rock. Sulphides occur in this cement, sometimes almost to its exclusion. The separate blocks of mudrock forming the breccia are sometimes as much as 10 feet in smallest diameter, but as a rule they are less than 5 feet across and separated by still finer breccia or powder." In places there are large fragments of syenite in the breccia. This description shows clearly that there was much movement in the pipe, causing the slickensiding and grinding to powder, but the blocks and fragments in the breccia are mainly angular with little evidence of rounding by rotation and thus the pipe falls into the first of Emmons' groups. The pipe was worked to the 375 ft. level but prospecting to 450 feet failed to discover deeper mineralization. Kent's Nob, a quarter of a mile to the north-west, is probably an offshoot of the main pipe.

Of the other deposits in the area most appear to be fissure veins, but both Rands (1890b, p. 2) and Ball (1902b, p. 2) refer to the pipe-like form of some of the ore bodies at Mt. Biggenden. Rands,

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[2] These flows—between Biggenden and Degilbo and on the Paradise field (Ball 1902b, p. 8 and map No. 1)—are among the most recent in Queensland, for the rock is so fresh that it is almost devoid of soil, while about 8 miles to the south-west are the Coalstoun lakes—crater lakes.

however, says (1890b, p. 2) that in his opinion the magnetite of this deposit came up in solution, perhaps as hydrated oxide, and was subsequently changed to magnetite; and Ball (1902b, p. 3) regarded the iron as originally a constituent of the slate, but (1903, p. 5) considered it to have been given off by the granite and described the deposit as a "typical contact deposit of the Christiana type."

The Argentine Silver Mines.

The Argentine or Star River Mines are situated about 45 miles north of Charters Towers. The geological succession as determined by Jack (1886a) is:—Steeply dipping schists and gneisses (placed by Jack as older than the Burdekin Beds, i.e. pre-Devonian); granite and, resting in places on the old metamorphics and in other places on the granite, a series of white sandstones, grits and conglomerates with relatively low dips. These latter, although unfossiliferous, Jack equated with the lower part of the Star Series and his section leaves little doubt about the correlation. The age of the Star Series is in doubt. Usually referred to the Lower Carboniferous, Reid (1930, pp. 15, 16 *et seq.*), placed the lower part in the Upper Devonian, a course also followed by Bryan and Jones (1946, p. 32 and table K). The exact determination of its age must await a re-examination of the fauna in the light of increased knowledge since Etheridge's description in 1892. The lodes, carrying argentiferous galena and other lead ores with, in places, some zinc and antimony sulphides, occur in all three formations.

Two questions arise—the source of the mineralizing solutions and their age. With regard to the former definite conclusions cannot be reached. The occurrence of lodes in the Star beds shows that they cannot be genetically connected with the granite, which is older than the Star. The only other igneous rock on the field mentioned by Jack (p. 8) is a fine grained dolerite dyke intrusive into the Star beds. Associated with the dyke is a vein, 3 to 6 inches wide, with lead ores. It is unlikely that this one dyke could be the source of the numerous lodes of the field, but it may be an offshoot from an igneous mass which is nowhere exposed on the field. Apart from the granite, intrusive rocks are very rare not only on the field but also in the surrounding district; Jack, however (p. 1), mentions a porphyry intrusive into the Star beds on the range north-east of Boolangalla (8 miles south-east of Argentine) which might also be an offshoot of such a buried igneous mass.

The lower limit of the age of the mineralization depends on the age of the Star Series, but cannot be earlier than Carboniferous. There is no definite evidence of the upper limit of the age as the Star beds are the youngest rocks in the area, but, being far distant from the area affected by the Upper Cretaceous orogeny, the mineralization must belong either to the Herberton or the Gympie Epoch. If the Star Series is Devonian in age, the former is probable; but if the Star Series be Carboniferous, there is difficulty in deciding between the two epochs, for the exact age of the Herberton Epoch cannot as yet be fixed. If that epoch extended to the Lower Carboniferous, the Argentine mineralization may well belong within it; but if it was Late Devonian then the mineralization must be referred to the Gympie Epoch, although it lies well to the west of the area affected by Permian diastrophism.

It can, then, be included only provisionally in the Gympie Epoch.

Some Other Areas of "Gympie" Mineralization.

Mackay District. Jack (1887b), Gibb Maitland (1889), Dunstan (1901, 1902a), and Ball (1910d) have all described ore deposits in Permian rocks, the mineralization coming from intrusions of diorite or granite. The only younger sediments described were referred to the "Desert Sandstone" and the exact age of these is unknown. Ores of gold, copper and lead were produced.

Some one hundred and thirty miles further west, at the Sellheim Silver Mines, Jack (1889c) has described Carboniferous and Permian beds into which dolerite, granite and syenite were intruded. Lodes carrying silver-lead were formed in the Permian rocks, and carrying silver, bismuth and lead in the granite and syenite.

About seventy miles south-west of Mackay, on the Mt. Flora Gold and Mineral Field, granite and porphyries were intruded into Permian indurated shales and slates. Copper-bearing lodes were formed in the slate and the granite, and Ball (1910c, pp. 11, 12) showed that mineralizing solutions came from both the granite and the porphyry dykes.

At Collaroy and Carmila, about 30 miles north and north-west of St. Lawrence, granite invaded fossiliferous Permian beds and produced lodes with copper, gold and silver-lead (Dunstan 1898b).

On the Rosewood goldfield, about sixty miles west of Rockhampton, the auriferous Caledonian reef in fossiliferous Permian rocks may have a genetic connection with granite some eight or nine miles distant (Rands, 1889b).

In none of these areas is there a definite upper limit to the age of mineralization, but all lie outside the area affected by the Upper Cretaceous orogeny and within the area affected by the Late Permian diastrophism, and may therefore be referred with some confidence to the Gympie Epoch.

Monsildale.

Reports on this area are those by Jackson (1901a), Cameron (1915), Cribb (1937b) and two unpublished memos by Ball (July 1940). This summary also includes information gained on a four day field trip by Dr. W. H. Bryan and myself.

The rocks of the area comprise:—

Post Lower Triassic		Granite, microgranite, diorite and aplite.
Lower Triassic	Neara Series	Shales, conglomerates and andesites.
Upper Palaeozoic probably Permian		Quartzites, cherts, greywackes and shales.
Ordovician?	Bunya Series	Mica phyllites.

The Bunya series is seen on the eastern fall of the Jimna range, where, near the crest, and on the Kilcoy–Louisavale road, indurated shales of the Neara Series rest upon it with a strong unconformity. A little to the west, right on the crest of the range, the shales are intruded by aplite and two miles further west by granite.

The quartzites, cherts and greywackes occupy a narrow strip, apparently little more than a mile wide, running a little west of north. The northern limit of this strip is about $1\frac{1}{4}$ miles north-west of Monsildale mill, whence it extends at least five miles south, the southern limit not having been mapped. On the west it is bounded by the Neara Series, and in R. 225 the junction is seen to be a fault. Probably the eastern boundary is also a faulted junction, but towards the north, in por. 46, Jackson (1901a, p. 531) described conglomerates, which must belong to the Neara Series, lying unconformably on the quartzites.

The Neara Series in por. 24 was invaded by granite and by aplite on the top of Jimna Range, granite intruded the quartzites in por. 11, and the other igneous types outcrop to the north and north-east of Monsildale.

Jackson (1901a) described a silver-lead deposit and Cameron (1915) a gold deposit in the quartzites. Cinnabar occurs associated with andesite and shales of the Neara Series and probably also in some of the older rocks (Ball refers to its occurrence in ''phyllitic shales'' which may be part of the Bunya Series or may be the well-jointed shales which occur with the quartzites and cherts).

Reference has been made above to the occurrence of cinnabar in the Neara Series (and older rocks) at Kilkivan, and the common association of mercury ores with basalts and andesites has also been stressed. It seems likely that both these Queensland deposits originated with the volcanic activity which produced the andesites and andesitic boulder beds of the Neara Series in the Lower Triassic.

The definite evidence that the granite is intrusive into the Neara Series, the association of gold and silver-lead ores with it, and the occurrence of the lodes (in part) in the Neara Series (A. K. Denmead, unpublished report) are important. These facts demonstrate that the ''Late Permian'' igneous activity and its accompanying mineralization extended to at least the end of the Lower Triassic.

The Kilkivan—Black Snake Area.

Mineralization here was in part Late Devonian or Lower Carboniferous and the area has been treated in detail above (p. 33). The mercury deposits are placed in the Lower Triassic.

Indooroopilly.

At Indooroopilly a small but rich deposit of silver-lead-zinc ore was mined some twenty years ago. The more important reports are those by Ball (1920, 1924, 1926). The ore occurred mainly in mica phyllites of the Bunya Series of probably Ordovician age. The ore bodies were genetically connected with rhyolite (''felsite'') dykes which outcrop commonly close to the anticlinal axis marked by the Taylor Range. At Finney's Hill, Indooroopilly, they were intruded into a fractured area and are so numerous as to constitute a dyke swarm (see map, Ball, 1920, p. 267). The ore body was not well defined, being irregular in shape, without any great linear extent but wide, and thus constituted a large pocket rather than a lode.

To explain the shape of the ore body and the intense brecciation of the phyllites in its vicinity, Ball (1920, p. 266; 1924, p. 84) suggested fracturing due to an arching of the strata above a plutonic or hypabyssal intrusion, or alternatively a production of these stresses by a surging ("sucking back, as it were") of the molten magma. The close association of the ore with the dykes leaves little doubt as to their genetic connection.

The evidence as to depth and temperature of formation is not entirely conclusive. The dykes are very fine and even grained, often sills or laccolites rather than dykes and they occur in a swarm, features which suggest intrusion close to the surface. The extensive brecciation of the ore bodies and along the fissures associated with, though not occupied by the ore bodies, also suggests shallow depth. On the other hand Ball (1921b, p. 472) records "a trench . . . opened in schist and interfoliated limestone with light honey-yellow garnet and distinct traces of galena." The garnet suggests high-temperature deposition but is limited in quantity and may be related to the garnet associated with gold at Mt. Coot-tha, which in turn is associated with the Enoggera granite, not with the dykes; alternatively the garnet may have resulted from regional metamorphism, as suggested by Ball. The balance of evidence is in favour of low-temperature deposition at a shallow depth.

As to the age of the dykes and thus the mineralization, the choice is between associating them either with the Enoggera granite or with the Brisbane Tuff, a rhyolitic and largely a welded tuff, at the base of the Ipswich Series. The dykes are not known anywhere to meet either the granite or the tuff. Bryan (1915, pp. 159-160) inclined to the former view, and, on general grounds, placed the dykes and the granite as Late Permian, though the local evidence puts the granite only as later than the Brisbane schists and earlier than the Ipswich Series. Ball (1920, p. 266; 1921a, p. 294) inclined to correlate the dykes with the Brisbane Tuff and in fact traced them to within a quarter of a mile of the Tuff. Mrs. Briggs (1929, p. 159) suggested the possible relationship of the dykes and the Tuff. Richards and Bryan (1934, p. 57) suggested that the swarm of rhyolitic intrusions at Indooroopilly might represent the denuded remnants of dykes which acted as feeders to the vent from which the tuff was ejected. They also suggested a possible connection with a coarse volcanic agglomerate containing fragments of rhyolite, at Upper Brookfield.

Recent field trips have added considerably to our knowledge of the Upper Brookfield volcanics. Rhyolites are an important constituent of the series and within the area is a structure which is almost certainly the rhyolite-filled neck of the volcano from which they were thrown out. Closely associated with this neck, though not actually meeting it, is a large rhyolitic dyke which macroscopically appears identical with the Indooroopilly dykes. This, together with the fine-grained nature of the dykes, which suggests much less cover at the time of intrusion than would be the case if they were connected with the granite, and the fact (Ball 1920, p. 266) that the mineralization was much later than the quartz veins given off from the granite and which are so widespread on the western side of Brisbane, weights the evidence heavily in favour of connection with the tuff.

The mineralization must then be regarded as of early Middle Triassic age.

In addition to the silver-lead mineralization at Indooroopilly, low-grade auriferous lodes are widely distributed in the Brisbane area. Most of these are closely associated with the Enoggera granite, though the largest and best known, that at Kingston, is far from any known plutonic intrusion.

The possibility that the Enoggera granite is younger than Late Permian should not be overlooked. Even an age later than the Brisbane Tuff is not definitely excluded. Such an age would imply that the Gympie phase continued into the Middle Triassic, even later than at Monsildale.

THE SEQUENCE OF EVENTS IN THE INDOOROOPILLY AREA.

Middle Triassic	Volcanic activity giving rise to the Brookfield volcanics and Brisbane tuff and intrusion of rhyolitic dykes especially near the axis of the geanticline. Silver-lead mineralization at Indooroopilly.
	Erosion
	Folding (formation of Brisbane geanticline), intrusion of Enoggera granite and formation of quartz veins in the Bunya Series. Introduction of small amounts of gold, molybdenite and copper ore.
	Erosion
Late Silurian ?	Metamorphism to phyllites (Bunya Series).
Cambrian-Ordovician ..	Deposition of bathyal muds.

North Arm.

The North Arm gold-silver ore occurs in trachytes and rhyolites which are probably, though not proved to be, of Mesozoic age (Morton, 1931). To the west the palaeozoic Kin Kin phyllites outcrop, and basalts of Tertiary age also occur in the district. The evidence of the Mesozoic age of the trachytes and rhyolites, first suggested by Jensen (1906, pp. 99, 100), is the occurrence of fossil plants in a series of shales, sandstones, conglomerates and tuffs with at least one interbedded flow of spherulitic rhyolite. The suite of plants was regarded by Whitehouse (1931a) as indicating an horizon little above the top of the Ipswich Series. Bryan and Massey (1926, p. 120) showed the area as Walloon (Middle Jurassic). Unfortunately there is a gap of about 1½ miles between the outcrop of the fossiliferous sediments and the country rock of the mines. Nevertheless, the occurrence of spherulitic rhyolite both at the mine and with the fossiliferous strata strongly suggests a similar age.

A dense rhyolite with felspar phenocrysts occurring in the mining area was regarded by Morton (1931, p. 271) as intrusive and as possibly the source of the reef-forming minerals.

The age of this deposit will be discussed further at the end of the section on Cracow.

Tansey Near Goomeri.

There have been several reports on this mine by officers of the Geological Survey, but the only published report is that by Denmead

(1946a). The geology of the district generally has been described by Reid (1925), though his map does not extend as far north as the mine He gave the succession in the area as:—

Late Tertiary Basalts, tuffs, shales etc.

Jurassic(?) Mondure Series = ? Bundamba Series.
Triassic (?) Goomeri Volcanics and Kinbombi boulder beds.
Triassic Manyung Series = Esk and Ipswich Series.

Upper Palaeozoic(?) Granites.
Lower Palaeozoic Wondai Series.

Bryan and Jones (1946, p. 50, and table R) regarded the Kinbombi Series as an extension of the Neara Series (= Lower Esk Series) and as older than the Manyung Series. The latter is lithologically similar to the Esk Series and contains a suite of fossil plants which, with others, occur in the Esk and the Ipswich Series. In the area immediately around the mine, an area in which the sediments are more than usually disturbed, there occur a number of felsite dykes and two diorite dykes. The mineralization occurs in a quartz vein up to 6 feet wide, associated with one of the diorite dykes in a zone of fissuring, fissuring which also affected the Manyung Series. The felsites commonly contain thin mineralized quartz veins on the joints and sometimes in sufficient numbers to constitute a lode. The fissuring was in part earlier, and in part later, than the intrusion of the diorite dykes. Denmead (p. 207) considered that "The constant accompaniment of vein quartz with the felsite intrusion suggests a genetic association between the latter and the ore. No quartz was found emanating from any of the felsite bodies, so it is more likely that both originated from the same deep-seated source than that the felsite dykes themselves have filled the role of mineralizers." The mineralization is clearly post-Middle Triassic (the age which the latest survey of the Ipswich flora suggests for the Ipswich Series and its partial equivalent the Esk Series (see Jones and de Jersey, 1947)), and it is reasonable to suppose it to be related to the folding movements which produced the moderately steep anticlines and synclines of the area. This folding affects all the rocks of the area (including the Upper Triassic Mondure Series), except the Tertiary basalts. Denmead considered that the orogeny and accompanying intrusions and mineralization were probably early Tertiary in age. He also stressed the association of argentiferous tetrahedrite and proustite with the gold (and pyrite, chalcopyrite, galena, sphalerite and mispickel) at Tansey as further evidence of this age, since the gold of North Arm and Cracow, thought to be of this age, have also an abnormally high silver content.

In the association of the ore with felsite dykes the Tansey occurrence shows a further likeness to the Cracow field.

It will be shown below, however, that the mineralization at Cracow almost certainly took place in Triassic times, towards the end of the Gympie Epoch and that at Tansey is also referred to that Epoch.

The Cracow District.

The more important reports comprise those by Denmead (1931a, b, 1933, 1937b and 1946b) and an unpublished report by Denmead which contains more geological, as distinct from mining, information than the published reports. I am indebted to Mr. Denmead and to the Chief

Government Geologist, Mr. C. Morton, for permission to use the information in the latter. Fossils from the Permian marine strata were listed by Whitehouse (1931b).

The succession as determined by Denmead is as follows:—

Mesozoic		Sandstones and shales with plant remains.
		Cracow Series, volcanics, chiefly rhyolites, felsite dykes.
		~~
Permian		Granite, Diorite, etc.
	Lower Bowen	Shales, sandstones and conglomerates with *Glossopteris*.
		Shales and limestones with marine fauna and with siliceous sponge beds at base.
		Volcanics, chiefly andesites.

Careful examination and extensive field-work by Denmead revealed no unconformity other than that between the Cracow Series and the underlying Lower Bowen marine, and his unpublished sections show this unconformity as strong and angular, indicating a prolonged period of erosion, a period during which granite and diorite invaded the older sediments and volcanics. There is no unconformity between the Cracow Series and the overlying sediments; in fact, in the Walhalla area the sediments grade downwards into tuffs of the Cracow Series, so that the fossils of the sediments become important as being indicative not only of the age of the sediments but also of the underlying volcanics. The fossils from these sediments all come from one shale bed met in prospecting bores in the Walhalla area four miles north-north-west of Cracow township. They comprise the following forms:—*

''Star Caps'' or detached sporangiophores of an Equisetalean plant

Todites williamsoni (Brongniart)

Cladophlebis australis (Morris)

Cladophlebis sp.

Marattiopsis sp.

?Dictyophyllum sp.

Thinnfeldia lancifolia (Morris)

Thinnfeldia feistmanteli Johnston

Sphenopteris superba Shirley

Neuropteridium moombraense Walkom

Taeniopteris spatulata McClelland

Taeniopteris sp. (fragment of a wide form with secondary veins at right angles to the midrib)

Detached strobilus

Gymnosperm seeds.

Thus there is an admixture of Esk, Ipswich and Walloon Series forms. This suggests that the beds may be the equivalent of the Bundamba Series, a conclusion which agrees with Whitehouse's (1945, fig. C, p. 27) mapping of the western part of the sandstones.

The Bundamba Series in the type area is poor in fossils but it is conformable with, and separated by only a slight erosion interval from,

* Descriptions and figures will be published in a forthcoming paper.

the Ipswich Series, which is Middle Triassic in age (Jones and de Jersey 1947); thus the sediments overlying the Cracow Series are probably Upper Triassic.

An interesting consequence is that the rhyolites of the Cracow Series into which they grade downwards must be placed no lower than Middle Triassic, a period in which until recently there was little evidence of volcanic action, other than the somewhat earlier acid tuffs at the base of the Ipswich and the Esk Series.

While some of the lodes show abundant evidence of occupying shear zones, as the Golden Mile, Sunrise, Golden Plateau, and White Hope, most of the smaller lodes occupy ordinary fissures or joint-planes and some, e.g., Rose's Pride and the Warrego, show brecciation; so that the intrusions from which the metalliferous solutions emanated must have taken place at only a moderate depth.

Denmead connected the ore genesis with the felsite dykes rather than the Auburn granite for the following reasons:—

1. Mineralization is most intense where the felsite dykes are most abundant.
2. The lodes, as well as the dykes, have their maximum development some three miles from the main granite, the lodes and the dykes decreasing in number as the granite is approached.
3. Several of the felsite dykes have small quartz veins within them especially towards their centres, so that it would appear that the mineralizing solutions actually arose within the dykes as they were solidifying.

It is more likely, however, that the ore-bearing solutions and the felsite dykes had a common origin, came from the same magma reservoir, than that the ores originated from the felsite dykes themselves; or alternatively that the ore formation was later than the intrusion of the dykes, the few quartz veins within the dykes being formed along lines of weakness in them, possibly due to renewed movement along old fault lines. Of these alternatives I favour the former, since the latter would leave us without any apparent igneous source for the ores.

The felsite dykes (light coloured fine-textured rocks, often porphyritic and sometimes with fluidal structure) are intrusive into and therefore younger than the Auburn granite, and Denmead considers them to be closely related to the rhyolites of the Cracow Series, though on what grounds other than that of general similarity of composition is not clear.

Lodes were formed in the Permian volcanics and to a lesser extent in the Cracow Series (e.g. at Walhalla), but not in the overlying sediments. Mineralization (as distinct from gangue formation) was confined to volcanics, the sediments of neither the Permian nor the Mesozoic being affected; and it seems likely that the country rock, the volcanics, both acid and basic, exercised a controlling effect on ore deposition, the solutions, as suggested by Denmead, being forced upwards along shears, fissures and joints and altering the volcanics to calcite and zeolites, which were precipitated along with the quartz and ores of the solutions. While the gangue of some of the loles (White Hope, etc.) is highly siliceous, in other cases (Rose's Pride, and Walhalla) calcite predominates. Denmead (1946b, p. 306-8) showed that localization of ore shoots was in part controlled by the felsite dykes, in part by shearing, and he thought that local differences in the composition of the andesite, not now detectable, may also have had a controlling effect.

If the mineralization is related to the felsite dykes two interpretations of its age are possible, depending upon whether the felsite dykes are genetically related to the Cracow Series or not.

In the first case the age is that of the Cracow Series itself, i.e., Middle Triassic. In the latter case it is post Cracow Series and the exact age is difficult to determine as there are no rocks on the field younger than this series, other than those sediments immediately overlying and conformable with it. These were unaffected by mineralization, not necessarily because ore deposition pre-dated them but probably because they are sediments, not volcanics, and, as pointed out above, volcanics were the favoured locus of the lodes.

Denmead (1946b, p. 208) suggested a Tertiary age for the mineralization, although this does not agree with his suggestions that it was connected with the felsites and these in turn with the volcanics of the Cracow Series. Elsewhere in this paper (p. 59) I shall put forward reasons for regarding the late Cretaceous rather than early Tertiary as a metallogenetic epoch; and, if the ore deposition was in fact later than the early Mesozoic vulcanism, it seems most reasonable to place it in that period.

In favour of a late Cretaceous age is that it was a period of ore deposition elsewhere—in the Maryborough district, and the sediments of the Maryborough area were invaded by numerous dykes though these are more basic than the felsite dykes of Cracow.

A comparison of conditions at Cracow with those at Indooroopilly shows such a close parallelism that the mineralization at Cracow is unhesitatingly referred to the Middle Triassic.

At both places it is connected with a series of acid (rhyolitic or felsitic) dykes which in turn are related to acid volcanic and tuffaceous rocks overlain by fossiliferous lacustrine sediments, and resting on the old eroded palaeozoic surface.

These latter appear to be rather younger (Upper as against Middle Triassic) at Cracow, but it may well be that the upper part of the Cracow Series is equivalent to the upper part of the sediments of the Ipswich Series, or it may be that the sediments overlying the Cracow Series are somewhat older than the rather limited plant assemblage suggests.

In the past it has been considered more than unlikely that mineralization took place in the Middle or Upper Triassic, because of the supposed limited igneous activity of those periods. However, evidence is accumulating that such activity was much more widespread than previously suspected. The evidence is set out above for Indooroopilly, North Arm and Cracow, and it is also suggested that the Brookfield volcanics are early Middle Triassic in age. Dr. E. O. Marks has always believed that Mesozoic volcanic activity was extensive and within the last month he has found rock identical with the Brisbane tuff and resting on the Neranleigh Series, as far from Brisbane as Beechmont.

The deposits of North Arm are connected with acid volcanics and, at no great distance, similar volcanics are interbedded with sediments carrying an intermixture of Walloon and Ipswich Series plants, just as there are sediments with an intermixture of Walloon, Ipswich and Esk plants at Cracow. It may well be that the mineralizing solutions emanated from early manifestations of this volcanic activity—as early as Middle Triassic, or from a common plutonic source.

The parallelism of the Tansey deposit is not so marked as is the case with Cracow, but here again mineralization is related to felsite dykes which invaded Middle Triassic lacustrine sediments.

A further point is that made by Denmead that the gold ores of Cracow, North Arm and Tansey all show an abnormally high silver content.

The mineralization of Cracow and North Arm is here placed in the Middle Triassic, but that at Tansey was probably slightly later—Upper Triassic.

Thus the mercury deposits of Monsildale and Kilkivan extend the late Permian epoch into the Lower Triassic, while the silver-lead of Indooroopilly and the gold of Cracow and North Arm extend it to the Middle Triassic, and the gold of Tansey to the Upper Triassic.

MINERALIZATION OF THE MARYBOROUGH EPOCH (UPPER CRETACEOUS).

The orogenic movements and metallogenesis of this epoch, although confined to a coastal pocket about Maryborough little more than fifty miles wide, were much more important than hitherto recognized. Strong folding resulted and associated with it were granitic intrusions which introduced copper, gold, silver and antimony with minor amounts of other metals.

The whole of this mineralization lies to the east of Reid's (1926) line marking the westerly limit of Late Cretaceous or post-Cretaceous folding. It is placed as Upper Cretaceous rather than Tertiary because of the much slighter folding shown by even the earliest Tertiary deposits than by the Cretaceous.

In this epoch, for which I suggest the name Maryborough Epoch, are placed the deposits of the Maryborough district, including the Neardie antimony mine and those of Yorkey's and Marodian goldfield.

The Maryborough District.

The succession in this area is as follows:—

Lower Cretaceous	Burrum Series	Lacustrine
	Maryborough Series ..	Marine
	Grahams Creek Series ..	Volcanic
Jurassic	Tiaro Series	Lacustrine
Triassic	Myrtle Creek Series ..	Lacustrine
	Brooweena Series	Lacustrine
Palaeozoic	Schists	Marine

All were folded at the same time into a series of moderately steep anticlines and synclines. In the same area are large granitic intrusions, e.g., to the east of Lakeside and at Boompa, and numerous dykes of porphyrite, e.g., in the Tiaro district. Jensen (1925, p. 141) regarded the intrusives as of post-Triassic but pre-Cretaceous age. Bryan and Massey (1926, pp. 117-119) summarized earlier views on the age of these intrusions and concluded that they took place during Triassic and Jurassic times. Bryan earlier (1926, p. 72) stated that the granites "intrude and metamorphose both the Brooweena and the overlying Myrtle Creek Series, but may be older than the Tiaro Series (in the restricted sense). On the other hand the attitude of the Mesozoic strata in the neighbourhood suggests that the intrusion post-dated their folding —i.e. that the intrusion took place in late Mesozoic or even early Tertiary times, but, in the absence of more detailed evidence, the writer will not urge such a radical hypothesis." Denmead (1946a, p. 208) has suggested a late Mesozoic or early Tertiary age for the mineralization at Tansey, at North Arm and at Cracow, connecting the mineralizing intrusion with the orogeny which folded the Maryborough, Burrum, Styx and earlier series; but it has been shown above that all these are early Mesozoic. Reid (1926) urged that folding, due to lateral pressures, took place between the 22nd and 28th parallels and east of a N.N.W.–S.S.E. line from Gayndah through Ipswich to Beaudesert in late Cretaceous or even Tertiary times, i.e., in a coastal strip one hundred miles wide.

Bryan and Jones (1946, pp. 66, 67) placed four series in the Eocene. Of these the Eyrian of south-western Queensland is far removed from the area under consideration; the strata of the Lowmead area are thrown into short anticlines and synclines with dips up to 30° (Ball 1915c, p. 8); and in the Ipswich district the Redbank Plains Series, usually little disturbed, is folded (together with the Silkstone Series) into anticlines and synclines with dips up to 45° (Jones 1927, p. 34). Of the Nagoorin Series little detail is available, but dips do not appear to exceed 10° (Jensen 1918, p. 12).

The folding of these Eocene deposits is, therefore, much less extensive and less violent than that affecting the Cretaceous Series (Maryborough and Burrum), the extent and intensity of the latter being indicated by dips as high as 80° (in contrast with the general 10° to 30° of the Eocene deposits).

It seems clear then that orogeny and intrusion took place in the Maryborough district in Upper Cretaceous times and that the area affected was much less extensive than that affected by Tertiary folding as defined by Reid's line.

In New Caledonia, nearly nine hundred miles to the north-east, Lower Cretaceous rocks (with a similar fauna to that of the Maryborough Series) and Upper Cretaceous geosynclinal deposits were strongly folded and invaded by serpentine in post-Eocene, probably Middle Tertiary, times (Piroutet, 1917, p. 307; Benson, 1924, p. 125). It is suggested here that the Upper Cretaceous movements in the Maryborough district represent the initiation of this orogeny and that the Tertiary folding was due to renewed activity within the same great orogeny.

It is also of interest in this connection that Whitehouse (1945, p. 23) has suggested that to the north of Roma some hundreds of miles to the west, some granites are later than the sediments (Bundamba Series).

The mineralization of this epoch was not extensive; it includes a number of copper- and gold-bearing lodes as the Teebar, the West Culgoa, the Munna and those of Yorkey's and Marodian goldfields, the lodes being in the granite (see Rands 1890a, pp. 7, 8). Ball (1902a) described many of these mines in detail but (p. 4) was unsure of the age of the granite, though inclined to consider it as Permo-Carboniferous. Of more interest is the Neardie Antimony Mine (Rands, 1890a, p. 6); the lode occurs in the palaeozoic rocks with granite intrusive into them two miles to the south-east. Two miles to the west coal measures outcrop (mapped as Burrum by Rands but now known to be Tiaro), and a further three miles to the west the granite and porphyries of Mt. Eaton, intrusive into the Tiaro, are found. There seems little doubt that the copper and antimony mineralization of these areas is connected with the intrusion of the granite in late Cretaceous times.

A point of interest and proof of the Post-Tiaro age of the intrusions, is the conversion of coal (Tiaro = Burrum of Dunstan) at Mount Bopple to anthracite and graphite by heat from the intrusions of syenite, syenitic granite, hornblende andesite and quartz andesite. (See Dunstan 1906).

GENERAL STATEMENT.

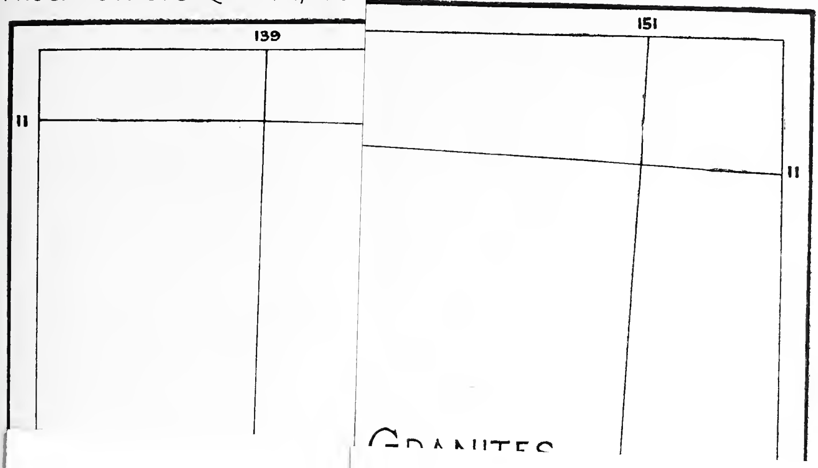
Metallogenetic Epochs.

In Australia as a whole the Pre-Cambrian epochs were the most important in the continent's history. This is so because much of the stable western half of the Australasian continental mass has been so deeply eroded that ores formed at great depths have been exposed. Queensland, on the eastern fringe of the stable portion, has some mineral fields which fall into the above category, but, by virtue of a much greater development of post-Proterozoic strata, it contains many more fields of younger age than does the western portion of the continent. Thus, in Queensland, of the four epochs of ore genesis, the Gympie Epoch was the period of most widespread ore-formation.

I. Nevertheless the Cloncurry Epoch, late Pre-Cambrian, was very important, for during that time the great silver-lead-zinc-copper deposits of Mt. Isa were formed, at considerable depths but not particularly high temperatures, by solutions which replaced strata crumpled and broken by thrusts which came mainly from the south-south-west. There is no proven igneous source for these ore-bearing solutions, but pegmatites five miles to south-south-west probably mark the upper limits of the responsible igneous intrusion.

The Mt. Isa field has a further importance in that it is the only area in Queensland which provides good evidence of the age of ore bodies contained in the basement rocks of the state, for only in that area are there ancient series overlain by fossiliferous Cambrian rocks.

To the north-north-west, at Lawn Hill, and to the north-west, at Little Tott's Creek, slight mineralization is found also in Lower and Middle Cambrian rocks; nevertheless, a late Pre-Cambrian is to be preferred to a Middle Cambrian age for the main mineralization, for the former coincides with the period of deformation of the rocks; the later slight mineralization may be regarded as a final delayed flicker of activity. The ores in these latter areas were formed at lesser depths than at Mt. Isa and within the zone of fracture.


139
151
11
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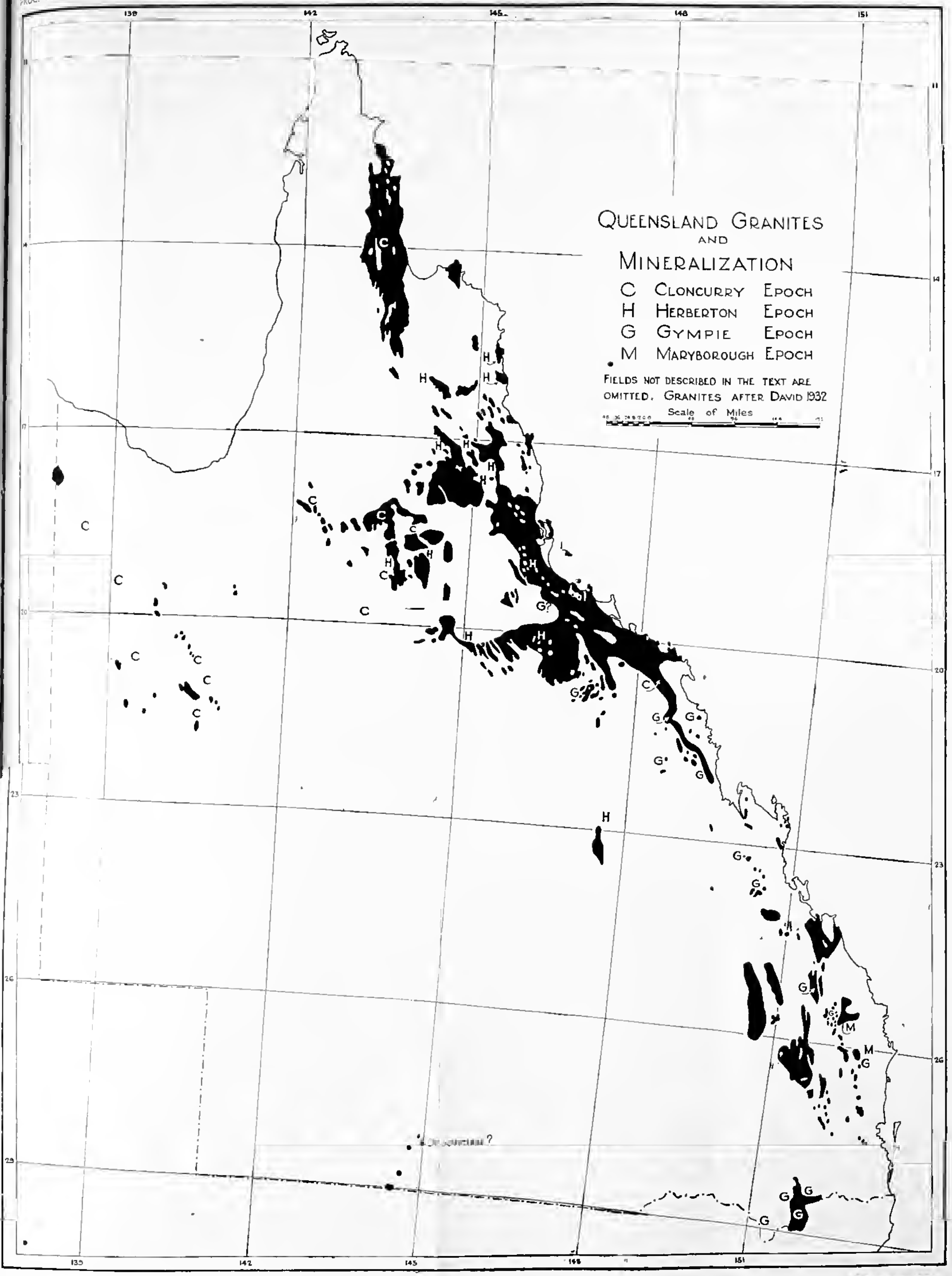

QUEENSLAND GRANITES
AND
MINERALIZATION
C CLONCURRY EPOCH
H HERBERTON EPOCH
G GYMPIE EPOCH
M MARYBOROUGH EPOCH
FIELDS NOT DESCRIBED IN THE TEXT ARE OMITTED. GRANITES AFTER DAVID 1932
Scale of Miles
C
H
G
M
138
142
145
148
151
11
14
17
20
23
26
29
135

The copper, gold and cobalt ores of the Cloncurry district, some of which show evidence of high temperatures as well as considerable depths, also are placed in this Epoch.

Further east, the Etheridge–Einasleigh area presents a complicated geological problem, but at least two periods of metallogenesis appear to be represented, of which the earlier, in which mainly copper but some gold was introduced, is equated with that of Mt. Isa. These ores were formed in close association with granitic intrusions and at high temperatures but in the zone of fracture. Again, the presence of graphite and the close association of granite with the gold and tin ores of the Croydon–Stanhills field is clear evidence of high-temperature conditions. Lodes occur frequently on shears, but the occurrence of brecciation and of ore on tension faults and joints suggests deposition at not more than medium depths.

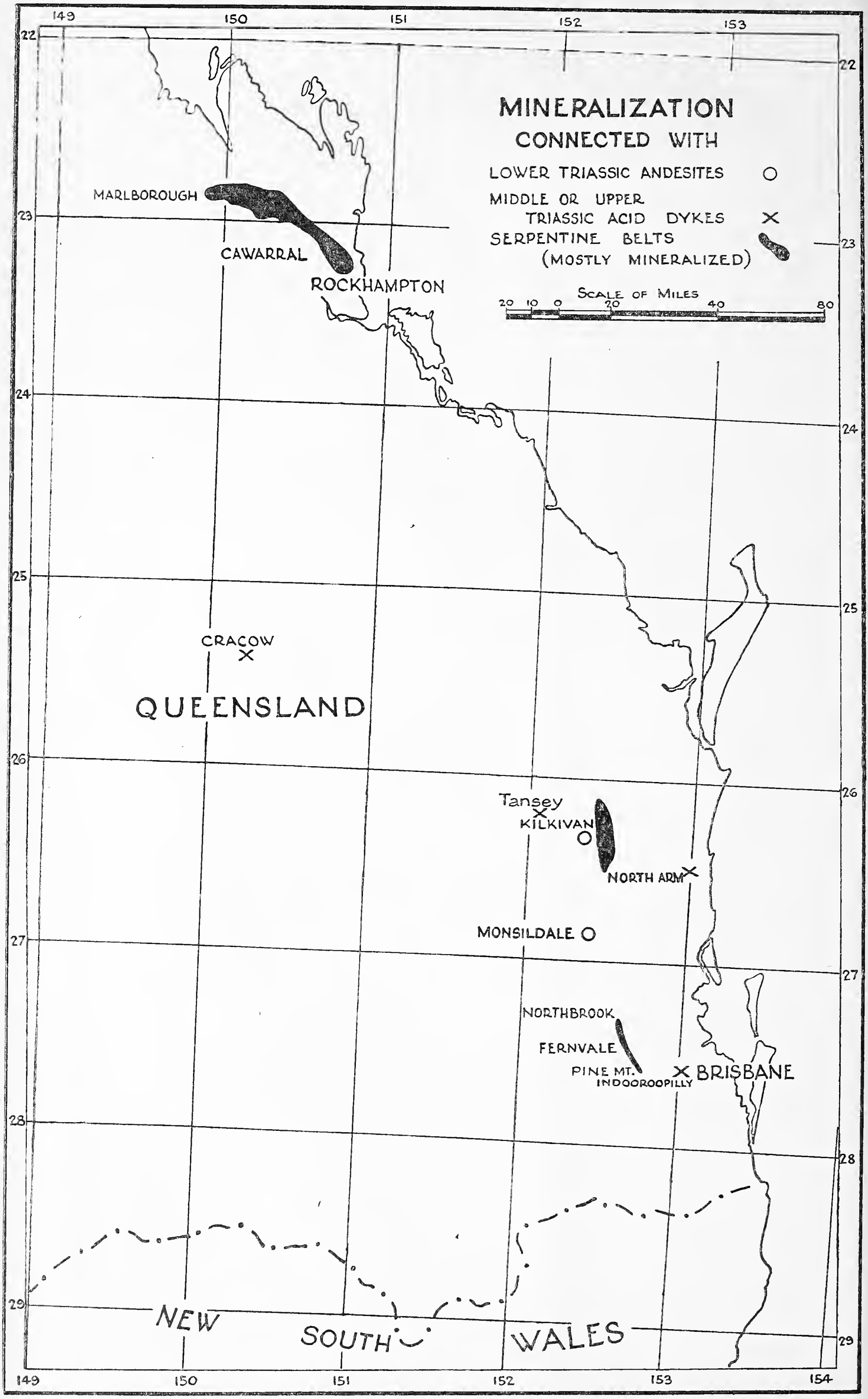
Other fields, as the Woolgar, Cape River, Normanby and Wenlock, where ores occur in rocks placed in the Pre-Cambrian on account of their degree of metamorphism, are also thought to belong to this Epoch.

II. The next period of ore genesis in Queensland was that of the Herberton Epoch, a time which previously has generally been regarded as of minor importance, but which has been shown above to be the time when many of the important metalliferous lodes of North Queensland were formed.

A. In the north of Queensland ores were introduced at this time, a time somewhere between Late Devonian and Middle Carboniferous, by granite and its highly siliceous marginal modifications. The second period of ore formation of the Etheridge–Einasleigh district belongs here, including the interesting gold-scheelite association at Percyville, while to the east a great variety of ores were introduced from at least the Cooktown district in the north to Kangaroo Hills in the south. The ore bodies include the copper- and silver-lead contact deposits of Chillagoe–Mungana, with garnet indicative of high-temperature deposition, and lodes and pipes associated with siliceous granites or marginal modifications of granite and containing the usual tin-wolfram association.

The whole of this group is associated with normal or siliceous granites. Somewhat further south the gold of Charters Towers was introduced by granodiorite or associated dykes; and while the upper limit of age of this igneous complex is uncertain, it is placed in this Epoch, since, like the Cooktown fields, it lies well to the west of the limit of Permian diastrophism. This group comprises the "Granitic phase."

B. As in the case of the Late Pre-Cambrian fields, these areas, the ores of which are associated with acid or sub-acid intrusions, lie in the northern half of the State; but further south, associated with the intrusion of serpentine (intrusions which did not affect Lower Carboniferous rocks) are relatively small quantities of gold, copper, cobalt and other ores and, as magmatic segregations in the serpentine, the State's only known resources of chromite. This serpentine belt (with its ores) outcrops intermittently from north of Rockhampton, southerly through Kilkivan to Ipswich. It comprises the "Serpentine phase." Its age, Late Devonian, can be more definitely fixed than that of the ores of the acid intrusions to the north, which may be somewhat later.


MINERALIZATION
CONNECTED WITH
LOWER TRIASSIC ANDESITES
MIDDLE OR UPPER
TRIASSIC ACID DYKES
SERPENTINE BELTS
(MOSTLY MINERALIZED)
SCALE OF MILES
20 10 0 20 40 80
MARLBOROUGH
CAWARRAL
ROCKHAMPTON
CRACOW
QUEENSLAND
Tansey
KILKIVAN
NORTH ARM
MONSILDALE
NORTHBROOK
FERNVALE
PINE MT.
INDOOROOPILLY
BRISBANE
NEW SOUTH WALES
149
150
151
152
153
154
22
23
24
25
26
27
28
29

III. The third metallogenetic epoch, the Gympie Epoch, Late Permian to Upper Triassic, was of the utmost importance in the State's history. The earlier portion of this Epoch, the Late Permian, is shown here to be less important than was formerly thought, and in particular the tin ores, the great majority of which were previously placed in the Permian, are shown to be of three distinct ages. On the other hand the Epoch and its igneous intrusion are now proved to extend beyond the Permian, even well into the Triassic.

The Epoch is divided into three phases, of which the first contains ores connected with acid to sub-acid plutonic intrusions; and the second and third phases, neither of which was previously recognized, contain ores connected with acid volcanic and hypabyssal rocks respectively.

The first phase, the Gympie, covers the time from Late-Permian to the end of the Lower Triassic and overlaps the second, the Kilkivan phase, which covers Lower Triassic time, while the third, the Indooroopilly phase, extends from Middle to Upper Triassic.

A. The Gympie phase.—A phase in which mineralization was genetically related to granitic intrusions, which, in turn, were related to the diastrophism of that time. This diastrophism, folding and block faulting, and the accompanying plutonic intrusions and mineralization were confined to the eastern highland region and to the area between this and the coast. Within this region mineralization was extensive from Stanthorpe near the southern border in the south to Townsville in the north. Included here are a number of areas, the age of the mineralization of which is not proved except that it was coincident with, or later than, the folding of the Permian strata. Such fields are placed in this Epoch for the good reason that they lie outside the limits of the area affected by the Upper Cretaceous orogeny, the only later epoch in which mineralization took place.

The ore deposits of this first phase show great variation of metallic content, from the gold-copper ore of Mount Morgan to the tin of Stanthorpe, the silver-zinc ore of Silverspur and the bismuth of Mount Biggenden. Likewise, the deposits vary in form, from disseminations and stock works, as those of Stanthorpe to lenticular ore-bodies in beds weakened by folding, as at Silverspur, to the breccia-filled pipe of Mount Shamrock and the inverted cone of Mount Morgan.

The other two phases contain deposits of very different type, deposits related to intermediate and to acid volcanic or hypabyssal rocks respectively.

B. The Kilkivan phase.—Ore deposits genetically related to the Lower Triassic andesitic volcanics of the Neara Series. This phase was of only minor importance, containing little besides the small mercury deposits of Kilkivan (the only workable ones known in the State) and the mercury deposits of Monsildale, which are of purely academic importance.

C. The Indooroopilly phase.—Mineralization genetically related to rhyolitic dykes at Indooroopilly and North Arm, and to felsite dykes at Cracow and at Tansey. The dykes in three of these areas, Indooroopilly, North Arm and Cracow, are, in turn, related to acid volcanics of Middle or Upper Triassic age. The minerals produced

The Age of Queensland Mineral Deposits as Suggested by David 1932 and the Author.

Area.	David 1932.	Jones 1947.	Remarks.
Mt. Isa and Lawn Hill	End of Older Proterozoic	CLONCURRY EPOCH	Cloncurry Epoch equals immediately pre-Lipalian, that is the end of Older Proterozoic in the sense of David
Cloncurry	End of Older Proterozoic	Cloncurry Epoch	
Etheridge-Einasleigh (1)	? End of Older Proterozoic	Cloncurry Epoch	David referred to the Einasleigh copper ores only
Croydon-Stanhills ..	..	Cloncurry Epoch	
Cape River, Woolgar, Normanby, Coen, &c.	..	? Cloncurry Epoch	
Etheridge-Einasleigh (2)	..	HERBERTON EPOCH granitic phase	The Herberton Epoch lies somewhere between the Late Devonian and the end of Lower Carboniferous time
Chillagoe-Mungana ..	Epi-Devonian ..	Herberton Epoch granitic phase	Ore related to granites, granodiorites or attendant dykes
Palmer	..	Herberton Epoch granitic phase	
Herberton-Irvinebank	Epi - Devonian (silver - lead) Late Permian (tin)	Herberton Epoch granitic phase	
Wolfram Camp and Bamford	Late Permian ..	Herberton Epoch granitic phase	
Kangaroo Hills ..	..	Herberton Epoch	
Kilkivan-Black Snake (1)	? Late Carboniferous (gold, copper, &c.)	Herberton Epoch Serpentine phase (gold, copper, &c.)	The Serpentine phase (late Devonian) may be within the Herberton Epoch
Serpentine Belt ..	? Late Carboniferous	Herberton Epoch Serpentine phase	
Charters Towers ..	Permian ..	Herberton Epoch granitic phase	
Cooktown	? Late Permian	Herberton Epoch granitic phase	
Copperfield	..	Herberton Epoch granitic phase	
Stanthorpe-Silverspur	Late Permian ..	GYMPIE EPOCH Gympie phase	The Gympie Epoch extends from Late Permian to Upper Triassic times

The Age of Queensland Mineral Deposits as Suggested by David 1932 and the Author—continued.

Area.	David 1932.	Jones 1947.	Remarks.
Mt. Morgan-Moonmera	Permian ..	Gympie Epoch Gympie phase	The Gympie phase covers Late Permian and Lower Triassic times
Mt. Shamrock - Mt. Biggenden	..	Gympie Epoch Gympie phase	
Argentine	..	? Gympie Epoch Gympie phase	
Mackay	..	Gympie Epoch Gympie phase	
Mt. Flora	..	Gympie Epoch Gympie phase	
Sellheim	..	Gympie Epoch Gympie phase	
Collaroy	..	Gympie Epoch Gympie phase	
Rosewood	..	Gympie Epoch Gympie phase	
Monsildale	..	Gympie Epoch Kilkivan phase	The Kilkivan phase covers Lower Triassic times
Kilkivan (2)	..	Gympie Epoch Kilkivan phase	
Indooroopilly	..	Gympie Epoch Indooroopilly phase	The Indooroopilly phase covers Middle and Upper Triassic time, but this deposit is Middle Triassic
North Arm	..	Gympie Epoch Indooroopilly phase	Middle or Upper Triassic
Cracow	..	Gympie Epoch Indooroopilly phase	Middle Triassic
Tansey	..	Gympie Epoch Indooroopilly phase	Upper Triassic
Maryborough District	..	MARY-BOROUGH EPOCH	Upper Cretaceous
Neardie Antimony Mine	..	Maryborough Epoch	
Yorkey's and Marodian gold and mineral field	..	Maryborough Epoch	

were ores of gold, except at Indooroopilly, where silver-lead was produced. The gold ores, especially that at North Arm, all have an unusually high silver content.

IV. The final period of metallogenesis in Queensland's history is the Maryborough Epoch, the Upper Cretaceous. While a post-Palaeozoic epoch has been recognized of recent years, it was thought by Reid and by Denmead to be possibly as late as Tertiary; Reid placed its boundaries well beyond those defined here, and Denmead included in it the deposits of both Cracow and Tansey. The subdivision of our Cainozoic deposits, the closer determination of their ages, and an analysis of the degree of folding of the early Tertiary and of the Cretaceous strata (p. 59) allow the fixing of the orogeny and the mineralization as Upper Cretaceous. The mineralization was of minor importance, the area affected being only the coastal area, close to Maryborough, and the ore introduced (gold, silver, copper, and antimony) being relatively small in quantity.

In the following table a comparison is made of the ages of the more important and the more significant ore deposits of Queensland as set out in the latest general survey (David, 1932) with the ages as determined by the present writer.

The Shifting Locus of Ore Deposition.

Andrews' (1925) generalization that ore deposition in Australia travelled north-east and east with the passage of time remains broadly true for Australia as a whole, but only if the fields of the Cloncurry Epoch of Queensland be neglected.

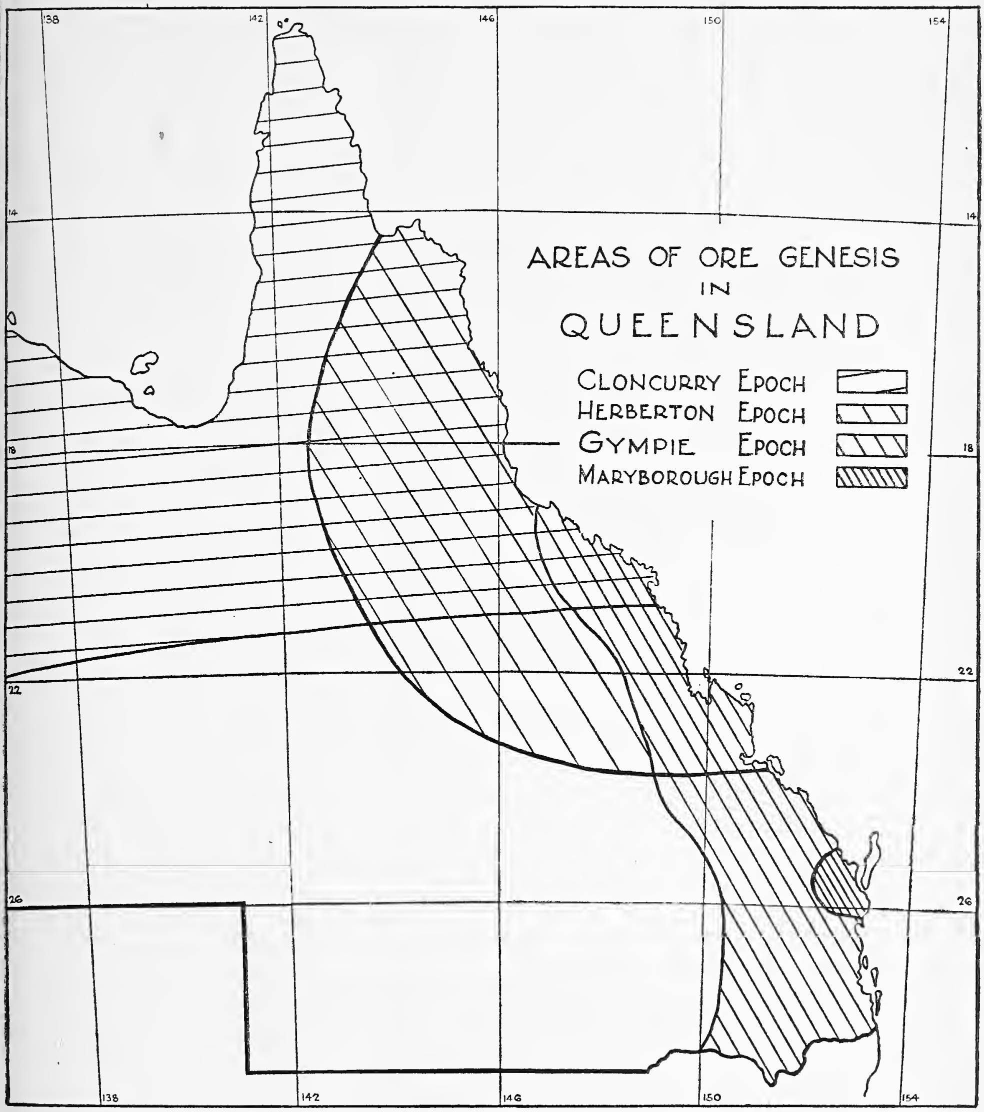
The ores of the Cloncurry Epoch are found from near the western border of the State to the present coastline, but are confined to the northern part of the State. All the known fields lie north of the twenty-second parallel of latitude, but other deposits may be concealed beneath the cover of the Great Artesian basin.

The Herberton Epoch saw a shift eastward of the locus, and ore formation was still mainly confined to the north except for those ores related to the serpentine intrusions.

The following epoch, the Gympie Epoch, saw a big shift to the east, the ore deposits being all located either in or to the east of the cordillera region, and an intensification of deposition in the south as compared with that of the Herberton. With one exception—the Argentine or Star River Silver mines—all are to the east of the line suggested by Reid (1930b) and by Carey and Browne (1938) as the westerly limit of Late Permian folding. The exception is also exceptional in its genetic relations—a possible relationship to an intermediate dyke. The ore deposits of this time which are related to acid dykes or to intermediate volcanics, are confined to the south of the State.

The Maryborough Epoch, the Upper Cretaceous, the final period of ore formation in Queensland, saw a further easterly movement and a great contraction of the area mineralized. Metallogenesis was confined to a coastal area eighty miles long and fifty miles deep, in the vicinity of Maryborough. This pocket, the area affected by Upper Cretaceous folding and intrusion, is but a portion of the area delimited in the west by Reid's Line—the line marking the limit of Mid-Tertiary folding.

The accompanying map shows the limits of the known deposits of the various epochs.



Sketch map showing the known areas affected by mineralizers derived from granitic magmas in the four metallogenetic epochs.

Change in Depth of Ore Formation.

Andrews (1903, 1925) emphasized that the Pre-Cambrian ore-bodies exhibited features characteristic of deposits formed in or close to the zone of flowage. Andrews' contention is borne out by the ore-bodies at Mount Isa and many of the Cloncurry fields, though they do not, except in a few cases, show evidence of particularly high temperatures, probably because of their considerable distance from their igneous sources. Only the stability of the Australian continent and the consequent long and continuous erosion have uncovered these deposits for our study and exploitation.

Nevertheless, the presence in the Mount Isa area of small ore deposits at several places in the Pre-Cambrian rocks close to their junction with the Cambrian series shows that the present topography of the Pre-Cambrians in that area is largely a rediscovered one and that the greater part of the erosion must have taken place before the deposition of the Cambrian sediments.

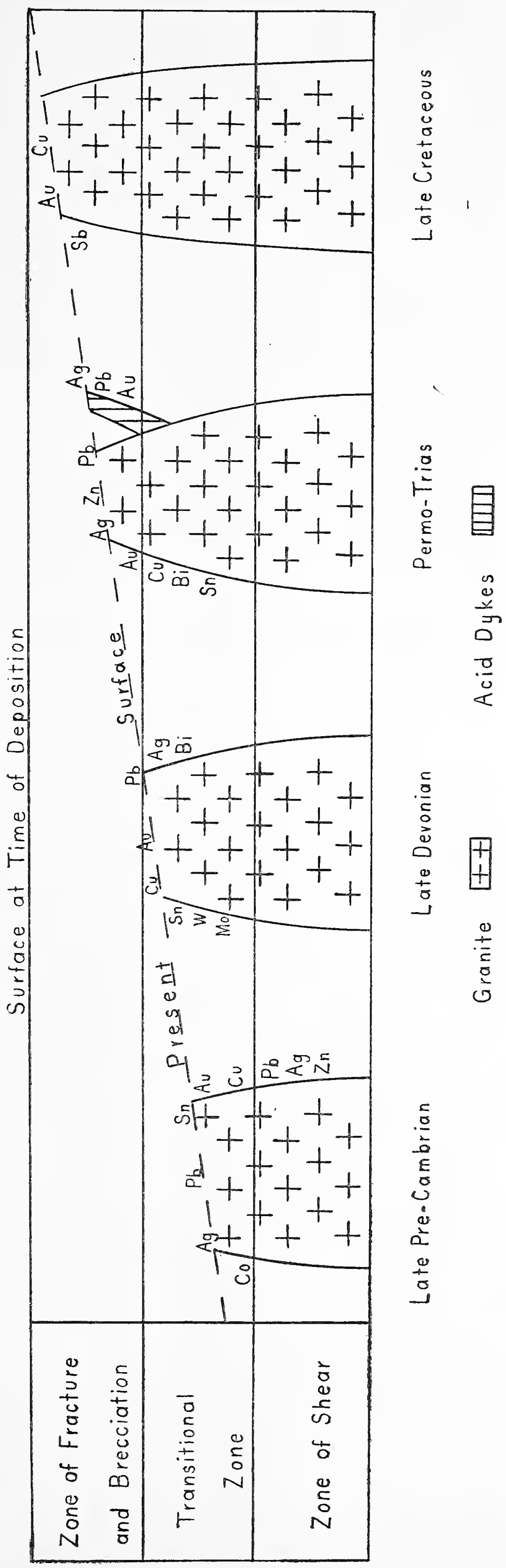
Belonging to the same, the Cloncurry Epoch, but lying mainly to the east of these deep-seated deposits, are numerous ore-bodies which were formed at somewhat shallower depths—ore-bodies which show the characteristics of the zone of fracture. Many, in spite of being formed at relatively shallow depths, as Croydon and Stanhills, exhibit evidence of high temperatures due to proximity to, or actual situation in, granitic rocks.

Similarly the deposits of the Herberton Epoch, those of the first phase of the Gympie and those of the Maryborough Epoch, were formed in the zone of fracture and probably at shallower depths than any of the Pre-Cambrian ore-bodies. In addition to fisure- and joint-fillings, these include the breccia-filled diatreme of Mount Shamrock and the quartz-filled diatremes of Bamford and Wolfram Camp. The ores related to the relatively shallow, hypabyssal, intrusions of serpentine also belong about this time.

In the Kilkivan phase of the Gympie Epoch are the mercury deposits of Kilkivan and Monsildale, the only known examples in Queensland of ore deposits directly related to volcanic rocks and formed at the surface of the crust.

The Indooroopilly phase comprises deposits genetically related to acid dykes and which were probably formed within the zone of fracture, and not far beneath the surface. Although the biggest and richest mine of the Cracow field which falls into this group shows extensive shearing of the rocks, many other reefs of the field are fissure or joint fillings and in some brecciation is characteristic. Further, overlying the main metalliferous strata, and to some extent mineralized, there are surface flows to which the mineralizing agent, the felsite dykes, are considered to be related.

Below is a diagrammatic representation of the relationship of the depth of the ore deposits to their age.



Diagrammatic Representation of the Depth of Ore Formation in the Several Metallogenetic Epochs.

Ore Deposition and Igneous Activity.

The ore deposits of Queensland in general show a close connection with igneous activity and usually with plutonic intrusion, the most notable exceptions being those of Mount Isa and Gympie. Of the former of these it is thought that the mineral-bearing solutions may have come from the same source as the pegmatites which outcrop five miles away. For the latter it is necessary to postulate an origin from a plutonic mass which is either distant or has not yet been found, rather than accept the suggestion that the greenstones are minor intrusions and the source of the ore-bearing solutions.

Particular ores exhibit an association with particular types of igneous rocks, associations which are tabulated below; but such a statement is necessarily incomplete, as some granites, for example, those of Kangaroo Hills, are referred to in the literature simply as granite. Some such "granites" may in fact be highly siliceous types, others may be granodiorites. There is room for much detailed work on this phase of the problem.

Association of Metals with Particular Igneous Types:

1. Siliceous granites and marginal modifications of granites: Ores of tin, tungsten, molybdenum and bismuth. Rarely silver-lead and gold.
2. Granite: Gold, silver-lead, zinc, copper, antimony and bismuth.
4. Granodiorite: Gold and copper.
4. Acid dykes: Gold and silver-lead.
5. Intermediate dykes: Silver-lead.
6. Intermediate volcanics: Mercury.
7. Serpentine: Chromite and gold.

The preceding remarks apply generally, but in particular a study of the tinfields of Queensland and the associates of the tin ore shows that three distinct types occur:

1. Fissure- and joint-fillings and pipes in or close to acid granite. The chief gangue minerals are quartz and black or brown tourmaline and sometimes a light-coloured mica. The chief associates are wolfram, molybdenite and arsenical pyrites.

2. Fissure- and joint-fillings and pipes in or close to acid granite. The gangue may be largely quartz, but chlorite is usually present and frequently makes up ninety per cent. of the gangue. Tourmaline is absent, but hornblende sometimes occurs. The most common associates are copper and wolfram, the wolfram being earlier than the cassiterite.

3. Fissure- or joint-fillings in both granite and metamorphics.

   Two groups of associates occur in the one area:

   (*a*) Usually in granite, quartz-chlorite lodes with cassiterite and subsidiary amounts of copper.

   (*b*) Usually in metamorphics, quartz lodes rarely with chlorite, usually with much manganese, iron and garnet; silver-lead, copper and zinc.

The tinfields are also of three ages, but these ages do not correspond to the three types—more than one type is found in rocks of the one age.

Field.	Type.	Age.
Cooktown	1	Herberton Epoch
Stanthorpe	1 grading into 2 across the N.S.W. border	Gympie Epoch
Herberton - Irvinebank - Watsonville area	2	Herberton Epoch
Kangaroo Hills	3	Herberton Epoch
Stanhills	?	Cloncurry Epoch

These three types cover six of the ten stages distinguished in the tin mines of Cornwall; but their occurrence, though suggestive, does not necessarily lend support to the theory of metallogenetic zones, for they do not all occur within the one area.

Although it was for long thought that the Triassic was a period when vulcanicity was at a minimum in south-east Queensland and represented by little more than the interesting but quite local Brisbane Tuff, evidence has gradually accumulated in support of E. O. Marks' contention that Triassic vulcanicity was of considerable importance. Thus there have been added to the known volcanic series of this period the acid volcanics of the North Arm–Eumundi district (Middle or Upper Triassic), the Cracow Series (Middle Triassic), and the rhyolites at Cape Moreton, and mention has already been made of the recent finding by Dr. E. O. Marks of representatives of the Brisbane Tuff as far afield as Beechmont. It is possible, too, that the isolated rhyolites of Point Lookout on Stradbroke Island, which present a somewhat old appearance, may belong here.

In this address it has been suggested that the volcanic series capping the divide between Moggil and Pullen Pullen creeks should also be regarded as Middle Triassic. Associated with these is a rhyolitic dyke very similar to those at Indooroopilly, which in turn appear most likely to be connected with the Brisbane Tuff. Rhyolitic dykes occur at North Arm and felsite dykes at Cracow and Tansey. Genetically connected with these acid dykes is silver-lead at Indooroopilly and gold at North Arm, Cracow and Tansey.

Thus not only was Triassic vulcanicity more extensive in south-eastern Queensland than formerly suspected, but dykes attendant upon that vulcanicity were responsible for quite extensive mineralization.

Ore Genesis and Orogenesis.

Each of the four metallogenetic epochs of Queensland corresponds with a period of igneous injection and with a major orogeny.

The Late Proterozoic orogeny was greater than any of its successors, judging by the folding and degree of metamorphism of the Proterozoic rocks, and it was accompanied by the formation of rich and extensive ore deposits deep beneath the pre-Cambrian surface. The orogeny was widespread, for metalliferous rocks affected by it are found from almost the western border to the present coastline, but in the southern half of the State any rocks of that age are concealed by later strata. The diastrophism and the metallogenesis were apparently complete by Lipalian times, for rocks in the Tasman geosyncline, regarded in part as of that age (the Greenstone Series), and the small area of rocks in the Cloncurry district possibly of that age (the Mount Quamby Series), were unaffected by it. Late Proterozoic (pre-Lipalian) thus seems a more likely age than Lower Cambrian for the metallogenesis. The rocks of the western portion—Cloncurry, Mount Isa and the Burketown field—have been unaffected by later diastrophism and consequently by later metallogenesis.

In contrast to the wide extent of the pre-Cambrian rocks, subsequent sedimentation, diastrophism and metallogenesis were virtually confined within the limits of the Tasman Geosyncline.

The age of the next metallogenetic epoch, the Herberton Epoch, cannot be defined as exactly as that of any of the others, and correspondingly the exact age of the orogeny which it accompanied is also uncertain. Ores derived from granitic magmas of this epoch are known in the north-eastern part of the State, an area of many unsolved geological problems, and one the tectonic history of which is the subject of difference of opinion. An analysis of the evidence is set out above (p. 29) and this shows that the age cannot be fixed at present more closely than between Late Devonian and the end of Lower Carboniferous times.

To the south, the great thickness of conformable strata of the Brisbane Schist Series was folded together possibly as early as the close of the Silurian in harmony with the folding of Silurian sediments in parts of New South Wales (Andrews, 1938, p. 168), and this movement may also have affected that part of North Queensland into which the series extends. Any such Late Silurian diastrophism was not accompanied by metallogenesis.

While the exact age of the Herberton Epoch is in doubt, so is that of the widespread Drummond orogeny, but it is highly probable that the two were closely related.

The granitic phase of this Epoch seems to have been confined to North Queensland, but the serpentine intrusions of the south may also be related to the Drummond orogeny, but being pre-Carboniferous they may be somewhat earlier.

The earth movements which marked the close of the Palaeozoic were for long regarded as epeirogenic, rather than orogenic, but work in the last sixteen years has shown that, at this time, a broad coastal belt was involved in folding and the mineralization of the Gympie Epoch is coextensive with this folded belt.

Conclusive evidence has been set out above (p. 50) that, in the Monsildale area at least, the granitic intrusions, which accompanied the orogeny, continued until the end of Lower Triassic times, though most of the associated ores were introduced during the earlier phases. The area mineralized coincides almost exactly with the area affected by Late Permian folding. A great number of ore deposits fall within this area, and the only exception is that of the Argentine silver mines, which lie a little to the west of the line but in an area singularly free from igneous intrusion and in which the ores can be genetically connected, only with an intermediate dyke.

Before the cessation of the acid plutonic intrusions, the andesites and andesitic boulder beds and interbedded shales of the Neara Series were deposited under lacustrine conditions. Associated with the andesites are the only known workable mercury deposits of Queensland, those of Kilkivan and the unimportant deposits of Monsildale.

This andesitic volcanic activity may mark the close of the history of the Tasman geosyncline, though the interbedded fresh water shales are akin lithologically and in their flora to those of the succeeding Esk Series. Nevertheless, the intrusion of acid dykes which produced the gold ores of Cracow, North Arm and Tansey and the silver-lead of Indooroopilly and the extrusion of the extensive volcanics thought to be related to them, may be regarded as the final flicker of the igneous activity which began in Permian times. Thus the igneous activity and the metallogenesis continued for a considerable time after the cessation of the orogenic movements.

The final period of ore genesis in Queensland corresponds in time and space with the Upper Cretaceous orogeny. Reid (1926) considered that the Cretaceous beds were folded together with the coastal Tertiary beds at a later date. But reasons have been given above (p. 59) in favour of two orogenies, the first of which, Upper Cretaceous, coincides in time with igneous intrusion and metallogenesis, and coincides also in area with highly folded strata.

The Upper Cretaceous metallogenetic epoch affected a much smaller area and produced much less ore than any of the earlier epochs.

The tectonic history of Queensland is not as yet well known but there is no evidence that orogenies other than the four detailed above were accompanied by ore genesis.

Metallogenesis in Relation to the Tasman Geosyncline.

The Tasman geosyncline, the most prominent and persistent feature of the geology of Eastern Australia, appears to have come into existence in late Pre-Cambrian times, but later than the orogeny and metallogenesis of that period. Hence the area mineralized in the Cloncurry Epoch, in contrast to areas mineralized during later Epochs, bears no relation in shape or extent to the geosyncline.

Both boundaries of this great linear trough are difficult to define at all accurately, the eastern because throughout its entire history it lay beyond the present coast line, the western because it lay, during part of its history at least, within an area later covered by the Cretaceous transgressions.

It has been shown above that during the Herberton Epoch disastrophism affected and mineralized rocks as far west as the Etheridge gold and mineral field. While the western part of this area was probably land or occupied by lakes during part of the Palaeozoic, the occurrence of schistose rocks and greywackes such as those of the Herberton Series, which is probably of early Palaeozoic age, and the fact that the whole area was affected by the same orogeny suggest that the western shore of the geosyncline was considerably further west than shown by Bryan and Jones (1946). It suggests that the Tasman geosyncline was a much wider structure than the ribbon-like trough shown by Andrews (1938).

While the Herberton mineralization probably defined fairly accurately the westward extension of the northern part of the trough, the Gympie mineralization was not coextensive with it in width and possibly not in length. The western limit of the mineralization was Reid's western limit of Permian folding, a line considerably to the east of the shore of the geosyncline; and while to the south the mineralized area extends to and beyond the State border, to the north both the mineralized area and the geosyncline pass out to sea.

Just when the geosyncline ceased to exist is also uncertain, though usually it has been considered that it had ceased to be a significant structure by, or soon after, the end of the Palaeozoic. Even if this be accepted, there is still the question whether or not the Neara Series, fresh-water strata of Lower Triassic age, should be included. On the one hand the great volume of andesitic material in that Series and the continuance of igneous intrusion and of metallogenesis until Middle Triassic times suggest the continuance of the geosyncline also; on the other hand this series has features in common with the Triassic lakes, and the continued existence of these conditions suggests that the geosyncline had already disappeared.

That the geosyncline did not continue throughout the Mesozoic is further suggested by the epicontinental character of the fauna of the Maryborough Series, a fauna closely akin to that of the wide shallow seas in which the Roma and Tambo Series were deposited. The epicontinental nature of these faunas and their affinities with those of New Guinea, New Caledonia, and New Zealand point to deposition in a shallow sea which extended far to the north-east, rather than in a geosyncline; and these features are also confirmatory evidence of the former extension of the Australasian continent to at least New Caledonia.

Bryan (1944) has supported the view that the Australasian continent existed in this form until the close of the Mesozoic era, a view to which the distribution of Cretaceous folding lends support.

We have then a picture of a great continental mass with a median geosyncline (the Tasman geosyncline) and a marginal geosyncline (the Circum-Australian). Within the median geosyncline ore deposits were formed during several epochs; but only the more westerly are preserved to us, the remainder being drowned by the break-up of the eastern part of the continent in Tertiary times. The history of ore genesis in the marginal geosyncline is not as clear as that of the median, most of the deposits probably being now beneath the sea; but the earlier of the two epochs in New Guinea appears to correspond in time to one of the more important times of metallogenesis in eastern Australia, the Gympie Epoch; while the Upper Cretaceous activity in Queensland appears to be the initiation of the movements which, somewhat later, led to ore genesis in both New Guinea and New Caledonia.

Comparison of the Metallogenetic Epochs of Queensland with those of Other Areas.

The history of ore genesis in Australia opens with the Late Archaeozoic epoch, one of the most important of all, during which gold and other ores associated with granites and pegmatites of pre-Proterozoic age (Simpson, 1940, p. 215) were formed over a great part of Western Australia. In Queensland the history opens somewhat later with the Late Proterozoic ore genesis and runs closely parallel with that of New South Wales, for the four epochs of Queensland have, with minor variations, their counterparts to the south; but in New South Wales, there is an additional epoch which (as regards ore genesis) was confined to that State. The supremely important period of ore genesis in Victoria was that of the Tabberabbera orogeny—epi-Middle Devonian, an epoch which was also important in Tasmania, while in South and Western Australia there was little activity after the Pre-Cambrian.

The ores of the late-Archaeozoic Epoch, confined to Western Australia, have been and still are the greatest gold producers of the whole continent; and many, if not all, of the tantalum lodes of the north-west, the most important source of this metal known, are of this age.

Turning to the Cloncurry Epoch, the Mount Isa field has a close parallel in that at Broken Hill in New South Wales, for not only is there a close parallelism of the trends of Archaeozoic rocks in the two areas (Hills 1946, fig. 1), but Mount Isa lies directly on the northerly extension of the Broken Hill trends. While Proterozoic strata carry the ore in the former area, rocks of this age are absent at Broken Hill, but nevertheless David (1932, p. 32) suggested that the granites which introduced the ore were of that age. Unlike those of Queensland, all the New South Wales fields of very ancient age lie in the far west.

There was no important ore formation at this time in Victoria; but in Tasmania ore genesis opened with the formation of small copper deposits, associated with basic igneous rocks of Proterozoic age, at Quamby Brook. In South Australia most of the gold and several important copper fields are in rocks of Older Proterozoic age and were probably formed during the uplift which closed this period; while in Western Australia this Epoch was second in importance only to that of the Archaeozoic, for the gold, copper and lead ores of the Peak Hill and Ashburton fields were formed at this time.

In South Australia copper deposits occur not only in the older Pre-Cambrian rocks but also in the Adelaide Series, as at Kapunda, Burra and Blinman, and in Lower Cambrian rocks at Ediacara. Andrews referred to emergence of this area in early Middle Cambrian times, but considered that the folding and alteration of the strata may have taken place somewhat later. There is at present little evidence to date this metallogenesis at all accurately, and it is here placed tentatively as Middle Cambrian.

Ore genesis in the next Australian epoch, epi-Ordovician, was virtually confined to New South Wales. There has been difference of opinion as to whether the gold and copper ores of the Cobar-Parkes-Forbes-Canbelego area, placed here as epi-Ordovician, are of Ordovician or of Silurian age. There is in fact some mineralization in Silurian beds, but Andrews (1938) emphasized that these small deposits are not of the deep-seated type, characteristic of the much more extensive lodes found in the Ordovician rocks. He also stressed that the Mitta-Mitta (epi-Ordovician) folding of Victoria reached north into this part of New South Wales and that the Ordovician rocks are much more highly metamorphosed than the Silurian. Thus an epi-Ordovician age seems more likely than epi-Silurian. There is no apparent igneous source for the gold-copper ores of Cobar. In the neighbourhood of

Eulo, in south-west Queensland, slates and granite appear through the cover of the Great Artesian Basin. Slight mineralization in the slates may perhaps indicate an extension of the epi-Ordovician activity to this State.

In Victoria most of the important goldfields occur in Ordovician rocks, but there are important deposits in Silurian strata. While the Ordovician strata to the east of the Mitta Mitta geanticline are unconformable with the Silurian, to the west of the geanticline they pass conformably into the Silurian. The Silurian closed with orogeny and plutonic intrusion; but again the western beds, those of the Zephyrine geosyncline, were unaffected, the area of the Mitta Mitta geanticline marking the western limit of the folding. It is more reasonable to relate the gold deposition which is found in both west and east and in both Ordovician and Silurian rocks to the huge granitic instrusions which accompanied the Tabberabbera orogeny (epi-Middle Devonian)—an orogeny which affected both Ordovician and Silurian rocks and both the western and eastern strata, than to intrusions accompanying movements which affected only portion of the mineralized area.

The Tabberabbera orogeny also affected south-east New South Wales (Brown 1932) but the ores there appear to be related to later intrusions; neither the orogeny nor the ore genesis extended into the other mainland States.

The bulk of the ore deposits of Tasmania, the rich gold-copper-silver-lead-zinc and tin deposits, were introduced by granitic magmas, the age of which, in the absence of Devonian and Carboniferous sediments later than earliest Devonian, has not been conclusively demonstrated. David placed them as epi-Silurian or epi-Devonian. Nye and Blake (1938) expressed the official view of the Geological Survey that not only these, but the ultrabasic intrusions and the Porphyroid Series (massive and sheared acid to intermediate intrusions), are of Devonian age; but, on the other hand, Andrews suggested that the last strong compressive movement to affect the west of Tasmania was at the close of the Silurian. The age of the metallogenesis must therefore remain in doubt for the moment, but if it were indeed Devonian it may well have been related to the Tabberabbera orogeny of epi-Middle Devonian times.

Sussmilch coined the term Kanimbla epoch for a great orogeny which he considered affected the whole of eastern Australia about the end of the Devonian or Lower Carboniferous, and David referred many of the ores of Victoria and New South Wales and some of those of North Queensland to this epi-Devonian epoch. Later work has shown that in Victoria and probably in Tasmania the diastrophism was somewhat earlier, and Carey and Browne have found evidence in New South Wales that it occurred at the end of the Lower Carboniferous; but in Queensland the study of the middle and upper Palaeozoic sediments and faunas has not yet proceeded far enough to place the equivalent orogeny, the Drummond movement, more closely than Late Devonian or Lower Carboniferous.

Thus the ore-bodies of the Herberton Epoch may have been formed somewhat earlier than the time of the Kanimbla orogeny. These deposits, connected with acid plutonic intrusions, are confined to North Queensland, but are more widespread than hitherto suspected.

The mineral deposits of central and south-eastern New South Wales are to be referred to the Kanimbla epoch rather than to the epi-Middle-Devonian, since the Tabberabbera orogeny affected only the extreme south-east of New South Wales and in some areas Upper Devonian rocks were affected by the metalliferous intrusions.

The ores of the Herberton Epoch in Queensland and those of the Kanimbla Epoch in New South Wales lie at either extremity of the Tasman geosyncline. Between these products of acid and sub-acid batholiths, and reaching almost to them at either end, are the ultra-basic intrusions of the Great Serpentine Belt and their associated ores. The serpentine, of Late Devonian age in Queensland, may be somewhat earlier than that of New South Wales, but reasons have been set out above (p. 36) for regarding them as contemporaneous.

The close of the Palaeozoic and (in Queensland) early Mesozoic saw renewal of activity in Queensland and New South Wales; but again there was restriction of the area affected, restriction to the eastern margin of Queensland and the north-east of New South Wales, to the area affected by late Permian folding. While in New South Wales the evidence is inconclusive, in south-eastern Queensland there is good evidence that intrusion and metallogenesis were prolonged until the end of the Lower Triassic, and in the same part of Queensland, as nowhere else in Australia, important ore deposits were formed in the Middle and Upper Triassic.

By the end of Triassic times by far the greater part of the ore-bodies not only of Queensland but of the whole of Australia had been formed. Later activity was confined to a small coastal area about Maryborough and the Cygnet district in Tasmania.

The mineralization about Maryborough is found in granites or old palaeozoics, granites which invaded the nearby Tiaro Coal Measures which lie below the Lower Cretaceous Maryborough Series. The latter, much more strongly folded than Cretaceous rocks in other parts of Queensland and the early Tertiary Series, has a fauna closely similar to that of the Lower Cretaceous deposits of New Caledonia. In the latter there was gentle folding of the Lower Cretaceous rocks, followed by deposition of geosynclinal Upper Cretaceous beds and crustal instability which culminated in a strong orogeny and ultrabasic intrusions in post-Eocene times (Piroutet 1917, Bensen 1924). The orogeny and metallogenesis in the Maryborough area, which is pre-Tertiary, may well have represented the onset of the orogeny which culminated far to the east and north-east in the mid-Tertiary; while, in Queensland in the Miocene, the renewal of these movements was responsible for the gentle folding of the Palaeozoic strata to the east of Reid's line. But this renewal was not accompanied by metallogenesis.

The small gold deposits of the Cygnet area of Tasmania are genetically connected with alkaline intrusives thought to be of Tertiary age (Skeats 1917). This is the only Cainozoic mineralization in Australia.

In New Caledonia, while the age of the ores associated with the serpentine are by their field relations post-Eocene and can, by general consideration of the Circum-Australian geosyncline, be fixed fairly closely as Mid-Tertiary, there was also an earlier epoch during which silver-lead, copper and other metals were introduced into highly metamorphosed rocks in the north-east corner of the island. Opinions as to the age both of the metamorphics and of the orogenesis vary, for while all workers other than Jensen regarded the metamorphics as very old and the ore-bodies as normal lodes, the latter (1936) suggested that the metamorphics were but a metamorphosed part of the Mesozoic strata and that the lodes were formed by lateral secretion. As the ores and the shears which they fill are confined to the metamorphics, the lodes are here considered as Palaeozoic.

Further to the north-west, still within the limits of the Circum-Australian geosyncline, in New Guinea and Papua, there were also two epochs in which important deposits of ore were formed. The earlier of these can be placed more exactly than the older epoch of New Caledonia as Permo-Trias, for it affected beds of that age but not the fossiliferous Jurassic strata. In this epoch gold and possibly copper ores also were formed. The later epoch was that of the Oligocene or possibly Miocene, when in conformity with other parts of the geosyncline, as Timor, Celebes and New Caledonia, there was orogenesis and in New Guinea at least, injection of granodiorite and of porphyries. These intrusions led to the formation of the auriferous lodes from which most of the existing alluvial gold was shed. (Benson, 1924; Fisher, 1935, 1939; Noakes, 1938, 1939; Glaessner, 1943).

The history of ore genesis in Australia was thus of great length, covering the time from the earliest known rocks, those of the Archaeozoic, to those of almost the youngest, the Tertiary. Within these wide limits deposits of nine (possibly ten) separate epochs can be distinguished in the various States, and during this time the locus of ore deposition moved east and north-east so that Cretaceous ores are found only in a small area in the north-east.

Apart from an insignificant deposit in Tasmania, the deposits of the Tertiary are found only in the area of the Circum-Australian geosyncline, in New Guinea and New Caledonia.

CONCLUSION.

From this somewhat detailed survey of Queensland Mineral fields and the brief review of those of the other States, New Guinea and New Caledonia, the following conclusions stand out:—

1. In Queensland there were four metallogenetic epochs, of which three were of major and one, the latest, of minor importance.
2. Coincident with two and possibly three of these, ores were also produced in one or more of the other States and there were five (or six) additional periods during which ores were formed in other States but not in Queensland; of these, three were of major importance.
3. Of the Queensland Epochs, one, the Herberton Epoch, can be divided into a granitic and a serpentine phase; another, the Gympie Epoch, includes three phases, related to granitic intrusions, intermediate flows and acid hypabyssal intrusions respectively.
4. The ore deposits of Queensland show characters consistent with depths decreasing with the passage of time.
5. Three distinct types of tin ore associations can be distinguished.

6. There was extensive volcanic activity in south-eastern Queensland in early Mesozoic times, some of which was associated with ore genesis.
7. There was a close association of ore genesis with orogenesis.
8. There was a major orogeny with metallogenesis in Upper Cretaceous times and renewal of the movements without ore genesis in Mid-Tertiary.
9. After Pre-Cambrian and until Tertiary times, the general picture is of an Australasian continent extending to at least New Guinea and New Caledonia, with, until Mesozoic times, a wide median geosyncline, and, after Palaeozoic times, a marginal geosyncline. In and about these geosynclines many ore deposits were formed but probably more than half have since been lost beneath the sea.

The preparation of this address, involving a survey of almost everything that has been written on the Geology of Queensland, has made more than ever clear to me that if mining is to develop and prosper in our State a sheet survey is an essential; for such a detailed and systematic survey is the basis of stratigraphy and stratigraphy is an essential to mining geology just as it is the basis of tectonic studies and, in fact, of all branches of geology.

Finally, I wish to acknowledge with gratitude much encouragement and kindly criticism from Associate Professor W. H. Bryan, several suggestions from Dr. F. W. Whitehouse, and the permission of the Chief Government Geologist, Mr. C. C. Morton, to make use of a number of unpublished reports by officers of the Geological Survey.

SUMMARY OF METALLOGENETIC EPOCHS IN AUSTRALIA, NEW CALEDONIA AND NEW GUINEA.

Period.	Areas affected and Main Metals Introduced.							
	New Caledonia.	New Guinea and Papua.	Queensland.	New South Wales.	Victoria.	Tasmania.	South Australia.	Western Australia.
Oligocene or Miocene	Area of Serpentine Intrusions. Ni, Cr.	Whole area. Au.	..	..	..	*Tertiary* Small gold deposits of Cygnet	..	..
Maryborough Epoch (Upper Cretaceous)	..	..	Maryborough District. Au, Cu, Sb.	..	..	..	..	..
Gympie Epoch (Permo-Trias) Gympie Phase	..	Cordillera and north coastal area. Au, Cu?	Eastern portion of the Tasman geosyncline. Au, Ag, Pb, Zn, Cu, Sn, Bi, W, Mo.	North - east (eastern portion of area of the Tasman geosyncline). Au, Ag, Cu, Sn, W, Bi, Mo.	..	..	..	..
Kilkivan Phase (Lower Triassic)	..	..	Kilkivan and Monsildale. Hg.	..	..	..	..	..
Indooroopilly Phase (Middle and Upper Triassic)	..	..	South - east Queensland. Au, Ag, Pb.	..	..	..	..	..
Epi-Lower Carboniferous (Kanimbla orogeny)		..		South-east to central portions. Au, Cu, Ag, Pb, Sn, W, Mo.	..	..	..	..

Herberton Epoch Granitic phase, Late Devonian or epi-Lower Carboniferous)	*Palaeozoic* Possibly early Palaeozoic. North east corner. Au, Ag, Pb, Zn, Cu, Sb.	..	Northern part of Tasman geosyncline. Au, Cu, Ag, Pb, Sn, W, Mo.	..	..	..	..	..
(Serpentine phase, Late Devonian)		..	Central and southern coastal. Au, Cr.	The Great Serpentine Belt. Cr, Cu.	..	..	..	..
Epi-Middle Devonian (Tabberabbera orogeny)	..	..	..	..	Central and east. Au.	? West and north-west. Os, Ni, Cu, Fe, Ag, Pb, Zn, Sn, W, Mo, Au.	..	..
Epi-Ordovician	..	..	..	Cobar - Forbes-Canbelego Area. Cu, Au.	..	..	..	..
Middle Cambrian	..	..	..	..	..	..	South. Cu.	..
Cloncurry Epoch (Late Proterozoic; Pre-Lipalian)	..	..	Northern portion. Au, Ag, Pb, Zn, Cu, Sn, W, Co.	Central west. Ag, Pb, Zn, Cu, Sn.	..	Quamby Brook District. Cu.	South. Au, Cu, Fe.	Central and north-west. Au, Cu, Ag, Pb.
Late Archaeozoic	..	..	..	..	..	..	..	Most except east central and east southern. Au, Sn, Ag, Pb.

SUMMARY OF METALLOGENETIC EPOCHS IN AUSTRALIA, NEW CALEDONIA AND NEW GUINEA.

Period.	Areas affected and Main Metals Introduced.							
	New Caledonia.	New Guinea and Papua.	Queensland.	New South Wales.	Victoria.	Tasmania.	South Australia.	Western Australia.
Oligocene or Miocene	Area of Serpontine Intrusions. Ni, Cr.	Whole area. Au.	..	..	..	*Tertiary* Small gold deposits of Cygnet	..	..
Maryborough Epoch (Upper Cretaceous)	..	..	Maryborough District. Au, Cu, Sb.	..	..	..	..	..
Gympie Epoch (Permo-Trias) Gympie Phase	..	Cordillera and north coastal area. Au, Cu?	Eastern portion of the Tasman geosyncline. Au, Ag, Pb, Zn, Cu, Sn, Bi, W, Mo.	North-east (eastern portion of area of the Tasman geosyncline). Au, Ag, Cu, Sn, W, Bi, Mo.	..	..	..	..
Kilkivan Phase (Lower Triassic)	..	..	Kilkivan and Monsildale. Hg.	..	..	..	..	..
Indooroopilly Phase (Middle and Upper Triassic)	..	..	South-east Queensland. Au, Ag, Pb.	..	..	..	..	..
Epi-Lower Carboniferous (Kanimbla orogeny)		..		South-east to central portions. Au, Cu, Ag, Pb, Sn, W, Mo.	..	..	..	..
Herberton Epoch Granitic phase, Late Devonian or epi-Lower Carboniferous)	*Palaeozoic* Possibly early Palaeozoic. North east corner. Au, Ag, Pb, Zn, Cu, Sb.	..	Northern part of Tasman geosyncline. Au, Cu, Ag, Pb, Sn, W, Mo.	..	..	..	..	..
(Serpentine phase, Late Devonian)		..	Central and southern coastal. Au, Cr.	The Great Serpentine Belt. Cr, Cu.	..	..	..	..
Epi-Middle Devonian (Tabberabbera orogeny)	..	..	..	..	Central and east. Au.	? West and north-west. Os, Ni, Cu, Fe, Ag, Pb, Zn, Sn, W, Mo, Au.	..	..
Epi-Ordovician	..	..	..	Cobar-Forbes-Canbelego Area. Cu, Au.	..	..	..	..
Middle Cambrian	..	..	..	..	..	..	South. Cu.	..
Cloncurry Epoch (Late Proterozoic; Pre-Lipalian)	..	..	Northern portion. Au, Ag, Pb, Zn, Cu, Sn, W, Co.	Central west. Ag, Pb, Zn, Cu, Sn.	..	Quamby Brook District. Cu.	South. Au, Cu, Fe.	Central and north-west. Au, Cu, Ag, Pb.
Late Archaeozoic	..	..	..	..	..	..	..	Most except east central and east southern. Au, Sn, Ag, Pb.

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A.A.A.S.—Australasian (Australian and New Zealand) Association for the Advancement of Science.

A.G.G.S.N.A.—Aerial Geological and Geophysical Survey of Northern Australia.

B.A.A.S.—British Association for the Advancement of Science.

Ec. Geol.—Economic Geology.

G.S.N.S.W.—Geological Survey of New South Wales.

P.L.S.N.S.W.—Proceedings of the Linnean Society of New South Wales.

P.R.S.N.S.W.—Journal and Proceedings of the Royal Society of New South Wales.

P.R.S.Q.—Proceedings of the Royal Society of Queensland.

P.R.S.Vic.—Proceedings of the Royal Society of Victoria.

Q.G.M.J.—Queensland Government Mining Journal.

Q.G.S.P.—Queensland Geological Survey Publication.

Q.J.G.S.—Quarterly Journal Geological Society of London.

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PROCEEDINGS

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THE DISTRIBUTION AND SEASONAL PREVALENCE OF ANOPHELINE MOSQUITOES IN NORTH QUEENSLAND.

By F. H. S. ROBERTS, D.Sc., Animal Health Station, Yeerongpilly.

(*Received 1st April, 1947; read before the Royal Society of Queensland 25th August, 1947; issued separately 16th August, 1948.*)

INTRODUCTION.

Following the outbreak of war in the South-West Pacific, North Queensland became an important military centre, as large numbers of troops were concentrated there prior to their departure for the forward areas. The main body of troops was quartered on the Atherton Tableland and was supplied through the ports of Townsville and Cairns. This involved the establishment of large numbers of men in and around these cities.

Cairns is the centre of an area of hypoendemic malaria, which extends as far south as the Mulgrave Valley or possibly Ingham (Cilento, 1924). During a sharp, benign tertian epidemic at Cairns in 1942, Heydon (unpublished) determined *Anopheles punctulatus farauti* Laveran as the vector species.

In the selection of camp sites it was important to locate these, as far as practicable, in areas where this anopheline did not occur. This was particularly desirable as many of the men had already served in New Guinea and had a high malaria rate. Areas suitable in other ways for camp sites were, then, thoroughly examined to determine the species of anophelines present. The Cairns and Townsville districts were subjected to intensive control work throughout the entire period of the war and were maintained under constant survey. Further information on the anophelines, their breeding habits, distribution and seasonal prevalence, was obtained through the activities of a Medical Research Unit, which was established at Cairns in 1943 to investigate the therapeutics of malaria. Large numbers of laboratory infected anophelines were required for the work of the Unit, and these, for some time, were obtained from larvae collected in the Cairns-Townsville area.

PHYSICAL GEOGRAPHY.

The observations recorded here covered the coastal area from Townsville to Cairns, the Cairns hinterland, comprising the Atherton Tableland and Mareeba district, and the country west of Townsville as far as Charters Towers.

The coastal plain, on which Townsville and Cairns are situated, is limited on the west by a spur of the Great Dividing Range, and is predominantly narrow, at one point being not more than a mile in width. Stands of rain-forest are conspicuous as far south as Ingham, whence the country to Townsville becomes very poor and is largely covered by stunted, open forest eucalypts. The area between Townsville and Charters Towers is similar to that between Ingham and Townsville, The Cairns hinterland, on the eastern slopes of the Great Dividing Range, lies immediately south-west of Cairns and rises to about 3,000 feet. This area was at one time covered with large tracts of rain-forest, much of which has since been cleared and the land devoted to agricultural purposes.

The coastal plain has a warm, humid summer and a pleasantly cool winter. In Cairns, the mean maximum temperature is 84.9° F and the mean minimum 68.2° F. The Cairns hinterland possesses a less humid climate, with lower summer temperatures and occasional frosts during the winter.

The entire area receives the bulk of its rainfall between December and April, the remainder of the year being comparatively dry. The average annual rainfall on the coastal plain ranges from 47 inches at Townsville to about 200 inches in the vicinity of Innisfail. Cairns receives 88 inches, whilst, on the Atherton Tableland, Atherton has an average rainfall of 52 inches.

The rich rain-forest country of the coastal plain and the Cairns hinterland is watered by permanent rivers and numerous creeks. In the poor, open forest eucalypt areas, the creeks dry out in the dry season and the rivers become a series of isolated waterholes. Numerous swamps are present on the coastal plain, particularly in the vicinity of Cairns and Townsville.

Mangrove communities are frequent on the coast, and are usually associated with large brackish swamps, a sequence of high tides and summer rains.

SPECIES OF ANOPHELINES PRESENT.

Prior to 1942, three species of anophelines were recorded from North Queensland, namely *Anopheles annulipes* Walker, *A. bancrofti bancrofti* Giles, and the two subspecies of *A. amictus Edwards, A. amictus amictus* Edwards and *A. amictus hilli* Woodhill and Lee.

Seven further species have since been added. These are *A. punctulatus farauti* Laveran, *A. novaguinensis* Venhuis, *A. meraukensis* Venhuis, *A. powelli* Lee, *A. stigmaticus* Skuse, *A. atratipes* Skuse, and *Bironella gracilis* Theobald (Lee and Woodhill 1944).

DISTRIBUTION.

A. punctulatus farauti Laveran.

This species was very common on the coastal plain between Daintree and Innisfail, where the adult populations at times attained pest proportions. South of Innisfail larvae were hard to find; none was encountered south of Ingham.*

On the high country, larvae were frequent at Kuranda at an altitude of 1,080 feet and rare at Mareeba, 1,300 feet. None was seen at any locality on the Atherton Tableland proper (above 2,000 feet).

This distribution appears to be associated with two factors, namely, the presence or absence of rain-forest, and altitude. Rain-forest apparently indicates the existence of conditions of humidity, temperature and shelter which this anopheline demands for its establishment.

* NOTE.—In a recent survey of the Ingham-Lucinda Point district, Marks (1946) obtained evidence that *A. punctulatus farauti* is widespread in this area.

Studies by Atherton and Lemerle (unpublished) and by Roberts and O'Sullivan (in the press) show that adults of *A. punctulatus farauti*, for the most part, rest during the day in the bush in moist, sheltered spots close to the ground. These conditions are provided by rain-forest. South of Ingham, the country supports only very isolated and small stands of rain-forest, except at high altitudes, and the extensive areas of dry, open eucalypt forest would be unsuitable as shelter for adults. At Kuranda, which is covered with large stands of rain-forest, for example, larvae were plentiful, while between here and Mareeba, where there is only scattered eucalypt, very few were seen.

A. punctulatus farauti was not found at any altitude greater than 1,300 feet (Mareeba). Large stands of rain-forest are present throughout the Atherton Tableland and also on high country elsewhere in Queensland, and, although this is considered indicative of favourable conditions of moisture and shelter, the low temperatures would appear to be inimical to the successful establishment of the species in these areas. It is of interest to note that Lee (1946) has recorded *A. punctulatus farauti* from altitudes up to 5,800 feet in New Guinea.

A. annulipes Walker.

This was a widespread species, and its larvae were dominant in open forest country. Only odd larvae could be found in those areas in Cairns city which were favoured by *A. punctulatus farauti*, and they became numerous only in the more open country. They were present throughout the Atherton Tableland up to altitudes of 3,000 feet and occurred in practically every creek, seepage, and pool of water throughout the area examined. In the open forest country, isolated pools left by the drying rivers and creeks were a very prolific source of larvae.

A. amictus hilli Woodhill and Lee.

This anopheline was seen only in sunlit, brackish swamps along the coast, sometimes polluted to such a degree as to be strikingly foul. In the Cairns district, it was confined to a few areas and was distinctly seasonal in its prevalence. Further north along the coast, it was reported as frequently attaining pest proportions, as it did in parts of Cairns during the early months of the year.

A. amictus amictus Edwards.

This subspecies was found throughout the entire area, except at the higher altitudes of the Atherton Tableland. It was very common at Townsville, where larvae were frequent on the edges of the fresh-water swamps on the Townsville Common and elsewhere. It appeared to prefer waters carrying a heavy clay suspension, frequently foul from pollution.

A. meraukensis Venhuis.

Larvae of this species are apparently widely distributed on the coastal plain, for they were collected at both Townsville and Cairns. They were never numerous and were seen only among collections of larvae of *A. annulipes* and *A. amictus amictus*.

A. novaguinensis Venhuis.

This species was not seen by the writer, but is recorded from Cape York to Irvinebank (Lee and Woodhill, 1944).

A. bancrofti bancrofti Giles.

This species was common on the coastal plain, particularly in the vicinity of Cairns, but appeared to be rare on the Atherton Tableland. One interesting feature of this anopheline is that larvae were never very numerous in any one particular breeding pool. The more permanent still waters, thickly covered with vegetation, mainly hyacinth, species of water lilies, and reeds, were the favoured breeding grounds.

A. powelli Lee.

This recently described species was taken at Jacky Jacky, Cape York Peninsula (Lee and Woodhill, 1944). It was not seen by the writer.

A. stigmaticus Skuse.

This delicate anopheline was first located breeding in shaded, clear, cool rock-pools on Freshwater Creek near Cairns and in the foothills of the Great Dividing Range. Larvae were widespread throughout the Atherton Tableland and could be found along the quiet, grassy edges of creeks up to altitudes of 3,000 feet. This species was never found on the coastal plain.

A. atratipes Skuse.

This anopheline was seen only on the Atherton Tableland, where its larvae and those of *A. stigmaticus* usually occurred together.

Bironella gracilis Theobald.

Odd larvae have been recorded from the Cairns area (Lee and Woodhill, 1944). It was found once by the writer in a densely shaded creek thickly covered with vegetation at Yorkie's Knob, near Cairns.

SEASONAL PREVALENCE.

Observations over an eighteen months' period in the Cairns area indicate that, as the year advances, there is a change in the prevalence of the more common species.

In the early months of the year, *A. amictus hilli* was dominant, high tides and the subsequent dilution of the seawater by the seasonal rains providing breeding waters specially favoured by this species. *A punctulatus farauti* was also very prevalent at that time, but its numbers did not commence to exceed those of *A. amictus hilli* until early March. By this time the breeding waters had apparently become unsuitable for *A. amictus hilli* as very few larvae could be found where previously they had been numerous. *A. punctulatus farauti* remained dominant until about May. The breeding grounds from February to May were widespread, and included not only the brackish marshes and more permanent swamps, but extended well into the open country, for example, in the canefields. *A. annulipes* was seen mainly in the open country, breeding in creeks, small pools and seepages, whilst larvae of *A. amictus amictus* were encountered only in small numbers in the open areas in company with *A. annulipes* and *A. punctulatus farauti*, though showing a preference for pools carrying a heavy clay suspension.

As the dry season advanced (June to August) *A. punctulatus farauti* was gradually driven out of the open country, and could be found mainly in the shelter of mangrove and rain-forest, particularly where a source of blood meals was present. *A. annulipes* was dominant in the open country, where *A. amictus amictus*, showing an increase in numbers, still remained.

During the next two months, *A. punctulatus farauti* could be found only in isolated, well sheltered areas. Finally, many of the breeding places previously occupied by it and *A. annulipes* were taken over by *A. amictus amictus*, which for a short period during October and early November became the dominant species.

The explanation of this sequence probably lies in the tolerance of the adults to changing conditions of humidity. It is known that *A. punctulatus farauti* requires a high humidity for the survival of its adults (Mackerras and Roberts, in the press). During the humid wet season, conditions are ideal for its propagation. Later, as the dry season advances, adults are driven back into more sheltered positions in timber to secure suitable conditions for survival. Finally, towards the end of the dry season, the adults appear capable to surviving only in isolated areas in mangrove swamps or rain-forest, where water is still present and where they are close to a source of blood meals.

A. annulipes and *A. amictus amictus*, on the other hand, do not appear to require such highly humid conditions. In fact, their distribution throughout Australia (Lee and Woodhill, 1944) and their preference for the more open and drier areas during the early part of the year in North Queensland, would indicate that the high humidity required by *A. punctulatus farauti* may not be suitable to them. This would account for these species becoming dominant during the dry season in the Cairns-Townsville area. The prevalence of *A. amictus amictus* towards the end of the year is also possibly associated with the increasing foulness of the now stagnant waters, which provide a type of breeding water favoured by this species.

DISCUSSION.

Several species of Australian anophelines are now known to be good hosts of malaria parasites (M. J. Mackerras and Roberts, in press), and there has been considerable discussion of the possibility that returning servicemen might initiate new foci of endemic infection. I. M. Mackerras (1947), reviewing the available evidence, has concluded that *A. punctulatus farauti* is the most dangerous species on the mainland of Australia, and that whilst other common mainland species are equally susceptible to infection, these are deficient in the additional attributes which characterise successful natural vectors. In Queensland, in particular, the zone of endemic malaria was considered to be limited to the distribution of *A. punctulatus farauti*, with the rest of the State liable only to sporadic infection.

The incidence of malaria during the past eighteen months, when large numbers of malarious men have been scattered throughout the State, supports Mackerras' opinion. There has been only one small localised outbreak and a few scattered cases outside the known endemic area, but no major epidemic. One feels justified in concluding, then, that malaria is not likely to be a problem in any part of Queensland which does not include *A. punctulatus farauti* in its anopheline fauna. The distribution and prevalence of this species, are, therefore crucial to any analysis of the malarial situation, actual or potential.

As regards distribution, it is believed that the limits of *A. punctulatus farauti* reported here are substantially correct. Throughout the war, various malaria control units surveyed the Atherton Tableland, but never reported its presence. Similarly, Perkins (1942 unpublished) in a careful survey, prior to that of the author's, also failed to find it at Townsville, as did the malaria control units subsequently stationed there for a considerable period. It may be remembered, too, that Hill (1925) spent several years studying the anophelines of Townsville without encountering it, although it could, of course, have been introduced since that date. For these reasons, and because of the high humidity required for survival of the adults, it seems very probable that Taylor's (1943) records of this species at Townsville, Charters Towers, Hughenden, and Mt. Isa are erroneous.

As regards prevalence, it is to be remembered that *A. punctulatus farauti* in North Queensland, is relatively zoophilous (Heydon unpublished; Roberts and O'Sullivan, in press), and that Heydon found a sporozoite rate of only 0·66 per cent during the 1942 benign tertian epidemic at Cairns. There is consequently strong reason to suspect that, like *A. culicifacies* in Southern India and Ceylon, *A. punctulatus farauti* can be associated with epidemic malaria only during periods of particularly high and prolonged abundance. In years of normal rainfall, its population begins to decline in May or June, as has been described above; cases of malaria occur, but there is insufficient time for an epidemic to build up. In 1942 (and also, from the available information in 1918, another epidemic year (Breinl and Taylor, 1918)), there was a wet season which extended well into the year. Showers during May, June, and July, 1942, maintained extensive breeding places, which would normally have dried up or become unsuitable. Winter temperatures were higher than usual, and extensive populations of the vector were able to maintain themselves until as late as September.

On this basis, the epidemic would be attributed, not to any fresh introduction of infection, but to special seasonal conditions reacting on a normally hypoendemic situation. The control measures which have been undertaken since then have not been tested by the occurrence of a high "epidemic potential." That they have reduced the normal hypoendemicity practically to zero gives reason to hope that they will cope efficiently with the epidemic risk when it arises.

SUMMARY.

1. Ten species of Anophelines have been recorded in North Queensland. Their distribution and seasonal prevalence in the Cairns and Townsville area are discussed.

2. In observations made by the writer, *A. punctulatus farauti*, the only important vector of malaria in Australia, did not occur south of Ingham, nor could it be found on the Atherton Tableland.

3. The distribution of this species appears to be associated with two factors, namely, the presence of rain-forest, which apparently expresses the conditions of the microclimate necessary for adult survival, and altitude, the species not being found above 1,300 feet.

4. In the Cairns area, there was a definite seasonal succession of the more common species. *A. amictus hilli* was dominant for the first two months of the year, then *A. punctulatus farauti* to about June, followed by *A. annulipes*, and finally *A. amictus amictus*. This succession is considered to be associated with changing conditions of humidity brought about by the seasonal distribution of the rainfall.

5. It is suggested that epidemic years at Cairns are characterised by a prolonged wet season and a relatively mild winter.

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TRIASSIC PLANTS FROM CRACOW.

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(With Plate I.)

(*Received* 30*th June*, 1947; *read before the Royal Society of Queensland August*, 1947; *issued separately* 16*th August*, 1948.)

In 1934 the Chief Government Geologist forwarded to this department for determination a collection of plant fossils made by Mr. A. K. Denmead from cores of bores sunk at Walhalla, Cracow. Dr. F. W. Whitehouse submitted a preliminary report on the plants.

I have now, in the course of an effort to determine the age of the Cracow ore deposits, made a further examination, the results of which are the subject of this short paper.

The following is a revised list of determinations:—

"Star-Caps" or detached sporangiophores of an equisetalean plant.

? *Equisetites* sp.

Dictyophyllum ? davidi.

Cladophlebis australis.

Cladophlebis sp.

Todites williamsoni.

Marattiopsis sp.

Thinnfeldia feistmanteli.

Thinnfeldia lancifolia.

Neuropteridium moombraense.

Sphenopteris superba.

Taeniopteris spatulata.

Taeniopteris sp.

Petiole of *T. spatulata.*

Gymnosperm seeds.

Detached strobilus.

This assemblage constitutes a mixture of forms some of which are found in the Esk Series, others in the Ipswich Series, others again in the Walloon Series, and still others which are common to two or all three of these.

Forms confined to the Esk Series: The one species of *Dictyophyllum* is very poorly preserved but may be *D. davidi,* which is known only from the Esk Series. *Todites williamsoni* is also known only from the Esk Series, but the name represents a type of frond rather than a species. *Neuropteridium moombraense* is known with certainty only from the Esk Series, but Jones and de Jersey (1947) have doubtfully referred a form from the Ipswich Series to this species.

Forms found in both Esk and Ipswich Series: Thinnfeldia lancifolia and *Sphenopteris superba.* The former is much more common in the Ipswich than in the Esk Series.

Forms confined to the Walloon Series: Taeniopteris spatulata is common in and characteristic of this series. It has in the past been considered diagnostic of the Walloon Series.

Forms common to all three Series: Cladophlebis australis occurs abundantly in all three series, but is most common in the Walloon Series. *Thinnfeldia feistmanteli* is much more common in the Esk and Ipswich Series than in the Walloon.

Genus not hitherto recorded from Australia: Marattiopsis is known from both Triassic (especially Rhaetic) and Jurassic rocks, though more common in the Jurassic. In the absence of specific determination, the genus does not help greatly in the determination of the age.

Thus the flora in a number of species is strongest in Ipswich and Esk Series forms (Middle Triassic), but the Jurassic element is strengthened by the fact that *T. spatulata* is by far the commonest species in the collection. The admixure of forms suggests an horizon between that of the Ipswich and Walloon Series—the Bundamba Series (Upper Triassic). The flora of the Bundamba Series is little known except in the lowermost 300 feet in the type area, where it is essentially similar to that of the Ipswich Series. If the Cracow Strata are correctly regarded as Bundamba, it suggests that there was either lateral or vertical change in the flora, and in particular an earlier appearance of *Taeniopteris spatulata* than previously known.

The suggestion that these beds are the equivalents of part at least of the Bundamba Series agrees with Whitehouse's mapping (1945, fig. C, p. 27) of the main mass of sandstone a few miles to the west.

"Star-Caps" or Detached Sporangiophores.

Plate I., fig. 1.

There are, in the collection, several curious structures which may be examples of those to which Harris referred as "Star-Caps" (1931, p. 11). They are circular and disc like, flat but slightly raised in the centre, with up to twenty-two radial ridges. Their diameter is 9 or 10 mm.

Harris (p. 12, pl. 11, fig. 4) showed that "Star-Caps" were attached terminally to a stem and suggested that they were modified leaf sheaths, the teeth of which were bent down over the stem apex. Harris' specimens were much smaller, 2-5 mm. diameter, than the Cracow examples and differed further in being slightly depressed in the centre instead of slightly raised, and with radial furrows instead of ridges. The Cracow specimens may be the under surface of large "Star-Caps," showing radial ridges instead of furrows and a raised instead of a depressed centre.

The other possibility is that the Cracow specimens represent impressions of the under sides of the heads of extremely large sporangiophores, but the latter exhibit ridges which are not strictly radial (see Harris 1931, pl. 11, fig. 12). Their interpretation as large "Star-Caps" seems more likely to be correct.

There is no evidence in the available material of an Equisetalean plant large enough to bear a cone of a size which would have such large sporangiophores, the only Equisetalean plant preserved being a very poor impression of *Equisetites?* which is only 7 mm. wide after compression. It is also unlikely that any of the described Ipswich or Esk Series forms would have borne such a large cone. There is, however, a very large undescribed Equisetalean form from the Ipswich Series in the Brisbane area, and a form such as that may well have had a cone of the size indicated.

DICTYOPHYLLUM ?DAVIDI Walkom.

Plate I., fig. 2.

1917 *Dictyophyllum davidi* Walkom, p. 10, pl. 3, fig. 2.

Remarks: A form which is very probably a species of *Dictyophyllum* is represented by two impressions, one of each surface of the one pinna. The pinna was more than 4.5 cm. long and, including the lobes, about 2.5 cm. wide. The acutely directed but bluntly rounded lobes reach only about one-quarter of the distance to the midrib of the pinna. The venation is indistinct, but each lobe has a midrib which gives off veins at an acute angle. The anastomosing veins cannot be seen. In size and form this agrees fairly well with *D. davidi,* but with such poor preservation it is not possible to be sure of its identity with that species.

TODITES WILLIAMSONI (Brongniart) Seward.

Plate I., figs. 3 and 4.

1928 *Todites williamsoni* (Brongniart) Walkom, p. 459, pl. xxvi, figs. 1, 2.

There are several detached pinnae which agree well with Walkom's description and figures. The longest is over 7 cm. and is limited only by the diameter of the bore core. The rachis is stout, about 1.5 mm.

in diameter with a median ridge. The pinnules are small, crowded, and almost semi-circular in shape, 3 to 4 mm. long. The venation is neuropterid, the midvein arising at or just below the centre of the base of the pinnule and running almost at right angles to the base. It loses its identity about two-thirds of the way to the apex. From either side of the midvein there arise four secondary veins, each of which, except the first, branching once. In a few pinnules (towards the end of the pinnae?) the midvein arises near the lower margin of the pinnule diverging only gradually from the rachis, the venation then approaching that of *Thinnfeldia odontopteroides* (Pl. I, fig. 4). No sporangia have been observed. Harris (1931, p. 35) has pointed out that two species had been included under *T. williamsoni*; the present form appears to agree with the first type, the type with smaller pinnules and with entire margins.

Cladophlebis australis (Morris) Seward.

For synomomy and figures see Walkom (1917, p. 3, pl. 5, figs. 1, 2a; pl. 7, fig. 1; pl. 8, fig. 1; text fig. 1).

Remarks: Several portions of well preserved, quite normal fronds of this species occur in the collection. The secondary veins divide once, close to the midrib.

CLADOPHLEBIS sp.

Plate II, fig. 5.

Remarks: One poorly preserved bipinnate frond differs from *C. australis.* It is less robust, the pinnules are more crowded, rather narrower, 2 mm. wide and 5 mm. long, and markedly falcate. The venation is indistinct, but it appears not to differ from that of *C. australis.*

MARATTIOPSIS sp.

Plate I, fig. 6.

Description: Two specimens only, both fertile, can be referred with certainty to this genus. The larger and better preserved fragment (Pl. I, fig. 6) is 22 mm. long and 8 mm. wide tapering gently upwards. Neither the base nor the apex of the pinna is preserved. The midrib is about 1 mm. wide, the secondary veins are almost at right angles to the midrib, about 8 to 10 in 5 mm. The impressions of the synangia, situated on the outer ends of the secondary veins, are 1.5 to 2 mm. long and about 0.5 mm. wide. No details of structure can be seen.

Remarks: Harris (1931, pp. 64-67) has summarised the available information on species of *Marattiopsis* and has pointed out that only five are well known. All of these are much wider and have much larger synangia than the Cracow specimens. Du Toit (1927, pp. 322-3, pl. xviii, figs. 1 and 2) placed specimens more comparable in size in *M. münsteri,* but his form has a marginal vein and was referred to

Yabeiella? dutoiti sp. nov. by Oishi (1931, p. 264). Close comparison with other species is impossible owing to the fragmentary nature of the Cracow material.

Many of the sterile specimens in the Cracow material have a very strong midrib which is markedly asymmetrical in position. These are all thought to be *Taeniopteris spatulata*, as several show the pinna tapering to a long petiole and as the fertile fragments which are undoubtedly *Marattiopsis* have a much narrower midrib.

Thinnfeldia lancifolia (Morris) Gothan.

For synonymy and figures see Walkom (1917, p. 21, pl. 3, fig. 3; pl. 4, fig. 1; pl. 7, fig. 2; text fig. 6).

Remarks: Three pinnules, detached, but lying parallel and clearly not much separated from the rachis, can be referred to this species. The pinnules are 20 mm. long and 9 mm. wide, rather longer than is normal in this species and approaching the size of *T. eskensis;* but specimens of *T. lancifolia* of this size are known. The angle between the secondary veins and the midrib, 20°, also approaches that in *T. eskensis.*

Thinnfeldia feistmanteli Johnston.

For synonomy and figures see Walkom (1917, p. 17, pl. 1, fig. 3; pl. 2, figs. 1, 2; text fig. 5).

Remarks: A portion of one frond shows the typical bipinnate division and traces of the odontopteroid venation of this species. It is the medium-sized type with pinnules about 5 mm. long.

Sphenopteris superba Shirley.

Plate I, fig. 7.

Remarks: Two fragments possibly belong to this species but are too poorly preserved to be identified with certainty, but that illustrated can be referred with confidence to this species.

Neuropteridium moombraense Walkom.

Plate I, figs. 8 and 9.

1928 *Neuropteridium moombraense* Walkom, p. 463, pl. 27, fig. 4.

Description: The material consists of four pinnules, two attached to a rachis and two unattached. The longest is 25 mm. long and 12 mm. wide; the broadest is 14 mm. wide and 22 mm. long. One is only 8 mm. wide. The margins, particularly the lower margin, are lobed. The venation is neuropterid, the rather weak mid-vein running about two-thirds the length of the pinnules. The secondary veins divide dichotomously close to the midrib and usually each branch divides dichotomously again. The secondary veins make an angle of about 75° with the rachis. The rachis is stout, 3 mm. wide and striated longitudinally.

Remarks: These pinnules agree very closely with Walkom's description and figure of the upper pinnules of *N. moombraense.* The lower pinnules differ, being much shorter and rhomboid in outline; none of the lower pinnules is preserved in the Cracow material.

TAENIOPTERIS SPATULATA McClelland.

Plate I, figs. 10-14.

For synonomy see Walkom 1917, p. 30.

Remarks: Specimens of this genus are difficult to distinguish from the species of *Marratiopsis* described above unless the lower portion of the frond is preserved. In *T. spatulata* the lamina of the pinna becomes gradually narrower and finally the pinna tapers into a long petiole. On the other hand, in *Marattiopsis* the pinnule is not petiolate and the base of the lamina is rounded or abruptly contracted (see Harris 1931, p. 65).

In the Cracow collection, there are fertile pinnules which must be referred to *Marattiopsis,* and also sterile pinnae which taper to a long petiole (Pl. I, figs. 13, 14) which are referred to *T. spatulata.*

The midrib of the Cracow specimens is strong—2 mm. wide—as is usual in this species, and in nearly all specimens it is asymmetrically placed, but to a greatly varying degree. This asymmetry appears (the evidence is not conclusive) to increase towards the petiole, the lamina on one side decreasing more rapidly than on the other; some specimens show lamina on one side only near the base. Further up the pinna the midrib is symmetrically placed. Frequently the lamina is bent back along its junction with the midrib and in some cases it is broken off, usually on one side only.

In the strong asymmetrical midrib and the gradual tapering to a petiole it is like *T. elongata* from the Maryborough Series (Walkom, 1918, p. 6, pl. 1, figs. 1-3), but is narrower and has more closely set secondary veins (15 or 16 in 5 mm.). While the specimens of *T. spatulata* figured by Walkom are symmetrical about the midrib, he included in the synonomy those forms figured by Feistmantel (1890) as *T. daintreei,* two of which, both small pinnae (pl. 27, fig. 4, 4a and pl. 28, fig. 6, 6a), show an asymmetrical midrib.

TAENIOPTERIS sp.

Remarks: A fragment of a wider pinna—13 mm.—is probably only a wider than usual specimen of *T. spatulata,* but may represent a distinct species. Walkom (1917, p. 30) included forms as large as this in *T. spatulata,* but in the Cracow material there is no gradation between the forms of the two sizes.

Gymnosperm Seeds.

Remarks: There is a number of detached seeds which do not appear to differ from the type common in the Ipswich Series. There is also one form which may be a scale of a conifer cone.

Detached Strobili.

Plate I, fig. 15.

Remarks: In the collection are two detached strobili which are poorly preserved but have a general resemblance to Equisetalean strobili such as *Calamostachys.* They may equally, however, be related to *Pteruchus.* The axis is 9 mm. long and about 0.5 mm. wide. From the axis are given off synangia, about 1.25 mm. long, which may have had a spiral arrangement but are now quite flattened.

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EXPLANATION OF PLATE I.

FIG. 1.—"Star-Cap" of an equisetalean plant. x 2.

FIG. 2.—*Dictyophyllum ? davidi.* Nat. size.

FIGS. 3 and 4.—*Todites williamsoni.* Fig. 3, Nat. size. Fig. 4, apical end of pinna x 2.

FIG. 5.—*Cladophlebis* sp. Nat. size.

FIG. 6.—*Marattiopsis* sp. x 2.

FIG. 7.—*Sphenopteris superba.* Nat. size.

FIGS. 8 and 9.—*Neuropteridium moombraense.* Fig. 8, x 2. Fig. 9, Nat. size.

FIGS. 10-14.—*Taeniopteris spatulata.*

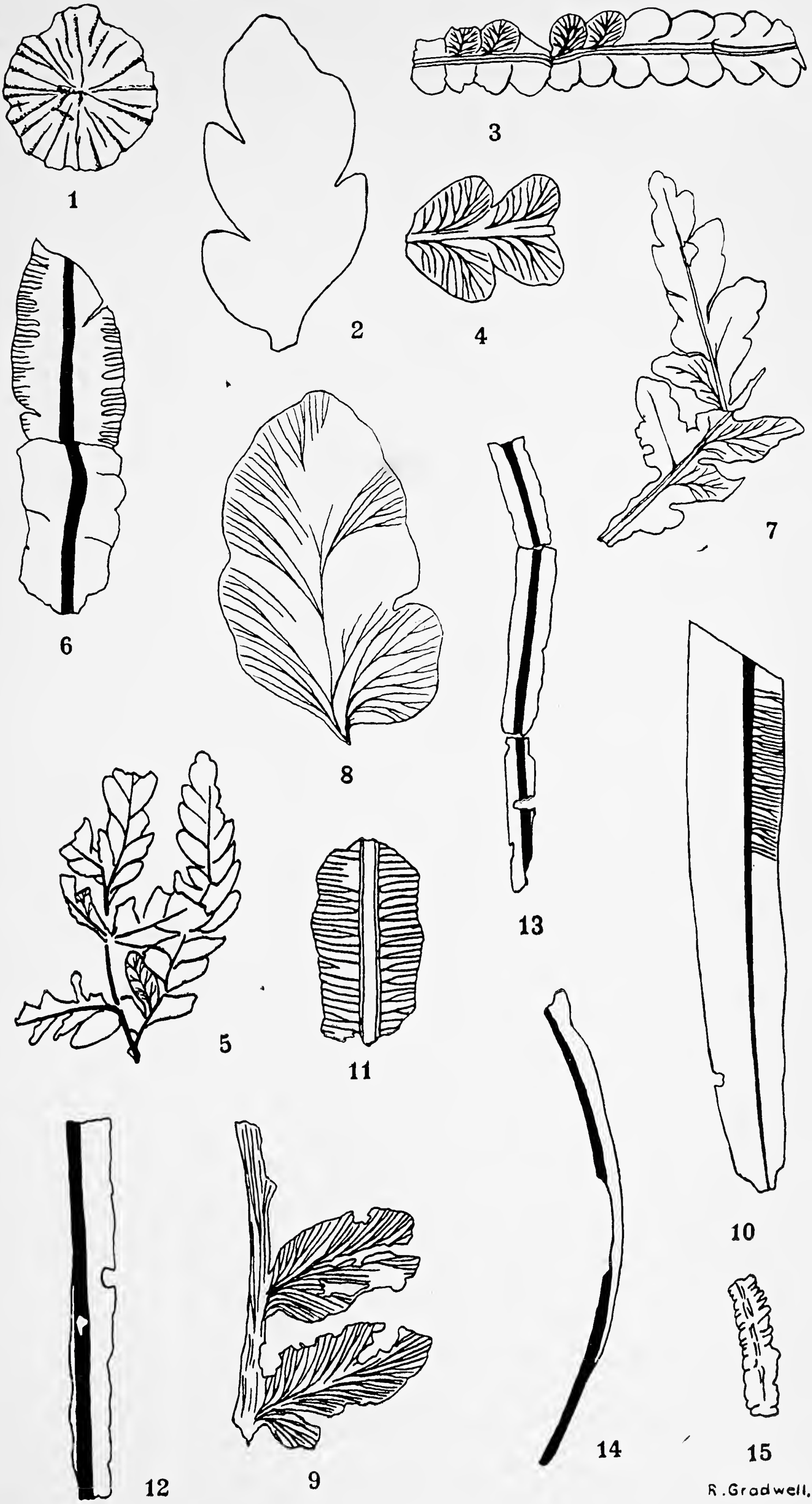
Fig. 10. Lower portion of pinna, showing asymmetrical midrib. x 2.

Fig. 11. Middle portion of pinna. x 2.

Fig. 12. Lower portion of pinna, with lamina on one side only. Nat. size.

Figs. 13 and 14. The pinna grading into the petiole. Nat. size.

FIG. 15.—Detached strobilus. x 2.



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HEAVY MINERAL BEACH SANDS OF SOUTHERN QUEENSLAND.

Part I.—The Nature, Distribution and Extent, and Manner of Formation of the Deposits.

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(With Three Text-figures and Plates II–IV.)

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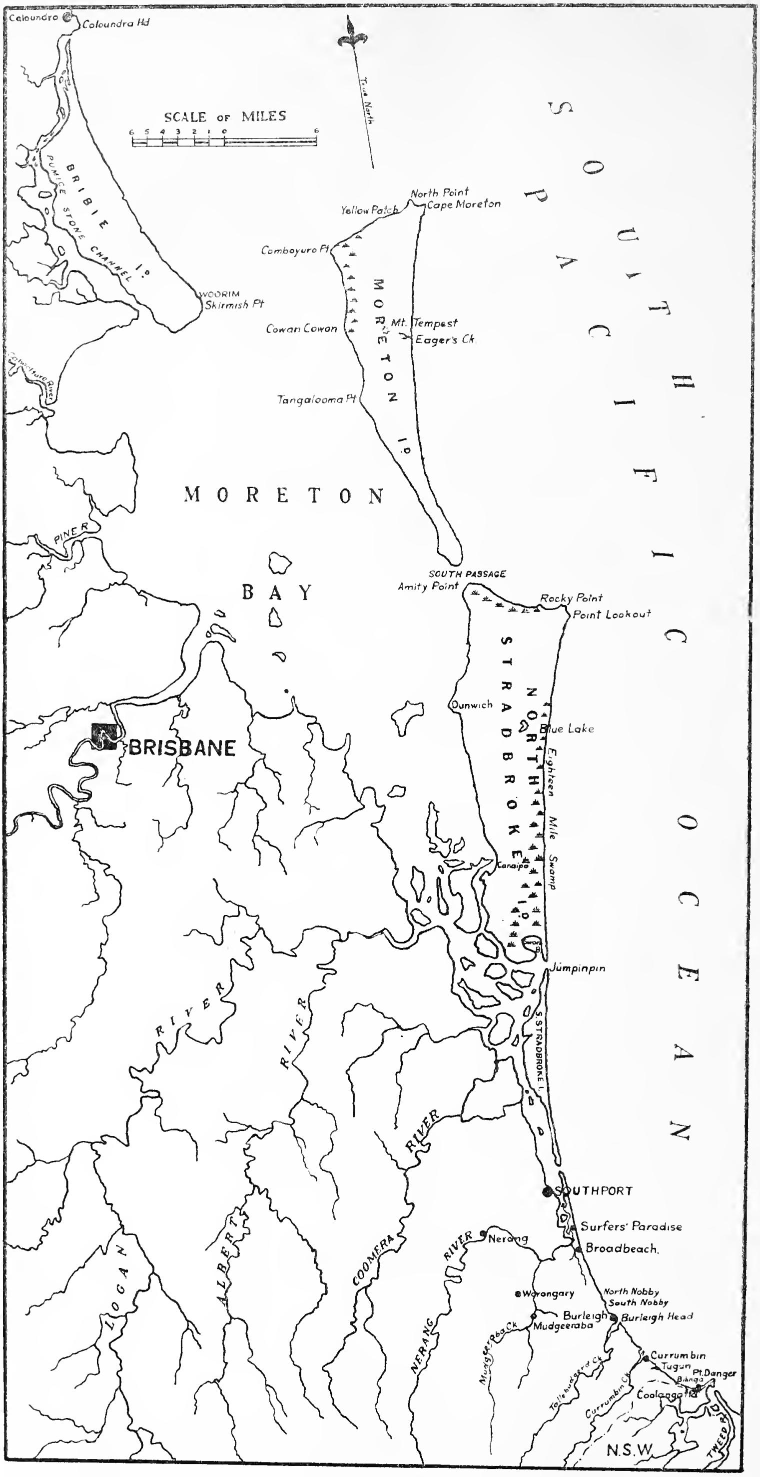
CONTENTS.

SUMMARY.

This paper gives an account of the nature, distribution and extent, and manner of formation of the heavy mineral beach sand deposits from Caloundra in Southern Queensland southwards to the New South Wales border. These sands, together with those of Northern New South Wales, constitute the greatest known source of detrital zircon and rutile in the world. Although the deposits are shown to occur below the fixed coastal dunes, no seams of economic value have been found below present sea-level. The value of Stradbroke Island as an area for large-scale exploitation by dredging methods is indicated.

INTRODUCTION.

The heavy mineral beach sands of the Southern Queensland coast have been known for many years. Small quantities of gold, tin, and platinum are reported to have been obtained from the "black sands" on the beaches near the New South Wales border as early as 1889 (v. Rands). It has only been in recent years, however, that the true value of these deposits has been appreciated, and some idea of their lateral and vertical distribution has been obtained.



TEXT-FIGURE 1.
Map of Region Investigated.

The heavy mineral beach deposits of Southern Queensland belong to the group of zircon-rutile-ilmenite sands and, together with those of Northern New South Wales, constitute the greatest known source of detrital zircon and rutile in the world. The large-scale exploitation of these extensive deposits originated essentially from the war-time demand for rutile and zircon.

Investigations, the results of which form the substance of the present paper, have been carried out as a research project within the University of Queensland by the writer during the years 1945 and 1946. The object of the work has been to determine the nature, distribution and extent, and the manner of formation of the zircon-rutile-ilmenite sands in Southern Queensland.

The region investigated extends from the New South Wales border northwards to Caloundra, at the northern extremity of Moreton Bay. Most systematic field work was carried out, however, on the South Coast, from Southport at the southern end of Moreton Bay to Point Danger in the extreme south-east corner of the State.

PHYSIOGRAPHY OF REGION INVESTIGATED.

The South Coast.

In the area under consideration the landward margin of the coastal plain coincides approximately with the 25-foot contour as shown on the Commonwealth One-mile Military contour maps. On the South Coast the coastal plain ranges up to a width of 5 miles.

It is generally flat and low-lying, containing large tracts of marsh-land, such as Stephens' Swamp near Burleigh and the Merrimac Swamp north of Mudgeeraba. It is naturally divided into three sections by spurs which extend from the coastal ranges seaward to Burleigh Head, to Currumbin, and to the Tweed River just south of the State border. The most northerly of these areas—that which extends from Southport to Burleigh—is the most extensive. It has a maximum width of 5 miles from Broadbeach to Worongary, and covers an area of some 28 square miles. The region between Burleigh and Currumbin is the least extensive, the narrow divide which separates Tallebudgera Creek from Currumbin Creek extending to within $\frac{3}{4}$ mile of the strandline. The most southerly of the three areas—that from Currumbin southwards to the Tweed—is the second most extensive. It ranges in width from less than a hundred yards in the Currumbin-Flat Rock region to 3 miles in the region inland from Bilinga, the average width of the area (portion of which lies beyond the State boundary) being $1\frac{1}{2}$ miles.

At a number of places hills rise from the coastal plain. Some of these, such as North Nobby, are entirely surrounded by lowland, but others, such as South Nobby (Little Burleigh), Kirra, Greenmount and Point Danger project seaward as headlands, with lowland only on their landward sides.

The landward margin of the coastal plain on the South Coast is very irregular in outline, but in both the Southport-Burleigh and the Currumbin-Tweed areas a strong general concavity is exhibited. The seaward part of the plain is covered by a belt of coastal dunes. This marginal zone varies in width up to a maximum of about $\frac{1}{2}$ mile in the Broadbeach region. Most of the dunes are fixed and vegetated with Banksias, Eucalypts, shrubs and other plants. These fixed dunes generally have retained their shape, and the individual ridges and hollows have been traced more or less parallel to the present coastline for distances up to 4 miles in the Broadbeach-North Nobby region. In height these fixed dunes usually range from 15 to 20 feet above mean sea-level, the hollows between them being about 6 feet lower. Although some of them are more pronounced than others and their spacing varies, a series of 15 well-defined, fixed dunes may be seen in the belt of coastal dunes just south of Broadbeach. The most inland of these old dunes are the broadest and the lowest, and from them the ground slopes gradually down to the swamp land behind. The most seaward of the coastal dunes—that is, the foredune—is a living and growing dune. It runs approximately parallel to the coastline, and generally is higher than any of the fixed dunes, often ranging from 20 to 25 feet in height. It attains its greatest height towards the northern end of the various bays in the area under consideration.

In front of the foredune a more or less horizontal platform of varying width is found in most places. This is known as the berm. Although it is nearly flat, with an average elevation of about 12 feet above mean sea-level, it usually has some small undulations. It is neither fixed nor stable. With prolonged periods of fine, calm weather it may attain a width of as much as 3 chains and, from its seaward margin, slope gradually down to the beach or have a fall of only a foot or two. With heavy cyclonic gales, however, as much as half-a-chain may be cut away, and a vertical scarp of 5 feet or more down to the beach produced.

The beaches themselves are sandy and wide, their width at low tide ranging between 100 and 200 feet. Generally they are very gently sloping and firm. Rockpebbles are usually found around the projecting headlands in varying amounts, and have been observed on the beach particularly on the northern side of headlands for distances of several miles.

The area is traversed by the Nerang River with its tributaries Mudgeeraba and Little Tallebudgera Creeks, by Tallebudgera Creek, Currumbin Creek, and two small creeks called Flat Rock Creek and Coolangatta Creek. Immediately south of Point Danger the Tweed River empties itself into the ocean, and that portion of the coastal plain area south of Currumbin which extends beyond the State border is traversed by one of its tributaries, Cobaki Creek.

The Nerang River flows in a general easterly direction over the coastal plain, but, on approaching the coast in the Harper's Wharf area of Broadbeach, it turns northward and runs in that direction for about 5 miles before entering the sea. This coastal strip between the river and the sea is essentially one long, narrow sandspit. It has its greatest width in the south where the zone of old, fixed dunes is strikingly developed, but in the recently-formed part north of the Jubilee Bridge there is only a foredune, while in the far north even the foredune has not formed yet.

Both Tallebudgera Creek and Currumbin Creek flow in narrow valleys in a general north-easterly direction throughout their courses, being separated from one another only by a narrow divide.

The coastline on the South Coast constitutes the southern part of a very gently arcuate bay, which extends from Point Danger at the State border northwards to Point Lookout on Stradbroke Island. While the total length of coastline in this bay is 56 miles, that part from Point Danger to the mouth of the Nerang River at Southport measures some 20 miles. Within the southern half of this part there are a series of smaller bays, between the rocky headlands of South Nobby, Burleigh, Currumbin, Kirra, Greenmount and Point Danger. None of these headlands, however, projects sufficiently far seawards to interfere greatly with the regularity of the coastline curve from Point Danger N.331°E. to Southport. This curve is deeper than that of the northern part of the bay, the greatest curvature actually being from Currumbin to Point Danger at the extreme southern end.

Stradbroke Island.

Northward from the mouth of the Nerang River Stradbroke Island stretches for a distance of some 36 miles, disregarding the break at Jumpinpin. This break, which occurred in the year 1894, following heavy erosion on both sides of a narrow neck of sand, has divided the island into two parts—North Stradbroke and South Stradbroke Island. Considered as a whole the island approximates in outline to that of an isosceles triangle, tapering southwards to a very acute angle. As the break occurs about two-thirds of the way from the northern end of the island, the width and area of South Stradbroke Island is small compared with that of North Stradbroke Island.

Stradbroke Island is almost entirely covered with sand dunes, and only at a few places close to sea-level on North Stradbroke Island does rock outcrop. These dunes are for the most part abnormally high and heavily vegetated. They attain a height of 719 feet on North Stradbroke Island, and generally on this island the old dune ridges are not less than 150 feet in height. On South Stradbroke Island, however, they are not nearly so high, nowhere exceeding 50 feet.

On the eastern and northern side of North Stradbroke Island the high fixed dunes are sharply truncated, and a coastal plain or coastal swamp is developed on their oceanic side. That on the eastern side of the island is known as the Eighteen-mile Swamp. It extends from Swan Bay virtually to Point Lookout, gradually decreasing in width northwards from a maximum of about 1½ miles just north of Jumpinpin. The coastal swamp on the northern side of the island, from Rocky Point to Amity, is somewhat less striking, but it is 5 miles long and ½ mile wide. Both are freshwater swamps.

On the seaward side of the long, triangular Eighteen-mile Swamp there is a belt of recent dunes up to 10 chains or so in width. The foredune is higher than that on the South Coast, and it reaches a height of about 40 feet at the northern end of the island. On South Stradbroke Island there is usually no coastal swamp,* and the foredune lies up against the old, fixed dunes. Along the northern side of Stradbroke Island the foredune again borders the coastal swamp, except between Rocky Point and Point Lookout where there is no swamp.

The continuity of the foredune along the eastern coast of the island is broken in places by "blow-outs"—U-shaped excavations open to the windward. These are especially noticeable on North Stradbroke Island, and the sand from them may be seen slowly encroaching on the Eighteen-mile Swamp.

* Towards the northern end of the island in some places a coastal swamp or lagoon a chain or two wide is present.

Immediately in front of the foredune a berm, similar to that along the South Coast, is well developed on South Stradbroke Island, but on North Stradbroke, particularly towards the northern end of the island, it is not well defined.

There is really no drainage system on the island, which appears to act like a gigantic sponge absorbing all the rain falling on it. This apparently oozes out to the coastal swamps, and to the beaches, where it can be seen running down in many places at low-tide.

The eastern coastline of Stradbroke Island constitutes the northern part of the bay which extends from Point Danger to Point Lookout. This northern part is longer than the southern, and measures about 35 miles in length. From the mouth of the Nerang River to Jumpinpin the coastline has the form of a very shallow curve running almost directly N.8°E., while from the Jumpinpin break to Point Lookout it runs in a curve not quite so shallow along a direction N.18°E.

The northern coastline of the island forms portion of the southern half of another, similarly gently arcuate, but smaller bay, which extends from Point Lookout to Cape Moreton on Moreton Island. While the total length of coastline in this bay is approximately 31½ miles, that part on Stradbroke Island measures some 7½ miles. From Point Lookout the direction is approximately N.300°E. to Amity Point, but this general north-westerly direction is modified to some extent in the south-eastern part by a number of projecting headlands.

Moreton Island.

Separated from Stradbroke by the shallow South Passage, Moreton Island stretches northward for some 24 miles. In its elongately triangular shape it resembles Stradbroke Island, and like the latter island it is almost entirely covered with sand dunes. In fact, it is only at its north-eastern extremity, around Cape Moreton, that solid rock is known to occur. The dunes are for the most part abnormally high and heavily vegetated. They attain a height of 919 feet in Mt. Tempest, some 8½ miles south-south-west of Cape Moreton, and generally they are not less than 150 feet in height.

As on North Stradbroke Island these high fixed dunes are steeply truncated around their boundary, and a coastal plain or coastal swamp in places is developed on their oceanic side. On the eastern side of the island this forms only a very narrow fringe. On the northern side, however, there is a fairly wide coastal swamp with several deep, freshwater lagoons from Yellow Patch to Comboyuro Point, and this also extends down the western side of the island for about 6 miles to Cowan-Cowan. It has its maximum width of approximately 1 mile at Comboyuro Point, and an average width of about ½ mile down to Cowan-Cowan.

On the outer or seaward edge of the coastal swamp the Recent, smaller dunes are found. On the eastern side of the island the foredune rises to a height of 35 feet in some places, but it is often cut into hollows and has a broken appearance. In many places the berm has been completely removed by erosion.

The beaches are very gently sloping and, because of their almost flat nature, they are particularly wide at low tide.

The eastern coastline of Moreton Island constitutes the larger part of the bay which extends from Point Lookout on Stradbroke Island to Cape Moreton. This bay to the south of Cape Moreton was originally named Moreton Bay by Captain Cook who believed the island to be part of the mainland, but with the disproval of this by Flinders in 1799 the bay to the west of Moreton Island became Moreton Bay, and no name has since been given to the ocean sweep from Cape Moreton to Point Lookout. The part of this bay formed by the eastern coastline of Moreton Island shows only a slight curvature, but, with its smaller length, this is more pronounced than that of the eastern coast of Stradbroke Island. From the southern end of the island the coastline continues to curve north-westward for some 8 miles, the actual direction being N.348°E., but the curve is much flatter than the part on Stradbroke Island. From this point the direction to Cape Moreton is N.13°E., this part of the coastline curve also being very gently arcuate. Thus the bay between Point Lookout and Cape Moreton with its long, curving, hooked outline is almost a repetition of that between Point Danger and Point Lookout.

The northern coastline of Moreton Island may be considered as portion of the southern half of a more deeply arcuate bay that extends from Cape Moreton to Caloundra Head. In this bay there is quite a wide break in the coastline, from Comboyuro Point on Moreton Island to Skirmish Point on Bribie Island (namely, the North Passage). From Cape Moreton to Comboyuro Point the coastline closely follows the direction N.254°E., except between Cape Moreton and North Point where the general direction is north-west.

Behind Moreton and Stradbroke Islands the region has been flooded by the sea to form the comparatively shallow basin of Moreton Bay.

Bribie Island and Caloundra.

Westward from Comboyuro Point on Moreton Island and separated from it by about 9½ miles of ocean, Bribie Island extends in a north-north-westerly direction for some 20 miles. Unlike North Stradbroke or Moreton Island, this island lies close to the mainland, being separated from it only by the narrow and shallow Pumice-stone Channel. In outline it does not resemble Moreton or Stradbroke Island. It has a fairly wide, blunt southern end, its greatest width about half-way along the island, and it narrows suddenly near the northern end to form the tapering spit that extends northwards towards Caloundra.

Bribie Island is entirely covered with sand but, although no rocks outcrop, deep boring has shown that the foundations of the island are of Bundamba Sandstone. The sand dunes are for the most part fixed, and in places heavily vegetated. These old dunes, however, do not rise to any great height, nowhere reaching an elevation of 50 feet above sea-level. The island, thus, is virtually low-lying, and in this property it resembles South Stradbroke Island—an island which also is close to the mainland.

On the eastern side of the island coastal swamps and lagoons are found in places, while in others the active foredune lies up against the old fixed dunes. The foredune itself is generally from 20 to 25 feet high, and often as high as, and in some places higher than, the fixed dunes behind it.

The eastern coastline of the island runs in a very shallow curve for 20 miles from Skirmish Point along a direction N.347°E. to a point a few hundred yards south of Deep Water Point on the mainland at Caloundra.

Caloundra, itself, lies partly within Pumice-stone Channel at the extreme northern end of Moreton Bay and partly on the open ocean. The projecting rocky headland known as Caloundra Head marks the northern end of the bay which extends north-westward from Cape Moreton.

NATURE OF DEPOSITS.

The heavy mineral deposits at present being worked in Southern Queensland take the form of more or less lenticular beds or seams in the upper part of the beach and in the berm and dunes immediately behind the beach. Sections at right angles to the strandline have shown these seams to be generally wedge-shaped, gradually thinning out seawards and thickening landwards before tapering to a rather abrupt end. Although they have been found to range in thickness up to 5 feet, their average thickness usually lies between 1 and 2 feet. Often a number of seams are found one above the other, separated by layers of quartz sand. When traced parallel to the beach in a northerly direction towards a headland, and also when traced inland, two or more of these seams not infrequently are found to unite, the amount of white sand between them gradually decreasing.

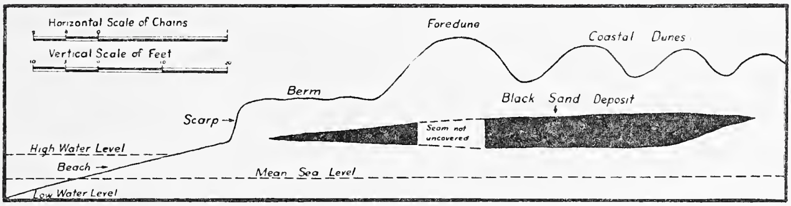
The seams generally are very well-defined, and for most of their extent almost horizontal. As well as the variation in thickness among the individual seams, there is considerable variation in the dimensions of the deposits. Their greater dimension appears almost invariably to be parallel to the strandline, and their lesser at right angles to it. Sections parallel to the beach have revealed lenticular beds with an average thickness of 1 foot extending for a distance only of 70 feet, while others of similar thickness have been traced for distances up to 12 chains and only slight evidence of their lenticularity has been seen. Indeed, it seems probable that certain of the individual lenses extend laterally for distances as great as a mile or more.

The lesser dimension or width of the lenses has been definitely determined in only a few places. This is because exploitation has been confined largely to the region immediately in front of the foredune where the overburden is least. Workings in this relatively narrow area have revealed seams with an exposed width of 35 feet extending into the foredune. Within the last two years, however, workings have been extended through the foredune in one region, and have been carried out just behind it in another. These have indicated that individual lenses may have a width of up to 4 chains although, owing to the method of working, it has not been possible definitely to establish this by actually following a seam continuously for this distance. With a row of bores at right angles to the strand line, also, there is always an element of doubt as to whether the seams encountered belong to the same or different lenses. So far the greatest distance which one black sand seam has definitely been traced inland is about 100 feet.

The fairly rapid tapering away of seams on the landward side has been strikingly revealed by the workings behind the foredune. In these workings one small section at right angles to the strandline has shown a seam decreasing from a thickness of 1 foot 6 inches to extinction in a distance of 17 feet (see Plate III., fig. 6), and several similar examples have been seen by the writer.

Recent exploitation has also shown that the lateral extent of the individual black sand lenses may be very irregular. In fact, the landward and seaward margins of deposits generally appear to have wavy outlines.

The seams range from pale grey to almost jet black in colour, depending on the degree of concentration and according to the amount of ilmenite and rutile present.



TEXT-FIGURE 2.

Section at right angles to strandline extending inland through northern end of Broadbeach Crown Land for 4½ chains, showing the nature of the heavy mineral deposit. (For the sake of clarity the thin layers of white sand which in places divide the lens into seams have been omitted.)

While the above deposits generally have a high concentration of heavy minerals, other deposits, in which the degree of heavy mineral concentration is not so great, are known to occur. These deposits contain heavy minerals in proportions ranging from about 15% to 20% by volume. They have been found in certain areas on the South Coast near the landward margin of the belt of coastal dunes. Although the exact shape of these low-grade deposits is not definitely known, since none of them has yet been exploited in Southern Queensland, most probably they are similar in nature to those described above. Boring has shown that these deposits have a thickness of 7 feet in some places, and that the heavy mineral grains are fairly evenly disseminated throughout their thickness. They have been found to be underlain by white sand containing practically no heavy minerals, while their upper margin often appears to merge into the "humusy" dune sand close to the surface, which has a somewhat similar pale-grey colour. Boring, also, has indicated that the lateral extent of these deposits is irregular, and they appear to cut out suddenly in certain places.

Although they have not yet been worked, it seems that in some places the sand-dunes themselves must also be classed as deposits, as they contain several per cent. of heavy mineral disseminated through them. This is particularly the case with the high fixed dunes on North Stradbroke and Moreton Island, and with the younger dunes at the northern end of bays. As the heavy mineral content of some of these dunes has been found to range up to 10 per cent. by volume, they constitute quite important low-grade deposits, suitable for large-scale exploitation by dredging methods. In such cases the heavy minerals are distinctly visible to the naked eye, and the dune sand material has a "pepper and salt" appearance.

DISTRIBUTION AND EXTENT OF DEPOSITS.

To obtain knowledge of the distribution and extent of the heavy mineral deposits in the area under consideration, a boring campaign was carried out by the writer with a post-hole digger to a maximum depth of 14 feet. Additional information was obtained from bores put down by certain of the private companies with post-hole diggers to a maximum depth of 22 feet, and from a number of deeper, cased bores sunk by them with hand and power-driven plants. Much valuable information was also obtained over a period of 18 months from the actual workings of the three operating companies on the South Coast.

A detailed log of each bore put down by the writer was made as boring proceeded, and a composite sample of fixed volume was taken by pushing a sharpened brass tube of 1¼-inch diameter vertically downwards through each full barrel of sand brought up in the post-hole digger. By this means a fairly complete core of small bulk was obtained. Selected samples of individual black sand seams passed through were also taken, and bagged separately. Each composite sample of fixed volume was passed over a Diester concentrating table at the treatment plant of Southport Minerals, and the heavy mineral concentrate bagged and its volume subsequently determined. A number of selected samples were concentrated in a prospecting dish, but carefully supervised tabling was found to involve a great saving in time and to eliminate the personal factor associated with panning.

The exact position of most of the bores put down by the writer was fixed with the aid of a steel tape and prismatic compass. In some cases, however, circumstances prevented this, and it was fixed approximately with the compass by intersection, and to some extent by pacing.

Since all boring was carried out within 30 feet of sea-level and the range of variation in height thus was small, an aneroid barometer was useless for the accurate determination of the surface elevation of the bore sites. The precise elevation of certain of the bore sites, however, was determined by Mr. G. Townsend, a Queensland Main Roads Commission surveyor, while the relative elevation of a number was determined by the writer with the aid of an Abney level and several marked poles which served as stadia rods. It has thus been possible to establish definitely the height above mean sea-level of black sand layers at various places throughout the area, and also to attempt to correlate some of the seams met in adjacent bores.

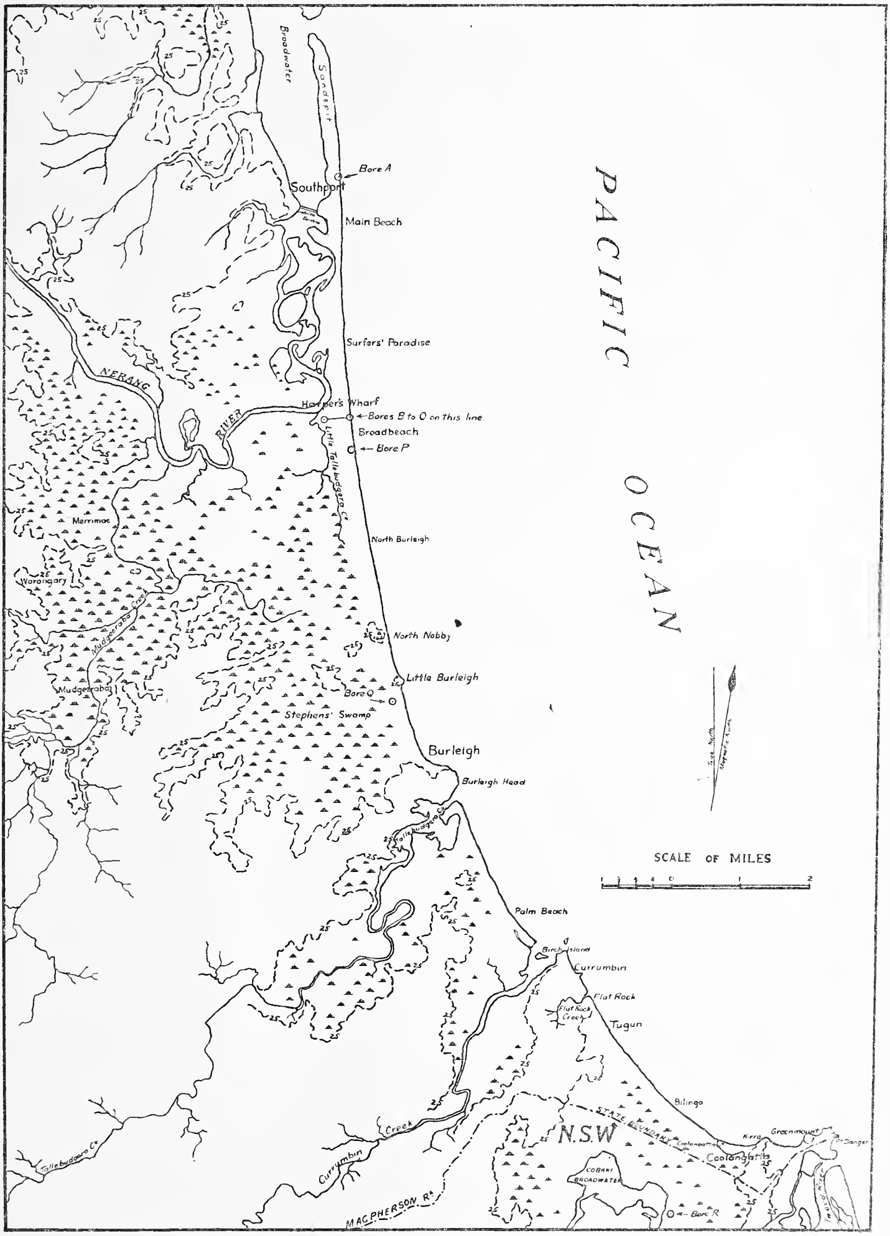
In the case of bores put down by the private companies, fairly complete logs and boring charts showing the exact location of the bores were generally obtained. In only a few cases, however, was it possible to obtain samples from these bores.

Most field work was carried out on the South Coast, as it is here that the heavy mineral sands are being exploited, and as it is the most accessible part of the region investigated.

The South Coast.

On the South Coast information concerning the distribution and extent of the black sand deposits has been collected from some 1,264 bores sunk with a post-hole digger in most cases to the maximum depth at which it is usable—namely, ground-water level. Data have also been obtained from 26 deeper bores, put down with casing to below ground-water level, but none of these has been sunk to a depth greater than 92 feet.

It is not proposed to give in this paper the log of every bore put down. A number of representative ones, however, will be given together with those of particular interest, and the information derived from all the boring. To avoid confusion with the identification of those bores the logs of which are given here, alphabetical letters will be used for them instead of the actual numbers given to them during field work.



Text-figure 3.

Map of South Coast Region, showing Bore Sites, etc.

(a) The Southport-Burleigh Area.

Systematic boring was commenced by the writer in the sand-spit area extending northward from the eastern end of the Jubilee Bridge, Southport, for approximately 2 miles to the mouth of the Nerang River. As this area is known to have been formed within the last 50 years, it is of particular interest. A row of bores was put down along the sandspit at 5 chain intervals about 15 feet in front of the foredune, another row was put down at points intermediate between those in the former series at 10 chain intervals approximately 1 chain behind the foredune, a third series was put down 5 chains further inland adjacent to the Broadwater side of the sandspit, and a number was put down at certain selected, intermediate points. In this manner the sandspit, which has an average width of only 15 chains, was covered with 71 bores arranged generally in a triangular pattern.

As the result of this work, seams of black sand were found in the coastal part of the sandspit throughout its length, but the portion flanking the Broadwater proved to be barren. In fact, no seams of black sand were encountered behind the foredune.

In some of the bores put down just in front of the foredune more than one black sand seam was passed through, but in no case was any of the individual seams found to exceed 1 foot in thickness. In the southern half of the sandspit, in fact, one seam of black sand averaging 8 inches in thickness only was passed through in most bores. The elevation of the top of this seam, which appears to persist for at least ½ mile (although as stated above, owing to the lenticularity of seams, this cannot definitely be proved with bores spaced at 5 chain intervals) has been found to be about 6½ feet above mean sea-level.

Although the berm along the sandspit was cut back from an average width of 70 feet to about 55 feet by the heavy seas associated with the cyclonic disturbance of February, 1946, no seams of black sand were exposed in the 5-foot scarp formed thereby at the top of the beach. None, moreover, was encountered in a number of bores put down on the beach at the base of this scarp. It is thus apparent that the seaward margin of the black sand deposits in this region must lie somewhere between 15 and 55 feet in front of the foredune. It is also clear that the landward margin lies below the foredune—which is up to a chain or so in width. Moreover, since seams were not passed through in every bore put down on the berm, the lateral extent of individual deposits is known to be restricted.

Although no thick seams of black sand were exposed in the scarp which marks the seaward edge of the berm, in many places small "pencil" seams a fraction of an inch in thickness were seen in this section. In some places these could be traced laterally for several yards, sometimes being found to unite to form slightly thicker pencil seams. It seems likely that it is the passage through these pencil seams which brings about the slight increases in heavy mineral concentration encountered at certain horizons in most of the bore cores.

Small accumulations of black sand, also, were noticed on the beach at various places about high-water mark (close to the foot of the scarp and particularly in small embayments in the scarp), but in all cases the layers were thin and the deposits were of very restricted extent.

The log of a fairly representative bore put down in front of the foredune on the sandspit is given hereunder.

Bore.	Location.	Elevation.	Log.	Remarks.
A	Southport sandspit, 15′ in front of toe of foredune, and 30 chains N. from Main Beach Surf Pavilion	13′ 0″ above mean sea-level	0′–5′ white sand 5′–5′ 6″ white sand with small proportion of heavy minerals disseminated through it. About 3%. 5′ 6″–7′ white sand 7′–7′ 9″ *black sand seam* 7′ 9″–11′ white sand 11′ ground-water	Thickness of black sand seam passed through was 9″. Total volume of heavy minerals in bore core was 5·5%. Seam contained 78% heavy minerals

No systematic boring was carried out in the old sandspit region extending from Main Beach, Southport, for approximately 3 miles southwards to Harper's Wharf, Broadbeach, as this area is heavily built upon. In fact, surface improvements in most of this area would probably be worth more than the underlying mineral. A number of test bores were, nevertheless, put down. In those sunk just in front of the foredune well-defined seams ranging up to about a foot in thickness were generally passed through, although in some bores none was met. Thicker seams were encountered in a number of bores put down behind the foredune, particularly in the Surfers' Paradise–Harper's Wharf region. A number of seams were also passed through in bores put down as far as 30 chains inland from the present strandline, but in bores sunk further inland adjacent to the Nerang River no seams were met.

More systematic boring was carried out in the coastal area from Harper's Wharf, Broadbeach, southwards for 6 miles to Burleigh. Information about the distribution and extent of the black sand deposits in this area, in fact, was obtained from some 418 bores and also from the actual workings of two operating companies—namely, Southport Minerals and Minerals Deposits Syndicate.

In the Harper's Wharf–North Nobby region the zone of coastal dunes attains a width of ½ mile, and a most striking series of parallel and persistent dune ridges and hollows is developed. As nearly one-half of this area is Crown Land and the remaining part is as yet only sparsely built upon, fairly systematic boring could readily be carried out throughout the region. In front of the foredune, borings and the beach workings of Southport Minerals have shown that black sand seams are well-developed in the area. Often several seams one above the other, separated by layers of white sand have been found (see plate iv., fig. 3). Usually they do not exceed 1 foot 6 inches in thickness individually, but their combined thickness sometimes reaches 3 feet. Laterally, individual seams have been traced for distances as great as 14 chains in the workings of Southport Minerals, just south of Broadbeach (plate ii., fig. 1). These workings also have graphically shown the seams of black sand increasing in thickness landwards, and extending into the foredune (see plate iv., fig. 1). In bores put down in the hollow just behind the foredune, the seams generally were found to be thicker, so the increase in thickness of the seams observed in sections at right angles to the strandline in front of the foredune apparently continues through the dune.

Extensive boring was carried out behind the second dune ridge, and large-scale workings have been conducted in this region in the Crown Land just south of Broadbeach. This work has shown that the seams usually attain their greatest thickness just behind the second dune ridge, and that from there individual lenses generally taper off landwards to their extinction within a chain or so. The workings of Mineral Deposits Syndicate and Southport Minerals in this area have strikingly revealed seams of black sand up to 4 feet 3 inches in thickness just behind the second dune (see plate iv., fig. 5) and, when continued inland, have shown the splitting of these thick seams into thinner seams separated by layers of white sand and their tapering away landwards. As the result of boring at approximately 1 chain intervals at right angles to the strandline, it would seem that the form and distribution of the black sand deposits as revealed in the workings in front of and behind the foredune, is generally the same throughout the length of this region, although there is variation in the extent of the deposits.

This distribution may be illustrated by the following representative line of bores put down to ground-water level at 1 chain intervals, commencing just in front of the foredune and extending inland for 5 chains.

Bore.	Location.	Elevation.	Log.	Remarks.
B	Five chains S. of end of Wharf road, Broadbeach; on berm 10 feet in front of toe of foredune	13′ 4″ above mean sea-level	0′–6′ 8″ white sand 6′ 8″–7′ 3″ *black sand seam* 7′ 3″–8′ 4″ white sand 8′ 4″–9′ 3″ *blach sand seam* 9′ 3″–10′ white sand 10′–10′ 7″ *black sand seam* 10′ 7″–11′ 6″ white sand 11′ 6″ ground-water	Total thickness of black sand seams was 2′ 1″. Volume of heavy minerals in bore core was 14·5%
C	One chain inland from Bore B; in hollow behind foredune	Not precisely determined. About 15′ above mean sea-level	0′–9′ white sand 9′–11′ 4″ *black sand seam* 11′ 4″–11′ 9″ white sand 11′ 9″–12′ 6″ *black sand seam* 12′ 6″–13′ 3″ white sand 13′ 3″ ground-water	Total thickness of black sand seams was 3′ 1″. Volume of heavy minerals in bore core was 18·9%
D	One chain inland from Bore C; behind second dune ridge.	Approximately 15′ above mean sea-level	0′–10′ 3″ white sand 10′ 3″–12′ 9″ *black sand seam* 12′ 9″–13′ white sand 13′–14′ *black sand seam* 14′ ground-water	Total thickness of black sand seams was 3′ 6″. Volume of heavy minerals in bore core was 19·5%
E	One chain inland from Bore D; behind fourth dune ridge	16′ 6″ above mean sea-level	0′–10′ 6″ white sand 10′ 6″–11′ 6″ *black sand seam* 11′ 6″–12′ white sand 12′–12′ 6″ *black sand seam* 12′ 6″–14′ white sand 14′ near ground-water	Total thickness of black sand seams was 1′ 6″. Volume of heavy minerals in bore core was 9·4%

Bore.	Location.	Elevation.	Log.	Remarks.
F	One chain inland from Bore E ; in sixth dune hollow in from present strandline	16′ 4″ above mean sea-level	0′–9′ 6″ white sand 9′ 6″–10′ *black sand seam* 10′–11′ 9″ white sand 11′ 9″–12′ 2″ *black sand seam* 12′ 2″–13′ 9″ white sand 13′ 9″ ground-water	Total thickness of black sand seams was 11″. Volume of heavy mineral in bore core was 5·6%
G	One chain inland from Bore F ; in hollow in area of fixed dunes	15′ 6″ above mean sea-level	0′–13′ white sand 13′ ground-water	No black sand seams passed through. Volume of heavy minerals in bore core was 0·5%

The sand in the lower parts of Bores C to G was generally stained brown by organic matter, and pumice and shell fragments were found on various horizons in all the bores.

Further inland in the wide belt of old, fixed dunes most bores put down by the writer were sunk in the hollows between dune ridges, in order to lessen the amount of white sand overburden to be passed through. In many of these bores good seams of black sand were passed through, but, although more than one seam was often encountered, none of the individual seams was found to have a thickness greater than 1 foot. In fact, the average thickness of individual seams was found to be about 8 inches. Most of these seams, however, have well-defined upper and lower margins and the heavy minerals composing them are well-concentrated. Although the precise form of these deposits cannot be determined definitely by boring, it seems most probable that they are lenticular bodies of similar nature but of generally smaller dimensions than the deposits adjacent to the strandline. From the bores put down in which no seams were encountered within this area, it would seem that the greater dimension of the individual deposits is again more or less parallel to the strandline, and that the lesser dimension is at right angles to it. As the result of boring it would appear, also, that there are at least three black sand deposits, separated by barren areas, in most places within the zone of fixed dunes in this Broadbeach–North Nobby area. Actually, the greatest distance inland from the present strandline in which a well-defined seam of black sand was passed through in borings in this region was 30 chains. In the region behind this point, the dunes are generally more widely spaced, less regular in outline, and of lesser height, with the ground gradually sloping downward to the swampland. Although a fairly large number of bores were put down in this region (which approximately is that west of the Pacific Highway), no seams of black sand were encountered. Only shallow boring could be carried out, however, as groundwater level throughout was very close to the surface.

The following continuation inland along the line of Bores B to G given above is a fairly representative series of borings throughout this belt of fixed dunes.

Bore.	Location.	Elevation.	Log.	Remarks.
H	Two chains inland from Bore G; in hollow between two dune ridges. *Eight chains inland from strandline*	14′ 10″ above mean sea-level	0′–6′ 3″ white sand 6′ 3″–6′ 10″ *black sand* 6′ 10″–12′ white sand 12′ ground-water	Black sand seam passed through was 7″ thick, and contained 70% heavy minerals. Total volume of heavy minerals in bore core was 3·7%
I	Two chains inland from Bore H, in hollow between two dune ridges. *Ten chains inland from strandline*	13′ 9″ above mean sea-level	0′–8′ 11″ white sand 8′ 11″–9′ 7″ *black sand* 9′ 7″–11′ 3″ white sand 11′ 3″ ground-water	Black sand seam passed through was 8″ thick and contained 82% heavy minerals. Total volume of heavy minerals in bore core was 5·1%
J	Two chains inland from Bore I, on eastern side of Surf Parade. *Twelve chains inland from strandline*	16′ 6″ above mean sea-level	0′–13′ 6″ white sand 13′ 6″ water	No black sand seam encountered. Volume of heavy minerals in bore core was 0·7%
K	Two chains inland from Bore J and *fourteen chains inland from strandline.* In fifth hollow between dune ridges east of Pacific Highway	17′ 2½″ above mean sea-level	0′–5′ 3″ white sand 5′ 3″–6′ 3″ white sand containing 5% of heavy minerals disseminated through it. 6′ 3″–9′ 2″ white sand 9′ 2″–9′ 7″ white sand containing 8% heavy minerals 9′ 7″–14′ white sand	No black sand seam encountered. Volume of heavy minerals in bore core was 0·85%
L	Two chains inland from Bore K, and *sixteen chains inland from strandline.* In fourth hollow between dune ridges east of Pacific Highway	14′ 10″ above mean sea-level	0′–5′ 7″ white sand 5′ 7″–6′ *black sand* 6′–7′ white sand 7′–7′ 4″ *black sand* 7′ 4″–11′ 6″ white sand 11′ 6″ ground-water	Total thickness of black sand seams was 9″. Volume of heavy minerals in bore core was 4·8%
M	Two chains inland from Bore L, and *eighteen chains from strandline.* In third hollow east of Pacific Highway	17′ 3″ above mean sea-level	0′–7′ 4″ white sand 7′ 4″–8′ 2″ *black sand* 8′ 2″–9′ white sand 9′–9′ 4″ *black sand* 9′ 4″–13′ 10″ white sand 13′ 10″ ground-water	Total thickness of black sand seams, was 1′ 2″. Volume of heavy minerals in bore core was 6·5%
N	Two chains inland from Bore M, and *twenty chains inland from strandline.* In first hollow east of Pacific Highway	14′ 8″ above mean sea-level	0′–7′ 3″ white sand 7′ 3″–7′ 8″ *black sand* 7′ 8″–8′ 6″ white sand 8′ 6″–9′ 2″ *black sand* 9′ 2″–9′ 6″ white sand 9′ 6″–9′ 10″ *black sand* 9′ 10″–12′ white sand 12′ water	Total thickness of black sand seams 1′ 5″. Volume of heavy minerals in bore core was 9·2%. Two lower seams contained 80% heavy minerals, while upper seam contained 55%

Bore.	Location.	Elevation.	Log.	Remarks.
O	Eight chains inland from Bore N. On western side of Pacific Highway, in deep hollow, near Little Tallebudgera Ck., which here marks the western limit of the coastal dunes	11′ 0″ above mean sea-level	0′–8′ 6″ white sand 8′ 6″ ground-water	No black sand seam encountered. Volume of heavy minerals in bore core was 0·8%

The following log of a cased bore put down with a hand-boring plant to a depth of 44 feet in the Broadbeach Crown Land area is of particular interest.

Bore.	Location.	Elevation.	Log.	Remarks.
P	Crown land between Broadbeach and North Burleigh. Twenty chains south of Broadbeach Esplanade and five chains inland from strandline	Not precisely determined. About 14′ above mean sea-level	0′–7′ 6″ white sand 7′ 6″–9′ whitish-grey sand containing 10% of heavy minerals 9′–10′ 6″ *black sand seam* 10′ 6″–11′ white sand containing 5% heavy minerals 11′–44′ white sand containing traces of heavy mineral only	Ground water was met at 11′. Black sand seam passed through was 1′ 6″ thick, and contained 70% heavy minerals. Total volume of heavy minerals in bore core was 2·4%. *Sand from 11′–44′ contained less than 0·1% heavy minerals.* Sand between these depths stained light-brown and contained shell fragments

From the above log it will be seen that no black sand deposits were met with below ground-water level (which is here very close to sea-level). This, also, is reported to be the case in a number of cased bores put down by Mineral Deposits Syndicate in the bottom of their Broadbeach excavations.

As boring was extended southwards towards North Nobby a decrease in the thickness of the black sand seams was noticeable, and in quite a number of bores no seams at all were met.

In the North Nobby–South Nobby (Little Burleigh) area, boring has shown that the distribution of the deposits is generally similar to that in the region immediately to the north. The rapid tapering away landwards of the large lens adjacent to the strandline was particularly striking again in bores sunk at 1 chain intervals at right angles to the beach. In one line of bores the thickness of the deposit decreased from 2 feet 9 inches just behind the second dune ridge, to 9 inches, then to 3 inches, and finally to extinction, while in a similar line a little to the north the decrease was from 4 feet 3 inches to 12 inches, to 9 inches, and then to extinction. As the boring campaign was extended towards the projecting headland of Little Burleigh a marked decrease in the thickness of the seams adjacent to the beach became apparent. In some bores just north of South Nobby only one seam a few inches thick was passed through, while in others none at all was encountered.

From South Nobby southwards to Burleigh extensive working of the area adjacent to the beach was carried out by Mineral Deposits Syndicate from 1941 to 1945, and a large number of bores have been put down. In the area first worked at the top of the beach just south of South Nobby a particularly well-concentrated seam up to 5 feet in thickness was exposed. This was followed southwards in a long dredging claim 1 chain wide just in front of the foredune, and was found to decrease gradually in thickness and to divide into two seams. At a distance of some 40 chains south from the northern end of the claim (that is, nearly opposite 4th Avenue, Burleigh) the workings revealed two seams 8 inches and 11 inches thick respectively, separated by 9 inches of white sand—that is, the total thickness of black sand had decreased from 60 inches to 19 inches. Workings in this claim and borings just in front of the foredune further south, moreover, revealed still further thinning, seams ranging from only 3 inches to 12 inches in thickness being found. Although the layers of black sand exposed in these workings were seen to extend into the foredune, owing to the greater depth of white sand overburden their inland extension was not exploited until 1944. During 1944, however, the overburden was removed from part of two long, adjacent dredging claims each a chain wide, and seams with a total thickness of up to three feet six inches exposed. Subsequent work in these two claims has generally revealed two or more black sand seams separated by layers of white sand. The seams were found to be thickest at the northern end of the claims (near Little Burleigh Headland) and to thin out and split up when traced southwards and landward. Some 22 chains south of the northern end of the more easterly of these two claims (that is, behind the foredune opposite a point between 5th and 6th Avenues, Burleigh) the face being worked one day in September, 1945, revealed the following section:—

0–15 feet	White sand
15 feet–16 feet	*Black sand seam*
16 feet–17 feet	White sand
17 feet–17 feet 9 inches	*Black sand seam*
17 feet 9 inches–19 feet	White sand with thin layers of black sand
19 feet–19 feet 9 inches	*Black sand seam*
19 feet 9 inches–21 feet 3 inches	White sand
21 feet 3 inches–21 feet 6 inches	*Black sand seam*
21 feet 6 inches–21 feet 8 inches	White sand
21 feet 8 inches	Ground-water.

Borings a chain or so further to the west, however, have revealed seams with an average total thickness of only 12 inches.

No systematic boring was carried out in the area between The Esplanade and the Pacific Highway from South Nobby to Burleigh, as this region is heavily built upon. Immediately behind The Esplanade the ground begins to slope downward to the swampland behind, with the dune ridges gradually decreasing in height and increasing in width. The zone of coastal dunes in this area, in fact, has a width of only about 15 chains.

In bores put down in the hollow just east of the Pacific Highway from Fifth Avenue northwards to Little Burleigh up to 6 feet of sand containing about 15% heavy minerals was found close to the surface. In the region of low fixed dunes on the western side of the Pacific Highway a similar heavy mineral deposit was passed through in most bores, extending southwards for about ½ mile. In all cases the heavy minerals were fairly evenly disseminated through the white sand. The deposit was found to have a maximum thickness of 7 feet, and to be underlain by very white quartz sand. In no case was more than one layer passed through in any one bore. No heavy mineral deposits of this nature were found in the southern part of the region near Burleigh Heads.

The log of a bore put down with casing to a depth of 25 feet in the region of low dunes adjacent to Stephens' Swamp, on the western side of the Pacific Highway, is given hereunder.

Bore.	Location.	Elevation.	Log.	Remarks.
Q	Sixteen chains south of Miami Hotel, Little Burleigh, and two chains west of Pacific Highway. Thirteen chains inland from strandline	18′ 3″ above mean sea-level	0′–1′ white humusy sand 1′–8′ *black sand deposit, containing 18·3% of heavy minerals.* 8′–12′ white sand 12′ ground-water 12′–25′ white sand containing traces of heavy minerals only	Thickness of heavy mineral deposit was 7′. Total volume of heavy minerals in bore core was 4·8%. Sand from 12′ to 25′ stained brown with organic matter

In the lowland behind the coastal dunes, a number of bores were put down to ground-water level, which is very close to the surface throughout this area, but no heavy mineral deposits were encountered in these shallow bores.

(*b*) *The Burleigh-Currumbin Area.*

Systematic boring between Burleigh Head and Currumbin was mainly confined to the area in front of the property line. In this portion of the South Coast, as stated above, the foothills of the narrow divide between Tallebudgera and Currumbin Creeks extend almost to the shore, and the coastal plain thus is very narrow.

As the result of a large number of bores put down at the top of the beach, on the berm in front of the foredune, and just behind the foredune, nothing or very little in the way of black sand deposits was found at the southern end of Palm Beach. However, from Nineteenth Avenue northwards to the mouth of Tallebudgera Creek the amount of black sand and the thickness of seams was found steadily to increase. In bores put down opposite the end of Nineteenth Avenue, Palm Beach—that is, some 120 chains northward from the mouth of Currumbin Creek and five-eighths of the way up from the southern end of this short bay—only one black sand seam 6 inches in thickness was passed through. Opposite Twenty-third Avenue, Palm Beach, however—that is, some 20 chains further north—the seam had increased to a thickness of 3 feet, and the degree of concentration had risen to 80% heavy minerals.

At the northern end of Palm Beach the berm was cut back to within 30 feet of the foredune by the heavy cyclonic gales of February-March, 1946, and seams of black sand ranging up to 1 foot 3 inches in thickness were exposed in the lower part of the 6-foot scarp formed at the top of the beach. In some places the lenticularity of these seams was strikingly revealed in this naturally-formed section (see plate iii., fig. 5), and in the upper part of the bank pencil seams were generally conspicuous. Excavations in this vicinity just behind the foredune at the southern end of Reserve 67 parish of Tallebudgera have recently exposed two well-defined seams of black sand each about 1 foot 6 inches in thickness separated by a layer of white sand 1 foot thick. No other dune excavations have yet been made in the Palm Beach area.

At the extreme southern end of Palm Beach in the area around Birch Island, at the mouth of Currumbin Creek, some twenty cased bores were recently put down to depths of from 30 to 50 feet by Rutile Sands Pty., of Currumbin. Although beach sand was passed through entirely in all these bores, no black sand deposits were found. Most of the sand was found to be organically stained to a brown colour. A number of these cased bores were sunk near the channel of Currumbin Creek, and some in the tea-tree swampland on the northern side of the Creek.

(c) *The Currumbin—Point Danger Area.*

In the Currumbin-Coolangatta region most systematic boring was again carried out in front of the property line, although some bores were sunk behind it, including a number on the western side of the Pacific Highway behind Bilinga.

From Flat Rock southwards to the mouth of Coolangatta Creek 728 bores in all have been put down to ground-water level in front of Pacific Parade, which runs parallel to the beach along the second dune ridge.

As the result of this work generally only small, low-grade seams of black sand were found from Coolangatta Creek northwards for some 2 miles to about opposite Shell St., Tugun. In fact, in few bores put down between these points were seams with a heavy mineral concentration greater than 30 per cent. and an individual thickness greater than 1 foot 6 inches found. From Shell St. northwards to Flat Rock, however, good, medium-to-high grade seams were encountered, the region immediately south of Flat Rock being particularly rich. Workings at the top of the beach in this latter area, in fact, have recently exposed a seam with a thickness of 4 feet and a heavy mineral concentration of from 80 to 90 per cent. This seam was seen to extend into the foredune but, because of the presence of Pacific Parade thereon, it could not be traced landwards. A bore put down in private property west of the road and near the cliff (really a foothill of a spur of the McPherson Range which extends to within 20 yards of the strandline), however, passed through a black sand seam 5 feet thick. When traced seawards at a point 25 feet in front of the dune the thickness of this seam was found to have decreased to 1 foot 5 inches, and boring has shown that it then tapers off fairly quickly.

The boring in front of Pacific Parade from Coolangatta Creek to Flat Rock also indicated the lenticular nature of the deposits in the region, and the irregular and generally wavy plan of their margins. Although irregular in outline, the landward margin of the black sand deposit adjacent to the beach in this region seems often to be about half-way beneath the foredune, while the seaward margin is approximately half-way between the toe of the foredune and high-water mark. In some places, however, boring indicated that the deposit extends all the way under the foredune and even still further inland, while in others it does not or barely extends into the foredune at all.

As the result of private boring in this region Rutile Sands Pty. of Currumbin have recently determined that 8,885 tons of heavy mineral concentrate may be obtained from their 1 chain-wide dredging claim, which extends along the top of the beach and generally includes the seaward half of the foredune from Coolangatta Creek northwards for some 3 miles.

On the western side of the Pacific Highway a number of bores were put down behind Bilinga towards the landward margin of the zone of old fixed dunes adjacent to the lowland whch serves as a Commonwealth aerodrome. Although no well-concentrated seams were encountered in any of these bores, sand impregnated with 10% of heavy minerals was found in some. Still further inland, in the Cobaki Swamp area, some 1¼ mile from the coast, a deep, cased bore has been put down to a depth of 92 feet with a power-driven plant. As this is the deepest known bore put down anywhere on the South Coast its log is given below. It might here be mentioned that, as Ball (1905, p. 6) has suggested, the swampland behind Tugun and Bilinga probably was formerly an inlet of the sea into which Cobaki Creek emptied itself.

Bore.	Location.	Elevation.	Log.	Remarks.
R	Cobaki Swamp area, just beyond State boundary. 1¼ miles inland (south) from Kirra	Not precisely determined. About 8′ above mean sea-level	0′–3′ humusy sand 3′ ground water 3′–55′ white sand containing traces of heavy minerals only. Sand variously stained brown, cream and grey 55–92 grey clay with small waterworn pebbles and detrital material	Bore sunk where Cobaki Creek believed to have flowed formerly. No black sand seams passed through. Total volume of heavy minerals in bore core was less than 0·1%

Reserves.

Owing to the lenticularity of the deposits with their wavy landward and seaward margins, and because of their known patchy distribution in the belt of coastal dunes, it has not been possible, with the spacing of the bores put down by the writer, to calculate precisely the reserves of heavy mineral concentrate on the South Coast. From the field investigations that have been carried out, however, it is clear that great quantities of heavy mineral occur in the zone of coastal dunes on the South Coast. Unfortunately, because of the heavily-built-on nature of the area, much of this cannot be worked. In fact, the available known reserves of heavy mineral concentrate are no greater than ¼ million tons. The only large area available for exploitation is the block of Crown land between the Pacific Highway and the beach from Broadbeach to North Burleigh. Varying but appreciable quantities of black sand, however, are still available on the various claims in front of the property line.

Although the zircon-rutile industry had its beginning on the South Coast only in 1941 approximately 50,000 tons of heavy mineral concentrate (quartz-free) have already been obtained (to the end of 1946). Practically all of this has come from three areas—namely, the Broadbeach-North Burleigh, Little Burleigh, and Flat Rock-Tugun areas.

STRADBROKE ISLAND.

Although it was not possible to cover all the oceanic coast of Stradbroke Island with bores spaced at close intervals, a fairly large number of bores were put down.

On the eastern side of South Stradbroke Island black sand deposits were found at the top of the beach and in the berm in front of the foredune at various places. In some of the bores put down individual seams with a thickness of up to 1 foot 6 inches were passed through, but in many none at all was encountered. As the result of the field work that has been carried out so far on South Stradbroke Island, in fact, it would appear that the black sand deposits are much less extensive than those on the South Coast. The best deposits were found at the southern end of the island near Southport and at the northern end near Jumpinpin. However, even in these places the deposits generally are thin, the average thickness being only about 8 inches. As there are no projecting headlands on the island, the deposits on the beach are ephemeral in nature, being moved from place to place by heavy storm seas. Owing to the greater height of the foredune than that on the South Coast, it is apparent that boring to a depth of 30 feet will be needed in some places to test the landward extent of the deposit adjacent to the beach.

On North Stradbroke Island a number of bores were put down with the post-hole digger at the top of the beach, on the berm in front of the foredune, and behind the foredune. As the result of the work on the eastern side of the island practically nothing (apart from a seam 1 foot thick in one bore) was found in the northern part, near Point Lookout. This is surprising, as the best and most extensive deposits are usually found at the northern end of arc-shaped bays. The almost complete absence of black sand deposits from this region may, however, be an apparent one only since, owing to the great height of wind-blown sand, only a few bores could be taken to ground-water level with the 14-foot post-hole digger. In fact, it seems very probable to the writer that good deposits of black sand occur just south of Point Lookout, probably a little inland from the present beach (which changes rapidly in this region), but that deeper boring—with more extensions for the post-hole digger—will be required to locate them. Nevertheless, from the work carried out so far, it would appear that the distribution of black sand seams on the eastern coast of North Stradbroke Island is rather irregular. The best seams were found some 15 miles south of Point Lookout (that is, about 5 mile north of Jumpinpin). Boring here indicated the presence of a large deposit of well-concentrated mineral in seams 3 feet to 4 feet thick. A smaller deposit was found about 6 miles south of Point Lookout (near a large accumulation of aboriginal kitchen middens, approximately due east of the Blue Lake), where seams with a thickness of 1 foot to 1 foot 6 inches were passed through, and other similar lenticular deposits were found further south—particularly in the region from 16 to 18 miles south of Point Lookout. In several places, also, accumulations of sand impregnated with about 20% of heavy minerals were located in bores put down in hollows adjacent to the Eighteen-mile Swamp. Surface accumulations of heavy minerals were noticed at the top of the beach at various places, particularly in embayments in the berm and "blow-outs," and thin layers of wind-concentrated heavy minerals were observed in and on the surface of the foredune.

Boring with a post-hole digger was also carried out about the old strandline in the Blue Lake region, on the landward side of the Eighteen-mile Swamp. Although no seams of black sand were encountered, sand containing an appreciable amount of wind-concentrated heavy mineral was found in practically all the bores put down both on the seaward and the landward side of the old foredune and in the older dunes behind it, for a distance of at least 1 mile inland. In fact, the heavy mineral content of this dune sand was found to range up to 9% by volume, the sand closest to the swamp having the lowest heavy mineral content (usually less than 1%), and that above having a higher content. Approximately 100 bores were put down over a length of 9 miles in this region of high fixed dunes and the yield of heavy minerals was found to average nearly 2% by volume. Since boring on both the seaward and landward flanks of these old dunes (which rise to heights of several hundred feet) revealed sand of rather similar grade, it seems most probable, from a knowledge of dune formation, that it extends through the entire dunes. Deep boring with a power-driven plant will, however, be necessary to prove this. If it is so, there definitely will be a very great quantity of material of a grade highly attractive for exploitation by dredging methods. It is not improbable, in fact, that all the high, fixed dunes from east to west on North Stradbroke Island contain a similar amount of wind-concentrated heavy minerals disseminated through them. Deep boring on a systematic basis will be needed to determine the precise grade and reserves of this low-grade material.

One bore was put down with casing in the Eighteen-mile Swamp. This was sunk to a depth of 36 feet near the landward margin of the swamp, just east of the Blue Lake. Although no black sand seams were encountered, the material was found to average 0.7% heavy mineral by volume. This is of importance as, if it is general, the ground necessary to float the dredge will contain enough heavy mineral to make this excavation work itself economic.

On the northern side of the island, apart from some surface concentrations, no black sand seams were found.

On the western side of the island, also, no thick seams of black sand were located, although small accumulations were found at the top of the beach just south of Amity, at One-mile, north of Dunwich, and at Canaipa. In these places the heavy minerals probably have been reconcentrated from the sand dunes adjacent to the beach.

Moreton Island.

Along the northern and eastern coast of Moreton Island bores were put down at intervals with the post-hole digger.

On the northern side of the island no thick seams were located, although thin layers and surface accumulations a few inches thick were found at the top of the beach in several places—particularly about North Point and Comboyuro Point.

On the eastern side of the island, bores were put down just in front of the foredune approximately at $\frac{1}{2}$-mile intervals. Apart from a few thin layers of poorly-concentrated material, no deposits were found from the southern end of the island northwards for a distance of 8 miles. In the region from 8 miles to 18 miles northward from the southern end of the island a few seams of black sand were found, the best being 2 feet in thickness. In many bores in this region, however, seams only a few inches in thickness were met with, and the deposits were found to be very restricted in extent. In the region from 18 miles north of the southern end of the island to Cape Moreton the best deposits were found. Although some seams 2 feet thick were found just south of Cape Moreton, the average thickness of the deposits even in this region was less than 1 foot, and the width of the lenses less than 1 chain. However, it was in this region at the extreme northern end of the east coast that the most continuous seams on the island were found.

As yet, no boring has been carried out behind the foredune and in the region of high, fixed dunes further inland. It is likely, however, that wind-concentrated heavy minerals will be found disseminated through the high, fixed dunes in a rather similar amount to that on North Stradbroke Island.

On the western side of the island small surface accumulations of black sand have been observed at the top of the beach at Tangalooma Point and at several other places.

Bribie Island and Caloundra.

Although a large number of bores were put down to ground-water level on Bribie Island practically no black sand was found anywhere on the island. No seams at all were passed through in any of the bores put down along the east coast both in front of and behind the foredune from Woorim northwards for 8 miles. A trace of heavy minerals was met with in a number of bores sunk near the third coastal lagoon (working northwards) 8 miles north of Woorim, but the layer was no more than $\frac{1}{2}$ inch in thickness. The only other black sand on the island was found at the northern end, in the sandspit opposite Caloundra, where some thin layers ranging from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in thickness were encountered. Quantities of sand from the top of the beach at various places along the eastern coast of the island were also panned in prospecting dishes, but virtually no heavy minerals at all were obtained. Thus, Bribie Island as a source of heavy minerals definitely may be disregarded.

A few thin layers of black sand were found at the top of the mainland beach fringing Pumicestone Channel at Caloundra. The thickest of these was one 2 inches in thickness observed in the small bank at the top of the beach at a point some 50 yards from the mouth of Pumicestone Channel. No black sand was seen on the main surfing beach at Caloundra and none was found in a number of bores sunk in front of and behind the foredune fringing this beach.

MANNER OF FORMATION OF THE DEPOSITS.

The heavy mineral beach sand deposits described above are all natural concentrates. They have been formed through the concentration of the heavy minerals mainly by wave action but to some extent also through the action of wind, while ocean currents also have played a part.

It is felt that the study of the processes of heavy mineral concentration operating at present provides us with the key to the actual manner of formaion of the various black sand deposits in the area under consideration.

A certain amount of heavy mineral concentration by wind action has been seen to take place at the top of the beach and particularly on the seaward side of the foredune during fine weather. The foredune itself is a "live" dune that is being built up of wind-blown sand which, although mainly quartz and calcareous detritus, contains a small percentage (usually about 1%) of heavy minerals. With an increase in the velocity of the wind the lighter quartz grains have been seen to be blown inland, leaving thin layers of black sand behind. Recent excavations into the foredune in the Tugun, Little Burleigh and Broadbeach areas have revealed many of these wind-formed heavy mineral layers. Always they are thin, never exceeding 1 inch in thickness, and as they are inclined at all angles up to about 30 degrees the dunes when cut into have shown a cross-bedded and banded structure. Since the south-east wind is the prevailing and the dominant wind and the chief sand transporter in the area under consideration, it is natural that these wind-formed layers are thickest and most abundant towards the northern end (that is, the most exposed part) of the various arc-shaped bays. Indeed, skims of wind-concentrated heavy minerals up to 1 inch in thickness have been obtained from the dunes just south of Point Lookout on Stradbroke and Cape Moreton on Moreton Island. On a smaller scale, heavy minerals may be seen concentrating on the windward side of wind ripples on the beach and the dunes. This process is most striking to watch, and may be seen even with only a moderate wind blowing. With a prolonged period of fine calm weather a fair amount of building up of the foredune and building out of the berm with wind-blown sand takes place and the slope of the beach becomes steeper. In the summer months, however, storms accompanied by heavy seas are not infrequent, and the high waves sometimes reach far beyond normal high-water mark and remove varying amounts of the berm, depending on the intensity and direction of the rough weather. During these storms the beach also is levelled, and the returning waves remove the lighter quartz sand in preference to the heavy minerals. Following the prolonged, cyclonic storms of May, 1945, in fact, from 20 to 25 feet of the berm was found to have been cut away all along the South Coast, while a further 8 feet was removed by a heavy cyclonic gale in March 1946. Thus, from December, 1944 (the time when a number of sections were first measured on the South Coast) to March, 1946, the berm was cut back some 33 feet in all, and a vertical cliff between 5 to 6 feet was formed on its seaward edge.* A large quantity of sand, thus, must have passed through the zone of wave action, and, following both these cyclones, well-concentrated black sand deposits were seen to have formed at the top of the beach, particularly at the northern end of the arc-shaped bays. At the northern end of Palm Beach just south of Burleigh Head, for example, a layer of black sand ranging from 6 inches to 1 foot in thickness was found at the top of the beach after the 1945 cyclonic disturbance, and immediately south of Flat Rock near

* From March, 1946, to the time of writing this paper—November, 1946—the weather has been mainly fine and calm in Southern Queensland and the berm has been built out a few feet, the drop down to the beach generally has become less and more gradual, and the beach itself has become a little steeper.

Tugun there was a layer up to 2 feet in thickness covering the upper part of the beach. It seems clear that these deposits are formed by the removal of the quartz sand in preference to the heavy minerals by the returning storm waves, and that the heavy minerals are obtained partly from the small amounts in the wind-blown sand and partly from the passage of previously-formed deposits through the zone of wave action, while some additional material is brought in from the ocean floor during the rough weather.* This natural concentration by wave action during storms has been observed to be most effective and extensive when the storms come from the south-east and, as this is the prevailing wind throughout the area, most gales come from this direction. It is thus natural that the most extensive deposits of black sand on the beach occur at the northern end of bays, which is most exposed to the south-east, and where the northerly headland acts as a barrier and provides a place for the natural accumulation of the heavy minerals. It has also been noticed that concentration is particularly great if the gales coincide with spring tides—since they then have a consequently greater power for the erosion of the berm.

The extent and stability of these recent black sand deposits formed at the top of the beach varies considerably. Those formed by abnormally high seas (the black sand being thrown up so far that it seldom can be retrieved) are the most stable. It is a matter of common knowledge and also of observation, however, that some deposits on the beach disappear overnight in a single storm with high seas. This is especially so with accumulations at the southern end of bays, the black sand being moved generally northwards. The deposits formed at the top of the beach at the northern end of the bays, however, are generally stable and fairly extensive. They have been found to extend from a point between normal low-water mark and high-water mark to a point some distance above normal high-water mark, depending on the height of the storm waves and the slope of the beach. During periods of fine weather these deposits are covered with wind-blown sand and become buried in this lighter material and partially covered by the growing berm. Indeed, a number of black sand seams representing distinct periods of concentration are sometimes found in the upper part of the beach, separated from one another by layers of white sand representing the fine weather between. Although the thickness of these recent seams is variable, they all seem to have the elongate-triangular cross-section like the deposits behind them (see above), with their maximum thickness landwards and tapering away seawards to extinction at some line between high-water and low-water marks. This wedge-shaped nature of the lenticular deposits is naturally the result of greater dropping of the heavy minerals as the carrying power of the high and powerful storm waves is lessened at the top of the beach. The natural sorting and concentration of the heavy minerals on the present beaches, then, is known to be due to the action of vigorous swirling waters, particularly those during heavy gales, between low-water mark and the upper point reached by the storm waves, which may be several feet above normal high-water mark. This process of natural concentration of the heavy minerals, in fact, is not unlike the artificial process of concentration by panning.

* The fact that there is still a small but notable amount of heavy minerals in the ocean sand adjacent to the coast has become evident through landing from a surf boat on to a sand bank (only 4 feet below water at low tide) ¼ of a mile offshore from Palm Beach and finding a large amount of black sand on it.

In the area under consideration the set of the inshore current is in a northerly direction, and it seems that a certain amount of heavy mineral is moved slowly northward by this current, which has a velocity of from a quarter to one knot.

As the nature of the lenticular seams of black sand found on the landward side of the berm and in the coastal dunes immediately behind it is precisely the same as in those found on the present beaches, it may be concluded that they have been formed in exactly the same manner. To explain the actual position and distribution of these older deposits, however, account must also be taken of the relative movements of land and sea from the close of the Pleistocene onwards, and of the process of natural reclamation.

The known movements comprise a eustatic rise of sea-level of the order of 200 feet or more at the close of the Pleistocene, and a mid-Recent negative movement of a few feet. The combination of these movements, together with the process of natural reclamation, provides the explanation to the physiography of the region investigated (which is described above). According to Daly (1934) the world-wide eustatic rise in sea-level at the close of the Pleistocene was slow and gradual and may even have taken as long as 16,000 years. With this slow coastal submergence, black sand seams might have been expected to occur down to quite a considerable depth below the surface of the coastal plain. However, although quite a number of cased bores have been put down to depths of up to 92 feet in the belt of coastal dunes and in the swampland behind them on the South Coast, no black sand seams have been found below present sea-level. In all except the most landward of these bores, however, quartz sand similar to that on the present beaches but often stained to a brownish colour was passed through from top to bottom. Although it is still desirable to put down more and deeper bores (to below 100 feet), from present indications, it would appear that no black sand seams occur below present sea-level. Their absence might be explained by the fact that during the slow submergence the natural heavy mineral concentrates formed were broken up by passing through the surf zone as the sea-level slowly rose. Thus, there was probably a more or less continual breaking up of the heavy mineral seams soon after their formation, and reconcentration again at a higher level.

It seems probable that the sea-level remained stationary for a considerable time after the submergence ended and, during this period, the process of natural reclamation proceeded without interruption. There was certainly abundant sand available for this purpose. It is believed that this reclamation was accelerated greatly by the small mid-Recent emergence, bringing some offshore bars (such as those across the three former bays in the South Coast area) above high-water level, and forming on their landward side shallow lagoons. These salt-water lagoons have gradually been changed into freshwater swamps and marshes and in places into dry lowland, by the silting up of the area (with wind-blown sand, discharges of sediments and debris from streams, and the growth of weeds, &c.). With this apparently rapid withdrawal eastward of the surf zone may be correlated the absence of black sand deposits from that part of the lowland area above present sea-level—since there were no powerful ocean waves in this region to concentrate the heavy minerals.

Following the elevation of the offshore bars above high-water level, dune growth began on the sandspit and, since then, it is believed, the strandline has slowly moved eastward and the belt of coastal dunes has gradually developed. This is indicated by the presence of black sand seams below many of these old fixed dunes.

Through the services of the Main Roads surveyor the level of the top of the black sand deposit found below the most landward of the coastal dunes has been determined as some 17 feet above mean sea-level. Since the level of the top of recently-formed deposits was found to range from 6 to 8 feet above mean sea-level (as stated above, they are formed by waves which reach above normal high-water mark), this deposit then must have been formed when the sea-level was about 10 feet above its present level. This would indicate a fall in sea-level of this amount together with that (probably only a few feet) required to bring the offshore bar above high-water level. The most landward known black sand seams, then, were apparently formed during the mid-Recent emergence, and this accounts for their greater thickness and elevated position. Their rather poor concentration may be the result of breaking down and consequent intermixing of the heavy minerals with quartz sand by erosive agents.

All the other black sand seams found within the belt of coastal dunes appear to have been formed by the sea at or no more than 5 feet above its present level. In fact, the highest level of the top of the uppermost seam found in a bore in this area was only 11 feet above mean sea-level, and the upper level of the top seam in the majority of the bores ranged between 6 and 8 feet above mean sea-level. This may be compared with the upper level of the top seam (which in the Southport sandspit is definitely known to have been formed within the last fifty years) found in the berm in front of the foredune, of from 6 to 8 feet above mean sea-level. As high-water mark is normally no more than 3 or 4 feet above mean sea-level in the area investigated, it is apparent that the upper portion of these recent seams was formed by storm waves which reached several feet above normal high-water mark. Similarly, it can be supposed that the upper part of seams or the top seam of a series encountered in the zone of fixed dunes was formed by waves which reached several feet above the normal high-water mark of the day.

It would appear that the individual deposits in this belt of coastal dunes were buried in lighter material largely wind-blown during fine weather, and slowly covered by the growing dunes as the strandline moved eastward, most probably through a slow and very small emergence and partly through natural reclamation.

The levels of the black sand deposits in the belt of coastal dunes on the seaward side of the swampland thus suggest that there have been not one but two movements of emergence in Recent times. While the earlier and greater of these movements may have been rather sudden, the later was definitely very slow. Indeed, this later movement of emergence may still be continuing.

With the gales coming from the south-east and with the northerly inshore current, it is natural that the richest and most extensive black sand deposits are found between the middle and the northern end of the various bays in the area under consideration.

The distribution of the deposits appears to be influenced to some extent also by the various river mouths and other breaks in the coastline, such as Jumpinpin and the South and North Passages. In fact, the area immediately to the north of the various breaks sometimes has been found to be almost barren of black sand seams. This is apparently the result of local current interferences and greater dropping of the heavy mineral on the southern side of these coastline breaks.

The influence of the South Passage together with the position of the area and the greater distance from the main source of the heavy minerals apparently account for the paucity of black sand seams along the southern part of the east coast of Moreton Island. The almost complete absence of heavy mineral beach sand deposits from Bribie Island and Caloundra appears to be the result of the very sheltered position of these places from the prevailing south-east winds. It is believed that these south-east gales, together with the northerly inshore current slowly have transported many of the heavy minerals northwards from their southerly source. Moreton Island, in fact, acts as a natural shield to Bribie Island. However, the absence of heavy mineral deposits from this island may also be due to some extent to the many shallow banks off its eastern coast—thereby giving smaller surf, deposition further out, and much lesser concentration of any heavy minerals present on the beach itself. Similar sheltered conditions, moreover, may account for the absence of extensive black sand deposits from that part of the Queensland coast fringed by the Great Barrier Reef, some distance further north.

The low-grade dune sand deposits must have been formed by particularly strong wind concentration. The heavy minerals which are disseminated through these deposits no doubt underwent initial concentration on the beaches, and were later picked up and redeposited by the wind. Those found on North Stradbroke Island are in keeping with the great height of the old, fixed dunes, which were apparently formed by abnormally powerful winds in the Pleistocene period.

CONCLUSION.

As the result of the field work carried out during this investigation well-concentrated black sand deposits have been found at intervals throughout the belt of Recent coastal dunes, but the deposits closest to the present strandline appear to be the most extensive. Boring in the swampland behind the Recent coastal dunes has revealed no striking deposits, and as the result of some thirty bores put down with casing to depths of up to 92 feet, also, it would seem that no deposits occur below present sea-level. Nevertheless, it is felt that more cased bores should be put down on the coastal plain to obtain a more complete knowledge of the full lateral and vertical distribution of our heavy mineral beach sand deposits. If the seams formed during the slow submergence at the close of the Pleistocene were continually being broken up and reconcentrated again as the strandline moved westwards with the rising sea-level, "fossil" black sand deposits might be found close to the surface along the landward margin of the coastal plain, adjacent to the old strandline. Moreover, since this former strandline must have remained at about the same place for a considerable time after the submergence terminated, quite extensive deposits might be expected to occur. As boring with the post-hole digger in this region could only be carried out to a few feet owing to the presence of ground-water, the sinking of cased bores to 20 or 30 feet is strongly urged to test this area.

Until boring has been carried out at very close intervals through the whole of the area under consideration, it is impossible to give any precise estimate of the reserves of heavy mineral concentrate. From the field investigations that have been carried out it is clear, however, that great quantities of material are available. Although exploitation of the rich seams in the Recent coastal dunes on the South Coast is seriously restricted by the heavily-built-on nature of this region, smaller deposits are continually being made available for working on the beaches, particularly just south of Little Burleigh, Burleigh Head, and Flat Rock. Indeed, it has already been possible to come back in two years' time, after working out the deposit at the top of the beach at Flat Rock, and to work the same area again.

From the deep boring that has been carried out, it is considered unlikely that dredging of the lowland immediately behind the Recent coastal dunes on the South Coast would be economic. This is partly because the available areas are too restricted, and also because the sand below ground-water level generally contains less than 0.3% by volume of heavy minerals. If it were possible to dredge the Recent coastal dunes also it is believed that dredging would be economically successful. It would, moreover, be very desirable, as in those areas available for exploitation only the richest deposits are being removed by the existing method of selective working—bulldozing off the overburden and hand picking the black sand.

Therefore, it is considered that the present rate of mining of the known and available heavy mineral deposits on the South Coast cannot be maintained for a period greater than 10 years, although an annual production of two or three thousand tons may be maintained more or less indefinitely.

It is felt that the future of the zircon-rutile industry in Southern Queensland and particularly its expansion lies with the deposits on Stradbroke and Moreton Islands. On both of these islands work will not be restricted in any way by private property, and particularly extensive areas are available. The large-scale exploitation of such areas as the Eighteen-mile Swamp on North Stradbroke Island together with the Recent coastal dunes on its seaward side and the high, Pleistocene dunes on its landward side should prove an attractive proposition for a dredging company. Before large-scale exploitation is commenced on this island, however, it will be necessary to carry out a programme of systematic deep boring with a power-driven plant.

With the peace-time demand for zircon and rutile the economic future of our war-born heavy mineral industry now seems assured. Our heavy mineral beach sands are a great national asset. To use this asset to full advantage, however, amalgamation of some of the operating companies, more thorough and more modern methods of working the deposits, and large-scale exploitation of certain areas is urged.

ACKNOWLEDGEMENTS.

This work has been financed by the Commonwealth Government Grant through the Council for Scientific and Industrial Research to the University of Queensland. I would like to thank the managers of Southport Minerals, Mineral Deposits Syndicate, Rutile Sands Pty., Australian Mining and Smelting Co., Tamco, Messrs. J. A. Watson and N. Pratt of Alluvial Gold (Oceania) Ltd., the Queensland Co-ordinator-General of Public Works (Mr. J. R. Kemp), Mr. G. Townsend, the Queensland Chief Government Geologist (Mr. C. C. Morton), and particularly the Queensland State Mining Engineer (Mr. I. W. Morley) and the Inspector of Mines for the Southern Division of Queensland (Mr. O. J. Carlson) for information and help during the progress of this investigation. I am indebted to Dr. R. W. Fairbridge of the University of Western Australia for permission to use the two aerial photographs which comprise Plate 2, and which were taken by him, and to Mr. J. T. Woods of the University of Queensland, who most carefully carried out the printing associated with the three text-figures. The project was initiated at the suggestion of Professor H. C. Richards, whose interest, together with that of Associate Professor W. H. Bryan and Mr. O. A. Jones, has been a source of encouragement.

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EXPLANATION OF PLATES.

PLATE II.

FIG. 1.—Aerial photograph of workings just in front of foredune at Broadbeach. The width of the coastal plain is well illustrated, with the zone of vegetated, fixed dunes immediately behind the foredune. A black sand seam can be seen extending into the dune in the face on the left-hand side of the photograph. High-water mark on the beach may be seen in the foreground, with the scarp which marks the seaward edge of the berm a little distance above it.

FIG. 2.—Aerial photograph showing the truncation of the high, fixed dunes on the eastern side of North Stradbroke Island, together with the coastal Eighteen-mile Swamp and the lower, Recent dunes on its seaward side. Below these Recent dunes black sand seams have been found, while the high dunes constitute low-grade, wind-concentrated deposits.

PLATE III.

FIG. 1.—View from Crown Land area just south of Broadbeach looking north along the foredune and showing the lightly grassed berm in front of it, and the beach.

FIG. 2.—View from Crown Land area just south of Broadbeach looking south and showing portion of the arcuate bay to Point Danger (faintly visible in the upper left-hand corner of the photograph). The prominent headland is Burleigh Head. The old black sand excavations in the foreground already have been partly filled in by wind-blown sand.

FIG. 3.—Hollow between two old dune ridges in Harpers' Wharf region of Broadbeach. The hollow is about 6 feet below the level of the crest of the dune ridges. Twenty chains inland from present strandline.

FIG. 4.—Looking westward across Stephens' Swamp, Burleigh, from a point about 16 chains south of Little Burleigh and 13 chains inland from present strandline. The low and fairly broad dunes adjacent to the swamp are in the foreground.

FIG. 5.—Section exposed in erosion scarp at top of beach showing tapering away of black sand lens laterally. On the left-hand edge of the photograph the seam is 1 foot thick, while on the right-hand edge it is 4 inches. About 20 chains south of the mouth of Tallebudgera Creek, Palm Beach.

FIG. 6.—Section at right angles to the strandline in workings behind foredune, showing the fairly rapid tapering away of a black sand lens landwards. In Crown Land area between Broadbeach and North Burleigh, and approximately 4 chains inland from beach. The seam can be seen decreasing from a thickness of 1 foot 6 inches to extinction in a distance of 17 feet.

PLATE IV.

FIG. 1.—Excavations showing black sand seams extending into the foredune between Broadbeach and North Burleigh. The well-defined, bedded nature of the seams is well illustrated, although some of the overlying white sand has fallen over part of the face. The total thickness of the black sand seams (neglecting the white sand layers between them) here is 3 feet 6 inches.

FIG. 2.—General view of excavations behind the foredune between Broadbeach and North Burleigh. The excavations are nearly down to ground-water level, and about 20 feet below the crest of the foredune. Part of the black sand deposit being worked may be seen in the right-hand portion of the photograph. The marks on the sand in the foreground were made by the bulldozer used to remove the white sand overburden.

FIG. 3.—Thin seams of black sand separated by layers of white sand exposed in a section about 10 feet in front of the foredune, south of Broadbeach. The total thickness of the black sand seams (ignoring the white sand layers between them) is 2 feet 3 inches.

FIG. 4.—Well-concentrated seam of black sand 2 feet 6 inches in thickness revealed in workings just behind the foredune at Broadbeach.

FIG. 5.—Thick black sand seam exposed in workings behind the foredune at Broadbeach. The seam measures 4 feet 3 inches in thickness. It contains three white sand layers, but each is less than 1 inch in thickness. About 1 foot of white sand not removed by the bulldozer may be seen overlying the black sand. Some of this white sand has fallen down, and this just covers the base of the seam.


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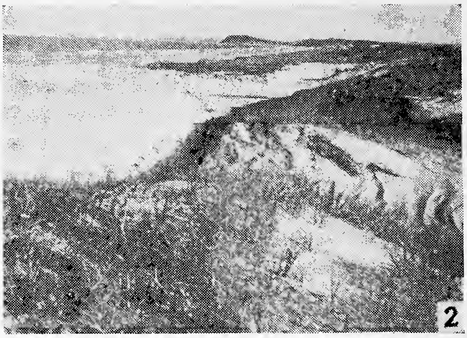
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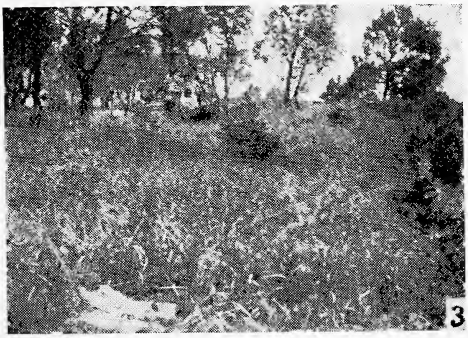
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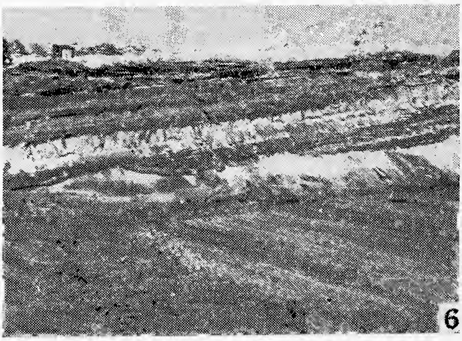
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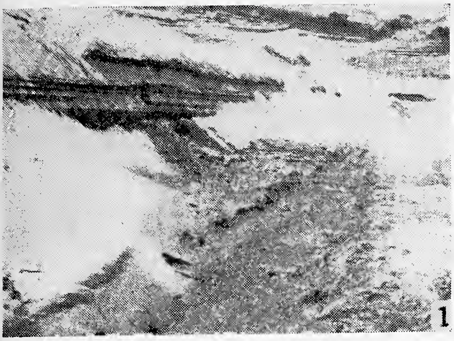
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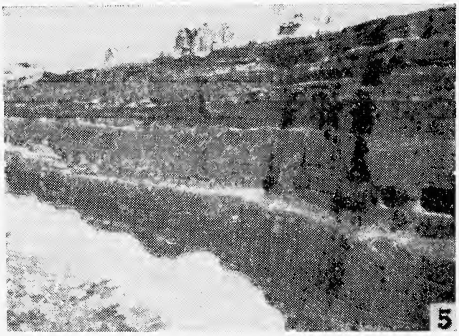
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H. C. RICHARDS MEMORIAL ADDRESS.

By W. H. BRYAN, M.C., D.Sc., Associate Professor of Geology, University of Queensland.

(*Delivered before the Royal Society of Queensland, 28th July, 1947; issued separately 16th August, 1948.*)

At the last meeting of this Society we stood, in silence and in sorrow, in memory of a great man—one who brought much honour to the Society and one whom the Society delighted to honour in return by twice making him its President. Our council has entrusted me with the sad but important duty of placing on record our appreciation of the life and work of Henry Caselli Richards.

Born in 1884, at Melton, a small country town in Victoria, Richards spent his boyhood far from the noise and bustle of cities, and as a result, although most of his life was passed in urban surroundings, he was always at home in the country, too, fitting easily and naturally into the rural way of life.

I am reminded of the occasion many years ago when, while doing field work in the Mount Lindsay area, he and I sheltered for the night in the slab-hut of a friendly bullock-driver. I shall always remember how, as he helped wash up the dishes after the simple meal, he and our host made easy and pleasant conversation based on the different methods of timber getting in Queensland and Victoria. And listening, I thought of the words of Paul: "I am made all things to all men."

Richards' parents were both Australian born and both of British stock, the name Caselli having no family significance.

His father, Benjamin Richards, was the headmaster of the local school, and it is probable that therein lies one of the reasons that the son made such an excellent teacher and was so outstandingly successful with large junior classes of students who came to him quite ignorant of his subject.

From his country school Richards went to Box Hill Grammar School where he did so well both in study and sport that he became captain of the school.

In 1904 he entered the University of Melbourne and enrolled as a science student with Geology and Chemistry as his major subjects. Here he came under the influence of Professor E. W. Skeats who had just been appointed to the chair of Geology. His association with Skeats, for whom he always retained a great admiration and regard, was to prove a very important influence throughout his life and was reflected in his methods of teaching and in his essentially practical outlook in all things geological.

During his University course he was a member of a party of students who visited Broken Hill, and on returning was awarded the prize given by A. E. Kitson for the best account of the excursion.

He graduated as Bachelor of Science in 1906 and remained to win the Dixson Final Honours Scholarship in 1907 and to take his Master's degree. From Melbourne he moved to Broken Hill to fill the position of Metallurgical Superintendent in the de Bavay Zinc Treatment Co., and was introduced to the then novel methods of treating ores by the flotation process.

Returning to Melbourne in 1908 to take up the Caroline Kay Research Scholarship, which he had been awarded, he spent two years in investigating the building-stones of Victoria, thus developing a phase of his geological work in which, in later years, he became the acknowledged Australian authority. During this period he was also employed as a Demonstrator in the School of Geology. In 1910 he was awarded the Grimwade prize. In the same year he came to Brisbane to take up a position as lecturer in charge of the departments of Chemistry, Geology, Mining and Metallurgy in the Central Technical College. He had scarcely settled down in that position when he was appointed the first lecturer in charge of the Department of Geology within the University of Queensland which had just been established. This marked the turning-point in his career and started him on an ever-widening series of activities that filled the major part of his active life. He was one of the eight original appointees to the University, the only surviving members of which are Mr. Alex Gibson (then Professor of Engineering) and Professor T. Parnell (the first Lecturer in Physics).

As I was one of his original students it was at this time that I first met the man who was to prove my staunch friend and wise counsellor for thirty-six years. When I sat before him at his inaugural lecture, he appeared almost incredibly boyish for the important position that he occupied. Round of face, fresh-complexioned and sturdily built, he might have been still in his teens. I afterwards learnt from him that only the previous year he, the acknowledged authority on building-stones in Victoria, on arriving at a quarry he had been requested to inspect, was asked by the quarry-master, "When will your father be along, sonny?" Richards' colleague, Michie, looked almost as young, and Priestley, too, seemed no more than an eager youth. Richards himself realised, in those early days that he looked younger than most of his students, a fact which sometimes caused embarrassing moments, especially when he led parties of us in the field. This offended his sense of what was proper to his position, and he resorted to the simple device of wearing a large and impressive helmet, quite unlike and superior to our ill-assorted head-gear, which marked him out and thus became a badge of office.

But when he spoke, Richards was instantly the leader of his students and the master of the situation, for he addressed us with such power and confidence that everything boyish disappeared and we knew him for what he was, an able and a vigorous lecturer, who handled his subject with ease and certainty.

From that very first day we liked him and trusted him, and he for his part offered his friendship to us all.

Richards' first task after his appointment to the University was to establish his department. This was little less than an act of creation, for there was literally nothing with which to build—no minerals, no rocks, no fossils, no books. But he threw himself into the job with such vigour and determination that by the time we, who formed his first batch of students, arrived, he already had the nucleus of a small but sound department, consisting of a diminutive lecture-room, which is now Professor Castlehow's study, a laboratory, where the classics lecture-room now is, and one other room, now occupied by Professor Alcock, which he shared with the Lecturer in Engineering, and which housed the beginnings of the departmental library.

One of his first acts was to convince Professor B. D. Steele, who was at that time the dean of the Faculty of Science and his senior in every way, that Mineralogy should be handed over to his little school of Geology and not be treated as an adjunct of Chemistry as had been contemplated.

Another early development, in which I, as a student eager to do a full course in geology, played a passive but not unimportant role, was to persuade the Senate, who had planned for one year's geology only, to extend the course first to two years, and then to the full three years.

In those early days when Richards, at first alone, and afterwards with the help of Dr. Walkom (now Director of the Australian Museum), was working day and night to build his department, one would have thought it impossible to do more. But Richards chose just that time to embark upon a very large research project—no less than a thorough examination of the volcanic rocks covering an area of some 4,000 square miles of south-eastern Queensland. This involved journeys on every holiday and numerous forced marches up and down mountains carrying great loads of specimens. I can speak with some feeling on the rigours of this campaign for I was privileged to be his companion on many of these excursions. The associated laboratory investigations were pursued just as relentlessly as the work in the field, so that by 1915 Richards had completed these classic researches, published them in the Proceedings of this Society, made them the basis of a thesis and been awarded the Doctorate of Science by the University of Melbourne.

By this time his growing department had been moved into the upper floor of one of the then newly erected Technical College buildings, namely the one immediately behind the building which the department now occupies.

One of Richards' first acts on arriving in Brisbane had been to join this Society to which he was elected in 1910. The following year he was made a member of the council and read his first paper to the Society on "The Building Stones of St. John's Cathedral."

In 1912 he occupied the position of Vice-President and the following year he was elected President, and read an address on "The Development of Petrology."

After an interval of a quarter of a century he again addressed us from the presidential chair, and many members will recall his almost impassioned appeal to the Society never to forget that the foremost reason for its existence was "the encouragement of scientific research."

From the very beginning Richards' interest in the Society had important practical results, for very soon its meetings were held in the Geology Theatre, a practice which has been followed ever since. He was the representative of the Society on many important occasions and was singularly successful in obtaining for our aims and objects the sympathetic consideration of those authorities in a position to help.

Richards made a point from the beginning of publishing the results of his researches in the proceedings of this Society, even when they may have been acceptable to more important publishing bodies; and he always urged his students to do likewise. As a result of this policy he himself contributed fifteen papers, while the total number which has come from his department is no less than 60.

In many other ways too he gave his strong support to this Society and I feel that we as members are deeply in his debt.

Although he felt no personal urge towards academic research, Richards' published papers show that his efforts were just as fruitful when directed into this channel as was the case with his other activities.

With the passage of time and following the demands of the community, Richards' interests were more and more concentrated on the applied aspects of scientific investigations, but throughout his teaching life, he never ceased to stress to his students the importance of pure research. Members of this Society may remember that on the last occasion on which he formally addressed us, he made use of one striking phrase. He said: " 'Research for its own sake' is a slogan that every one of us should paste in his hat."

For some years after 1914 I saw little of Richards, but when I returned in 1920 it was to join the department of Geology as his lecturer and to renew our friendship on an even happier basis. By this time the foundations of his department had been well and truly laid and he himself had (in 1918) been elevated to the Professorial Chair which he was to occupy with such distinction until his death 29 years later, by which time his little School of Geology had grown to be numerically the largest in the Commonwealth and had achieved a considerable reputation for the geological researches of its staff and graduates. Wherever one turns in the department one sees evidence of his wisdom, his far-sightedness and his thoroughness. The room in which we are now assembled was personally planned by him down to its last detail.

Once the establishment of the School of Geology on a solid foundation had been successfully achieved, Richards' interests and influence spread in ever-widening circles; first within the University, then in the wider field of Science—ultimately reaching out to the world of Art. In all, he undertook a multiplicity of tasks, but whatever he turned his hand to, he did thoroughly and well.

As an officer of the University his power and prestige grew rapidly and he became successively Dean of the Faculty of Science, President of the Professorial Board (a position which he held for 8 years), an elected member of the Senate, and finally the Deputy Chancellor. None of these offices was a sinecure and each felt the impact of his personality. He was a most active chairman of the Buildings and Grounds Committee of the Senate and in that capacity, as in his membership of the University Works Board, he had much to do with the planning and development of the new University at St. Lucia. In particular he was justly proud of the part he played in ensuring that the buildings should be faced with stone and that the stone should come from Queensland's own quarries.

During his thirty-six years at the University, thousands of students passed through his hands, and they will remember him, not hazily as the lecturer, but vividly as the man! For he never wore that cloak of detachment that is popularly supposed to cover the scientist and hide his personality from the vulgar view. But on the other hand, Richards' individuality, though striking, did not depend in any measure on strange mannerisms, unusual teaching methods or freakish points of view. His strong personality was based on a sound, sane and liberal outlook on life. His teaching too, if somewhat didactic in method, was based only on sound and well-established principles, which he expounded with vigour and lucidity. He was never tempted to make a lecture-point by exaggeration or by any other departure from the truth, as he clearly saw it.

It was the combination of these virtues of sound sense and obvious sincerity, together with his warm friendliness that made him so approachable to students, and which placed on his broad shoulders so many of their minor and even some of their major troubles.

Not his students only sought his guidance, but members of the University from every quarter and of every grade, converged upon the man, who, although perhaps busier than anyone else in the institution, always found time to give courteous attention to their troubles and who sent them forth usually with renewed hope, and, at least, with sound counsel.

Only once have I known him turn a supplicant away from his door, and even that dismissal was more in sorrow than in anger. The occasion was when a pleasant and very handsome young undergraduate from India, who could scarcely speak a word of English, and who had inevitably failed in our annual examinations, endeavoured to bribe his Professor with a pair of slippers. But these were no ordinary slippers. Gorgeous with gold embroidery, they must have been designed and fashioned for the feet of a reigning rajah at least! As Richards saw the episode, the young fellow was more to be pitied than blamed, for he had not yet made himself familiar with the customs of his adopted country.

One of the most pleasant features of Richards' department was the way in which his graduates, both recent and those of long standing, would drop in quite informally from time to time to report progress or to ask for a word of advice.

Richards was a very easy and pleasant man to work with and for, as I who have collaborated with him on many occasions and have been his assistant for 27 years can readily attest. Invariably courteous, he was also invariably considerate—a rarer and a deeper virtue. Although he seldom complained, one knew instinctively and surely, what pleased him and when he was disappointed. Such knowledge is an excellent lubricant for any departmental machine, and largely explained why his machine, in particular, ran so smoothly.

Richards was notably successful in conference and committee and often succeeded in having his views adopted in the face of considerable opposition. He was not by nature aggressive, but in those fights which he felt impelled to wage, in Faculty or Board, his method was invariable and was as simple as it was effective, consisting as it did in a preparation for the battle as thorough as time would allow, followed by a strong frontal attack at the very first engagement. He never attempted to outflank the opposition; subtle strategems were not used; the assault was immediate and direct. This method was often so effective that the victory of his cause was virtually secured, while his opponents were engaged in what they thought were the preliminary skirmishes.

But although a doughty fighter he could always appreciate the other fellow's point of view. Indeed it was no uncommon practice for him to state, very clearly and honestly too, the case for his opponent, much to that gentleman's embarrassment, and sometimes to his chagrin, before proceeding to attack that case with all the forces he could muster.

As time went on, appreciation of Richards' very unusual talents spread beyond the University and he was called on by the State and by the Commonwealth to perform many important tasks both in Australia and abroad. These calls from outside were reinforced by his own personal urge to put into practice his considered opinion, that one of the most important functions of the University was to give direct aid to the community outside its walls. In this way he personally did all that any one man could to counteract that tendency to introversion common to most universities.

These excursions beyond the University walls were at first concerned with purely scientific problems, but many aspects of applied science were soon added, to be followed later by even more diversified activities spread over a large part of the field of human endeavour. They are so numerous that I cannot attempt to deal with them all even briefly but must confine myself to some of the more important.

Of these many outside activities, the one which was most widely known and appreciated, and which I think will be for ever associated with his name, was his chairmanship of the Great Barrier Reef Committee. This position he held from 1928, when he assisted the late Sir Matthew Nathan to bring the Committee into existence) until his death a few short weeks ago. If he did not actually put the Great Barrier Reef on the map in the strictly literal sense, he made it a reality for many people for whom it had previously been no more than a name.

For this purpose he gathered together a large team of scientists and others interested, and raised adequate funds from governmental and other sources. With the Committee assembled and financed and a special journal established in which to record its findings, a long series of researches was initiated which, while they were concerned particularly with the nature and origin of our own great Reef, were of far wider application and significance, covering as they did almost every aspect of coral-reef research.

Three major projects in particular claimed world-wide attention, namely, the drilling of bores through the Reef at Michalmas Cay in the north and at Heron Island in the south, and the establishment of a research station at Low Isles, where a first-class team of scientists did excellent work based on continuous observations over a period of twelve months.

Another role in which Richards did outstandingly good work for the community was as State Chairman of the Council for Scientific and Industrial Research, a position that he held from 1925 to 1944. This office afforded him the opportunity of using his exceptional talents for getting together people with apparently conflicting interests, welding them into a team, and ultimately reaching conclusions to their mutual advantage. Here, too, he showed most clearly his very remarkable versatility, for he seemed to be as much at home in problems affecting sheep and cattle as he was in those concerning rocks and minerals.

He always showed an especial interest in geological problems associated with engineering, and I have heard it said by those who should know that he himself would have made an excellent engineer. His work on the foundations of the Grey Street Bridge is exemplary in its thoroughness and attention to all relevant detail. So impressed were the engineers of Australia with this aspect of Richards' work that they did him the very rare honour of making him one of themselves by electing him an honorary member of the Institution of Engineers.

But his diversity of interests and achievements should not lead us into forgetting that Richards was first and foremost a geologist; that his many activities radiated from a common centre; and that that centre or nucleus was his position as Professor of Geology. It was particularly fitting, therefore, that in 1929 he was chosen as a member of the State Commission on Mining. Reading through the very valuable recommendations of the report of that commission one can see on every page, indeed, in almost every paragraph, the imprint of his personality.

While he could always see clearly the practical applications of pure research, Richards appreciated just as nicely the converse way in which applied science could aid academic studies. Thus on the one hand he recognised, while making an investigation into the nature and origin of the calcareous muds and coral reefs of Moreton Bay, that they might prove suitable raw material for the manufacture of cement; on the other hand it was while searching for limestone deposits for that same cement industry that he found and described at Gigoomgan a fossil reef almost unique in type and as such of great academic interest.

The high quality of Richards' geological work was recognised outside the State, too, by his brother Geologists, who, as early as 1924, elected him President of the Geology Section of the Australasian Association for the Advancement of Science. It was his geological work, too, which led the Royal Society of New South Wales to select him to deliver the W. B. Clarke Memorial Lecture in 1937 and to present him with the Clarke Medal "for researches in Natural Science" in the following year. The Commonwealth Government was glad to appoint him as its representative at the South African Meeting of the International Geological Congress.

Nevertheless, as his qualities became more clearly appreciated, the geologist was called upon to undertake an ever-growing and ever-widening range of non-geological activities which, in the end, extended well beyond the range not only of things geologic but of things scientific. For example, he was chosen by the Commonwealth Government in 1932 as its representative to act with Mr. S. F. Markham, who had been appointed by the Carnegie Corporation of New York to make a survey of the Art Galleries and Museums of Australia. Although, at that time, these things were beyond the bounds even of his wide range of interests, Richards, as always, threw himself into the new work, and soon became completely absorbed by it. The survey was thorough and successful, and the report a model of its kind.

Rather surprisingly, Richards found far more to interest him in the Art Galleries than in the Museums, and it is no more than the truth to say that one of the results of this survey was to open a new world to him, a world which brought a great deal of happiness to his later years. When he visited Europe in 1935 it was with a love of art already firmly planted in him, so that I was not surprised on his return to hear far more from him about art galleries than geological museums.

Another result of the Survey was his appointment by the Carnegie Corporation as its Australian representative. In this capacity, Richards did such eminently satisfactory work that the Corporation, in 1936, presented him with a handsome medal "in recognition of their appreciation of his constant interest and help in the work of the Corporation."

Richards' influence in our local art world grew steadily, and he became both Chairman of the John Darnell Fine Arts Committee and Chairman of Trustees of the Queensland Art Gallery.

It was typical of the man and symbolic of his change in outlook that, in 1945, he arranged a most successful exhibition of pictures in the laboratories of his department of geology.

I have said nothing so far of Richards' family life. We tend to forget when dealing with one who played such an important part as a leader of the community, how very important both to the man himself and to the community he serves, is the domestic background to his public life. In spite of the range and intensity of his public interests, Richards nevertheless found ample time for a full and happy home life.

When at Broken Hill, in 1908, he met Grace Christian, of Melbourne, a daughter of Thomas Christian, who was so closely and successfully associated with the Charters Towers goldfield in its heyday. They were married at Malvern, Victoria, early in 1911. The important part which his wife played in Richards' life will be appreciated only by their close friends, for although Mrs. Richards was content to play what appeared to be merely a passive role, the truth was quite otherwise, since, in addition to her calm and poise which contrasted so strongly with his more positive personality, she possessed a store of deep wisdom and sound judgment which Richards always called upon before making the more important decisions of his life.

To them, in the pleasant home, "Boongah," that they built at Auchenflower, were born a son, Jack, and, later, a daughter, Peggy, both of whom brought Richards great happiness in his earlier years and great comfort in the later ones. Jack, of whom he was always justly proud, did a brilliant engineering course at the University, won a Rhodes Scholarship, and is now Assistant Manager of Broken Hill Proprietary's works at Newcastle. It is good to see again in the son so many of the virtues of the father. It makes the loss seem less irreparable. His daughter, too, who married Dr. Norman Martin, shows in many ways the influence of her father. It was his joy and solace that he was able to have so much of her company during those last quiet months that ended his vigorous career.

It commonly happens that the achievements of men of initiative and determination are reached only at the cost of considerable unpopularity. The very strength of character that is the basis of their success, all too frequently makes more enemies than friends. But Richards was everywhere popular and his friends were legion. Although, as we have seen, his achievements were outstanding, he will be remembered by those who knew him, not for what he did, but for what he was; for the simplicity and directness of his character rather than for the number and variety of his accomplishments; for the mildness of his manner rather than for the strength of his actions; for his almost care-free disposition rather than for the thoroughness of his methods; for the smiling face that hid the grim determination; in short, for his warm humanity rather than for his cold efficiency.

Such contrasts between the man and his work seem almost paradoxical, but the explanation is plain: Henry Caselli Richards was a great man, and his were the simple virtues of the great.

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THREE SPECIES OF ENDIANDRA (FAMILY LAURACEAE) FROM EASTERN AUSTRALIA.

By C. T. White, Government Botanist, Brisbane.

(Plate V.)

(*Received 24th October; read before the Royal Society of Queensland, 24th November,* 1947; *issued separately, 22nd September,* 1948.)

For some years past I have been interested in the Australian Lauraceae, especially in the correct identification of various timbers from them on the Australian market. So far as I can see, one of these cut on the Dorrigo Plateau has not yet been given a botanical name. I have now received specimens which enable me to do this and a description of it is offered herewith.

Endiandra introrsa sp. nov.

Arbor ad 30 m. alta, trunco ad 1 m. diam.; partibus novellis pilis fulvis sericeis dense obsitis. Folia lanceolata supra atro-viridia subtus distincte pallidiora sed vix glaucescentia, supra glabra, subtus pilis brevibus plus vel minus sparse obsita deinde glabra, in sicco utrinque reticulata, venis et venulis subtus elevatis et prominentioribus, lamina 4–9 cm. longa, 1·3–2·5 cm. lata; petiolo 3–5 mm. longo. Paniculae pauciflorae ex axillis superioribus orientes, foliis multo breviores; ramulis validis tenuiter pubescentibus. Flores 3 mm. diam., pedicelli 1 mm. longi, perianthii segmenta suborbicularia extus tenuiter pubescentia. Stamina 3 antheris introrsis, staminodiis 3 ligulatis alternantia. Ovarium glabrum, liberum. Fructus subglobosus, leviter depressus, 6 cm. diam.

New South Wales: Orara West, common in rain-forest, *W. T. Jones* No. 3 (type: a few flowers and immature fruits), May 1946 (tree over 100 ft., and 3 ft. diam.; the very large plum-like fruits over 2 in. diam. are quite common wherever one goes in the area: local name "Plum" and timber cut and sold under that name); Coramba, ex N.S.Wales Forestry Commission, in National Herbarium, Sydney (fruits), March 1933.

Type in Herbarium, Brisbane; isotype in National Herbarium, Sydney.

Only three flowers were available for dissection; in the two examined however, the anthers were definitely introrse, an exceptional feature in the genus. The introrse or extrorse dehiscence in Lauraceae is looked upon as of definite generic value and one genus *Pseudocryptocarya* Teschner is distinguished from *Cryptocarya* R.Br. solely on the introrse, not extrorse dehiscence of the anthers of the third or inner series of stamens. As the anthers of some species of *Endiandra* have been described as semi-extrorse, I do not feel disposed to propose a new genus in this case. In the past the species has been confused with *E. virens* F. Muell.

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Endiandra virens F. Muell. Fragm. Phytogr. Austr. ii, 90 (1860); Meissn. in DC. Prodr. xv, I, 509 (1864); Benth. Fl. Austr. v, 302 (1870); F. M. Bailey Queensl. Fl. iv, 1305 (1901); Maiden For. Fl. N.S.Wales, v, 12, pl. 154 (1913); Francis Austr. Rain-Forest Trees, 122 (1929).

E. exostemonea F. Muell. Vict. Nat. ix, 42, 1892. F. M. Bailey Queensl. Fl. iv, 1306, 1901.

E. Lowiana F. M. Bail. Bull. xviii (Bot. Bull. v) Dept. Agric. Brisbane 25 (1892), Queensl. Fl. iv, 1307, Pl. LV, fig. 3 (1901).

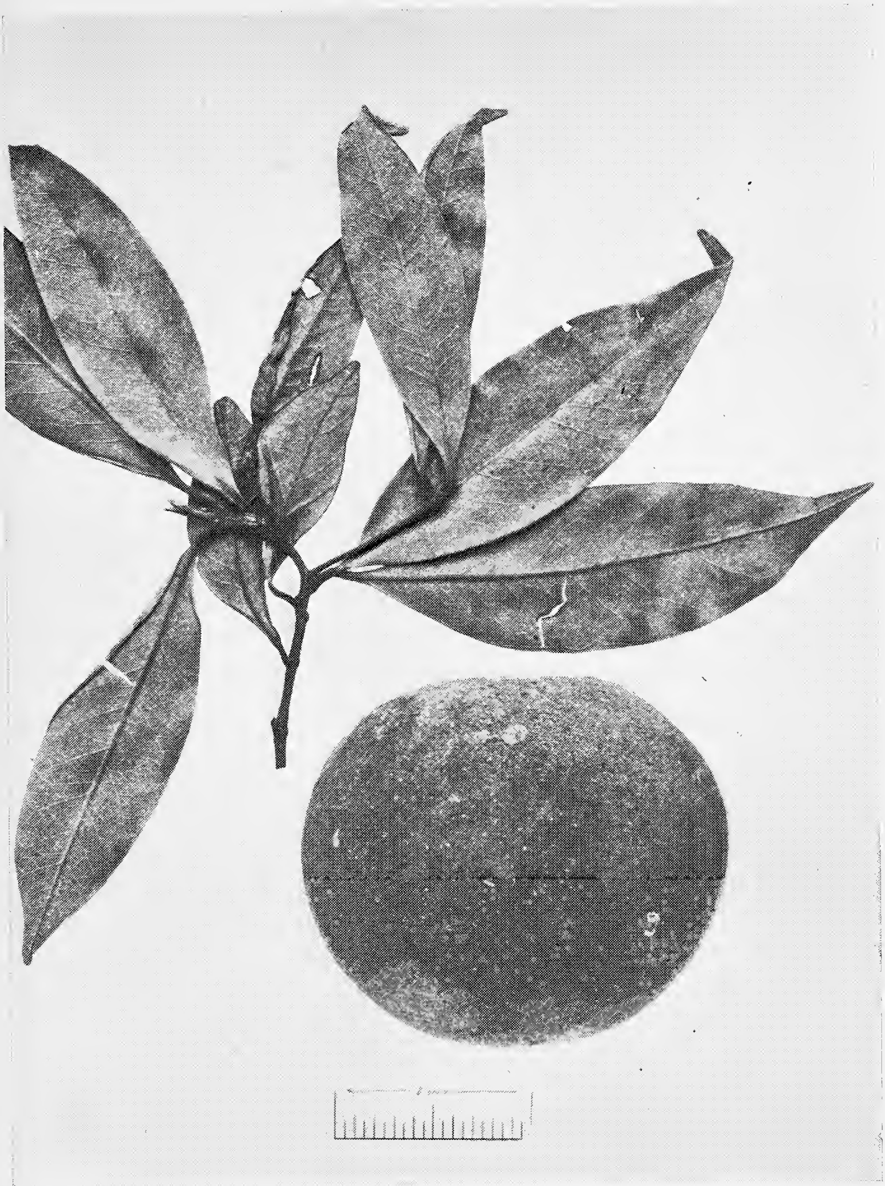
Distribution: From the Comboyne Plateau and Coff's Harbour (N.S.Wales) to Daintree River (North Queensland).

This is a common tree in some of the rain-forests of coastal Queensland. The tropical specimens have on the whole, larger, broader leaves but both the tropical and extra-tropical specimens show considerable range in this respect. Mueller in his original description of *E. exostemonea* stressed the protruding stamens. This however is a feature of the fully developed flowers of *E. virens* F. Muell. as illustrated in Miss Flockton's excellent drawing in Maiden's "Forest Flora" (l.c.). The swollen turbinate base of the perianth tube with a distinct rim below the lobes, the unequal perianth segments and the protruding stamens give the flowers of this species a very distinctive appearance.

Endiandra microneura nom. nov.

E. reticulata C. T. White in Proc. Roy. Soc. Queensl. xlvii, 27 (1936), non *E. reticulata* Gillespie (1931).

As the specific epithet *reticulata* was preoccupied in the genus for a Fijian species a new one becomes necessary for the North Queensland species.



[*Photo. Agriculture and Stock.*

Endiandra introrsa C. T. White, sp. nov. Leafy branch and detached fruit, both natural size.

STUDIES IN QUEENSLAND GRASSES, III.

By S. T. BLAKE, M.Sc., Queensland Herbarium, Botanic Gardens, Brisbane.

(*Received, 27th October; read before the Royal Society of Queensland, 24th November,* 1947; *issued separately, 22nd September,* 1948.)

In this paper there are recorded the first definite Queensland localities for a number of grasses. A few of these species have been mentioned previously in different publications as occurring in Queensland, but without mention of any definite locality. Two new species are described, one new name proposed, and the identification of some others discussed.

Enneapogon cylindricus *N. T. Burbidge* in Proc. Linn. Soc. London, sess. 153, 89, fig. 5 (1941).

QUEENSLAND.—Burke District: Close to Queensland—Northern Territory Border in 20° 54′ S. lat., dominating a treeless plain on light grey-brown light clay, 630 ft., May 28th, 1947, *S. T. Blake* 17956. Mitchell District: Oakley, N. of Longreach, on low sparsely timbered sandy ridge, about 620 ft., June 2nd, 1936, *S. T. Blake* 11645.

New for Queensland: the species was known previously from Western Australia and South Australia. It is noteworthy on account of its developing three kinds of inflorescences. The usual terminal inflorescence is relatively long and dense and unusually narrow, 6–14 cm. long and 5–10 mm. wide including the awns. In addition there are developed short panicles with cleistogamous spikelets more or less completely enclosed in the upper leaf-sheaths; while larger, much modified solitary cleistogamous spikelets are produced in the axils of the basal leaves. At maturity the culms readily disarticulate.

Eragrostis Basedowii *Jedwabnik* in Bot. Archiv iv, 328 (1923).

QUEENSLAND.—Gregory North District: 30–35 miles S. of Bedourie, on silt beds, July 21st, 1936, *S. T. Blake* 12306. Gregory South District: 40 miles W. of Betoota, on drift sand, July 17th, 1936, *S. T. Blake* 12194; Mt. Howitt Station, 80 miles W. of Eromanga, bed of small lake among old sand-hills, July 5th, 1936, *S. T. Blake* 11984; Nockatunga Station, 27° 40′ S., 142° 50′ E., between channels of Wilson R. on loamy sand "claypans" among Chenopodiaceae, June 27th, 1936, *S. T. Blake* 11831. Warrego District: Dynevor Lakes, 30 miles E. of Thargomindah, on sand, ca. 500 ft., June 23rd, 1936; *S. T. Blake* 11759; Dynevor Downs, in rather damp sandy land at edge of large lake, April 2nd, 1941, *C. T. White* 11576.

New for Queensland; previously known from South and Central Australia and Western New South Wales. It is readily known by the following combination of characters: Spikelets densely clustered, sessile, 10–25 mm. long by 2·5–4 mm. wide, compressed; rhachilla more or less exposed and readily breaking up between the florets at maturity; lemmas granular; paleas with the keels coarsely ciliate with stout rather long spinous hairs; very small anthers of 0·2–0·25 mm.; and small ovoid-ellipsoid grain 0·5–0·7 mm. long; it is an annual grass.

Eragrostis confertiflora *J. M. Black* in Trans. Roy. Soc. S. Austral. lv, 136 (1931).

QUEENSLAND.—Burke District: Normanton, on flood flats, chiefly on patches of sand, August 9th, 1936, *S. T. Blake* 12515; near Kajabbi, at muddy edge of pool about 500 ft., June 6th, 1935, *S. T. Blake* 9300; Flinders R., at 19° 30′ S., August 20th, 1936, *S. T. Blake* 12642; Flinders R., August, 1916, *C. T. White*. Gregory North District: Boulia, sandy or stony channel banks, 500 ft., June 28th, 1934, *S. T. Blake* 6454; Elderslie Station, W. of Winton, in channels of Western R., Nov. 28th, 1935, *S. T. Blake* 10023; Elderslie, fairly general in moist places, Sept. 9th, 1934, *J. F. Kennedy* 8; Tranby Station, approx. 145° 25′ E., 22° 40′ S., at edge of dam, about 600 ft., May 8th, 1936, *S. T. Blake* 11416. Gregory South District: Birdsville, on alluvial flats, July 19th, 1936, *S. T. Blake* 12215A; Mt. Howitt Station, 80 miles W. of Eromanga, in bed of small lake among old sandhills, July 5th, 1936, *S. T. Blake* 11987. Mitchell District: Tower Hill, April, 1919, *C. T. White*; Muttaburra, April, 1919, *C. T. White;* Evesham, Darr R., *C. W. de Burgh Birch;* Longreach, on mud-bank in Thomson R., 600 ft., July 3rd, 1934, *S. T. Blake* 6624; Blackall, damp shady banks of Barcoo R., 920 ft., July 14th, 1934, *S. T. Blake* 6754A; Blackall, in channel of Barcoo R. around waterhole, Nov. 21st, 1940, *L. S. Smith & S. L. Everist* 902.

These are the first localised records for Queensland for this species. It is known also from New South Wales, South and Central Australia.

Eragrostis Kennedyae *F. Turner* in Proc. Linn. Soc. N.S.Wales, 2nd ser. viii, 535 (1894).

QUEENSLAND.—Gregory South District: Tenham Station, approx. 25° 50′ S., 142° 50′ E., edge of depression on reddish sandy loam, July 9th, 1936, *S. T. Blake* 12034; Earlstoun Station, between Quilpie and Windorah, very common in mulga (*Acacia aneura*) country on reddish silty clay, April 23rd, 1934, *S. T. Blake* 5463; Warrego District: Charleville, in depressions with *Eucalyptus coolabah*, about 1,000 ft., April 4th, 1936, *S. T. Blake* 11035.

New for Queensland; elsewhere known from N.S.Wales, South, Central and Western Australia.

Eragrostis pergracilis *S. T. Blake;* species nova, affinis *E. Dielsii* Pilger et *E. falcatae* Gaud., sed ab hac differt spiculis longioribus brevius pedicellatis, lemmatibus arctius appressis et antheris brevioribus; ab illa differt spiculis angustioribus longius pedicellatis, lemmatibus minoribus; ab utraque gracilitate, caryopsi tenui utraque facie fere plana distinguenda.

Gramen annuum (?), gracillimum, erectum, viride, plerumque 10–30 cm. sed usque ad 40 cm. altum, basi glabrum. Culmi fasciculati, simplices, stricti vel basin versus leviter geniculati, filiformes, teretes, crebre sed leviter striati, glabri, laeves vel minime scaberuli, sub panicula 0·3–0·7 mm. crassi, 2–4-nodes. Foliorum vaginae internodis breviores vel multo breviores, plerumque arctae, striatae, sursum admodum carinatae, auriculis breviter pubescentes, ceterum glabrae laevesque; laminae vaginis angustiores et eis breviores longioresve, plerumque involuto-filiformes, 1–5 cm. longae, explanatae usque ad 1·5 mm. latae, 9–11-nerves, inferne admodum carinatae, supra nervis admodum scaberulae, ceterum glabrae laevesque. Panicula longe exserta, pro more $\frac{1}{4}$–$\frac{1}{3}$ partem plantae occupans, ambitu plus minusve oblonga, saepe densa, 5–10 cm. longa, 2–6 cm. lata; axis communis recta vel fere recta, inferne teres, sursum angulata, glabra, laevis vel parte superiore sparsissime et minute asperula; rami filiformes, flexuosi, plus minusve compressi vel angulati, laeves vel fere laeves, demum oblique patentes, internodis axis longiores vel saepius breviores, inferiores usque ad 2·5 cm. longi, a basi ramulosi, superiores gradatim breviores; ramuli breves, appressi, paucispiculati. Spiculae subsessiles (pedicelli laterales 0·3–0·5 mm. longi, terminales usque ad 2 mm. longi), tereti-filiformes, suberectae sed curvae vel flexuosae, purpureae vel pallidae, permultiflorae, 1–4 cm. longae, 1–1·2 mm. crassae; rhachilla filiformis leviter compressa, flexuosa, glabra laevisque, internodis 0·6–0·7 mm. longis. Glumae 1-nerves, ovatae, obtusae, admodum inaequales, 1–1·4 mm. longae, inferior brevior latiorque. Lemmata arcte imbricata apice appressa vel leviter hiantia, concava, 1·5–1·6 mm. longa, a latere visa semi-elliptica obtusa carina fere recta, explanata late elliptica vel admodum ovata, obtusissima, plus minusve emarginata, apice tandem saepe erosula, glabra, laevia; nervi validi, medius (carina) sursum scaberulus, laterales breviores in tertia parte superiore evanidi et nervi medii quam marginum admodum propiores. Palea lemmate admodum brevior, 1·3–1·4 mm. longa, curvula, late oblanceolata, truncata vel fere truncata, carinis minutissime scaberulis sub apice evanidis, marginibus inflexis angustis. Stamina 3; antherae oblongae, 0·3–0·4 mm. longae. Caryopsis antice visa ovato-elliptica utrinque obtuse rotundata, a latere visa elliptico-linearis, a dorso valde compressa utraque facie fere plana (haud sulcata), marginibus rotundata, 0·45–0·55 mm. longa, 0·3–0·35 mm. lata, circiter 0·15 mm. crassa.

QUEENSLAND.—Gregory South District: Earlstoun Station, between Quilpie and Windorah, in mulga (*Acacia aneura*) country, on reddish silty clay, April 23rd, 1934, *S. T. Blake* 5461; Nockatunga Station, 27° 40′ S., 142° 50′ E., between channels of Wilson R., on loamy sand ''claypans'' among Chenopodiaceae, June 27th, 1936, *S. T. Blake* 11848. Warrego District: Dynevor Downs, in mulga scrub on reddish very silty loam, about 500 ft., May 22nd, 1939, *S. T. Blake* 14084 (TYPE); Dynevor Downs, June, 1905, *W. B. Nutting;* Eulo, on hard red mulga country, very common, March 29th, 1941, *C. T. White* 11544; Boduna, Wanko Siding, June, 1941, *L. T. East* 2; Coniston, about 80 miles SSE. of Charleville, on hard red-brown sandy loam with limonite gravel, almost bare, rare, March 26th, 1946, *S. L. Everist* 2936.

Eragrostis pergracilis is a grass with extremely slender culms, leaves, and spikelets; the spikelets are also unusually long. It appears to be an annual, but like other grasses of the dry regions, it may persist into the second year if the rainfall is suitable. It is closely allied to *E. falcata* Gaud. (*E. trichophylla* Benth.), *E. lacunaria* F. Muell. (*E. Rankingii* F. M. Bail.), and *E. Dielsii* Pilger, but the species may be distinguished by the following key:—

Lemmas with the lateral nerves distinctly nearer to the margin than to the midvein, broadest distinctly below the middle and distinctly narrowed upwards; leaf-sheaths bearded at the mouth and ciliate on the margins; anthers about 0·25 mm. long; grain laterally compressed, furrowed along one edge; inflorescence occupying about $\frac{1}{2}$ the height of the plant .. .. .. *E. lacunaria.*

Lemmas with the lateral nerves midway between the margin and the midvein, or even somewhat nearer the latter, broadest at or very shortly below the middle, not much narrowed upwards, so that the apex (at least when flattened) is broadly obtuse or emarginate; leaf-sheaths usually neither distinctly bearded at the mouth nor ciliate on the margins; anthers 0·4–0·7 mm. long; grain dorsally compressed; inflorescence occupying $\frac{1}{4}$–$\frac{1}{3}$ the height of the plant, or rarely more in very small individuals:

    Spikelets, at least the lateral ones, sessile to subsessile, with the pedicels rarely so long as 0·5 mm.; anthers 0·4–0·5 mm. long; grain more or less elliptic, thin; plants usually annual:

        Spikelets 1–2 mm. wide; internodes of rhachilla about 0·5 mm. long; lemmas 1·75–2·5 mm. long; grain more or less concavo-convex, 0·75–1 mm. long; plant more or less scabrous, the culms and leaves not particularly slender *E. Dielsii.*

        Spikelets 1–1·2 mm. wide; internodes of rhachilla 0·6–0·7 mm. long; lemmas 1·5–1·6 mm. long; grain nearly flat on both faces, 0·45–0·55 mm. long; plant smooth, the culms and leaves very fine .. .. *E. pergracilis.*

    Spikelets all distinctly pedicelled with the pedicels at least 0·5 mm. long; anthers 0·5–0·7 mm. long; grain narrow-ovate; perennial plant with lemmas 1·5–1·7 mm. long .. .. *E. falcata.*

Eragrostis xerophila *Domin* in Jour. Linn. Soc. xli, t. 12, fig. 18–20 (1912).

QUEENSLAND.—Gregory North District: Carandotta, SE. of Urandangie, on brown sandy loam flats, Nov. 11th, 1935, *S. T. Blake* 10164, and on grassland downs on brown gravelly loam, Nov. 11th, 1935, *S. T. Blake* 10155; Kalkadoon Station, approx. 22° 30′ S., 142° 25′ E., in low gidgea (*Acacia Cambagei*) ridges on light reddish brown clay silt, about 600 ft., May 10th, 1936, *S. T. Blake* 11458. Gregory South District: W. of Betoota, on claypans, July 17th, 1936, *S. T. Blake* 12204. Mitchell District: Near Longreach, on reddish very sandy loam among shrubs and small trees, July 4th, 1934, *S. T. Blake* 6654.

New for Queensland; originally described from Western Australia and known also from South Australia and the Northern Territory. It is closely allied to *E. setifolia* Nees from which it differs in the more knotty rhizome, 5–16-noded (not 2–6-noded) culms, with the leaf-sheaths mostly longer than the internodes (not conspicuously shorter), the broader (1·5–3 mm.) flatter blades, usually narrower panicle, and slightly wider commonly erect spikelets. In the field the flat, relatively broad, decurved leaves are characteristic.

Chloris Gabrielae *Domin* in Biblioth. Bot. xx, heft 85, 368, fig. 83 (1915).

Through the courtesy of Mr. C. E. Hubbard I have seen a fragment of Domin's type, and there is no doubt that it is conspecific with *Chloris virgata* Sw., a grass now widespread in Queensland, which was discussed by S. L. Everist in Queensl. Agric. Jour. xlvii, 182-186 (1937).

Trisetum spicatum (*L.*) *Richt.*, Pl. Eur. i, 59 (1890).

QUEENSLAND.—Moreton District: Mt. Cordeaux, on cliff-sides, 3,600 ft., Nov. 20th, 1938, *S. T. Blake* 13870; Mt. Merino, McPherson Range, at cliff-edge of beech forest, 3,650 ft., Dec. 9th, 1943, *S. T. Blake* 15372.

Genus new for Queensland. The species is very widely spread in many parts of the world, particularly on mountains. In Australia it has been previously known from New South Wales, Victoria and Tasmania, but it has usually been referred to as *Trisetum subspicatum* (L.) Beauv. The basis of both names is *Aira spicata* L.

Eriochloa crebra *S. T. Blake;* species nova, affinis *E. pseudo-acrotrichae* (Stapf ex Thell.) C. E. Hubbard ex S. T. Blake, sed foliis brevioribus latioribusque collo fere glabris, spiculis paullo brevioribus minus attenuatis submuticis, lemmate superiore brevius cuspidato vel submutico praecipue differt.

Gramen perenne, caespitosum, viride, erectum, plerumque circa 1 m. altum; innovationes intravaginales. Culmi erecti, basi leviter geniculati vel stricti, 2–3-nodes, simplices vel pauciramosi ramis erectis, molles, striati saepe etiam sulcati, laeves, sub inflorescentia et prope nodos pubescentes, ceterum glabri. Vaginae foliorum striatae, laeves, praecipue prope margines nodosque parce breviterque pubescentes vel fere omnino glabrae, arctae vel solutae, inferiores internodis longiores, superiores breviores; collum glabrum vel parce pubescens; ligula ad serium ciliorum circa 1 mm. longorum redacta; laminae lineares sensim acutae, planae vel marginibus plus minusve incurvae, utrinque breviter pubescentes, nervis 7–9 primariis percursae, pro more 8–20 cm. longae, pro more 3·5–7 mm. latae. Inflorescentia longe exserta, angusta, 10–20 cm. longa, circa 5–7 mm. lata, e racemis 5–10 constructa; axis communis leviter flexuosa, compresso-triquetra, circa 0·5–0·7 mm. lata, striata, breviter pubescens. Racemi breviter pedunculati vel subsessiles, erecti, 2–5 cm. longi, axis communis internodis longiores, densi, saepius subcompositi; rhachis dense scaberula neque pilosa, triquetra, prope basin pubescens, 0·3–0·6 mm. lata; pedicelli 0·4–2 mm. longi, clavato-filiformes, brevissime pubescentes, apicem versus longe albo-pilosi (pilis usque ad 2·5 mm. longis). Spiculae ovato-lanceolatae vel elliptico-lanceolatae, e $\frac{1}{3}$–$\frac{2}{5}$ partibus inferioribus gradatim acutae, 3·7–4·2 mm. longae, 1·2–1·3 mm. latae, dilute virides vel purpureo-variegatae, parte majore longiuscule albo-pilosae. Gluma inferior cupuliformis margine minute crenulata, saepe purpurea vel atro-violacea, 0·3–0·5 mm. longa. Gluma superior spiculae formam congruens et ejus apicem attingens, explanata anguste ovata, plus minusve acuta sed apice ipso anguste triangulari-obtusa vel truncatula, plus minusve apiculata mucronulo usque ad 0·1 mm. longo, 5–nervis, dorso majore parte longiuscule albo-pilosa. Lemma inferum gluma superiore aequilongum vel subbrevius, explanatum ellipticum, anguste obtusatum, marginibus hyalinis sursum ciliolatum, majore parte longe albo-pilosum, 5–nerve; palea et flos 0. Anthoecium superum oblongo-ellipticum, sub apice anguste rotundato subacutum, submuticum vel cuspidulatum, stramineum, subtiliter reticulatum admodum punctulatum, apice ipso minute hispidulum, 2·2–2·5 mm. longum (cuspidulo usque ad 0·25 mm. longo incluso), et glumae superioris $\frac{3}{5}$–$\frac{2}{3}$ partes aequilongum, circa 1·2 mm. latum. Antherae 0·9–1 mm. longae, inclusae. Caryopsis olivacea, oblongo-elliptica, circa 1·6 mm. longa, 0·9 mm. lata.

QUEENSLAND.—Burke District: Richmond, in *Astrebla* grassland, about 700 ft., June 18th, 1934, *S. T. Blake* 6303; Hughenden, grassland downs on grey-brown clay loam, about 1,100 ft., May 20th, 1936, *S. T. Blake* 11563; Flinders R., *Sutherland* 65 (MEL). North Kennedy District: Antil Plains, March 23rd, 1933, *C. T. White* 8814. Mitchell District: N. of Ilfracombe, in open grassland on dark brown clay, about 700 ft., May 3rd, 1936, *S. T. Blake* 11358 (TYPE). Leichhardt District: Springsure, *Wuth* (MEL); Springsure, Nov. 1886, *H. S. Hicks* (MEL). Port Curtis District: Rockhampton, *A. Dietrich* 1459 (MEL). Maranoa District: Balonne R., April, 1940, *W. M. Willoughby* 7; Noondoo, near Dirranbandi, on grey silt-clay plain with scattered *Eucalyptus coolabah*, about 600 ft., Feb. 28th, 1936, *S. T. Blake* 10573. Darling Downs District: Apunyal, via Dalby, April, 1935, *L. Baker* 10; Inglewood, cultivated in grass experimental plots, Jan. 20th, 1934, *C. T. White* 9757A. Moreton District: Lawnton, cultivated in grass experimental plots, Nov. 30th, 1933, *C. T. White* 9903.

NEW SOUTH WALES.—Murrumbidgee, in 1886, *K. H. Bennet* (MEL).

A relatively tall and stout species with broad flat soft leaves found chiefly in the grasslands of the interior, where it is at times very common. It appears to be a perennial, though possibly only a short-lived one, and it is evidently an excellent fodder grass. Among other Australian species it is closely similar to *E. pseudo-acrotricha* (Stapf ex Thell.) C. E. Hubbard ex S. T. Blake, but it is usually a taller and coarser plant with rather broader though shorter leaves more or less glabrous on the collar, with somewhat shorter spikelets broadest nearer the middle and acute and more or less muticous (not setaceously acuminate) at the tips, submuticous to shortly cuspidate fertile florets and smaller anthers and grain. It is also close to an as yet undetermined form from the coastal brackish marshes, but the latter is harder and more rigid, more or less pruinose, and the spikelets are more neatly arranged in two rows.

Panicum incomtum *Trin.* Gram. Pan. 200 (1826); Sp. Gram. Ic. ii, t. 232 (1829).

Panicum Prenticeanum F. M. Bail. 3rd Suppl. Syn. Queensl. Fl. 82 (1890), Catal. Pl. Queensl. 55 (1890), Queensl. Fl. vi, 1831 (1902), Compreh. Catal. 610, fig. 589 (1913).

Panicum sarmentosum Roxb. var. *Prenticeanum* (F. M. Bail.) Domin in Biblioth. Bot. xx, heft 85, 315 (1915); Hughes in Kew Bull. 1923, 324 (1923).

QUEENSLAND.—Cook District: Daintree, along track and in other slightly open places in rain-forest, July 7th, 1943, *S. T. Blake* 14989; Harvey's Creek, in 1889, *F. M. Bailey* (TYPE of *P. Prenticeanum*); Behana Creek, in 1889, *F. M. Bailey;* Middle Tully R., July, 1889, *J. F. Bailey;* without definite locality, *E. Cowley* 45B, 87B.

Mrs. Agnes Chase, in Jour. Arnold Arb. xx, 311 (1939), has pointed out that *Panicum incomtum* Trin. differs from *P. sarmentosum* Roxb., which has a larger much more open panicle with non-viscid branches and appears to be known only from Sumatra. *P. incomtum* is known from India, Southern China, Malaysia and North-East Queensland, where it appears to be invariably associated with rain-forest, chiefly at the forest edge, where it scrambles to about 5 metres in height.

Panicum bicoloratum *S. T. Blake*, nomen novum.

Panicum bicolor R.Br. Prodr. 191 (1810), non Moench, Meth. 206 (1794).

Panicum fulgidum Hughes in Kew Bull. 1923, 323 (1923), non Stapf in Prain, Fl. Trop. Afr. ix, 668 (1920).

Hughes, when renaming *Panicum bicolor* R.Br. because of the earlier homonym of Moench, overlooked the fact that the epithet she chose had already been employed by Stapf for another species of the genus. Hence a third name is required for the species, which in Queensland is restricted to the Moreton and Wide Bay Districts, and in New South Wales extends at least as far south as Sydney. I have seen no specimen of the type-collection, but have seen representatives of other collections cited by Hughes, l.c.

Panicum Whitei *J. M. Black* in Trans. Roy. Soc. S.Austr. xli, 632 (1917).

QUEENSLAND.—Cook District: Mitchell R. at Dunbar Crossing, June, 1943, *F. W. Whitehouse*. Burke District: Inverleigh, between Normanton and Burketown, depressions in grassland, May 31st, 1935, *S. T. Blake* 9201; Iffley Station, about 130 miles S. of Normanton, grassland plain (*Astrebla*, etc.) on heavy dark grey soil, forming pure stands in places, August 20th, 1936, *S. T. Blake* 12633; Julia Creek, lower places on open downs on greenish-grey fine silt, about 400 ft., June 21st, 1934, *S. T. Blake* 6341; Richmond, stream bank on greenish grey fine silt, June 17th, 1934, *S. T. Blake* 6277; Hughenden, grassland downs on grey-brown clay loam, about 1,100 ft., May 19th, 1936, *S. T. Blake* 11551. Gregory North District: Frensham, near Kynuna, grassland downs on grey-brown clay silt *ca.* 750 ft., very common in places, May 13th, 1936, *S. T. Blake* 11491; Middleton, between Boulia and Winton, on stream banks, June 29th, 1934, *S. T. Blake* 6491; Tranby, approx. 22° 40′ S., 142° 25′ E., near a dam, also common in grassland, about 600 ft., May 8th, 1936, *S. T. Blake* 11418. Gregory South District: Cooper's Creek, 7 miles E. of Windorah, in heavy grey clay on flood plain, June 25th, 1937, *S. L. Everist* 1551; Windorah, on flood-plain of Cooper's Creek, July 12th, 1936, *S. T. Blake* 12084; Mt. Howitt Station, about 100 miles W. of Eromanga, between channels of Cooper's Creek, on grey silt clay, July 6th, 1936, *S. T. Blake* 11012; Nockatunga Station, approx. 27° 40′ S., 142° 50′ E., between channels of Wilson R., on loamy sand "claypans" among chenopods, June 27th, 1936, *S. T. Blake* 11843. Mitchell District: Prairie, in Eucalyptus forest on light grey sand about 1,450 ft., May 22nd, 1936, *S. T. Blake* 11598; Corinda Station, on flooded flats of Torrens Creek, brownish grey clay soil, in Black Gidyea (*Acacia* sp.) scrubs, April 8th, 1946, *S. L. Everist* 2573; Longreach, about 600 ft., a common channel grass, July 3rd, 1934, *S. T. Blake* 6630; Warbreccan Station, near Longreach, Feb., 1941, *J. B. Hastings*; Alice R., 30 miles SW. of Barcaldine, in silt on river bank, Nov. 20th, 1939, *S. L. Everist* 1923. Warrego District: Charleville, banks of Warrego R. on dark greenish brown loam, about 950 ft., April 21st, 1934, *S. T. Blake* 5436; about 25 miles S. of Wyandra, depressions in grassland on light brown silt clay about 700 ft., April 13th, 1936, *S. T. Blake* 11231. Maranoa District: near Bollon in damp places along creek banks, April 2nd, 1941, *C. T. White* 11539.

This grass is a prominent species on ground subject to flooding by the braided streams of the inland drainage system, sometimes forming a prominent part of the pasture of the "channel country", though it sometimes is also common on the Mitchell grass (*Astrebla* spp.) grasslands. It is commonly known as "pepper grass", sometimes, particularly in the more northern parts of its range, as "pigeon grass". It is a rather leafy slender grass, usually about 1–1½ metres high when in flower though often much less, and commonly behaves as an annual, though it may persist into the second year if water relationships are favourable. It has been confused with *Panicum decompositum* R.Br., and the name was cited as a synonym of this by Hughes in Kew Bull. 1923, 325 (1923), but it is a more slender, less brittle grass, with a less rigid panicle of which the lower branches are not verticillate, while the fertile floret is dark coloured with prominent though slender pallid nerves and often falls before the glumes.

Brachiaria miliiformis (*Presl*) *Chase* in Contrib. U.S. Nat. Herb. xxii, 35 (1920).

Panicum miliiforme Presl. Rel. Haenk. i, 300 (1830).

This species is widely spread in Queensland, from the coast to the inland regions. It is not uncommon in agricultural districts as a weed of cultivation headlands, and is generally regarded as a good fodder grass, although it is an annual. It is particularly characteristic of light-textured soils. The species was recorded as *Panicum distachyum* L. by Benth. Fl. Austral. vii, 478 (1878); F. M. Bail. & Staiger, Illustr. Monogr. Grasses Queensl. (1879); F. M. Bail. Syn. Queensl. Fl. 623 (1883), Catal. Pl. Queensl. 54 (1890), Queensl. Fl. vi, 1825 (1902), Compreh. Catal. 604 (1913); Domin in Biblioth. Bot. xx, heft 85, 306 (1915). It was recorded as *Brachiaria distachya* (L.) Hughes by Hughes in Kew Bull. 1923, 315 (1923).

But according to C. E. Hubbard and R. E. Vaughan, Grasses of Mauritius and Rodriguez, 79 (1940), *B. distachya* differs from *B. miliiformis* in its smaller spikelets (2·5–3 mm.), smaller leaves, fewer and shorter racemes, and in the peduncle being pilose towards the summit.

Hitchcock, in Lignan Sci. Jour. vii, 214 (1931), synonymises *Panicum miliiforme* Presl with *P. subquadripara* Trin. under *Brachiaria subquadripara* (Trin.) Hitchc., but to judge from Trinius' description and figure in Gram. Ic. t. 198 (1829) and specimens from Ceylon agreeing therewith, our plant has plumper, more obovate, shortly acute to obtuse or apiculate spikelets which are rather distinctly different from the more or less narrowly elliptic, sharply acute or acuminate spikelets of *B. subquadripara*. Presl's species came from the Philippine Islands, and the Australian plants agree with all the material seen from that region.

Brachiaria praetervisa (*Domin*) *C. E. Hubbard* in Kew Bull. 1934, 446 (1934).

Panicum praetervisum Domin in Biblioth. Bot. xx, heft 85, 309 (1915).

Panicum Kochii Mez in Notizbl. Bot. Gart. Berlin vii, 60 (1917).

Urochloa praetervisa (Domin) Hughes in Kew Bull. 1923, 319 (1923).

QUEENSLAND.—Gregory North District: 35 miles S. of Bedourie, flood plain of Eyre's Creek, July 21st, 1936, *S. T. Blake* 12301. Gregory South District: Cooper's Creek, Mt. Howitt Station, 110 miles W. of Eromanga, on shady stream banks, July 6th, 1936, *S. T. Blake* 12014. Warrego District: Carbeen, near Cunnamulla, on sand-ridges under shade of trees, not common, March 26th, 1941, *C. T. White* 11559.

New for Queensland; previously known from South Australia and Western New South Wales. It is closely similar to *B. Windersii* C. E. Hubbard, a species rather widely spread in Queensland, chiefly in inland districts, but differs from it in the fewer less spreading racemes with rather larger spikelets more closely arranged on pedicels lacking the characteristic long hairs of *B. Windersii*, while the leaf-blades are relatively broader.

Setaria Carnei *Hitchc.* in Proc. Linn. Soc. N.S.Wales lii, 185 (1927).

QUEENSLAND.—Burke District: Lorraine, between Burketown and Cloncurry, flood bank of Leichhardt R., June 3rd, 1935, *S. T. Blake* 9266.

New for Queensland; previously known from Western Australia; determination by C. E. Hubbard. This is the only Australian species so far known with the involucral bristles retrorsely barbed.

Paractaenum novae-hollandiae *Beauv.* Agrostogr. 47, *t.* 10, *f.* 6 (1812).

QUEENSLAND.—Gregory North District: 30 miles S. of Bedourie, on sandhills, July 21st, 1936, *S. T. Blake* 12282. Gregory South District: Birdsville, on the sides of desert sand-dunes, July 19th, 1936, *S. T. Blake* 12242; On Mt. Howitt Station, about 110 miles W. of Eromanga, on sandhills among the channels of Cooper's Creek, July 6th, 1936, *S. T. Blake* 11992.

New for Queensland, and not uncommon on the dunes of the Simpson Desert. Originally described from Western Australia, and known also from South Australia, New South Wales and Central Australia.

Uranthoecium truncatum (Maiden & Betche) Stapf in Hook. Ic. Pl. *t.* 3073 (1916).

Rottboellia truncata Maiden & Betche in Proc. Linn. Soc. N.S.Wales xxi, 741, *t.* 69 (1906).

QUEENSLAND.—Burke District: Oorindi, grassland plain on light brown gravelly sandy loam, 428 ft., May 18th, 1936, *S. T. Blake* 11540; Nonda, dominant grass in shallow depressions in heavy dark brown soil, 515 ft., Feb. 5th, 1931, *C. E. Hubbard & C. W. Winders* 7211; Hughenden, Feb., 1933, *J. H. McCarthy*, and March, 1933, *J. H. McCarthy*. Mitchell District: Prairie, in open damp somewhat sandy patch, about 1,450 ft., May 22nd, 1936, *S. T. Blake* 11571; about half-way between Prairie and Aramac, with *Chloris pectinata* and *Dactyloctenium radulans* on a low open flat in the "desert country", Feb. 18th, 1937, *S. L. Everist & L. S. Smith* 229; Warbreccan Station, near Longreach, Feb., 1941, *J. B. Hastings;* near Yaraka, *E. M. Bowman.* Gregory North District: Two Rivers, Selwyn, April 24th, 1936, *S. H. Teece;* Frensham, near Kynuna, in grassland downs on grey-brown clay silt, about 750 ft., May 13th, 1936, *S. T. Blake* 11493; Warenda Station, on Winton-Boulia Road, Jan. 27th, 1937, *S. L. Everist & L. S. Smith* 132; Tranby, approx. 22° 40′ S., 142° 25′ E., near a dam, about 600 ft., May 5th, 1936, *S. T. Blake* 11417. Gregory South District: Cooper's Creek, Mt. Howitt Station, 110 miles W. of Eromanga, in the channels, July 6th, 1936, *S. T. Blake* 12021. Warrego District: Cunnamulla, in small depressions in grassland, on light brown silt clay, about 600 ft., April 12th, 1936, *S. T. Blake* 11200.

New for Queensland; previously known from New South Wales.

Spathia neurosa *Ewart & Archer* in Ewart & Davies Fl. N. Territ. 26, pl. I (1917).

QUEENSLAND.—Burke District: About 35 miles N. of Camooweal, occasional in treeless grassland (chiefly *Astrebla elymoides*) on grey cracky but rather puffy soil, about 990 ft., May 25th, 1947, *S. T. Blake* 17931; about 50 miles SSE. of Camooweal, treeless *Astrebla* grassland, 670 ft., May 28th, 1947, *S. T. Blake* 17955.

New for Queensland. This montypic genus was known previously only from the Northern Territory.

CORRECTION.

Aristida utilis *F. M. Bail.* In the discussion on *Streptachne stipoides* R.Br. and *Aristida utilis* F. M. Bail. in Proc. Roy. Soc. Queensl. lvi, 11–22 (1944) an error in citation occurs on p. 12, line 1, and on p. 16 line 9. In each place the reference to Hughes should read: Hughes, Kew Bull. 1923, 302 (1923).

STUDIES IN AUSTRALIAN APOCYNACEAE AND ASCLEPIADACEAE, I.

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In 1942, at the suggestion of Mr. C. T. White, a revision of the Australian Apocynaceae and Asclepiadaceae was undertaken as a necessary accompaniment to a search for possible rubber-producing plants in Queensland, but since 1945 this work has progressed only in an intermittent way. While most of the systematic work has been completed, it may be some time before the revision is finalised, and it was felt that some of the more outstanding undescribed species and combinations should be published in a preliminary paper.

Apocynaceae.

Melodinus Bacellianus (*F. Muell.*) *S. T. Blake,* comb. nova.

Wrightia Bacelliana F. Muell. in Vict. Nat. viii, 178 (1892).

Melodinus Murpe F. M. Bail. Bot. Bull. x, 23 (1895).

Trichostemanthemum Bacellianum (F. Muell.) Domin in Biblioth. Bot. lxxxix, 520 (1928).

Wrightia Bacelliana was described from flowering specimens, *Melodinus Murpe* from fruiting ones. Having seen the types of both and having collected specimens in flower and fruit, I fully agree with Domin that they are conspecific, but I cannot accept his opinion that the species is generically distinct from *Melodinus*. The insertion of the stamens and the very thick dissected corona-lobes are rather different from the general trend in *Melodinus,* but the Indo-Malaysian *M. orientalis* Bl. shows an intermediate condition.

Cerbera dilatata *S. T. Blake;* species nova, affinis *C. floribundo* K. Schum., sed foliorum venis lateralibus plurioribus ad costam fere directis, sepalis persistentibus, tubo corollae medio superiore valde dilatato, fructu minore praecipue differt.

Arbor magna, latice perfluido albo viscido abundans; truncus erectus cylindricus cortice extus griseo dense squamato obtectus. Ramuli robusti, rugulosi, cicatricibus foliorum delapsorum crebre notati. Folia apicem ramulorum versus spiraliter conferta, glabra; petioli plerumque 1·5–2·5 cm. longi; laminae anguste oblongae vel oblanceolatae, breviter subabrupteque obtuse acuminatae vel raro subacutae, basin versus gradatim cuneatae, supra nitidulae subtus opacae, plerumque 12–20 cm. longae et 2·5–5 cm. latae; costa prominula; nervi laterales utrinsecus costam 23–30, tenues, haud prominuli, e costa angulo 70°–80° egredientes, fere recti, solum prope marginem curvati. Panicula terminalis, plus minusve corymbosa, densiflora, pedunculo valido circa 3 cm. longo incluso circa 10 cm. longa lataque; bracteae suboblongae, incurvae, circa 1 cm. longae, mox caducae; pedicelli circa 1 cm. longi. Sepala oblonga admodum elliptica, apice rotundata, 7 mm. longa, persistentia, marginibus anguste membranacea repandula. Corolla (in vivo) alba; tubus 2 cm. longus, inferne subcylindricus circiter 1·5 mm. latus, medio superiore gradatim valde dilatatus usque 6 mm. latus, fauce ipsa constrictus; lobi oblique late ovati, leviter emarginati, circa 4·5 mm. longi. Stamina prope faucem inserta. Fructus cyaneus, subellipsoideus, acutus, facie adaxiali compressus, circa 5–6 cm. longus, 3–3·5 cm. latus.

QUEENSLAND.—Cook District: Danbulla, near Atherton, in rain-forest, 2,500 ft. and higher, common, Nov. 28th, 1942, *S. T. Blake* 14749 (tall rather slender tree with sparse irregularly spreading but not large crown with the leaves clustered at ends of branches and all parts with copious white latex; trunk cylindrical to base; bark pale grey, tessellately scaly or slightly corky in very large trees, with a tough black layer against sapwood which is very white; leaves dull green above, paler beneath; fruit green to purple; local name: milky pine) (in fruit); Yungaburra, Jan., 1918, *C. T. White* (leaves scattered, crowded towards ends of branches; very milky) (leaves only); Gadgarra, rain-forest, March, 1932, *W. D. Francis* (in flower); Gadgarra, in rain-forest, 800 m., common, July 24th, 1929, *S. F. Kajewski* 1141 (a very large tree up to 30 metres high, petals cream-pink, sweetly scented, sap milky, common name: milky pine) (in flower and very young fruit); near Malanda, at roadside, cleared rain-forest, yellowish soil, about 2,400 ft., Sept. 2nd, 1943, *S. T. Blake* 15249 (tree of 30 ft. with pale grey pustular bark with some longitudinal fissures and somewhat scaly, blackish immediately beneath surface and separating from inner ochraceous bark which has much white fluid sticky latex; sapwood whitish; wood white; leaves green, paler beneath; flowers white, strongly scented; occasional in rain-forest on yellowish, not red soils) (in flower); Mt. Bartle Frere, North Peak, near foot of western spur, about 2,450 ft., in rain-forest, August 31st, 1943, *S. T. Blake* 15244 (tall massive tree with cylindrical trunk with occasional protruberances and depressions; bark creamy grey closely tessellately fissured, brown to black beneath surface, more or less ochraceous towards whitish sapwood, with abundant white latex) (loose leaves and fruit from ground); near Goldsborough, upper Mulgrave R., in rain-forest, 230–500 ft., July 28th, 1943, *S. T. Blake* 15033 (tree 40–60 ft., straight or nearly so, with rather sparse crown of dark green leaves paler beneath; banches spreading; trunk not buttressed, cylindrical, bark grey, compactly scaly with longitudinal loosely anastomosing darker lines of lenticels, blackish beneath and readily separating from the deep cream inner bark, the latter together with the twigs, leaves and flowers with abundant very fluid very sticky white latex; flowers strongly scented; calyx greenish; corolla white; fruit from ground, said to be blue when fresh) (flowers and old fruits; TYPE); Mt. Toressa, in 1904, *F. M. Bailey* in Bellenden Ker Expedition, no. 72 (tree 60 ft. high, 2 ft. diam.) (foliage and remains of inflorescence); Deeral, near Babinda, occasional in rain-forest on rather steep slope, about 350 ft., July 13th, 1943, *S. T. Blake* 14970 (tree with rather sparse crown; branchlets and branches spreading; bark with vertical lines of packed dark lenticels and some transverse wrinkles, the outer layer grey on outside, black beneath, readily separating from the inner bark which is thicker, ochre-coloured and with much white latex; leaves green; flowers in terminal cymes, rather numerous, white, scented; corollas, fruit and leaves picked up from the ground) (loose leaves, corollas and fruits); Babinda, in rain-forest, rather common at 350 ft., July 25th, 1943, *S. T. Blake* 15024 (tree 30–40 ft.; crown fairly dense, main branches slightly spreading; trunk cylindrical with occasional small protruberances; outer bark greyish white indistinctly scaly, very dark brown beneath, readily separating from the rather thick ochre-coloured inner bark, which, together with twigs and flowers, has abundant very fluid very sticky white latex; leaves glossy green above, paler beneath, those on young trees up to 17½ × 3 in.; flower-buds with pink tips; flowers strongly scented; calyx greenish white; corolla white withering to a dirty brown; fruit and seeds from ground) (flowering twigs and loose fruits); Jogo near Innisfail, a rain-forest tree on well drained ground about 50 ft., Sept. 10th, 1943, *S. T. Blake* 15270 (tall tree with rather compact crown and leaves at ends of branches; bark dark grey, longitudinally fissured with occasional protruberances; leaves and fruit from the ground) (loose leaves and fruit).

This species has been confused with *C. Manghas* L. and *C. Odollam* L., from both of which it differs in the narrower leaves with more widely spaced lateral veins, much smaller sepals and corolla lobes, the much inflated upper half of the corolla-tube, and in the smaller ellipsoid blue fruits. It is more closely allied to *C. floribunda* K. Schum., and resembles it more closely in the field, but the more numerous finer lateral veins nearly straight for most of their length, the persistent sepals, shape of the corolla-tube and the rather smaller, more acute fruits sufficiently distinguish it. The size of the leaves varies considerably, and particularly on young shoots may greatly exceed the dimensions given in the above description.

Wrightia versicolor *S. T. Blake;* species nova, affinis *W. pubescenti* R.Br., sed foliis glabris, bracteolis minimis, sepalis dorso glabris praecipue differt.

Arbor 5–10 m. alta; truncus cortice griseo tandem squamoso lactescenti obtectus, basin versus canaliculatus. Ramuli tenues, teretes vel juniores plus minusve compressi, divaricati, glabri, lenticellis parvis sparsis praediti. Folia tempore sicco decidua, tempore florenti crescentia, prominule petiolata, glaberrima; petioli tenues, supra canaliculati, 4–8 mm. longi; laminae ovatae vel ellipticae, apice breviter acuminatae, basi subacutae vel admodum attenuatae, pro more 5–7·5 cm. longae, 2–3·5 cm. latae, membranaceae; nervi laterales utrinsecus costam 10–15, tenues. Cymae terminales, 2–8-florae, foliis breviores et usque ad 4 cm. longae, sessiles vel breviter pedunculatae, puberulae vel glabrescentes; bracteolae facillime caducae, suboblongae, acutiusculae, prominule 1-nerves, 1–3 mm. longae; pedicelli graciles, 6–9 mm. longi. Flores graviter melliodori, versicolores, extus subvirides vel subflavi, intus primum flavi tandem cremeobrunnei vel subaurantiaci corona aurantiaci antheris flavi. Calyx fere ad basin partitus; lobi ovati, obtusi, glabri vel margine anguste subhyalina minute ciliolati, 4 mm. longi, basi interiore 1–2 squamis hyalinis oblongis vel oblatis admodum denticulatis praediti. Corollae tubus subcylindricus supra medio minime dilatatus, fauce constrictus atque leviter incrassatus, glaberrimus, circiter 5–5·5 mm. longus, circiter 2·75 mm. latus; lobi tubo circa duplo longiores, oblongi, dense papilloso-puberuli, circiter 9–10 mm. longi, 5 mm. lati; corona aurantiaca, e squamis 10 carnosis planis apice diviso leviter penicillatis constructa, quaram 5 in corollae lobis sitae et eis dimidio inferiore (marginibus exceptis) adnatae, circiter 6 mm. longae, spathulatae, breviter irregulariterque 3–5-dentatae vel -lobae, apicibus exceptis glabrae, 5 in sinubus sitae, circiter 4 mm. longae, late lineares bilobae, lateribus inferioribus puberulae. Stamina flava, in cono angusto 6·5–7 mm. longo cohaerentia, filamentis et connectivo dense pubescentia. Pistillum circa 10·5 mm. altum; carpelli 2, a stylo uniti, circa 1·5 mm. alti. Folliculi lineares, valde lenticellati, 10–14 cm. longi; carpelli usque ad tempus maturitatis cohaerentes; semina 9–13 mm. longa, linearia, coma circiter 3 cm. longa praedita.

QUEENSLAND.—Cook District: Lizard Island, *C. Walter* (MEL; in flower); Fitzroy Island, coll. 29 (MEL; in flower); Mt. Surprise Creek, *W. Armit* 766 (MEL; in flower); 100 mile swamp, scrubs, *W. Armit* 807 (tree 40 ft. high, very handsome orange or yellow flowers) (MEL; in flower). North Kennedy District: 13 miles N. of Charters Towers in rather open monsoon forest on hard reddish sandy soil, Nov. 13th, 1942, *S. T. Blake* 14672 (slender straight tree, 15–25 ft., with rather sparse divaricately branched crown of light green leaves probably deciduous; all parts with copious white latex; trunk slightly fluted; bark grey outside, green within, rather scaly and rather prominently tessellated on NW. side, smoother on SE.; flowers with sickly honey scent; buds greenish yellow; corolla cream brown to nearly orange inside; corona lobes orange; anthers yellow) (in flower); Barrabas scrub, W. of Ravenswood, in monsoon forest on deep loose coarse whitish sand, about 1,000 ft., abundant, Nov. 17th, 1942, *S. T. Blake* 14702 (deciduous tree 20–30 ft. or more high with rather narrow rather pale but dull green crown; trunk slightly fluted with grey tessellated slightly scaly bark, pale creamy brown with a very narrow green zone when cut; leaves dull light green above, paler beneath; buds greenish to yellowish; open flower with sickly honey scent, greenish yellow outside, yellow to cream brown inside with the corona more or less orange; anthers yellow. All parts with copious white latex) (in flower and fruit; TYPE); and from same place, April 1st, 1943, *S. T. Blake* 14893 (straight tree to 30 ft. with rather narrow green crown, slightly fluted trunk with grey tessellately scaly grey bark with green subsurface, white sapwood and copious flow of white latex; bark nearly smooth on small trees; leaves dull pale green above, paler beneath; follicles dark green with whitish pustules, sometimes distinct, but not seen just mature) (in fruit with old leaves; PARATYPE).

This species is readily and sharply distinguished from *W. pubescens* R.Br. by its entirely glabrous leaves and young shoots, variously coloured flowers (which are pure white in *W. pubescens*) and tiny bracts. The flowers of *W. versicolor* are greenish yellow outside, the inside at first yellow, turning to cream-brown or orange, with orange corona and yellow anthers.

Parsonsia fulva *S. T. Blake;* species nova, affinis *P. Langianae* F. Muell., sed foliis brevius acuminatis haud nitidis densius pubescentibus, floribus majoribus, corollae extus fere glabrae lobis tubo circiter duplo longioribus revolutis praecipue differt.

Liana robusta, lignea, altissime scandens, haud lactescens, partes juniores fulvo-pubescentes. Ramuli robusti, teretes, pilis fulvis tenuibus curvatis dense pubescentes. Glandulae axillares subulatae, circiter 0·8–0·9 mm. longae. Folia heteroblastica, longiuscule petiolata, fulvo-pubescentia, supra in sicco nigricantes; petioli plerumque 1·5–3 cm. longi, supra leviter canaliculati, ceterum subteretes; laminae adultae chartaceae, ovatae vel plus minusve ellipticae, 1½–2-plo longiores quam latae, breviter acuminatae ceterum obtusae, basi subacutae vel obtusae vel subtruncatae vel in surculis sterilibus saepius prominule cordatae, pro more 7–13 cm. longae et 3·5–8 cm. latae vel eae surculorum sterilium usque ad 17 cm. longae et 11·5 cm. latae, marginibus saepe leviter recurvae, subtus praecipue nervis dense pubescentes supra glabrescentes; nervi validi, supra impressi, subtus conspicue elevati, costam utrinsecus 5–8 laterales rectiusculi prope marginem curvati. Inflorescentia cymoso-paniculata decomposita; paniculae laxiflorae plus minusve trichotomae, in axillaribus superioribus ramulorum, plerumque oppositae, dense fulvo-pubescentes, foliis breviores longioresve, 3·5–8 cm. latae, cymis ultimis laxis usque ad 8-floris; pedunculi tenuiores, petiolis longiores; pedicelli pro more 4–5 (raro 3·5) mm. longi. Flores flavi, in alabastro ovoidei fere in medio admodum constricti, obtusiusculi, circa 3·5 mm. longi. Calyx 1·8–2 mm. longus, usque ad basin partitus, intus basi 5 glandulis carnosis subtriangularibus 0·2 mm. longis praeditus; lobi ovati, acuti vel fere acuti, erecti apice leviter patuli, dorso dense pubescentes, intus glabri pilis paucis apice sitis exceptis. Corolla breviter campanulata, calyce admodum brevior; tubus 1·5 mm. longus, subcylindricus, glaber vel extra fauce puberulus; lobi in alabastro fere valvati, tandem recurvi vel plus minusve reflexi, suboblongi (apice acuti basi dilatati), 2·7 mm. longi, 0·8 mm. lati, basi superiore pilis retrorsis barbati, ceterum glabri. Conus antherarum fere omnino exsertus, 2·2–2·3 mm. longus, nitidus; antherae dorso convexae; lobi basales steriles oblique obovati, oblique obtusi, 0·4 mm. longi, a sese styloque divergentes, margine externo recti ibique antheras proximas tangentes; filamenta fere in medio tubo corollae inserta, fere recta, dorso compressa, barbata, 1 mm. longa, basi a latere valde compressa. Squamae hypogynae liberae, quadratae, truncatae, 0·7 mm. longae, circum ovarium incurvae.

Ovarium ovoideum, glabrum, 0·7 mm. altum. Fructus lineari-subteres, fulvo-pubescens, 15–20 cm. longus; semina 7–9 mm. longa, coma 2·5–3 cm. longa fulvo-brunnea praedita.

QUEENSLAND.—Moreton District: Mt. Glorious, Jan., 1945, *M. S. Clemens;* (fruit); Mt. Glorious, in rain-forest, about 2,000 ft., Nov. 17th, 1946, *S. T. Blake* 17373 (tall woody liana with yellowish watery juice; leaves dark green above, somewhat tawny beneath, flowers yellow) (flowers); Tamborine Mtn., *J. Shirley* (flowers and fruit); Tamborine Mtn., Feb., 1917, *H. A. Longman & C. T. White* (fruit); Tamborine Mtn., Dec., 1921, *C. T. White* 1786 (flowers, juvenile leaves); Tamborine Mtn., common in rain-forest, May 16th, 1945, *C. T. White* 12724 (large liana; leaves dull dark green above, pale yellowish green beneath) (young fruit, also sterile twig); Tamborine Mtn., in rain-forest, about 1,700 ft., May 7th, 1945, *S. T. Blake* 15825 (tall woody climber with pale brownish thin sticky juice; leaves dull green above, tawny-tinted below) (old fruits); McPherson Range, Jan., 1917, *C. T. White* (flowers and fruit); Lamington National Park, 3,000 ft., Nov. 27th, 1942, *C. T. White* 11882 (common rain-forest climber) (flowers); Mt. Roberts, McPherson Range, common in rain-forest, about 2,900 ft., Nov. 20th, 1944, *S. T. Blake* 15467 (canopy liana; twigs with watery yellowish slightly sticky juice; leaves dark green above, paler and tinged tawny beneath, old leaves turning yellowish and finally dark brown above, paler and more tawny beneath; flowers scented, corolla tube tawny, lobes revolute, cream; anthers yellow) (in flower and fruit, also sterile shoots all from the same plant—TYPE); McPherson Range, very common between Mt. Roberts and Mt. Merino, in rain-forest, 1,600–3,800 ft., April 18th, 1943, *S. T. Blake* 14931 (stout canopy liana with abundant clear yellowish to brownish thin slightly sticky juice in twigs and bark; bark rather thick and hard, pustular, gray, more or less ochraceous when cut; leaves dark green above, more or less tawny beneath, the lower ones distinctly cordate, those on young shoots narrower, mostly sinuately lobed; fruit mature, tawny; foliage of tawny appearance when viewed against the light) (fruiting twigs, sterile twigs, juvenile foliage); Mt. Roberts, McPherson Range, in rain-forest, about 2,650 ft., Dec. 20th, 1943, *S. T. Blake* 15380 (stout liana climbing to tops of highest trees; bark rather thick and hard, pustular, grey, more or less ochre-coloured when cut, with rather copious flow of brownish juice; shoots with rather much clear yellowish thin slightly sticky juice; leaves dark green above, tawny beneath, the lower ones distinctly cordate, those on young shoots narrower, mostly sinuately lobed; flowers faintly scented; calyx somewhat tawny; corolla dull cream, lobes recurved; anther-cone dull brownish yellow; all specimens from same plant from which fruiting specimens of no. 14931 were obtained) (flowering twigs, young shoots and leaves from sterile shoots); Lamington National Park: near foot of Ballanjui Falls, in rain-forest, about 1,700 ft., Dec. 4th, 1943, *S. T. Blake* 15367 (tall canopy liana with copious watery pale brownish sap in branches; leaves dull green above, paler beneath, veins prominent on both sides, decidedly tawny beneath; young growth and inflorescence tawny; flowers faintly scented; calyx somewhat tawny; corolla cream, lobes recurved; anther-cone dull brownish yellow) (flowering and sterile twigs); Springbrook, 3,000 ft., Aug. 10th, 1930, *C. T. White* 7054 (common climber over rain-forest trees) (in fruit); Springbrook, 3,000 ft., Sept. 29th, 1930, *C. E. Hubbard* 4266 (rambling over trees and shrubs in rain-forest) (in fruit).

NEW SOUTH WALES.—North Coast: Beaury, common in rain-forest, May 29th, 1945, *C. T. White* 12754 (climber, leaves dull dark green above, paler beneath) (in young fruit); Richmond R., Oct., 1867, *I. A. Henderson* 76 (MEL); Rous, Richmond R., April, 1891, *W. Bauerlen* 251 (young fruit; NSW); Ballina to Bangalow, Nov., 1903, *Maiden & Boorman* (flowers; NSW).

A stout woody species, climbing to the tops of the highest trees in the rain-forest, rather abundant in the areas where it has been observed, but not noticed at an elevation below 1,700 ft. No latex is produced, but there is a fair abundance of yellowish to brownish clear thin slightly sticky juice in the bark and twigs. In the herbarium it has been confused with *P. velutina* R.Br. which is also tawny-pubescent on the leaves and inflorescences; but *P. velutina* has all mature leaves cordate at the base and smaller on the average, smaller dense-flowered panicles in which the sepals are more spreading, and the corollas are more urceolate in shape with short erect lobes. In both species the seedling leaves are thinner in texture and more or less hastately 3-lobed; in *P. velutina* all the mature leaves are more or less prominently cordate, but in *P. fulva* cordate leaves are restricted to sterile shoots, while those on flowering twigs are at most subtruncate at base and are often more or less cuneate. *P. fulva* appears to be most closely allied to the North Queensland *P. Langiana* F. Muell., but this has leaves of a rather thinner texture, more oblong in shape and with a longer acumen, shining on the upper surface, less pubescent between the veins, and smaller flowers of which the lobes of the corolla are about as long as the tube and are incurved at the tips.

Parsonsia tenuis *S. T. Blake;* species nova, affinis *P. ventricosae* F. Muell., sed corollae tubo breviore cylindrico haud ventricoso, lobis longioribus, antheris minus carinatis differt.

Frutex gracillimus volubilis, praecipue novellis pilis patulis fulvis pubescens, haud lactescens. Ramuli teretes, striati, tandem glabri et lenticellos parvos sparsos gerentes. Glandulae axillares paucae, subulatae, fuscae, circiter 0·5 mm. longae. Folia prominule petiolata, homoblastica; petioli plerumque 7–12 mm. longi, pubescentes; laminae chartaceae, oblongo-lanceolatae, acute acuminatae admodum caudatae, basi obtusissimae vel subcordatae, 3–4-plo longiores quam latae, 3·7–7·5 cm. longae, 1–2·2 cm. latae, marginibus anguste recurvae vel revolutae ceterum planae, utrinque crebre papillosae pubescentesque vel supra tandem fere glabrae, subtus pallidiores; nervi haud prominuli, utrinque elevati, laterales gracillimi utrinsecus costam gracilem 7–10 egredientes. Cymae axillares vel pseudo-terminales, pedunculatae, laxe divaricatae, rariflorae, pubescentes, quam folia breviores, pedunculo excluso 1–2 cm. longae, usque ad 4 cm. latae; pedunculi tenues, 0·5–2·5 cm. longi; bracteae bracteolaeque ovatae vel lanceolatae, 0·9–1·4 mm. longae; pedicelli graciles, 3–4 mm. longi. Flores cremei; alabastri oblongi, acuti, 5 mm. longi. Calyx usque ad basin fissus, extus parce pubescens, intus basi glandulis membranaceis ovatis bipartitis circiter 0·25 mm. altis praeditus; sepala similia, deltoidea, acuta vel anguste rotundata, 3–nervia, 0·8–1·7 mm. longa. Corolla rotata; tubus cylindricus, 1·8 mm. longus, 1·5 mm. latus, fauce admodum dilatata barbatus, ceterum glaber; lobi patuli, oblongi, obtusi vel breviter acuminati, apice marginibusque recurvi, 4 mm. longi, 1·7 mm. lati, extus parce pubescentes, intus praecipue basi barbati sursum saepe glabrescentes, apice minute ciliolati. Conus antherarum majore parte exsertus, 3 mm. longus, glaber, angulatus; antherae dorso elevato-carinatae; lobi basales steriles semielliptici margine exteriore recti a sese divergentes 0·7 mm. longi, ei antherarum contiguarum basin versus superpositi; filamenta in tertiam partem inferiorem corollae tubi posita, recta, 1 mm. longa, sursum pubescentia. Squamae hypogynae discretae, oblongae, subtruncatae, crassae, 0·75 mm. longae. Ovarium semiovoideum, glabrum, laeve, 0·9 mm. altum. Folliculi 4·5–9 cm. longi, graciles, pubescentes vel glabrescentes, placentis distinctis. Semina circa 6 cm. longa, coma usque duplo longior.

QUEENSLAND.—Moreton District: Mt. Merino, McPherson Range, in beech (*Nothofagus*) forest, 3,650 ft., Oct. 4th, 1942, *S. T. Blake* 14657 (a slender twiner with rather scanty thin yellowish slightly sticky juice; leaves rather light green above, paler beneath; calyx light greenish; corolla cream) (in flower; TYPE); Mt. Merino, McPherson Range, in beech (*Nothofagus*) forest 3,650 ft., Oct. 12th, 1947, *S. T. Blake* 18172 (slender twiner with scant turbid watery juice, leaves dull green above, more or less olive green beneath, flowers cream) (in flower); Mt. Merino, McPherson Range, at cliff-edge of beech (*Nothofagus*) forest, 3,650 ft., Dec. 9th, 1943, *S. T. Blake* 15369 (slender twiner with watery juice; leaves dull green above, pallid green beneath; fruit pale green) (in fruit; PARATYPE); Lamington National Park, McPherson Range, close to Upper Coomera R., in rain-forest, about 2,400 ft., Oct.

4th, 1942, *S. T. Blake* 14659 (slender twiner, leaves green above, paler beneath; flowers cream) (in flower); Lamington National Park, near Mt. Hobwee, 4,000 ft., *C. T. White* 6182, Sept. 1st, 1929 (climber, flowers white) (in flower).

A very slender species closely resembling *P. induplicata* F. Muell. and *P. ventricosa* F. Muell. in vegetative characters, but in these the leaves are glabrous or nearly so, while in *P. induplicata* also the under surface, particularly of the younger leaves, is purplish in colour. In *P. tenuis* the leaves are rather distinctly papillose, and the under surface is permanently pubescent. *P. induplicata* is further distinguished by the inflexed corolla-lobes and scarcely keeled anthers. *P. ventricosa* has a nearly globose corolla-tube with short erect lobes and the anthers strongly ridged on the back, while *P. tenuis* has a short cylindrical corolla-tube with long spreading lobes with recurved margins and less prominently ridged anthers. The prominently ridged anthers of *P. ventricosa* and *P. tenuis* distinguish these two species from all others in the genus.

The genus *Lyonsia* R.Br. was originally distinguished on the grounds that the two placentae of the ovary were united in the fruit, while they remained free in *Parsonsia*. This difference, though marked enough in the original species, is quite uncorrelated with other characters in the more numerous species now known. Other botanists, e.g. Bentham, in Fl. Austral. iv, 320 (1869), relied on a supposed valvate aestivation of the corolla in *Lyonsia*, but I find the corolla-lobes overlapping in the bud in all species, though in some species very slightly so and only at the tips. These seems little doubt that F. Mueller (Fragm. vi, 126–130: 1868) was right in treating *Lyonsia* as synonymous with *Parsonsia*. The following transfers are accordingly made here:

Parsonsia largiflorens (*F. Muell.*) *S. T. Blake*, comb. nova.
Lyonsia largiflorens F. Muell. ex Benth. Fl. Austral. iv, 322 (1869).

Parsonsia latifolia (*Benth.*) *S. T. Blake*, comb. nova.
Lyonsia latifolia Benth. Fl. Austral. iv, 323 (1869).

Parsonsia plaesiophylla *S. T. Blake*, nomen novum.
Lyonsia oblongifolia Benth. Fl. Austral. iv, 323 (1869), non *Parsonsia oblongifolia* Merr. in Philip. Jour. Sci. xxvii, 50 (1925).

Asclepiadaceae.

Marsdenia suberosa, *S. T. Blake;* species nova, ob corticem crassum suberosum, folia oblonga, corollae tubum fauce antrorsim inferne retrorsim barbatum distincta.

Frutex lactescens, alte volubilis; caules tenues, in parte majore cortice cremeo molli suberoso sulcato obtecti; novelli parce minuteque puberuli. Ramuli virides, laeves. Folia patentia; petioli puberuli, plerumque 1·5–2·5 cm. longi; laminae oblongae, apice obtuso apiculatae vel abrupte acuminatae, basi truncatae vel cordatae, 5·5–8·5 cm. longae, 1·8–3·4 cm. latae, circiter $2\frac{1}{2}$–$3\frac{1}{2}$-plo longiores quam latae, subtus pallidiores, tenuiter coriaceae, valide venosae nervis utrinque elevatis supra pallidioribus utrinsecus costam 6–8 lateralibus positis, paginae superioris basi glandulis multis (circiter 12–20) praeditae. Cymae e fasciculis florum dense aggregatis constructae, pedunculatae, pedunculis solitariis lateralibus puberulis 5–8 mm. longis; pedicelli 5–9 mm. longis. Flores albidi, odorati, in alabastro ovoidei, circiter 4 mm. longi et 3 mm. lati. Sepala suborbicularia, 1·9–2 mm. longa lataque, tenuiter herbacea, marginibus hyalinis ciliata. Corolla globoso-campanulata, usque ad mediam vel paullo plus partita, extus glabra; tubus subviridis, intus subter lobis pilis retrorsis barbatus, sub fauce ipsa sinubusque glaber; lobi suberecti, albi, semiovati, obtusi, 1·8–2 mm. longi, 1·6–1·8 mm. lati, basi inter sinus linea elevata antrorsim curvata praediti et ibi antrorsim dense longeque barbati (i.e., faux corollae undulato-elevata antrorsim dense longeque barbata). Gynostegium: columna staminalis ovoidea, acuta, basin versus ad corollam adnata, pars libera conica, 1·5 mm. longa, 1·7 mm. lata; antherae subtriangulares, cum appendice alba triangulari 0·8 mm. longa 1·3 mm. longae; coronae squamae tenuiter membranaceae, subdeltoideae, apice acutae vel plus minusve truncatae, omni basi adnatae haud peltatae, 0·4–0·45 mm. longae, 0·3–0·4 mm. latae; pollinia compresse allantoidea, 0·3 mm. longa; styli apex late rotundus umbonulatus.

QUEENSLAND.—South Kennedy District: Crediton, July-Nov., 1947, *M. S. Clemens* (flowers, young fruits). Wide Bay District: Gympie, *F. H. Kenny* (sterile), and *J. Shirley* (sterile). Moreton District: Gold Creek, near Brisbane, Oct., 1928, *A. A. Girault* (flowers); Mt. Nebo, Samford Range, October 31st, 1934, *C. T. White* (flowers); Roberts Plateau, July, 1917, *S. H. McCarthy* (sterile); Mt. Roberts, McPherson Range, eastern slopes, light rain-forest, about 2,200–2,300 ft., Dec. 7th, 1946, *S. T. Blake* 17375 (twiner with fissured cream corky bark; much white latex in bark and pith; leaves deep green above, paler and duller beneath, those of younger parts with whitish veins; flowers scented, nearly white, mouth prominently bearded) (TYPE; flowers and coppice shoots); same locality and notes, Dec. 11th, 1943, *S. T. Blake* 15374 (flowers). Darling Downs District: Killarney, Nov. 25th, 1917, *C. T. White* (flowers); and Jan., 1912, *J. L. Boorman* (flowers; NSW, BRI).

NEW SOUTH WALES.—North Coast: Unumgar, near Mt. Lindesay, moderately common at edge of light rain-forest, March 12th, 1944, *C. T. White* 12739 ("only sterile material available"); Tabulam to Drake, Dec., 1903, *J. H. Maiden & J. L. Boorman* (flowers; NSW, BRI).

Rather conspicuously distinct from other Australian species in the very corky bark of all but the youngest parts of the stems and branches, oblong leaves with the veins paler on the upper side and whitish on young plants, and in the corolla both antrorsely bearded at the throat and retrorsely bearded lower down the tube.

Cynanchum Bowmanii *S. T. Blake*, nomen novum.

Cynanchum ovatum (Benth.) Domin in Biblioth. Bot. lxxxix, 531 (1928), non (E. Mey.) Druce in Rep. Bot. Exch. Cl. Brit. Isles 1916, 618 (1917).

Vincetoxicum ovatum Benth. Fl. Austral. iv, 330 (1869).

Cynanchum dichasiale O. Schwarz in Fedde, Repert. xxiv, 94 (1927). This is **Secamone elliptica** R.Br., as testified by specimens from the two collections he cites, *Bleeser* 244 (MEL) and *Bleeser* 586 (NSW).

Tylophora crebriflora *S. T. Blake*, nomen novum.

Tylophora floribunda Benth. Fl. Austral. iv, 335 (1869), non Miq. in Ann. Mus. Bot. Lugd. Bat. ii, 128 (1866).

THE GENUS TABANUS IN AUSTRALIA.

By G. H. Hardy, Queensland University, Brisbane.

(With One Text Figure.)

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The genus *Tabanus* is a large world-wide and medically important group of blood-sucking flies of which over 100 species have been recorded from Australia. No subdivision of their enormous numbers has proved satisfactory, but characters of obvious group value, characters tested for nearly all the species in Australia, suggest a manner in which a subdivision may be built up.

It has become apparent that part of the Australian element forms one or two groups that are probably endemic forms isolated in the Australian region; or perhaps they have their near allies in South America, the others being mainly groups normal to the tropical Indo-Pacific area, and two species only having affinities with the Holarctic Tabanid fauna.

The division here proposed relies upon a new method of using the frontal measurements, and for the purpose of the present paper, the frontal proportions used are those limited to the area enclosed by the four eye-corners. The notes added include the more important data gathered when examining the collections in Sydney which include the material studied by the late E. W. Ferguson and the late F. H. Taylor, and the bred material in the collection of Miss K. English. The accompanying figure explains the terms used.

Key to the Subgenera of Tabanus.

1. Species with narrow frons which is never less than four times longer than broad between the four eye-corners. Those species that have this low proportion, never have the appendix to the vein R_4, and this appendix rarely occurs elsewhere .. *Cydistomyia* Taylor

   Species with a broad frons, being never more than four times longer than broad between the four eye-corners, and if as much as four times, then the appendix is present on vein R_4; it is usually present elsewhere 2

2. Frons exceptionally wide and diverging towards the antennae. The eye-margins are so rounded that only the upper corners are definite. From the upper corners to the subcallus, the length of the frons is one and a half times the width measured at the uppermost point of the subcallus .. .. *Dasybasis* Macq.

   Frons not so wide. All eye-corners are well-defined and the area between them is two or more times longer than wide 3

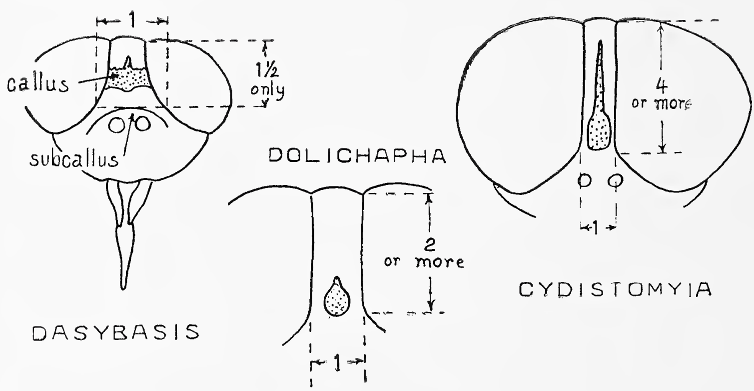
3. Frons without or with only one callus. Eyes hairy to bare and in life usually green with red reflections, rarely all red .. .. *Dolichapha* Enderlein

   Frons with two calli, and with the eye-margins strongly converging towards the antennae. The eyes are bare and, in life, are conspicuously variegated .. .. *Tabanus* Lin.

In the above key, the frontal measurements involve general proportions and were gained by using a micrometer-eyepiece which gave the larger species a frons length of 30 to 36 units on the measuring scale. This yielded a formula in numbers that represents: (1) the length of the frons between the eye-corners at the summit and those near the antennae; (2) the width between those eye-corners near the antennae; (3) the width between the eye-corners at the summit. An example of such measurements taken, may be represented by the numerals 31 : 6 : 7, each of the three numbers representing the three readings respectively.

The relative frontal proportion was calculated by using the length of the frons and the width between those eye-corners nearest the antennae, and this proportion, in the example, becomes $\frac{31}{6} = 5{\cdot}17$. Ignoring the decimal figures, the frons proportion becomes five times longer than wide. These figures would not conform to published measurements of the frons, as authors have been including the length of the subcallus in the length of the frons; moreover the method here used has the convenience of restricting the frontal area to that which permits a ready estimate of proportions.

The difference between the width of the frons at the summit, and that near the antennae (one unit in the example) shows the converging and diverging frons, a feature of some significance, but the frons is liable to slight variations owing to a general trend for the frons on some specimens to collapse slightly by shrinkage after death, especially so at the summit.



Text Figure.

The head of subgenus *Dasybasis,* seen anteriorly. From the summit to the subcallus the slope causes a foreshortening in the figure and the true length invariably is about one and a half times the width at the subcallus. The callus shown reaches from eye to eye and has a short extension.

Subgenus *Dolichapha* has the frons never less than twice, and never more than four times as long as the width between the eye-corners near the antennae. The callus shown is rather pear-shaped and is widely separated from the eye-margins.

Subgenus *Cydistomyia* has a very narrow frons which, at its widest, is never less than four times longer than broad. The callus shown is narrowly separated from the eye-margins and it has an extension that nearly reaches the summit.

Subgenus Dasybasis Macquart.

Dipt. Exot. suppl. 2, 1846, 25.—*T. gentilis*-group Hardy, Stylops, 3, 1943, 47.—Section 2, Hardy, Proc. Linn. Soc. N.S.Wales, 64: 1939, 42 (in part).

Genotype: *Dasybasis appendiculatus* Macquart (monotypical).

The inner margins of the eyes diverge so widely towards the antennae that eye-corners are apparent only at the summit, from where the measurement is taken to the top of the subcallus (marked by a groove); and the frons is only one and a half times longer than it is wide at that groove level. The eyes are densely hairy and the appendix is present on vein R_4. The characteristic spots on the wing are replaced on one species by a general dark suffusion over much of the wing.

Key to Species and Subspecies of Dasybasis.

1. A brownish species with spotted wings; small and distinctive in appearance	*appendiculatus* Macq.
Black or grey species	2
2. Wings with conspicuous spots	3
Wings suffused with black; a black species with abnormally long hairs on the frons	*neolatifrons* Ferg. & Hill
3. Black species with long hairs on the frons. Annulations of the antennae normal	*froggatti* Ric.
Greyish species with short scanty hairs on the frons ..	4
4. Annulations of the antennae normal, being about one third the total length of the third segment ..	*gentilis* Macq.
Annulations of the antennae very small, being about one quarter of the length of the third segment, and narrow in proportion	*gentilis* subsp. *imminutus* n.subsp.

Tabanus appendiculatus Macquart, 1846.

Ferguson has identified a series of specimens under this name, and two of these have the frontal proportions of 13:9:5 and 14:10:5, making the length about one and a half times the width. The annulations of the antennae tend to amalgamate, thus causing them to appear to have a reduced number on most specimens. The species seems to be confined to the eastern side of Australia.

Tabanus gentilis Erichson, 1842.

A specimen from Mangalore collected by White, has its frontal proportions 15:11:6, and my notes refer to a slight extension to the callus, seen on all specimens; but this is a feature missing in *T. froggatti*. The annulations cover fully one third of the third antennal segment, but are not quite as long as those on *T. froggatti*. This form is known only from Tasmania, the type-locality for the species.

Tabanus gentilis subsp. imminutus new subspecies.

This form is referred to *T. gentilis* by Taylor and by Fuller, but all their specimens seen from New South Wales (Armidale, Dorrigo, and Barrington Tops), and also from Victoria (Ararat), differ from the typical form by having the annulations of the third antennal segment so conspicuously reduced in diameter and length, that the subspecies stands morphologically distinct in this character at least. Of the total length of the third antennal segment, these annulations cover only one quarter, and the general reduction is somewhat in conformity with the trend to limit these annulations seen on *T. appendiculatus*, where the segments tend to become fused together. The present species is definitely known from the mountain regions of Victoria and New South Wales; the record from Western Australia is evidently made in error through a misplaced locality label.

TABANUS FROGGATTI Ricardo, 1915.

So far, this species is known only from Mt. Kosciusko and a wide area around that mountain including Canberra. It is quite a valid species, shown to differ slightly in the larvae, and also it conspicuously differs in the annulations of the antennae.

TABANUS NEOLATIFRONS Ferguson & Hill, 1921.

On the type of *T. latifrons* Ferguson (name preoccupied) the proportions of the frons are 18:12:6, and in no way does it differ in shape from other species of *Dasybasis*. The figure given in Ferguson 1921 (Pl. 2, fig. 1) is misleading, as it shows a rather parallel frons and all the eye-corners well defined, but the description states correctly that it is "very broad anteriorly, distinctly narrowed at vertex". The species is only known from Tasmania.

Subgenus DOLICHAPHA Enderlein.

Enderlein, Deut. Ent. Zeit. 1930, 66.—Sections 2 (in part) and 3, Hardy 1939.

Genotype: *T. gregarius* Erichson, Tasmania (monotypical).

The frons ranges between twice and four times longer than wide and the eyes are hairy or bare. The appendix on vein R_4 is nearly always present and it is invariably so when the frons approaches its narrowest proportions.

Many species in this subgenus have been confused in literature and in collections, but there appear to be several natural groups under it that are able to be isolated, one from the other. The more typical species, belonging to the *gregarius*-group, are all dark flies varying in frontal proportions between twice and two and a half times longer than wide, as far as yet known; and the nine species are between 9 and 13 mm. long except *T. cirrus* Ric., which is 15 mm.

KEY TO THE SPECIES OF THE GREGARIUS-GROUP.

1. Callus separated from the eyes by a pulverulent strip ..		2
Callus reaching from eye to eye		3
2. Callus small with a short extension ..	*cirrus* Ric.; *dixoni* Ferg.; *dubiosa* Ric.; *tasmanicus* Ferg.	
Callus without an extension. Costal border of wing strongly suffused fuscous	*gregarius* Erichson	
3. Callus with a short broad extension	*indefinitus* Taylor	
Callus without a definite extension, but may taper from the base towards the summit uniformly		4
4. Callus extending less than half-way towards the summit	*flindersi* Ferguson; *hobartensis* White	
Callus large, covering the frons over half-way towards the summit	*imperfectus* Walker	

One of White's specimens of *imperfectus* has its frons with the proportions 15:7:5; *gregarius* has 16:8:6; *hobartensis* and *tasmanicus*, both identified by Ferguson, have 17:8:6; *flindersi* paratype has 20:10:8; *dixoni* paratype has 21:10:8 and *cirrus* has 25:10:8.

TABANUS MICRODONTUS Macquart, 1847.

One of White's specimens from Mangalore has the frontal proportions 20:8:6, and a larger one identified by myself has its proportions 24:10:8, giving the length two and a half times the width. The callus is very broad and wedge-shaped, two thirds the width of the frons basally; but, as the sides are indented, the indentation may be regarded as marking where the enormous extension begins, the sides forming a gothic-shaped arch nearly reaching the summit of the head.

The male described as *wynyardensis* Hardy 1915, and some others have normal eyes, the facets being enlarged over the central area and brown. The line of demarcation between the two sets of facets ends at the frontal eye-border, level with the antennae.

The vein R_4 is entirely without an appendix, leading White to suggest that the fly may be related to *T. victoriensis,* and it is difficult to see any close relationship with any of the species under *Dolichapha.* It may stand as an intermediate form between this and the *Cydistomyia,* retaining a primitive frontal character of the latter subgenus.

TABANUS NEOCIRRUS Ricardo, 1917.

Under the name *T. bassii* Ferguson 1921, stands a complex of possibly three species, including two from Swansea (Tasmania) which is the type locality of *T. neocirrus.* These two specimens have the frontal proportions of 15:8:7, and 17:8:7, whereas these measurements on specimens from Wynyard, recorded in Hardy 1934, have their proportions varying from 20:8:7 to 16:6:6. The former shows the length to be twice, the latter two and a half times longer than wide, indicating a possible confusion in identities.

TABANUS REGISGEORGII Macquart, 1838.

Three names are standing as synonyms of this species. No authentic specimens were found under *postponens* Walker 1848, but specimens otherwise placed as such have the frontal proportions of the present species. The frons on the type of *spadix* Taylor 1916, has the frontal proportions 14:8:5 and the two labelled as being the type of *brisbanensis* Taylor 1917, have respectively 16:8:7 (in Sydney) and 18:9:6 (in Brisbane). The species occurs on the coast from Northern Queensland southwards to Western Australia and it may be subject to geographical variation over this long coastline.

TABANUS REGISGEORGII subsp. DIEMENIENSIS Ferguson 1921.

Taylor included this island form in his *brisbanensis*, but Ferguson proposed using another name as it does not have the enlarged facets on the male eye. The type-female has the frontal proportions 15:8:7 and two paratypes have 15:8:6. The fly is very abundant in Tasmania, occurring over tidal marshes of the estuaries, and apparently it breeds in the mud of brackish water.

TABANUS CIRCUMDATUS—complex.

Ricardo brought together several names into this complex, and on account of the close affinities between the species, she placed the names as synonyms of *circumdatus* Walker. It became generally recognised that her rendering was not in accord with the original descriptions. It appears that, after she saw White's material collected in Tasmania, with one species selected as being the *circumdatus* of Walker, this new rendering was generally accepted. As far as now can be ascertained, every specimen sent to England for comparison was of the same species as that of White, and the allied species were, apparently, never submitted for comparison. Ferguson has gathered together a number of specimens belonging to the complex and these await study; none of them bears an identification label. All those that have been isolated as named species belong to the one species *circumdatus* as identified by White. This does not agree with *circumdatus* as described by Walker. Already from the complex originally given three species have been isolated, but their exact identities need confirmation.

The list given by Ricardo, with two subsequently added, was:—

T. acutipalpis Macquart 1854 (King Island, Tasmania): all white hairs on the palpi and stated to be 11 mm. long. Both Ricardo and Ferguson recorded that the type material covers specimens larger than *circumdatus* accepted by them, namely over 15 mm.

T. edentulus Macquart 1848 (Tasmania) also has white hairs on the palpi and is 11 mm. long. White gives 11 to 14 mm. and his species falls to *exulans* Erichson.

T. hebes Walker 1848 (p. 159) is 12 to 14 mm. long, but the locality given as Africa evidently is an error. It might be *edentulus*, as no mention is made of black hairs on the palpi.

T. nepos Walker 1848 (p. 181), being 16 mm. long and without a locality mentioned, might be *acutipalpis* or an ally.

T. circumdatus Walker (p. 185) is without locality and only 10 mm. long. It agrees with New South Wales specimens in having black hairs on the palpi, and not with *circumdatus* White which has since been renamed.

T. fraterculus Macquart 1849, is 12 mm. long, but Ricardo gives 13 to 15 mm. The type is probably from Sydney, not Tasmania as recorded.

T. abstersus Walker 1860 from New South Wales, is 10 mm.

T. brevidentatus Macquart 1854, from Sydney, only 8 mm. long, cannot belong here if, as stated, the eyes are bare.

T. antecedens Walker 1854 from Tasmania is 10 mm., but Ricardo gives 12 to 14 mm., and the name is preoccupied by a male of unknown identity from the mainland.

T. flindersi Ferguson 1921, is the *antecedens* White.

T. whitei Hardy 1939, is the *circumdatus* White.

Where the length has been given in lines (12 to the inch), that number has been doubled to render the measurement in millimeters (25 to the inch), which computation may be lower than actually the case.

The above data, though unsatisfactory for the purpose, do suggest that at least six species fall under this complex as follows: 1 *nepos* Walker (*acutipalpis* Macq.); 2 *exulans* Erichson (*edentulus* Macq.; *abstersus* Walker); 3 *hebes* Walk. (*fraterculus* Macq.); 4 *circumdatus* Walk.; 5 *flindersi* Ferguson (female of *antecedens* Walker, preoccupied); 6 *whitei* Hardy (*circumdatus* White nec Walker); 7 *brevidentatus* Macq.

Those species numbered 1, 2, 5 and 6 may be recognised species from Tasmania, whilst that numbered 4 could be recognised if New South Wales be accepted as the locality. Those under 3 are not recognisable, whilst that under 7 could hardly belong to this complex.

Tabanus acutipalpis Macquart, 1838.

This Tasmanian species is distinguished by markings of the abdomen, and those seen standing under the name from the mainland do not show those markings but have the same strongly depressed abdomen and are about equal in size; however these mainland specimens vary greatly in their frontal proportions.

A Tasmanian specimen identified by me has its frontal proportions 28:9:8 and the callus reaches from eye to eye, with a tapering extension reaching half-way towards the summit. The species resembles rather closely *T. whitei,* but the three abdominal lines of spots, of which the outer spots are oblique marks, will readily distinguish the form.

Tabanus whitei Hardy, 1939.

Authentically identified specimens standing under the name *circumdatus* are: (*a*) from Illawarra, proportions 24:8:8—compared with the type at the British Museum; (*b*) from Burnett River and Eidsvold (Queensland), proportions respectively 25:8:7 and 25:8:8—determined by Austen; (*c*) from Burnett River, 24:8:9, determined by Marshall; (*d*) Two from Mangalore (Tasmania), 23:8:9 and 25:8:8—identified by White. All these appear alike and have the frons three times longer than wide, and have only white hairs on the palpi.

Other specimens under the name *circumdatus,* however, do not agree and one, identified by Taylor, has not only a different frontal proportion, but also has black hairs on the palpi, in which it corresponds with the *circumdatus* of Australian collections prior to White's effort to determine the specific identity.

Tabanus circumdatus Walker, 1848.

In accord with Walker's description this species has the palpi "clothed with short black hairs". A specimen identified by Taylor has the palpi with some black hairs and the frontal proportions are 20:9:8, thus the length is about twice the width, as in *flindersi* Ferg.

Tabanus exulans Erichson, 1842.

The "palpis concoloribus" of the original descriptions suggests that all hairs of the palpi are white, and in this and other characters it agrees with White's interpretation of *edentulus.* Two of White's identified specimens have the frontal proportions 20:7:7 and 21:7:7, whilst a Milson Island specimen has 22:8:7, which is near enough to be conspecific. The length is three times the width.

Tabanus flindersi Ferguson, 1921.

New synonym:—Under the name *antecedens* Walker, stand a Mangalore specimen identified by White and a Flinders Island specimen identified by Austen. Together with a paratype of *flindersi* Ferg., these have the frontal proportions 20:10:7. Other paratypes of *flindersi* have 20:10:8, and it seems remarkable that Ferguson did not record his species as being conspecific with White's. A male from Mangalore is without the enlarged facets in the eyes. The species has not been seen outside Tasmania and adjacent islands.

Tabanus vestustus-complex.

The typical form of this complex belongs to the same natural group as that to which the majority of the *circumdatus*-complex falls, but with specimens under the name *vestustus*, has been included a species from Low Island (Queensland). The Low Island specimen has bare eyes but otherwise bears some resemblance, so advantage is here taken to incorporate further species with a similar appearance, leaving their individual relationships for future consideration.

All species in this complex either have a slight sandy-coloured pulverulent overlay, or else a dense white pubescence; they are all associated with coastal breeding so far as known. The appendix is present on vein R_4 and the frontal length is 2 to 3 times the width.

Key to Species of the vestustus-complex.

1.	Species with densely hairy eyes	2
	Eyes with scattered hairs or entirely bare	3
2.	Lower half of frons above the subcallus, entirely covered with a square callus. Frontal length twice the width. Body covered with a dense whitish pubescence	*rubricallosus* Ric.
	Without a frontal callus, or if abraded a small false callus may appear. The average frons length is two and a half times the width. Body sandy-coloured	*vestustus* Walk.
3.	Eyes with scattered hairs. A pear-shaped callus with a lineal extension is reported for this species which has not been seen in Australian collections. Recorded from North-West Australia ..	*umbripennis* Ric.
	Eyes entirely bare; frontal callus absent	4
4.	Frons length between eye-corners is about three times the width. New South Wales. 16 mm. ..	*vespiformis* Ferg. & Henry
	Frons length usually under two and a half times the width. Northern Australia and nearby islands. 12 mm.	*leucopterus* v.d.Wulp.

The frontal proportions of *vestustus* Walker seem to vary, the specimen from Western Australia recorded by Taylor, 1918, having 27:10:10, whilst Tasmanian specimens show 23:9:8. The type of *vespiformis* F. & H. has 30:9:9, and the type of *griseohirta* Taylor (i.e., *leucopterus* v.d. Wulp) has 21:9:8, but on *leucopterus* from Magnetic Island, identified by Taylor, the proportions are 23:9:8; other *leucopterus* identified by Ferguson and Hill show the length under 2½ times the width for this species.

TABANUS RUBRICALLOSUS Ricardo.

Ann. Mag. Nat. Hist. (8) xiii, 1914, 478—New Caledonia.

A drawing of the frons made from the type of this species shows a form identical with a species reared by Miss K. English in New South Wales. The species is new to the Australian list, but whether it be capable of division into subspecies has yet to be determined. There are two old specimens in the Macleay Museum which are erroneously identified, and two more in the Taylor collection found without names, and the latter form part of the series reared by Miss English. The frontal proportions are 21:11:10.

Subgenus CYDISTOMYIA Taylor.

Taylor, Proc. Linn. Soc. N.S.Wales, 44: 1919, 47.—Section 1, Hardy 1939.

Genotype: *C. doddi* Taylor, Queensland (monotypical).

Eyes bare, and the frontal proportions are between four and nine times longer than wide, but may be more. The appendix on vein R_4 is rarely present, and never present on those forms having the frons only four times longer than wide. About 35 species fall to this genus as far as known, but it would appear to be a complex of at least three main groups.

The *posticus*-group, with the frontal proportions about four to five times longer than wide, is rather strongly represented in Australia, and is widely distributed, the remainder being mainly northern flies. The genotype was not examined, but a drawing of its frons by Mr. E. H. Zeck and some New Guinea specimens have been seen, thus the systematic position of the fly was assured. The name *Cydistomyia* probably will fall to synonymy when species of the Indo-Pacific region become better known.

New Synonym:—The *Tabanus spiolatus* of Taylor (Rec. Aust. Mus. 12: 1918, 64) has been mis-named, it being a male specimen of *T. parvicallosus* Ricardo.

Subgenus TABANUS Lin.

Linnaeus, Fauna Suec. 1861, 462—Section IV, Hardy 1939.

Genotype: *Tabanus bovinus* Lin., Europe (Designated by Latreille 1810).

Two Australian species are in accord with species of the European fauna in having the strongly converging frons, two clearly separated calli, and variegated eyes. The frontal proportion of the two Australian species is three and a half times longer than wide.

Very unfortunately, there has been a confusion in nomenclature in the literature, and the names of both these now well known species need to be changed.

TABANUS PALLIPENNIS Macquart.

Macquart, Dipt. Exot. suppl. 1, 1846, 32, nec Ferguson & Hill 1920. *Atylotus rufinotatus* Bigot 1892.—*Tabanus rufinotatus* Ricardo 1914 and 1917; Hill 1921; Ferguson 1921.—*Tabanus elesteem* Summers 1912. *Tabanus lineatus* Taylor 1913 (preoccupied); Austen 1914.

Synonymy: The new synonymy lies in substituting the name *pallipennis* Macq. for *rufinotatus* Bigot. Macquart's description agrees with this determination and not with that made by Ferguson and Hill in 1920. Moreover the latter species does not occur in any area from which Macquart received *Tabanus,* and the common form here referred to could hardly have escaped Macquart's attentions. The words of the original description "trois callosités" which includes the subcallus*, and "un peu grisaitre" for the wings can apply only to the present species.

The type of *lineatus* has its frontal proportions 21:6:8, and the male, reared by Hill, has the normal enlarged facets in the eyes, but no sign of the white transverse band which is so obvious in the species given a new name below.

TABANUS PARTICAECUS new name.

T. pallipennis Ferguson & Hill, Proc. Linn. Soc. N.S.Wales, 45: 1920, 463; Johnston & Bancroft 1920; Hardy 1939; nec Macquart 1846.

Synonymy: As this species does not occur in any area from which Macquart secured flies, and in addition as it does not agree with any original description of these flies, and the determination made by Ferguson and Hill was only tentative, it is advisable that a new name be given to cover the form.

The name here proposed is based on the fact that the male has a white opaque horizontal bar that must render quite blind the area of the eye covered by it.

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* Mr. H. Oldroyd draws my attention to the view held by Ferguson and Hill, that the third callus was the ocellar one. However a pseudocallus is liable to form by abrasion both at the point where the obliterated anterior ocellus presumably occurred, and also on the subcallus adjacent to the lower callus. It is evident that Macquart's material was abraded but it is not known to what extent.

GRAVITATIONAL TECTONICS AT SHORNCLIFFE, S.E. QUEENSLAND.

By Rhodes W. Fairbridge, B.A., D.Sc., F.G.S.

(Plates VI.-X.; Nine Text-Figures and Maps.)

(*Received 4th August*, 1947; *accepted for publication*, 20*th January*, 1948; issued separately, 11th October, 1948.)

CONTENTS.

I. INTRODUCTION.

Shorncliffe (lat. 27° 20′ S., long. 153° 05′ E.) is a small seaside resort contiguous with Sandgate, some twelve miles E.N.E. of the centre of Brisbane. It is situated on a prominent headland, Cabbage Tree Head, on the north-west side of Moreton Bay, between the broad sandy sweep of Bramble Bay and the muddy, mangrove-lined channel of Cabbage Tree Creek (see plate VI.). The headland rises to about sixty feet above sea-level and is bounded on the south, east and north by cliffs. The surrounding country is low and swampy for the most part, except in a line to W.N.W., where the hill continues in a long narrow ridge.

Geomorphologically the headland is almost a tied island, since it is almost surrounded by alluvial flats and mangrove swamps. During the mid-Recent period of the "ten foot" elevated sea-level it was a long, narrow peninsula nearly two miles long and one hundred to three hundred yards across. In the late Pleistocene (late Monastir) period of the "25 foot" sea-level and the earlier, even higher levels, it must have been an island.*

* I am following the now widely accepted classification of Quaternary eustatic levels which has quite recently been summarized by Zeuner (1945). It is always possible that local conditions may cause variations in the accepted levels, and for this reason it is customary to mark the height in inverted commas. I am hoping to present a fuller discussion of this subject elsewhere.

It is cliffed all along the eastern and northern sides, averaging about forty to fifty feet in height. Most of the cliffs are now well-vegetated and particularly on the northern side, on a line between Eagle Parade and Cliff Road, they are strictly "fossil" cliffs, since they are separated by several hundred yards of alluvial flats from the sea.

At the foot of the south-eastern cliffs there is a wide marine bench, averaging one hundred and fifty feet across and ranging from about three to five feet above datum. The surface is now suffering differential erosion and in the shales are some interesting examples of "pool-level" weathering. The presence of this old bench has already been reported by Jack and by Steers.

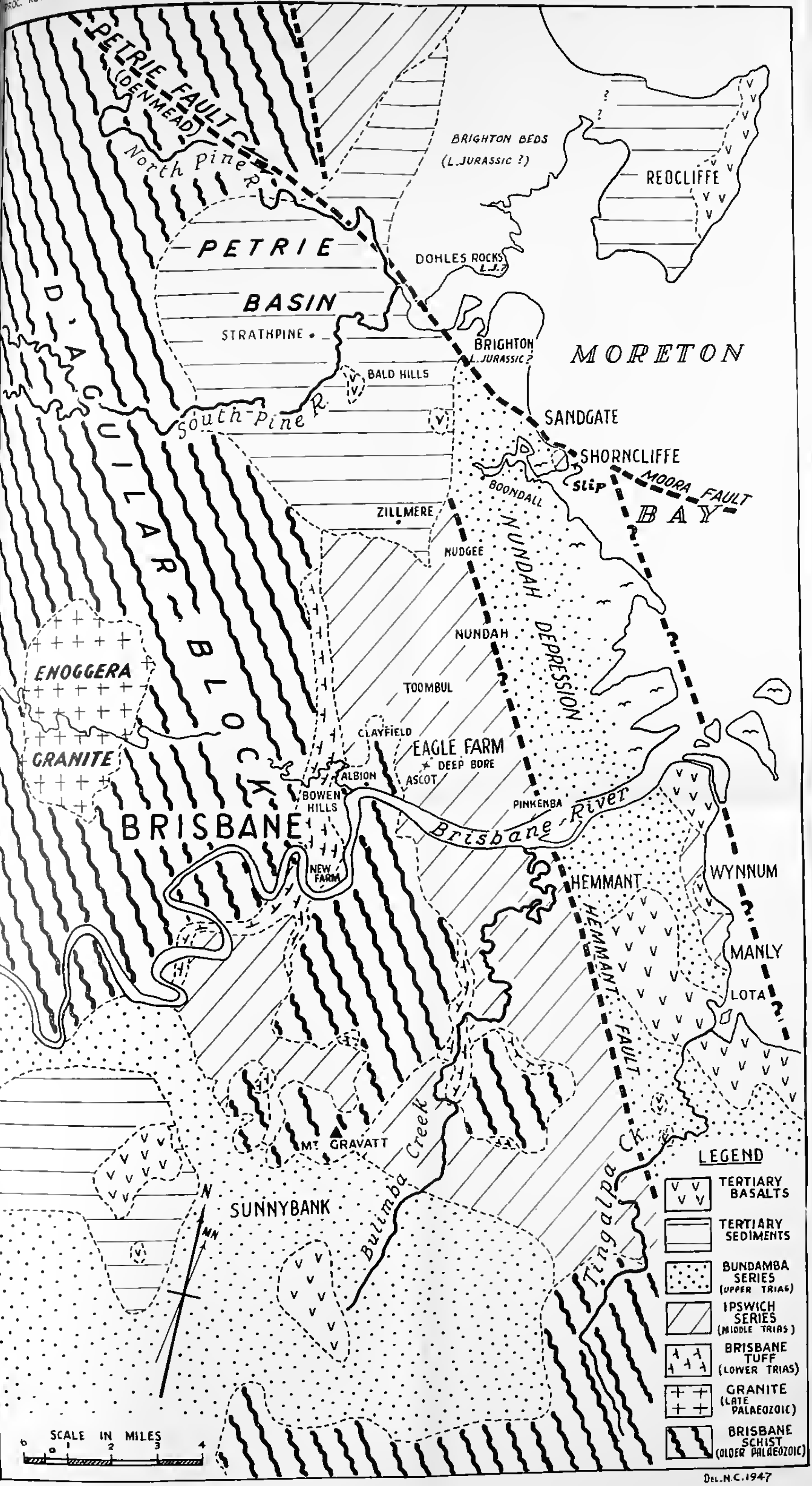
In the rocky cliffs are exposed a succession of sandstones and shales, belonging to the Ipswich series of Triassic age. A striking low-angle thrust-plane can be observed, and in the beds on the foreshore there are numerous little intensely folded structures. These miniature Alpine-type structures in the Mesozoic of Queensland are somewhat paradoxical. As yet, no satisfactory explanation has been offered for them.

Strangely enough, in spite of the proximity of Shorncliffe and Sandgate to Brisbane, the area has never been thoroughly examined before. The most complete information to date on the Brisbane-Sandgate area, with a summary of all preceding work, is to be found in an unpublished thesis by N. H. Fisher, 1931 (to be seen at the Geology Department, University of Queensland). The earliest mapping, with brief notes, was done by Rands (1887). The only deep bore in this general area was carried out some seven miles south of Sandgate at Eagle Farm in 1889; it was described by Jack and Etheridge (1892), though full details did not appear until Marks' East Moreton work was published (1910). The area embraced by the latter work, however, did not actually reach up as far north as Sandgate.

A significant note on water springs at Sandgate by Dunstan appeared in 1897, when he suggested their possible correlation with a zone of faults associated with the contorted beds. This was not, however, depicted by him in a cross-section drawn from Zillmere to Shorncliffe, made after a further reconnaissance twenty years later (1919), when he showed a gentle Trias syncline, some six miles across (N.E.-S.W.), though terminating at Sandgate with some local crumples.

Nevertheless, the evidence further down the strike on the south side of the Brisbane River has always been in favour of normal faulting to explain the high dips and sudden contrasts in the Mesozoic sediments there. Jack, in 1897, reporting on a bore through over one thousand feet of Ipswich beds at Lindum Mere, noted dips of 20° near the surface, becoming horizontal lower down. He postulated a fault between Lindum and Manly. Marks (1910) also noted faults in the Manly area, and Ball (1930) regarded the depression between Tingalpa and Manly as a down-faulted trough, though Marks only depicted it as synclinal. In 1945, in the company of Mr. Ball, I had the opportunity to visit the section and we both certainly gathered the impression of considerable faulting.

To the north of Sandgate, at Brighton and at Dohle's Rocks, at the mouth of the Pine River, there are more or less flat-lying shales with plant fossils. These "Brighton beds" are probably Lower Jurassic, which would suggest a fault or flexure between here and the steeply dipping Trias of Sandgate (Jones and de Jersey, with appendix by Woods, 1947).



[Face page 180.

Thus, from the literature, and from general reconnaissance, one may draw the initial conclusion that the Shorncliffe-Sandgate section lies in an area of Triassic sediments, which are normally but slightly undulating, but in the line of the strike (roughly N.W.-S.E.), in a zone about two to three miles wide and very many miles in length, there is a marked development of normal or high-angle faulting with steep dips (see Fig. 1).

My first introduction to this locality was due to the good offices of the late Professor H. C. Richards of the University of Queensland, assisted by his colleagues Associate Professor W. H. Bryan and Mr. O. A. Jones, and by Mr. L. C. Ball, then chief geologist of the Geological Survey of Queensland. Since then, stimulated by the discussions we had at Shorncliffe, I have repeatedly returned to this interesting spot and made careful measurements, photographs and notes. Mr. Jack Woods, of the University of Queensland, rendered valuable assistance in the field. It is as a result of encouragement from Dr. Bryan and Mr. Ball, that I have put down these notes, with some suggestions as to further work in this line which may be of help in the elucidation of the fascinating structural history of eastern Australia.

The area is covered topographically by the Australian Military Map Series (one inch to the mile scale) "Brisbane" sheet, and by R.A.A.F. vertical aerial photographs (used for the preparation of that sheet) of 1/21,000 scale (16.5.44, nos. 52-55).

II. GENERAL STRATIGRAPHY.

The Trias in south-east Queensland is represented by a fresh-water succession, comparable in a broad way with similar Triassic continental rocks elsewhere in eastern Australia, such as the Hawkesbury and the Clarence series of New South Wales. Correlation in detail, however, cannot be carried out, since these fresh-water beds were laid down in various, only partially connected, basins. Mesozoic plants, nevertheless, give a broad palaeobotanical basis to the classification.

The sequence is divided into lower, more carbonaceous beds, the "Ipswich series" (probably Middle Trias), and upper, more arenaceous beds, the "Bundamba series" (probably Upper Trias). At the base in places around Brisbane is found some early Trias volcanic material, the "Brisbane tuff." Together, the tuff and the Ipswich series rest on the intensely folded, somewhat metamorphosed and granite-intruded "Brisbane schist" series (approximately Ordovician-Silurian). The surface of the latter, far from being peneplaned, was deeply dissected at the beginning of the Mesozoic, and the Trias is laid down in deep valleys and abutting the steep crags of the older mountains. As Marks has shown (1910), evidence for this buried topography is abundant around Brisbane, and many of the former physical eminences have been re-exposed to form hills again to-day. As a rule, the contact between the younger and older series is not faulted.

Within a mile of one such elevation of Brisbane schist (Ascot), at the Eagle Farm bore (1889), some 1,680 feet of Ipswich series were penetrated before reaching the schist. This is the most accurate figure available for judging the thickness of the succession at Shorncliffe.

Other evidence for its total thickness comes from further south-west in the Ipswich basin itself, where Cameron in his map of the Ipswich coalfield (1922) put the thicknesses of the Ipswich and Bundamba series at 3,000 and 1,600 feet respectively.

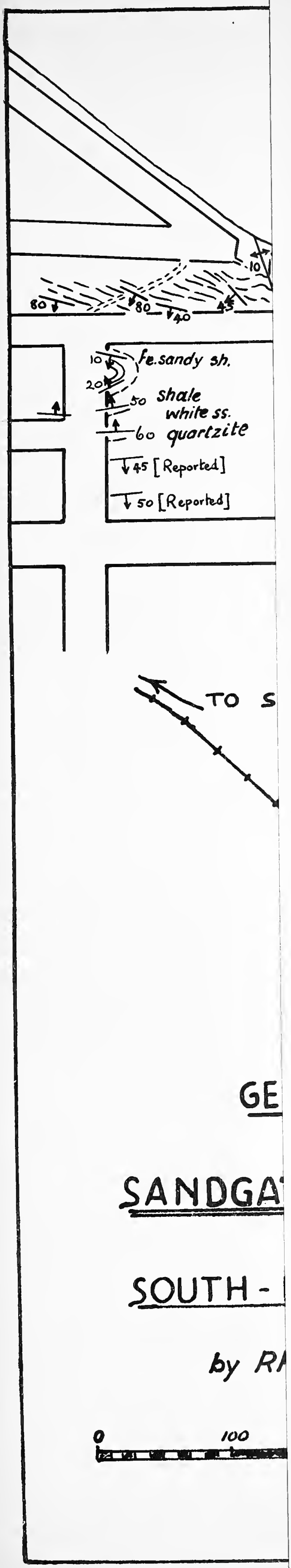
Cameron was of the opinion that the Mesozoics were originally laid down all over the Brisbane schist area and only subsequently divided into easterly and westerly basins by the upwarp of the older rocks along the regional N.W.-S.E. lines (the D'Aguilar block). Very coarse and thick conglomerates are found all around the foot of the D'Aguilar block, which grades sharply down to the south-east to disappear beneath the Ipswich series, approximately along the E.N.E.-W.S.W. line of the Brisbane River. This boundary Cameron (1899) had regarded previously as faulted but in 1907 he preferred to describe it as a former cliffed coast, which, one may presume, was gradually destroyed and inundated by the rising Trias inland sea. With this interpretation, Dorothy Hill, in her study of the Ipswich-Esk sequence (1930) agrees.

Walkom (1918), in drawing a Trias palaeogeographic map of Queensland, marked only a small basin in south-east Queensland with the D'Aguilar region inundated, though with further discoveries, as Bryan and Whitehouse showed (1926), this basin should now be extended to include a far larger area to the west, north-west and south, while Bryan and Jones (1945) have pushed it out further still.

While one might conclude from such maps that the Triassic sequence was laid down everywhere in south-east Queensland, in point of fact, remembering the extremely rugged nature of the Palaeozoic topography, it is probable that only the youngest Triassic was so widespread, and most of the earlier stages were divided into piedmont basins. Between these there is a great diversity in facies, which gradually become more uniform as one goes up in the section.

In this way, the lowest members of the Ipswich series are generally massive angular conglomerates and breccias, mostly quartzitic and obviously coming directly from the Brisbane schists. Higher up in the succession, these coarse clastics tend to reappear from place to place, but generally become more rounded and diversified towards the top. After the basal conglomerates and breccias come silts, grits and current-bedded sandstones rapidly alternating with bituminous shales, coal seams and fire clays. Again, higher up, the succession gradually becomes more stabilized and more consistently arenaceous. Typically, near the top, are white, yellow and purple sandstones.

The overlying Bundamba series are rather similar to the uppermost Ipswich, so that, although local lithological distinctions may be made within the Ipswich Basin (*sensu stricto*), these cannot be regarded as reliable for long-distance correlations. The Bundambas are, however, notably transgressive and cover a wider area than the Ipswich series. This transgression was due to a "sudden downwarp" in the Ipswich-Esk basins, according to Dorothy Hill (1930a, p. 182), and a similar break is found 160 miles N.N.W. along the strike at Mundubbera. Reeves (1947) also noted this pre-Bundamba tectonic disturbance in the broad region to the west, between Roma and Springsure. There thus seems to be good reason for expecting the extension of such tectonic events even beyond those particular areas; for example, to the Shorncliffe-Sandgate section and other localities in the basins east of the D'Aguilar block.



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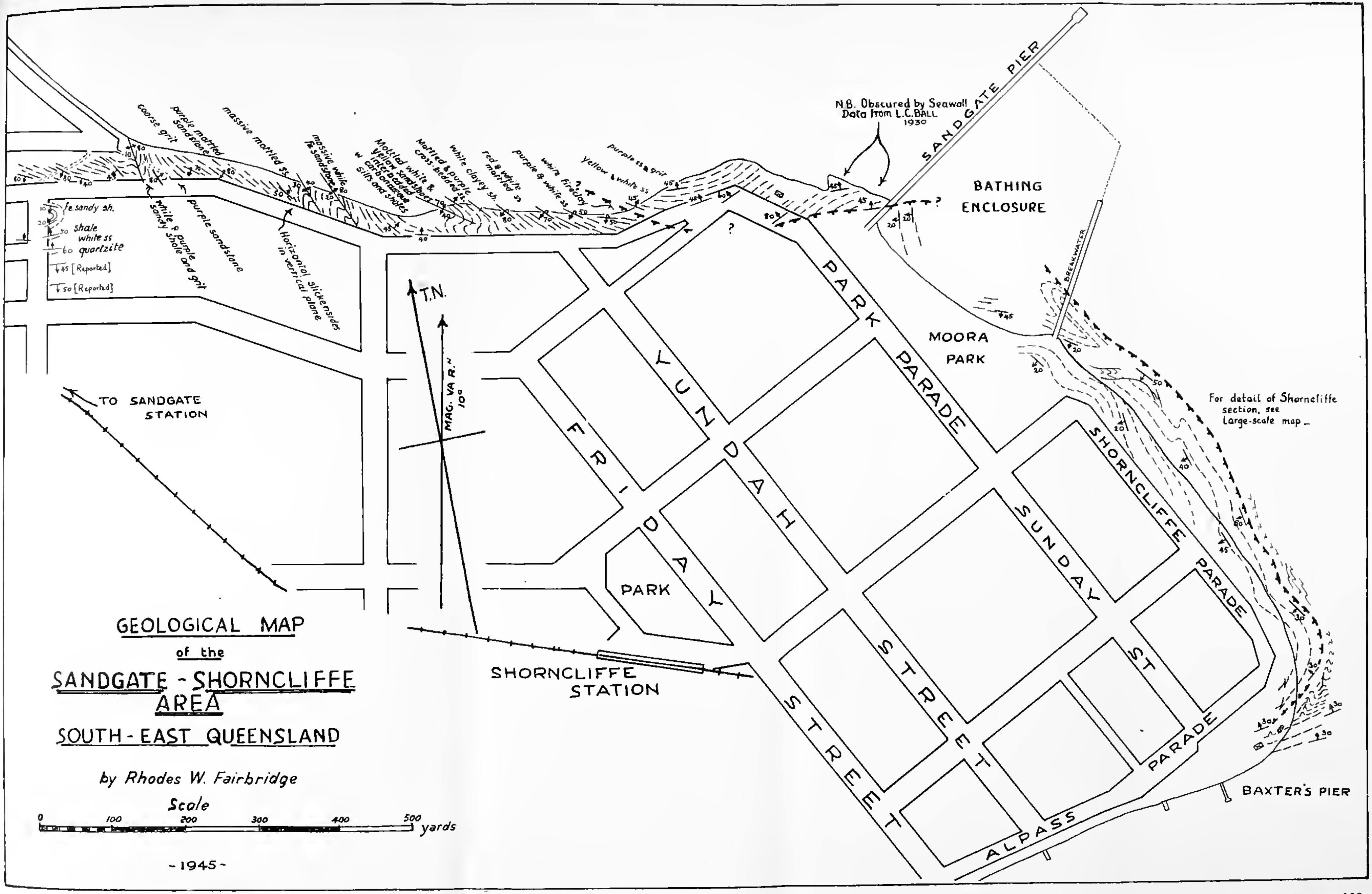

GEOLOGICAL MAP
of the
SANDGATE - SHORNCLIFFE AREA
SOUTH - EAST QUEENSLAND
by Rhodes W. Fairbridge
Scale
0 100 200 300 400 500 yards
-1945-
SANDGATE PIER
BATHING ENCLOSURE
N.B. Obscured by Seawall
Data from L.C. BALL 1930
BREAKWATER
MOORA PARK
PARK
For detail of Shorncliffe section, see Large-scale map
PARK PARADE
YUNDAH STREET
FRIDAY STREET
SUNDAY ST
SHORNCLIFFE PARADE
ALPASS PARADE
STREET
BAXTER'S PIER
TO SANDGATE STATION
SHORNCLIFFE STATION
T.N.
MAG. VAR.N 10°
coarse grit
purple mottled sandstone
massive mottled ss
massive white fe sandstone
Mottled white & yellow sandstone interbedded w carbonaceous sills and shales
Mottled white & cross bedded ss
Mottled & purple
white clayey sh.
red & white mottled ss
purple & white ss
white fireclay
yellow & white ss
purple ss & grit
white & purple sandy shale and grit
purple sandstone
Horizontal slickensides in vertical plane
fe sandy sh.
shale
white ss
quartzite
45 [Reported]
50 [Reported]

III. DESCRIPTION OF THE SECTIONS.

The sections at Shorncliffe and Sandgate are exposed all along the cliffs and foreshore for nearly two miles. Behind this line, however, except for small exposures in gutters, the formation is obscured by houses and gardens and then plunges beneath the alluvium and is not seen again till it reappears several miles to the south-west. Thus there is visible only a narrow strip through a zone affected by highly complex tectonics and any isolated dip measurements away from this well-exposed strip are likely to be misleading.

The exposed strip may be divided into two geographically separate parts—the Shorncliffe section to the south-east, and the Sandgate section to the north-west (see fig. 2). The dividing line is roughly about the position of Sandgate Pier. It just happens that near here, opposite Moora Park, a short breakwater has been constructed, which has caused a good deal of sand to accumulate, forming a nice children's beach, but completely obscuring the rocky foreshore.

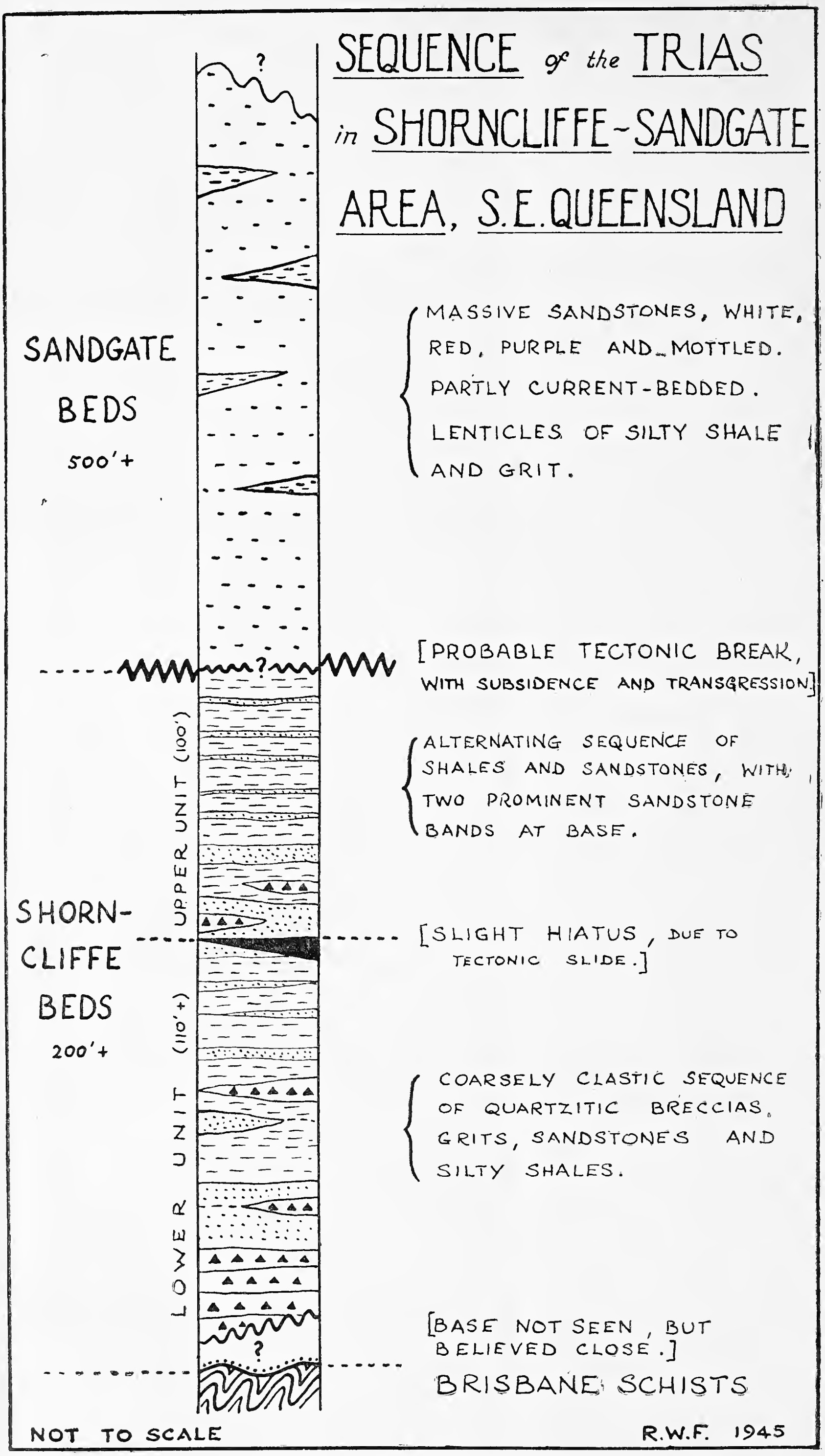
The *Shorncliffe Section* is an exposure 1,000 yards long on the cliffs and foreshore bench around Cabbage Tree Head. A low-angle fault plane crosses the cliff in the southernmost point and follows the outer edge of the marine bench of the foreshore. There do not appear to be any beds in common between the upper and the lower of these two tectonic units, but it is believed that no great thickness has been cut out.

The *Sandgate Section*, for its part, is exposed in another line of cliffs nearly a mile long, running westwards and west-north-west from a headland near the base of the Sandgate Pier. The easterly half of this cliff-line is faced by the sea without any intermediate rock bench, while the westerly half continues inland as a "fossil cliff" when the new coastline swings to the north. In this fossil cliff line unfortunately the rocks are so overgrown that very little can be seen.

It might appear at first sight that the Shorncliffe section represents the lower half of the Ipswich series and the Sandgate section the upper half, since the northernmost Shorncliffe beds seem to dip beneath the Sandgate beds.

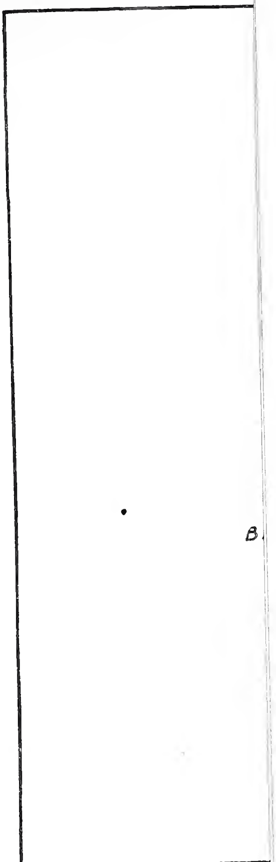
While there appears to be no doubt that the Shorncliffe section represents the lower parts of the Ipswich series (both on palaeontological and lithological grounds), the arenaceous series in the Sandgate cliffs contain no fossils so far identified and their lithological similarities with both upper Ipswich series and Bundamba series renders their precise age identification difficult. As will appear in the tectonic discussion, there is good reason for assuming a tectonic break at the top of the Shorncliffe succession.

As noted already, in the Esk-Ipswich and Roma-Springsure areas, the Bundamba series are regarded as transgressive, following upon a tectonic disturbance. It seems not unlikely thus, that, not only on lithologic but also on tectonic grounds, the beds of the Sandgate section may be compared with Bundamba.



TEXT FIG. 4.

Sequence of the Trias in Shorncliffe-Sandgate area.



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25 : DIP (IN

: MAJOR

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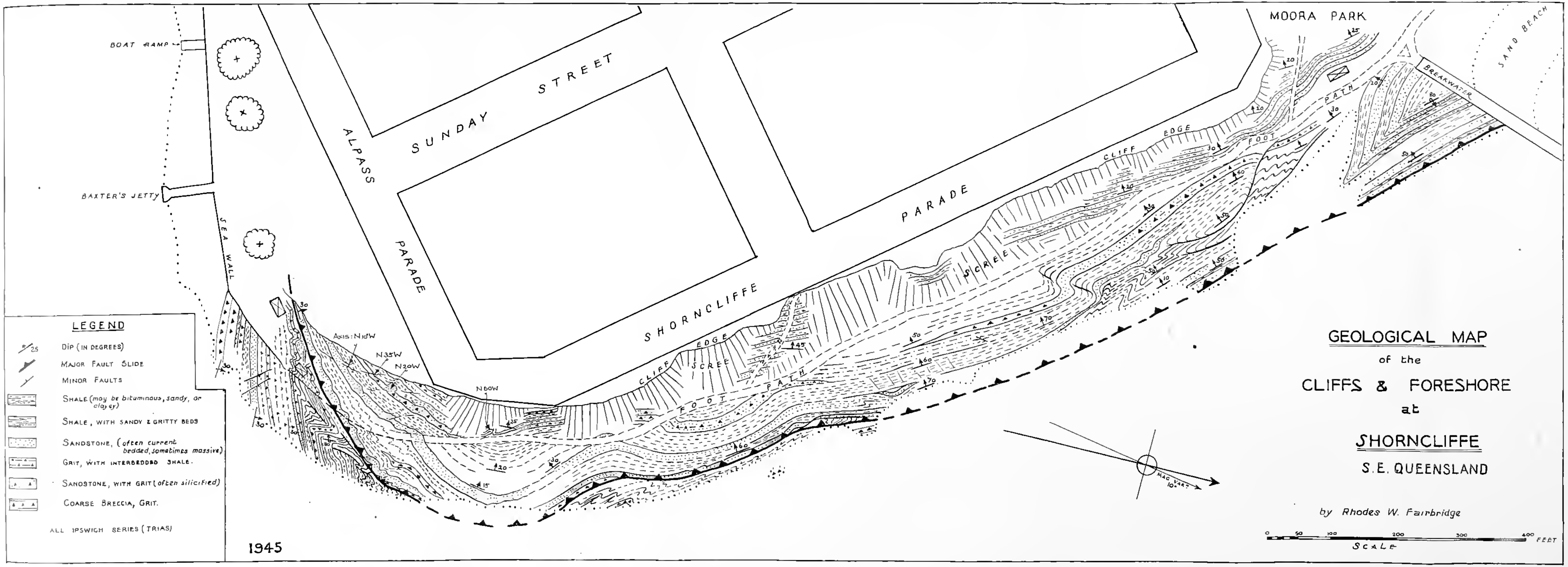

GEOLOGICAL MAP
of the
CLIFFS & FORESHORE
at
SHORNCLIFFE
S.E. QUEENSLAND
by Rhodes W. Fairbridge
1945
LEGEND
Dip (in degrees)
Major Fault Slide
Minor Faults
Shale (may be bituminous, sandy, or clayey)
Shale, with sandy & gritty beds
Sandstone, (often current bedded, sometimes massive)
Grit, with interbedded shale.
Sandstone, with grit (often silicified)
Coarse Breccia, Grit.
All Ipswich Series (Trias)
SCALE
0
50
100
200
300
400
FEET
MAG. VAR. 10°
MOORA PARK
SAND BEACH
BREAKWATER
BOAT RAMP
BAXTER'S JETTY
SEA WALL
SUNDAY STREET
ALPASS PARADE
SHORNCLIFFE PARADE
CLIFF EDGE
SCREE
FOOT PATH
Axis: N10W
N35W
N20W
N60W

Nevertheless, it is felt that for clarity it will be best not to make any assumptions in this direction, and that the two sections be given local names for the moment. They may be defined as follows:—

1. *Shorncliffe Beds:* Type section exposed from the southern extremity of Shorncliffe, on the cliffs and foreshore around Cabbage Tree Head as far as the Sandgate breakwater (see fig. 3).

   The fact that the section is divided by a tectonic slide plane is not regarded as of any stratigraphical significance, though a small hiatus may be expected. In this way the section is divided into an upper and a lower unit.

2. *Sandgate Beds:* Type section exposed from the Sandgate Pier along the cliffs as far as Sandgate Town Hall. Believed to be transgressive upon tectonically disturbed Shorncliffe beds but contact obscured at Moora Park (see fig. 2).

We shall deal with the stratigraphic relationships first.

(*a*) Stratigraphic Relationships.

1. *Shorncliffe Beds.*

(i) Our *Lower Unit* consists of over 110 feet of coarsely clastic rocks for the most part (see fig. 4). At the base there is a thirty-foot series of very massive beds of angular conglomerate, breccia and grit. The boulders appear to come mostly from the quartzitic members of the older Palaeozoic Brisbane schist. Specimens up to a foot in diameter were noted. Smaller pebbles from the softer phyllitic and greywacke members of that series also appear near the base.

As noted already by Ball (1930), these conglomerates and breccias are very similar in lithology to the basal beds of the Ipswich series at other points, and it appears likely that we are within only a few feet of the Brisbane schists here. It is noteworthy that there are no fragments of the Brisbane tuff in these clastic beds, a fact which only goes further to show the capricious distribution of that volcanic horizon.

Going upwards the clastic material becomes gradually finer and is eventually replaced by an alternation of silty shales with sandstone and breccia lenticles. In the latter, the fragments are up to half-an-inch in diameter as a rule. Approximately the uppermost forty feet consist of more bituminous shales, with lenticles of poor coal, alternating with sandier beds and breccias.

(ii) *Upper Unit:* As already noted, the Lower is separated from the Upper Unit by a tectonic plane (approximately parallel to the bedding). The lithology continues with very much the same character however. There is thus no evidence of any marked hiatus.

The base of the Upper Unit is marked by two prominent sandstone members each about five to ten feet thick and separated by a 10–15-foot layer of bituminous shales. Lenticles of coarse quartzitic grit and breccia still occur.

Higher up there is an alternating sequence of bituminous or silty shales and sandstone. The bituminous shales contain numerous but fragmentary plant remains. The arenaceous beds may be either quartzitic with considerable diagenetic hardening or else may be quite soft, weathering easily.

Current-bedding is common, directions of source varying from north-west and west to south-west. There is a little intraformational slumping in places, but only on a very small scale in some of the silty beds, where interpenetration phenomena are seen. In one place there are antidune structures, as described by Lamont (1938), indicating perhaps the sudden current induced after a slump. Evidence of contemporary movement and seismic action is suggested by the occurrence of intraformational faulting and the filling of seismic crevices by contemporary sands.

2. *Sandgate Beds.*

The Upper Unit of the Shorncliffe beds consists of sharply alternating shales and arenaceous beds near the top. It is just here that the cliff section is obscured in the vicinity of Moora Park, and there might seem to be some reason for assuming an uninterrupted sequence into the upper group. Nevertheless, there is a well-marked change which may have some tectonic significance.

This upper group consists almost entirely of arenaceous material, consisting of massive, well-bedded and current-bedded sandstones, white, red, purple and mottled. There are only thin intercalations here and there of silty shale and, in one place, some white fire clay. No identifiable fossils were found in the sequence, but carbonized plant debris was seen in one of the shale lenticles.

Owing to the poorly defined bedding and to the soft nature of these Sandgate beds (many of the cliffs being run down and overgrown), it was relatively difficult to map them. The thickness at Sandgate, however, is believed to be in excess of 500 feet.

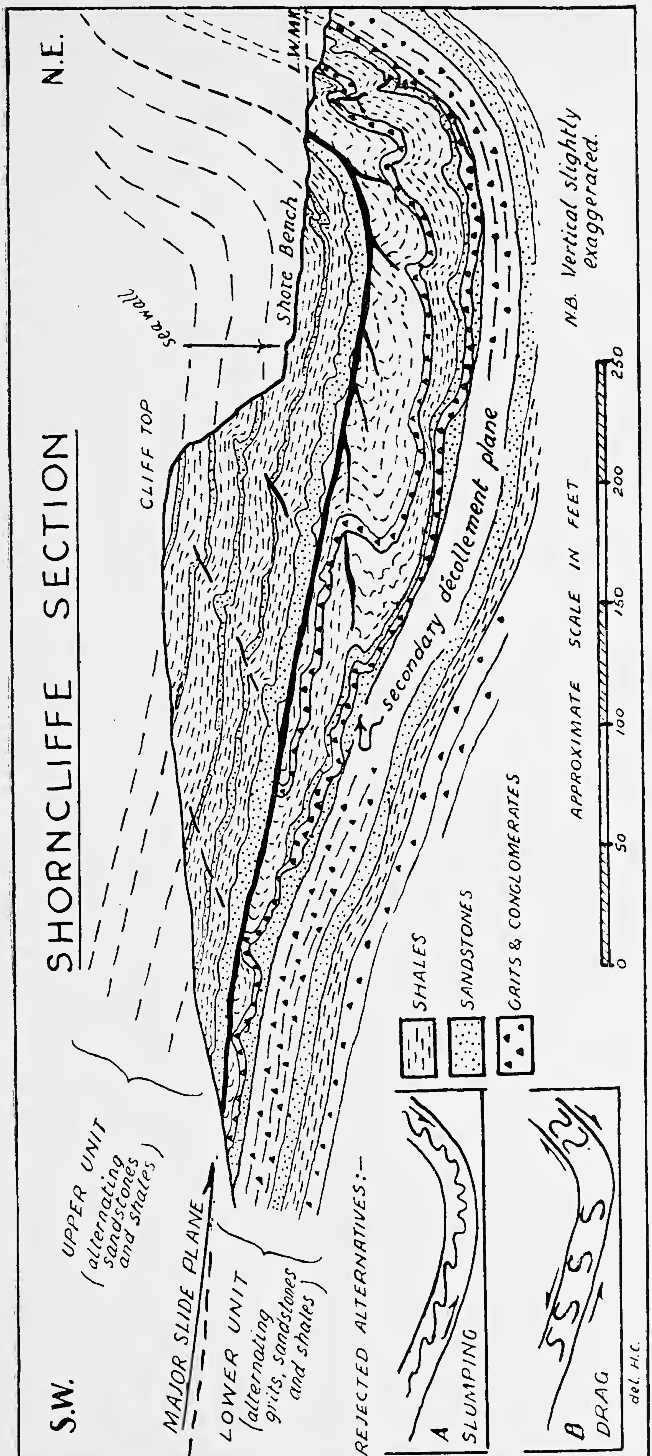
(*b*) Tectonic Relationships.

Tectonics in the Sandgate-Shorncliffe Trias are complicated and quite clearly of two distinct generations. There is abundant evidence of soft-rock tectonic deformation on the one hand, while, on the other, there is superimposed on those structures a later deformation which has fractured and slickensided the hard quartzites, and folded up the previously simple structural forms (see fig. 5).

1. *Tectonics of the First Generation.*

This is expressed primarily by a low-angle fault-plane, which, in common parlance, may be called a "low-angle thrust," but which, as will appear in due course, is better described simply as a "slide" (see pl. VII., figs. 1 and 2). Such a feature would be due to a mass slippage down a gently inclined plane under influence of gravity, and would most likely have come to a rest in a practically horizontal attitude, with the exception of the brow region which would tend to ride up.

To-day this slide plane is found to enter the section at the south-western extremity of Shorncliffe, coming down along the cliffs and across the bench on the foreshore to follow around the outer edge of the bench as far as the Sandgate breakwater. From there on it is obscured by beach sand and is not seen again. Consideration will be given in due course to its possible extension. In no place, however, is it observed to die out.



TEXT FIG. 5.

Cross-section of the structure at Shorncliffe, partly diagrammatic. This shows the unilateral sliding and disharmonic folding of the first generation, superimposed by the simple synclinal structure of the second generation. Insets show the contrast between the minor flowage structures in the Shorncliffe section and the arrangement of (A) slump and (B) drag folds as they would appear in analogous synclines (rejected hypotheses).

Beneath the sole of the slide there is a highly contorted zone for a depth of about twenty to forty feet, below which the disturbance gradually dies out so that the underlying strata show no sign of the movement. The dip of this underlying unit is, where measurable, approximately the same as that of the slide plane and of the overlying beds. The strike of the lower unit is also the same along most of the foreshore, but at the southern extremity the strike is about 10–15° different from that of the slide, so that there is a slight divergence in the outcrops here.

The crumpling beneath the sole is mostly carried out in bituminous shales alternating with thinner bands of silt and breccia. Below these there are more competent sandstones and breccias. Notable *disharmonic folding* takes place at the contact and also in many places in the body of these shales against the more competent bands of intercalated breccias. The largest of these folds has an amplitude of about twenty feet. Incipient thrust faults appear in or near their axial planes, though they die out quite quickly in both directions (see fig. 5).

Slickensiding is most common in the shales, with numerous highly polished and curving surfaces. Against the actual under-plane of the slide, the puckering and plucking in the shales is intense. There is no doubt that these bituminous shales have acted as the lubricating agent to the slide. The sandy and breccia beds are generally unbroken in these folds, showing considerable flowage. Crestal regions are thickened and flanks thinned. It is significant that as a rule there is no cleavage in these clastic beds, which to-day in places are so diagenetically hardened as to ring to a hammer blow.

The direction of the movement is very precisely demonstrated by the dragging and by the puckering. These accessory folds are in almost every case overturned or overthrust towards the north-east or east-north-east. In one place, 100 feet N.E. of the shelter on the southern extremity of Shorncliffe, one may observe the shales standing vertically and dragged over in the uppermost six inches into the slide plane to the north-east.

Now to the overlying tectonic unit: as noted above it does not appear, as is usual in Alpine nappe structures, to belong to completely different series. On the contrary, it is almost certainly of about the same age as the underlying unit. From the lithology, it appears to be slightly higher in the stratigraphic column, though with little or no hiatus between its lowest member and the highest beds of the underlying tectonic unit.

The attitude of these overlying beds is exactly conformable with the plane of the slide, except for localized disharmonic crumpling (see pl. IX., fig. 1). Dip and strike are thus so parallel that for 800 yards the same sandstone bed, except for minor lithological variations, forms the base of the slide. Higher up in these beds, there is some incipient folding in places, but normally the succession is surprisingly undisturbed in view of the transportation it has suffered.

Along most of the south-east side of the section there is little or no disturbance. To the south, there is a series of little thrusts, partly expressed as faults in the shales, and partly by flowage in the arenaceous beds (see pl. IX., fig. 2; pl. X., fig. 2). These planes characteristically curve upwards, from being parallel with the bedding to about 45° to it. In one place there is a miniature box-fold ("Kofferfalte," see pl. VIII.). In another there is a reverse (antithetic) thrust developed in the shale moving back and up at 45° to the bedding, that is at right-angles to the little upward-curving thrust (see pl. X., fig. 1).

To the north these disturbances are on a bigger scale. Also they appear differently, since in the south, the section is crossing the dip of the slide, while here in the north-east, the section is planed off parallel to the strike. Here, the same phenomena may be observed from a different angle: thrusts in the shales, flowage in the sandstones. From this viewpoint it may be seen that many of these incipient thrusts have a shallow basin-shaped strike-section.

As to the age of the first generation of tectonics, there is very little direct evidence. It may be seen on the one hand that the movements were carried out while the rock was in a relatively soft condition. The diagenetic hardening of the quartzitic members to-day absolutely precludes fluidal folding of this sort in any but an unconsolidated state. On the other hand, there has taken place the mass movement of a group of strata at least half-a-mile long, quarter-of-a-mile across and some hundreds of feet in thickness; it has remained quite coherent and, when viewed on the broad scale, it has not suffered distortion. It must therefore have been partially consolidated at least. No sign of the slide, however, is found in the Sandgate beds.

For the moment then, we must put the age of the movement in the Trias itself, after the completion of the sedimentation of the lower and upper units of the Shorncliffe beds, but possibly before the deposition of the overlying succession of Sandgate beds. It is nevertheless not beyond the bounds of possibility that merely we have found no evidence in the upper group and that in fact the movement came at the end of the Trias or soon after.

2. *Tectonics of the Second Generation.*

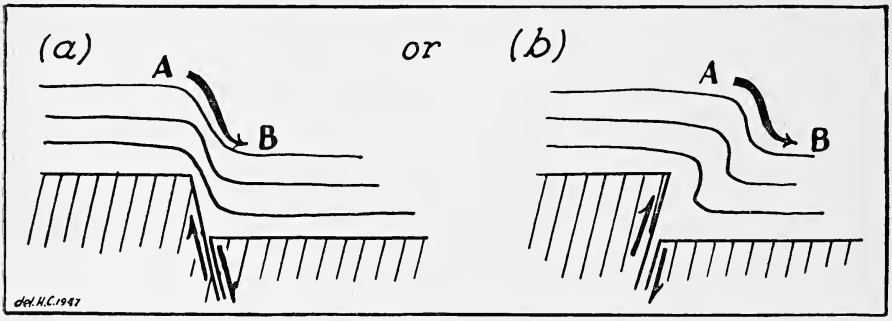
As already indicated, long after the first movement, when the rocks were all fairly well hardened, a second tectonic event took place. This was in the nature of a compressive movement, leading to a well-marked flexure in a N.W.-S.E. to W.N.W.-E.S.E. trend. A 10–20° difference in strike may perhaps be distinguished between this and the earlier trends.

In the Shorncliffe beds this movement caused the buckling of the originally flat- or nearly flat- lying slide into a steep syncline. To-day, therefore, we find the slide plane in the south dipping at 30° N., while on the north-east it dips at 50–60° S.W. (see fig. 5). In the south-west and west it is not well exposed, but appears to dip at 20° or 30° N.E.

Since this folding took place when the rock was already in a hardened condition an appropriate jointing system appeared, which is quite independent of the structures of the first generation. Movement in a horizontal sense along some of these vertical joints is demonstrated by horizontal slickensides, in the vertical-plane at right-angles to the strike, and especially well preserved in the resistant quartzites.

Turning now to the northerly section, exposed in the Sandgate cliffs, we see that here too there is a tight folding, which has affected the already consolidated rocks (see fig. 7). First of all, it must be again re-emphasized that in no place has the structure (either of first or second generation) of the Shorncliffe section been seen in relation to that of the Sandgate cliffs. And the differences in stratigraphy and style of folding are so great that it is very difficult to suggest any other really satisfactory hypothesis for explaining this structure.

There is no foreshore bench here, and the lithology consists of seemingly endless feet of unfossiliferous sandstones; no constant lithological horizon was found, such as would aid the mapping. The cliffs with exposures run over 1,000 yards in an almost east-west direction. The strike averages W.N.W.-E.S.E., varying in the main from E.-W. to N.W.-S.E. Only in the headland west of Sandgate Pier does there appear a strikingly abnormal series of steep northerly dips with E.N.E.-W.S.W. strikes; this particular section may be regarded as down-faulted to the north, or perhaps rather as the lower limb of a high-angle thrust.



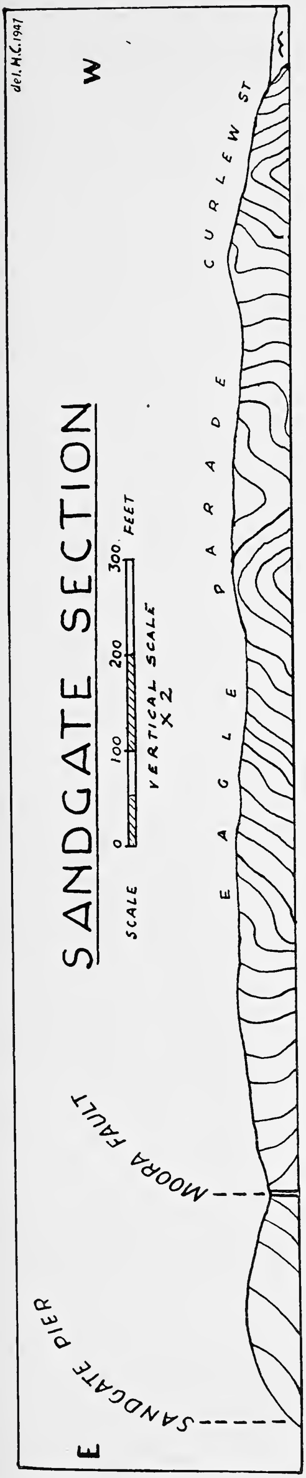
TEXT FIG. 6.

Two types of monocline in soft sediments overlying a hardened basement fractured by (*a*) normal and (*b*) reversed (thrust) faults. Gravitational slides should occur from A to B.

The main cliff-section, therefore, is seen to cut obliquely across the strike, exposing a highly folded zone, some five hundred yards across (measured at right-angles to the strike). No less than four tight asymmetrical little anticlines appear in this section. All are steep (70–80°) on the north-east side and gentle (10–30°) on the south-west (see fig. 7). These appear to be in the nature of drag folds or flexures in the north-east flank of a compound monoclinal structure, but owing to the lack of marker beds the cross-section of this area cannot be regarded as more than a suggestion.

As noted above, the easterly headland, just west of Sandgate Pier, appears to be a down-faulted or steeply-overthrust block. In the corner of a slight bay, 350 yards west of the pier, there is an obscured section where there is an outcrop of white fire clay and a perpetual spring. There is a 90° difference in dip in fifty yards here, and a sudden change in strike. The contact is thus taken as faulted. On the eastern side of the headland, at the base of the pier, there is again a big difference in dip and a 90° change in strike. Along the pathway up to the top of the headland (the north end of Park Parade) there is abundant evidence of crushing and disturbance in a nearly vertical plane. This all appears to be the one fracture and I have called it "Moora Fault," as it crosses the north end of Moora Park.

The lack of any recognizable relationship between the primary tectonics of the Shorncliffe section and the folding of the Sandgate beds tempts one to conclude that the latter is younger, and probably to be correlated with the second generation of the Shorncliffe tectonics. The Sandgate beds are in certain places hardened and show horizontal, vertical-plane slickensides. The folding, furthermore, is not particularly characteristic of soft-rock deformation and is in conformity with the strike of the second generation movements.



TEXT FIG. 7.

Cross-section of the structure at Sandgate, partly diagrammatic. Interpreted from the attitude of the drag folds as the east limb of a fold, probably a faulted monocline (second generation tectonics), but owing to lack of marker beds and poor exposures this interpretation is partly hypothetical. The upper Trias here consists of unfossiliferous sandstones with lenticular shales and grits.

As to the age of these movements, a wide range is possible. In the Ipswich basin, major faulting, with sympathetic Saxonian type folding, characteristically of monoclinal nature, not only occurred in the Trias, but also at the end of the Trias, in the Jurassic, and even later. Looking northwards, there was considerable folding in the Maryborough basin at the end of the Cretaceous. In the Petrie Basin, considerable faulting and disturbance is found in Tertiary beds. At Shorncliffe and Sandgate there are, however, no visible contacts with post-Triassic rocks, so that for the moment the best that may be said is that the second generation of tectonic movements was post-Trias.

IV. A NOTE ON GRAVITATIONAL TECTONICS.

The terms "low-angle thrust," "bedding-plane fault" and "slide" may be used to describe the main structural feature in the first generation tectonics at Shorncliffe. These expressions imply a movement which is essentially superficial (that is, the thrust plane does not descend to great depths, but rather originates at the surface and ends at the surface) and, also, which is very often due to gravitation.

Gravity as a cause for the secondary, though very impressive superficial, "nappes" of the northern Alps and other mobile belts is not a new concept. It has been known since the days of de la Beche, of Reyer and of Schardt, but had been made rather "unfashionable" during the last half-century of extreme "nappism," as the French have aptly called the more imaginary Alpine theories. The concept was revived, however, during the last decade or so by Jeffreys, Haarmann, van Bemmelen, Ampferer, Lugeon and many others, so that gravitation may now be regarded as an essential feature of structural geology in Europe to-day.

Sliding under the influence of gravity is inevitably a secondary tectogenetic process, since sliding implies a slope, and that slope is introduced by the primary deformation, be it tensional or compressional. Sliding is thus a feature not only of Alpine tectonics, but also of the Germanotype, "Saxonian" or fault-fold tectonics which are a feature of deformation in soft sedimentary rocks overlying a semi-rigid or semi-mobile fractured basement. The movements in the latter may be alternately tensional, compressional or "jostling," and the resultant structures on the surface are often of a monoclinal nature.

When, however, a monocline is produced in a soft sedimentary series a steep slope will be formed which is quite obviously unstable. From stratigraphic, oceanographic, experimental and engineering evidence, it is now recognized that in soft well-bedded sediments that slope must only exceed a few degrees before the superficial sediments (often up to several hundred feet thick) begin to slide, generally gliding away along a more lubricated clayey layer (see fig. 6). Tension faults will open up along the crest of the structure and overfolding and overthrusting will result near the foot. A relatively undisturbed segment of sediments may thus be carried right over the contemporaneous sequence, at the foot of the monocline, the only evidence being the occasional little disharmonic folds and traces of "décollement" along the more argillaceous bedding planes. Since gravity is the prime mover, we often find the juxtaposition of small tension faults and compression folds with shears, where sliding has been alternately eased or blocked. These processes are well recognized even on a nearly microscopic scale in subaqueously slid strata (Fairbridge, 1946).

V. SUGGESTED INTERPRETATION.

(*a*) *Local Factors.*

With the information of the foregoing section in our hands, we can have little hesitation in identifying the gravity slide at Shorncliffe. The next question may naturally be: from where did it slide? Field evidence shows that it came from the south-west, but there is little in the structure to show whether it slid two or twenty miles; both are possible tectonically. But from the very close lithological relation between the upper and lower units, as well as from their parallelism, one may conclude that the distance was not great, say two to three miles at the most.

Two to three miles south-west of Shorncliffe brings us to the other side of a low-lying depression, regarded by Dunstan (1919) as a syncline between the Triassic series of Nundah-Zillmere and those of Shorncliffe-Sandgate (see fig. 1). To the north-west along this trend one may observe the eastern margin of the D'Aguilar Palaeozoic complex, which is mainly monoclinal, but also heavily faulted, according to Jensen (1906) and others. Further evidence of the faulting has subsequently been observed by Ball (1916, 1918, 1930) running in a N.W.-S.E. zone.

Going south-east in the line of the regional strike direction brings us to Hemmant, already recognized by Marks (1910) as an important fault. This trend extends further south-east in a well-marked line, throwing down Ipswich series (and even its base the Brisbane tuff) to the east, where the Bundambas appear. The throw depends on the local thickness of the Ipswich series, but, by comparison elsewhere, it may therefore be somewhere between one and three thousand feet. It is unquestionably a very important line, although actually at Hemmant itself its true magnitude is not immediately obvious. To the east there appears to be a down-faulted syncline or graben between Hemmant and Manly, where another zone of notable faults is apparent.

Ball (1916), in following down the faulted eastern boundary of the D'Aguilar horst, came to the conclusion that the faulted zone seen between Dakabin and Petrie might very reasonably be continued in the direct line to the south-east of the big enclave of Tertiary and Quarternary known as the Petrie Basin, and actually south of the Brisbane River in the Hemmant Line.

David (1932) apparently accepted this extension of the Hemmant Line so much as a matter of course that he said "steep dips are seen at Sandgate . . . . but the strata there are near to a major fault, the Hemmant fault."

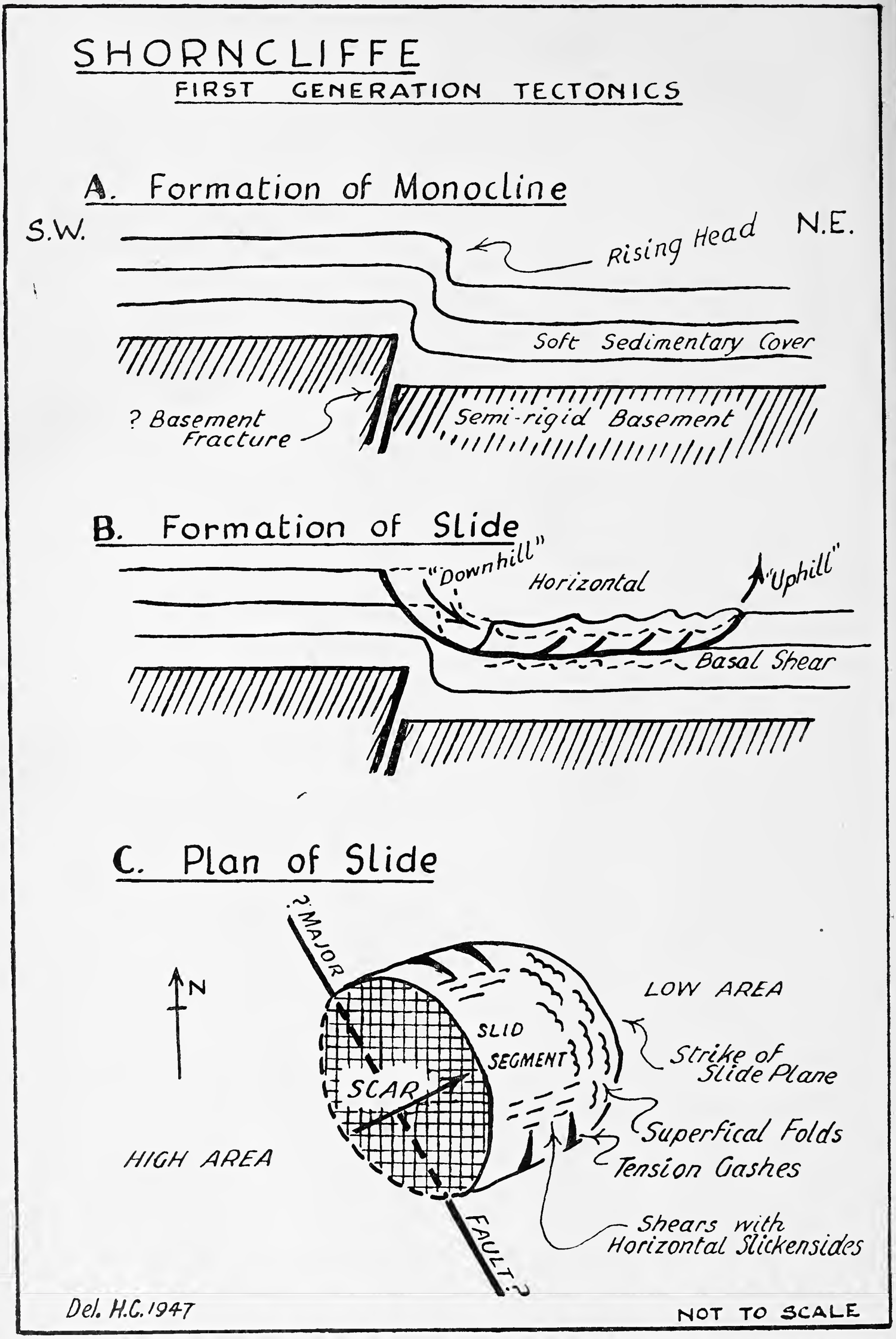
The D'Aguilar horst also exhibits certain transverse displacements (Denmead, 1928), but I have the impression that these are in the nature of transcurrent or tear faults in most of which the southern side has moved several miles to the east. As I have indicated, quite tentatively (on fig. 1), the Petrie Fault (of Denmead), when extended to the E.S.E., coincides quite remarkably with the Sandgate disturbance (Moora Fault).

I would also like to postulate another transcurrent fault offsetting the Brisbane Schists to the east in the south, along a line somewhere south of Ipswich to Cleveland, but most of the evidence is deeply buried beneath a cover of Trias and younger sediments. The principal movement on such lines would, of course, have been pre-Trias.

We know but little of the age of the previously-mentioned longitudinal faults, except that they are essentially Mesozoic (mainly post-Trias to late-Cretaceous), but there is no doubt the main lines of the D'Aguilar border faults must have been formed already before the Trias. As often recognized elsewhere, such major basement faults are liable as a rule to continue through many periods, suffering repeated revival from time to time. It is likely, too, that in places the faults have a high-angle thrust nature.

Even in the Petrie Basin Tertiary there is a series of little thrust faults in this N.N.W. to N.W. trend (Jones, 1926; Ball, 1932; Beasley, 1944), which may well be posthumous and antithetic in character.

For a working hypothesis, therefore, we may suggest that the monoclinally flexed and faulted eastern margin of the D'Aguilar horst was overlapped by the Ipswich sea in the Sandgate-Brisbane area. A revival of movement along this fault zone (probably several hundred yards wide) produced a faulted monocline of the type so well known in the Saxonian areas of the world. A large, gravitational slide took place (at the end of Middle Trias times) off the easterly, down-throw side, having come "unstuck" along a slippery shale band, gliding gently



TEXT FIG. 8.

Interpretation of the first generation (intra-Triassic) tectonics at Shorncliffe. (*a*) Formation of simple monocline after basement fracturing. (Whether this fracture is normal or reversed does not materially alter the slide.) (*b*) Formation of a gravitational slide. (Takes place *pari passu* with the rising of the monocline.) (*c*) Plan of possible outline of the original slide, showing juxtaposition of compression and tension structures. (Not to scale.)

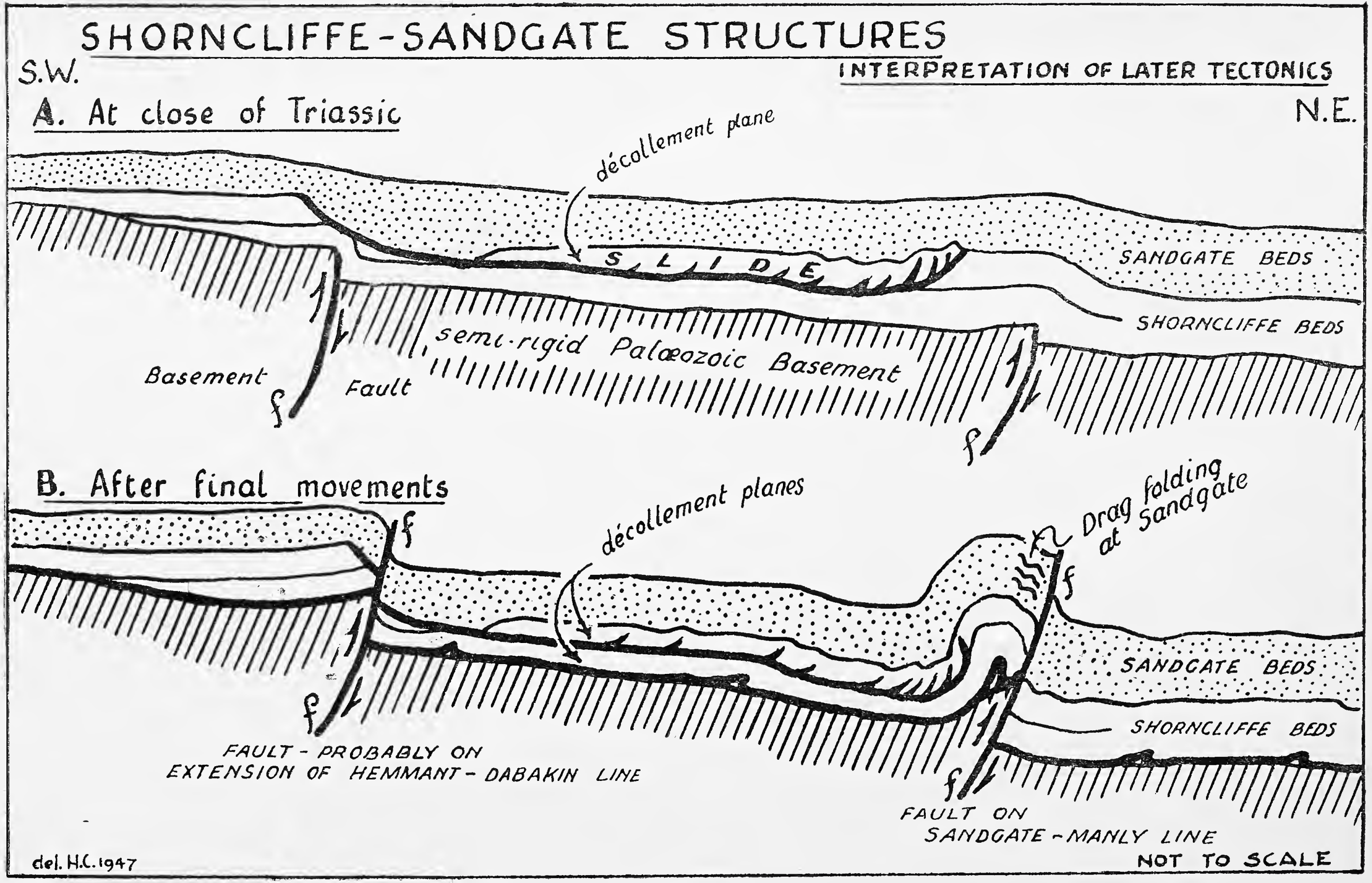
down the bedding plane and out onto the flat, finally curving up to the surface, and coming to a halt some two or three miles to the east (fig. 8). The old Palaeozoic contact was probably not a smooth peneplaned surface (Marks, 1910; and others) and did not offer a good plane for "décollement." The slip took place higher up, gliding in the first thick band of well-lubricated shales. This outer part of the D'Aguilar Palaeozoic block was probably tilted gently down at the margins, so that there was a slight easterly slope which gave further assistance to gravitative tendencies.

Further sedimentation (Bundamba) took place, to be followed by further faulting and folding (again monoclinal or perhaps of the "box" type), but this time some few miles east of the Hemmant-Dakabin Line, and thus again following the usual Saxonian principle of outwards migration of the tectonic zone (fig. 9).

This new line of disturbance would be in the strike of the Manly-Wynnum-Sandgate line of steeply dipping beds, as suggested already by Ball (1930). At Wynnum there is an elevated belt of Ipswich, analogous, in position at any rate, to the Shorncliffe-Sandgate doming. It seems difficult to explain these structures without the assumption of a second fault-line, of similar character, running parallel to the Hemmant Line about three miles further east. At Sandgate, however, we note a local sigmoidal variation in the otherwise rather strikingly rectilinear pattern. This is accompanied by our "Moora Fault." Again, such sigmoidal variations are essentially normal in any such Saxonian picture, since they are the surface expression of horizontal basement movements, underlain by transcurrent or tear faults, in the general framework of jostling blocks. It would not be surprising, therefore, if this oblique trend were eventually correlated with Denmead's Petrie line, referred to above.

Ball (1930) postulated his "pronounced crustal fracture" forming the western boundary of Moreton Bay and I have depicted this (with appropriately broken lines) on my locality map (fig. 1). He supposed this to be down-thrown on the west, while the Hemmant-Petrie Line is down-thrown on the east to make a graben-like depression, referred to by Ball as the "Nundah Syncline." With this in mind he surmised that there would probably be buried Ipswich coal seams in this depression, while to the east of it, in the Moreton Bay region, there would be an up-thrown block of older rocks. At Sandgate I have shown from the nature of the drag folds that the structure seems to be thrown down to the north-east. This, however, does not really run counter to Ball's hypothesis, since it is probable that the Sandgate structure is controlled by my "Moora Fault," which is a transverse displacement, which may be the south-easterly continuation of Denmead's Petrie Fault.

The expression "jostling" also gives the key to the type of faulting. It is not purely horst and graben, elevation and subsidence bounded by normal faults, but upthrusts and down-squeezing, at high angles, and with the maintenance of a horizontal potential. Not only do high-angle thrusts or "reverse" faults better explain the tectonic details, but the lack of contemporary vulcanicity in this locality speaks against tension faults. The Brisbane tuff area lies well to the west, and in any case is rather older.



TEXT FIG. 9.

Interpretation of the second generation tectonics at Sandgate, showing (*a*) first, the sedimentary cover of later Trias Sandgate beds, resting on the irregular surface of Shorncliffe beds, deformed by tectonics of the first generation; and (*b*) after the final movements (probably late Cretaceous and Tertiary) with revised basement fracturing (thrusting), tilting, and disharmonic folding of all the superficial strata, including the earlier slide. (Not to scale.)

(*b*) *Regional Significance.*

Eastern Queensland, as is well known, lies along one of the earth's major Caledonian-Hercynian geosynclinal belts. During the Mesozoic and Tertiary, the history has been basically one of epeirogeny, expressed by orogeny of a low order, in the "jostling" movements of longitudinal, more or less rigid blocks, with faulting and folding mainly restricted to their margins. This is the Saxonian or Germanotype of tectonics, so well known in Northern Europe, and intra-Mesozoic in age too.

Now, already over twenty years ago, Bryan (1925) drew a greatly idealized cross-section through one of the widest parts of the eastern Queensland orogenic belt, from Injune and Springsure to Fraser Island. He depicted here a succession of more or less evenly bedded Mesozoic and Tertiary rocks overlying a strongly folded basement of Palaeozoic. The post-Palaeozoics are shown as forming a series of asymmetric folds of very great amplitude, steep to the west and gentle to the east, except in the coastal area, to the east of the main Palaeozoic "core." While the geological knowledge of Queensland has advanced greatly in the last two decades, the broad lines of this structural picture, as presented by Bryan, remain basically correct.

This post-Palaeozoic epeirogenic deformation has been carried out, it appears, in a series of broad asymmetrical upwarping movements. While local axes of uplift and depression may be distinguished for the horst and graben (or senkungsfeld) tectonics of certain detailed structures, a series of overall structural axes should be identifiable with this broad upwarping. The greatest and earliest of these elevations seem to lie more or less along the line of the present coast of central Queensland; in the southern part of the State only a coastal plain intervenes. In consequence, the oldest rocks outcrop nearest the coast and younger rocks appear progressively westwards. These axes have nevertheless migrated somewhat during the Mesozoic and Tertiary. In this way the major axis seems to have migrated slowly westwards, elevating the inland basins and tilting the whole geosynclinal belt to the east.

Let us now apply this information to Bryan's cross-section and tilt the latter up at its eastern end, so that the gently dipping eastern flanks of the broad post-Palaeozoic folds become horizontal. The steep western flanks will at the same time become vertical, and we may then observe a series of *monoclines*, stepping down to the west. Further south from the line of Bryan's section, the picture is not so uniform, and a section through the D'Aguilar Ranges would show a horst or dome, bounded on either side by a monocline, faulted in places, with a considerable throw-down to the west and to the east (see especially D. Hill, 1930a, 1930b; Süssmilch, 1933; and others).

Whether these monoclines may be correlated or not with the successive former axes of the main upwarping, or whether they are more or less contemporaneous remains to be elucidated. Bryan (1925, p. 37) was of the opinion that they were late or post-Cretaceous.

The D'Aguilar-Brisbane "geanticline" may in fact represent the core of the old geosyncline and would thus be the first median swell in the orogenic break-up of that belt. Granitic intrusions seem to support this interpretation. Its margins are essentially faulted monoclines and box-folds, and have something in common with the horst and graben tectonics of the Basin and Range province of America, but not perhaps as much as one might conclude from Süssmilch's interpretation (1933).

An intensely interesting area is that of Maryborough and Pialba, some 140 miles to the north. While practically every other Mesozoic area of the Queensland geosynclinal belt exhibits undisturbed or only Saxonian structures, here in the north-eastern extremity of the region there might be evidence of bigger movements (see Dunstan, 1912, 1918). Whether or not the tectonic character of these is truly Alpinotype, as distinct from Alpidic in age, connected with a marine Cretaceous geosynclinal or marginal shelf zone, remains to be demonstrated.

On the evidence, I would hardly think so; the Maryborough basin exposes limited outcrops of traces of four or five fairly big anticlines and synclines. These are not known to be faulted, though dips are fairly high. It is true that Maryborough lies on the easternmost borders of the Australian continent, but there is no convincing evidence that these folds are the westernmost dying-out of a great post-Cretaceous Alpine orogeny, which affected the Coral Sea-Tasman Sea area, as suggested by Bryan (1925), David (1932), van Bemmelen (1933) and others. Similar high dips are reported (personal communication by L. C. Ball) from the Cretaceous Styx Coalfield (north of Rockhampton), and here again there is solid evidence for basement fragmentation. These structures suggest mainly Saxonian tectonics, but in a zone of thicker sedimentation than further west. There is certainly no crushed belt or dynamic metamorphism and the occurrence of Cretaceous granites and other intrusives is insufficient basis for assuming an Alpinotype orogeny.

It should not be imagined therefore that Saxonian tectonics in Queensland are exclusively of the fault-fold type. The thickness of the soft sediments and the type of basement fragmentation are both fundamental controls in governing the type of structure developed. Elsewhere in eastern Queensland we see all gradations in type. As in Germany, where the Permian salt, gypsum and shale beds play a special rôle in assisting the lubrication of basal sliding in disharmonic folding, I suspect analogous horizons (carbonaceous shales especially) in Queensland permit widespread "décollement."

One has only to study the published sections by the Geological Survey of Queensland and others to see the structural analogies with Saxonian and Jura-type regions. For example, Ball (1912) shows at Mount Mulligan a simple synclinal graben, a subsided block with faulted monoclinal boundaries. In the Serocold axis of the Springsure district we see a square-sided box-fold ("Kofferfalte"), so typical of disharmonically folded areas (Reid, 1930). Again, in his long sections from the Baralaba coalfield to Kalewa, Reid (1945) shows the transition from an overthrust zone to a zone of open folds which die out below, indicating basement "décollement."

The series of transcurrent (tear) faults disclosed in detail by mining operations on the Gympie Coalfield (Dunstan, 1911) are the superficial expression of torsional horizontal movements in the basement.

The faulted monocline (partly upthrust) of the Ipswich fault at Ipswich (Cameron, 1907, 1922) is perhaps the most typical expression of the vertical movements in deep-seated structures. In striking contrast to the near-vertical dips near the fault, in the Walloon-Rosewood area one may cross mile after mile of almost completely flat and undisturbed beds at no great distance from the disturbed Ipswich zone (Reid, 1922).

It may be seen now that the Shorncliffe-Sandgate tectonics are not anomalous in the picture of the Saxonian tectonics during the Mesozoic and Tertiary evolution of the eastern Australian geosynclinal belt. Further research is obviously suggested by this conclusion. Not only will any future boring in the Sandgate area be of the highest interest, but so will every new discovery of faulting or contorted folding in these post-Palaeozic rocks of eastern Queensland. It suggests, too, that every locality already known to have disturbed sections should be re-examined and that correlations should be attempted between them.

Finally, I must close with an apology: for the admittedly incomplete nature of this work and for the admittedly somewhat hypothetical sections presented. I have striven toward what may be regarded as rather daring working hypotheses, but the reason for this course, I hope, is clear. The structural picture of eastern Queensland is extraordinarily interesting. It is as complex as it is varied, but its elucidation will surely be facilitated by reference and analogy in the realm of geotectonics.

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EXPLANATION OF PLATES.

Plate VI.

Shorncliffe, foreshore and cliffs; air photograph, looking south-west. D'Aguilar Range in distance. (Photo.: R.W.F.—R.A.A.F., Moreton Bay research, No. 25.)

Plate VII.

Fig. 1.—Southern end of Shorncliffe tectonic slide-plane dipping 20° N.W. under sandstones of similar altitude, and overriding contorted sandstones and shales. (Photo.: R.W.F. 3264.)

Fig. 2.—Eastern edge of the slide, showing local overturned folds beneath it. (Photo.: R.W.F. 2847.)

Plate VIII.

Disharmonic fold (axis: N. 20° W.) about 50 feet above the base of the Shorncliffe slide. Note the relatively horizontal underlying unit overridden (from left to right) along the bedding plane by the upper unit, which just here is crumpled into a minor ''box'' fold. The core of quartz grit (now very hard) is slightly overthrust, but was sufficiently unconsolidated and saturated at that time to fill all the crevices by injection. Overlying beds of alternating sandstone and shale has taken up the movement which dies out within 10 feet. (Photo.: R.W.F. 3266.)

Plate IX.

Fig. 1.—Small disharmonic fold on the foreshore at Shorncliffe, a few feet above the slide-plane. The height of the fold is about 18 inches, as shown by the film carton (3 inches long), which also marks the local bedding plane slip, the movement coming from left to right. While the rock is now an alternation of very hard quartz sandstones and shale, its deformation while in soft condition is shown by the absence of cleavage. (Photo.: R.W.F. 3091.)

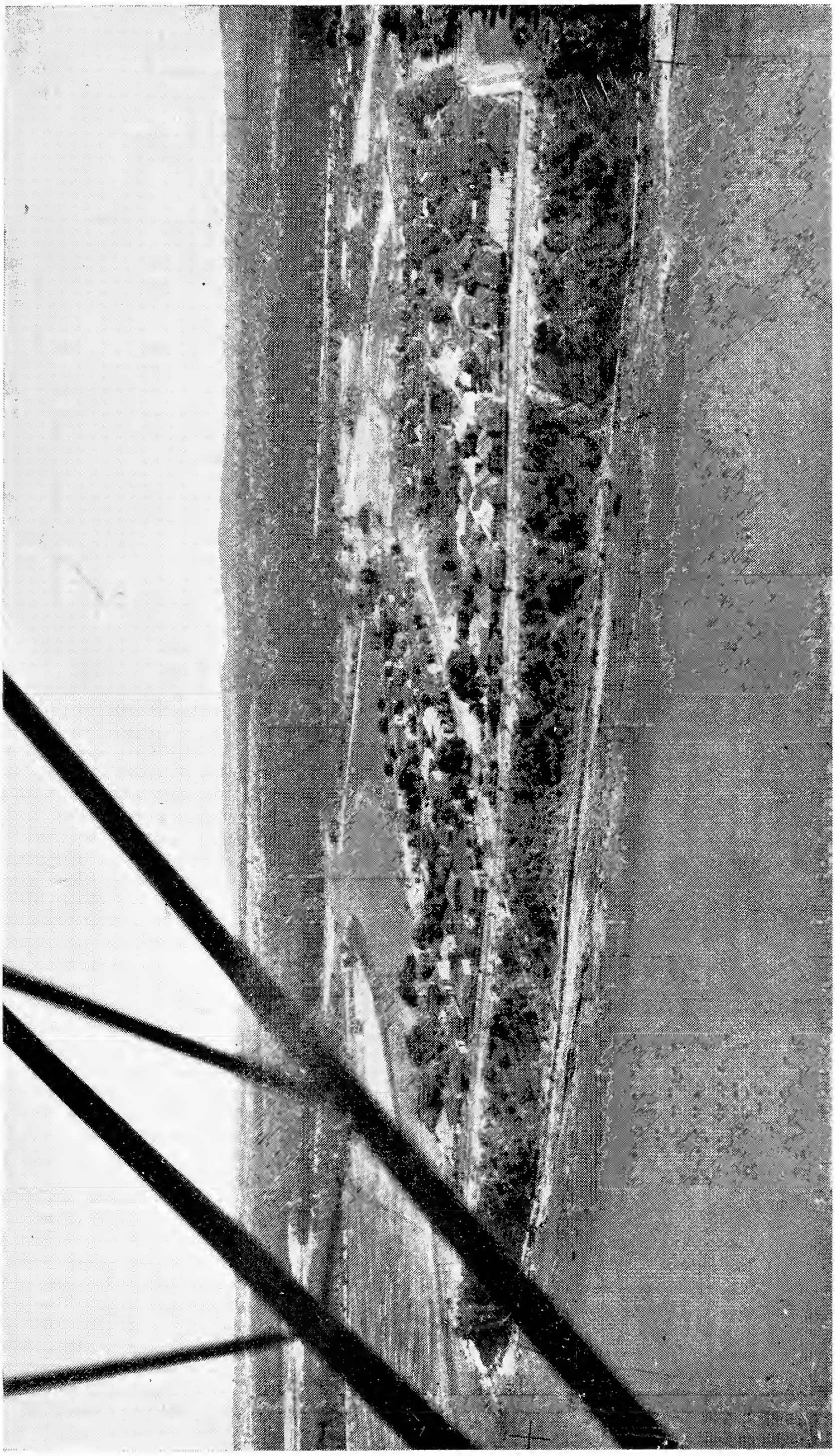
Fig. 2.—Minor overthrust cutting up through very hard quartz sandstones and grit. The irregularity of this plane, together with the flowing overturns into the thrust (without associated cleavage) indicates deformations in a soft, almost water-saturated condition. (Photo.: R.W.F. 3265.)

Plate X.

Fig. 1.—Upwards curving secondary slip-plane found in the cliff-side near the south-east extremity of Shorncliffe. It occurs about 60 feet above the base of the main slide. The scale is indicated by the film carton (3 inches long).

The strata are mainly thin-bedded shales with a 6-9 inch band of quartzitic grit in the lower part of the photo. Note how the slide begins on the left-hand side with a bedding-plane slip, beneath the grit. The latter it cuts through at 30° to the original horizontal and gradually becomes steeper and steeper until it reaches a higher grit band (off the picture) where it resumes the bedding plane slip. A small antithetic fault from the right centre works backwards and upwards through the shales. (Photo.: R.W.F. 3094.)

Fig. 2.—Contorted shale and overthrust grit, a few feet above the base of the slide at Shorncliffe. Miniature overfolds and faulted disharmonic folds in the finely banded shales contrast with the simple ''thrust'' faults in the grit; other parts of the grit must have been then unconsolidated, since the fault in this view dies out rapidly in the coarse grit. (Photo.: R.W.F. 3281.)



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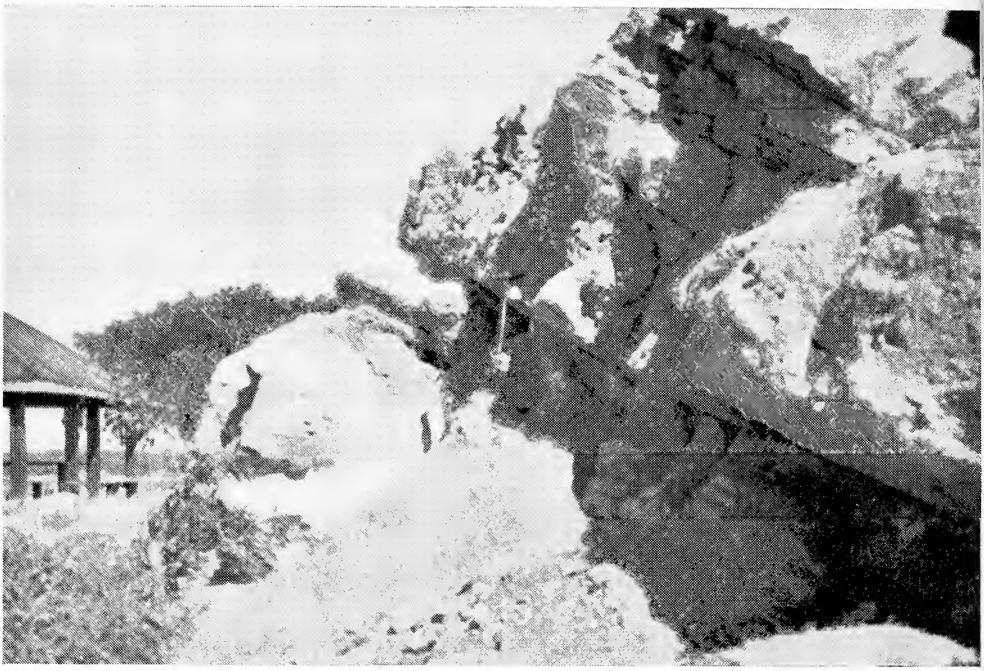

Fig. 1.

Fig. 2.

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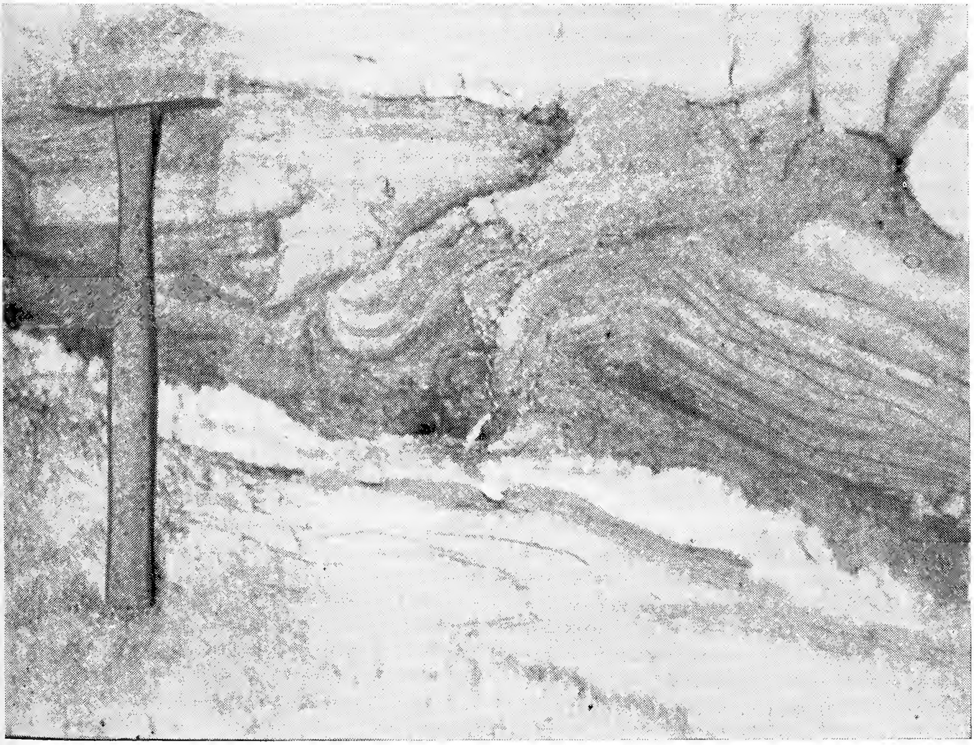

Fig. 2.

MISCELLANEOUS NOTES.

An Unexpected Inlier of Greenstone.

An unexpected inlier of greenstone occurs on the Sandgate-Bald Hills road, adjacent to Resub. 1, por. 100, par. of Nundah. Recently the known extent of this greenstone has been increased by Professor Bryan, Mr. O. A. Jones and Mr. A. K. Denmead, who have found it across the road in por. 102.

The stratigraphy of the locality is complex; there are rocks of the Triassic Ipswich Series a short distance to the south; the Jurassic Brighton Beds to the north and north-east; and the Petrie Series Tertiaries to the west and south-west. About three-quarters of a mile to the east is an outcrop of weathered basalt believed to be Tertiary in age.

The nearest outcrop of the Lower Palaeozoic Greenstone Series is at Petrie, about five miles to the north-west.

The occurrence is certainly of much structural significance, but just what that significance is, must be, at present, entirely conjectural. The simplest explanation is that the greenstone has been thrown up by faulting. In this connection it is interesting to note that a line drawn from Petrie, which appears to be the point of intersection of at least two major faults involving the Greenstone Series, and this locality under discussion is parallel to and quite close to much of the course of the lower part of the Pine River. Further, if this line be continued to the south-east it passes quite close to Shorncliffe, where the unusually severe deformation of representatives of the Ipswich Series does not find ready explanation.

J. T. Woods.

Seedlings of Mulga.

Seeds of Mulga (*Acacia aneura*) germinated after heavy rains in February, 1947. Seedlings were collected in the Wyandra district near the end of March, 1947. No seedlings were observed in shaded situations and none remote from large trees. The greatest numbers of seedlings were found on hard, bare patches of ground. This may be due to the higher temperature of the surface soil, the greater intensity of light or to lack of competition for water. The last factor is probably not important because the soil had been thoroughly saturated by the rain. Interesting features of the seedlings themselves are the great depth of roots, the rapid thickening of that portion of the root immediately below the hypocotyl, and the fact that only two bipinnate leaves are produced, all later leaves being phyllodineous. Of mature mulga, four main forms are recognized—Low Mulga, Whipstick Mulga, Umbrella Mulga and Tall Mulga.

S. L. Everist.

Palaeontological and Lithological Notes.

(1) Of two specimens of graptolitic shale alike in every detail, one found at Brookfield had previously been exhibited to the Society as evidence of the age of the Neranleigh Series which occurs there. The second was obtained from a small collection in one of the colleges attached to the University of Queensland. The practical identity of the

two specimens confirmed a persistent rumour that the specimen obtained at Brookfield was not collected *in situ,* but had probably been placed there by one of the senior students. There was now no authentic record of any graptolite having been collected in Queensland.

(2) A large specimen of the felspar Albite collected from the Greenstone Series on the roadside between Dayboro' and Mount Mee. This find strengthened the opinion that the Greenstones may prove to be spilitic in character.

(3) A specimen of Anorthoclase Basalt from Sugar's Quarry on the bank of the Brisbane River about two miles above its junction with the Bremer River. Such rocks are relatively rare, the only other known specimen from Queensland being that which Professor H. C. Richards found at Mapleton and exhibited to the Society many years ago.

W. H. BRYAN.

The Royal Society of Queensland.

Report of Council for 1946.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting the Annual Report of the Society, for the year 1946.

At Ordinary Meetings throughout the year four addresses were given and one symposium was held, while one evening was devoted to exhibits, one to the study of plans suitable for a Royal Society building, and one to accounts of the Science Students' Association's expedition. The Annual Memorial Lecture held this year in honour of Dr. Robert Logan Jack was delivered by Dr. Dorothy Hill. Nine original papers were accepted for publication in the Proceedings.

The Mueller Medal awarded for Researches in Natural Science was presented on behalf of the Australian and New Zealand Association for the Advancement of Science to Mr. C. T. White. The Australian Natural History Medallion for 1946 was awarded by scientific societies in Victoria to Mr. H. A. Longman.

The Royal Society, in co-operation with other scientific bodies, has taken steps towards the construction of a Science House in Brisbane. Much progress has already been made in this direction, and it is hoped that a more definite statement can be made in the near future.

The Council wishes to apologise for the delay in the issuing of Volume LVII. of the Proceedings, this being due to the delay in printing at the present time.

There are 6 honorary life members, 5 life members, 3 corresponding members, 228 ordinary members, and 16 associate members in the Society. This year the Society has lost one member by resignation, while 25 ordinary members have been elected.

Attendance at Council meetings was as follows:—O. A. Jones, 8; H. J. Wilkinson, 8; E. M. Shepherd, 9; E. W. Bick, 9; M. I. R. Scott, 8; M. F. Hickey, 6; S. T. Blake, 5; B. Baird, 8; S. B. Watkins, 8; H. J. G. Hines, 3; C. Ogilvie, 1; W. Boardman, 6; H. C. Webster, 9.

O. A. JONES, President.

MARGARET I. R. SCOTT, Hon. Secretary.

THE ROYAL SOCIETY OF QUEENSLAND.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDED 31ST DECEMBER, 1946.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
31st December— 1945.							
Balance in Commonwealth Bank	135	11	6	Government Printer, Abstracts	14	7	3
Subscriptions	172	4	6	Government Printer on Account Volume	60	0	0
Interest on Commonwealth Loans	4	11	3	State Government Insurance (Library)	0	19	3
Savings Bank Interest	3	7	1	Hon. Secretary, Postages, &c.	14	9	6½
Refreshments, Collections	5	19	9	Lanternist	1	10	0
Exchanges	0	6	0	Hon. Librarian, Postages	1	0	0
				Hon. Treasurer, Postages and Duty	1	17	6
				Refreshments	8	1	3
				Cash in Hand	0	19	2½
				Balance in Commonwealth Bank	218	16	1
	£322	0	1		£322	0	1

Examined and found correct.

L. P. HERDSMAN, Hon. Auditor.

E. W. BICK, Hon. Treasurer.

28th February, 1947.

Abstract of Proceedings, 31st March, 1947.

The Annual Meeting of the Society was held in the Geology Department of the University on Monday, 31st March, 1947, with the President (Mr. O. A. Jones) in the chair. About thirty members and friends were present. Apologies were received from His Excellency the Governor, Professor Richards, Professor Bostock, Dr. Hickey, Mr. Stoney, Mr. Longman, Mr. Perkins, Mr. Bick, Miss Baird and Miss Marks.

The minutes of the last Annual Meeting were read and confirmed. The Annual Report was adopted and the Balance-sheet received. The meeting was notified that His Excellency the Governor had accepted the position of Patron of the Society. Mr. J. B. Davenport was elected to Ordinary Membership.

The following officers were elected for 1947:—

President: Mr. E. M. Shepherd.
Vice-President: Professor H. C. Webster.
Hon. Treasurer: Mr. E. W. Bick.
Hon. Secretary: Miss M. I. R. Scott.
Librarian: Miss B. Baird.
Editors: Mr. S. T. Blake, Dr. M. F. Hickey.
Members of Council: Mr. C. Ogilvie, Mr. W. Boardman, Dr. D. Hill, Miss E. N. Marks, Mr. E. C. Tommerup.
Hon. Auditor: Mr. L. P. Herdsman.

The Presidential Address entitled "Ore Genesis in Queensland" was delivered by the retiring President, Mr. O. A. Jones. A vote of thanks was moved by Professor W. H. Bryan, seconded by Professor H. J. Wilkinson, and carried by acclamation.

Abstract of Proceedings, 28th April, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 28th April, at 8 p.m., with the President (Mr. E. M. Shepherd) in the chair. About forty members and friends were present. The minutes of the previous Ordinary Meeting were read and confirmed. Nominations for Ordinary Membership were received as follows:—Mr. V. J. Bahr, Dr. C. D. Gillies, and Mr. J. S. Womersley.

Mr. S. L. Everist exhibited specimens and photographs of Mulga (*Acacia aneura*) in various stages. The series included seedlings less than six weeks old, plants one year and two years old, and twig specimens from different types of mature trees. Seeds germinated after heavy rains in February, 1947, and were collected near the end of March, 1947. No seedlings were observed in shaded situations, and none remote from large trees. The greatest numbers of seedlings were found on hard bare patches. This may be due to the higher temperature of the surface soil, the greater intensity of light or to lack of competition for water. The last factor is probably not important because the soil had been thoroughly saturated by the rain. Interesting features of the seedlings themselves are the great depth of the roots, the rapid thickening of that portion of the root immediately below the hypocotyl and the fact that only two bipinnate leaves are produced, all later leaves being phyllodineous. The various growth-forms of mature mulga were also discussed briefly. The four main forms recognised are:—Low Mulga, Whipstick Mulga, Umbrella Mulga, and Tall Mulga.

Dr. Dorothy Hill exhibited a geological relief model, 65½ inches by 34½ inches, prepared in the Department of Geology of the University. This relief, exaggerated four times, was based on the military 1-mile sheets of Samford, Brisbane, Ipswich, and Beenleigh, and the geology was compiled from all available sources. A remarkable correspondence between geology and physiography was evident.

Mr. J. M. Harvey exhibited an all-glass fractional distillation apparatus. The apparatus exhibited was assembled with standard ground glass joints and equipped with a new type of fractionating column consisting of a number of separate "pear and ball" units. These units gave a more efficient fractionation, and any number may be used, depending on the degree of fractionation required.

Mr. Harvey also exhibited a modified McLeod gauge. This compact apparatus eliminates the disadvantages of unwieldiness and fragility in the original McLeod gauge. Its advantages are simplicity and ease of reading and the facility with which it can be incorporated into a low-pressure system.

Dr. W. H. Bryan exhibited:

(1) Two specimens of graptolitic shale alike in every detail. The first, which was found by him at Brookfield, had previously been exhibited to the Society as evidence of the age of the Neranleigh Series which occurs there. The second was obtained from a small collection in one of the colleges attached to the University of Queensland. The practical identity of the two specimens confirmed a persistent rumour that the specimen obtained by him at Brookfield was not collected *in situ*, but had probably been placed there by one of his senior students. Dr. Bryan pointed out that there was now no authentic record of any graptolite having been collected in Queensland.

(2) A large specimen of the felspar Albite collected from the Greenstone Series on the roadside between Dayboro' and Mount Mee. Dr. Bryan stated that this find strengthened the opinion that the Greenstones may prove to be spilitic in character.

(3) A specimen of Anorthoclase Basalt from Sugar's Quarry on the bank of the Brisbane River, about 2 miles above its junction with the Bremer River. Dr. Bryan explained that such rocks were relatively rare, the only other known specimen from Queensland being that which Professor H. C. Richards found at Mapleton and exhibited to the Society many years ago.

Mr. R. H. Mathams exhibited an O.G.A.L. colorimeter. During the war, when imports from England were extremely difficult, Optical Glass Association, Ltd., was commissioned to manufacture a colorimeter to incorporate the advantages and to eliminate the disadvantages of other colorimeters on the market. The instrument exhibited is one of the first to be used in Australia. The main advantages of this instrument are:—(1) The light source is incorporated in the base of the apparatus, a parabolic mirror being used to give parallel light; (2) The instrument may be used in any room, although bright sunlight should be avoided; (3) Measurements up to 100 mm. may be made by using elongated cups when working with pale-coloured solutions; micro plungers and cups are also provided; (4) Dummy eye-pieces are supplied for ease of reading; (5) Both scales are illuminated and read simultaneously to avoid parallax error.

Mr. T. R. Lowth exhibited a collection of plant fossils from Brittains' claypit, Darra (portion 67, parish of Oxley). Included were various species of *Thinnfeldia* (chiefly *T. odontopteroides*), a *Cladophlebis*, and *Tæniopteris*. The exhibits are significant as the area had always been mapped as Cainozoic, and dicotyledonous leaves have been collected from Hurworth's quarry to the south, and the claypit of the Queensland Cement Co. to the north-west.

Mr. A. K. Denmead exhibited a specimen of fine-grained sandstone bearing the impression of a fossil lycopod. The specimen was collected by Mr. J. E. Ridgway, Government Geologist, from the Charters Towers–Clermont road, approximately 100 miles from Charters Towers (parish of Moonbago, county Albany), and submitted through the Acting Chief Government Geologist to Mr. O. A. Jones, M.Sc., who diagnosed it as probably a new species of *Protolepidodendron*, a genus not previously recorded from Queensland. Two species have, however, been described by A. B. Walkom from the Devonian rocks of Yalwal, New South Wales. The alternating beds of shale and sandstone from which the specimen was collected are practically horizontal over a wide area.

Mr. C. Ogilvie exhibited a large specimen from the upper portion of a full-grown Waddy-Wood (*Acacia Peuce*) collected during his recent trip to the interior. This is a particularly hard and heavy wood—one of the world's heaviest—and a specimen taken from a post after fifty years in the ground, had lost only the sapwood. The tree occurs in only a few localities, on very small areas, and is the only timber available within about 200 miles of Birdsville for rails, &c.

Dr. F. W. Whitehouse exhibited a variety of concretions from the Cretaceous sediments of Western Queensland.

Abstract of Proceedings, 30th June, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 30th June, with the President (Mr. E. M. Shepherd) in the chair. About thirty members and friends were present. The minutes of the previous meeting were read and confirmed. Reference was made by the President to the death of Professor H. C. Richards, a prominent member of the Society. Mr. J. E. O'Hagan was elected to Ordinary Membership, and Mr. J. H. R. Watson to Associate Membership. The appointment of Mr. G. Mack to the Council was confirmed.

Mr. V. J. Bahr gave a lecture on Tropical Cyclones. After outling the history of the study of Tropical Cyclones, the three forces acting on the flow of air around a low-pressure centre were explained, viz.—(*a*) The Gradient Force, (*b*) The Geostrophic Force, and (*c*) The Cyclostrophic Force, thereby deriving the Gradient wind equation, which however, is only applicable at approximately 2,000 feet above the surface, owing to surface friction effects.

The areas of occurrence were then described and the present-day theories for the origin of the Tropical Cyclones discussed. Whilst the earlier theorists relied solely upon a convection theory, the modern tendency is to associate the formation of these depressions with the Inter-Tropical Front following the trend of modern air-mass and frontal analysis introduced by the Norwegian meteorologists, Bjerknes and Bergeron. Due to a surge of north-westerly or north-easterly air on the northern boundary of the front, a wave is formed along the front which acts as an enhanced area of convergence and thus a circulation is set up. It was shown that Tropical Cyclones cannot form between latitudes 5°N. and 5°S., since in this area the Geostrophic Force is negligible and centres of low pressure are filled up as rapidly as they are formed.

On attaining full development, the cyclones tend to follow a parabolic curve, although when they assume a circular rather than an elliptic shape their movement is rather erratic. After briefly giving the properties of these storms and the methods used in their location, mention was made of the utilization of microseisms in the Carribean Sea and the Central Pacific for the tracking of cyclones and the possibility of utilizing this method in the Queensland area.

Abstract of Proceedings, 28th July, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 28th July, with the President (Mr. E. M. Shepherd) in the chair. About fifty members and friends were present. The minutes of the previous meeting were read and confirmed. Dr. I. M. Mackerras and Mr. W. Puregger were proposed for Ordinary Membership.

The evening was devoted to "Henry Caselli Richards: A Memorial Address," delivered by Professor W. H. Bryan.

Others who paid tribute to Professor Richards were Mr. L. C. Ball, Professor D. A. Herbert, Mr. O. A. Jones, Mr. J. T. Woods, Mr. C. Ogilvie, Dr. I. Mackerras, Mr. E. V. Robinson, Dr. E. O. Marks, Mr. C. C. Morton, and Mr. E. M. Shepherd.

Professor H. J. Wilkinson moved a vote of thanks to Professor Bryan, thanking him for the excellent address and memorial he had prepared for the Society, and also paid personal tribute to Professor Richards.

Abstract of Proceedings, 25th August, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 25th August, with the President (Mr. E. M. Shepherd) in the chair. About thirty-five members and friends were present. The minutes of the previous meeting were read and confirmed. Dr. I. M. Mackerass and Mr. W. Puregger were elected to Ordinary Membership and Mr. K. R. Levingston was proposed for Ordinary Membership.

The following papers were presented:—"The Distribution and Seasonal Prevalence of Anopheline Mosquitoes in North Queensland," by F. H. S. Roberts; and "Triassic Plants from Cracow," by O. A. Jones.

Mr. J. P. Callaghan exhibited an electron-multiplier photocell. This type of photocell is still rare in Australia, but is being produced commercially in U.S.A. It differs from normal photocells in having a series of focussing and reflecting electrodes (dynodes) interposed between the anode and cathode, so that the photo-current is amplified by secondary emission. The sensitivity is about 2 amps/lumen, the current amplification being about 10^6.

Mr. J. T. Woods exhibited specimens of mud-balls in tuff collected at a locality in the Numinbah Valley discovered by Mr. P. G. Grant. The occurrence of this rock type in an area in which volcanic rocks and their associates are generally of Tertiary age is of interest, since the only other known occurrences of mud-ball tuff in South-eastern Queensland are at a few localities within the Brisbane Tuff of Triassic age.

Mr. C. C. Morton exhibited a fulgerite from Moreton Island. This fulgerite has been described in the "Queensland Government Mining Journal," January, 1947, p. 20.

Mr. C. H. V. Harding gave a short non-technical discussion on the design and construction of the new Burdekin River Bridge, and illustrated his remarks with a 1 in 48 scale model of the main pier and two plans.

Abstract of Proceedings, 29th September, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 29th September, with Mr. O. A. Jones (Vice-President) in the chair. About sixty members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. K. R. Levingston was elected to Ordinary Membership. Professor L. J. A. Teakle and Mr. T. A. Lang were proposed for Ordinary Membership.

The Australian Natural History medallion was presented to Mr. Heber A. Longman on behalf of the Field Naturalists' Club of Victoria. The Vice-President, in presenting the medal, referred on the one hand to the leading part Mr. Longman had taken in the scientific life of the community, twice President of the Royal Society of Queensland, twelve years as its editor, Vice-Chairman of the Great Barrier Reef Committee, &c., as well as his long and successful career as Director of the Queensland Museum. On the other hand he referred to the numerous (over seventy) scientific contributions made by Mr. Longman, especially on fossil reptiles and marsupials—contributions which had received tributes from specialists throughout the world.

Mr. L. J. Webb exhibited specimens of the ripe fruits of "Finger Cherry" (*Rhodomyrtus macrocarpa*). These fruits, which look innocent and appetizing, have a sinister reputation in North Queensland. Over the past fifty or sixty years, certain cases of sudden and permanent blindness in humans (and on two occasions, calves and goats) have been attributed to eating "Finger Cherries." A number of these cases was recently summarised by Dr. Flecker, of Cairns, in the "Medical Journal of Australia." Several remarkable theories have been advanced to explain the alleged effects (e.g., due to transient saponin, fungus, &c.).

Samples of leaves and fruits have now been forwarded (C.S.I.R. Drug Plants Survey) to Dr. F. H. Shaw, Melbourne, and Mr. W. J. Dunstan, Sydney, for pharmacological and chemical assays. When tested in Brisbane, the plant gave negative tests for alkaloids and prussic acid, and positive tests for a certain (steroid?) type of saponin. Also the juice from the leaves (p.o.) was found to cause paralysis of hindquarters in two guinea pigs.

A symposium was held on "Trace Elements in Plants and Animals." Professor L. J. H. Teakle, in opening the symposium, discussed minor elements and plant growth. He said that, as the knowledge of chemistry progresses, it has been posible to determine those elements necessary for plant growth. Nearly 150 years ago, the so-called major elements, such as calcium, magnesium, potassium and phosphorus, were determined as essential, but only recently the list has been extended to include those required in very small amounts for the growth of higher plants. Mazé, of France, in 1914, claimed that zinc and boron were essential, but his conclusions were not accepted by most workers. However, it was established beyond doubt that the following elements in very small quantities were required by plants:—Boron, by Miss K. Warington at Rothamsted in 1923; zinc, by Lipman and Sommer in California in 1926; manganese, by Samuel and Piper in Adelaide in 1929; copper, by Sommer in California in 1931; molybdenum, by Arnon in California in 1937. Besides these there are elements which are recognised as stimulating or possibly essential, including aluminium, silicon, sodium, chlorine, gallium, and nickel. These elements are of more than mere academic interest. Deficiency in the field causes much loss of production on many soil types in practically every agricultural country. Their use has proved of considerable value in the utilising of erstwhile derelict soil in Great Britain during the war period. Field occurrences of copper deficiency in tomatoes, cereals, pastures, maize and currants, and of zinc deficiency of flax and pine trees were shown on the screen. Specimens of plants showing copper and zinc deficiencies were exhibited. Minor element deficiencies are not responsible for all unsatisfactory plant growth by any means. However, the deficiencies are important factors on some soil types, particularly the sandier and poorer soils, but also sometimes on the better-class types. When crops have shown evidence of deficiency, good results have been obtained in their connection, and it can be expected that these minor elements will play an increasingly important part in Australian agriculture in the future. Diagnosis of minor element deficiencies is accomplished by several means:—(1) Leaf and other plant symptoms; (2) consideration of the mineral complex, and other soil properties; (3) analysis of the plant or parts of the plant; (4) responses of the plant to injections and soil treatments; (5) measurement of the effect of curative treatment on the yield and quality of the crop.

Mr. G. Moule gave a brief description of the work on copper deficiency of sheep undertaken by Dr. Bennetts between 1932 and 1942 in the Gin Gin (W.A.) area. He also received the information available from the C.S.I.R. Nutrition Laboratory, Adelaide, in connection with Coast Disease of sheep, which is due to a dual deficiency of copper and cobalt. He described the work which had been carried out in Queensland by Mr. J. Lee and himself since 1945, and demonstrated wool samples which showed copper deficiency and the beneficial effects of copper supplementation. A short film showing enzootic anoxia of lambs was shown.

Abstracts of Proceedings, 27th October, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 27th October, with the President (Mr. E. M. Shepherd) in the chair. About forty members and friends were present. The minutes of the previous meeting were read and confirmed. Professor L. J. H. Teakle and Mr. T. A. Lang were elected to Ordinary Membership. Mr. Grahame Gipps was nominated for Ordinary Membership.

Mr. D. F. Robertson gave an address entitled "The Application of Radioactive and Stable Isotopes in Tracing the Metabolism of Living Tissues." The progress of particular elements and compounds through many living organisms, the synthesis of organic compounds and the mechanism leading up to their excretion have been very difficult to determine by standard methods of analysis. A sensitive means of following a particular sample of an element through obscure reactions has come into extensive use whereby the normal atoms of the element have an unusually high proportion of a rare isotope of that element mixed with them. Two parallel types of investigation have developed—one employing the rarer stable isotopes, the other, artificially produced radioactive isotopes. The progress of the element loaded with a rare stable isotope may be followed by detecting proportions of that isotope greater than normal. The change in proportion indicates the extent to which the test material has been absorbed into a particular specimen of the tissue. The mass-spectrograph is the outstanding apparatus for analysis of such isotope mixtures, but reliable information may be found by density determinations of high accuracy. Radioactive tracer elements are detected by the rays they emit. Measurements of activity may be made directly on the living body but have a much wider application where samples of activated tissues may be removed for detailed examination. Detailed distribution of activity may be recorded by placing a tissue section in contact with a photographic film. The elements of widest organic application are hydrogen, carbon, nitrogen and oxygen. Of these, nitrogen and oxygen have no radioactive forms lasting long enough to be of use. The rays of active hydrogen, H^3, are very weak. Carbon has two active forms, C^{11} (half life 21 minutes) and C^{14} (half life 5,000 years). Stable isotopes are used most in this field.

Growth of bone is revealed by the uptake of radioactive calcium or strontium, there being higher activity in regions where new bone is being laid down most rapidly. Radioactive iron has given valuable information through the conversion of inorganic iron into haemoglobin. Radioactive sodium has a special use in indicating the amount of blood circulating to various parts of the body as an aid in diagnosis of diseases restricting flow of blood to extremities. The increased concentration of phosphorus in rapidly growing malignant tissues has led to the administration of radioactive phosphorus in quantities great enough for the radiation to destroy sensitive malignant tissue such as is widely disseminated in persons suffering from leukemia or polycythemia vera. Iodine is applied similarly to control over-active thyroid glands. Tracer elements are being applied in a variety of ways toward revealing more of the normal and abnormal physiology of plants and insects.

Abstract of Proceedings, 24th November, 1947.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 24th November, with the President (Mr. E. M. Shepherd) in the chair. The minutes of the previous meeting were read and confirmed. Mr. Grahame de V. Gipps was elected to Ordinary Membership.

The following papers were presented:—

"Three Species of Endiandra (Family Lauraceae) from Eastern Australia," by C. T. White.

"Studies in Queensland Grasses III.," by S. T. Blake.

"Studies in Australian Apocynaceae and Asclepiadaceae I.," by S. T. Blake.

"Genus Tabanus in Australia," by G. H. Hardy.

PUBLICATIONS RECEIVED.

The following Institutions and Societies are on our Exchange List, and their publications are hereby gratefully acknowledged.

ARGENTINE—

Dereccion general de Estadistica, Buenos Aires.
Observatorio M. Lasagna.
Universidad de Buenos Aires.
Universidad National de La Plata.

AUSTRALIA—

General—

A.W.A.
Australasian Association for the Advancement of Science.
Australasian Institute of Mining Engineers.
Australian Chemical Institute.
Australian Institute of Mining and Metallurgy.
Australian Journal of Experimental Biology and Medical Science.
Australian Science Abstracts.
Australian Veterinary Society.
Council for Scientific and Industrial Research.
Standards Association of Australia.

Federal Government—

Commonwealth Bureau of Census and Statistics, Canberra.
Department of Health.
Forestry Bureau.

New South Wales—

Department of Agriculture, Sydney.
Australian Museum, Sydney.
Botanic Gardens, Sydney.
Department of Fisheries, Sydney.
Department of Mines, Sydney.
Geological Survey.
Linnean Society of New South Wales.
Naturalists' Society of New South Wales.
N.S.W. National Herbarium.
Public Library, Sydney.
Royal Society of New South Wales.
Technological Museum, Sydney.
University of Sydney.

Queensland—

Crohamhurst Observatory.
Department of Agriculture, Brisbane.
Department of Mines, Brisbane.
Government Statistician, Queensland.
North Queensland Naturalists' Club.
Queensland Museum, Brisbane.
Queensland Naturalists' Club, Brisbane.
Queensland, University of.
Royal Geographical Society of Australasia (Queensland), Brisbane.

South Australia—

Adelaide, University of.
Department of Mines, Adelaide.
Geological Survey, Adelaide.
Public Library, Museum and Art Gallery, Adelaide.
Royal Geographical Society of Australasia, Adelaide.
Royal Society of South Australia.
Royal Society of South Australia, Field Naturalists' Section.
Waite Agricultural Research Institute.

Tasmania—

Geological Survey.
Mines Department.
Queen Victoria Museum, Launceston.
Royal Society of Tasmania.
Tasmania, University of.

Victoria—

Department of Agriculture, Melbourne.
Department of Mines, Melbourne.
Field Naturalists' Club of Victoria.
Geological Survey.
McCoy Society, Melbourne.
National Museum, Melbourne.
Royal Society of Victoria.

Western Australia—

Geological Survey.
Mines Department, Perth.
Royal Society of Western Australia.

AUSTRIA—

Naturhistorisches Museum, Vienna.

BELGIUM—

Académie Royale de Belgique.
Société Royale de Botanique de Belgique.
Société Royale Zoologique de Belgique.

BRAZIL—
Instituto de Biologia Vegetal, Rio de Janeiro.
Instituto Oswaldo Cruz, Rio de Janeiro.
Government. Departmento Nacionale da Produccao Animal.
Government. Servico Geologico e Mineralogico.
Ministerio de Agricultura Industria y Commercio, Rio de Janeiro.
Museu Paulista, Sao Paulo.
Universidade de Sao Paulo.

CANADA—
Department of Agriculture, Ottawa.
Department of Mines, Ottawa.
Geological Survey, Ottawa.
Nova Scotian Institute of Science.
Royal Astronomical Society of Canada.
Royal Canadian Institute.
Royal Society of Canada.

CEYLON—
Ceylon Journal of Science.
Colombo Museum.

CHILE—
Sociedad de biologia de Conception.

CUBA—
Sociedad Geografica de Cuba, Habana.
Universidad de Habana.

CZECHOSLOVAKIA—
Acta botannica Bohemica.
Charles University, Prague.
Czechoslovakian Entomological Society.
Masarykova Universita, Brno.

DENMARK—
The University, Copenhagen.

ESTONIA—
Tartu University.

FINLAND—
Societas pro fauna et flora fennica.

FRANCE—
Marseille Faculté des Sciences.
Montpellier, University of.
Museum National d'Histoire naturelle, Paris.
Société botanique de France.
Société des Sciences naturelles de l'Ouest, Nantes.
Société entomologique de France.
Société française de microscopie.
Société géologique et mineralogique de Bretagne, Rennes.
Société scientifique de Bretagne, Rennes.
Station Zoologique de Cette.

FORMOSA—
Taihoku Imperial University.

GERMANY—
Akademie der Wissenschaften, Leipzig.
Badische Landsverein für Naturkunde.
Bayerische Akademie der Wissenschaften, Munich.
Botanische Garten u. Museum, Berlin.
Deutsche Entomologische Institut.
Deutsche Geologische Gesellschaft, Berlin.
Deutsche Kolonial- und Uebersee Museum, Bremen.
Gesellschaft für Erdkunde, Berlin.
K. Leopoldinisch-Carolinische deutsche Akademie der Naturforscher, Halle.
Museum für Naturkunde, Berlin.
Naturhistorisch-medizinischer Vereins, Heidelberg.
Naturhistorischer Verein der preus. Rheinland und Westfalens, Bonn.
Naturwissenschaftlicher Verein zu Bremen.
Reichsamt für Wetterdienst, Berlin.
Sächsische Akademie der Wissenschaften, Leipzig.
Senckenbergische Bibliothek, Frankfurt a. Main.
Zentralblatt für Bakteriologie, *etc.*
Zoologisches Museum, Berlin.
Zoologisches Museum, Hamburg.

GOLD COAST—
Geological Survey.

GREAT BRITAIN—
Botanical Society of Edinburgh.
Bristol Museum and Art Gallery.
British Museum (Natural History), London.
Cambridge Philosophical Society.
Conchological Society of Great Britain and Ireland, Manchester.
Imperial Agricultural Bureaux.
Imperial Bureau of Plant Genetics, Aberystwyth.
Imperial Institute of Entomology, London.
Leeds Philosophical and Literary Society.
Manchester Literary and Philosophical Society.
Rothamsted Experimental Station.
Royal Botanic Gardens, Kew.
Royal Empire Society, London.
Royal Society of Edinburgh.
Royal Society of London.
Wales, University College of.

HAWAII—

Bernice Pauahi Bishop Museum, Honolulu.

HOLLAND—

K. Akademie van Wetenschappen te Amsterdam.
Royal Netherlands Academy.
Technische Hoogeschool, Delft.
University of Amsterdam.

INDIA—

Geological Survey of India.
Imperial Agricultural Research Institute, New Delhi.

IRELAND—

Royal Dublin Society.
Royal Irish Academy, Dublin.

ITALY—

R. Accademia delle Scienze dell' Instituto di Bologna.
R. Instituto superiore agrario di Bologna.
Museo civico di storia naturale, Genoa.
R. Scuola superiore d'agricoltura in Portici.
Societa Toscana di Scienze Naturali, Pisa.

JAPAN—

Agricultural Chemical Society of Japan.
Japanese Journal of Zoology.
Kyoto Imperial University.
National Research Council of Japan, Tokyo.
Ohara Institut, Kurashiki.
Tokyo Bunrika Daigaku.
Tokyo Imperial University.

MEXICO—

Academia nacional de ciencias Antonio Alzate.
Instituto Geologico de Mexico.
Observatorio Meteorologico Central, Tacubaya.
Secretario de Agriculture y Fomento.

NETHERLANDS INDIES—

Jardin Botanique, Buitenzorg.
K. Naturkundige Vereeniging in Ned.-Indië.

NEW ZEALAND—

Auckland Institute and Museum.
Department of Scientific and Industrial Research, Wellington.
Dominion Laboratory, Wellington.
Dominion Museum, Wellington.
Geological Survey of New Zealand.
Royal Society of New Zealand.

PERU—

Sociedad Geologica del Peru.

PHILIPPINES—

Bureau of Science, Manila.

POLAND—

Geological Institute, Warsaw.
Panstwowe museum zoologiczne.
Polskie Towarzystwo Przyrodnikow im Kopernika, Lwow.
Sociétés Savantes Polonaises.
University of Lwow.

PORTUGAL—

Academia Polytechnicada, Oporto.
Instituto Botanico, Coimbra.
Sociedade Broterniana, Coimbra.

RUSSIA—

Academy of Sciences, Leningrad.
Bureau of Applied Entomology, Leningrad.
Laboratory of Palaeontology, Moscow University.
Lenin Academy of Agriculture Sciences, Leningrad.

SOUTH AFRICA—

Durban Museum, Natal.
Geological Society of South Africa, Johannesburg.
Natal Government Museum, Pietermaritzburg.
National Museum, Bloemfontein.
South African Museum, Capetown.
Transvaal Museum, Pretoria.

SPAIN—

Real Academia de Ciencias, Madrid.
Academia de Ciencias de Zaragoza.
Real Academia de Ciencias y Artes de Barcelona.
Museo de Historia Natural, Valencia.

SWEDEN—

Göteborgs K. Vetenskaps-och Vitterhets Samhället.
K. Fysiografiska Sällskapet, Lund.
Uppsala University.

SWITZERLAND—

Naturforschende Gesellschaft, Zurich.
Société de Physique et d'histoire naturelle, Genève.

TRINIDAD—

Imperial College of Tropical Agriculture.

URAGUAY—

Museo de historia natural, Montevideo.

UNITED STATES—

Academy of Natural Sciences, Philadelphia.
Academy of Science, St. Louis.
American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
American Museum of Natural History, New York.
American Philosophical Society, Philadelphia.
Arnold Arboretum, Jamaica Plain.
Boston Society of Natural Sciences.
Buffalo Society of Natural History.
California Academy of Sciences.
California, University of.
California, University of, Los Angeles.
Carnegie Institution, Washington.
Cornell University.
Federal Government—
  Bureau of Standards.
  Department of Agriculture.
  Geological Survey.
  Library of Congress.
  Public Health Service.
Field Museum of Natural History, Chicago. (Now under new name.)
Florida State Geological Survey.
Harvard University.
Illinois Natural History Survey.
Illinois, University of.
Indiana Academy of Science.
Institute of Biological Research, Baltimore.
Iowa, University of.
John Crerar Library, Chicago.
Johns Hopkins University.
Kansas Academy of Science, Lawrence.
Kansas, University of.
Lloyd Library, Cincinnati.
Michigan Academy of Arts, Science, and Letters.
Michigan, University of.
Minnesota Geological Survey.
Minnesota, University of.
Missouri Botanic Garden, St. Louis.
Museum of Comparative Zoology, Harvard.
National Academy of Science, Washington.
National Research Council, Washington.
New York Academy of Sciences.
New York Zoological Society.
Ohio State University.
Portland Society of Natural History.
Puget Sound Biological Station, Seattle.
Rochester Academy of Science.
San Diego Society of Natural History.
Smithsonian Institution, Washington.
State College of Washington, Pullman.
United States National Museum, Washington.
Vanderbilt Marine Museum, Huntington.
Western Society of Engineers, Chicago.
Wisconsin Academy of Arts, Science, and Letters, Madison.
Wistar Institute of Anatomy and Biology, Philadelphia.
Yale University—
  Bingham Oceanographic Laboratory.
  Peabody Museum of Natural History.

List of Members.

Honorary Life Members.

*Bennett, F., B.Sc.	"Irby," 25th North Street, Mackay.
*Henderson, J. B., O.B.E., F.C.S., F.I.C.	c/- Mrs. L. Crawford, Laurel Avenue, Chelmer, S.W. 3.
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Life Members.

East, J. D., B.Sc.	District Geologist's Office, Rockhampton.
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*White, C. T.	Government Botanist, Botanic Gardens, Brisbane.

Corresponding Members.

*Domin, Dr. K.	Czech University, Prague.
Gregory, Professor W. K.	Columbia University, New York.
*Skeats, Prof. E. W., D.Sc.	The University, Melbourne, Victoria.

Ordinary Members.

Archibald, Dr. L., M.Sc., M.B., B.S.	Health Department, Brisbane.
Atherton, D. O., M.Agr.Sc.	Department of Agriculture and Stock, Brisbane.
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Bick, I. R., M.Sc.	The University, Brisbane.
*Blake, S. T., M.Sc.	Botanic Gardens, Brisbane.
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Boardman, W., M.Sc.	Zoology Department, University, Melbourne.
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*Bostock, J., M.D., B.S., D.P.M., M.R.C.S., L.R.C.P.	Wickham Terrace, Brisbane.
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Boys, R. S., L.D.S.	P.O. Box 135, Toowoomba.
Braes, E. M.	Zinc Corporation, Cobar, N.S.W.

* Members who have contributed papers to the Society.

Brameld, H. G., B.E.	"Green Gables," Highland Terrace, St. Lucia Heights.
*Briggs, Mrs. C.	First Avenue, Eagle Junction, Brisbane.
Brimblecombe, A. R., M.Sc.	Department of Agriculture and Stock, Brisbane.
*Briton, N. W., B.Vet.Sc.	Agricultural College, Lawes.
Brown, Jas., B.A., M.D., Ch.B. (Edin.), D.Ph. (Cambridge)	"Widmoorene," Margaret Street, Toowoomba
Browne, H. V.	Cavendish Road, Coorparoo.
*Bryan, Professor W. H., M.C., D.Sc.	The University, Brisbane.
*Bryan, W. W., M.Agr.Sc.	Agricultural High School and College, Lawes.
Buzacott, J. H., M.Sc.	Sugar Experiment Station, Box 146, Gordonvale.
Byth, Mrs. G.	Physiology Department, University, Brisbane.
Caldwell, N. E. H., M.Agr.Sc. ..	Department of Agriculture and Stock, Brisbane.
Callaghan, J. P., M.Sc.	Institute of Medical Research, Herston Road, Brisbane.
Campbell, Miss B., B.Sc.	The University, Brisbane.
Cardno, G. F., B.E.	New Zealand Chambers, Queen Street, Brisbane.
Carson-Cooling, Geo., M.Sc.	172 Wilston Road, Brisbane.
Carter, S. B.Sc.	187 Waterworks Road Ashgrove, W. 3.
Cawley, Miss B. V., B.Sc.	Chemistry Department, University, Brisbane.
Chamberlain, W. J., D.Sc.	City Chemist, City Hall, Brisbane.
Chapman, C. C.	Coronation Drive, St. Lucia, Brisbane.
Chippendale, F., M.Agr.Sc.	Department of Agriculture and Stock, Brisbane.
Christian, C. S., M.Sc.	Division of Plant Industry, C.S.I.R., Canberra.
Cilento, Sir R. W., M.D., B.S. ..	Department of Health, Brisbane.
Clark, C., M.A.	Bureau of Industry, Brisbane.
Clarke, Miss H.	c/- W. Peterman, Box 194C, G.P.O., Brisbane.
Coleman, F. B.	Department of Agriculture and Stock, Brisbane.
Common, I. F. B., B.Agr.Sc. ..	Department of Agriculture and Stock, Rockhampton.
Connah, T. H., M.Sc.	Geological Survey Office, Brisbane.
Coote, Miss D., B.Sc.	Chemistry Department, University, Brisbane.
Cottrell-Dormer, W., M.Agr.Sc. ..	Department of Agriculture, New Guinea Administration, Port Moresby, New Guinea.
Cribb, H. G., B.Sc.	Geological Survey Office, Brisbane.
Croll, Gifford, M.B.	Sherwood, Brisbane.
Cummings, R. P., M.A.	University of Queensland, Brisbane.
Daniels, C. L.	Mount Isa Mines Ltd., Mount Isa.
Davenport, J. B., B.Sc.	Chemistry Department, University, Brisbane.
de Jersey, N. J., M.Sc.	Durack Street, Moorooka, Brisbane.
*Denmead, A. K., M.Sc.	District Geologist's Office, Charters Towers.
Dimmock, T. D., B.Sc.	C/o Dental Hospital, Turbot Street, Brisbane.
*Dodd, Alan P., O.B.E.	Prickly-pear Laboratory, Sherwood, Brisbane.

* Members who have contributed papers to the Society.

Donaldson, R. J.	care of Gibbs, Bright, and Co., Queen Street, Brisbane.
Earnshaw, P. A., M.B., Ch.M., F.R.A.C.P.	Ballow Chambers, Wickham Terrace, Brisbane.
Edmiston, E. S., M.Sc.	The University, Brisbane.
Elliott, T. M. B.	Stanford X-ray Co. Pty., Ltd., Wickham Terrace, Brisbane.
Ellis, C., B.E.	Forestry Department, Brisbane.
England, Miss D., B.Sc.	Biology Department, University, Brisbane.
Erskine, T. W., T.T.S.C.	Brisbane Boys' College, Toowong
Evans, C. K., M.Sc.	Piper Street, Ipswich.
Everist, S. L., B.Sc.	Botanic Gardens, Brisbane.
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Vol. LIX., Part 2.

PROCEEDINGS

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OF

QUEENSLAND

FOR 1948

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CONTENTS.

Vol. LX.

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Vol. LX., No. 1.

Proceedings of the Royal Society of Queensland.

Presidential Address :

By E. M. Shepherd, M.E., A.M.I.C.E., A.M.I.E., Aust.

(*Delivered before the Royal Society of Queensland, 30th March,* 1948; *issued separately, 24th November,* 1949.)

Your Excellency,

Ladies and Gentlemen,

Since the last Annual General Meeting, this Society has suffered the grievous loss of six of its very distinguished members. With deep regret I refer to the deaths of Professors H. C. Richards, R. W. H. Hawken, E. J. Goddard—all three Past Presidents of the Society—and Doctors G. P. Dixon, S. F. McDonald, and A. Jefferis Turner.

Professor Richards was twice President, and was always a very good friend to the Society. A very energetic worker, geological science owes much to him. He will be particularly remembered for work on the geology of South-Eastern Queensland and the Great Barrier Reef, but his keen interest in scientific research extended beyond the sphere of geology.

Professor Hawken's reputation as an engineer extended far beyond the walls of his University and his professional advice was freely sought for special work. An original thinker, he made some notable contributions to engineering knowledge. Few men have been held in greater personal and professional esteem by other members of his profession.

Professor Goddard will be remembered for the successful application of his biological knowledge to national problems—particularly in agriculture—and the prominent part he played in the foundation and organization of the Medical School. He also took a deep interest in marine biology.

All three of these men, besides carrying out their professorial duties with great distinction, were also notable for outstanding work in a wider sphere.

Doctor G. P. Dixon had a distinguished career as a Surgeon and was awarded the order of C.B.E. for outstanding work in the first world war. He was for many years associated with the Children's Hospital in Brisbane.

Doctor S. F. McDonald was one of the best known Paediatric Physicians in Brisbane. In the first world war he had a distinguished career with the Royal Army Medical Corps, and in the second he did outstanding specialized work for the R.A.A.F., in which he attained the rank of Group Captain.

By most of us, Doctor A. Jefferis Turner will be remembered for the wonderful work he did for the health of the children of Queensland when he was Director of Child Welfare. The scientific world will also remember him as a world authority on Australian Lepidoptera. Dr. Turner's regular contributions have been a feature of our Proceedings, which have contained 15 papers by him, the first in 1903, the last in 1947, and this represents only a small fraction of his contributions to scientific literature.

Of all six, it can be said that they did well by their fellow men.

As you will have noticed in your Council's report, thanks to the co-operation of the Government Printer, Mr. Tucker, there has been notable improvement in the printing of the Society's Proceedings, which had been seriously delayed during the war years. The position, however, is not yet satisfactory.

Another matter of very great concern to your Council has been the tremendous increase in the cost of printing, and it has become clear that either the Society must greatly increase its revenue or decrease its output of original scientific literature, which latter would be a blow to our principal object, namely, the furtherance of the natural and applied sciences. A remedy might be increased membership, and I feel that our membership is much smaller than it should be. For this reason, an appeal was recently sent to all members for their co-operation to increase it.

I regret that no further outstanding progress has been made towards the erection of a "Science House" in Brisbane, as the building position is still prohibitive. The kindred Scientific Societies of Brisbane have not, however, abandoned this objective of being housed under a common roof. An outstanding advantage of this would be that library resources of the several societies might be pooled with outstanding benefit to all. At present, the lack of easily accessible scientific library facilities in Brisbane is a disgrace to all concerned.

And now, before I become more technical, I should like to express my thanks to the Members of the Council, whose harmonious co-operation has made my term of office a pleasurable experience, and particularly to our Secretary, on whom has fallen the greatest burden of keeping the Society going; and above all I desire to place on record our deep appreciation of the splendid service rendered to the Society by Mr. E. W. Bick who is now retiring from the position of Honorary Treasurer which he has occupied for twenty-six years.

SOME FACTORS IN THE HYDROLOGY OF QUEENSLAND.

For the main theme of my address to-night, I propose to discuss some of the hydrological factors which have had much influence on the development of natural resources in Queensland.

The importance of expanding agriculture and husbandry in the hungry world of to-day is too well known to need emphasising, and a primary need is for clear thinking on the subject of our natural resources—particularly those of land and water—if our national efforts are to produce the greatest possible return in the future. It was not without justification that Sir David Rivett in the course of his Macrossan Memorial Lecture in 1944, suggested that Australia could be granted less than second class honours for its soil and climate. Queensland, as a whole, can claim no more than this for her water resources and the total quantity of water carried by her streams is comparatively very small. While saying this, I have not lost sight of the fact that we can boast a locality which, due to the influence of the massive Bellenden Ker Range, has the highest rainfall in Australia, and is one of the wet spots of the world, nor am I forgetting the tremendous floods that frequently have followed in the wake of tropical cyclones, and the excellent farm lands which do exist. The truth is that the wet areas suitable for agriculture form a comparatively narrow strip along the eastern coast, and that drought occurs with at least as much regularity as floods. This is a fact which is very often overlooked.

Why do we have this problem ? A consideration of climate as a long-period integration of day-to-day weather conditions, and their resultant effect on soil and vegetation may provide much of the answer, but it can best be explained by examining the various phases of the hydrologic cycle by which moisture is transferred from the ocean to the land and thence back to the ocean with its various adventures on its way.

The hydrologic cycle is initiated by radiation from the sun. As a result of insolation, water is evaporated from the ocean and the moisture-charged air is carried over the land. Here the moisture-content may be supplemented from land sources—water which has been evaporated from streams, swamps, lakes and wet ground, or transpired from the leaves of vegetation—and the air-mass travels on until favourable conditions cause it to discharge portion of its moisture as rain. This rain falls on vegetation, ground or water-surface. Some of it evaporates rapidly from wet surfaces and puddles, some of it infiltrates into the ground, some of it runs off into ponds and streams which feed the rivers by which the water not evaporated on the way returns to the ocean.

Of the water that infiltrates the ground, some of it is used by growing vegetation and is eventually transpired back into the atmosphere. Some of it continues underground to emerge eventually in springs, wells, or perhaps artesian bores. Over a long period, the cycle must be in a general state of equilibrium; the moisture in the air masses which crossed from sea to land, less that which is carried across the coast back over the sea, must equal the water carried to the sea by the rivers.

In the case of Queensland, this volume is estimated to be only a small percentage of the total volume which falls as rain. Most of the water from rain is re-evaporated.

I shall now attempt to review the major processes in the hydrological cycle as it concerns Queensland, beginning with precipitation. Here, the only important form of precipitation is rain. Snow is a rarity.

RAIN.

The prevailing fashion in meteorology is to work in terms of air-mass movements and the fronts along which masses of air having different properties or characteristics meet, and some meteorologists go so far as to claim that all the important rain-producing influences—except, perhaps, orographic conditions where the influence of high mountains predominate—are frontal in character.

There are several different types of air-mass movement which affect the weather of Queensland, and a review of the prevailing rain-producing influences and their relative importance may be of interest.

Rimmer, Hall and Hassock (1939) in their analysis of Queensland rainfall classified it into :—

(1). Coastal instability rain due to the influence of the coast on moist unstable air, *i.e.*, air with a high lapse-rate.

(2). Thunderstorm instability rain due to heat thunderstorms originating in stagnant air.

(3). Cyclonic rain associated with closed areas of low pressure round which there was the characteristic wind circulation.

(4). Rainfail associated with frontal discontinuities and any other causes.

Twelve stations in Queensland were selected by them and were analysed for each of these rain-conditions for a twelve-year period 1925–1936. Although the stations are too widely scattered and the period too short for an accurate quantitative analysis, a fairly satisfactory picture of the prevailing causes of rain over the whole State can be obtained. In Table I an attempt has been made to show roughly the origin of rainfalls in the different parts of Queensland based on this analysis, the approximate proportion of the total average annual rainfall which belongs to each class being therein indicated.

TABLE I.

Approximate Proportions of Rain of Various Origin in Queensland, Mainly Based on Analysis by Rimmer, Hall and Hossack, shown as Percentage of Annual Value :—

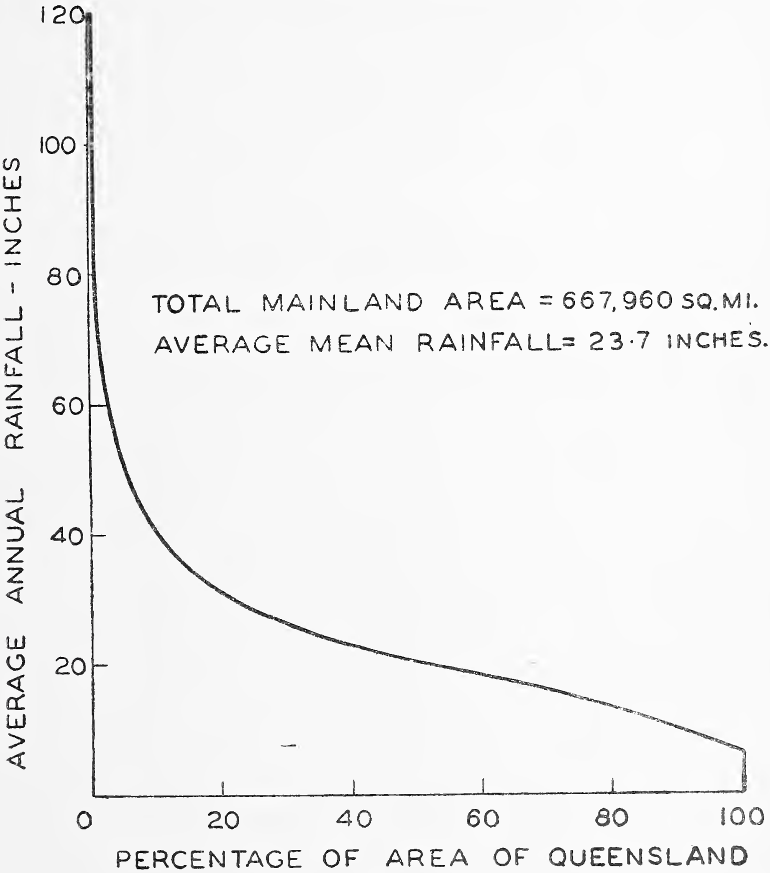
Region.	Approximate Range of Average Annual Rainfall.	Class of Rain. (1) Coastal Instability Rain.	(2) Thunderstorm Instability Rain.	(3) Cyclonic Rain.	(4) Frontal Rain and Other Causes.
	Inches.	Per cent.	Per cent.	Per cent.	Per cent.
Far North-West (Gulf) ..	20–60	Under 5	About 55	About 15	25–30
Wet North Coastal Strip (Cairns Area)	Over 50	Over 50	About 15	About 25	5–10
Northern Sub-coastal (Highland) area.. ..	25–40	5–15	30–40	10–20	25–35
South-East Coastal Area..	35–60	25–40	20–30	15–20	25–35
South-East Sub-coastal (Highland) area.. ..	25–35	5–10	30–35	10–15	40–50
Central West	15–25	Nil	30–35	5–10	55–65
Far South-West	Under 15	Nil	30–40	5–10	55–65

These Values can be Regarded as only Approximately Correct, and being Based on Average Values over a Limited Period, do not Necessarily Hold for Any One Year. Rimmer, Hall and Hossack's Analysis Covered the Period 1935 to 1936.

There is a great range in average annual rainfall throughout the State, and as an example of extreme variation, the average rainfall on the seaward slopes of the Bellenden Ker Range in North Queensland exceeds 170 inches per year, over 262 inches being recorded at Babinda in 1939 and over 81 inches from a nearby station (Deeral) in one month, but 50 miles to the west, over the ranges, the annual average rainfall falls off to about 30 inches.

At the lower extreme, Birdsville, in the south-west corner, has an average annual rainfall of about $5\frac{3}{4}$ inches and Rosebeath about $5\frac{1}{2}$ inches. No year seems ever to have been entirely rainless at any station, but official records show that only 79 points of rain fell at Coorabulka and 95 points at Boulia in 1905; and as the maximum amount for any one month was 21 points in the former case, the year was effectively rainless so far as growing vegetation was concerned.

For the whole State, the average mean rainfall is about 23·7 inches. Figure 1 shows in graphical form the relative proportions with given rainfalls. This shows what a small proportion of the State has a high rainfall, that nearly 80 per cent. of the area has less than 30 inches of rain annually, and nearly 50 per cent. has less than 20 inches.



TEXT FIG. 1.

Proportion of Queensland with Average Annual Rainfall Exceeding any Given Value.

Some particular points of interest in connection with rainfall distribution are, that the coastal instability rain is of considerable importance in the winter on the northern sugar-land but does not usually penetrate beyond the coast ranges ; thunderstorm rains are very important to inland areas, but are rather erratic, although liable to provide rain in almost any month with their least influence during the winter ; and cyclonic rains are of utmost importance as flood producers but are also very uncertain and erratic.

Generally speaking, cyclonic rains are restricted to the summer months and mostly affect the northern and eastern areas. For example, the cyclone which devastated Mackay in January 1918, travelled inland over the Fitzroy basin and caused the highest known flooding at Rockhampton. During this flood period, the Fitzroy River discharged some 25 million acre-feet of water, compared with its annual average of about 4,235,000 acre-feet. The terrible 1893 flood in the Brisbane River, the catastrophic flood at Clermont in December 1916, when 61 people lost their lives, and the floods of January, 1947, in the South-Coast rivers, were all due to tropical cyclones. Many more such could be quoted.

How much of the rain grouped into the fourth class is of the normal frontal type associated with the cold fronts which advance from the west and south-west is uncertain, since rain seems more generally to be associated with southward surges of warm moist air from the oceans to the north of Australia. Whatever is the major factor, the results are erratic and no influence produces any regular and reliable rainfall, although this class-group includes perhaps the most important falls of general rain, averaging from about 4 or 5 inches per year in the far south-west to perhaps 14 inches in the south-east, predominantly in summer, but spread fairly well throughout the year.

On the whole, if the land received its average rainfall each year, we would be comparatively well off, but in many country districts, drought is so frequent that enduring it is almost a phase of the national life. The cause is fundamentally due to latitude. It may be recalled that Queensland extends from about latitude 11°S. at Cape York to latitude 29°S., and that most of the deserts in the world are found to occupy much the same latitudes, although admittedly on the western sides of the continents. These latitudes are also those of the south-east trade winds which tend to blow steadily from the south-east except where continental land masses cause considerable modification. Being steady in character and blowing towards warmer areas, trade-winds in either hemisphere generally bring conditions of fine clear weather with few storms, although their regions are subject to spectacular disturbances in the nature of tropical hurricanes which occur usually on the western margins of the ocean trade-wind zones.

The result is that, except where orographic rain occurs (as when the seaward slopes of high coastal ranges have an abnormal influence), the prevailing condition for Queensland is one of fine weather interrupted somewhat erratically both in time and place either by cyclonic depressions which probably originate from the inter-tropical front to the north, mainly in the summer, or by disturbances associated with fronts which are perhaps extreme northward surges from the south polar front.

The effect of the southern frontal influence, which appears to be the most regular of the rain-producing factors in the southern states, becomes increasingly erratic towards the north, but here rain comes more frequently from either tropical or "monsoonal" cyclones, of which the latter are the less spectacular and entering from the west probably bring the most widespread rain. Tropical cyclones from the Coral Sea are the greatest flood-producers for the eastern areas.

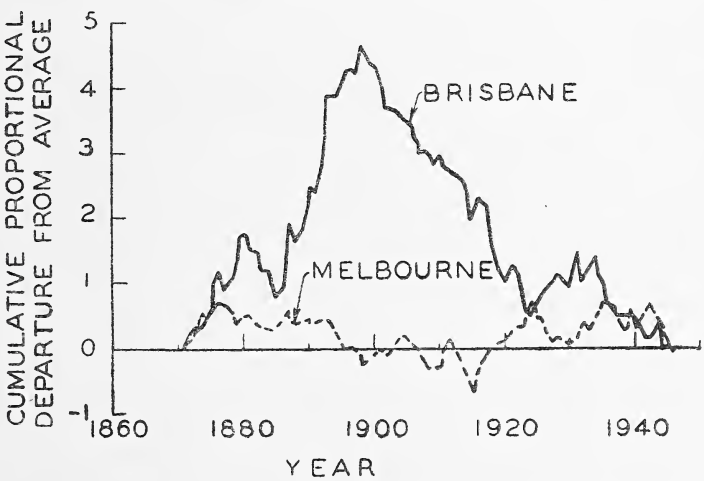
As no rain-bringing influence is constant or regular, with some minor exceptions, rain in Queensland is uncertain in any place and in any month, with the result that years of drought and years of flood are erratically spaced.

In the country, it is customary to hear the "old-timers" state that the seasons are not what they were, and this is actually reflected in rainfall averages. In Brisbane, for example, the average annual rainfall since the start of the century has actually been some ten inches lower than that in the latter half of the nineteenth century. A similar but slightly less decrease in the average has also occurred at Sydney.

As far as Brisbane is concerned, this lower rainfall has been accompanied by much fewer big floods in the Brisbane River, one of the few favourable results.

To test how widespread the reduction has been, averages for two 37 year periods, chosen to make best use of available records, have been worked out for a number of selected stations, and the interesting fact appears that the phenomenon did not occur in the far south where the rainfall is mostly during the winter and is generally due to south-polar frontal influences which are probably much more regular than the factors producing rain in Queensland.

Figure 2 may help to show how average rainfalls have varied at Brisbane and Melbourne respectively. In this diagram the cumulative sum of the proportional variation from the mean have been plotted against the time; *i.e.*, it is a "mass curve" of the proportional variations. Thus an upward slope of the curve indicates that rainfalls were above average, and *vice versa*.



Text Fig. 2.

Trends in Average Annual Rainfalls at Brisbane and Melbourne.

A fall in average rainfall over a large area is a fact. An interesting speculation is whether this is fortuitous; whether it follows some definite cycle; and whether settlement of the country has had any influence.

Personally, I think that available evidence favours the first suggestion. In spite of a prevailing belief that removal of forests causes a reduction of rainfall, such scientific evidence as is available does not support it.

Perhaps the combined effects of clearing land and of grazing on the huge areas of the western plains, with its modification to the grass-cover, might be expected to change the radiation characteristics of the land, or its rate of evaporation or transpiration with some influence on the air-masses thereover. However, as the rain-bringing influences, cyclones and other mass movements, originated far from these areas and the moisture precipitated travelled in from far beyond their borders, it seems unlikely that such influence would be great. Moreover, it might be expected that the effect would be least near the coast, which is not so.

Fluctuation in rainfall and climate over comparatively long periods is not unknown in other lands and has attracted the attention of investigators. Long-period climatic variations have sometimes been evident from the fluctuations in level of large inland lakes and from observed variations in the growth-rings of very old trees, and such variations have been examined by different workers with a view to correlating them with various supposed or known cycles such as sunspot cycles; but the results would seem to be inconclusive.

This question of cycles has always been a very live subject in hydrology, and one which must be approached cautiously. Perhaps the two most commonly quoted are the sunspot cycle of about 11 years and the Bruckner cycle of about 35 years, but the conclusions of the more orthodox schools of meteorology seem generally to discredit their influence in meteorology and hydrology.

Certainly the examination of the discharge of some rivers in Queensland in relation to sunspot numbers has shown no correlation, but the fluctuations of river discharge in the far south appear to follow the sunspot variations a little better. Perhaps the influence of sunspots on air-mass movements and consequent rainfall is too small to be generally felt, but there is some reason to expect that they should influence polar areas more than equatorial ones, if at all.

A sunspot is apparently a gigantic whirlpool or cyclone in the molten or gaseous surface of the sun. It is often associated with a huge flare-up of hot gases from which come streams of charged particles, probably mostly electrons with some positive ions, which, when they reach the neighbourhood of the earth, are concentrated into the polar regions under the influence of the earth's magnetic field. As the arrival of these particles represents the introduction of some energy to the polar atmosphere, it is logical to expect that the influence of sunspots on polar frontal activities and consequently the climate in high latitudes, if at all appreciable, would be greater than their influence on tropical activities.

Failure to correlate certain periodic climatic changes, akin to that in our rainfall-average, led some investigators to try the effect of chance and to conclude that many variations apparently periodic could well be fortuitous. It would seem that the observed fluctuation in the rainfall-average could easily be due to chance also, since the number of samples (*i.e.*, averaged rain-producing conditions for each year) are too small—being not over 100—for reliable statistical treatment. If this is so, it is to be hoped that the average rainfall during the recent period has been below normal, not that it was above normal during the latter part of the nineteenth century, and that the future will bring better rainfalls than we have had recently.

With respect to correlation of climatic data, it may be of interest to quote the following passage from " Science Today," Vol. 2, No. 39 :—

" ADVANCE WEATHER."

" Some of the difficulties confronting the meteorologist who is optimistic enough to attempt seasonal forecasts were well illustrated in a paper lately presented by Sir Gilbert Walker before the Royal Meteorological Society, London.

" Sir Gilbert was led to investigate possible connections between past and present weather in different areas of the world, as part of his efforts, while Director-General of Indian Observatories, to find a satisfactory basis for ' fore-shadowing ' the Indian moonsoon.

" Later, on return to England, he extended his inquiries to include practically all parts of the world. His latest investigation, which has a moral, is on Arctic Ice.

. . . .

" His conclusions may be thus, depressingly, summarized.

" Anyone who had attempted during the twenty years up to 1905 to forecast the amount of ice off the Newfoundland Banks from knowledge of barometric pressure in Iceland and Greenland during the previous winter would have had a fair measure of success.

" Equally, from 1906 onwards, a forecast which would be worth having could have been obtained by forgetting about Iceland and Greenland, and working instead from the pressure at Barrow in Alaska to the North-West.

. . . .

" On the other hand, the pre-1905 formula would have been useless under post-1906 conditions, and vice-versa : nor is there any certainty for the future that pre-1905 conditions will not return.

" The change may have been due, as Sir Gilbert suggests, to a swinging over from the North to the North-West as the main source of Newfoundland ice. This, however would have been of small consolation, after the event, to the forecaster.

"The fact is, the ocean of the air is of enormous extent and, by present methods, literally incalculable ; and no attempted short-cut, in the shape either of local periodicities or of inter-regional connections, has yet stood the one test which matters—that of time."

This quotation has no direct bearing on our problems, but, as stated, it may have a moral.

RUN-OFF.

The lack of permanently flowing rivers in Queensland has often been commented upon. Most of our rivers appear as strings of water-holes or as large dry sandy or gravelly beds in empty flood-channels for most of the year, and springs are—on the whole—rare, showing that the permanent ground water level is comparatively low.

It is estimated that on an average little more than 10 per cent. of the aggregate rainfall over the whole land-area of Queensland ever finds its way back to the ocean, and a great proportion of this run-off is in the far north—the Peninsula and Gulf area where, as yet, it is of little value. The balance must be evaporated, since the proportion that goes underground and could possibly find its way to the sea *via* the artesian beds is almost negligible.

Some of the re-evaporated water probably falls again as rain but this is believed to be of so little importance in Queensland that it may be neglected.

TABLE II.—DATA ON AVERAGE FLOW FROM SELECTED STREAMS.

Stream Catchment.	Catchment Area, Square Miles.	Number of Years Record.	Mean Annual Discharge, Acre Feet.	Lowest Annual Discharge.		Lowest Average Annual Discharge for:— Two Consecutive Years.		Three Consecutive Years.		Four Consecutive Years.		Greatest Annual Discharge.		Approximate Average Mean Rainfall, Inches.
				Acre Feet.	% of Mean.	Acre Feet.	% of Mean.	Acre Feet.	% of Mean.	Acre Feet.	% of Mean.	Acre Feet.	% of Mean.	
Barker's Creek above Holbrook	590	28	42,500	235	0·55	2,610	6·1	2,960	7·0	6,520	15·4	127,600	300	29
Barron River above Kuranda	736	23	622,000	175,450	28·0	245,340	39·4	445,120	71·5	412,650	66·2	1,548,000	249	62
Brisbane River above Lowood	3,950	37	542,000	79,300	14·5	118,300	21·7	233,000	43·0	287,500	53·0	2,095,000	385	33
Condamine River above Killarney	32·6	25	12,200	1,810	14·8	2,190	16·6	4,180	34·4	4,382	36·0	66,940	550	41
Dawson River above Taroom	6,100	30	259,000	11,860	4·6	35,910	13·9	57,740	22·2	113,730	43·8	1,165,000	450	24
Fitzroy River above Yaamba	53,480	23	4,236,000	219,000	5·2	337,350	7·9	710,000	16·8	1,413,000	33·4	28,260,000	668	25½
Lockyer Creek above Tarampa	965	28	58,700	2,770	4·7	4,200	7·2	6,876	11·7	14,910	25·4	308,680	527	29
Logan River above Beaudesert	569	32	107,600	27,420	25·5	32,720	30·5	57,840	53·8	56,760	52·8	454,116	422	35
Stanley River above Silverton	515	28	304,000	47,500	15·6	51,800	17·0	130,000	42·8	212,400	70·0	1,134,000	370	49

Chatley (1938), in an analysis of conditions in the valley of the Yangtse River in China, estimated that an annual average of some 40 inches of rain fell over a catchment aggregating about 750,000 square miles, which is slightly more than the area of Queensland (about 668,000 square miles of mainland area). The mean annual discharge of the river was equivalent to some 14½ inches of this, so that some 35 per cent. of the water returned to the sea. The corresponding figure for the whole world has been variously estimated at from 22 to 30 per cent.

For an area upwards of 100,000 square miles which constitutes the catchments of the Fitzroy and Burdekin River systems, the figure does not appear to exceed 6 per cent. For the Brisbane River, it is probably a little above 9 per cent. Water which falls on a very large part of Queensland never reaches the sea at all, since the rivers draining towards Lake Eyre form a closed system. Hence on general world standards, our proportion of run-off is poor. With the exception of small underground discharges, the balance of the water from rain after evaporation passes off the land generally with northward travelling air-masses, perhaps to be precipitated in the region of the inter-tropical front, in the Indian Ocean or Africa.

If we could obtain our average run-off each year, we might be reasonably well-off, but all too frequently, a year and more will pass with almost negligible run-off, a fact which is frequently not appreciated.

To illustrate the erroneous conclusions which may be drawn from average figures only, let us consider the run-off figures for some selected streams shown in Table II. Here, the values of run-off for one dry year, two, three and four consecutive dry years respectively are shown as a percentage of the mean. This table illustrates why we have so few large irrigation and hydro-electric schemes, since, to make water available, it is necessary to find some means of storing almost the whole requirements for upwards of two years, and this stored water is subject to a very high evaporative loss. Far too often when a good dam site can be found, there is too little water to exploit it, and when there is enough water, no storage of sufficient capacity can be found.

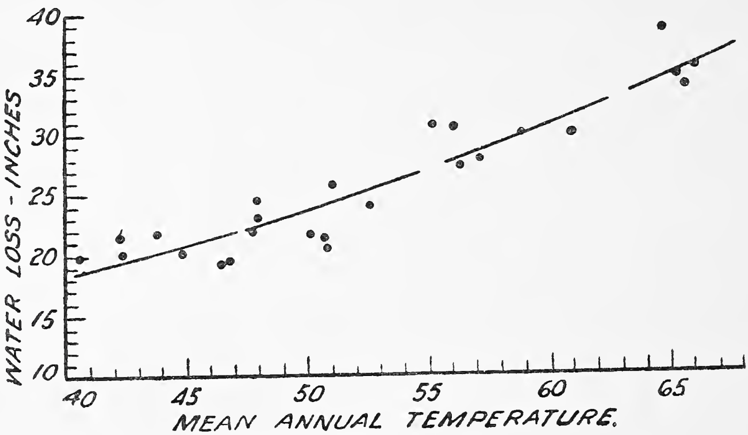
Some of the most widely publicised proposals for huge schemes are but " pipe dreams," based on wishful thinking instead of true engineering.

When possible, actual run-off is measured by gauging flows, but it is obviously not practicable to gauge all streams, and hence it is of the utmost importance to be able to estimate run-off from rainfall records which are frequently all the information available. Moreover, as hydrologists and engineers cannot yet predict the future, the probable behaviour of a scheme has to be analysed in the light of past events for which the keeping of accurate records is essential. Text-books provide many formulae, excellent for the conditions for which they were worked out, but found to be of little value here in Queensland, and to understand why this is so it is necessary to consider the factors which influence run-off.

Stream-flow or run-off represents the portion of the rainfall which is left after evaporation, transpiration and seepage into deep ground-water have taken their quota, and hydrologists generally regard it as a residual component. Consequently, in stream-flow analysis, it is usual to think in terms of " losses " which have to be subtracted from rainfall to give run-off, rather than to regard run-off as a proportion of the rainfall. This line of argument at any rate is much more workable in practice.

The relationship between rainfall and run-off varies almost from day to day and is dependant on such factors as rainfall intensity, temperature, condition of existing vegetation, soil-moisture present, relative humidity and wind. The inter-relationship between the various factors is very complex and is still only imperfectly understood. However, empirical formulae may often be obtained to express the average or integrated conditions with fair reliability but which fail to provide short-period accuracy, and from meteorological data, we may be able to predict the average discharge of a stream without being able to determine with comparable accuracy the run-off following any given storm.

Research in America by Williams and others (1940) has shown that where the rainfall is adequate to maintain stream-flow throughout the year, long-period average catchment losses, when estimated as the equivalent depth of water over the catchment, vary from about 18 inches a year for a mean annual temperature of 39°F. to about 35 inches for a mean annual temperature of 65°F., and the average run-off is, of course, equal to the difference between the mean precipitation and losses. Some results of the investigations are shown in Fig. 3.



TEXT FIG. 3.

Comparison of Mean Annual Water Loss and Mean Annual Temperature for Selected Basins in U.S.A. with Mean Annual Precipitation in Excess of 30 Inches. (After Williams.)

However, in regions such as most of Queensland where the rain is insufficient to satisfy all the potential evaporation and needs of vegetation for many months of the year, run-off occurs only during limited periods when the rate of precipitation exceeds that of evaporation, transpiration and other losses, and the amount of the potential loss which is satisfied depends largely on the intensity and duration of the rain, making it unpredictable.

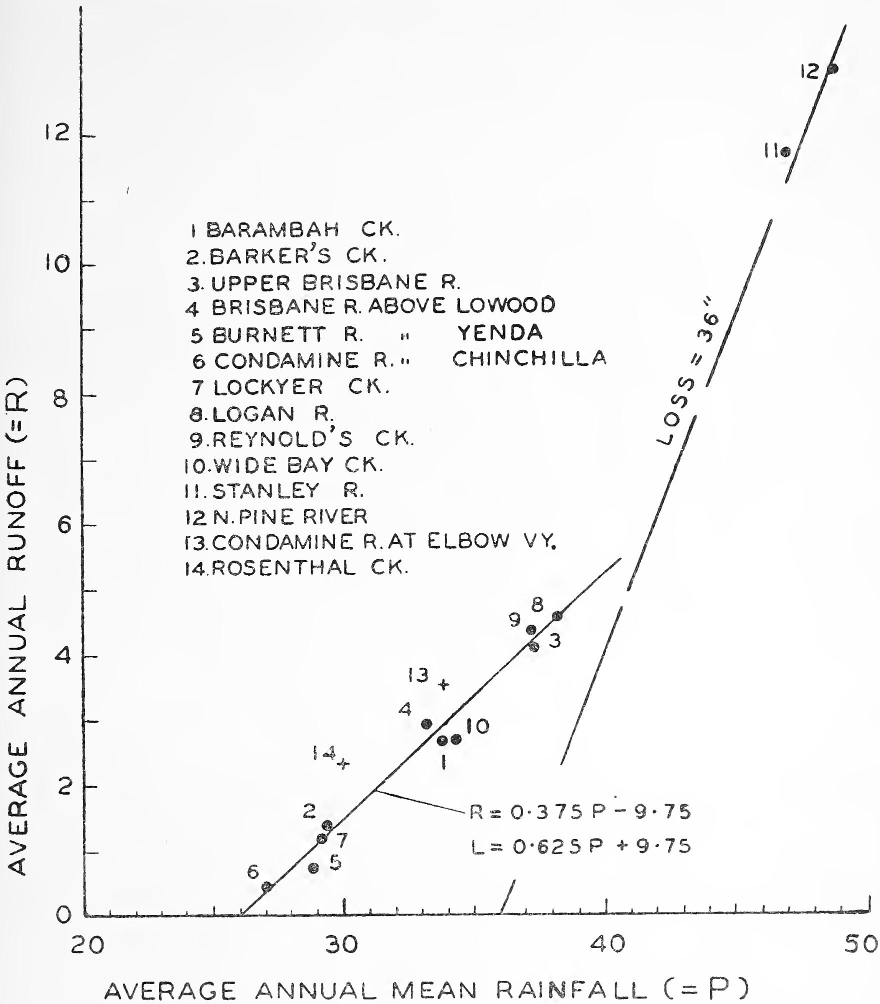
Over long periods, however, they tend to average out fairly well and, when the mean temperature is much the same, the average run-off may be given approximately by a formula of the type :—

$$R = AP - B,$$

and water loss as

$$L = P - R = (1 - A)\ P + B\ ;\ i.e.,\ L = CP + B\ ;\ \text{where}$$

R is average annual run-off given as inches depth in the catchment, P is average annual precipitation and L the average annual water-loss in the same units; A, B, and C are constants; B is about 10, and little run-off ever occurs when the mean rainfall is less than 20 inches per annum, although in a colder climate, this rainfall might produce substantial run-off.

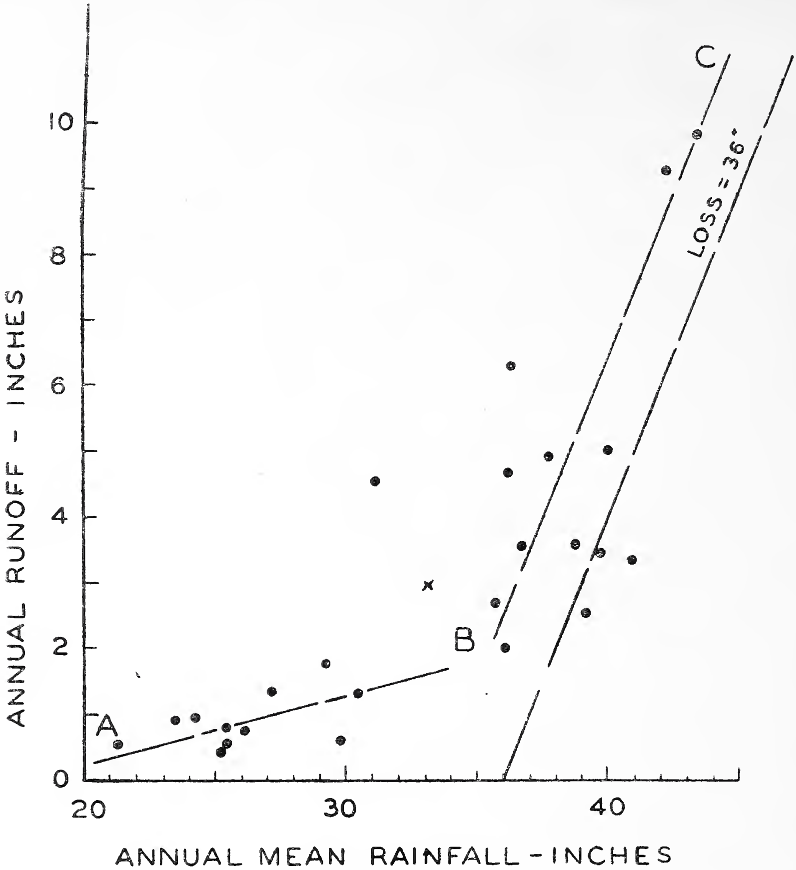


Text Fig. 4.

Relationship between Average Values of Rainfall and Run-off for some Queensland Streams.

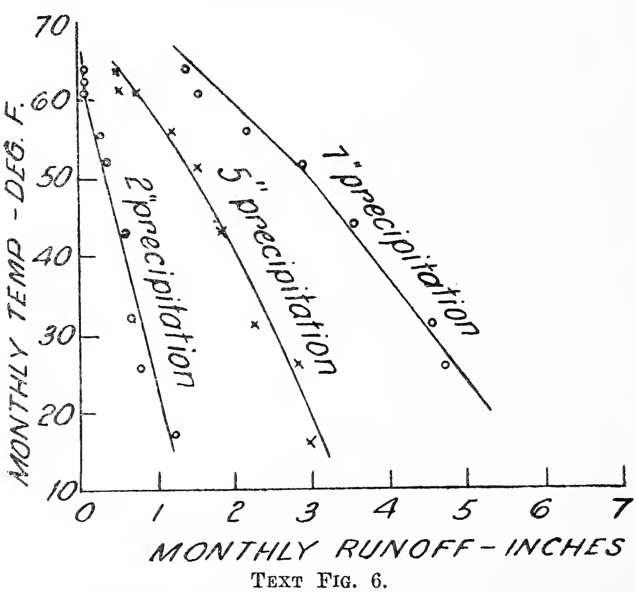
In Figure 4 the average annual mean values for rainfall and run-off on selected catchments in Queensland—mainly in the south-eastern portion without any great difference in their mean temperatures—have been plotted. The areas of these catchments vary greatly and area has a minor influence if at all. Note the tendency to plot on to two separate lines. Points marked 13 and 14 represent catchments which are at higher elevation and experience lower mean temperatures with smaller loss than the others.

In the preparation of this diagram, long-period average figures were used and they group with some semblance of order. However, in Figure 5 the annual mean values of rainfall and run-off for one stream—Brisbane River



TEXT FIG. 5.

Plot of Annual Values for Mean Rainfall and Run-off for the Brisbane River above Lowood.



TEXT FIG. 6.

Temp.-Rainfall Run-off Relation, Sacandaga River, near Hope, N.Y. (After Hoyt and Langbein.)

TEXT FIG. 7.
Isotherms Showing Normal Mean Annual Temperatures in Queensland (°F.) and Location of Evaporation Gauges.

above Lowood—are plotted. The point X denotes the average of these values such as is plotted in Figure 4. The scattering is very pronounced, and the points seem to follow lines A–B and B–C rather than the trend of average values in Figure 4. Such lack of order makes the hydrologist's task very difficult. Figure 6 shows on a monthly basis approximate rainfall—run-off relations as they apply to the Sacandaga River, near Hope, N.Y., according to Hoyt and Langbein (1944).

In this case conditions were chosen so that the catchment was in a comparatively similar state at the start of each month represented.

The rapid decrease of run-off with increase in temperature is of particular significance to Queensland when it is remembered that the monthly mean temperature is seldom below 50°F. and ranges up to above 80°F., as shown on Figure 7.

Actually, Figure 6 shows higher values for the monthly loss corresponding to a given temperature than might be expected from an average catchment in Queensland, but nevertheless it indicates the great reduction to be found in run-off as the mean temperature rises.

It is reasonable to assume, and there is evidence in support of this, that in an ideal catchment subject to regular weather conditions and with adequate rainfall and free from any extreme variations of temperature, wind, or rate of precipitation, the loss by evaporation and transpiration from vegetation would be definite, and calculable from meteorological data.

Let us consider what takes place in such a catchment which always enjoys "average" conditions. After rain has fallen, some of it remains on wet surfaces of ground or vegetation, some penetrates into the ground, some remains in little puddles, some finds its way directly or over the surface of the ground into ponds and streams. This last, when supplemented by spring and groundwater flow, forms the run-off. The aggregate loss from this must vary with the actual number of wettings and might be expected to be a function of the number of wet days in the month. In addition, there is evaporation direct from the surface of streams, ponds and wet ground.

The water which penetrates the ground is of very great importance. Some of it occupies the pores in the soil and is held there against gravity by capillary forces, until removed by the roots of growing vegetation. There is probably a maximum quantity of water which can be held by the soil in this way and it can be pictured as a sort of balancing reservoir which supplies vegetation in between falls of rain. The amount of this storage is considered to be usually of the order of 4 to 5 inches depth of water. Other water in the soil is gravitation water, slowly moving through the ground down to the water-table and eventually reappearing as spring-water, or ground-water flow in streams. This water may be partially available to trees with deep roots but, generally speaking, is not available to vegetation. The ground-water flow supplements the surface run-off to give the total run-off.

Many formulae have been suggested to cover the losses in particular catchments. To be generally applicable, such formulae must contain a temperature factor.

However, of a number examined, no formula appears generally satisfactory for Queensland conditions, although probably excellent for the catchments for which they were derived.

The most workable quantitative analysis appears to be that made by Thornthwaite (1944) who deduced formulae for monthly potential evapotranspiration, this being the mean value of all evaporation and transpiration losses when there is adequate precipitation to satisfy it. For a single place, his formula for the value of evapotranspiration based on a standard month of 30 days with 12 hours of possible sunshine, is : $e = ct^a$, where e is the monthly evaporation in cm., c and a are factors depending on climate, and t is the mean monthly temperature in degrees centigrade. The formulae are not simple and a is a function of Thornthwaite's (T — E) factor used in his classification of climates. Thornthwaite's researches have indicated that evapotranspiration from areas in their natural state is a function almost entirely of the mean temperature. Corrections have to be applied to the values for a standard month to allow for the lengths of actual months and the latitude as affecting the extent of daylight hours.

When the monthly potential evapotranspiration loss is greater than the precipitation plus the moisture available from soil-storage it cannot be satisfied, and the actual evapotranspiration loss is equal to the sum of the latter.

Actually, Thornthwaite's analysis really should apply to a small area with uniform conditions. When a whole catchment is analysed using his method, adopting average mean conditions, we make the somewhat drastic assumption that the use of averaged primary factors gives the same result as integrating the results of the actual variable factors at each point over the whole area.

When the method is applied to Queensland catchments, fairly good agreement is found with wet catchments such as the Barron River in North Queensland, where rainfall is high and capable of meeting most of the potential losses, and conditions are fairly uniform over the catchment. However, the method fails to predict run-off with dry catchments, because surface run-off occurs only during periods of high intensity of rainfall—which are far beyond the average figures ; and average figures usually are the only ones available for the analysis. Thus, an analysis following Thornthwaite's method with average monthly figures gives no run-off for streams like the Dawson River. Such an analysis, however, makes it fairly clear why the groundwater level is low over most areas except the wet coastal strip and why so many streams quickly dry up when rain stops falling. Except in exceptionally wet months, there is not enough water fully to satisfy the potential demands of evaporation and plant life.

Calculated values are no satisfactory substitute for stream-gauge figures, and probably never will be, but it is believed that very valuable information can be obtained by analyses along the lines indicated by Thornthwaite, not only with regard to calculating run-off but also with respect to water requirements for irrigation, especially when required to supplement an insufficient rainfall.

AGGREGATE ANNUAL RUN-OFF AND AVAILABLE WATER.

On the average, the streams and rivers of the eastern coastal area from the New South Wales border to the Barron—the area which includes most of the closer settlement—will discharge annually into the ocean about 40 million acre-feet of water and the rivers of the Peninsula and Gulf, perhaps a little more, but what can be done with water from the Peninsula and Gulf Rivers, too, is still quite problematical.

If I may speculate on what proportion of this water will ever be available for use on the land, I would suggest, firstly, that over half will flow down short streams near the coast, or into small tributaries which enter the lower reaches of rivers at too low an elevation for exploitation, or in unsuitable country, or in areas in which extra water is not required due to satisfactory rainfall ; secondly, that, of the areas which would benefit from water-conservation only a small proportion will be found to have exploitable facilities for adequate storage, and that even with good storage facilities a large proportion of the water will escape in times of major floods, or be evaporated from storage. Hence, if all these factors are combined, it will be seen that only a small fraction of the aggregate stream-flow will ever be exploitable, probably under ten per cent.

The figures mentioned above do not refer to the rivers west of the Main Divide which belong to the Darling and Lake Eyre systems, but allowing for these also, it seems that the upper limit of the amount of exploitable water will be found to average appreciably under 10 million acre-feet per year for the whole of Queensland.

EVAPORATION.

Evaporation in most of Queensland is very high and a knowledge of actual values is of great importance. Evaporation from a small free-water-surface is measured with an evaporimeter, which is an open tank with an accurate measuring device to determine the level of the surface of water therein.

Many sizes and types are in use in various parts of the world. As numerous factors influence the rate of evaporation, interpretation of results is sometimes difficult. For engineering purposes, it is usually sufficient to determine the mean " coefficient " for the evaporimeter, which is the ratio of evaporation from a large surface such as a lake or reservoir to the measured pan evaporation. This coefficient varies with the pan diameter. There are some 13 evaporimeters distributed over the State operated by several authorities, from which fairly satisfactory data for most areas and climatic districts can be deduced. The evaporation pans are all of the sunken cylindrical type, seven are 4 feet in diameter, five are 3 feet and one is 2 feet 6 inches. Some are concrete-walled ; some are double-walled metal tanks with charcoal packing ; some are similar but with a water-jacket ; and some started as double-walled tanks of either type, but the space between the walls has been since concreted. Some tanks are available as bird-baths, some are netted over. The result is that although reasonably good data for most work are available, much research is desirable to give precise interpretation of results and to determine with precision the relative relationship between data from the various gauges and the actual evaporation from large bodies of water, such as storage reservoirs. For such interpretation of results as is possible, we are dependent on overseas investigations.

The location with the highest recorded evaporation is Winton, with an average of approximately 99 inches pan-evaporation. Winton also has the highest average mean temperature, at about 75·8°F., with lowest rainfall (15·6 inches per year) among the stations. The mean coefficient for this pan is uncertain, but is probably between 0·85 and 0·80.

For the 3 feet diameter pans, the coefficient is probably about 3 per cent. to 4 per cent. less than for a similar 4 feet diameter pan, and for a 2 feet 6 inches diameter pan, less by about double this amount.

The correct coefficient for the 3 feet diameter water-jacketed pan known as the Australian Standard Pan does not seem to have been accurately determined, in spite of some published reports that it is about 0·90. Probably the value is nearer to 0·80 than 0·90.

Table III summarises the average results from some Queensland evaporimeters. It is found however, that evaporation varies considerably at any place from year to year. Dry years have slightly higher evaporation than wet ones. Also, inland stations have higher figures than coastal ones, apparently due to the much drier air.

The relationship between the pan-evaporation and evaporation from the surface of the land and vegetation is not known ; there are no lysimeters in the country, and at present there seems to be no way by which evapotranspiration could be measured directly.

GROUND WATER.

Almost all soils and rocks are to some extent porous, or are traversed by porous channels, so that rain-water will percolate through them under gravity and will accumulate wherever conditions allow it. Ground-water emerges

TABLE III.—SUMMARY OF RESULTS FROM EVAPORATION GAUGES IN QUEENSLAND.

Station.	Approximate Elevation feet above sea level.	Pan Diameter.	Type of Construction §.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Approximate Average Mean Temperature °F.	Calculated Evapo-transpiration after Thornthwaite (inches.)	Approximate Mean Rainfall (inches.)
Blackall	930	4′ 0″	B	10·8	8·5	8·1	6·2	4·4	3·0	3·1	4·5	6·4	8·9	9·8	10·9	84·6	74·4	46·8	20·6
Charleville	965	4′ 0″	BC	10·7	8·8	8·2	6·1	4·2	2·7	2·7	4·0	5·9	8·0	9·2	10·3	80·8	70·0	43·7	19·5
Home Hill	36	4′ 0″	BC	7·5	5·6	6·2	5·5	4·4	3·7	4·0	4·8	6·1	7·7	8·2	8·5	72·2	74·4	48·8	33·0
St. George	650	4′ 0″	BC	10·3	8·8	8·0	5·4	3·5	2·3	2·3	3·5	5·5	7·9	8·9	9·9	76·3	68·8	39·8	19·8
Taroom	700(a)	4′ 0″	B	7·8	6·2	6·2	4·8	3·5	2·3	2·5	3·8	5·2	7·0	7·8	7·9	65·0	*(69·0)	41·7	24·8
Warwick	1,485	4′ 0″	B	7·2	6·0	5·7	4·0	2·9	2·0	2·0	2·7	4·0	5·6	6·4	7·2	55·7	63·5	33·6	27·4
Winton	605	4′ 0″	B	12·0	9·2	9·3	7·4	5·7	4·1	4·3	6·0	8·0	10·2	11·0	12·1	99·3	75·8	52·2	15·6
Biloela	510	2′ 6″	C	9·2	7·1	7·8	6·2	4·8	3·6	3·6	4·5	6·0	7·7	8·3	9·4	78·2	*(69·0)	37·2	28·4
Brisbane	137	3′ 0″	A.C.	6·8	5·5	5·0	4·3	3·3	3·6	3·9	3·8	4·8	5·8	6·4	7·2	60·4	68·9	39·2	14·9
Rockhampton	37	3′ 0″	A.C.	5·5	4·7	5·0	4·2	3·5	3·7	2·7	3·3	4·2	5·3	5·6	5·8	53·5	73·1	46·8	39·3
Somerset Dam	340	3′ 0″	C	5·4	4·6	4·6	3·8	3·3	2·6	2·5	3·1	3·8	4·7	5·2	5·6	49·2	66·5	38·1	39·5

§ Construction :—A denotes metal tanks with water jacket.
B denotes metal tanks with charcoal packing.
C denotes concrete tank.
AC denotes tank originally with water jacket—now concreted.
BC denotes tank originally with charcoal packing—now concreted.

* These temperatures have been estimated.

Evaporation Gauges have been established also at South Johnstone and Gilruth Plains, but are not included in the above table as available records are very short.

in springs and as the dry-weather flow of streams. This water is also available from wells and bores which penetrate the water-bearing strata. Underground water, not being visible, is often overlooked, but forms a very important hydrological asset.

When it percolates deeply and penetrates beneath relatively impervious strata which prevent any upward flow and cause pressure to be built up which can force the water to a level above that of the ground, we have artesian conditions.

THE GREAT ARTESIAN BASIN.

No discussion of Queensland hydrology would be complete without reference to the Great Artesian Basin, which lies under some 350,000 square miles of the State, probably the largest in area in the world. Great concern has been felt about the decrease in yield from the bores as a result of decrease in the pressure, and this has inspired a considerable amount of research into all phases of the problem.

The deliberations of scientific societies during the earlier years of this century were frequently enlivened by the strong controversy which raged as to the origin of the Great Artesian Basin, ranging round the rival theories of connate (or fossil) water which had been imprisoned when the beds were laid down, a plutonic origin and a meteoric origin, that is, from rainfall. When it was proved that there was a continuous pressure-gradient outwards from potential intake beds, the protagonists of the meteoric theory felt that their case was proved, with a corollary that the future yield from the bores was assured, due to steady replenishment of water from the intake beds. This conclusion seemed adequate until some sceptical mathematician—or perhaps merely an engineer—tried to work out quantitative answers and found that he could not balance both sides of the account, inflow and outflow, and thereby revealed a weakness in the simple meteoric theory. The rate of flow through rocks such as form the aquifers is calculable with reasonable accuracy if rock-grain-size is known, and is found to be very small.

The mathematical approach, very greatly helped by the researches of Meinzer, Wenzel and Theis in America, suggest that most of the water which has flowed from the bores had been released from a form of elastic storage, mainly due to the compressibility of the water itself and the material forming the aquifers in which it was held. Thus, to some extent, the claims of the connate school generally have been justified even though its adherents do not appear to have appreciated what physical conditions were operating.

To understand the implications of the mathematical approach, a knowledge of the general structure of the basin is necessary.

In the artesian basin, water fills the spaces between the grains of the sandstone strata forming the water-beds or aquifers, which are sealed off from the ground-surface by impervious shales and clays and overlie an impervious floor. The aquifers outcrop on the eastern margin of the basin at higher levels and there is hydraulic continuity between the ground-water in this area and the deep aquifers. When first formed, the sandstone must have been water-logged and it is hard to imagine any geological sequence in which it did not remain fully charged with water, any leakage being replenished from ground-water in marginal areas. Whether the water was supplemented from plutonic sources or not, is beside the point. As time went by the clays and shales were deposited over the sandstones which now form the main aquifers and these subsided until they occupied their present levels, the hydrostatic pressure in them gradually increasing. Weakness or faults in the overlying strata caused leakage such as the mound-springs of the western margin, and an equilibrium was probably reached with intake from groundwater in the exposed eastern marginal beds, leakage to the surface from various points, and continuous but not necessarily regular hydraulic gradients in between. Actually, it is a very complex system with many complicating factors but this was probably the general picture before the first bore was drilled.

Were it possible to estimate the former aggregate flow of all the mound-springs and related phenomena which formed natural outlets from the artesian beds, it probably would be possible to obtain a figure for the present rate of replenishment, and this would undoubtedly be much less than the present aggregate flow from all bores. Thus, for years, it seems that more water has been drawn from the basin than enters it, this being made possible by a readjustment of the elastic conditions and consequent volume-changes in the material of the aquifers and in the water itself, and involving a general reduction of the hydrostatic pressure within the aquifers.

As a result of the pressure reduction, both the water itself and the individual grains of the rock—largely silica—expand elastically. The uplift pressure acting on the base of overlying impervious strata is reduced, thereby increasing the load tending to compress the aquifer, since this pressure is equal to the weight of overlying materials, less the uplift-pressure. Also, the effect probably extends far into the shales and clays adjoining the aquifers, and it is well known that the capacity of clay to take up or give out water is greatly affected by changes in pressure, although movements of water in shales and clays are extremely slow.

The general principles are easy to state. To determine the physical constants and deduce working formulae which will give results conforming with observations are not so easy, and there is still need of a great deal of research covering theoretical principles and practical measurements in the field before a quantitative valuation is possible, and it is suggested that the next phase in the investigation of the problem of the Artesian Basin should be on a mathematical and physical basis.

Methods have been worked out by which physical constants can be derived from observation of the pressure-change in aquifers. For example, the rates of increase in pressure at various points in an aquifer when a bore is closed can give very valuable information.

The present state of knowledge suggests that there is a comparatively small but steady flow into the basin from marginal intake-beds, that leakage into the ocean from the beds must be very small and affects only the northern portion, that there will be a continued decrease in pressure throughout the basin and in the total yield from bores for many years, so that, in many areas now artesian, bores will ultimately cease to flow, but that there will always be adequate water for all normal requirements available by pumping. Near the intake areas, artesian conditions will probably be permanent.

It is no secret that only a very small fraction of the total water from flowing bores is now used for domestic or stock purposes, or to grow potential food-materials, and this volume should be available by replenishment for ever. The major part of the water at the present time is merely evaporated from the bore-drains and swamps or transpired.

SHALLOW GROUND WATER.

Shallow ground-water resources in other than the artesian aquifers must not be overlooked, and will probably play a greater part in future irrigated farming than hitherto. The Burdekin Delta, the Lower Burnett area and the Lockyer Valley are successful examples, and there will be many more ; but it is essential that the conditions be understood before full use can be made of such waters. In porous sand-beds nature has provided a means of storage under conditions which can largely foil evaporation, but the boundaries of such reservoirs are not visible to the eye, nor can such limits and the continued availability of water be determined except by careful and skilled investigations, often expensive in time and money. These factors have, as yet, hindered development except on a small scale, but the advances of modern hydrology have shown the way to overcome them.

CONCLUSION.

I cannot claim to have presented any original ideas in this address and it may be all familiar to those who have any knowledge of hydrology. Nevertheless, I hope that I have given you something to think over, and have not overstrained your patience. I hope also, that you will not feel that I have presented too gloomy a picture of the agricultural and water resources of Queensland. In this respect, the fact that there are about 1,800,000 acres under crops speaks for itself, but it must be remembered that Queensland is a large country and this area is only about half of one per cent. of the total. It is the possibility of future large-scale expansion which we must consider and this may not prove easy, as the uncultivated land is generally less favourable, and the incidence of drought has, in the past, nullified many an attempt to expand agriculture.

There is, however, no need to be pessimistic. I would suggest instead that Nature, by her queer mixture of good and bad, has merely issued a challenge to us to make the best of our resources and I would stress the necessity to adapt our methods to suit her ways.

Much can be done, and will eventually be done, towards conservation of fodder and water in bounteous years for use in bad ones and to ensure the best use of meagre resources. Also, perhaps, some man of genius will be found to combine statesmanship with psychology and hydrology and produce a workable scheme of drought insurance under which the good years can be exploited with greater security than at present.

This would be a notable achievement. Another consideration is that greater aggregate production under irrigation could be obtained by designing some schemes to suit years of medium drought and deliberately to allow them to fail at least partially in years of extreme drought, instead of adopting the usual practice of designing for the worst possible conditions.

For all these we shall need precise knowledge of conditions, lack of which has been our greatest handicap to date. We must realize that all our problems may not be solved merely by copying methods successful in other lands, or by relying on results of research made overseas, and it is hoped that future programmes of national research will not exclude the various branches of hydrology. Systematic research into its problems will pay dividends.

Before concluding, I should like to thank the many people and authorities from whom the information used has been obtained, and, in particular, Mr. W. H. R. Nimmo, Chief Engineer of the Stanley River Works Board; Mr. A. S. Richards, Deputy Director, Commonwealth Meteorological Bureau; Mr. T. A. Lang, Commissioner of Irrigation; and his officers.

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SCOLYTIDAE AND PLATYPODIDAE.

Contribution 86.

NEW SPECIES AND NEW RECORDS OF AUSTRALIAN SCOLYTIDAE.

By KARL E. SCHEDL.

(Communicated by A. R. Brimblecombe.)

WITH ONE TEXT-FIGURE.

(*Received,* 13*th April,* 1948; *read before the Royal Society of Queensland,* 27*th September,* 1948; *issued separately,* 24*th November,* 1949.)

The Director of the Commonwealth Institute of Entomology, London, Dr. W. J. Hall, has given me the opportunity of examining series of Scolytid bark and timber beetles originating from Australia and collected mainly by A. R. Brimblecombe from various trees and shrubs in that country. The results of the examination are given herewith and include new records of known species and descriptions of new species.

NEW RECORDS OF KNOWN SPECIES.

Hylesinus varians Lea: Queensland, Wongabel, 12.ii.1935, from a species of liana, J. H. Smith.

Leperisinus tricolor Schedl: Queensland, Emu Vale, 10.ii.1939, from a species of scrub tree, A. R. Brimblecombe.

Cryphalus subcompactus Lea: Queensland, Atherton, 2.v.1941, ex *Grevillea robusta,* A. R. Brimblecombe; Imbil, 12.xii.1938, ex *Grevillea robusta*, A. R. Brimblecombe.

Stephanoderes darwinensis Schedl: Queensland, Cairns, 17.ii.1933, ex *Sarcocephalus cordatus*, J. H. Smith; New South Wales, Castle Hill, 2.x.1945, ex apple tree, A. H. Friend.

Stephanoderes melasomus Lea: Queensland, Brisbane, 5.viii.1945, ex *Poinciana regia*, A. R. Brimblecombe.

Hypothenemus erythrinae Egg.: Queensland, Redland Bay, 20.ix.1939, ex *Passiflora edulis*, A. R. Brimblecombe; Brisbane, 29.iii.1946, ex *Poinciana regia*, A. R. Brimblecombe.

Hypothenemus tantillus Lea: Queensland, Brisbane, 26.vi.1937, ex *Ficus hillii*, A. R. Brimblecombe; Brisbane, 26.ii.1938, ex *Wistaria floribunda*, A. R. Brimblecombe; Brisbane, 5.vi.1938, ex *Eucalyptus tereticornis*, A. R. Brimblecombe.

Xyleborus eucalypticus Schedl: Queensland, Imbil, 20.vii.1938, ex *Euroschinus falcatus*, A. R. Brimblecombe.

Xyleborus fuscobrunneus Eichh.: Queensland, Yarraman, 8.ii.1934, A. R. Brimblecombe; Dalby, 1936, ex *Araucaria cunninghamii*, A. R. Brimblecombe; Emu Creek, 25.ii.1941, ex *Araucaria cunninghamii*, A. R. Brimblecombe.

In comparison with the type of this species one of the Australian specimens is imperceptibly longer, and with elytra slightly more elongate, while another specimen corresponds with the type in every respect.

Xyleborus testaceus Walk.: Queensland, Stratford, 15.iii.1937, A. R. Brimblecombe.

Xyleborus torquatus Eichh.: Queensland, Yarraman, 18.v.1936, ex *Sideroxylon pohlmannianum*, A. R. Brimblecombe.

Xyleborus similis Ferr.: Queensland, Imbil, 20.vii.1938, ex *Excaecaria dallachyana*, A. R. Brimblecombe.

Descriptions of New Species.

Cryphalus asperulus n.sp.

Female :—Piceous, 1·2 mm. long, 2·4 times as long as wide. In general appearance, closely resembling certain species of *Trypophloeus* ; the anterior margin of the pronotum with two median asperities, the summit very high, the elytra slender and without distinct rows of punctures.

Front plano-convex, slightly transversely depressed below, densely and minutely punctulate, sometimes with a faint indication of a longitudinal carina visible only by a certain illumination. Antennal club very large, apex very broadly rounded, with three broadly rounded rows of setae on the outer side.

Pronotum distinctly wider than long (15 : 11·5), base finely margined, faintly bisinuate, posterior angles obtuse, arcuate throughout and more abrupt towards the base, apex broadly rounded although very slightly acuminate in the middle where four asperities, two larger and a smaller one on each side, are situated ; summit very high, well behind the middle ; anteriorly with four partly interrupted rows of low asperities on a rather narrow area ; remaining space on the sides and posteriorly, indistinctly and minutely punctulate ; pubescence sparse, short, inconspicuous. Scutellum triangular, opaque.

Elytra as wide, and 2·2 times as long, as the pronotum, cylindrical, sides parallel to beyond the middle, very slightly angulately rounded at the apex, disc minutely punctulate and almost without traces of striae ; declivity commencing somewhat behind the middle, obliquely convex, with slightly impressed striae but indistinct strial punctures, interspaces one to three each with a row of very short, semi-erect yellowish scales, the entire elytra with also a rather inconspicuous short and fine pubescence, slightly more distinct on the declivity.

Types in the British Museum and in my collection.

Locality : Queensland, Imbil, 12.xii.1938, ex *Grevillea robusta*, A. R. Brimblecombe.

Two specimens from the type series are slightly smaller, the sides of the pronotum are more strongly narrowed from the base to the apex (*i.e.*, the outline is more triangular), the elytral declivity commences farther forward and is more oblique. Probably these two specimens are males, the more cylindrical specimens being females.

Cryphalus brimblecombei n.sp.

Female :—Piceous, moderately shining, 1·7 mm. long, 2·1 times as long as wide. The only *Cryphalus* from the Australian region without, or at most with only faint traces of, striae on the entire elytra, but with a plush of very short scales and sparsely placed, long, erect hairs.

Front plano-convex, minutely punctulate, glabrous or nearly so.

Pronotum 1·2 times as wide as long, widest near the base, from there uniformly and rather broadly rounded towards the apex, the latter medianly with four blunt and low asperities ; summit moderately high, somewhat behind the middle ; anteriorly with a rather wide area of numerous low asperities which become connected at their base towards the summit ; the rather long posterior area and the sides densely and minutely punctulate, covered with minute scales visible under high magnification only, and with sparsely placed long erect hairs, especially on the anterior half. Scutellum minute, hardly visible.

Elytra not quite as wide, and 1·6 times as long, as the pronotum, sides subparallel basally to the middle, then gradually narrowed to the broadly rounded apex ; declivity commencing shortly before the middle, obliquely convex ; the entire elytra very densely and finely punctured, with a dense cover of minute inclined scales and scattered long yellow hairs, elytral striae at most as faint traces.

Types in the British Museum and in my collection.

Locality : Queensland, Emu Vale, 8.iii.1941, ex *Cryptocarya erythroxylon*, A. R. Brimblecombe.

In one of the four females the elytral striae are slightly more distinct. The species is named in honour of Mr. A. R. Brimblecombe, who has collected so many bark-beetles, most of them new to science, in Australian forests.

Hypocryphalus nigrosetosus n.sp.

Female :—Piceous 1·6 mm. long, 2·1 times as long as wide. Somewhat similar to *H. densepilosus* Schedl, but the anterior margin of the pronotum more broadly arcuate, the elytral declivity more steeply convex and with a different vestiture.

Front plano-convex, of a silky appearance, minutely punctulate, with small shallow punctures, nearly glabrous.

Pronotum 1·3 times as wide as long, base finely margined, very slightly bisinuate, sides subparallel on the basal two-fifths ; anterior margin semi-circularly rounded and armed with six low and rather blunt asperities ; summit slightly behind the middle ; anterior area steeply convex, covered with numerous low asperities ; posterior area very densely punctulate and with rather sparsely placed pale yellow and inclined slender scales. Scutellum moderate in size, triangular in outline, very slightly wider than long.

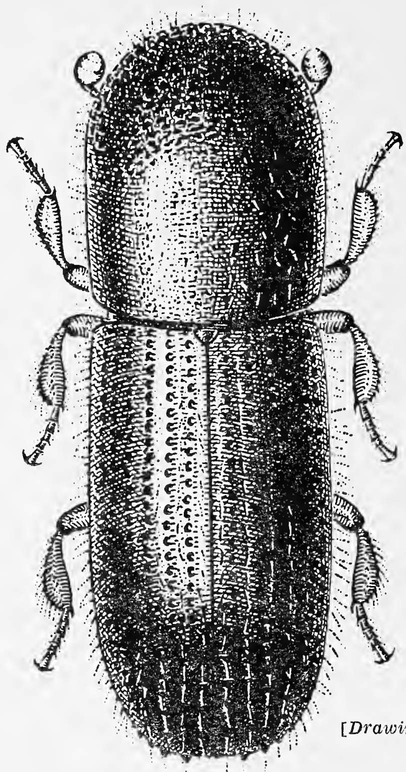
Elytra not quite as wide, and 1·8 times as long, as the pronotum, humeral angles only slightly rounded, sides parallel on the anterior half, then very gradually narrowed to the broadly and uniformly rounded apex ; declivity commencing at about the middle, moderately obliquely convex ; disc striato-punctate, the striae inconspicuous near the base, becoming more distinct towards the middle and on the declivity, strial punctures hardly distinguishable, interspaces rather wide, irregularly, triseriately and finely punctured, from these punctures arising small scales, which are more hairlike on the basal half of the elytra, stouter, more distinctly yellow and inclined on the declivity, each interspace also with a row of short, dark and rather stout bristles.

Types in the British Museum and in my collection.

Locality : Queensland, Kalpowar, 26.i.1939, from a species of rain forest tree, possibly *Capparis nobilis*, A. R. Brimblecombe.

Xyleborus pseudoangustatus n.sp.

Female:—Piceous when mature, 2·1 mm. long, basal half of the pronotum and the base of the elytra sometimes fuscous. Very closely allied to the European species, *X. saxeseni* Ratz., but slightly shorter and stouter, the elytral declivity slightly more sloping and more opaque, the granules on the first and third interstices more strongly developed. The proportions of the elytra length and width and the sculpturing of this species resemble those of *X. sobrinus* Eichh. from Japan.



[*Drawing by William Manley.*

TEXT FIG. 1.
Xyleborus pseudoangustatus Schedl.
Adult, × 45.

Front plano-convex, with a faintly developed longitudinal carina, semi-opaque, densely minutely punctulate, moderately strongly punctured, sparsely pubescent, with a fringe of yellow hairs on the anterior margin.

Pronotum almost imperceptibly longer than wide (22·5 : 21), posterior angles rectangular and very slightly rounded, sides subparallel for more than the basal half; apex broadly rounded; summit well before the middle, with a shallow transverse impression behind; anterior area short, steeply convex, covered with numerous, densely placed, small asperities; posterior area subshining, minutely reticulate, finely and rather sparsely punctured; pubescence rather sparse, inconspicuous, consisting of fine hairs. Scutellum triangular, moderate in size.

Elytra as wide, and 1·6 times as long, as the pronotum, cylindrical, sides subparallel to slightly beyond the middle, thence gradually narrowed, apex broadly rounded, subtransverse, up to the third interstice; declivity commencing at the middle, obliquely convex; disc shining, with fairly regular and at most faintly impressed rows of moderately sized punctures, interstices each with a row of distinctly finer punctures from which arise yellow hairs; declivity more or less opaque, the striae and strial punctures becoming obscure, each interstice with a row of rather pointed granules, the second interstice faintly impressed and devoid of granules on the lower part, but with a larger granule opposite the second interstice on the apical margin; the pubescence longer and more conspicuous than on the disc.

Types in the British Museum and in my collection.

Locality: Queensland, Stapleton, viii.1936, ex *Eucalyptus maculata*, A. R. Brimblecombe; Stapleton, 14.ix.1936, ex *Eucalyptus maculata*, J. W. Gottstein; Brookfield, 3.i.1938, ex loquat, A. R. Brimbecombe; Stanthorpe, 14.iii.1946, ex apple, J. H. Smith; Stanthorpe, 8.ii.1946, ex plum, J. H. Smith: New South Wales, West Pennant Hills, 2.x.1945, ex apple-wood, A. H. Friend.

THE RARE GEMPYLID FISH, LEPIDOCYBIUM FLAVO-BRUNNEUM (SMITH).

By IAN S. R. MUNRO, M.Sc., Division of Fisheries, Council for Scientific and Industrial Research.

(*Received, 6th May,* 1948; *read before the Royal Society of Queensland, 27th September,* 1948; *issued separately, 24th November,* 1949.)

PLATE 1.

SUMMARY.

Comparison is made between type-specimens of *Xenogramma carinatum* Waite, *Nesogrammus thompsoni* Fowler and *Lepidocyvium flavo-brunneum* (Smith). All these names are shown to be synonymous and *L. flavo-brunneum* has priority. The structure of the unique scale-network and lateral line are described and figured. The systematic position and distribution are discussed. Dissection of the caudal skeleton establishes the correct systematic position according to Regan's classification to be the Family Gempylidae and not the Scombridae. The first record from Australian waters is made.

INTRODUCTION.

During July, 1947, the Marine Biological Laboratory of the Fisheries Division, Council for Scientific and Industrial Research, received a specimen of the rare fish, *Lepidocybium flavo-brunneum* (Smith). The species is probably best known by the later combination, *Xenogramma carinatum* Waite. The specimen was forwarded by Mr. J. C. Woore of the New South Wales Fisheries Department. It was noticed by him in a box of Luderick or Blackfish, *Girella tricuspidata* (Quoy and Gaimard), consigned from Nelsons Bay, Port Stephens, to the Sydney Fish Markets. This occurrence represents a new record for Australia proper. The characters of this species have been clearly defined in the excellent descriptions of Waite (1904) and Myers (1932). The New South Wales specimen agrees in most details with these descriptions and with the holotype of *X. carinatum* in the Australian Museum (Reg. No. I. 5599). The specimen is illustrated in Plate 1., fig. 2, and its fin counts are summarised in Table 1.

Xenogramma carinatum was originally described from Lord Howe Island (Waite 1904). Examples have been observed in California (Myers 1932), Japan (Kamohara 1938) and Peru (Nichols and LaMonte 1943). During 1926, Noronha (April 10) described from the Madeira Islands and Kishinouye (May 25) described from Japan new species which they designated respectively as *Diplogonurus maderensis* and *Lepidosarda retigramma*. Myers (1932) demonstrated that the latter was a synonym of *X. carinatum*, and Fowler (1936) confirmed Myers' opinion that *Diplogonurus maderensis* was a further synonym. Fowler failed to recognise that this species was identical also with *Nesogrammus thompsoni* described by him previously (1923) from Honolulu, Hawaii. All these names give precedence to the earlier name of Waite, but there is an even earlier combination that has been overlooked by authors. This is *Cybium flavo-brunneum* Smith, described from the Cape of Good Hope (Smith 1849) and placed in *Lepidocybium* by Gill (1863). The present author has drawn attention to this point previously (Munro 1943, p. 70), when considering the generic limits of the Scomberomorinae, and now notes that the same suggestion was put forward independently by Kamohara (1938).

TAXONOMY.

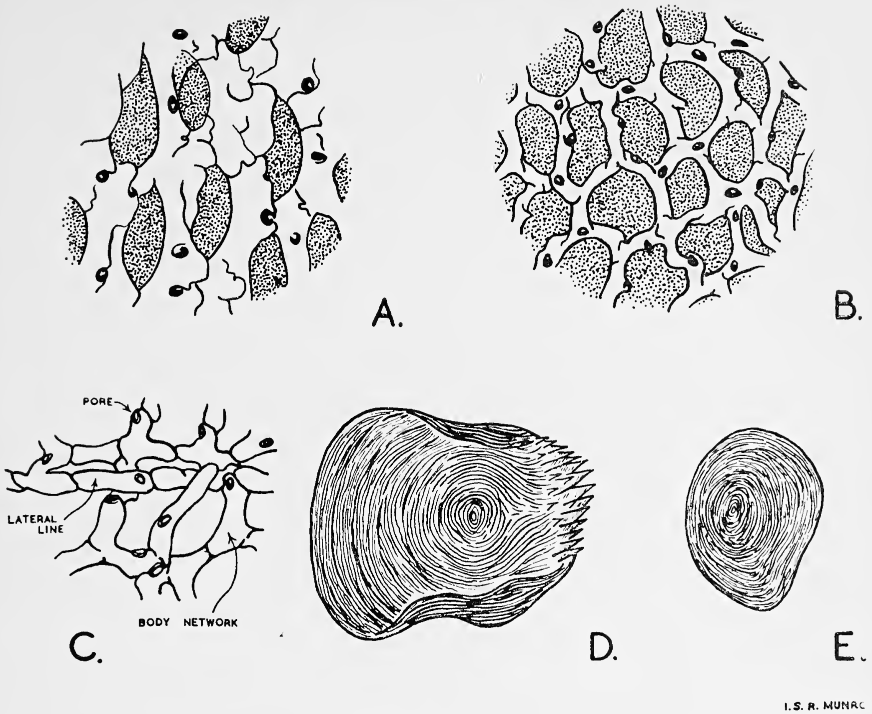
Comparison of *L. flavo-brunneum* and *X. carinatum*.

Dr. Ethelwyn Trewavas has re-examined the holotype of *L. flavo-brunneum* in the British Museum and has provided me (*in litt.*) with data on certain points that were not clearly described by Smith (1849). Smith's account appears to be poorly known and, for this reason, his illustration is reproduced herein for comparison with the New South Wales specimen (*vide* Plate 1). From considerations put forward in the following sub-sections, in which individual characters are compared, it is concluded that *X. carinatum* is identical with and predated by *Lepidocybium flavo-brunneum.*

(a) *Teeth.*—Gill (1863) erected the genus *Lepidocybium* to accommodate *Cybium flavo-brunneum* which differs from all the Scomberomorinid fishes in dentition. The teeth are conical and recurved and those of the lower jaw are larger than those of the upper jaw. Smith (1849) states that "the teeth of the upper jaw are small and cylindrical, about half a line apart and slightly curved inwards ; those of the lower jaw are considerably larger, more apart from each other, and with a slight curvature inwards." Also "there are besides two large fangs curving backwards a little behind the front of the upper jaw on the anterior part of the palate." This description fits in every detail the dentition of the specimen of *Xenogramma* from New South Wales. The fangs of the upper jaw are paired in the Australian specimen, but similar duplication is noted by Waite (Lord Howe Island) and Myers (California). It is impossible to separate *X. carinatum* from *L. flavo-brunneum* on the basis of dentition.

(b) *Scale-network.*—Myers (1932) describes the singularly unusual arrangement and structure of the body-scales of *X. carinatum* as follows :—"Each scale is surrounded and separated from its fellows by a narrow area of integument in which are embedded small scales many of which appear to be perforated by sensory pores. The general effect is that of a mosaic of large darkly coloured scales separated by a network of narrow light lines, the lines being pierced by many small pores." Noronha (1926) and Kishinouye (1926) both describe this network of tubule-bearing scales on the body region, but Smith (1849) described nothing of this nature in *L. flavo-brunneum.* Dr. Trewavas's re-examination of the old stuffed skin, identified as Smith's holotype in the British Museum, indicates beyond doubt that much the same scale structure as described above for *X. carinatum* is possessed also by *L. flavo-brunneum.* Apparently most of the scales no longer remain on the skin and it is difficult to be sure of the detail of the individual scales. Dr. Trewavas writes "the pale reticulations . . . . are very evident over most of the body and consist of tubes, either empty or filled with a white cheesy substance." She also forwarded drawings of groups of body-scales and the detail of one drawing is reproduced here for comparison with a similar portion of the squamation of the Australian specimen (see Text-fig. 1). With regard to this character also, there is complete agreement between *X. carinatum* and *L. flavo-brunneum.*

(c) *Lateral line.*—No lateral line is mentioned in *L. flavo-brunneum* by Smith (1849) and Dr. Trewavas writes "I have looked carefully at the type . . . . . . , but, whichever way I turn it and in whatever light, I cannot find a lateral line. I can see a faint vertical tract as in *Xenogramma*



TEXT FIG. 1.

Squamation of *Lepidocybium flavo-brunneum* (Smith).

A. Holotype of *L. flavo-brunneum* in the British Museum, from a sketch by Dr. Trewavas. The large, stippled areas are occupied by the large, normal scales. These are surrounded by a network of small, pore-bearing, tubular scales. B. Example of "*Xenogramma carinatum* Waite" from Port Stephens, New South Wales, showing detail comparable with Fig. A. C. Detail of structure of pore-bearing, tubular scales of the lateral line and general body network, showing anastomosis. D. Large, normal body-scale of ctenoid type. E. Large, normal body-scale of cycloid type.

behind the pectoral on both sides, but examination with a lens shows only a short stretch of tubules similar to those of the general reticulum, all directed vertically. On one side I imagined a short piece in front of the mid-lateral keel of the caudal peduncle, but examination with a lens showed nothing different from surrounding skin." It is difficult to relate this to the very distinctive tortuous lateral line described in *Xenogramma* by Waite (1904). The structure is clearly marked in the New South Wales specimen and the course can still be followed, with some difficulty, in Waite's specimen at the Australian Museum (Reg. No. I. 5599). Myers (1932) admits that it is very faint and difficult to trace in the Californian specimen. Fowler (1923) described in his *Nesogrammus thompsoni* from Hawaii, a lateral line identical with that of *X. carinatum*. The course fails to show at all in the photograph reproduced by Myers (1932) or in the photograph of the holotype of *N. thompsoni* that I have received from the Bishop Museum. Nichols and LaMonte (1943) specifically mention the absence of a lateral line in the Peruvian specimen. Kishinouye (1926) and Noronha (1926) respectively find no separate lateral line in their *Lepidosarda retigramma* and *Diplogonurus maderensis*. Both authors consider that its place is taken by the tubule-bearing porous scales of the reticulum as in the genus *Ruvettus*. Fowler

(1936), who examined photographs of Madeira specimens, failed to notice the full detail of the lateral line, but does not hesitate to unite *D. maderensis* with *X. carinatum.* The dotted line in his figure is probably not an accurate representation of the true lateral line.

The lateral line of the Australian specimen was examined under a binocular microscope. It was observed that the component, tubule-bearing porous scales are no different structurally from the scales which form the body-reticulum. In the lateral line the porous scales are arranged end-to-end forming a continuous chain. On the rest of the body the porous scales lack this directional arrangement and anastomose irregularly with others of their kind, and even unite irregularly with those of the lateral line. Thus, in the limited field of the microscope, the lateral line does not stand out clearly, and it is extremely difficult to trace its course through the neighbouring network of tubule-bearing scales. As a second test, a small portion of skin containing both lateral line and body-scales was removed from the Australian specimen and subjected to heat and sunlight. A small amount of weathering had the effect of obliterating the course of the lateral line across the skin. The lateral line does not appear to be very distinct under some circumstances and does not show in photographs. It could easily become rather indistinct and pass unnoticed in old, preserved or dried specimens. The fact that Dr. Trewavas has been able to discern small tracts of tubules with linear arrangement in certain likely positions on the holotype of *L. flavo-brunneum* is sufficient evidence to suggest that a lateral line had been present, but has become obscured by the general weathering of the stuffed skin now nearly one hundred years old.

(d) *Fin-counts.*—Smith's (1849) description of *L. flavo-brunneum* does not indicate any fin-counts but these data are given by Günther (1860), who also examined the holotype. Günther states that the first dorsal fin has twelve spines, but it is clear from Smith's figure (see Plate I., fig. 1) that there are only nine. This latter number agrees with the respective counts given for the other known specimens (see Table 1). The general fin-formulae are very similar in *L. flavo-brunneum* and *X. carinatum* and it is impossible to separate the two species on this basis.

(e) *Gill-rakers.*—Smith does not indicate the gill-rakers in his account of *L. flavo-brunneum* and it is now impossible to check, as the gill-rakers were removed from the holotype when the skin was prepared by the taxidermist. Authors agree that rakers are absent or rudimentary in *X. carinatum.* The Australian specimen has six vestigial projections on the ventral limb of the first gill-arch.

(f) *Eye.*—Smith (1849) describes and illustrates the eye of *L. flavo-brunneum* as almost circular but Dr. Trewavas found that the orbits were slightly greater in vertical than in horizontal diameter although there was distortion due to the insertion of a glass eye. Waite, Myers and Kishinouye describe an ovoid eye in *X. carinatum.* The exact shape varies, and in the Australian specimen, the vertical diameter is almost twice the horizontal. It is doubtful whether the eye shape differs in the two species, except perhaps in degree of elongation, which is known to be a variable character.

Comparison of *N. thompsoni* and *X. carinatum.*

Nichols and LaMonte (1943) noted that *Nesogrammus thompsoni* Fowler, described from Honolulu, was identical with *X. carinatum* Waite. The description given by Fowler (1923) certainly suggests that his fish is identical with *X. carinatum.* He did not figure his species, but Dr. Peter Buck,

TABLE I.

SUMMARY OF MERISTIC CHARACTERS OF *Lepidocybium flavo-brunneum* (SMITH).

Species.	Locality.	Authority.	Dorsal Spines.	Dorsal Rays.	Dorsal Finlets.	Anal Spines.	Anal Finlets.	Pectoral Rays.	Gill Rakers.	Vertebrae.	Length (mm.)
Lepidocybium flavo-brunneum	Cape of Good Hope	Günther 1860 ..	IX	18	5	15	4	..	..	..	610
Lepidosarda retigramma	Japan	Kishinouye 1926 ..	VIII	18	6	14	5	17	0	32	1,000
Diplogonurus maderensis	Madeira Islands ..	Noronha 1926 ..	..	..	..	..	..	..	0	..	800
Nesogrammus thompsoni	Hawaii	Fowler 1923 ..	XI	17	6	14	5	15	0	..	965
Xenogramma carinatum	Lord Howe Island ..	Waite 1904 ..	IX	18	6	14	5	15	0	30	575
	California	Myers 1932	IX	16	5	15	4	15	0	..	734
	Madeira Islands ..	Fowler 1936 ..	IX	17	6	14	4	..	0	..	800
	Japan	Kamohara 1938 ..	IX	17	4	13	4	16	..	..	460
	Peru	Nichols and LaMonte 1943	..	..	6	..	5	..	0	..	1,220
	New South Wales ..	*supra cit.*	IX	17	6	14	5	16	0	..	575
Range of Variation	World distribution ..	..	VIII–XI	16–18	4–6	13–15	4–5	15–17	0	30–32	460–1,220

Director of the Bishop Museum, has forwarded me a photograph of the holotype (Reg. No. 3396). The fish depicted is undoubtedly a specimen of *X. carinatum* and is therefore identical with *L. flavo-brunneum*. Dr. C. H. Edmondson of the Bishop Museum informs me (*in litt.*) that Fowler's type specimen agrees closely with the descriptions of Waite (1904) and Myers (1932). He mentions the oily nature of the specimen, a character noted in most specimens of *X. carinatum*.

Nichols and LaMonte (1943) have incorrectly suggested that the genus *Xenogramma* Waite (= *Lepidocybium* Gill) is a synonym of *Grammatorycnus* Gill (= *Grammatorycnus auct.*). The error arises from the confusion of two species referred to *Nesogrammus* Evermann and Seale, namely *piersoni* Evermann and Seale and *thompsoni* Fowler. It is accepted that *Nesogrammus piersoni* Evermann and Seale (1906) from Sorsogan, Philippine Islands, and *Thynnus bicarinatus* Quoy and Gaimard (1824) from Sharks Bay, Western Australia, are conspecific. Since these species are respective genotypes, it follows that the genus *Nesogrammus* is a synonym of *Grammatorycnus*. It is also true, as shown in the preceding paragraph, that *thompsoni* Fowler, referred to *Nesogrammus* by its originator, is a synonym of *X. carinatum*. Provided that *thompsoni* and *piersoni* are one and the same species, it might be argued that *X. carinatum* = *G. bicarinatus* and thus *Xenogramma* = *Grammatorycnus*. However this is definitely not the case, as *thompsoni* and *piersoni* belong to distinct genera and are even referable to different families. Only *piersoni* rightly belongs to *Nesogrammus*, and Fowler erroneously placed *thompsoni* in this genus. Nichols and LaMonte (1943) are thus incorrect in assuming that the known examples of *Xenogramma*, being larger fish, are the adults of the smaller fish that have been referred to *Grammatorycnus* by authors. *Grammatorycnus bicarinatus* (Quoy and Gaimard) is a well-known Scombrid fish, common on the coasts of Queensland and Western Australia. It is a very different fish from the Gempylid species, *X. carinatum*.

References to Species in Literature.

Cybium flavo-brunneum Smith 1849, Pl. XX (Cape of Good Hope—TYPE LOCALITY) ; Bleeker 1860, p. 53 (Cape of Good Hope) ; Günther 1860, p. 373 (Cape of Good Hope) ; Gilchrist 1902, p. 128 (Cape of Good Hope).

Scomberomorus flavo-brunneum Thompson 1918, p. 113 (Cape of Good Hope) ; Barnard 1927, p. 802 (Cape Seas ; *non* Aru Is., an error of transcription, this species not being mentioned by Weber 1911, p. 31. Weber's record from Barkai is *S. commersonii*) ; Kamohara 1938, p. 46 (reference).

Lepidocybium flavo-brunneum Gill 1863, p. 125 (designation of *C. flavo-brunneum* Smith as Genotype) ; Okada 1938, p. 169 (Sikoku, Japan) ; Munro 1943, pp. 69-71 (synonymy).

Xenogramma carinatum Waite 1904, p. 158 and Pl. XIX, fig. 1 (Lord Howe Is.—TYPE LOCALITY) ; Myers 1932, pp. 111-118 and Pl. VII (Long Beach, Los Angeles, California) ; Barnhart 1936, p. 38 and fig. 133 (California) ; Fowler 1936, p. 1275 and fig. 545 (Funchal, Madeira) ; Walford 1937, p. 30 and Pl. I, fig. b (California) ; Kamohara 1938, p. 46 and Pl. III, fig. 1 (E. coast of Chiba-ken and Tosa Market, Japan) ; Okada 1938, p. 170 (Honsyu, Japan) ; Nichols and LaMonte 1943, p. 50 (25 miles off Cabo Blanco, Peru) ; Barnhart and Hubbs 1944, p. 52 (California, after Myers) ; Hildebrand 1946, p. 359 (Cabo Blanco, Peru).

Diplogonurus maderensis Noronha 1926, p. 381 and fig. 1 (Camarade Lobos—TYPE LOCALITY, and Porto Santo, Madeira) ; Fowler 1936, pp. 627, 1275 (Funchal, Madeira).

Lepidosarda retigramma Kishinouye 1926, p. 378 and figs. 1-3 (E. coast of Chiba-ken—TYPE LOCALITY, Owase, Miye-ken, Pacific coast of Hondo, Japan).

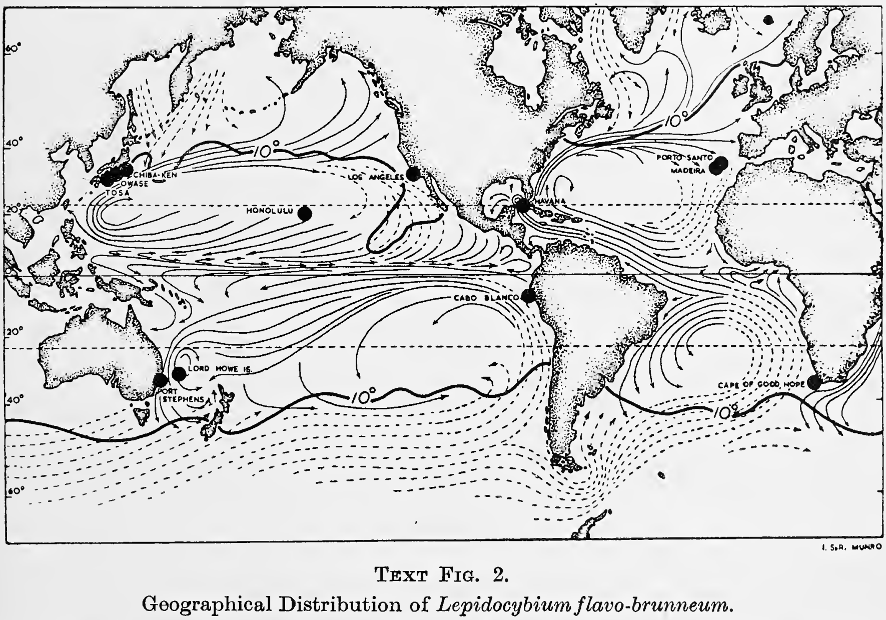
Nesogrammus thompsoni Fowler 1923, p. 376 (Honolulu, Hawaii—TYPE LOCALITY); Jordan 1925, p. 11 (Honolulu, after Fowler); Nichols and LaMonte 1943, p. 50 (reference).

Grammatorycnus thompsoni Fowler 1928, p. 135 (Honolulu).

? *Thrysites niger* Poey 1875, p. 148 and Pl. III (Havana, Cuba—TYPE LOCALITY); Goode and Bean 1895, p. 519 (reference); Jordan and Evermann 1896, p. 879 (Havana). A doubtful species described from a fragment and thought by authors to belong to this species.

Distribution.

The range of *L. flavo-brunneum*, based on records of a limited number of specimens described under the several specific names listed above, is illustrated in Text-fig. 2. The species appears to be quite widely distributed but is restricted, presumably by temperature tolerance, to the equatorial regions of both northern and southern hemispheres. All records apply to the Pacific and Atlantic Oceans and no specimens have been obtained from the Indian Ocean. Although all records apply to localities adjacent to land, the species appears to be oceanic in habit and is known to occur at great depths. As indicated in Text-fig. 2, the sub-surface distribution corresponds rather well with the area enclosed by the ten-degree centigrade isotherms at two hundred metres depth. The literature indicates that the species normally lives at depths equivalent to this and even considerably deeper. The distribution appears to be governed principally by temperature with a lower limit of tolerance. All localities from which the species has been recorded are influenced by the warm equatorial currents.



TEXT FIG. 2.

Geographical Distribution of *Lepidocybium flavo-brunneum*.

Showing correlation with the 10° Centigrade isotherms at a depth of 200 metres and with the influence of the warm equatorial ocean currents.

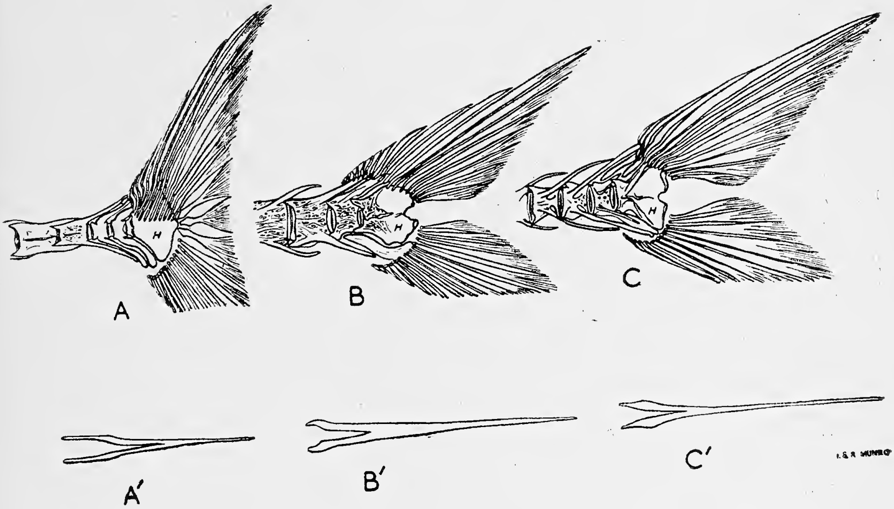
The correct distribution includes only Madeira, South Africa, Japan, Hawaii, New South Wales, Lord Howe Island, California and Peru. The inclusion of Aru Island is incorrect and is due to an error in transcription by Thompson (1918). Cuba may be included tentatively on the basis that the assumed synonymy with *T. niger* Poey is correct.

Systematic Position.

This aberrant species, *L. flavo-brunneum*, was referred by Smith (1849) to the genus *Cybium* Cuvier, which is equivalent to and preoccupied by *Scomberomorus* Lacépède Munro (1943). Gill (1863) recognised that it differed from the typical Scomberomorinids and proposed *Lepidocybium* for its reception. The teeth are conical and recurved and those of the upper jaw are much smaller than those of the lower, while in *Scomberomorus* the teeth are laterally flattened and of equivalent size in both jaws. Also *Lepidocybium* has 9 spines comprising a very low first dorsal fin and only 4 or 5 dorsal finlets. All species of *Scomberomorus* have relatively higher dorsal fins with no fewer than 14 component spines and always rather more finlets (7 to 10). The genus is obviously not Scomberomorinid but was included tentatively in that group as an aberrant sub-genus by Munro (1943).

Kishinouye (1926) considered that this fish, which he named *Lepidosarda retigramma*, had sufficient of the characters of the Cybiidae (Scomberomorinae) to justify inclusion in that sub-family. He admits that the species is not absolutely typical of that group. Of the numerous genera comprising the Scombriformes, one of the closer relatives is *Grammatorycnus*, of which *Nesogrammus* is a synonym. Due to this superficial similarity, Fowler (1923) incorrectly referred *thompsoni* (a synonym of *flavo-brunneum*) to *Nesogrammus*. Although there is a vague superficial resemblance between *Lepidocybium* and *Grammatorycnus*, these genera differ in all essentials. The latter has a double lateral line, large non-perforate body-scales, and dentition and spinous dorsal fin which are typically Scomberomorid. *Grammatorycnus* possesses a low spinous dorsal fin and finlet-counts of 12 and 6-7 respectively and a low vertebral count of 31. In these respects it resembles *Lepidocybium* with 8, 4-5 and 32 respectively.

Waite (1904) referred his *X. carinatum* to the Gempylidae without further comment. Noronha (1926) placed his *Diplogonurus maderensis* in a separate family, the Diplogonuridae, closely related to the Gempylidae. He points out the superficial resemblance to the Gempylid genus *Ruvettus* Cocco, namely the oiliness of the flesh and the perforated scales scattered over the whole body-surface. The structure and arrangement of the perforate scales in these two genera are very different. Also *Lepidocybium* differs from *Ruvettus* and the Gempylidae generally in respect to the wide peduncular keel possessed by the former and not by the latter. Due to the superficial resemblance to *Ruvettus*, Myers (1932) placed *Xenogramma* (= *Lepidocybium*) in the Gempylidae rather than the Scomberomorinae. He lays greatest stress on the superficial similarity in appearance, external structural details, oily flesh and deep-sea habit. It might be considered that such features are in the nature of adaptive convergence resulting from ecological causes rather than true family relationship. He does point out that the character of the basal parts of the caudal rays is the most important feature by which the Gempylidae can be separated from the Scombridae. Such skeletal features were not observed by Kishinouye (1926). Regan (1909) in his classification of the Scombroidei separates the divisions of the sub-order on the basis that in the division Trichiuriformes, " the caudal rays are not deeply forked at the base, the hypural in great part exposed " and in the Scombriformes " the hypural nearly or quite hidden by the deeply forked bases of the caudal fin-rays." It is to the first of these divisions that the family Gempylidae belongs, and to the second is referred the family Scombridae. The usage of Scombridae is in the broad sense and includes *Scomber*, *Thunnus*, *Scomberomorus*, *Acanthocybium*, *Grammatorycnus*, *Gasterochisma* and various related genera.



TEXT FIG. 3.

Structure and Arrangement of Caudal Fin-Rays in the Families Scombridae and Gempylidae.

A, A′. *Auxis thazard* (Lacépède), Family Scombridae. B, B′. *Lepidocybium flavobrunneum* (Smith), Family Gempylidae. C. C′. *Thyrsites atun* (Euphrasen), Family Gempylidae. A to C. Disposition of basal proportions of caudal rays in relation to the hypural bone (H). Complete rays are shown in the dorsal half of each fin. In the ventral half of each fin the basal portions of the caudal rays have been cut away to reveal the position of the hypural bone. A′ to C′. Sectional views of individual rays, showing relative amount of bifurcation basally. The deep forking in the Scombridae cause the basal rami to encase completely and obscure the hypural. In the Gempylidae this notching is shallow and therefore leaves the hypural largely exposed.

The Australian specimen has been sacrificed as a museum piece in order to investigate the skeletal structure of the caudal region, and to establish definitely, on the basis of Regan's classification, the true systematic position of the species. Removal of the flesh in the caudal region has revealed that the arrangement is definitely that of the Gempylidae. Text-fig. 3 shows the detailed structure and arrangement of the caudal rays in this specimen (*Lepidocybium*) and in examples of the Scombridae (*Auxis*) and Gempylidae (*Thrysites*). In an example of the Scomberomorinae (*Indocybium semifasciatum*) similarly examined, the arrangement in no way approaches *Lepidocybium* but is typically that of the Scombriformes, since the basis of the caudal rays are deeply forked and the hypural bone is hidden in the pocket formed by the divided basal parts of the caudal rays. In *Lepidocybium*, as in *Thrysites* and other Gempylids, the notching of the basal parts is very shallow and obscures practically none of the hypural bone. This character, supported by the fact that the caudal rays are not widely divergent as in most Scombridae (Starks 1911), indicates conclusively that *Lepidocybium* is Gempylid and not Scombrid. Other supporting characters are the caniniform dentition and the relatively low placing of the pectoral fin.

It is realised that *Lepidocybium* is the only Gempylid genus that possesses wide peduncular keels. Kamohara (1938) separates it, on this basis, from the more typical genera *Ruvettus*, *Gempylus*, *Mimasea*, *Epinnula*, *Prometheichthys*, *Jordanidia*, *Thrysites*, etc. It seems that *Lepidocybium*, although definitely belonging within the limits of the Gempylidae, must represent one of the more primitive species in that group. It forms a possible link between this family and the Scombriformes. The nearest representatives in the Scombridae are the Scomberomorinid genera and some affinities are possessed also by *Grammatorycnus*. The peduncular keel in *Lepidocybium* is presumably a character carried over from the Scombridae.

ACKNOWLEDGMENTS.

Appreciation is extended to Dr. Ethelwyn Trewavas of the ichthyological staff of the British Museum (Natural History), London, and to Dr. Peter Buck, Director, and Dr. C. H. Edmondson, Zoologist, of the Bernice P. Bishop Museum, Honolulu, Hawaii. They have kindly re-examined holotypes in these museums and provided sketches and photographs. The work described in this paper was carried out as part of the research programme of the Division of Fisheries, C.S.I.R.

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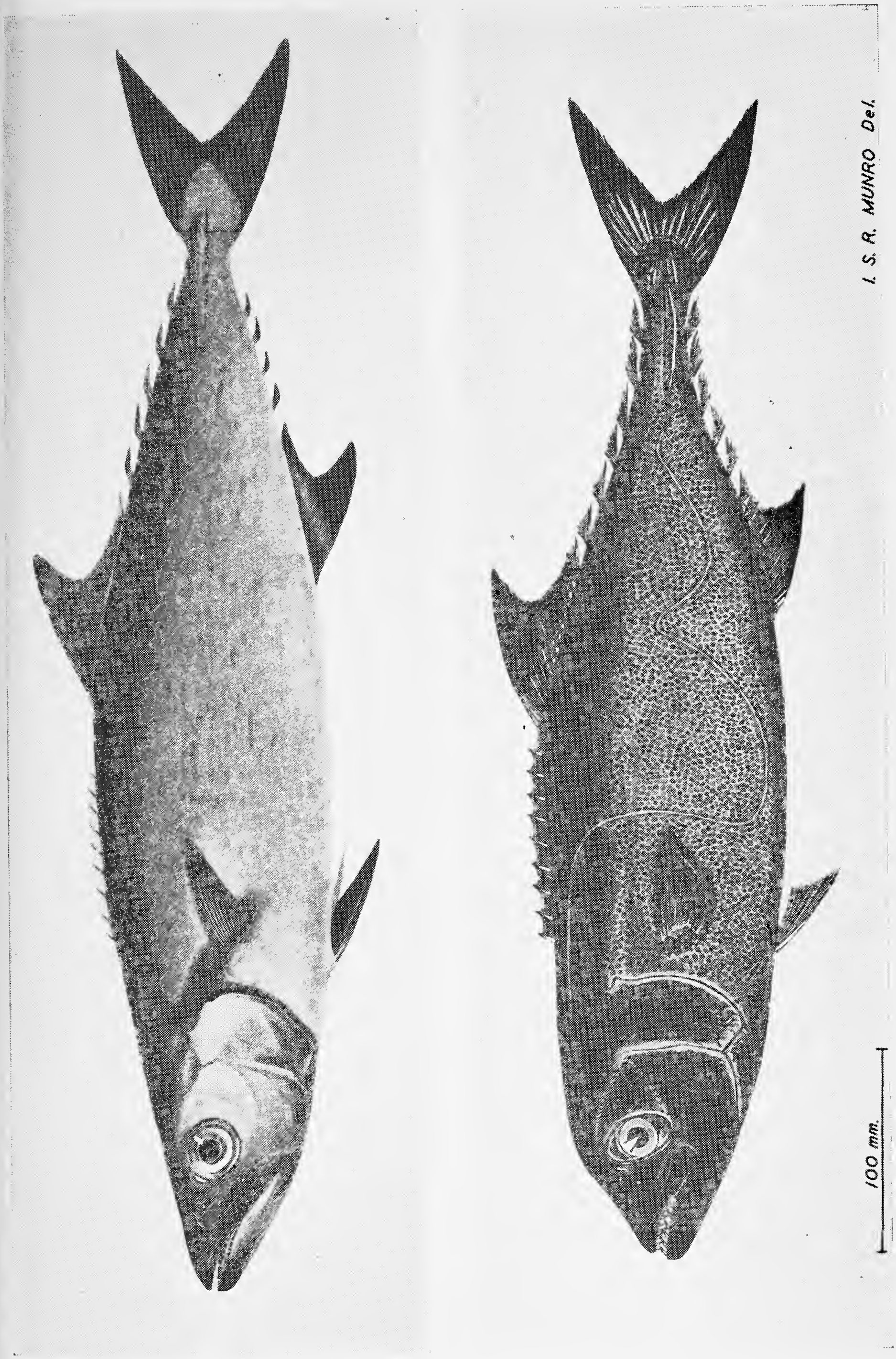

EXPLANATION OF PLATE 1.

Fig. 1.—*Lepidocybium flavo-brunneum* (Smith). Reproduction of Sir Andrew Smith's original illustration of the holotype from South Africa.

Fig. 2.—*Lepidocybium flavo-brunneum* (Smith). From a specimen 575 mm. total length, obtained from Port Stephens, New South Wales.

THE GENUS EMBOTHRIUM FORST. (FAMILY PROTEACEAE) IN AUSTRALIA.

By C. T. White, M.Sc., Government Botanist, Brisbane.

(*Received, 10th September, 1948; read before the Royal Society of Queensland, 27th September, 1948; issued separately, 24th November, 1949.*)

The genus *Embothrium* Forst., with the species now described, consists of seven species, four of which are found in South America, two in Australia and one in New Guinea. One of the South American species, *E. coccineum* Forst., the Chilean or Patagonian Fire Tree, is cultivated in the open in the warmer parts of the British Isles. The genus is very closely allied to *Telopea* R. Br., which differs in having large bracts subtending the inflorescence. The affinity of the two genera is indicated in the popular name of " Queensland Waratah " applied to one of the Australian species of *Embothrium*. Up to the present only one species of this genus, a native of north-east Queensland, has been recognised from Australia. The species now proposed, a native of New South Wales and south-east Queensland, was previously regarded as a variety of the northern tree ; but it presents many differences and I have no hesitation in raising it to specific rank.

Key to Australian Species.

Leaves very acute, pinnately divided, or those below the inflorescence entire or slightly lobed, lateral nerves few (4–6) and markedly ascending, especially in the entire leaves ; rhachis thinly pubescent, pedicels and perianth glabrous ; a native of N.S. Wales and south-east Queensland. . . . . *E. pinnatum.*

Leaves rounded or scarcely acute, simple, lateral nerves numerous (12–15 or more), spreading ; rhachis, pedicels and perianth densely ferruginous-pubescent ; a native of north-east Queensland . . . . *E. wickhamii.*

E. pinnatum, stat. nov.

E. wickhamii W. Hill & F. Muell. var. *pinnata* Maid. & Betche in Proc. Linn. Soc. N.S. Wales xxv, 795 (1910) ; Maid. For. Flora N.S. Wales v, 91, pl. 167 (1911) ; Francis Aust. Rain-Forest Trees 90 (1929).

Arbor ad 25 m. alta, cortice brunneo vel griseo pustulis numerosis asperato, ramulis junioribus ferrugineo-pubescentibus mox glabris. Folia lobata, profunde pinnatifida (simulate pinnata) vel sub inflorescentiam integra, pinnis vel lobis oppositis vel suboppositis ; lamina in foliis integris lanceolata 8–14 cm. longa, 1·5–3 cm. lata, apice acuta, basi in petiolum 1·5–4 cm. longum gradatim angustata, rhachi cum petiolo in foliis pinnatifidis 6–22 cm. longa, petiolo ipso 4–11 cm. longo, lobis 8–12 cm. longis, 1·5–2·5 cm. latis, nervis praecipuis tenuibus adscendentibus utrinque plus vel minus immersis. Inflorescentia corymbosa multiflora rubra, perianthio saepe purpureo suffulto, pedicellis 3–4 cm. longis atque perianthiis glabris, perianthio ca. 3 cm. longo ; pistillo 3·5 cm. longo, disco obliquo. Folliculus stipitatus, apice stylo incrassato coronatus, cum stipite et stylo ca. 10 cm. longus, 2·5 cm. diam., stipite ipso 1·5 cm. longo, stylo 1·5–2 cm. longo.

New South Wales :—Dorrigo, *J. L. Boorman* (type : flowers and fruits), Nov. 1909, *C. T. White* 7489 (old fruits) Oct. 1930 ; Bellingen, *Hewitt* ; Oraro River, in the " scrubs " among the hills, *C. E. Vale* ; Ulong, *W. Heron* (all except *C. T. White* 7489 ex Nat. Herb., Sydney).

Queensland :—Moreton District : Springbrook, *C. T. White* (flowers) Dec. 1915 ; McPherson Range, *C. T. White* (flowers and fruits) Jan. 1919 ; Roberts Plateau, McPherson Range, *J. Shirley* ; Lamington National Park, Echo Point, *D. A. & L. S.*

Smith (flowers), Dec. 1943 (small slender tree 20–30 feet, bark pale mottled with dark grey); McPherson Range, alt. 2,000–3,000 ft., common in rain-forest of various types, *S. T. Blake* 15368 (flowers), Dec. 1943 (more or less irregular tree 20–30 feet; trunk short cylindrical with numerous transverse ridges; bark grey, closely pustular-roughened outer layer beneath blackish-brown mottled with deep cream, separating from reddish brown inner layer, sapwood whitish vertically ridged and wrinkled; leaves glossy green above, paler and duller beneath; inflorescence more or less rose red, pedicels rose, perianth slightly purplish outside, red inside with three dark longitudinal lines, style and stigma deep rose).

Embothrium pinnatum is popularly know in Queensland as the Queensland Waratah and is a common component of the rain-forests of the McPherson Range at 2,500–3,500 ft. altitude.

E. wickhamii W. Hill & F. Muell. Fragm. Phytogr. Austr. viii, 164 (1874) and ix, 194 (1875); J. F. Bail. in Queensl. Agric. Journ. v, 403, pl. cxliii (1899); F. M. Bail. Queensl. Fl. iv. 1358 (1901).

Tree 80–90 ft.; young shoots densely ferruginous-pubescent, older parts with the exception of the inflorescence glabrous; branchlets stout. Leaves coriaceous, narrowly lanceolate, apex blunt or slightly tapering but scarcely acute; base acute tapering into a rather long petiole, blade 9–15 (up to 26) cm. long, 2–4 cm. broad, petiole 1·5–3 cm. long; midrib more or less impressed on the upper and elevated on the lower surface; lateral nerves and reticulations more or less impressed on both surfaces but sometimes scarcely visible. main lateral nerves 12–15 (up to 30 or more on very long leaves) on each side of the midrib. Racemes 5–6 cm. long, densely flowered, rhachis densely clothed like the flowers with a dark ferruginous pubescence; pedicels 3–3·5 cm. long; petals (perianth segments) 4 cm. long; torus very oblique; pistil 5 cm. long, glabrous; ovary on a long slender stipes. Follicle woody, 6–8 cm. long, 2·5–3 cm. diam., borne on a stout stipes and crowned by the persistent and thickened style, though in older capsules this is broken off; seeds 8, 5·5 cm. long, the upper part flat on one side, convex and deeply imbedded in the valve, lower part extended into a strong wing, straight and thickened and with a strong intramarginal vein on the dorsal side, curved on the ventral.

QUEENSLAND:—Cook District: Bellenden Ker Range, alt. 2,500 ft., *W. Hill* (TYPE); Rocky Creek nr. Atherton, *J. F. Bailey* (old fruits), June, 1899; Atherton and Evelyn, *J. F. Bailey* (old flowers), June 1899 (Local name "Red Silky Oak"); Yungaburra, *J. L. Tardent* 192 (old flowers), October 1929 (occasional tree on tableland; bears a heavy crop of handsome red flowers); Kairi, *J. L. Tardent* (very young flowers and mature fruits), Sept. 1930; Thornton Peak, *L. J. Brass & C. T. White* 300 (fruits), Sept. 1937; Gadgarra near Peeramon, in rain forest, alt. 2,500 ft., *S. T. Blake* 15257 (flowers), Sept. 1943 (tall tree with rather prominent, thick, rounded buttresses with somewhat concave margins; bark pale grey with rather coarse transversely oblong lenticels, the outer layer dark brown beneath with the lenticels pale, readily separating from the ochraceous inner layer; sapwood pale; leaves green; flowers red).

Satin Oak, as recommended by the Queensland Forest Service, has been adopted as the standard trade name of the timber. The tree in North Queensland is variously known as Red Oak, Pink Silky Oak and Lowland Bull Oak. E. H. F. Swain, in his "Timbers and Forest Products of Queensland" p. 88, states that though the tree is common enough on the Atherton Tableland and on the ranges from 2,000–3,000 ft. altitude, it is essentially a tree of the hot and wet lowlands from Innisfail to Cooktown.

NOTES ON AUSTRALIAN CYPERACEAE, VII.

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(*Received 24th September, 1948; read before the Royal Society of Queensland, 27th September, 1948; issued separately 30th December, 1949.*)

In this paper eight new species are described and two previously described species are recorded from Australia for the first time; some critical species are discussed and necessary adjustments in nomenclature are made.

Scirpus wakefieldianus *S. T. Blake*, nomen et status novus.

Scirpus inundatus (R.Br.) Poir. var. *pseudosetaceus* Kükenth. in Candollea vi, 427 (1936), non *S. pseudosetaceus* Daveau.

Descriptio hic ampliata:

Herba annua, viridis, caespitosa, usque ad 14 cm. alta, basi saepe ramosa. *Culmi* erecti, filiformes, striati, usque ad 0·5 mm. crassi, glabri laevesque, basi foliati. *Folia* pauca, plerumque brevia et saepe fere ad vaginas redacta, acuta vel obtusa, usque ad 0·7 mm. lata, tenuissime 5-nervia, supra concava subtus plus minusve convexa; vaginae dorso purpureae, antice albohyalinae, omnino tenuiter plurinerves, apice leviter inflatae plus minusve truncatae. *Bractea* unica, quasi culmum continuans, erecta vel leviter excurva recurvave, spiculas superans et interdum usque ad 22 mm. longa. *Inflorescentia* quasi lateralis, e spiculis plerumque 3–5 sessilibus divergentibus constructa. *Spiculae* variegatae, ovoideae, obtusae, plus minusve angulatae (haud teretes), 3–4 mm. longae, circa 2·5 mm. latae, multiflorae. *Glumae* incurvae, explanatae suborbiculares, obtusissimae, brevissime apiculatae vel muticae apice saepe patulae, 11-nerves, obtuse carinatae carina viridi crassa percurrente et saepius minute excurrente, lateribus tenuiter membranaceae plus minusve purpureae tenuiter nervosae, marginibus angustae, hyalinae, omnino glabrae, 1·9–2 mm. longae subaequilatae. *Stamen* 1; anther linearis, apiculata, 0·5 mm. longa. *Stylus* brevis, 0·4–0·5 mm. longus; stigmata 3, admodum longiora. *Nux* straminea, nitida, ambitu suborbicularis, trigona, leviter compressa, breviter apiculata, minute stipitata, 0·8 mm. longa, 0·6 mm. lata, angulis leviter costulata, lateribus omnibus convexula, longitudinaliter striata et transversim trabeculata cellulis extimis transversim oblongis in seriebus circa 6–8 fere regulariter dispositis.

VICTORIA.—Gippsland: Reedy Creek, Cann River, 8th Nov. 1947, *N. A. Wakefield* 2031; Cann River, in damp depression, 29th October 1947, *N. A. Wakefield* 2011; Cann River, 18th Nov. 1947, *N. A. Wakefield* 2101; Cann River, Sports Ground, 24th Nov. 1947, *N. A. Wakefield* 2105. Central: Healesville, Mt. Blackspur, damp gully in Eucalyptus forest, about 2,000 ft., 26th Feb. 1905, *B. P. G. Hochreutiner* 3017 (TYPE).

This species is similar to *Scirpus inundatus* (R.Br.) Poir. in habit, in the solitary stamen with a relatively short anther and the pale-coloured trigonous nut more or less distinctly convex between the ribbed angles, but differs conspicuously in the longitudinally striate and transversely trabeculate nut which is also relatively somewhat broader and more nearly orbicular than obovate in outline.

I am indebted to Dr. Kükenthal for a piece of the type of *S. inundatus* (R.Br.) Poir. var. *pseudosetaceus* Kükenth., and to Mr. Wakefield for the fine series of specimens cited above. In one flower, two stamens were observed; in another, two stigmas.

Scirpus montivagus *S. T. Blake;* species nova, affinis *S. inundato* (R.Br.) Poir., sed foliis culmum longe superantibus, rhizomate longe repente, spiculis nucibusque paullo majoribus, glumis crassioribus, nuce longius acuminato-apiculata ejus cellulis extimis minoribus praecipue differt.

Herba perennis, caespites humiles densos foliosos efformans; rhizoma repens, ramosum, tenuissimum fere filiforme. *Culmi* aggregati, plus minusve erecti, setacei, subtrigoni, striati ceterum laeves, glabri, sub inflorescentia 1·5–4 cm. alti, 0·3–0·5 mm. crassi, prope basin foliati. Folia pro ratione longissima, culmum longe superantia et usque ad 7·5 cm. longa, stricta, 0·4–0·6 mm. lata, supra canaliculata, subtus plus minusve convexa, apicem obtusum versus plus minusve plana, glabra, enerves vel supra 3-nerves, pro more 2–4 ad basin omnis culmi sita; vaginae antice plus minusve hyalinae, interiores integrae apice truncatae. *Inflorescentia* quasi lateralis, e spiculis 1–3 divergentibus sessilibus constructa. *Bracteae* 2; inferior foliis similis, erecta quasi culmum continuans vel plus minusve inflexa, basi dilatata, longissima, pro more 2·5–4·5 cm. longa (i.e., culmo aequilonga vel paullo longior); superior glumiformis. *Spiculae* pallide virentes, ovoideae vel oblongo-ovoideae, plus minusve obtusae, polygonae, multiflorae, 3–5 mm. longae, circa 2–2·5 mm. latae. *Glumae* ovato-oblongae, obtuse rotundatae muticae, incurvae, 7-nerves, dorso 1-nervis sursum carinatae coriaceae carina crassa percurrente, lateribus membranaceae tenuissime nervatae, marginibus latiuscule hyalinae, omnino glabrae, 2·1–2·2 mm. longae et 1·2–1·3 mm. latae (explanatae). *Stamen* 1; anther linearis, apiculata, circa 1·2 mm. longa. *Stylus* 0·6–0·7 mm. longus; stigmata 3, manifeste longiora. *Nux* nitida, straminea vel pallide brunnea, ambitu obovata breviter subabrupteque acuminata, triquetra, leviter compressa angulis anguste costata, inter costulis convexula, 1·15–1·25 mm. longa, 0·75–0·8 mm. lata, cellulis extimis perminutis.

VICTORIA.—North-East: Mt. Buffalo, in morasses about 4,500 ft., forming dense light-green patches, 25th Jan. 1935, *S. T. Blake* 7375 (TYPE); soaks between Mt. Nelson and Timm's Lookout, Bogong High Plains, about 5,800 ft., 12th Jan. 1946, *J. H. Willis.*

Very similar to *S. inundatus* (R.Br.) Poir. in general features of the spikelet, but very different in appearance by reason of the numerous long leaves, long bracts and elongated branched rhizomes. The backs of the glumes are much thicker in texture, and the side-nerves are very faint and indistinct. The anther is about twice as long; and the nut is longer, relatively narrower, much more narrowed towards the base, more prominently acuminate-apiculate (almost rostrate), decidedly brown in colour when mature instead of whitish to yellowish, and with even smaller external cells.

Fimbristylis nuda *Boeck.* in Flora lviii, 110 (1875).

F. humilis S. T. Blake in Proc. Roy. Soc. Queensl. xlviii, 91 (1937), non Peter (1936).

Fimbristylis nuda Boeck. was tentatively referred by Bentham, Fl. Austral. vii, 302 (1878), to *F. acuminata* Vahl, but appears to have been overlooked by subsequent botanists; it was unknown to me at the time the description of *F. humilis* was drawn up, as was also the homonym of Peter. I am indebted to Mr. E. Nelmes of the Kew Herbarium for a copy of Boeckeler's description, for "Flora" is not well represented in Australian libraries, and vol. lviii is absent from all.

I have not seen any specimen of the type-collection (Port Denison, *Amalie Dietrich*), but Boeckeler's description agrees so well with *F. humilis* S. T. Blake that there can be no doubt about the species. The exactly oval, obtuse, terete spikelets 2–1·5 lines long with very small, obtuse, obtusely keeled, reddish glumes and the broad style and tiny nut with only 4–5 transverse wrinkles described by Boeckeler do not at all accord with *F. acuminata* Vahl or *F. setacea* Benth. (*F. acuminata* Vahl. var. *setacea* (Benth.) Benth.), both of which have longer, acute, less densely flowered spikelets (about 5 mm. long in *F. setacea* and up to 10 mm. long in *F. acuminata*) with pallid, subacute glumes, and with usually more numerous transverse wrinkles on the nuts.

Fimbristylis nuda is rather widely spread in Queensland and the Northern Territory.

Fimbristylis eragrostis (*Nees & Meyen*) *Hance* in J. Linn. Soc. London xiii, 132 (1873).

Abildgaardia eragrostis Nees & Meyen in Wight Contrib. Bot. Ind. 95 (1834).

QUEENSLAND.—Cook Distict: Near Cairns, in open (chiefly bloodwood) forest on light-grey podzolised soil on gentle slope, about 50 ft., 4th Dec. 1941, *S. T. Blake* 14510.

New for Australia; previously known from China to New Guinea.

Fimbristylis insignis *Thw.* Enum. Pl. Zeyl. 349 (1864).

QUEENSLAND.—North Kennedy District: About 10 miles S. of Tully, in very open *Casuarina-Melaleuca* dwarf forest on swampy sandy soil, chiefly in wet places, about 40 ft., 29th April 1945, *S. T. Blake & L. J. Webb* 15801.

New for Australia; previously reported from Ceylon, China, Borneo and New Guinea. The type-collection, from Ceylon, is represented in Herb. Melbourne.

Schoenus maschalinus *R. & S.* Syst. Veg. ii, 77 (1817).

Schoenus axillaris (R.Br.) Poir. Encycl. Suppl. ii, 251 (1811) non Lam.

Chaetospora axillaris R.Br. Prodr. 233 (1810).

Schoenus subaxillaris Kükenth. in Fedde Repert. xliv, 89 (1938).

Schoenus foliatus (Hook. f.) S. T. Blake in Proc. Roy. Soc. Queensl. li, 48 (Feb. 1940), in J. Arnold Arb. xxix, 93 (1948).

Schoenus foliatus (Hook. f.) Kükenth. in Fedde Repert. xlviii, 248 (Sept. 1940).

Scirpus foliatus Hook. f. in Hook. London J. Bot. iii, 414 (1844).

Helothrix pusilla Nees in Ann. Nat. Hist. ser. I, vi, 45 (1841) non *Schoenus pusillus* Sw.

Helothrix axillaris (R.Br.) Palla in All. Bot. Zeitschr. viii, 68 (1902).

Scleria setifera Boeck. in Flora xli, 648 (1858) ; *syn. nov.*

This is the species widely known in Australian and New Zealand literature as *Schoenus axillaris* (R.Br.) Poir., but the name is illegitimate because of the prior homonym of Swartz. Kükenthal, in 1938, l.c., accordingly proposed the new name *Schoenus subaxillaris* Kükenth. for the species. Then in 1940, ll.cc., he and I independently made the combination *Schoenus foliatus* based on *Scirpus foliatus* Hook f., and under this combination I recorded the species for New Guinea (1948, l.c.). All modern authors appear to have overlooked the fact that Roemer and Schultes adjusted the nomenclature as early as 1817, and their name, *Schoenus maschalinus,* is clearly the legitimate one for the species. From the description there can be no doubt that *Scleria setifera* Boeck. is the same species, but this appears to be the first occasion that Boeckeler's name has been associated with it.

Schoenus pennisetis *S. T. Blake;* species nova, quoad facies *S. odontocarpo* F. Muell. simillimus, sed *S. nano* (Nees) Benth. ut videtur affinior, a quo tamen inflorescentia laxe paniculata, spiculis minoribus, nuce obovoidea crebre reticulata differt.

Herba annua, glaberrima, viridis vel purpurascens, usque ad 13 cm. alta. *Culmi* fasciculati, erecti vel obliqui, capillares, subtrigoni, manifeste sulcati, asperuli, sub inflorescentia enodes, basi foliati. *Foliorum* vaginae arctiusculae, nitidae, purpureae, ore plus minusve oblique sectae, omnino glabrae; laminae setaceae, 0·35–0·5 mm. latae, marginibus plus minusve incurvae, dorso uninerves plus minusve carinatae, supra laxe reticulatae, laeves, usque ad basem inflorescentiae raro patentes. *Inflorescentia* laxe paniculata, 1·2–5 cm. longa, e fasciculis 1–3 inter se distantibus constructa, usque ad 10-spiculata; bracteae foliis similes, basi vaginantes, saltem ima fasciculo suo longior; rami vel pedicelli 2–4-ni vel singuli, compresso-filiformes, e vagina exserti et usque ad 10 mm. longi. *Spiculae* atro-sanguineae, anguste oblongae et plus minusve lanceolatae, primo acutae mox obtusae, compressae, 1–2-florae, 4·5–5 mm. longae, 1·2–1·3 mm. latae. *Glumae* 5–6, obtusae, leviter incurvae, marginibus angustissime albo-hyalinae, lateribus atrosanguineae, carina obtusa laevi pallidiores; superiores anguste ovatae, inferiores vacuae multo breviores pro rata latiores plus minusve mucronatae. *Setae hypogynae* 6, purpurascentes, nucem superantes, in majore parte dense plumoso-ciliatae, sursum antrorsim scabrae, in toro conspicuo sitae. *Stamina* 3; antherae lineares, circa 2·5 mm. longae apiculo albido circa 0·3 mm. longo incluso. *Stylus* sub stigmatibus circa 2 mm. longus, tenuis. *Nux* candida, inter setas hypogynas sessilis, obovoidea, obtusa, manifeste tricostulata costulis in stylum fere decurrentibus, lateribus convexa crebre reticulata, (toro 0·25 mm. longo incluso) 1·25 mm. longa, 0·6–0·7 mm. lata.

WESTERN AUSTRALIA.—South-West Division: Cannington, near Perth, swampy heath on sand, alt. 6–7 m., common on cleared patch, 22nd August 1947, *S. T. Blake* 17986 (TYPE) ; Cannington swamp, 22nd August 1947, *N. T. Burbidge.*

In its slender annual habit with few, small, loosely paniculate, dark-purple spikelets, this new species closely resembles *S. odontocarpus* F. Muell., but differs in having well developed hypogynous bristles, and finely reticulate (not coarsely scrobiculate) nuts with the marginal ribs not toothed at the apex but more or less decurrent into the style. The hypogynous bristles are more like those of *S. nanus* (Nees) Benth., but this species also has a coarsely scrobiculate nut, while the spikelets are fewer, more or less capitate, mostly longer, and with shorter, shortly apiculate anthers.

Schoenus rigens *S. T. Blake,* nomen novum.

Chaetospora distans F. Muell. Fragm. ix, 35 (1875).

Schoenus distans (F. Muell.) F. Muell. First Census Austr. Pl. 127 (1882), non Michx. (1803).

Schoenus calostachyus (R.Br.) Poir. var. *distans* (F. Muell.) Benth. Fl. Austral. vii, 368 (1878).

Western Australia.—South-Western Division: Murchison R., *Oldfield* (MEL; LECTOTYPE); Cannington, near Perth, swampy heath on sand, alt. 6–7 m., 22nd August, 1947, *S. T. Blake* 17985; Busselton, *A. & E. Pries* (MEL).

Without doubt closely allied to *S. calostachyus* (R.Br.) Poir., differing from it in that the culm is nodeless below the inflorescence which occupies much the greater part of the plant, in the shorter leaves and bracts, the few shortly or very shortly pedicellate erect spikelets (the pedicels often scarcely exserted) with rather fewer dull glumes, and the prominently tuberculate nut.

Both the Oldfield and the Pries collections are cited with the original description, and are in the flowering state only. The latter collection is fragmentary; Oldfield's collection is chosen as lectotype because it gives a better idea of the plant.

Schoenus clandestinus *S. T. Blake;* species nova, ob habitum depresse pulviniformem, culmos fere nullos quare spiculos solitarios in rhizomate fere sessiles, atque nucem omnino pubescentem, distinctissima.

Herba perennis, e rhizomate ramoso pulvinos humiles 5–15 cm. latos efformans. *Culmi* fere nulli, sub fructu usque ad 1 mm. longi. *Folia* plura, plerumque basalia, dense conferta; laminae strictae vel leviter curvae, circa 1–2 cm. longae 0·4–0·5 mm. latae, obtusae, planae vel leviter incurvae, subtus manifeste trinerves et bisulcatae, supra uninerves, pilis brevibus plus minusve conicis basi tuberculatis scabridae vel tandem (pilis ipsis delapsis sed tuberculis persistentibus) asperatae; vaginae breves, apertae, dorso purpureae, membranaceae trinerves nervis sursum plus minusve scabridae, marginibus late albo-hyalinae, apice ciliolatae, truncatae vel in auriculas breves obtusas excurrentes; folia caulina 2–3, brevia vel brevissima, fere evaginantia. *Spicula* in quoque culmo unica, erecta, lanceolata, 8 mm. longa, 1–2-flora; rhachilla inter flores breviter producta, internodo fere recto, circa 0·5 mm. longo. *Glumae* 3–4, oblongo-lanceolatae basi plus minusve dilatatae et ibi ciliolatae, apice acutae, carina excepta tenues, plus minusve stramineae, ima vacua vix brevior. *Setae hypogynae* 3–0, nuce breviores, ciliatae. *Stamina* 3; antherae lineares, circa 3 mm. longae, connectivo brevissime producto. *Stylus* longus, gracilis, 3–3·5 mm. longus; stigmata 3, fimbriolata. Nux pallida, obovoidea, turgida vix trigona, undique hispidula, 1·4 mm. longa, 0·9–1·0 mm. lata.

Western Australia.—South-West Division: 10–20 miles N. of Northampton, in sandy heath, 3rd September 1947, *S. T. Blake* 18139.

An extraordinary species forming small practically stemless mats with only the leaf-blades and styles projecting above the surface of the sand.

Schoenus latitans *S. T. Blake;* species nova, affinis *S. clandestino* S. T. Blake, sed spiculis longioribus, setis hypogynis longioribus, nuce ellipsoidea sulcata differt.

Herba perennis, fere acaulis, e rhizomate ramoso pulvinos humiles 5–15 cm. latos pallide virides efformans. *Culmi* usque ad 3 mm. alti, foliis circumdati. Folia plura, dense conferta; laminae pallide virides, saepe plus minusve tortiles, plerumque 2–3 cm. longae, 0·3–0·5 mm. latae, subacutae, supra planae uninerves, subtus 3-nerves plus minusve bisulcatae omnino plus minusve scabridae pilis minimis tenuiter conicis basi subtuberculatis; vaginae longae (circa 2 cm. longae), apertae, flavo-brunneae vel brunneae, nitidulae, apice ciliolatae truncatae vel in lobulos breves obtusos excurrentes, dorso firmae, marginibus late hyalinae; folia caulina circa 3 breviora, fere evaginantia. *Spicula* in quoque culmo unica, erecta, pallida, anguste linearis, 17–24 mm. longa, 3-flora, flore summo saepe tabescenti; rhachillae internodi inter flores usque ad 2 mm. longi, manifeste curvi. *Glumae* 4, lanceolato-lineares, acutae, tenuissime membranaceae dense hispidulae, marginibus hyalinis glabrae, ima florigera, secunda aequilonga, tertia brevia, summa multo brevior angustissima. *Setae hypogynae* 3, inaequales, nuce multo longiores vel ea breviores, ciliatae. *Stamina* 3. *Stylus* tenuissimus, circa 17 mm. longus; stigmata 3, multo breviora, minutissime fimbriolata. *Nux* ellipsoidea, utrinque obtusa, 1·6 mm. longa, 1·0 mm. lata, admodum compressa, longitudinaliter sulcata, dense pubescens.

WESTERN AUSTRALIA.—South-West Division: 10–20 miles N. of Northampton, in sandy heath, 3rd Sept. 1947, *S. T. Blake* 18140.

Associated with *S. clandestinus* S. T. Blake and resembling it in habit, but differs in the paler green leaves often twisted when dry, brown (not purple) sheaths, longer spikelets with hispidulous glumes and more elongated internodes of the rhachilla, well developed hypogynous bristles much longer than the nut, and the sulcate ellipsoid (not obovoid) nut.

Lepidosperma persecans *S. T. Blake;* species nova, affinis *L. gladiato* Labill. a quo culmis foliisque marginibus scaberrimis, foliis planis, spiculis 3–4-floris, nuce minore laevi, squamis hypogynis haud caudatis praecipue differt.

Herba dura perennis, e rhizomate crasso caespites laete virides magnos haud densos efformans. *Culmi* stricti, fere erecti, 1·2–1·6 (fide notulis in schedula usque 2 m.) alti, 5–9 mm. lati (sub panicula distincte angustati), ancipites, secus medium utrinque convexi, lateribus latis compressis, marginibus acutis serrulato-scaberrimi, omnino crebre striati asperuli. *Folia* flabellata, plura, culmo breviora et eo dissimilia, 8–15 mm. lata, haud rigida, ancipitia, inferne secus medium leviter convexa lateribus planis latis, sursum omnino plana tenuia, apice ustulato obliqua vel incurva, omnino striata, marginibus scabra, hic inde inter nervos quasi septata; vaginae breves, plus minusve brunneae vel atrobrunneae, nitidae, haud resinosae. *Bracteae* inferiores breviter vaginantes, foliiformes, erectae vel obliquae, paniculis partialibus suis breviores, raro ima longior; bracteolae setaceae, basi vaginantes, omnino scabrae. *Panicula* ambitu ovata vel lanceolata, plerumque continua densa, 9–16 cm. longa, 3–4 cm. lata, e fasciculis ramorum 7–9 constructa; axis fere recta, plus minusve triquetra, antice canaliculata, angulis scabra; paniculae partiales erectae, singulae vel binae (raro ternae) e bractea vix exsertae (interdum basi inclusae), pyramidales vel oblongae, compositae, densae. *Spiculae* congestae, sessiles, plus minusve patulae, ovoideae vel oblongae, 5–6 mm. longae, 3-florae, summa fertilis, interdum flore quarto tabescente addito. *Glumae* 7–8, atrobrunneae, canescentes, ovatae, breviter mucronatae, superiores anguste obtusae, apice plus minusve excurvae et ibi marginibus involutae, inferiores gradatim breviores obtusiores apice plus minusve rectae. *Squamae hypogynae* ovatae, acuminatae, apice minutissime ciliolatae, tertiam partem nucis adaequantes. *Nux* ovato-oblonga angulis latis leviter costulata, 2·7–3 mm. longa, 1·4–1·5 mm. lata, demum brunneo-olivacea nitidula, laevis; stylobasis brevissima obtusissima, pubescens.

WESTERN AUSTRALIA.—South-West Division: W. of Manjimup, bank of Donnelly R., tending to form stands near the water's edge, about 135 m., 29th August 1947, *S. T. Blake* 18033.

This is a tall species evidently allied to *L. gladiatum* Labill. and *L. effusum* Benth., differing from both in that the culms are extremely scabrous on the margins, the leaves are flat and thin for the greater part, and the nut is narrower with a very smooth even surface. In general the spikelet has 7 glumes, of which I and II are empty, III and IV subtend bisexual but functionally sterile flowers, V is empty, VI subtends the fertile flower and VII is empty and tabescent; occasionally VII subtends an abortive flower, and in one case a large empty glume was found intercalated between VI and VII.

Lepidosperma rostratum *S. T. Blake;* species nova, ob nucem pyriformem longe rostratam alte tricostatam atque costas marginales sursum transversim junctas valde distincta.

Herba perennis, caespitosa, viridis, rhizomate brevi. *Culmi* stricte erecti, 20–30 cm. alti, manifeste pluricostulati ceterum subteretes vel subtrigoni vel plus minusve biconvexi, 0·85–1·2 mm. crassi, laeves, enodes. *Folia* culmo subconformia nisi multo breviora angustiora, apice fere plana acutissima haud rigida, saepius fere ad vaginas redacta; vaginae albidae vel stramineae vel pallide brunnescentes, nitidae. *Bracteae* breves vel brevissimae, ima interdum elongata sed inflorescentiam raro adaequans. *Inflorescentia* depauperata, angustissima, spiciformis, 2·5–5 cm. longa, usque ad 4 mm. lata; rami inferiores e vagina bractearum suarum interdum exserti et spiculas sessiles usque ad 4 gerentes, vel omnes unispiculati e bracteis haud exserti. *Spiculae* sessiles, alternae, contiguae, demum ovoideae, 4–4·5 mm. longae, teretes, biflorae, flore inferiore sterili. *Glumae* 4–5, dorso atro-brunneae, lateribus pallidiores rubido-striatae, tandem omnino plus minusve griseae, minute strigillosae, anguste ovatae, inferiores excurvo-aristatae, superiores mucronulatae. *Squamae hypogynae* crassae, oblongae vel lanceolatae, acutae vel obtusae vel dentatae, partem nucis angustatam admodum superantes. *Nux* subpyriformis, ob stylobasem rostrata, manifeste 3-costata omni costa prope basem in tuberculo grosso exeunte et sub apice nucis cum costa transversa undulata conjuncta, lateribus plus minusve lacunosa, cum stylobasi suboblonga fere 1 mm. alta 3·1–3·2 mm. longa, 1·6–1·8 mm. lata.

WESTERN AUSTRALIA.—South-West Division: Cannington, near Perth, swampy heath on sand, alt. 6–7 m., in wetter places, 22nd August 1947, *S. T. Blake* 17988.

Very distinct by reason of the prominently rostrate pyriform nut prominently ribbed at the angles and with a transverse ridge joining the angles below the style-base. The long style-base is unique among the Australian species, and both the shape of the nut and its ridges are unique in the genus.

Tetraria microcarpa *S. T. Blake;* species nova, in subgenus *Eu-Tetrariam* (C. B. Clarke) Kükenth. sect. *Mucronatosquamas* Kükenth. inserenda, sed ob culmum sub inflorescentia uninodem, folia basalia plura longissima, paniculas partiales capituliformes, spiculas parvas trifloras, nucem pro ratione minutam, valde distincta.

Herba perennis, dense caespitosa, 20–30 cm. alta; rhizoma breve, ramosum, nodosum. *Culmi* erecti, 1·1–1·3 mm. crassi, sub inflorescentia stricti vel fere stricti, obtuse trigoni, crebre striati, uninodes, ruguloso-asperuli sursum angulis scabridi, glabri, prope basem valde bulboso-incrassatam plurifoliati. *Folia* culmum superantia, viridia, plana vel plus minusve complicata, in apicem setaceum plus minusve flexuosum longe attenuata, 2–2·5 mm. lata, carinata et utrinsecus costam supra impressam nervis 3 primariis striata, marginibus costaque sursum scabra; vaginae longae, arctae, ea folii caulini clausa striata antice sursum membranacea, ore oblique secto ciliolata, eae foliorum basalium antice apertae marginibus albo-membranaceae, tandem in fibrillis vix reticulatis fissae, infimae elaminatae duriores brunnescentes. *Bracteae* foliaceae, inferiores vaginantes inflorescentiam longe superantes, superiores gradatim breviores evaginantes. *Inflorescentia* angusta, plus minusve flexuosa, 5–7-nodis, 6–15 cm. longa, 7–10 mm. lata, interrupta, subspiciformis; paniculae partiales ad capitula ovoidea plus minusve composita 7–10 mm. longa et 6–7 mm. lata plus minusve pedunculata redactae; pedunculi singuli, erecti, complanati, scaberuli, inferiores usque ad 4 cm. longi, superiores brevissimi. *Spiculae* dense aggregatae, lanceolatae, compressae, 3·5–4 mm. longae, 3-florae, floribus omnibus hermaphroditis sed flore supremo solum fertili. *Glumae* 6, distichae, membranaceae, pallide sanguineo-striatae, carinato-naviculares, lanceolatae, acutae vel acuminatae, inferiores breviores plus minusve mucronatae. *Torus* prominens, incrassatus. *Setae hypogynae* 2, tenuissimae, minutae, vel 0. *Stamina* 3; antherae lineares auriculis basalibus brevissimis connectivo longe producto subulato, in toto circa 1·5 mm. longae. *Stylus* glaber, sursum tenuis, basem versus incrassatus; stigmata 3. *Nux* turgide obovoidea, tricostata, breviter valideque stipitata, laevis, stylobasi inclusa 1·5 mm. longa, 0·9 mm. lata; stylobasis pyramidalis vel depresso-pyramidalis, crassa, angulis super nucis humeros decurrentibus.

WESTERN AUSTRALIA.—South-West Division: 10–20 miles N. of Northampton, in sandy heath, 3rd September 1947, *S. T. Blake* 18138.

This is the fourth species of this predominantly African genus to be found in Australia; it is well distinguished by the 1-noded culms, numerous long basal leaves, and clustered small 3-flowered spikelets with tiny nuts.

Scleria laxa *R.Br.* Prodr. 240 (1810).

Scleria filipendula S. T. Blake in Proc. Roy. Soc. Queensl. lviii, 49 (1947).

When the account of *S. filipendula* was drawn up a few years ago, the interpretation of *S. laxa* and allied species was based largely on Domin's remarks in Biblioth. Bot. xx, heft 85, 488-9 (1915) and his references to C. B. Clarke's disposition of specimens in the Kew Herbarium, duplicates of some of which were available at Brisbane. Shortly after the paper was published, a fresh enquiry was undertaken when studying recently collected specimens from the Northern Territory and Brass's specimens from New Guinea. The material at Melbourne and Sydney was examined at the same time. Duplicates of the specimens cited by Domin under *S. laxa* were found not to agree sufficiently with R. Brown's original description, which called for a plant with smooth, glabrous stems and leaves, few-flowered subnodding panicles with unisexual sub-1-flowered spikelets, and rugose nuts. No Australian form has yet been observed to have less than three flowers in the male spikelets; otherwise four collections were found which agreed with this description, namely: a *Dallachy* specimen from Rockingham Bay in Melbourne, a *Banks and Solander* specimen with imperfect nuts in Sydney, and *Blake* 5233 (type of *S. filipendula*) and *Blake* 9381 (from Cairns) in Brisbane. Brown would have seen the Banks and Solander collection, and (unless all the material had imperfect nuts) it would be reasonable to presume that he regarded it as representing *S. laxa* since it does not agree with his descriptions of other species. Through the kindness of Dr. J. Ramsbottom, I have examined a photograph and fragment of Brown's type in the British Museum of Natural History. There seems no doubt that *S. filipendula* is conspecific with Brown's species and that Clarke and Domin had completely misinterpreted it, even though Clarke's annotation-slip is attached to the type-sheet.

The plants referred to *S. laxa* in my earlier paper now appear to me to be only glabrescent states of *S. rugosa* R.Br. Glabrous and more or less hairy states are known now in several species, and the presence or absence of indumentum appears to have no value for the discrimination of species. There is also some doubt as to the status of *S. benthamii* C. B. Clarke; my earlier interpretation of a specimen at Brisbane as a duplicate-type appears to have been erroneous, and the specimen now appears to be one of *S. tessellata* Willd. var. *debilis* Benth. The discussion of this and other problems must be postponed; some of these involve misidentifications which originated in the early part of last century.

A REVIEW OF THE GENUS BULBOPHYLLUM (ORCHIDACEAE) IN AUSTRALIA.

(WITH PLATES II–VII.)

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The genus *Bulbophyllum* is one of the largest in the family *Orchidaceae* and is widely distributed throughout southern Asia, the East Indies and Australasia, reaching its greatest development in the equatorial regions. Of the many hundreds of known species, twenty-eight are recorded for Australia where they range along the eastern seaboard from the far north of Queensland to a point a hundred miles or so south of Sydney. As is to be expected, the bulk of the species occur in the jungles of the far north of Queensland, and so far, twenty-three have been recorded there. Southern Queensland and northern New South Wales have eight species, and but three are found in the vicinity of Sydney.

There has been some confusion between the genera *Cirrhopetalum*, *Bulbophyllum*, *Dendrobium* and some others. It would be most difficult to define exactly the difference between the last two and it is here that the greatest confusion arose. In their review of the genus *Dendrobium* in Australia, Proc. Linn. Soc. N.S.Wales Vol. lxxii, 5–6, pp. 233-251, the present authors discuss those species of *Dendrobium* removed from *Bulbophyllum*. These changes in nomenclature and the addition of many new species since the publication of Bailey's "Queensland Flora," Vol. v, in 1902, make the present paper appear desirable. The types of the species described by Hunt in this paper are in the Queensland Herbarium, Brisbane; those of the species described by Rupp are in the National Herbarium of New South Wales, Sydney.

The paper will fall into four parts:—

1. Accepted species in alphabetical order.
2. Excluded species.
3. Artificial key to the accepted species.
4. Index.

PART I.

1. **B. adenocarpum** Schltr. in Fedde Repert. viii, 568 (1910).

Apparently nothing is known of this species beyond the original description, a translation of which is as follows:—Epiphyte on branches of trees, about 5 cm. high; rhizome creeping, with long, filiform, twining, roots. Pseudo-bulbs rather narrow, conical, with one leaf at the top, 0·5–0·7 cm. high, and 3·0–3·5 mm. in diameter near the base. Leaf erect, linear, sub-acute, contracted almost into a narrow petiole near the base, 3·5–4·5 cm. long, 3·0–3·5 mm. broad near the middle. Peduncle filiform from a slender base with a small tightly sheathing bract, 2·0–2·5 cm. long, glabrous. Flower almost erect, fairly large, sepals almost oblong, glabrous, medial nerve prominently but not strongly raised, sparsely glandular at the shortly produced apex, 6 mm. long; laterals about as long, similar, but with the anterior margins dilated and very oblique at the base; petals obliquely ovate-lanceolate, obtuse, 5 mm. long; labellum convex, oblong obtuse, base curved inwards, 3 parallel nerves on the upper surface extending almost to the apex, equal in length to the petals, glabrous. Column short, wings large, tips shortly produced into subulate points. Anther cucullate, humped. Ovary pedicellate, clavate, densely covered with warty glands, 6 mm. long including the pedicel.

Mt. Bartle Frere, N.Queensl., Stephen Johnson, in 1891.

2. **B. aurantiacum** F. Muell. Fragm. iii, 39 (1862); Benth. Fl. Austral. vi, 288 (1873); F. M. Bail. Queensl. Fl. v, 1537 (1902); Rupp, Orch. N.S.Wales, 124 (1943).

Dendrobium aurantiacum (F. Muell.) F. Muell. Fragm. vii, 98 (1870).

B. aurantiacum var. *Wattsii* F. M. Bail. Queensl. Agr. J. xxxi, part 3, 192–193 (1913).

Difficulties are experienced in identifying this species owing to the variations in its leaves which are sometimes quite flat and broad, sometimes semi-terete but channelled like those of *B. crassulifolium,* but much larger. The flowers vary from orange to pale green, but the labellum is always dark orange or reddish. Bentham's statement that the flowers are "smaller even than those of *B. shepherdii*" (*B. crassulifolium*) is a mistake.

3. **B. baileyi** F. Muell. Fragm. ix, 5 (1875); Fitzg. Austral. Orch. ii, part 5 (1893); F. M. Bail. Queensl. Fl. v, 1536 (1902).

B. punctatum R. D. Fitzg. in Journ. Bot. xxi, 205 (1883); F. M. Bail. Queensl. Fl. v, 1540 (1902).

4. **B. bowkettae** F. M. Bail. in Proc. Roy. Soc. Queensl. i, 89 (1885) and Queensl. Fl. v, 1538 (1902). See plate VII, fig. 3.

5. **B. bracteatum** F. M. Bail. Bot. Bull. iv, 17 (1891) and Queensl. Fl. v, 1539 (1902); Rupp, Orch. N.S.Wales, 125 (1943).

Adelopetalum bracteatum (F. M. Bail.) Fitzg. Austral. Orch. ii, part 5 (1893).

We agree with F. M. Bailey's treatment of this species as a *Bulbophyllum* (Queensl. Fl. v, 1539 (1902) and Rupp, Orch. N.S.Wales, 125 (1943)). The plant is not uncommon and we have had ample opportunity of examining fresh material. The petals, being about half the length of the sepals, are not particularly inconspicuous.

6. **B. cilioglossum** Rogers and Nicholls Trans. Roy. Soc. S.Austr. lix, 204 (1935).

This plant has been received lately from several widely scattered areas of North Queensland—Ingham, Hambledon, Gadgarra.

7. **B. cochleatum** Schltr. in Fedde Repert. viii, 455 (1910).

The remark under *B. adenocarpum* applies also to this species.

A very small epiphyte creeping on the branches of trees; stems short, pseudo-bulbs close together; pseudo-bulbs ellipsoid, about 1·2 cm. high with a single leaf. Leaf erect, linear-acute, fleshy, 1·3–3·0 cm. long, 1·5–2·0 mm. broad. Peduncle very narrow and hair-like, glabrous, with a minute bract, one-flowered. Flowers inverted like those of *B. polyblopharon* Schltr., but smaller. Dorsal sepal lanceolate, acute, glabrous, 6·5 mm. long; laterals as long, connate to the sixth apical part in a lanceolate, acutely bifid, glabrous, lamina; petals lanceolate, very acute, glabrous, margins here and there inconspicuously dentate, very little shorter than the sepals; labellum narrow at the base with two short, broad, lateral wings and then dilating in the lamina to an obtuse, elliptical, concave, spoon-shape; the lamina densely beset with long, clavate hairs, equal to the petals. Column short, wings subulate, exceeding the anther; anther cucullate, glabrous; ovary cylindrical, 1·5 mm. long, glabrous.

Bellenden Ker Ra., *Stephen Johnson,* 1891.

8. **B. crassulifolium** (A. Cunn. apud Lindl.) Rupp in Proc. Linn. Soc. N.S.Wales lxii, 27 (1937), and Orch. N.S.Wales, 123 (1943); Rolfe in Orchid Review xiii, 143 (1905).

B. shepherdii (F. Muell.) F. Muell. Fragm. iii, 40 (1862); Benth. Fl. Austral. vi, 288 (1873); Fitzg. Austral. Orch. i, part 5 (1879); Reichb. f. Xen. Orch. ii, 166, and Beitr. Syst. Pfl. 52 (1871); F. M. Bail. Queensl. Fl. v, 1537 (1902).

B. schillerianum Reichb. f. in Otto, Hamburg Gartenz. xvi, 423 (1860).

Dendrobium crassulifolium A. Cunn. apud Lindl. Bot. Reg. Misc. 33 (1839).

Dendrobium shepherdii F. Muell. Fragm. i, 190 (1859).

This plant, together with *B. exiguum* and *B. elisae* are the only species of *Bulbophyllum* which have been found south of the Hunter R. in N.S.Wales. Both *B. exiguum* and *B. crassulifolium* have been found as much as 100 miles south of Sydney, while *B. elisae* has been recorded on the Blue Mountains. (Plate III, fig. 3).

8a. **B. crassulifolium** var. **intermedium** (F. M. Bail.) Nicholls in Nth. Queensl. Nat. v, 49 (1937).

B. intermedium F. M. Bail. Queensl. Fl. v, 1537 (1902).

Tamborine Mt., *Mrs. H. Curtis,* 1925.

9. **B. elisae** (F. Muell.) Benth. Fl. Austral. vi, 289 (1873); Fitzg. Austral. Orch. ii, part I (1884); F. M. Bail. Queens. Fl. v, 1539 (1902); Rupp Orch. N.S.Wales 125 (1943).

Cirrhopetalum elisae F. Muell. Fragm. vi, 120, t. 57 (1868).

The peculiarities of this species have been well discussed by Rogers in Trans. Roy. Soc. S.Austral. li, 2 (1926). He expressed the opinion that if it were to be retained in *Bulbophyllum* a special section would be required for it. Bentham, followed by Bailey, describes the flowers as "white, tinged with pink." In our experience they are usually green with a dark red labellum. Specimens from the Dorrigo district of N.S.Wales have been found with reddish-purple flowers.

10. **B. evasum** Hunt & Rupp, species nova. Plate III, fig. 1.

Rhizoma serpens, circa 2·5 mm. crassum, squamatum. Pseudo-bulbi fere obsoleti. *Folia* sparsa. Folium unicum ovato-oblongum vel ellipticum, 3·0–4·5 cm. longum, circa 1·5 cm. latum, oblique emarginatum, crasse coriaceum, vena media depressa. *Pedunculum* inter folia saepe prope folii basem situm, filiforme, rubrum, 6–7 cm. altum, bracteis 2–3. *Inflorescentia* ad pedunculum summum capitata. *Flores* stipati, numerosi, minuti (usque ad 4 mm. longi), punicei venis coccineis; bracteae acutae, permanentes. *Sepalum dorsale* circa 3 mm. longum, cucullatum, ovatum, apice flavo, 3-nervis. *Sepala lateralia* paulum longiora, oblonga, acuta, ad basem unita et dilatata (neque calcar formantia), intus prope venas pubescentia, 5-nervia. *Petala* circa 2 mm. longa, falcato-lanceolata, alba, 1-nervia. *Labellum* crassissimum, 2 mm. longum, ad basem latum, antice contractum, dense glandulosum, rubidum, supra canaliculatum, jugis duobus conspicuis praeditum. *Columna* brevissima et lata, obtuse bifida; alae magnae, lanceolatae. *Anthera* bifida. *Pollinia* 2, obovata; caudiculum absens. *Stigma* laterale ovatum.

Rhizome creeping, about 2·5 mm. in diameter, more or less clothed with scarious scales. Pseudo-bulbs obsolete or represented by a slight swelling of the rhizome covered by a scaly bract. Leaves sparsely scattered at intervals of 2–4 cm. Individual leaf ovate-oblong or elliptical, 3–4.5 cm. long, about 1·5 cm. wide, obliquely and minutely emarginate, coarsely coriaceous, mid-vein depressed. Peduncle arising between the leaves or near the base of a leaf, red, filiform, 6–7 cm. high, with 1–2 sheathing bracts at the base and a shorter one higher up. Inflorescence a crowded capitate raceme at the top of the peduncle. Flowers numerous (up to 20), minute (3–4 mm. long), subsessile, not expanding widely, pink with heavy crimson longitudinal veins, segments somewhat rigid. Floral bracts ovate-acute, persistent. Dorsal sepal about 3 mm. long, ovate, cucullate, with 3 crimson veins, tip yellowish, subacute. Lateral sepals a little longer, united and somewhat dilated in their basal third, but not forming a definite spur, oblong, acute, with 2 marginal and 3 intermediate crimson veins; very glandular–pubescent about the veins on their inner surfaces. Petals about 2 mm. long or a little more, whitish with crimson tips and a single median vein, falcate-lanceolate. Labellum about as long as the petals, deep red, very thick and glandular-papillose, tapering from a broad, hastate base to a narrow but obtuse apex, deflexed; upper surface with a smooth median channel tapering from the base to a point well in front of the middle, and bordered by 2 papillose ridges which are thickened basally to project into a short spur on either side, these spurs constituting the lobes of the hastate base of the labellum. Claw of labellum slender, attached to the column-foot. Column very short and broad, bluntly bifid, its foot rather long, bent upward; wings very large, lanceolate-acuminate, much higher than the anther, inclined forward. Anther blunt, bifid. Pollinia 2, obovate, no caudicle. Stigma conspicuous, laterally ovate.

Summit of Bellenden Ker Range, collector not specified 30.6.1889 (Queensland Herbarium); Zarda, Roots Creek track, Mt. Spurgeon, H. Flecker 2.1936 (TYPE); Cardwell, *Mrs. W. Kirkwood* 8.1946; Bellenden Ker Range, *J. H. Wilkie* 9.1946; Chilverton, *S. E. Stephens* 11.1946; Hambledon, *A. E. Johnson* 11.1946 and 10.1947, flowering (CO-TYPE). All N. Queensland localities.

11. **B. exiguum** F. Muell. Fragm. ii, 72 (1860); Benth. Fl. Austral. vi, 288 (1873); F. M. Bail. Queensl. Fl. v, 1538 (1902); Rupp, Orch. N.S.Wales, 125 (1943).

Dendrobium exiguum (F. Muell.) F. Muell. Fragm. v, 95 (1865); R. D. Fitzg. Austral. Orch. ii, part 5 (1893).

B. exiguum F. Muell. var. *dallachyi* F. M. Bail. Queensl. Fl. v, 1538 (1902).

12. **B. gadgarrense** Rupp, species nova. Plate III, fig. 2.

Rhizomata gracilia, late serpentia et ramosa, plus minusve squamis fuscis-purpureis scariosis contecta. Pseudo-bulbi minimi in rhizomate prostrati; apices truncati, sursum curvati. Folis 2–6·5 cm. longa, crassa, linearia, supra canaliculata. Flores albi, numerosi, solitarii vel fasciculati in pedunculis brevissimis. Sepala aequalia, circa 0·6 mm. longa, spiculis filiformibus; sepala lateralia ad bases unita et cum columnae pede apice filiforme, sepala lateralia ad bases unita et cum columnae pede calcar obtusum formantia. Petala minuta, oblonga, obtusissima. Labellum 2 mm. longum, aurantiacum, crassum, deflexum, obtusum, supra canaliculatum. Columna brevis alis parvis; anthera obtusa. Stigma et pollinia in speciminibus visis obscura.

Rhizomes slender, extensively creeping and branching, more or less covered with purplish-brown scarious sheathing bracts. Pseudo-bulbs very small, about 3–4 mm. long, prostrate on the rhizome except at their upturned truncate apices, much wrinkled when dry. Leaf 1 to each pseudo-bulb, thick and fleshy, linear, channelled on the upper surface, 2–6·5 cm. long. Flowers numerous, white, solitary or in clusters, on very short peduncles almost concealed by the scarious scales of the rhizome. Sepals equal, about 6 mm. long, with long filiform points; the lateral pair united basally and dilated to form a spur with the column-foot. Petals scarcely more than 1 mm. long, oblong, with blunt rounded apex tipped with yellow. Labellum nearly 2 mm. long, orange, thick and glandular, decurved or almost reflexed in front, obtuse, channelled above, attached at its base to the column-foot by a short claw. Column short and rather broad, its wings small but as high as the anther, its foot longer than the column itself. Anther very obtuse. Stigma obscure, and pollinia not seen.

Gadgarra, Atherton Tableland, N.Queensland, *S. F. Kajewski*; same locality, 9.1945; *W. W. Abell* (TYPE); Mt. Islay, N. Queensland, 9.1947, *A. E. Johnson.*

The species has some affinities with *B. crassulifolium* Cunn., and might be mistaken for a long-sepalled variety of it; but the floral details are really very different. The petals of *B. crassulifolium* are very broadly lanceolate, while those of *B. gadgarrense* are oblong with very blunt rounded apices. The sepals of the latter are three times as long as those of the former, which are never prolonged into filiform points. Kajewski's specimens in the Queensland Herbarium were labelled *B. prenticei* F. Muell.; but this species, subsequently removed by Nicholls to *Dendrobium,* is quite a different plant, and there is no resemblance between the flowers at all. The leaves of the new species are very variable in length, but there is no increase of width in the long forms.

13. **B. globuliforme** W. H. Nicholls in Orchidol. Zeyl. v, 123 (1938) and Vict. Nat. lxii, 12 (1945).

This species is probably the smallest of all Australian orchids. It has been recorded so far only from the New South Wales side of the McPherson Range and from Bryden in the upper Brisbane River valley.

14. **B. johnsonii** Hunt, species nova. Plate IV, fig. 1.

Rhizoma serpens. *Pseudo-bulbi* ad intervalla circa 3 cm. siti, oblique coniformes, depressi, rhizoma amplectantes, sulcati, rufuli, circa 1·5 cm. longi et 1·0 cm. lati. *Folium* unicum, circa 7 cm. longum et 1·8 cm. latum, ellipticum, petiolatum, aliquatenus coriaceum; costa media prominens. *Flos* unicus. *Pedunculum* erectum, circa 2·5 cm. longum, bracteam minimam ad medium gerens, e tubere in rhizomate emergens, *Sepala lateralia* circa 1 cm. longa, lineari-lanceolata, acuta, flava, crassa, rugosa, ad basem striis rubris notata; sepalum dorsale circa 8 mm. longum, lanceolatum, acutum, cucullatum, flavum, striis rubris 3–5 notatum; petala circa 2 mm. longa, ovata, flava, striis rubris 3 notata, ad apices glandibus minimis praedita; labellum circa 8 mm. longum, lineare, supra e basi et subtus ex apice sulcata utrinque sulco prope medium evanescenti, rubidum apice flavo, subtus glandibus minimis praeditum, ad pedem incurvum columnae per unguem brevem fixum, manifeste mobile. Columna circa 1 mm. alta, flava, alis filiformibus; stigma magnum ovatum.

Hambledon, N.Queensland, *A. E. Johnson,* 10.1947.

Rhizome creeping 3·5 mm. in diameter. Pseudo-bulbs spaced at intervals of about 3 cm., obliquely conical, depressed, clasping the rhizome, channelled, reddish, about 1·5 cm. long and 1 cm. wide. Leaf solitary, about 7 cm. long and 1·8 cm. wide, elliptical, petiolate, thin-coriaceous, mid-rib prominent, light green. Flowers solitary on numerous peduncles rising from slight protuberances on the rhizome either below the pseudo-bulbs or between them. Peduncle erect, about 2·5 cm. long, red below the small sheathing mid-way bract and greenish above it. Lateral sepals 1 cm. long, linear-lanceolate, acute, yellow with short red striae at the base, somewhat leathery in texture, longitudinally ridged; dorsal sepal 8 mm. long, lanceolate, acute, cucullate over the column, yellowish, heavily marked with 3–5 bright red raised striae; petals about 2 mm. long, ovate, yellowish with three red striae, minutely glandular-dotted towards the tips; labellum about as long as the dorsal sepal, linear, channelled above towards the base and almost throughout its whole length below, deep red with a yellow tip, minutely glandular-dotted below, attached to the up-curved column-foot by a short claw, very mobile. Column about 1 mm. high, yellow; wings erect, filiform, as high as the anther or exceeding it; stigma comparatively large, oval; column-foot somewhat longer than the column, reddish, curved upwards.

15. **B. kirkwoodae** Hunt, species nova. Plate 5.

Rhizoma serpens. *Pseudo-bulbi* ad intervalla 1–2 cm. siti, oblique coniformes, sulcati, rhizoma amplectantes, virides, 1·0–1·5 cm. longi. folium unicum, ellipticum, circa 3·5 cm. longum, ad apicem obtusum recurvum, petiolatum, aliquatenus coriaceum, costa media prominens. Pedunculum 2–3 cm. longum, ad basem incrassatum, bracteis duabus rubris praeditum. Flos unicus, flavus, striis coccineis notatus; sepala sulcata. Sepalum dorsale circa 6 mm. longum, lineari-lanceolatum, acutum, apice apiculatum et recurvatum; sepala lateralia longiora, fere oblonga, minime apiculata; calcar parvum, curvum; petala circa 1·5 mm. longa, ovata, acuta, flava, praecipue apicibus maculis coccineis notata; labellum circa 5 mm. longum, lineare, coccineum, apice flavo, supra e basi subtus ex apice sulcatum, in ungui tenui mobile. Columna minima, flava, maculis coccineis notata; alae filiformae; stigma ovatum; pes columnae curvus utrinque callo amplo lato obtuso erecto praeditus.

Chilverton, Atherton Tableland, N. Queensland, July, 1947, *Mrs. Kirkwood.* Flowered in Ipswich, 11.47.

Rhizome creeping, about 2 mm. in diameter, covered with the scarious remains of sheathing scales. Pseudo-bulbs spaced at intervals of 1–2 cm. obliquely conical, depressed, clasping the rhizome, channelled, green, 1–1·5 cm. long. Leaf solitary, elliptical, 3·5 cm. long, petiolate, thinly coriaceous, generally recurved towards the somewhat obtuse apex, green, paler below, mid-rib prominent. Peduncles 2–3 cm. long, thickened at the base, rising from the rhizome either from below the pseudo-bulbs or the intervening nodes; bracts two, reddish, sheathing, one at the base and the other two-thirds of the way up. Flower solitary, yellow, heavily veined with crimson, sepals with several longitudinal furrows; dorsal sepal about 6 mm. long, linear-lanceolate, acute, with a minutely apiculate deflexed tip; lateral sepals somewhat longer, almost oblong, minutely apiculate; spur small, bent forward; petals about 1·5 mm. long, ovate, acute, yellow, heavily speckled with crimson especially at the tips; labellum about 5 mm. long, linear, very dark crimson with a dark yellow tip, deeply channelled towards the base above and lightly channelled anteriorly below, very mobile on a fine claw. Column minute, yellow dotted with crimson, wings filiform, projecting forward, exceeding the anther; stigma oval; column-foot very much longer than the column, curved, with a large, broad, erect, obtuse callus on each side near the labellum claw.

This species is very similar to *B. johnsonii* Hunt, and also to *B. Whitei* Hunt & Rupp, but more especially to the former. It can be distinguished from these, and, in fact, from all other Australian species of the genus, by the presence of the two remarkable calli at the end of the column-foot.

16. **B. lageniforme** F. M. Bail. in Queensl. Agric. Journ. xv, 1, July, 1904.

There has been no reference to this species since its original description and it was known only by the solitary specimen in the Queensland Herbarium. Recently, however, Mr. W. H. Nicholls of Melbourne succeeded in flowering a plant which proved to be this species. The authors are very much indebted to him for the fine plate he prepared for this paper (Plate II).

The original description is as follows:—

Rhizome creeping, rather slender, and nearly glabrous, corrugated when dry; pseudo-bulbs numerous, but not crowded, flask-shaped, like the utricle of *Carex,* smooth, becoming corrugated when dry, almost 1 cm. high. Leaves solitary, linear-lanceolate, about 4 cm. long, widest part about 7 mm., mid-rib sharp and prominent, with numerous parallel veins on either side; upper surface foveolar-dotted. Peduncles filiform, about as long as the leaves, bearing a linear bract near the centre, and a similar but shorter one close under the flower. Flowers 1 or 2, open and somewhat bell-shaped. Pedicels about 7 mm. long slightly enlarging upwards, and prominently tuberculose in the upper part. Sepals about 8·5 mm. long, 3–nerved, dorsal one lanceolate, laterals much broader at the base, apex recurved. Petals ovate-lanceolate, shorter than the sepals, transparent, 3–nerved, the lateral nerves not reaching the apex. Labellum coriaceous, articulate at the base of the column, shorter than the other segments, ovate, margins recurved, disk with 3 prominent ribs. Column rather slender, a little over a third as long as the petals; wings prominent, truncate or toothed at the top, anther-lid depressed.

Mr. Nicholls states that the flower of *B. lageniforme* is pale greenish with brown markings. He also observed, and illustrated in his plate, that the lamina of the labellum has two prominent ribs, not three as given in the original description, unless the prominent channel is included.

17. **B. lilianae** Rendle in Journ. Bot. lv, 308 (1917).

There has been no reference made to this species since its discovery. The following is a translation of the original description.

A small epiphyte; rhizome long and thin, branching, terete, about 1 mm. in diameter. Roots almost filiform, bent, glabrous. Pseudo-bulbs narrowly cylindrical, oblique, about 1 cm. high and 5 mm. thick, very rugose when dried. Leaf solitary, subsessile, 0·8–2 cm. long, and 7 mm. broad, reflexed, linear-oblong or oblong-elliptical, apex minutely apiculate, thick, mid-rib channelled above and prominent below. Peduncle one-flowered, about 2 cm. long, filiform, mid-bract tubuliform, sheathing. Flower small, supporting bract hardly 2 mm. long, ovate, acuminate, yellowish-green. Pedicel, with ovary, 8 mm. long. The backs of the sepals glandular, 3–nerved. Dorsal sepal 6·3 mm. long, 2·75 mm. wide, lanceolate-oblong, apex obtuse and obscurely apiculate; lateral sepals 6 mm. long, 4·3 mm. wide, ovate, apices as in the dorsal; petals 4·5 mm. long, 1·75–2 mm. wide, lanceolate, almost obtuse, apices scarcely apiculate, 3–nerved; labellum 3·75 mm. long, 1·5 mm. wide, greatly recurved, convex, apex obtuse, base obscurely lobed, reddish-brown when dried. Column 2 mm. high, wings broad, vaguely toothed; ovary and pedicel glandular.

Summit of Bellenden Ker in small forest and dense scrub, altitude approx. 5,000 ft. Flowers in March.

The author also remarks:—"Evidently near *B. adenocarpum* Schltr. which I know only from the description and which it resembles in the convex labellum and warted ovary; it differs in foliage, the leaves of *B. adenocarpum* being linear and much longer—3·5–4·5 cm." (Plate IV, fig. 2).

18. **B. macphersonii** Rupp in Vict. Nat. li, 81 (1934).

B. purpurascens F. M. Bail. in Proc. Roy. Soc. Queensl. i, 88 (1885).

Osyricera purpurascens (F. M. Bail.) Deane, R. D. Fitzg. Austral. Orch. ii, 5 (1893); F. M. Bail. Queensl. Fl. v, 1540 (1902).

The story of the nomenclature of this diminutive but beautiful species is so interesting that we venture to outline it here. As far back as 1884 Bailey described it under the name *Bulbophyllum purpurascens*. Fitzgerald executed a plate of it, but died before it could be published. When Deane and Stopps later were able to publish those plates now constituting Austr. Orch. Vol. II, Part v, the former argued with Bailey that this particular plant was not a *Bulbophyllum,* but belonged to the genus *Osyricera.* Bailey demurred at first, but ultimately consented to the transfer, and it appears in Austr. Orch., l.c., as *Osyricera purpurascens.* Some years afterwards, and subsequently to the deaths of Bailey and Deane, the genus *Osyricera* was absorbed into *Bulbophyllum.* But Bailey's name could not be retained, because it was found that in 1862 a Javanese species had been named *B. purpurascens.* Our little Queensland plant was therefore nameless; and as no one had seen it for many years, no one cared to deal with it. In 1934 specimens reached Rupp from North Queensland which he recognised from Fitzgerald's plate; the determination was confirmed by Rogers, and the plant was re-named *B. macphersonii* after Mr. Kenneth MacPherson of Proserpine, who had sent the specimens. Since then this species has frequently been recorded from Bellenden Ker and other northern mountains.

19. **B. minutissimum** (F. Muell.) F. Muell. Fragm. xi, 53 (1878); R. D. Fitzg. Austral. Orch. ii, 2 (1885); F. M. Bail. Queensl. Fl. v, 1538 (1902); Rupp, Orch. N.S.Wales, 124 (1943).

Dendrobium minutissimum F. Muell. Fragm. v, 95 (1865).

20. **B. nematopodum** F. Muell. Fragm. viii, 30 (1872); Benth. Fl. Austr. vi, 287 (1873); F. M. Bail. Queensl. Fl. v, 1536 (1902).

This very little-known plant has recently been received by one of us (T.E.H.) from the Bellenden Ker area where it was collected by Mr. J. H. Wilkie, and from the Big Tableland, Cooktown, collected and forwarded by Mrs. W. Kirkwood of Cairns. The plants continued growing strongly and have bloomed. A description made from living material is given to supplement those cited above. It is figured on Plate VI.

Rhizome creeping. Pseudo-bulbs very closely overlapping, globular with a long neck, 1·5 cm. high and 1 cm. in diameter near the base, the whole pseudo-bulb covered by the soft, fibrous remains of persistent sheathing scales. Leaf solitary, linear-lanceolate, 4–13 cm. long and up to 2 cm. wide, contracted into a fairly long petiole, fleshy. Flower solitary, greenish-yellow, not expanding fully; peduncle about 1 cm. long, red, persistent; pedicel with ovary about 5 cm. long, greenish with crimson markings, subtended at the base by a short sheathing bract. Lateral sepals about 1 cm. long, broad-lanceolate, slightly falcate, somewhat fleshy, pale yellowish green with irregular lines of crimson dots, attached to the short basal projection of the column; dorsal sepal very slightly shorter, cucullate, lanceolate; petals about 2 mm. long, green with a prominent crimson dot at the apex of each; labellum about 3 mm. long on a very small claw, mobile, very thick, curved, obtuse, margins towards the base, erect, each with a smooth ridge running forward parallel to the edge, reddish. Column leaning forward, slender, green, wings each terminating in two hair-like points exceeding the anther; anther green, acute; stigma narrow with a prominent crimson spot below it; column-foot short, tapering, curved, spotted with red.

21. **B. newportii** (F. M. Bail.) Rolfe in Orch. Rev., xvii, 94 (1909).

Sarcochilus newportii F. M. Bail. Queensl. Fl. vi, 2014 (1902).

The material in the Queensland Herbarium has been examined and we support Rolfe's transfer of the species to *Bulbophyllum* (Plate VII, fig. 1).

22. **B. radicans** F. M. Bail. in Queensl. Agric. Journ. i, 81 (1897) and Queensl. Fl. v, 1536 (1902).

A plant of this rare species was received recently from Mr. A. Johnson of Hambledon, Nth. Queensland. The plant is indistinguishable from *B. cilioglossum* unless flowers are present. It is very closely allied to that species.

23. **B. toressae** F. M. Bail. 3rd Suppl. Syn. Queensl. Fl. 72 (1890) and Queensl. Fl. v, 1538 (1902).

There is an excellent exposition and plate of this species by W. H. Nicholls in Nth. Queensl. Nat. x, 66 (1941).

24. **B. trilobum** Schltr. in Fedde; Repert. viii, 455 (1910).

This is another species of which nothing appears to be known beyond the original description. A translation is given below.

Epiphytic, decumbent on branches of trees, up to 7 cm. high. Rhizomes prostrate, with numerous long flexuous filiform roots, glabrous. Pseudo-bulbs scattered, obliquely ovoid, 1–leaved, 5–7 mm. high, 4–5 mm. in diameter about the middle. Leaves erect, coriaceous, glabrous, obtuse or apiculate, oblong or oblong-elliptical, 3–4 cm. long, 0·7–1 cm. wide. Racemes exceeding the leaves, laxly 4–6-flowered, slenderly pedunculate; peduncle erect, filiform, usually a little longer than the raceme, glabrous; bracts minute, ovate-acuminate, much shorter than the pedicel of the ovary. Flowers erect, of medium size, pale rose. Dorsal sepal oblong, obtuse, glabrous, 6–7 mm. long; lateral sepals equal and similar to the dorsal but somewhat obliquely dilated towards the base. Petals obtuse, obliquely elliptical, glabrous, about 5 mm. long. Labellum ligulate, curved, 3–lobed, as long as the petals; below the middle hispid-papillose; lateral lobes conspicuous, subfalcate-lanceolate and finely acuminate; mid-lobe nearly 3 times larger, ligulate, obtuse, pink, glabrous. Column short, teeth obliquely lanceolate exceeding the anther, foot slender, very long. Ovary glabrous, club-shaped, together with the pedicel about 7 mm. long.

25. **B. wanjurum** Hunt in Nth. Queensl. Nat. xiv, 82 (1947).
Mt. Bartle-Frere, *J. H. Wilkie*, Sept., 1946.

26. **B. weinthalii** Rogers in Trans. Roy. Soc. S. Austral. lvii, 95 (1933); F. A. Weinthal in Austral. Orch. Rev. iv, 2 (1939); Rupp Orch. N.S.Wales, 124 (1943).

This species was discovered near Dorrigo, N.S.Wales, and subsequently was found to extend to southern Queensland. It grows high up on "Hoop pines" (*Araucaria cunninghamii* Ait.). It is remarkable for the extraordinary size of its flower which is often as large as pseudobulb and leaf combined; it is on a short peduncle which cannot remain erect under its weight.

27. **B. whitei** Hunt & Rupp, species nova. Plate VII, fig. 2.

Rhizoma gracile, serpens, ramosum. Pseudobulbi haud dense congesti, 1·0–1·5 cm. alti, virides vel fusco-rubri, oblique ovoidei, depressi, costati vel rugosi. Folium ovatum vel late lanceolatum, plerumque apiculatum, coriaceum, tenuiter canaliculatum, usque ad 4 cm. longum. Flos unicus, aureo-viridis vel aurantiacus, circa 1·5 cm. latus, in pedunculo gracillimo 2–3 cm. longo situs. Bracteae 2. Sepalum dorsale circa 4 mm. longum, cucullatum, oblongum, plus minusve apiculatum, venis conspicuis longitudinalibus 3 notatum. Sepala lateralia circa 5–6 mm. longa, oblique ovata, ad basem venis rubris brevissimis notata. Petala minima, lutea, ad margines minute maculata, ad apices fusco-rubra. Labellum in ungue brevi irritabile, circa 5 mm. longum, angustum, crassum, obtusum, ad basem marginibus erectis; dimidio posteriore rubrum, dimidio anteriore croceum papillosum. Columna brevis et lata, alis pone antheram albam extensis. Rostellum acutum; stigma fere triangulare.

Rhizome extensively creeping, branching, but not forming dense masses as in *B. bowkettae*. Pseudo-bulbs about 1·5 cm. apart, green deepening to red-brown in age, obliquely depressed-ovoid, ribbed and the older ones wrinkled, their bases flattened but closely embracing the rhizome, their apices very obtuse. Leaf ovate to broad-lanceolate, usually apiculate, coriaceous, shallowly channelled above, variable in dimensions but not exceeding 4 cm. in length. Flower solitary, golden-green or orange, about 1·5 cm. across the expanded lateral sepals, on a filiform peduncle 2–3 cm. long, arising usually between the pseudo-bulbs; bracts 2, a scarious clasping one at the base, and a smaller one half-way up; lower half of peduncle red, upper half green. Dorsal sepal about 4 mm. long, oblong but more or less apiculate, slightly cucullate, pale green with 3 conspicuous longitudinal red veins. Lateral sepals 5–6 mm. long, obliquely ovate, widely expanding, golden-green or orange, with a few very short red veins at the base. Petals very small, rather light yellow with a deep red blunt apex, mid-vein red, small red dots scattered near the margins. Labellum on a somewhat irritable claw, nearly as long as the lateral sepals but very much narrower, slightly deflexed, obtuse, thick and papillose, margins raised at the base to embrace the column; basal half red, distal half crocus-yellow. Column short and rather broad, its wings extending behind the anther, and produced at the sides into filiform points just higher than the anther. Rostellum pointed; stigma almost triangular; anther white.

Gadgarra, *W. Abell,* 7.1946; Mt. Bartle Frere, *J. H. Wilkie,* 7.1946 (TYPE).

We have pleasure in naming this attractive little species in honour of Mr. C. T. White, M.Sc., Queensland Government Botanist, whose wide experience and knowledge are always so generously made available to students of the Australian flora.

28. **B. wilkianum** Hunt in Nth. Queensl. Nat. xiv, 82 (March 1947). Mt. Bartle Frere, *J. H. Wilkie,* 9.1946.

PART 2.

Excluded Species.

B. lichenastrum F. Muell. Fragm. vii, 60 (1869); Benth. Fl. Austral. vi, 287 (1873); F. M. Bail. Queensl. Fl. v, 1537 (1962).

Dendrobium lichenastrum Kränzlin in Engl. Pflanzenr. iv, 50, ii B, 21, 289 (1910); W. H. Nicholls in Nth. Queensl. Nat. vi, 55–56 (1938); Rupp and Hunt in Proc. Linn. Soc. N.S.Wales, lxxii, 245 (1948).

B. prenticei F. Muell. in South. Sci. Rec. p. 173 (1881); F. M. Bail. Queensl. Fl. v, 1539 (1902).

Dendrobium prenticei W. H. Nicholls in Nth. Queensl. Nat. vi, 55–56 (1938); Rupp and Hunt in Proc. Linn. Soc. N.S.Wales, lxxii, 246-247 (1948).

B. taylori F. Muell. Fragm. vii, 150 (1869-71).

Dendrobium uniflos F. M. Bail. in Proc. Roy. Soc. Queensl. i, 11 (1884).

Dendrobium taylori (F. Muell.) R. D. Fitzg. Austral. Orch. ii, part 3 (1888).

Cadetia taylori (F. Muell.) Schltr. in Fedde Repert. i, 424 (1912).

PART 3.

An Artificial Key to the Genus in Australia.

1. Flowers solitary:
  2. Pseudo-bulbs 4–angled, crowded, leaves large:
    3. Flowers reddish .. .. *B. cilioglossum*
    3*. Flowers yellow .. .. *B. radicans*
  2*. Pseudo-bulbs conical or globular, more or less rugose:
    4. Pseudo-bulbs under 3 mm. in diameter:
      5. Leaf minute:
        6. Flowers white with red striae .. .. .. *B. minutissimum*
        6*. Flowers white .. .. *B. globuliforme*
      5*. Leaf fleshy not minute:
        7. Flower practically sessile in the leaf-channel, leaf beautifully patterned .. .. *B. toressae*
        7*. Flower on a short pedicel not sessile in the leaf-channel:
          8. Lateral sepals united for their whole length .. *B. macphersonii*
          8*. Lateral sepals not united for their whole length:
            9. Leaf linear, very fleshy, channelled above, rounded below:
              10. Sepals with long filiform points .. .. *B. gadgarrense*
              10*. Sepals without filiform points .. .. *B. crassulifolium*
            9*. Leaf oblong or oblong-linear, very thick, flower generally red-orange .. .. .. *B. aurantiacum*
    4*. Pseudo-bulbs over 3 mm. in diameter:
      11. Petals less than half the length of the sepals:
        12. Pseudo-bulbs crowded .. .. *B. nematopodum*
        12*. Pseudo-bulbs spaced widely apart:
          13. Leaf fleshy .. .. *B. bowkettae*
          13*. Leaf coriaceous:
            14. Leaf over 5 cm. long .. .. *B. johnsonii*
            14*. Leaf under 5 cm. long:
              15. Column-foot with two large erect glands .. *B. kirkwoodae*
              15*. Column-foot without glands .. .. .. *B. whitei*
      11*. Petals half or more than half the length of the sepals:
        16. Leaf large, very broad and fleshy, floral segments up to 2 cm. long .. .. *B. baileyi*
        16*. Leaf not large and broad, flowers smaller:
          17. Leaf linear:
            18. Leaf 3·5–4·5 cm. long, ovary warty .. .. *B. adenocarpum*
            18*. Leaf 1·3–3·0 cm. long, fleshy, flowers inverted *B. cochleatum*
          17*. Leaf ovate, elliptical or oblong:
            19. Flower on peduncle 2 cm. or more long, ovary warty .. .. *B. lilianae*
            19*. Flower on very short peduncle .. .. *B. weinthalii*

1*. Flowers in racemes:
  20. Pseudo-bulbs absent, flowers in a capitate raceme .. *B. evasum*

20*. Pseudo-bulbs present:
- 21. Dorsal sepal very much shorter than the lateral sepals .. *B. elisae*
- 21*. Dorsal sepal almost or quite as long as the lateral sepals:
  - 22. Labellum 3-lobed:
    - 23. Flowers white with green nerves .. .. .. *B. wanjurum*
    - 23*. Flowers pink:
      - 24. Mid-lobe of labellum papillose .. .. .. *B. newportii*
      - 24*. Mid-lobe of labellum glabrous .. .. .. *B. trilobum*
  - 22*. Labellum entire:
    - 25. Leaf more or less linear:
      - 26. Sepals about 8·5 mm. long, labellum with prominent ribs .. .. *B. lageniforme*
      - 26*. Sepals about 5 mm. long, labellum without prominent ribs, channelled, pubescent .. *B. wilkianum*
    - 25*. Leaf more or less ovate:
      - 27. Raceme hoary and purplish .. .. .. *B. bracteatum*
      - 27*. Raceme glabrous, flowers white .. .. *B. exiguum*

PART 4.

INDEX.

EXPLANATION OF PLATES.

(Habit-figures all natural size.)

Plate II.

Bulbophyllum lageniforme F. M. Bail. A, plant; B, column, side view; C, lateral sepal; D, dorsal sepal; E, petal; F, column, front view; G, pollinia; H, labellum, front view; I, labellum, from above; J, labellum, from below; K, labellum, side view; L, flower, from above; M, flower, front view, with peduncle, etc.

Plate III.

Fig. 1: *Bulbophyllum evasum* Hunt & Rupp. A, plant; B, capsules, slightly enlarged; flower, from the side; D, column from the side; E, labellum, from the side.

Fig. 2: *Bulbophyllum gadgarrense* Rupp. A, flowering branch; B, flower, from the front; C, flower, from the side; D, side view of labellum (*l*), petals (*p*), and column-foot, with sepals and column removed.

Fig. 3: *Bulbophyllum crassulifolium* (A. Cunn.) Rupp. Flower from the front.

Plate IV.

Fig. 1: *Bulbophyllum johnsonii* Hunt. A, plant; B, sepal; C, dorsal sepal; D, petal, showing striae and glandular dots; E, column and labellum, from the side.

Fig. 2: *Bulbophyllum lilianae* Rendle. A, plant; B, leaf; C, flower, from the side. (From specimen in the Queensland Herbarium.)

Plate V.

Bulbophyllum kirkwoodae Hunt. A, plant; B, flower, from in front; C, column and labellum, from the side; D, column, from the side; E, labellum, from in front.

Plate VI.

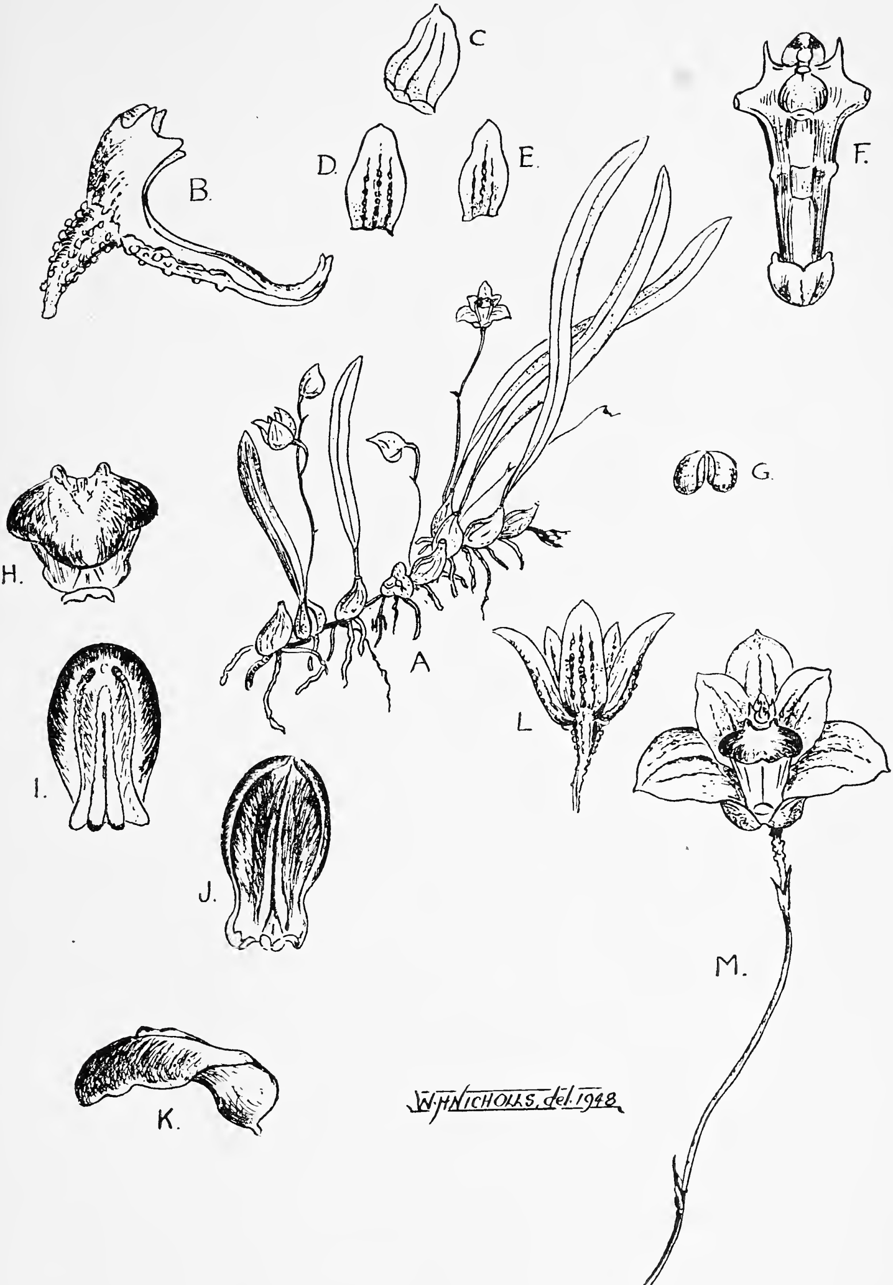
Bulbophyllum nematopodum F. Muell. A, plant; B, group of pseudo-bulbs with one stripped of the remains of the old sheathing scales; C, flower, from the side; D, flower, from in front; E, column and labellum, from the side; F, labellum, from behind.

Plate VII.

Fig. 1: *Bulbophyllum newportii* (F. M. Bail.) Rolfe. A, plant; B, flower, from side, with one petal removed and a sepal turned back; C, labellum, from the side; D, petal. (From specimen in the Queensland Herbarium.)

Fig. 2: *Bulbophyllum whitei* Hunt & Rupp. A, plant, B, flower, from in front; C, flower, from the side; D, column, from in front; E, column and labellum, from the side; F, top of column, from the side.

Fig. 3: *Bulbophyllum bowkettae* F. M. Bail. A, plant; B, flower, from the side; C, flower, from the side, with sepals removed; D, column and labellum, from the side.



Bulbophyllum lageniforme F. M. Bail.

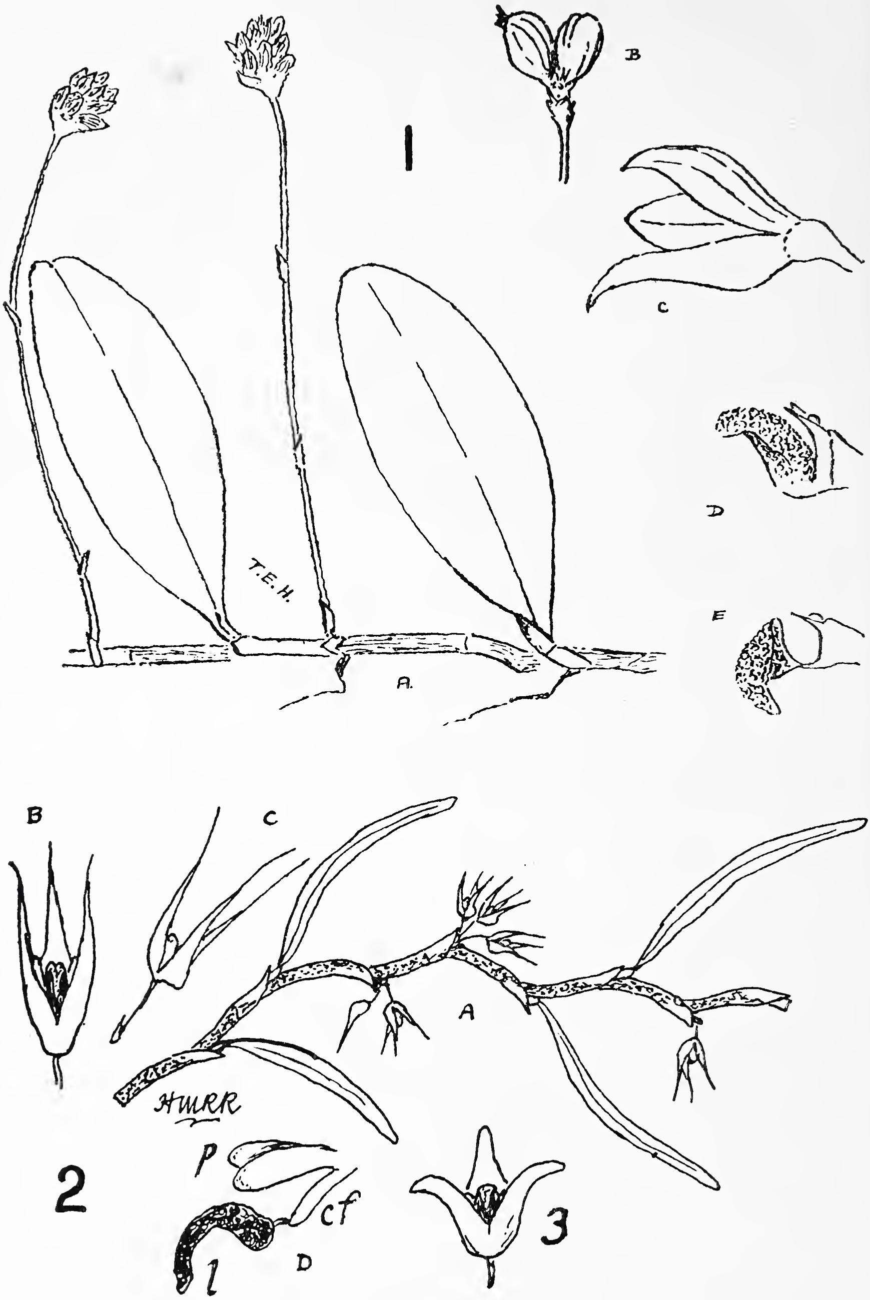


FIG. 1, *Bulbophyllum evasum* Hunt & Rupp; FIG. 2, *Bulbophyllum gadgarrense* Rupp; FIG. 3, *Bulbophyllum crassulifolium* (A. Cunn.) Rupp.

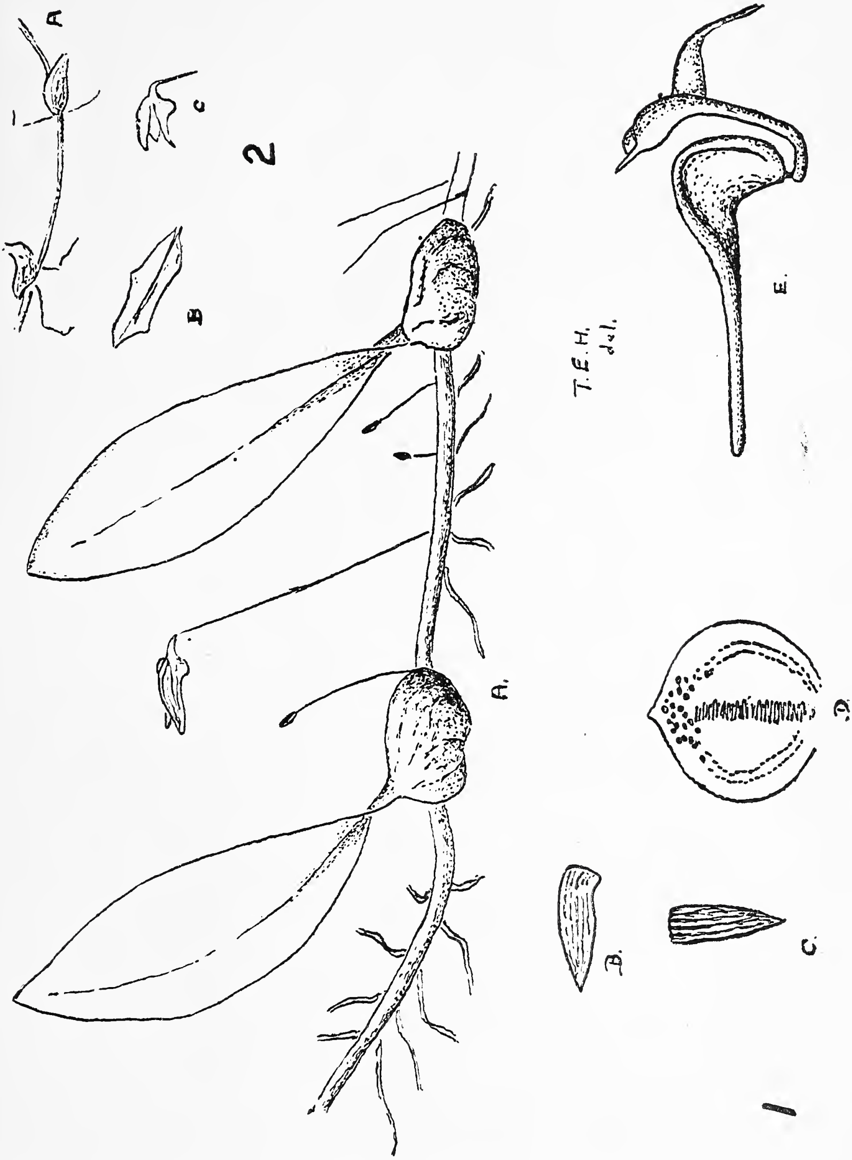
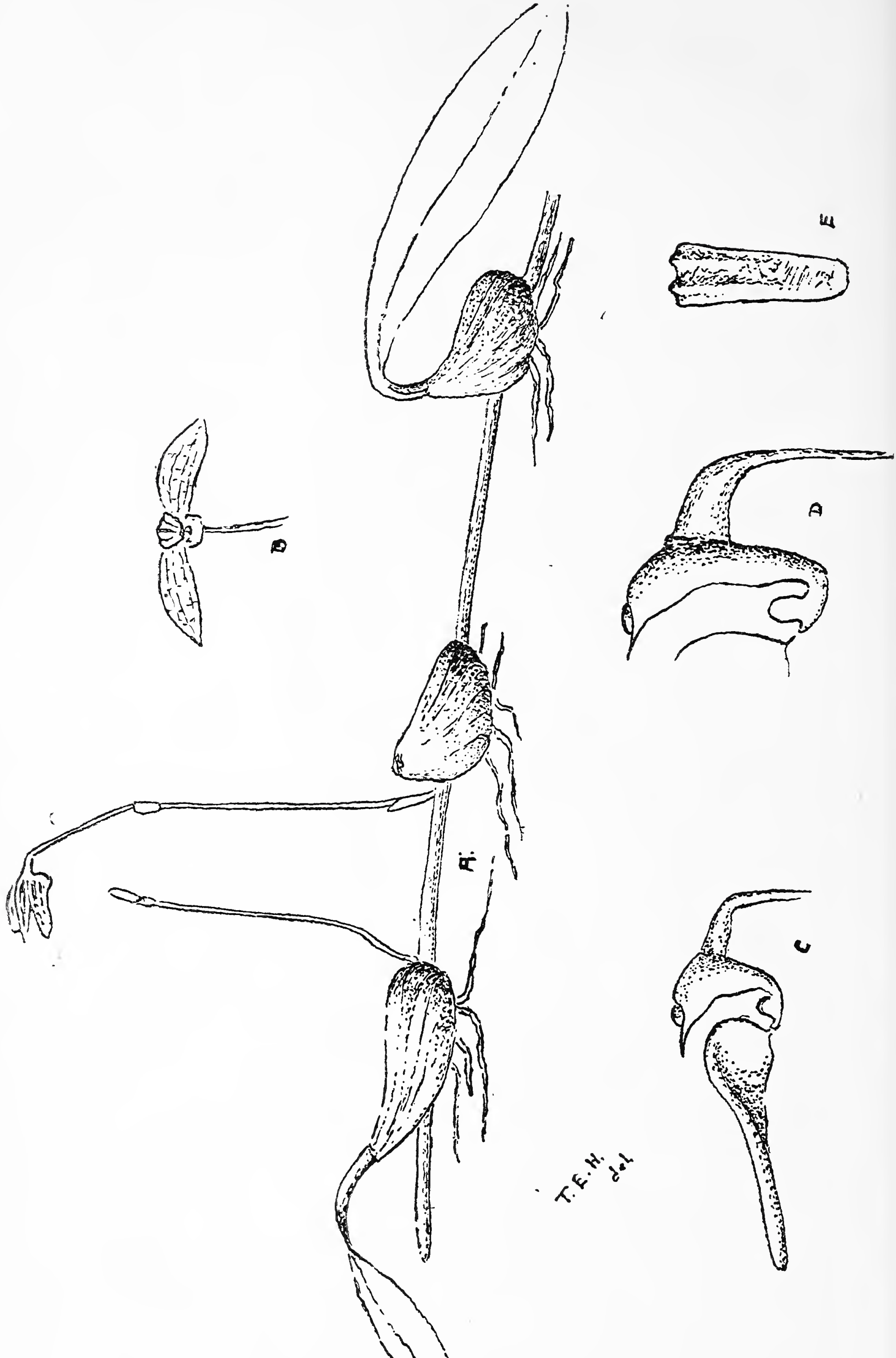


FIG. 1, *Bulbophyllum johnsonii* Hunt; FIG. 2, *Bulbophyllum lilianae* Rendle.



Bulbophyllum kirkwoodae Hunt.

Bulbophyllum nematopodum F. Muell.

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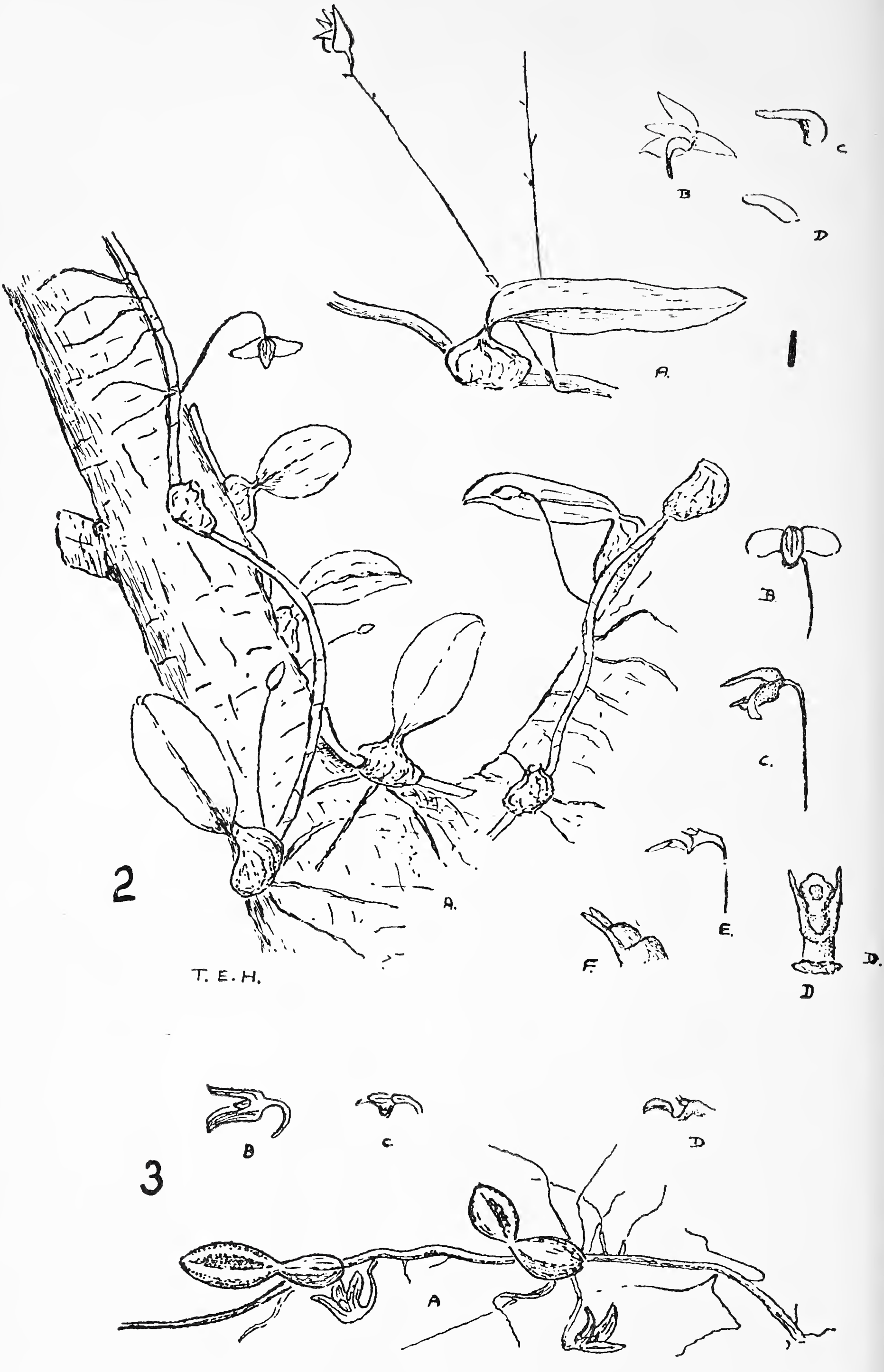
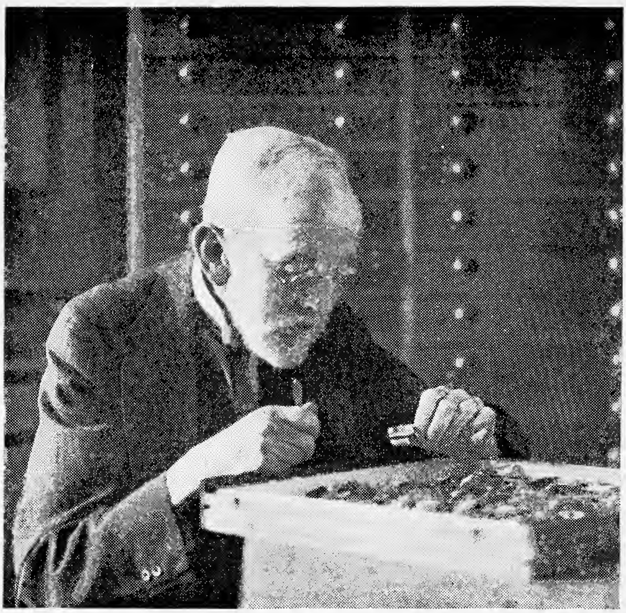


FIG. 1, *Bulbophyllum newportii* (F. M. Bail.) Rolfe; FIG. 2, *Bulbophyllum whitei* Hunt & Rupp; FIG. 3, *Bulbophyllum bowkettae* F. M. Bail.



ALFRED JEFFERIS TURNER.
1861-1947.

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A. J. TURNER MEMORIAL ADDRESS:

ALFRED JEFFERIS TURNER AND AMATEUR ENTOMOLOGY IN AUSTRALIA.

By I. M. MACKERRAS, M.B., Ch.M., B.Sc., Queensland Institute of Medical Research, Brisbane.

(PLATE VIII.)

(*Delivered before the Royal Society of Queensland, 29th November,* 1948; *issued separately* 30*th December,* 1949.)

It is my privilege tonight to deliver this lecture in memory of the late Alfred Jefferis Turner. He deserved the honour of inclusion in your Memorial Series equally for his work in public health as for his contributions to entomology. An evening's discourse could be filled with either; but one felt that, without neglecting too much his medical achievements, one might picture him to you best in relation to his friends and peers of that great band of amateur naturalists who have contributed so much to our knowledge of the Australian fauna and flora, honouring and remembering them with him. He would himself have preferred to share their company than to stand alone before the public gaze. That more than half the lecture should be devoted to Turner is nevertheless appropriate, for it bears his name, and he was remarkable even in that remarkable company.

He belonged to the group of naturalists who concerned themselves mainly with insects, so we may confine our review to the entomologists. In order to indicate clearly, however, the part that he and they really played, it is necessary to digress for a few moments at the outset to outline the development of entomological knowledge in this country.

HISTORY OF ENTOMOLOGY IN AUSTRALIA.

Musgrave has divided Australian entomological history into three periods: Fabrician (1770-1830), Westwoodian (1831-1861), and Macleayan (1862-1929). I would be inclined to amalgamate the first two, subdivide the third, and add another, which has become more definite since he wrote. It is to be emphasised that these four periods are by no means sharply separated; each overlaps, sometimes widely, the period on either side, but each is distinguished by a central influence which is easily recognized.

The lecture was concerned primarily with Turner's work, and did not touch on his public activities in science. He was a member and trustee of this Society for many years, a Fellow of the Royal Entomological Society of London, a foundation member of the Entomological Society of Queensland (President 1930, 1931), a member of the Linnean Society of New South Wales and several other scientific societies in Australia, President of the Queensland Branch of the British Medical Association in 1906, and twice President of the Section of Pediatrics of the Australasian Medical Congress (1908, 1927). Truly he lived a full life.

1. Period of Exploration (1770-1860). This was the period of the early exploration by sea (Cook, Flinders, King, the early French navigators), and the somewhat later explorations by land (Mitchell, Eyre, Leichhardt, Gregory) and by sea (*Astrolabe, Novara, Eugenie*). It is the time, too, when Darwin (1836), Hooker (1841) and Huxley (1847-50) visited us, the last-named with more profit than the others, for he married a most charming lady he met in Sydney. The insects collected by these explorers were, for the most part, sent to England and the continent, where they were described by Fabricius, Donovan, Latreille, Westwood, G. R. Waterhouse, Francis Walker, Macquart and others. Westwood, it may be noted, began as an industrious amateur, and later became the first Hope Professor of Invertebrate Zoology at Oxford, occupying the Chair which was endowed by another eminent amateur and patron of entomology.

2. Macleayan Period (1861-1890). This was really a long and overlapping period, for the first of the Macleays landed in Sydney in 1825, and the influence of the family, as Musgrave has properly pointed out, extends even to the present day. But in 1858 Sir William Macleay took up his residence in Elizabeth Bay House, founded the Entomological Society of New South Wales in 1862, offered the Macleay collection to the University in 1873 and appointed George Masters its curator in 1874. He was one of the founders of the Linnean Society of New South Wales in the same year, and he placed entomology on its feet in Australia, for he ensured to local workers the means to publish their results. We shall have more to say of the Macleays later.

3. The Period of the Amateurs (1891-1927). With an abundant, new, and intensely interesting fauna around them, with ready means of publication, not only in the Linnean Society but also in the Royal Societies which by then were flourishing, with life at a more gentle tempo and an amount of leisure which has now passed from memory, it is not surprising that amateur entomology flowered and bore a great crop of rich fruit. Such names as Blackburn, Carter, Sloane and Waterhouse come instantly to mind, and Turner lived and worked through the whole period. Like the Macleays, we must say something more of them in the next section.

It is necessary, in justice, to be clear that these were not the only workers. There were professional entomologists too, few in numbers, but of amazing capacity and prodigious industry. Froggatt, Tryon, French in the economic field, Skuse (really a relict of the Macleayan Period), Lea, Hacker in the museums, are names which could not be passed over in any historical sketch, however brief. They paved the way for the next period. To be just, too, we must remember that there were still workers abroad who were receiving and describing a great deal of material from Australia. I will only mention Edward Meyrick, to whose profound knowledge of the Microlepidoptera Turner frequently expressed his indebtedness.

4. The Period of the Professionals (1928-). Entomology began to lose its amateur status in the twenties. The Departments of Agriculture grew as the value of research and advice on economic problems became apparent; there were research fellowships in Sydney and Brisbane and lectureships in the Universities (that in Queensland inaugurated in 1927); and the Division of Economic Entomology of the C.S.I.R. was founded in 1928. From then on young people interested

in insects no longer became doctors or parsons or pastoralists, and devoted their sometimes considerable leisure to their hobby; they took an appropriate degree in a University and made entomology their profession. For some their profession has been their hobby and their life, and they are doing great things; for others, I fear, it has become by use merely their job, and that is a pity. It may not be all their fault that this is so, and it might be very wise for State organizations to consider seriously how best to stimulate their workers and give them intellectual elbow-room, so that their enthusiasm and originality of thought may be kept young and keen throughout their working lives.

In the meantime, the amateurs are vanishing. Entomology is no longer a simple systematic and observational science; it is, perhaps too fast, becoming a complex part of experimental biology, and the amateurs will not return. Let us honour them while we may.

THE AMATEUR ENTOMOLOGISTS.

There have been many amateurs, some taxonomists, some students of life-histories and behaviour of insects in the field, some simply collectors who fed those who were in a position to work up the material. All contributed to our knowledge, and a choice of examples for this brief and sketchy survey is exceedingly difficult and invidious. Mine I know to be full of bias. I have picked a brief half dozen, partly for historical sequence, partly to show their varied interests, partly because I knew and admired some of them.

Sir William Macleay (1820-1891). The Macleay history in Australia began in 1825, when Alexander Macleay, F.R.S., F.L.S., arrived in the colony to take over the post of Colonial Secretary. He brought with him a collection of insects already known as one of the finest in England, he built Elizabeth Bay House and its beautiful garden, founded the Australian Museum, and helped scientific workers when he could. His son, William Sharp Macleay, M.A., F.L.S., inherited the collection and the property in 1848. He was already a well-known amateur scientist, who had described many ''Annulosa'' and propounded a theory of organic plan and relationships. He had strong views on teaching biology in British Universities. He added to the Macleay collection, but published no new work after his arrival in Australia.

Sir William Macleay, F.L.S., nephew to Alexander, was first a squatter and later a member of Parliament. In 1865 he succeeded to the Macleay possessions, and, more important, to the Macleay tradition, and he retired from public activities in 1874 to devote the rest of his life to the promotion of science. He added greatly to the family collections, and among his many papers were 39 on insects. He did more: he endowed a curatorship for the Macleay collection in the University, and he provided in his will that the Linnean Society of New South Wales would never, he hoped, suffer want. He not only gave the Society a home to live in and an income sufficient to meet all ordinary costs of publication, but he enabled it to support a Macleay Bacteriologist and four Research Fellows. Macleay was not simply a great amateur of natural history, he was a great benefactor of science in Australia.

Rev. Thomas Blackburn (1844-1912). An Englishman, who came to South Australia in 1888, he collected and wrote on Coleoptera in his leisure hours. If one had not known Turner, one would have said that

Blackburn's leisure must have been considerable, for he described more than 3,000 species in 75 published papers. Although I have seen no record that they met, he forms a link in time between Macleay and the later amateurs.

T. G. Sloane (1858-1932) was another Coleopterist and another link with Macleay, whom he knew as a young man. He lived on his sheep property in southern New South Wales, and apparently had considerable leisure, for he collected quite extensively in different parts of Australia. He published 61 papers, chiefly on Carabidae and Cicindelidae. He came occasionally to Linnean meetings at Elizabeth Bay, but took little active part, and seemed to enjoy most a quiet chat with other entomologists in a corner of the supper-room after the meetings. He bequeathed his collection to the C.S.I.R. at Canberra.

H. J. Carter (1858-1940) was a school-master and a contemporary of Blackburn, arriving in Australia in 1881, but he lived in Sydney and did not publish his first paper until 1905. He retired from teaching in 1914, so that he had ample leisure to study his beloved beetles. He published 65 papers, described 1,167 new species in several families but mostly Buprestidae, and, like Turner, he devoted a great deal of attention to clear systematic classification in order to make easier the path of those who followed. Tall, grey, bearded, he was an indefatigable collector with umbrella and net, and a sheer delight to all who accompanied him. There have been few who inspired such universal warm affection; no one could do him justice in a brief paragraph.

G. A. Waterhouse (1877-) comes naturally to mind after Carter, for they were close friends. He and his associate, George Lyell of Victoria, are the last survivors of that band of which I speak. He is frail now, but he has had a great influence on the scientific life of Australia. He retired early from his official position, but was always busy, a little with business affairs, mostly with administration of scientific bodies. I think he must have served in one executive capacity or another on practically every scientific organization in New South Wales, as well as the A.N.R.C., the A.N.Z.A.A.S., and, for a brief period, the C.S.I.R. Spare and active, he collected and wrote as energetically on the butterflies as he served in administration. He knew everyone who had collected butterflies, and he systematised all the knowledge that was accumulated, on life histories as well as taxonomy. It is chiefly due to his efforts that the Rhopalocera is the most precisely documented group of insects in Australia today. The Australian and National Museums have been enriched by the Waterhouse and Lyell collections.

One could speak of others: of R. J. Tillyard, who, before he became the leader of professional entomologists, was a most eminent amateur; of Eustace Ferguson, a careful and accurate student of the Diptera, who died too young; in Queensland of T. L. Bancroft, whose collections kept many workers busy for years; Rowland Illidge, whom Waterhouse described as "one of the finest nature lovers in Australia"; Eland Shaw, the one man who has made the Blattidae of Australia intelligible, as we have found thankfully in our recent studies of the group; W. B. Barnard, close friend and associate of Turner, whose collection is now in the Queensland Museum; but time will not permit. Even the few examples I have given do, I think, show clearly our debt to the amateur entomologists of our country.

Where does ALFRED JEFFERIS TURNER stand in this company? He lived from 1861 to 1947, he arrived in Australia in 1888, and he began to publish on entomology in 1894, so he was the contemporary, as he was the friend, of almost all those I have named. He shared their enthusiasm and their energy; he shared with Carter and Waterhouse the love of clear systematics; he shared with them all the quality of an unusual personality, perhaps with closest affinity to Carter, but less robust, more effacing, more often seemingly detached from the world, and with a quaint whimsicality that was all his own. In entomology he was their peer, but he differed from nearly all of them in one important respect: he made distinguished contributions to knowledge and progress, not in one field alone but in two. It will be the purpose of the remainder of this lecture to show briefly what he achieved in each.

TURNER'S CONTRIBUTION TO MEDICINE.

Turner's first appointment in Australia was in 1889 as resident medical officer of the Brisbane Hospital for Sick Children. His interest in young children remained life-long, but his concern with preventive medicine was a later development. One would find it difficult to believe this, were it not for his own avowal in his Jackson Lecture. His first paper (*Aust. Med. Gaz.*, Dec. 1890) was a review of the diseases he had encountered in children in Brisbane. Typhoid, scarlet fever, diphtheria and whooping cough furnished a very large proportion of their patients. His helplessness in the treatment of diphtheria (the mortality was 70 per cent. in babies under 2 years old) worried and saddened him, and led him to visit Von Behring when he was abroad in 1894. As a result, he introduced diphtheria anti-toxin to Queensland in 1895, with results which exceeded his greatest hopes. He was among the first to acclaim Behring as "one of the greatest benefactors of the human race," and the experience, I think, gave him a stimulus which lasted throughout his life. It made him, too, a pioneer in the clinical use of bacteriology in the diagnosis of diphtheria and other infections in Queensland.

His more important contributions during this early period were:

- 1892: Confirmation of the presence of hookworm in children in Queensland (in association with Dr. Lockhart Gibson).
- 1895: Introduction of diphtheria anti-toxin.
- 1897: First identification of meningococcal meningitis in Brisbane.
- 1897: Introduction of Widal test for typhoid.
- 1897: Recognition of lead poisoning in Queensland children (confirmation of work since 1892 in collaboration with Dr. Lockhart Gibson).

The impact with prevention came in 1900, when bubonic plague invaded Queensland, and Turner was appointed Health Officer for Northern and Central Queensland. He had a strenuous time, and another side of his nature was revealed. This mild, retiring little man, who rarely raised his voice above a gentle murmur, did not hesitate to address the Mayor and Aldermen of Townsville in these terms (*Townsville Daily Bulletin*, 13 June, 1900):

"SIRS,—

"As you are doubtless already informed, a case of plague has occurred in the centre of the city . . . . When the plague once reaches a city it usually remains there several months, and the city of Townsville must not expect to be an exception. Whether you will have only a few cases of the disease during this time, or whether you will have many cases with a large mortality, depends certainly on yourselves.

''At present the sanitary condition of your city is bad, and you are not making haste to improve it. I have now been here over three weeks, and, although I must acknowledge the courtesy with which I have been received and the readiness with which my suggestions have been formally accepted, I cannot see that anything has been actually done. I recommended the wholesale poisoning of rats: so far not one single rat has been poisoned by the Municipality. I advised the distribution of leaflets to householders. I am informed that these have been printed, but not yet distributed. I earnestly advocated the clearing of the city of rubbish. I am not aware that a single cart-load has yet been removed as a result of my representations. The Municipality of Cairns did more in the three days I was there than the Municipality of Townsville has effected in three weeks . . . .

''You have an able and energetic Health Officer in the person of Dr. Linford Row. I have asked for his correspondence book, and find that he has given you most excellent advice, which you have not taken. . . .''

The Mayor was furious!

He returned to England in 1901 to take the D.P.H. at Cambridge. His interest in prevention was confirmed.

In addition to his major work on infant welfare, Turner took part in two campaigns to prevent disease in children. The first was against hookworm. He had fired the first shot in 1897, and he fired another in 1909: ''When our statesmen have a little time to spare for the things that really matter, I should like them to pay some attention to . . . . the ravages of parasitic anaemia.'' The life cycle was known, and means of prevention were clear. Efforts to get action, however, were fruitless until the Rockefeller team began to work in 1917, and all Turner could report was that he ''had learnt something about the obstacles in the way of preventive medicine.''

The experience with lead poisoning was not much more encouraging. Gibson and Turner had recognized the condition in the nineties, but the source of the lead was obscure, until Gibson's brilliant observation on the powdering of out-door paint and the way children ingested it. Then the campaign began, and the controversies, too, for there was opposition from highly placed medical men as well as from vested interests. Finally, the battle was won, but it was a pyrrhic victory, for Turner wrote in 1938: ''Queensland has developed a masterpiece of political strategy: to proclaim excellent regulations, and so conciliate those who were asking for them; and then, by not enforcing these regulations, to conciliate those who thought it was not in their interest to observe them.'' The struggle has been carried on in this city by Dr. Jarvis Nye, who demonstrated that, in addition to the immediate effects of lead poisoning so acutely appreciated by Gibson and Turner, there was a later sequel of fatal chronic nephritis. It is over now, but the end was reached not so much through administrative action as by education of the people and technical improvements in paint manufacture. Young children rarely suffer from lead poisoning today, only the young middle aged die from the nephritis which had its origin twenty or thirty years ago.

The Infant Welfare Service.

"When I started private practice this baby problem obsessed me. Only then did I realise my own ignorance. I sought guidance from all the latest books . . . . I tried many methods . . . . and made appalling mistakes. I gained knowledge slowly, but it was based on hard experience." Clearly the answer to infant mortality was not in the hospitals. Babies did not thrive even in special hospitals, the danger of intercurrent infection was great, and Turner agreed with the mothers who were unwilling to take their babies to hospital unless they were very ill. In 1910, he analysed the statistics of infant mortality. The greatest single cause of death was diarrhoea and enteritis; its incidence was highest in summer, and he attributed it to artificial feeding, ignorance, dirt, and flies. Here was a condition which should be preventible, but the campaign would have to be carried into the homes.

He began by taking an active part in organizing a supply of pasteurised milk. The venture failed, because existing means of transport could not cope with the problem of distribution, and ice-chests could not be supplied to the homes to keep the milk chilled between deliveries. Such difficulties are easy to forget in these days of speedy transport and domestic refrigerators. Even if it had not failed, there was still the problem of educating the mothers and caring for the babies in their homes.

It had to rest there while war service intervened, but, on his return, Turner was delighted to find that a major step had been taken in the establishment of four baby health centres under the direction of Miss Chatfield, Lady Superintendent of the Diamantina Hospital. He was appointed honorary medical officer to the Valley centre in 1922, Director of Infant Welfare in 1926 at the age of 65, when most men would think of relaxing, and he retired in 1937. During that time, the service grew from 4 centres to 104 clinics and branches and a mobile clinic in a railway car which travelled the out-back of the State. The impetus he gave is still not lost, for in 1948 there are 184 clinics and branches operating and 12 new ones approved.

Their task was to attack ignorance, to carry their service into the homes, and to induce mothers to visit the clinics and make all possible use of their facilities. More specifically, they had to train mothers to feed their babies at the breast, and, when this could not be done, to determine the correct mixtures to be given, demonstrate asepsis in their preparation and administration, and educate the mothers in general cleanliness, hygiene and care of their babies. Gradually the contra-indications to breast-feeding were whittled down until few were left, and gradually the techniques of infant care were developed until recommendations could be made with confidence and routines laid down with precision. It was a long and arduous work, and through it all neither Turner nor his successors ever forgot that the babies were individuals whose individual needs could not be met by mass-production methods.

The results were excellent. The infant mortality rate per 1,000 fell from 70·3 in 1908 to 36·2 in 1936, and the proportion caused by diarrhoea and enteritis fell from 42·7 per cent. to 4·3 per cent. As a consequence, the relative significance of pre-natal and neo-natal causes increased from 35·8 per cent. to 72 per cent. Turner set out to examine this. Queensland in 1936 had an infant mortality of 36·2 per 1,000, South Australia one of 31·1. The difference had become apparent during the preceding few years, and was entirely due to deaths in the first month of life. Expectant mothers in South Australia were receiving an organized liberal issue of milk, in Queensland they were not. He believed that this was the explanation, and that here was another way in which the infant mortality might be attacked.

Turner would have been the last to claim that all this progress was due to the unaided efforts of his own organization, or that there was nothing more to be done. He and his associates drew freely on the experience of New Zealand, other Australian States and the northern hemisphere, and acknowledged freely the help that they received; other adventitious factors quite outside their control operated to assist in the improvement; but they did by their own work make a fine contribution to the care of the very young, of which Queensland might well be proud. Turner, too, would not have needed the experience of the recent epidemic to realise that the problem of gastro-enteritis was not completely solved, but that there is still a residue, just as dangerous in its smaller way, more subtle in its path of infection, but just as preventible as the summer diarrhoea which he tackled so successfully. We cannot be complacent while any preventible causes of infant deaths remain.

During his retirement, Turner was less easily stirred to action, but he returned to the fray occasionally to defend a cherished principle, publishing some eight articles and letters in medical journals, and disarming criticism with the plea: "I will ask your readers to endure the tediousness of an old man, who still imagines himself youthful and enthusiastic." Almost his last medical publication, appropriately enough, was a note on breast-feeding in the *Medical Journal of Australia* for 3rd April, 1943. His last was an obituary of his old friend, Lockhart Gibson.

TURNER'S CONTRIBUTION TO ENTOMOLOGY.

You have heard, in brief, the story of a full and active life, of achievement which has left its record in a large and efficient organization and in 115 published papers and notes on medical subjects. That is surely enough for one man, yet I have still to speak of his hobby, in which, if the one can be balanced against the other, his contribution must be rated just as high.

The tasks which have faced amateur entomologists in Australia have been: firstly, to make known our extensive and varied insect fauna; secondly, to organize that knowledge into clear, intelligible systematics; thirdly, to use the organized knowledge to clarify the phylogeny and zoogeography of the groups they have studied; and fourthly, to elucidate the life histories and behaviour of these odd and curious creatures. There is enough work here to keep many generations occupied, and the pity is that there are so few left to do it. Not many, even within the smaller groups, have ranged over the whole field. Turner chose the moths, attracted by their delicate beauty and infinite variety, and undeterred by the magnitude and difficulty of the problems they presented. He did range widely, but he was primarily a systematist, and his writings on the living insects were few as compared with his descriptive papers.

The first activity of an entomologist engaged on the tasks I have indicated is to collect his material in the field. Turner was a great collector. He gathered his spoil in every State and in every environment from the northern rain-forest to Tasmania, and from the mountain tops to the coast. Goldfinch, himself an outstanding collector, used to tell me that Turner had an amazing eye for a moth, however camouflaged it might be against a background of mottled tree-trunk or roughened bark. I doubt that he was physically strong enough to use the incandescent light and the vigorous kick on the trees so successfully employed by Goldfinch to bring the insects fluttering into view, but he did not despise night collecting, as the following story will show. Waiting on a Brisbane suburban station one night, he spied a rare moth circling around a light; he climbed the lamp post, secured his specimen, and returned to the ground, where he found, to his mild surprise, "there was quite a crowd."

By his own efforts, by exchanges with his friends, especially W. B. Barnard, by accessions from other friends, who collected moths as opportunity offered simply because Turner might like them, and sometimes by purchase, he amassed a collection of more than 50,000 specimens; but long before that stage had been reached, he was engaged on the second activity of the entomologist, namely, sorting and arranging his collections. This, the most pleasurable work of all to a man of his temperament, is a never-ending task, for every new development and improvement in classification means a rearrangement in the cabinets, and Turner was engaged on it almost to his last days. The portrait shows him characteristically at work. He was adept at setting even the smallest "Micro," a group in which he was particularly interested, and his cabinets were a joy to look at. The whole collection was bequeathed to the C.S.I.R. at Canberra, where it is now safely housed and carefully tended. The companion Barnard collection, on which he also worked, was also willed to Canberra, but by arrangement is now housed in the Queensland Museum. As each was enriched by the available duplicates from the other, and as the identifications in both were checked by Turner, their value is very great.

The third activity, describing one's material so that it can be recognised by other workers, is, to my mind, the most tedious and difficult at all. I am not a Lepidopterist, so cannot do Turner's publications full justice. But there are certain characteristics which any worker can recognize as good or bad, and Turner's work shows much good. He published 121 papers on entomology, his first, on the Microlepidoptera of Moreton Bay, in *Trans. Roy. Soc. S.Aust.* in 1894, and his last, on the Boarmiidae, in *Proc. Roy. Soc. Queensl.* in 1947. He described about 3,500 new species, and erected 4 new families and more than 450 new genera. This is no small achievement for any man, amateur or professional.

When one examines his papers, one sees a meticulous care and attention to detail, and at the same time an admirable brevity. One receives the impression that no point of value has been omitted, but no redundant word left in. A proportion of the papers were simply descriptive, but the majority were part of a definite plan of revision of whole groups, and these contain keys to genera, brief discussions of relationships, and other points of general interest. He always gave the Latin or Greek derivations of the names he proposed, and even in the descriptive papers there were often helpful little notes to guide later workers in placing the species. He was meticulous in designating types and indicating localities, and, though he cared little for pure taxonomy for its own sake, he was equally meticulous in recording synonymy. He made mistakes—no worker is infallible—but he corrected them as soon as they became known, and several of his publications begin with these little lists of corrections and emendations. When one considers the enormous number of genera and species with which he dealt, they are astonishingly few.

Altogether, an outsider can hardly fail to be impressed that this is good, clear, sound systematics. I stand open to correction, but I doubt if the lepidopterists will disagree with me.

The final activity one may undertake, within the limits I have set out, is to attempt to synthesise one's information and reach some conclusions of general biological or philosophical significance. This is dangerous ground, and Turner trod it warily. Even in a very early paper on protoplasm, which he read before this Society in 1899, he said: "These problems . . . . take us into regions where observation and experiment, the methods of science, are unavailing, and where the human mind is ever in danger of mistaking its self-evolved imaginations as equivalent to demonstrated truths, or worse still, of mistaking merely verbal solutions for real." In entomology, he confined his generalisations almost entirely to phylogeny, rarely touching on zoogeography or problems of evolution and adaptation.

He was keenly interested in this kind of synthesis, for he wanted to see the Lepidoptera as a whole, and there are several passages in papers as far back as 1918 in which he discussed it; but he reserved for his later leisure the attempt to review the whole classification and inter-relationships of the various assemblages within the Order. This he did in *Proc. Linn. Soc. N.S.Wales* for 1946 (published in 1947). He took Meyrick's classifications, reviewed them critically, analysed the characters that had been used, and built a new, more natural classification on that which Tillyard had developed. His analysis is penetrating and full of wisdom; thus: "I have heard the objection raised, that neuration is an unsatisfactory guide to classification, because it is often so variable. The fact alleged is correct; the deduction is fallacious . . . . Some details of neuration . . . . may . . . . vary . . . . within the limits of a species; others may give good generic characters, others again are characteristic of whole families or even of superfamilies. Only by careful study can we learn their relative importance. There is a . . . . supposition that a character that has proved valuable in one group will necessarily prove of equal value in another group. Nature has no respect for this assumption."

In brief, Turner accepted Tillyard's primary division into Homoneura and Heteroneura, but made a more fundamental cleavage of the Heteroneura into two new divisions, which he called the Asthenocorda and Sthenocorda, and reduced the Rhopalocera to a subdivision of the Asthenocorda. He might be suspected of compromising with convenience and tradition here, for the distinctions between the subdivisions seem rather slender, but it was not Turner's nature to compromise with the truth as he saw it. He rounded off the work by defining the super-families and families within the various divisions and subdivisions. This work would seem to mark a definite advance in the clarity of the classification and the expression of relationships. He did not expect it to be final, for he regarded no classification as fixed and immutable; but he expressed the simple hope that "it will deserve attention by anyone who attempts a future classification." I certainly think it will.

I find that I cannot now end this Section better than with words I used many months ago, when his passing was still fresh in our minds: "It would be ungracious to his memory to say that Turner's death was a loss to Australian entomology. He lived a full life, he completed the task he set himself, and he left, not only a collection which will be an indispensable tool for all future workers, but the results of a vast amount of original work clearly and systematically presented, so that future workers . . . . can step off from a clearly defined frontier into the territory that is still unexplored. His name and his work will live as long as zoology remains an orderly and systematic science."

CONCLUSION.

And so I come to the end of a long story. I have tried to show the extent of our debt to those enthusiastic amateurs who made entomology their hobby; and I have tried also to show how Turner contributed his full measure, not only as an amateur entomologist, but in the public health of the community. If it has been tedious, it is in the telling, not in the subject. I do not think he was a genius, but I confess I do not know exactly what the word means. It is given to very few to establish some completely new principle, to open up some entirely new field of scientific endeavour. Most of our knowledge and most of its useful application have come from the work of people who have been endowed with industry to complete their tasks, intelligence to tackle their difficulties, clarity of mind to see their problem as a whole, and common sense to derive and test their conclusions. Among these Turner stands high. And as enthusiasm and an unwavering love of truth are the hall-marks of the research worker, so Turner qualifies on those grounds too to be ranked among the research workers of our time.

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THE SENSORY PITS OF INSECTS CONSIDERED AS DIELECTRIC WAVE GUIDES AND RESONATORS TO INFRA-RED RAYS.

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(With Three Text-Figures.)

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CONTENTS.

INTRODUCTION.

As far as I am aware, the function of at least some of the antennal sensory pits of insects is admitted by recent reviewers to be unknown. It is the purpose of this paper to demonstrate a possibility that these pits sense heat radiation. The electromagnetic waves constituting heat radiation are considered as being reflected by the walls of the tubes and hollow surfaces of the organs so as to transmit energy from the surface of the insect to the sensory style, and to form nodes and antinodes of electric field strength in the neighbourhood of the sensory style.

The conditions for such transmission and resonance at the longest wavelength possible, are that the cross-sectional dimensions of the dielectric should be of the order of a wavelength. For any particular case, however, there is a number of other discrete wavelengths, shorter than the maximum, for which there occurs good transmission (or resonance, as the case may be). Each such wavelength bears a definite relation to the dimension of the cavity. The literature on pit-like sensillae of insects shows that their transverse dimensions lie between 2 and 80 microns. Most of the energy radiated from bodies at normal temperatures is at wavelengths within this range.

The ideas used in this paper arise from a consideration of man-made apparatus operating on wavelengths of 1 to 100 cm. in which the wave is always polarised. Natural emitters would not in general emit polarised radiation. However we may consider infra-red radiation from such emitters as coming from many elements having random direction. To each element ordinary wave concepts will apply.

A SPECIAL SENSE IN INSECTS.

The existence of a non-tactile sense of an obscure nature has been shown by many observers. It has been described as olfactory, but a dependence on a gaseous emanation has not been shown in many cases, nor has it been satisfactorily demonstrated upon which organs the supposed olfactory sense depends.

THE EXISTENCE OF ORGANS OF UNCERTAIN FUNCTION.

As related by Eltringham (1933, pp. 94-97), agreement has not been reached on the function of the coelomic and ampullaceous sensillae. Lubbock (1882, p. 228) suggested that their function was auditory.

It is considered by Lefroy (appendix to Smith, 1919) that these organs have a delayed olfactory sense. I will endeavour to show that a theory of electromagnetic function is more tenable than either of the two sensory theories mentioned above.

SENSILLAE OF A WAVEGUIDE OR RESONATOR TYPE.

The table below summarises data obtained from the works on the subject. Only those sensillae are included for which quantitative data was available. Column 5 gives the estimated longest possible resonant or cut-off wavelength on the assumption that they contain air only.

Figure No.	Name of Insect.	Common Name.	Dimensions Microns.	Greatest Wavelength. Microns.	Type of Orifice.
1	*Musca vomitoria* . .	. .	39	. .	Open
2	*Melolontha vulgaris* . .	Chafer . .	23	27	Open
3	*Melolontha vulgaris* . .	Chafer . .	. .	. .	Open
4	*Melolontha vulgaris* . .	Chafer . .	. .	. .	Open
5	*Formica*	Ant . .	. .	. .	. .
6	*Tabanus borinus* . .	. .	. .	. .	Open
7	*Eucera longicornis* . .	. .	Sphere 17 cyl. 5	20 8·5	Closed
8	*Libellula depressa* . .	. .	13	. .	Closed
9	*Tetrix*	Grasshopper	Sphere 21	24	Closed
10	*Myrmica rubra*	. .	(*a*) 9 dia. x 14 (*b*) 6 dia. cyl.	12 8	Closed Closed
11	*Stenobothrus*	. .	. .	. .	Closed
12	*Caloptenus*	Locust . .	. .	. .	Closed
13	*Apis mellifica*	Honey bee	8	10	Open
14	*Apis mellifica*	Honey bee	7	9	Open
. .	*Diptera*	. .	8 to 40	9 to 46	From Smith

Their main transverse dimensions are from 5 to 40 microns, and maximum wavelengths are of the same order. Now, from the well-known Wien's law, it is known that for thermal radiations the wavelength at which emission of radiation is a maximum at a temperature of T deg. absolute is equal to 2900/ T microns. Radiation of importance would be that from animals and other bodies at a temperature of about 25 deg. C. or 298 deg. absolute. At such a temperature emission is a maximum at a wavelength of about 10 microns. At this temperature emission not less than $\frac{1}{4}$ of the maximum occurs over the range of wavelength 5 to 24 microns. Radiation within the range of the organs is emitted by the sun, though at a very much less intensity than visible radiation.

As an illustration of the theory, consider Forel's flask organ (fig. 10). The long tube could act as a high pass filter, allowing only transmission of a wavelength not much greater than the diameter; the bulb at the end could resonate, inducing a disturbance in the enclosed sense-hair probably in the form of a temperature gradient. Organs with no long tubular neck would, by our hypothesis, lack this long wave exclusion property and could perceive strong radiation even if not quite of the resonant frequency. Reports of the diameter of the long tube shown in figs. 5 and 10 are somewhat vague. It may be as small as 2 microns.

In the case of *Eucera longicornis* (fig. 7), consider an E_0 wave in the circular tube of diameter 5 microns communicating with the spherical cavity of diameter 18 microns. These dimensions have been estimated from Hick's drawings (1859). (An "E_0 wave" is the conventional description for the simplest type of wave in which the lines of magnetic force are transverse.) It may be shown, by using the solution given in Lamont (1942, pp. 27-8), that the maximum wavelength at which transmission can occur in the tube is equal to $5 \times 1{\cdot}3 = 6{\cdot}5$ microns. A wave near this to which the resonator may tune is the E wave of the third kind given by Lamont on p. 79, for which the wavelength

$$= 0{\cdot}36 \times \text{diameter of sphere}$$
$$= 0{\cdot}36 \times 17$$
$$= 6{\cdot}1 \text{ microns.}$$

The correspondence between the two wavelengths is good. The significance of this however may not be high because of errors in measuring the drawing and because the wave types have been chosen to suit.

EXPLANATION OF TEXT FIGS. 1 AND 2.

(These figures are not all to the same scale; the explanations are copied from the works cited).

FIG. 1.

Antenna of blowfly, *Musca vomitoria*—section of wall of antenna showing the chambers and their sacculi, the diameter of the largest being 1/660 of an inch. After Hicks (1859).

FIG. 2.

Melolontha vulgaris. After Hicks.

FIG. 3.

Melolontha vulgaris. From Packard (1898) after Hauser, olfactory pits of the antennae.

FIG. 4.

Olfactory pits of *Melolontha vulgaris* seen in vertical section, from Packard after Hauser.

FIG. 5.

Olfactory pits of the antennae of *Formica.* From Packard after Kraepelin.

FIG. 6.

Tabanus borinus from Packard after Hauser. Vertical section through a single olfactory in the antenna of the horse fly.

FIG. 7.

Eucera longicornis after Hicks. Section of wall of antenna showing sacs or cells beneath. M, membrane closing in the openings in internal membrane, diameter 1/1700 of an inch.

FIG. 8.

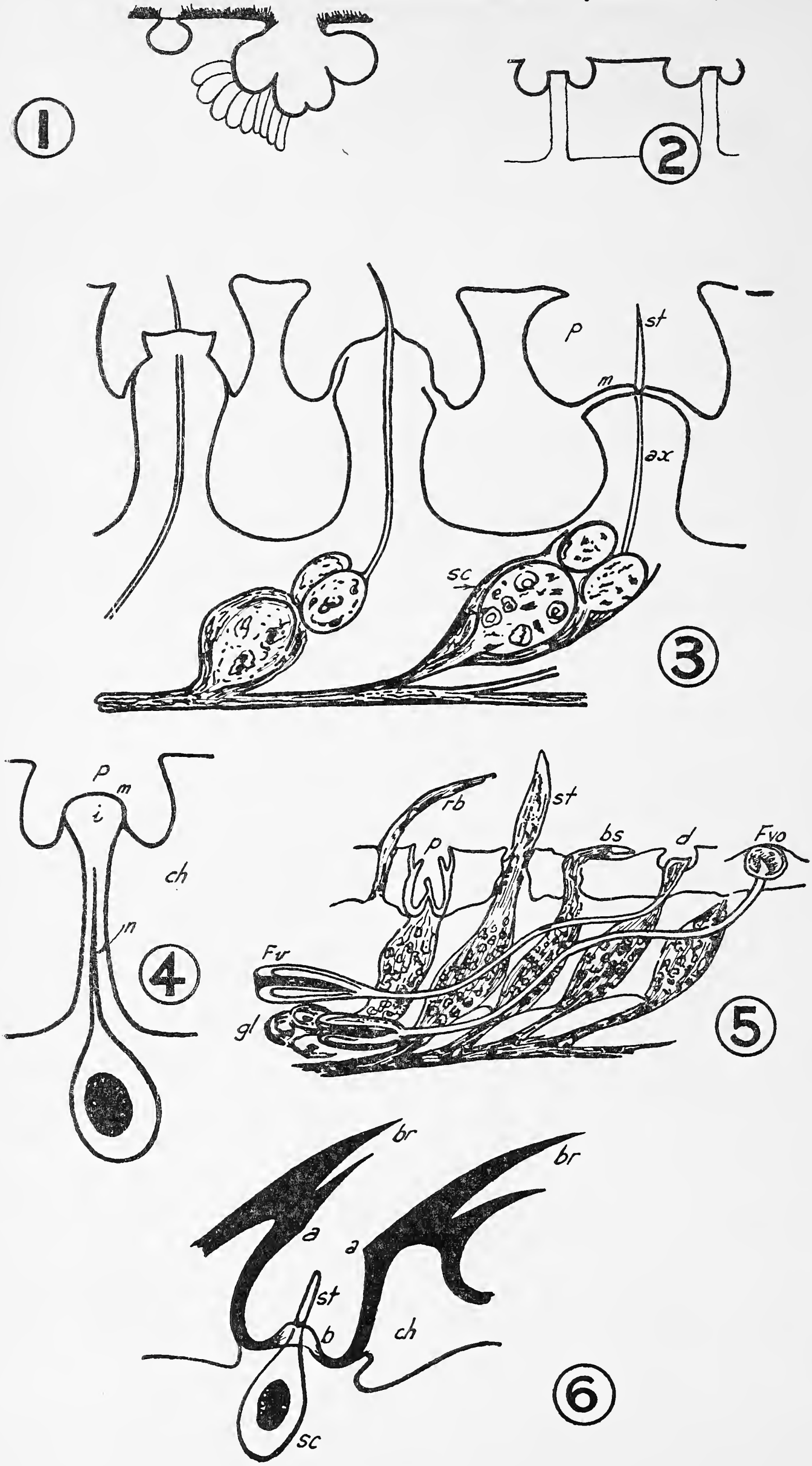
Libellula depressa after Hicks. Portion of wall of the third joint of the antenna. (1) Large sacs with plicated walls closed externally by a delicate membrane. (2) Small simple sacs also closed by membrane.

FIG. 9.

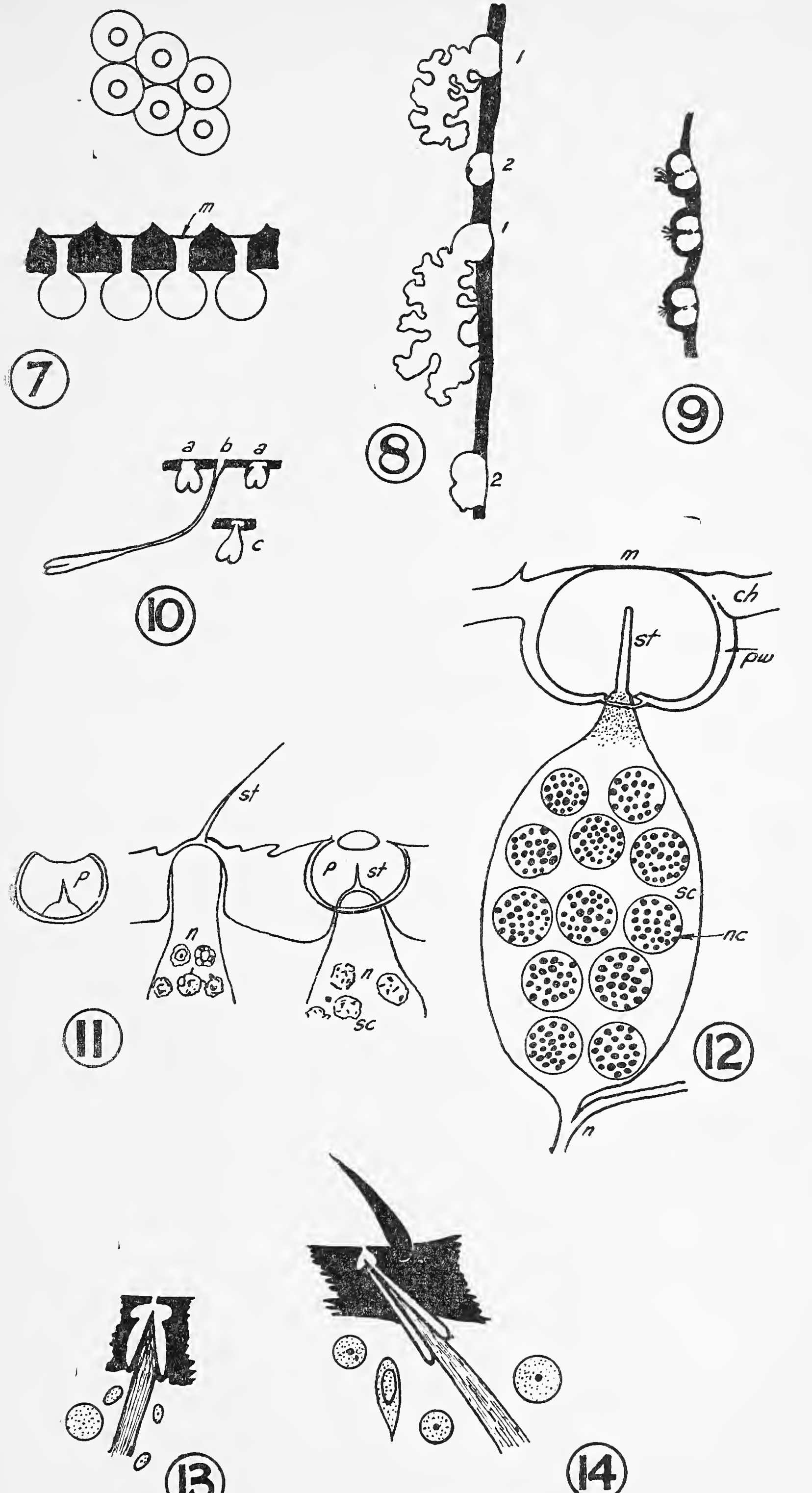
Tetrix, after Hicks.

FIG. 10.

Antenna of *Myrmica rubra,* section of antenna wall, after Hicks. (*a*) The larger and more usual form, diameter 1/2700 of an inch, length from 1/1900 to 1/1700 of an inch. (*b*) Diameter 1/4000 of an inch. (*c*) Another form of (*a*).



TEXT FIG. 1.



TEXT FIG 2.

EXPLANATION OF TEXT FIGS. 1 AND 2—*continued.*

FIG. 11.

Olfactory pits of the antenna of *Stenobothrus*—from Packard after Hanser.

FIG. 12.

Olfactory pits of the antenna of *Stenobothrus*—from Packard after Hauser.

FIG. 13.

Internal anatomy of a pit peg of honey bee—from McIndoo (1914) after Schenk.

FIG. 14.

Internal anatomy of a Forel's flask of honey bee. From McIndoo after Schenk.

EXPLANATION OF LETTERS ON FIGURES.

a.a : circular thickening of the skin surrounding the opening of the olfactory pit;
ax : thread-like continuation of the nerve-cell;
b : vesicle-like bottom of the olfactory pit, through which the olfactory style passes;
br : bristle in Fig. 6, stout and protecting the olfactory pit;
bs : bent bristle or seta;
ch : chitinous integument of the antennae;
d : seen in section;
f : invaginated pit;
Fv : Forel's flask-shaped organ;
Fvo : its opening seen from the surface;
gl : gland-like mass of cells;
i : entrance into the canal belonging to the pit;
m : membrane;
n : nerve of special sense;
nc : nucleus of the sense or ganglion cell;
p : olfactory pit;
pw : wall of pit;
sc : sense of ganglion cell;
st : olfactory or sense-style; sometimes peg-shaped;
tb : tactile bristle.

THE STRUCTURE OF THE BIOLOGICAL WAVEGUIDE AND CAVITY RESONATOR.

From the descriptions available it appears that the walls of the cavities are chitinous. Some organs are contained within the heavy chitinous integument while others have below the level of the integument a thin-walled chitinous sac. I have assumed that the latter is surrounded by the body tissues and fluids and that the chief component of these, at least from the electromagnetic aspect, is water. Authorities are uncertain on whether the organs are liquid-filled. Three possible interface conditions are worth considering:

(*a*) air inside, thick chitin wall;

(*b*) air inside, thin chitin wall, water outside;

(*c*) water inside, chitin wall.

For the organs to function as postulated, reflection at the interfaces is necessary. Such reflection occurs where there is a large discontinuity in either conductivity or dielectric constant. Reflection in this way is illustrated by the case of radar pulses which are reflected from various objects not necessarily metallic.

In cases (*a*) and (*b*) the discontinuity could be large. Two subdivisions of case (*b*) require consideration:

1. reflection at the interface of the air and the chitin as in (*a*);
2. chitin negligibly thin or transparent. Reflection is then as if between air and water.

As described below, chitin is transparent at about 1 to 2·5 and 4 to 5·5 microns.

In the case (*c*) adequate reflection would occur at certain wavelengths only. Also in this case attenuation of the wave due to absorbtion in the water would be enormous at certain wavelengths.

It is shown below that chitin is probably opaque to radiation at more than 6 microns wavelength. Water is opaque at 3, 6 and at more than 11 microns. Therefore wavelengths between about 7 and 11 microns could be transmitted through the water and reflected successively from the walls of the cavity, due to the difference in conductivity across the interface. However, attenuation by absorption in the wall would be high.

NOTE ON INFRA-RED TRANSMISSION BY CHITIN AND WATER.

Coblentz (1911, p. 651-2) notes that dry chitin has the characteristic absorption spectrum of complex carbohydrates, in which there is great and usually complete opacity from 2·8 to 3·8 microns and beyond 6 microns.

For white of egg, Stair and Coblentz (1935, p. 306) show that considerable opacity extends out from 6 to 14 microns, so presumably chitin is similarly opaque between 6 and 14 microns.

The behaviour of water resembles that of chitin, absorbing at 3 and 6 microns, but it differs in having considerable transmission between about 6·4 microns and 11 microns (Fowle, 1917, p. 50).

The equivalent cut-off or resonant wavelength in free space for a water-filled cavity is approximately 1·3 times that for an air-filled cavity. It is quite unlikely however that the organs are always liquid-filled. The apparent dryness of the surface (Imms 1938, p. 12) is considered a contra-indication to a function like the olfactory sense of man. Smith (1919) found no trace of "fluid" in the pits. Eltringham (1933, p. 104) finds that the presence of a "fluid" on the olfactory organs has not been satisfactorily demonstrated. However, Carpenter (1924) says that the pits are filled with a "fluid," and Forel (1928, pp. 117-8) depicts the elongated tube organ with liquid partly filling the bulb.

In some insects a membrane closes the organ. Such membranes are shown in figures 1, 7, 9 and 12. As drawn, their thickness appears to be a very small fraction of a wavelength, and therefore attenuation of the wave in passing through them would be very small.

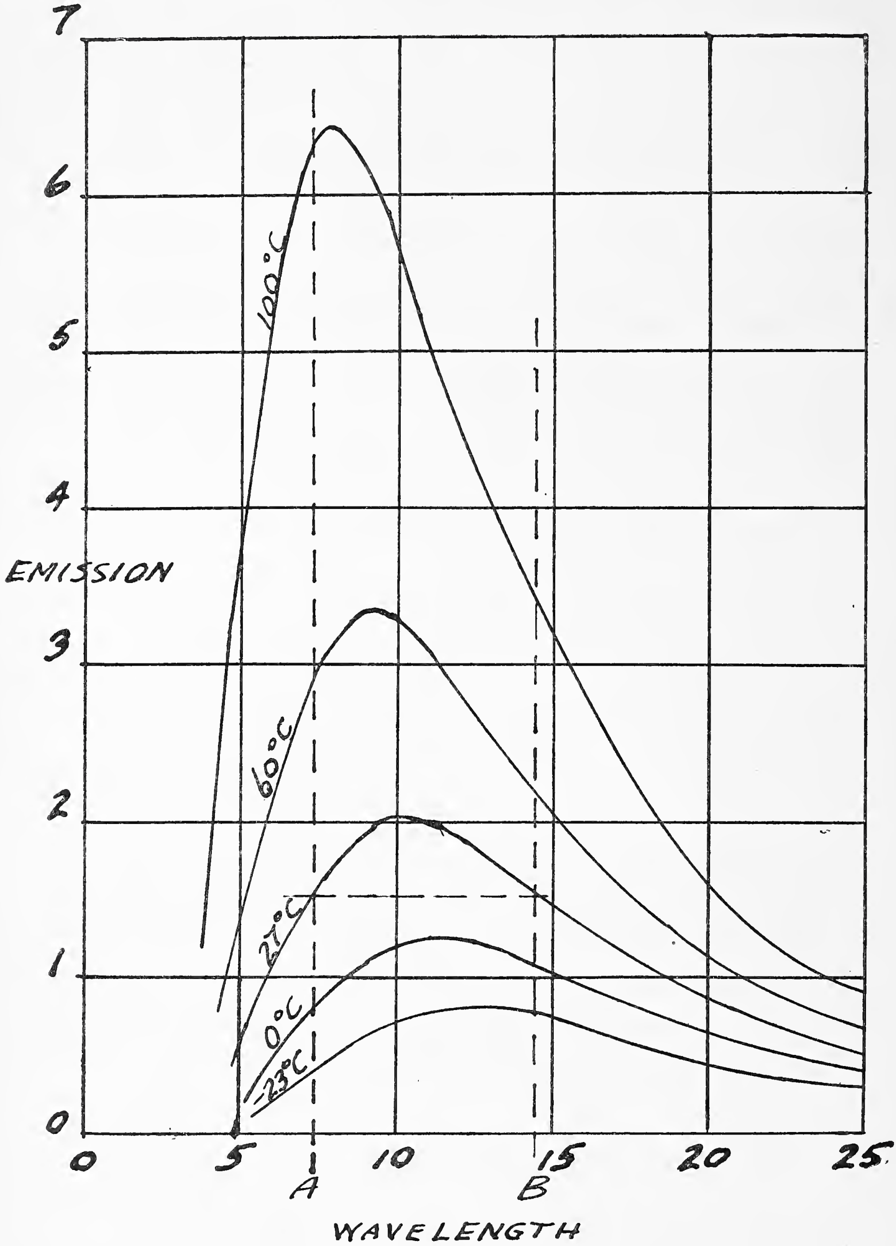
EXAMPLES OF THE BEHAVIOUR OF INSECTS HAVING SENSORY PITS.

(*a*) Honey Bee,

(*b*) Ichneumon Wasp.

It is stated by Marshall (1934) that bees are significantly attracted to hive wax and that amputation of the antennae produces a loss of olfactory recognition of the wax.

Presumably a fairly uniform temperature prevails within the hive. Maeterlinck (1912, p. 65) has described how bees control the hive temperature by means of their metabolism. The production and fabrication of the wax is dependent on appropriate and, presumably, fairly critical temperatures. It would not be surprising, therefore, if bees were equipped to detect temperature. Two temperatures would be important to them—a temperature at which the wax was soft and workable, and another at which it was sufficiently rigid. Now two varieties of hollow sensillae have been described in the bee; the pit peg (fig. 13) and Forel's Flask (fig. 14). Their resonant wavelengths have been tentatively put down at 10 and 9 microns respectively. The essential for this argument is that they are different.



TEXT FIG. 3.

Graph based on Wien's law illustrating measurement of temperature by differential sensitivity.

Emission rates at resonant wavelengths A and B are equal at 27 deg. C. only.

Now on examination of isothermal Wien's law curves it is seen that at 322°K and greater the emission at 9 microns is greater than the emission at 10 microns. At 290°K and less, the emission at 10 microns is greater than at 9 microns. At temperatures between 322 and 290°K the two emission rates will each be less than the maximum at the particular temperature, and at a temperature of about 306°K they will be equal. Here then are some elements of a "null" method of determining temperature. Such a system having sensory elements of more than one size could determine temperature of a source independently of the intensity at the point of observation. Text. fig. 3 illustrates the method using wavelengths 7·5 and 14·5.

The accuracy with which the dimensions can be obtained from published drawings hardly justifies any precision in predicting the temperature at balance, but the deduced temperature of 306°K (33°C) at least approaches a temperature at which beeswax would be plastic. Admittedly it is easy to imagine the bee determining the stiffness of the wax by simpler, more anthropomorphic means. The thermal radiation within the hive may well be a factor in the unity of their society.

The ability of the ichneumon to detect its prey in the trunk of a tree with great precision, is described by Fox (1940, p. 50). According to Lubbock (1891, p. 57-9) this insect has 5,000 pits on the antennae. Dry wood is known to be transparent to certain infra-red rays. This mysterious sense may depend on location by the insect of heat radiation from the grub passing through the wood.

These hypothetical cases contrast with the case of the bug *Rhodinus prolixus* to which the detection of a warm surface is important. According to Wigglesworth and Gillett (1934) it reacts not to radiation but to air temperature. They describe four types of sensillae on its antennae none of which is of the hollow type. In this case, therefore, insensitivity to radiation and absence of resonator type sensillae occur together.

DIRECTION FINDING.

Some insects have large arrays of pit-like organs on the antennae. If detection of phase difference between elements at different distances from the source were possible, such arrays would enable a determination of direction of the source.

In *Eucera longicornis,* described by Hicks 1859, pp. 147-154 the organs are arranged regularly as shown in figure 7 of this paper; and there are 2,000 in each of the 10 joints which are furnished with them.

Forel (1908, p. 141) doubts the total of 20,000 organs as described by Hicks and says that in the case of champagne cork organs the total is 2,000. A total of 2,000 is more in accord with the number drawn by Hicks.

In spite of the disparity between these two accounts it seems that in the case of this and many other species the number of organs is adequate for discrimination of direction.

SUMMARY.

A survey has been made of some published accounts of the size, shape, and structure of the sensory pits of insects; and an examination of these factors supports the hypothesis that they are especially suitable for sensing infra-red radiation, that some would have a pronounced selective sensitivity to certain bands of wavelength, and that combinations of pits of different sizes could find, without contact, whether a surface had a particular temperature.

Further consideration of their structure and distribution on the surface may explain some aspects of direction finding by insects.

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Vol. LX. No. 9.

WESTRINGIA, AN AUSTRALIAN GENUS OF LABIATAE.

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(With Plate IX.)
(Communicated by C. T. White.)

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During the fall and winter 1944, I was stationed in Brisbane and took advantage of what spare time the army left me to spend a day each week at the Brisbane Botanic Gardens. A three days' visit was also paid to the Sydney Botanic Gardens, and a stay of one week was enjoyed in Melbourne. Four months later, I had another opportunity to pass through both Melbourne and Sydney. The following paper is the result of the studies thus carried on in my spare time, and I would apologize for the incompleteness of the paper, for not drawing up new descriptions of the old species, and for disregarding what taxonomic characters the flowers might have afforded.

Westringia as a topic of study was suggested by Mr. C. T. White, to whom I offer my sincere thanks for placing the facilities of the Queensland Herbarium at my disposal. I am equally grateful to all the personnel of the three institutions visited, especially to Mr. J. H. Willis, Mrs. D. A. Lee, and Mr. S. T. Blake. I also appreciate the understanding attitude of the army officers who made arrangements so that I could devote as much time as possible to this little piece of research.

Later, in 1946 and 1947, the collections of the Gray Herbarium, the Arnold Arboretum, and the Smithsonian Institution were also revised and many new collections were thus studied, but none represented a new entity or a notable range extension.

The genus revised herewith is confined to Australia and has been monographed twice before; by Robert Brown in his Prodromus Florae Novae Hollandiae et Insulae Van Diemen, 501 (1810), and by Bentham in Lab. Gen. & Sp. (1823-36). Unfortunately, the latter was not available to me at the time this manuscript was first drafted. I assumed at the time that Bentham's treatment published soon after in the 12th vol. of De Candolle's Prodromus in 1848, agreed substantially with the earlier treatment. But in 1870, Bentham gave a more elaborate treatment in his Flora Australiensis with a key, good and precise descriptions, ranges, citations of specimens, and a wealth of new varieties and quite a few critical notes. On that occasion, specimens from the Melbourne herbarium were borrowed by Bentham, revised, and authenticated on the verso of the labels with an initial B. A revised account of the Queensland species was published by C. T. White and W. D. Francis in the Proceedings of the Royal Society of Queensland, 33: 159-163 (1921). The genus grew from the first described species in 1797, to 8 in 1810, to 11 species and 3 varieties in 1870, to reach 26 recognized species and 2 accepted varieties in this paper.

Most of the literature on this genus has been available to me, but the type material of many a taxonomic unit is in Europe and presently out of reach. In one case, *W. triphylla* Aiton ex W. Baxt. in London, Hort. Brit. Supp., 2: 681, *nomen,* I have been unable to reach any conclusion as to the proper location of the said name within the genus.

Horticulture.

For a century and a half, one species has been and is still cultivated for decorative purposes. This species being the first known to science, *Westringia rosmariniformis* Sm., it appears that this was a random choice. Without expressing any opinion as to their hardiness, I may say that most other species would be at least just as good as the above and some, especially *W. amabilis* n., seem to be much more desirable as a garden plant.

DISTRIBUTION BY STATES.

W.A.	S.A.	VIC.	TAS.	N.S.W.	QUEEN.
cephalantha					
discipulorum					
		senifolia			
grevillina	*grevillina*		*angustifolia*		
			quaterna		
dampieri	*dampieri*		*brevifolia*	*rosmarini-formis*	*rosmarini-formis*
					tenuicaulis
					parvifolia
					longepedun-culata
rigida	*rigida*	*rigida*		*rigida*	*tenuicaulis*
				cheelii	*cheelii*
		eremicola		*eremicola*	*eremicola*
			Raleighii		*sericea*
			rubiaefolia	*lucida*	*grandifolia*
				longifolia	
				blakeana	*blakeana*
		violacea		*glabra*	*glabra*
		williamsonii		*amabilis*	*amabilis*
Number of species by state:					
5 sp.	3 sp.	5 sp.	5 sp.	9 sp.	11 sp.

From the above, it is obvious that Tasmania, the smallest state, also has the highest degree of endemism, its five species being all endemic to the island state. These endemics are, however, related to species from four other states: *W. quaterna* and *W. angustifolia* are closest to *W. grevillina* of Southern and Western Australia, and *W. brevifolia* duplicates the same pattern with *W. dampieri,* while *W. raleighii* is the vicariant of *W. rosmariniformis, W. sericea* and *W. grandifolia* of Queensland and New South Wales, and *W. rubiaefolia* is the counterpart of the alpine *W. lucida* of N. S. Wales.

The subgenus *Muellera* is endemic to Western Australia, and of three other species found in that state two also occur in South Australia while the other is the wide-ranging and polymorphic *W. rigida,* the commonest species of the genus. Vicariant forms of the two Western-Southern Australian species are found in Tasmania as given above.

South Australia alone has no endemics, its three species being also found in Western Australia, one of them, *W. rigida,* extending to Victoria and New South Wales.

The state of Victoria has both of the wide-ranging species, *W. rigida* and *W. eremicola,* the latter also occurring in N. S. Wales and Queensland. There are also 3 endemics. All three, *W. williamsonii, W. senifolia* and *W. violacea,* are vicariants, respectively, of *W. amabilis, W. rosmariniformis* and *W. glabra* of N.S. Wales and Queensland.

With a much larger number of species, 9 species, the state of New South Wales has but 2 endemics. One is *W. longifolia,* a species closely related to *W. glabra* and *W. blakeana,* while *W. lucida* is the vicariant of *W. rubiaefolia* of Tasmania. Two others are the wide-ranging *W. rigida* and *W. eremicola,* while all the others, 5 species, also occur in, and only in, Queensland.

Nearly half of the species of the genus occur in Queensland, 11 of them, including 5 endemics. The six other species also occur in N. S. Wales, with one of them, *W. eremicola,* extending as far south as the state of Victoria.

The genus as a whole is coastal and alpine, being confined to the southern and eastern part of the continent, and absent from the interior, from the Northern Territory, from Northern Queensland, and from much of Western Australia.

One may add the interesting fact that from an evolutionary point of view the Western Australian species are widest apart while the Queensland forms present the finest divisions within the genus.

Value of Descriptive Characters.

Habit. The size of the plant is usually impossible to derive from the average specimen, but a few well annotated labels seem to indicate that most species are bushy shrubs up to 2 meters high. In most, the ramification is diffuse, but is sometimes dense as in *W. senifolia* F. Muell. One species, *W. lucida* n., is a low depressed plant, and *W. rubiaefolia* R. Br. often has the same habit in alpine places. *W. tenuicaulis* White & Francis usually has many upright stems from a caudex, and the stems, 1 foot high or less, are most often simple or with only one or two appressed branches.

It may be well worth mentioning that the number of branches per node nearly always agrees with the number of leaves. In dried and flattened-out mounted specimens, branches are more quickly and easily counted than leaves.

Pubescence. Varies greatly in density from one species to another, and, to a smaller extent, within the same species. The pubescence of the under side of the leaf and of the outer part of the calyx often offers good characters.

Leaf. Because of the wide range of characters they offer, the leaves more than any other part of the plant have been used to separate the different species of *Westringia* Sm. The leaves may be in 2's, 3's, 4's, 5's, or 6's and the number is fairly constant within one species. Out of well over 1,000 specimens examined, about 20 did not conform to their specific pattern of leaf-insertion, and most of these are taken care of by two varieties (*W. eremicola* A. Cunn. var. *quaterna* Benth., and *W. violacea* F. Muell. var. *bacchi* n.). One specimen of *W. angustifolia*

R. Br. had quite a few leaves in 2's and in another specimen of *W. tenuicaulis* White & Francis they were in 4's. On the same specimen, leaves will sometimes vary in number at different nodes. This hardly ever occurs in three-leaved species, but is frequent in four-leaved species, a few of the leaves being in 3's. And in *W. senifolia* F. Muell. the leaves may be in 5's and 6's and even 4's on the same plant, 5 being the most frequent number. The leaf may be flat or its *margins* may be slightly recurved or partly revolute or so completely revolute that the underside of the leaf is not visible any more except for the median nerve. These four conditions are fairly constant within the same species, but as a certain amount of appreciation enters in their evaluation, it is difficult to make full use of this character. The appearance and density of the *pubescence* of the underside of the leaf is often a useful character. The leaf is usually uninerved with, in the larger-leaved species, a faint suggestion of a tri-nerved or even pinnate *nervation.* The margin of the leaf is always entire, but its *shape* varies to some extent and offers a good descriptive character. It may also be said that in *W. eremicola* A. Cunn. the leaf is most often conspicuously recurved, a condition hardly ever occurring in other species. The *size* of the leaf varies within narrow limits for each species except *W. rigida* R. Br., but varies greatly from species to species. Furthermore, they are sometimes dimorphous, those subtending a flower being much smaller than the others.

Petiole. Always very short and without any variations that could be taxonomically useful.

Inflorescence. Flowers are solitary in the axils of leaves, but in two species they are borne in heads. Although solitary in the axil of each leaf, the flowers are usually 3 to 4 to a node, a few successive flower-bearing nodes alternating with a few sterile nodes. This latter condition is naturally absent in subgen. *Muellera* where the heads terminate the branches, thus arresting further growth.

Flower. The two *bracts* subtending the flowers are either acicular or linear. They vary somewhat from species to species, but are always small and inconspicuous. The *calyx* is nerved or smooth, glabrous to white tomentose, with 5 broadly deltoid to narrowly lanceolate teeth. The pubescence of the outer side of the calyx usually conforms to that of the under surface of the leaves, but the shape of the teeth and their length relative to the length of the tube are characteristic of each species. Lobation of calyx has been much used in keys of earlier treatments, but I have not used this although the character has been actually used to bring related species together. It was felt that the number of leaves per node and the absence or presence and type of pubescence were better key-characters, as they are more clear-cut and will admit of a lesser amount of personal appreciation. In the sub-genus *Muellera* the lobes are rounded and the deep sinuses are acute. In the sub-genus *Euwestringia,* the lobation is very shallow with excurrent nerves in 3 species: (3) *W. angustifolia,* (4) *W. grevillina,* and (5) *W. quaterna.* The last two species, but not the first one, have a small notch in the middle of each sinus. In all other species, the calyx has acute teeth with fairly deep rounded or acute sinuses. With rounded sinuses are (6) *W. senifolia,* (7) *W. rosmariniformis,* (8) *W. brevifolia,* (9) *W. dampieri,* (10) *W. parvifolia,* (11) *W. longepedunculata,* (12) *W. tenuicaulis.* With a somewhat intermediate condition are (13) *W. rigida,* (14) *W. cheelii;* and with very deep acute sinuses: (15) *W. eremicola,* (16) *W. raleighii,* (17) *W. sericea,* (18) *W. grandifolia,* (19) *W. lucida,* (20) *W. rubiaefolia,*

(21) *W. longfolia,* (22) *W. blakeana,* (23) *W. glabra,* (24) *W. violacea,* (25) *W. williamsonii, and* (26) *W. amabilis,* the last two having even somewhat overlapping lobes. When better known, the *corollas* will certainly offer very good characters: shape, margin, marking and colour. Unfortunately, most herbarium specimens do not bear any flowers, and when flowers are present, corollas are always discoloured and withered. Only exceptionally do herbarium labels bear any annotations as to their colouring and marking. The two live species I have seen, together with the few coloured illustrations that have been published, lead me to believe that the corollas would offer very good specific characters as to colouring, marking, and size. But shape of the corolla appears to be uniform throughout the genus. The androecium and gynoecium hardly vary at all in different species.

Flowers of Labiatae are notorious for the way they lose their colour, and this especially applies to *Westringia.* The best method yet known to me for preserving the original colour of thin flowers, especially violet flowers such as are found in *Viola,* Labiatae, etc., is the insalivation method which is as follows: when making a collection of specimens in the field, some of the full-grown corollas are detached and split longitudinally. Small pieces of ordinary collecting paper (i.e., newsprint) are torn off and a drop or two of water is placed on each piece. If water is not handy at the time, which is most often the case, saliva is a most satisfactory substitute. Then the split corolla is spread over the drop of water and thus prepared may be placed within the collecting sheet with the rest of the specimen to be dried in any one of the usual manners. Colour preservation thus obtained is around 90 per cent. perfect and by drying 5 or 6 flowers one is pretty sure of having at least 2 or 3 flowers with their original colours fully preserved permanently. These insalivated flowers will most of the time remain lightly glued to the piece of newsprint when dried. Hence it is advisable to insalivate some showing the inside and some the outside of the corolla.

Nomenclature of Types.

For definitions of terms used in designating type material, see Rhodora 46: 344 (1944) or "American Thalictra and their Old World Allies" in Contrib. Gray Herb. 152: 344 (1944).

Herbarium Abbreviations.

In the following treatment, V stands for the National Herbarium of Victoria preserved at the Botanic Gardens in Melbourne, NSW for the National Herbarium of New South Wales preserved at the Botanic Gardens in Sydney, Q for the Queensland Herbarium preserved in Brisbane, and B for my own herbarium.

WESTRINGIA J. E. Smith.

Vetensk. Akad. Handl. Stockh., 171 (1797), also Tracts, 3: 292 (1798). Species typica quia princeps *W. rosmariniformis* Sm.

Artificial Key to the Species and Varieties.

a. Stem about 30 cm. high, straight, virgate simple or sometimes slightly branched; leaves in 3's, rarely in 4's .. 12. *tenuicaulis*

aa. Stem much branched:

b. Leaves (and usually the branches) in 5's or 6's .. 6. *senifolia*

bb. Leaves in 3's or 4's:

c. Nearly all the leaves and most of the branches in 4's:

d. Flowers in terminal heads; calyces exceeding the floral leaves .. .. 2. *discipulorum*

dd. Flowers distributed along the branches; calyces much shorter than the floral leaves:
e. Mature leaves glabrous:
f. Leaves strongly revolute, so that the lower surface is hidden; calyx scarcely lobed .. 5. *quaterna*
ff. Leaves flat; calyx deeply lobed with acute sinuses:
g. Leaves with parallel margins .. .. 24a. *violacea* var. *bacchi*
gg. Leaves with convex margins:
h. Leaves not more than 1 cm. long .. .. 20. *rubiaefolia*
hh. Leaves conspicuously dimorphous; stem-leaves 2–3 cm. long .. .. .. 25. *williamsonii*
ee. Leaves revolute, pubescent beneath:
i. Leaves 5–10 mm. long .. .. 8. *brevifolia*
ii. Leaves 10–30 mm. long:
j. Leaves 0·6–1·0 mm. wide .. . 15a. *eremicola* var. *quaterna*
jj. Leaves 1·5–2·5 mm. wide:
k. Calyx with teeth more than half as long as tube:
l. Calyx with rounded sinuses, the teeth only slightly more than half as long as tube; leaves 1·5–2·0 mm. wide .. .. .. 7. *rosmariniformis*
ll. Calyx with acute sinuses, the teeth nearly as long as tube; leaves 2·0–2·5 mm. wide 16. *raleighii*
kk. Calyx with teeth less than half as long as tube and rounded sinuses .. .. .. 9. *dampieri*
cc. Leaves and branches all in 3's:
m. Flowers capitate, the heads terminating the branches 1. *cephalantha*
mm. Flowers not capitate, scattered along the branches:
n. Leaves 1·5–10·0 mm. long:
o. Leaves conspicuously revolute and cinereous-pubescent beneath:
p. Calyx with teeth less than half as long as tube .. .. 13. *rigida*
pp. Calyx with teeth more than half as long as tube .. .. 15. *eremicola*
oo. Leaves flat or subrevolute, glabrous or puberulous:
q. Leaves ovate or elliptic:
r. Leaves 8–12 mm. long, exceeding the calyx 19. *lucida*
rr. Leaves 1·5–5·0 mm. long, overtopped by the calyces:
s. Leaves 3–5 mm. long; peduncles 2–3 mm. long .. .. 11. *longepedunculata*
ss. Leaves 1·5–3·0 mm. long; peduncles 0–5 mm. long .. .. 10. *parvifolia*
qq. Leaves more or less lanceolate .. .. 14. *cheelii*
nn. Leaves 10–50 mm. long:
t. Leaves revolute, densely pubescent beneath:
u. Calyx with teeth less than half as long as tube:
v. Leaves completely revolute, so that the undersurface, except for the midrib, is hidden; pubescence cinereous on under-surface of leaf and on outside of calyx .. 4. *grevillina*
vv. Leaves incompletely revolute; pubescence silvery; calyx usually nearly glabrous and shining .. .. 3. *angustifolia*
uu. Calyx with teeth more than half as long as tube:
w. Pubescence cinereous; leaves 0·5–1·5 mm. wide, dull on the upper surface .. .. 15. *eremicola*
ww. Pubescence silvery-silky; leaves 2–8 mm. wide, shining on upper surface:
x. Leaves 4–8 mm. wide; calyx about 10 mm. long .. .. 18. *grandifolia*
xx. Leaves 2–3 mm. wide; calyx 8 mm. long or shorter .. .. 17. *sericea*

tt. Leaves flat or subrevolute, glabrous or puberulent beneath, never cinereous nor silvery:
  y. Leaves with convex margins:
    z. Leaves not dimorphous; calyx with teeth longer than the tube:
      A. Leaves 3–5 cm. long .. .. .. 22. *blakeana*
      AA. Leaves 1–2 cm. long .. .. .. 24. *violacea*
    zz. Leaves dimorphous:
      B. Flowers rose-coloured:
        C. Leaves ovate or ovate-lanceolate .. 26. *amabilis*
        CC. Leaves narrowly lanceolate .. .. 23. *glabra*
      BB. Flowers violet .. .. 24. *violacea*
  yy. Leaves with parallel margins, very narrow, 1·5 mm. wide .. .. 21. *longifolia.*

Sub-genus **Muellera** sub-gen. nov.

Flores in capitibus terminalibus aggregati. Folia floralia in bracteas mutata. Lobi calycis rotundi. Species typica *Westringia cephalantha* F. Muell.

Dedicated to Baron Sir Ferdinand von Mueller, this sub-genus is set apart from the other species because of its conspicuously different inflorescence. The characters given above might be sufficient to warrant generic segregation of *Muellera,* but lack of familiarity with related genera does not permit me to give a considered opinion on the expediency of such a segregation.

1. W. CEPHALANTHA F. Muell., Frag. Phyt. Austr. vi, 110 (1868). WESTERN AUSTRALIA. Fig. 1: leaf, *R. Helms,* Gasolbine, 12 Nov. 1891; 2: reduced floral leaf, id.; 3: bract, id.; 4: calyx, id.

The type collection, DRUMMOND 76, W. Aust., 1849 (V, TYPE; NSW, ISOTYPE) has leaves in 3's as have all other specimens examined, but *Drummond* 170, Western Australia, 1848 (NSW, V, PARATYPES) has its leaves in 4's, heads about 1 cm. in diameter, and is *W. discipulorum* S. Moore.

2. W. DISCIPULORUM S. Moore in Journ. Bot. lix, 248 (1921). WESTERN AUSTRALIA. Fig. 5: leaf, *J. Drummond,* West. Australia; 6: floral leaf, id.; 7: bract, id.; 8: calyx, id.; 9: corolla, stamens, and pistil, id.

Close to *W. cephalantha* F. Muell., but heads and flowers larger, leaves in 4's and shorter, but floral leaves longer. Type collected at Yorkrabine, by state school, no. 811, not seen, the only specimens at hand being two sheets of *Drummond 170,* paratypes of *W. cephalantha* F. Muell. and one unnumbered collection by *Drummond* from Western Australia. Vernacular: White Button Bush.

Sub-genus **Euwestringia** sub-gen. nov.

Inflorescentia typica generis. Flores solitarii in axillis foliorum tamen saepius 3—4 in nodis singulis. Axillae floriferentes ca. 3—4, proximae, aliae axillarum, et sequentium et praecedentium, steriles sunt. Lobi calycis vel acuti vel nervis excurrentibus, nunquam rotundi. Species typica et generis et sub-generis: *Westringia rosmariniformis* Sm. sit. Ista selecta est tam quam typica tam quia in primis descripta fuit.

3. W. ANGUSTIFOLIA R. Br. Prod. Fl. Nov. Holl. 501 (1810). TASMANIA. Fig. 10: leaf, *J. Bufton,* Port Arthur; 11: calyx, *T. Gulliver,* Tasmania.

Type not seen.

4. W. GREVILLINA F. Muell. Trans. Phil. Soc. Vict. i, 49 (1855). SOUTH AUSTRALIA, WESTERN AUSTRALIA. Fig. 12: leaf, *Carl Wilhemi,* Port Lincoln district; 13: calyx, id.

The type collection in the herbarium in Melbourne has supplied the illustrations for this species.

5. **W. quaterna** sp. n.

TASMANIA. Fig. 14: leaf, *R. A. Black* 777-004 (5)A; 15: calyx, id.

Caulis et rami quaterni minute pubescentes. Folia 18–28 mm. long. et 1.5–2.0 mm. lat., caulinaria quaterna et ramealia terna, scabra, atro-viridia, haud dimorpha, plus minusve falcata, magis revoluta, apice mucronata, inferne pubescentia. Flores axillares nec numerosi. Pedunculi 1.5–2.0 mm. Bracteae 1.0–1.5 mm. Calyx obpyramidalis, 3.5–4.5 mm. long., 4–5 mm. lat., glaber vel puberulens, lucidus plus minusve brunneus, nervis saepius paullum undulatis et valde excurrentibus modo dentium, sinubus vix notatis nisi ad mediam emarginatis. Flores ignoti.

TASMANIA; *Raleigh A. Black* 777-004(5)A, Neika Stn., Jan. 1, 1946 (B, TYPE; Q, V, fragments).

The only other species in Tasmania with leaves and branches 4 to a node is *W. brevifolia* Benth. with leaves much smaller and pubescent underneath.

6. W. SENIFOLIA F Muell., Trans. Phil. Soc. Vict. i, 49 (1855); *W. senifolia* F. Muell. var. *canescens* Benth., Fl. Aust. v, 130 (1870). VICTORIA. Fig. 16: leaf, *C. Walter,* Victorian Alps, journey of 1892; 17: calyx, id.

The type, *Mueller,* Buffalo Range, 8 mart. 1853, is in Melbourne along with paratypes. Two more paratypes are in Sydney. Var. *canescens* Benth. does not seem to represent even a well defined extreme form.

7. W. ROSMARINIFORMIS Sm., Vetensk. Akad. Handl. Stockh. 171 (1797), also Tracts, 3: 292 (1798); *Cunila fruticosa* Willd., Sp. Pl. 1: 122 (1797); *Westringia fruticosa* (Willd.) Druce, Rep. Bot. Exch. Cl. Brit. Isles, 652 (1917). QUEENSLAND, NEW SOUTH WALES. Fig. 18: leaf, *C. T. White* 1.324; 19: calyx, *J. L. Boorman,* Botany Bay.

In so far as I can ascertain, *Cunila fruticosa* Willd. and *Westringia rosmariniformis* Sm., were published the same year. Consequently, I am here retaining the first accepted name *W. rosmariniformis* Sm. till further data on publication dates becoming available might suggest that a different course should prove more in accordance with the International Rules of Nomenclature.

W. rosmarinacea published in Andrew's Bot. Rep. 3: t. 214 (1902) is obviously nothing but a spelling mistake. Specimens used for the drawings in the aforementioned publication had previously been authenticated by Smith, hence that plate has given us the present interpretation of *W. rosmariniformis* Sm. along with the original description and drawings. The type material is not available to me.

Part of Bentham's type material of *W. brevifolia* belongs to *W. rosmariniformis* Sm.

8. W. BREVIFOLIA Benth., Lab. Gen. & Sp. 459 (1834). TASMANIA. Fig. 20: leaf, *J. Milligan* 1174, Flinders Island; 21: calyx, id.

The original description I have not seen, but the specimen, *Gunn*, Tasmania (V), might possibly be type material.

9. W. DAMPIERI R. Br. Prod. Fl. Nov. Holl. 501 (1810). SOUTH AUSTRALIA, WESTERN AUSTRALIA. Fig. 22: leaf, *Brooke,* Israelite Bay, 1884; 23: calyx, id.

No type material available.

10. W. PARVIFOLIA White & Francis in Proc. Roy. Soc. Queensl. xxxiii, 160 (1921). QUEENSLAND. Fig. 24: leaf, *C. T. White,* Yelarbon; 25: calyx, id.

Type material: *C. T. White,* Yelarbon (Q, TYPE; Q, V, ISOTYPES).

11. **W. longepedunculata** sp. n. QUEENSLAND. Fig. 26: leaf, *Doggrell* 142; 27: calyx, id.

Planta per partes juvenes minutissime pubescens. Folia terna 3–5 mm. long., ovata vel oblonga, crassa, plana, internodiis breviora, haud dimorpha. Flores conspicue pedunculati. Pedunculus 2.0–2.5 mm. Calyx anguste obconicus, 5.5–6.0 mm. long., tubo 4.5–5.0 mm. long., dentibus deltoideis ca. 1 mm. long. bracteis ca. 1 mm. Flores ca. 8 mm. long.

QUEENSLAND: *R. H. Doggrell* 142, Inglewood Dist., 4′ slender shrub (Q, TYPE; V, fragment).

12. W. TENUICAULIS White & Francis in Proc. Roy. Soc. Queensl. xxxiii, 162 (1921). QUEENSLAND. Fig. 28: leaf, *Jas. Keys* 672; 29: calyx, *S. T. Blake* 3390 near Nikenbah.

A species very well characterized by its numerous rigidly erect stems, simple or nearly so, springing from a thickened rootstock. Type collection: *Jas. Keys* 672 (Q, TYPE; V, fragment).

13. W. RIGIDA R. Br. Prod. Fl. Nov. Holl. 501 (1810); *W. cinerea* R. Br., loc. cit.; *W. rigida* R. Br. *β brevifolia* Benth. ex DC. Prod. xii, 570 (1848). NEW SOUTH WALES, VICTORIA, SOUTH AUSTRALIA, WESTERN AUSTRALIA. Fig. 30: leaf, *Max Koch* 2178; 31: calyx, *E. Morris* 1107, Broken Hill.

W. lurida Gand. might belong here, but the original description is confusing to me. No type material seen of any of the abovementioned units.

W. rigida R. Br. is extremely variable as to size and shape of the leaves.

14. W. CHEELII Maiden & Betche in Proc. Linn. Soc. N. S. Wales, xxxv, 792 (1911). QUEENSLAND, NEW SOUTH WALES. Fig. 32: leaf, *C. E. Hubbard* 5066; 33: calyx, id.

Type collection: *J. L. Boorman,* road form Goonoo to Mudgee, October 1908 (NSW, TYPE).

15. W. EREMICOLA A. Cunn. ex Benth. Lab. Gen. et Sp. 459 (1834). QUEENSLAND, NEW SOUTH WALES, VICTORIA. Fig. 34: leaf, *F. M. Bailey,* Mt. Gravatt; 35: calyx, id.

Duplicates of all specimens cited by *Bentham* in his Fl. Aust. are available at Melbourne; the type-collection may best be Cunningham's collection, near the Lachlan River. One of the syntypes of *W. longifolia* R. Br. belongs here; see that species for discussion.

15a. W. EREMICOLA A. Cunn. var. QUATERNA Benth. Fl. Aust. v, 130 (1870). NEW SOUTH WALES. Fig. 36: leaf, *Jephcott*, Hume River, 1828; 37: calyx, id.

Type in the National Herbarium of Victoria at Melbourne: Shoalhaven gullies, near Glenroch.

16. **W. raleighii** sp. n. TASMANIA. Fig. 38: leaf *R. A. Black* 777–001(2)A; 39 calyx id.

Rami juvenes folia inferna et calyces densissime albo-pubescentes, pilis brevibus et sericeis. Rami quaterni. Folia 11–16 mm. long. et 2·2–2·5 mm. lat., anguste lanceolata, quaterna vel in ramis terna, ambitu attenuata, superne lucida, marginibus revolutis. Petioli ca. 2 mm. Pedunculi ca. 1 mm. Bracteae 2·5–3·4 mm. Calyx 8–9 mm.; tubo 4·0–4·5 mm. et dentibus 4·0–4·5 mm. sinubus acutis. Flores ignoti.

TASMANIA: *Raleigh A. Black*, 777–001(2)A, Hobart, Sandy Bay, Feb. 14, 1946 (B, TYPE; Q, V, fragments).

This new species is named in honour of Raleigh A. Black, an outstanding amateur botanist who collected the type-material and whose specimens, unusually well pressed and prepared, were placed at my disposal.

17. **W. sericea** sp. n. QUEENSLAND. Fig. 40: leaf, *C. T. White* 9939; 41: calyx, id.

Planta ramis juvenibus foliis infernis et subtus calycibus sericeo-pubescentibus. Folia terna haud dimorpha anguste lanceolata vel linearia marginibus paullum revolutis, 2–3 cm. long., 2–4 mm. lat. Petioli ca. 1·5 mm. long. Pedunculi ca. 1 mm. long. Bracteae 2·0–2·5 mm. Calyx 7–8 mm. long., tubo 3·5–4·5 mm. long., dentibus 3·5–4·0 mm. long. Corolla ca. 12 mm. long., villosa.

QUEENSLAND: *C. T. White* 9939, Moreton District, Mt. Greville, very common on rocky ridges, shrub up to 2 m. high, fl. lavender, 31 March 1934 (Q TYPE, and 4 ISOTYPES); *N. Michael* 2075, Mt. Greville, a small low shrub, 10 Oct. 1934 (Q): *E. G. Smith*, Moreton District, Mt. Edwards (Q).

18. W. GRANDIFOLIA F. Muell. ex Benth. Fl. Aust. v, 128 (1870); *Westringia rosmariniformis* Sm. var. *grandifolia* F. Muell. ex White & Francis in Proc. Roy. Soc. Queensl. xxxiii, 162 (1921). QUEENSLAND. Fig. 42: leaf, *F. Mueller*, Granite Mountains; 43: calyx, id.

Type material seen: *F. Mueller*, Granite Mountains (V, TYPE; NSW, Q, ISOTYPES); *Leichhardt*, Biroa (V PARATYPE). I agree with Bentham that the characters of this species are as clear-cut as those of any other *Westringia*. The locality given in the Flora Australiensis, Glasshouse Mountains, is apparently a misprint for Granite Mountains.

19. **W. lucida** sp. n. NEW SOUTH WALES. Fig. 44: leaf, *Lemberg*, Kosciusko; 45: calyx, id.

Planta verosimiliter minor. Folia 8–12 mm. long., 6–8 mm. lat., 3 in nodo, plana, ovata, glabra, basi rotunda, summa obtusa vel rotunda, nervo medio obscuro, per ambas paginas lucida. Petioli ca. 1 mm. Flores ca. 10 mm. long., minores, haud agglomerati. Pedunculi ca. 0·5 mm. Folia floralia calycem superantia nec quam sterilia conspicue breviora. Calyx 6·5–7·0 mm. long., lucidus, puberulens, tubo ca. 4·5 mm. long., lobis triangularibus 2·0–2·5 mm. long.

New South Wales: M. R. Lemberg, near and to the North of Mt. Kosciusko, Jan. 1943. (NSW, type; V, Q, fragments of same).

20. W. rubiaefolia R. Br. Prod. Fl. Nov. Holl. 501 (1810); *Westringia rubiaefolia* R. Br. var.? *sub-sericea* Benth. Fl. Aust. v, 131 (1870). Tasmania. Fig. 46: leaf, *G. F. Story,* Swanport; 47: calyx, *J. Milligan* 1301; 48 calyx, *C. F. Story,* Swanport.

Type material seen: *Robert Brown,* Derwent River (NSW, V, isotypes).

The type of Bentham's variety is in Melbourne: *Mulligan* 1301, marshes in the head of the Douglas River, low thick bushy shrub, 12 Dec. 1851 (V, type; Q, fragment). It is made up of 5 fragments; 4 of them are typical of the species, the fifth one has the underside of the leaves densely pubescent. In the absence of any other similar material, I do not know whether to regard this specimen as abnormal or worth varietal rank.

21. W. longifolia R. Br. Prod. Fl. Nov. Holl. 501 (1810); *Prostanthera linearis* Sieber ex Bentham, Lab. Gen. et Sp. 455 (1834). New South Wales. Fig. 49: leaf, *Atkin,* Campbelltown; 50: calyx id.

One of the syntypes, *R. Brown,* Grose River, N.S. Wales, is preserved in Melbourne and belongs to *W. eremicola* A. Cunn. However, as the original description clearly refers to *W. longifolia* as identified by the various collections at hand, I am inclined to think that the syntypes are heterogeneous and I prefer for the present to keep *W. longifolia* in its heretofore accepted sense pending eventual checking on syntypes preserved in Robert Brown's herbarium.

22. **W. blakeana** sp. n. Queensland, New South Wales. Fig. 51: leaf, *S. T. Blake* 15436; 52: calyx, id.

Planta 1·5–2·5 m. alta, glabra vel puberulens. Folia terna lanceolato-linearia ambitu gradatim cuneata, 3–5 cm. long., 3–5 mm. lat., nec dimorpha. Petioli ca. 1·5 mm. Pedunculi ca. 1·5 mm. Bracteae 4·0–6·5 mm. Calyx 7·5–9·0 mm. long., obconicus, tubo 3·5–4·0 mm. long., dentibus 4–5 m. long. Corolla villosa ca. 15 mm. long.

Queensland: *S. T. Blake* 15436, Moreton District, Lamington National Park, in *Eucalyptus-Casuarina* forest near Picnic Ck., ca. 2,400 ft., rather open virgate shrub ca. 1½–2 m. high, the branches and young shoots purplish; calyx purplish; corolla mostly pale lilac, the throat and tube becoming nearly white, the middle lobe of lower lip with brown spots, 2 Nov. 1944. (Q. type, and 3 isotypes); *C. T. White* 11843, Lamington National Park, alt. 800 m., common in *Eucalyptus* forest, shrub 2 m., upright growth, fls. pale lilac, 10 Oct. 1942 (Q).

New South Wales: *C. T. White* 1·509, Minyon via Mullimbimby, shrub up to 8 ft. high, flowers lavender, very common in thick undergrowth in *Eucalyptus* forest, 26 Aug. 1936 (Q).

23. W. glabra R. Br. Prod. Fl. Nov. Holl. 501 (1810). Queensland, New South Wales. Fig. 53: leaf, *C. T. White* 1897, Mt. Cooroora; 54: calyx, id.

Type from Shoalwater Bay, Queensland, not seen, but I have at hand a copy of R. Brown's MSS. description and a tracing of the type made by C. T. White.

24. W. violacea F. Muell. Trans. Phil. Soc. Vict. i, 49 (1855). Victoria. Fig. 55: leaf, *J. H. Willis & R. V. Smith,* Lerderberg Gorge.

The type of *W. violacea* F. Muell. comes from near the mouth of the Goulburn River, was collected by the describer himself in March, 1853, and is preserved in Melbourne Another specimen collected 11 Nov. 1945 by *J. H. Willis* & *R. V. Smith* at the Lerderberg Gorge was studied when fresh and seems to agree fairly well with the type. The corolla was violaceous, white in the throat, with two longitudinal rows of 4 brown spots each on the labellum. At the Melbourne Botanic Gardens there are also two other specimens with leaves in 4's coming from the Bacchus Marsh area. These specimens have smaller oblong-linear leaves and seem to be closest to *W. violacea* F. Muell. For them I propose:

24a. W. VIOLACEA F. Muell, var. **bacchi** var. n. VICTORIA. Fig. 56: leaf, *P. R. H. St.-John,* Bacchus Marsh.

Foliis quaternis oblongo-linearibus, (6)–8–12–(25) mm. long., 1·5–3·0 mm. lat.

VICTORIA: *C. S. Sutton,* Lerderberg River near Bacchus Marsh (V); *P. R. H. St.-John,* Bacchus Marsh (probably in the Lerderberg River Gorge), 1 Sept. 1904 (V, TYPE; Q, ISOTYPE).

25. **W. williamsonii** Willis & Boivin sp. n. VICTORIA. Fig. 57: leaf, *H. B. Williamson,* Mt. Zero; 58: calyx, id.

Caulis et rami in apice minute pubescentes. Folia glabra quaterna, petiolis ca. 2 mm., plana vel subrevoluta, conspicue dimorpha, sterilia anguste oblanceolata 20–30 mm. long., 3·5–5·0 mm. lat., basi anguste cuneata, summa fere rotunda, submucronata. Flores axillares. Calyx 6·0–6·5 mm. long., obconicus, minute pubescens, bracteis ca. 2 mm.; tubo 4 mm. long.; lobis acutis 2·0–2·5 mm. long.

VICTORIA: *H. B. Williamson,* Mt. Zero (V, TYPE; Q, fragment).

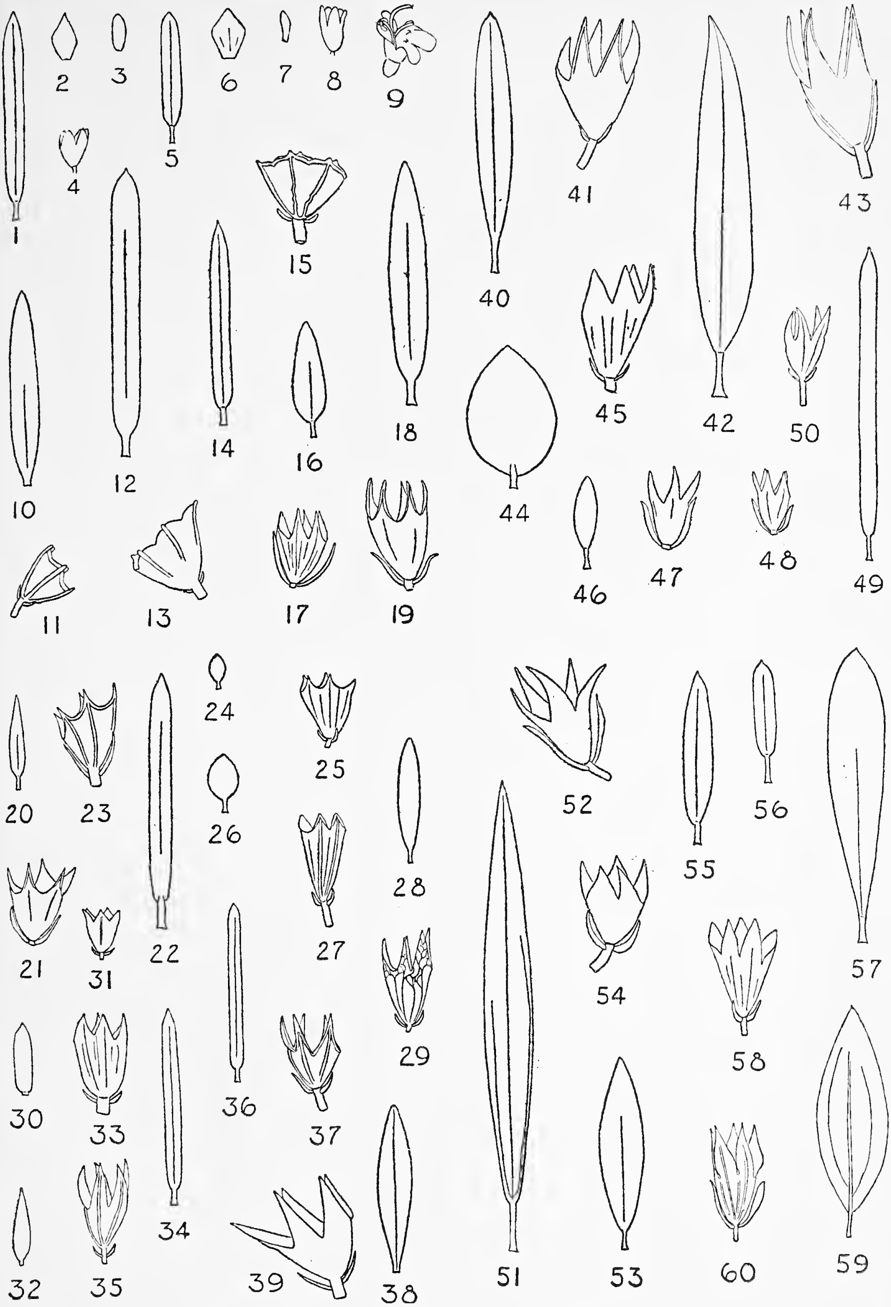
26. **W. amabilis** sp. n. QUEENSLAND, NEW SOUTH WALES. Fig. 59: leaf, *M. S. Clemens,* Ballandean, Oct. 1944; 60: calyx, id.

Omnino puberula nisi in foliis maturis. Folia 12–20 mm. long., 4–8 mm. lat., tria in nodo, plana, ovato-lanceolata, summa acuta mucronata, basi cuneata, nervis lateralibus duobus saepius inferne conspicuis, nervulis anastomosantibus autem nonnunquam notabilibus. Petioli 1·5–2·0 mm. longi. Flores ca. 15 mm. long., agglomerati in apice caulis et ramorum abbreviatorum. Pedunculi 1·0–1·2 mm. Bracteae 3–4 mm. long., paullulum dilatatae. Calyx 6·5–8·0 mm. long., folia floralia persaepius superans, lobis 3–4 mm. longis, lanceolatis, tubi calycis longitudinem approximantibus.

QUEENSLAND: *Mrs. M. S. Clemens,* Darling Downs District, near Ballandean, "a lovely shrub," Oct. 1944 (Q, TYPE & ISOTYPE); idem, Nov. 1944 (Q).

NEW SOUTH WALES: *J. H. Maiden,* Mt. Seaview, Nov. 1897 (NSW).

This new species has been very well characterized indeed by its collector, for its rather large and extremely abundant flowers makes it a very decorative shrub. The size and shape of the leaves also make this species easy to recognize at a glance.



EXPLANATION OF PLATE IX.—*Westringia* spp.

For detailed explanation of each figure, see text. Numbers in brackets refer to numbering of species in text.

1, 2, 3, 4—(1) *W. cephalantha;* 5, 6, 7, 8, 9—(2) *W. discipulorum;* 10, 11—(3) *W. angustifolia;* 12, 13—(4) *W. grevillina*; 14, 15—(5) *W. quaterna;* 16, 17—(6) *W. senifolia;* 18, 19—(7) *W. rosmariniformis;* 20, 21—(8) *W. brevifolia;* 22, 23—(9) *W. dampieri;* 24, 25—(10) *W. parvifolia;* 26, 27—(11) *W. longepedunculata;* 28, 29—(12) *W. tenuicaulis;* 30, 31—(13) *W. rigida;* 32, 33—(14) *W. cheelii;* 34, 35—(15) *W. eremicola;* 36, 37—(15a) *W. eremicola* var. *quaterna;* 38, 39—(16) *W. raleighii;* 40, 41—(17) *W. sericea;* 42, 43—(18) *W. grandifolia;* 44, 45—(19) *W. lucida;* 46, 47, 48—(20) *W. rubiaefolia;* 49, 50—(21) *W. longifolia;* 51, 52—(22) *W. blakeana;* 53, 54—(23) *W. glabra;* 55—(24) *W. violacea;* 56 (24a) *W. violacea* var. *bacchi;* 57, 58—(25) *W. williamsonii;* 59, 60—(26) *W. amabilis.*

The Royal Society of Queensland.

Report of the Council for 1947.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting the Annual Report of the Society for the year 1947.

At Ordinary Meetings throughout the year two addresses were given and two symposia held, while two evenings were devoted to exhibits. The Annual Memorial Lecture was held this year in honour of Professor H. C. Richards, and was delivered by Professor W. H. Bryan. Nine original papers were accepted for publication in the Proceedings.

During the year there has been an improvement in the position with regard to publication, due to co-operation of the Government Printer with the Council, and Volumes LVII and LVIII have both been issued. Nevertheless the position is still difficult, though it is hoped that no serious delays will occur in the future. The high cost of printing is causing the Council some concern, and it may prove necessary either to restrict activities or to find means of increasing income.

There are 6 honorary life members, 6 life members, 3 corresponding members, 229 ordinary members, and 17 associate members in the Society. This year the Society has lost 4 members by death and 5 by resignation, while 11 ordinary members and 1 associate member have been elected.

Attendance at Council Meetings was as follows:—E. M. Shepherd 11; O. A. Jones 12; H. C. Webster 9; E. W. Bick 9; M. I. R. Scott 12; M. F. Hickey 8; S. T. Blake 9; B. Baird 8; C. Ogilvie 3; D. Hill 11; E. N. Marks 8; E. C. Tommerup 0; W. Boardman (resigned June) 2; G. Mack (appointed June) 4.

E. M. SHEPHERD, President.

MARGARET I. R. SCOTT, Hon. Secretary.

THE ROYAL SOCIETY OF QUEENSLAND.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDED 31ST DECEMBER, 1947.

RECEIPTS.

	£ s. d.	£ s. d.
Balance in Commonwealth Bank, 31st December, 1946	218 16 1	
Cash in Hand, 31st December, 1946	0 19 2½	
		219 15 3½
Subscriptions	191 12 6	
Less Returned Cheque	1 1 0	
		190 11 6
Commonwealth Loan Interest	4 11 3	
Savings Bank Interest	4 3 9	
		8 15 0
Exchange	..	0 6 0
		£419 7 9½

EXPENDITURE.

	£ s. d.	£ s. d.	£ s. d.
Government Printer—			
1945 Volume: Cost		162 16 11	
Less—			
Government Subsidy	65 18 4		
Amount paid in 1946	60 0 0		
		125 18 4	
		36 18 7	
1946 Volume: On Account		60 0 0	
			96 18 7
Library Insurance		..	0 19 3
Stencils and Roneoing		6 1 0	
Less Contribution by Geology Department		0 2 6	
			5 18 6
Lanternist		..	1 0 0
Stationery, Stamps, &c.—			
Hon. Secretary		18 11 5	
Hon. Librarian		10 13 6½	
Hon. Treasurer		3 0 0	
			32 4 11½
Refreshments		7 11 4	
Less Collections		5 4 0	
			2 7 4
Balance in Commonwealth Bank, 31st December, 1947		277 14 9	
Cash in Hand		2 6 5½	
		280 1 2½	
Less Amount owing to Hon. Secretary		0 2 0½	
			279 19 2
			£419 7 9½

Examined and found correct.

L. P. HERDSMAN, Hon. Auditor.

26th February, 1948.

E. W. BICK, Hon. Treasurer.

Abstract of Proceedings, 30th March, 1948.

The Annual General Meeting of the Society was held in the Geology Department of the University on Tuesday, 30th March, with the President (Mr. E. M. Shepherd) in the chair. About fifty members and friends were present. The President extended a welcome to His Excellency the Governor. An apology was received from Mr. E. W. Bick.

The minutes of the last Annual General Meeting were read and confirmed. The Annual Report was adopted and the Balance-sheet received. Dr. J. I. Tonge, Mr. A. H. Basire, Mr. A. B. Cribb, and Miss M. M. Noyes were proposed for Ordinary Membership and Miss E. Exley for Associate Membership.

The following officers were elected for 1948:—

President: Professor H. C. Webster.

Vice-President: Dr. D. Hill.

Hon. Secretary: Miss M. I. R. Scott.

Hon. Treasurer: Miss E. N. Marks.

Librarian: Miss B. Baird.

Editors: Mr. S. T. Blake, Professor M. F. Hickey.

Members of Council: Mr. O. A. Jones, Mr. R. F. Langdon, Mr. G. Mack, Dr. A. L. Reimann, Mr. J. H. Simmonds.

The Presidential Address, entitled "Some Hydrological Factors in Queensland," was delivered by the retiring President, Mr. E. M. Shepherd. A vote of thanks was moved by Dr. F. W. Whitehouse, seconded by Mr. C. Ogilvie, and carried by acclamation.

Abstract of Proceedings, 27th April, 1948.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Tuesday, 27th April, with the President (Professor H. C. Webster) in the chair. About sixty members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. E. W. Bick, on the nomination of the Council, was elected to Honorary Life Membership. The following were elected to Ordinary Membership: Dr. J. I. Tonge, Mr. A. H. Basire, Mr. A. B. Cribb, and Miss M. M. Noyes. Miss E. Exley was elected to Associate Membership. The following were nominated for Ordinary Membership: Mr. G. R. M. Grant, Mr. C. Berglin, Mr. F. S. Colliver, Mr. J. W. Morrison, Mr. W. F. Machin, Mr. I. A. Evans, Mr. N. M. Haysom, Miss P. R. Pennycuick.

Dr. F. W. Whitehouse gave an address entitled "The Coastline of Queensland." He said that the coastline of Queensland has two markedly different parts—the gulf coast with shorelines almost everywhere advancing, and the east coast over considerable portions of which the shoreline is receding. The gulf coast is, for a great part of its length, a transient line that moves inwards over the imperceptibly sloping plain at the height of the monsoon season. The east coast has a number of peculiar features (a series of "reversed J" bays; curiously restricted but repeated features such as giant sand hills, salt flats, etc.) that end at the New South Wales border, where a prominent break occurs, not only in coast types but also in the deeper water forms. The influence of tidal types, wave, wind and current actions, and of movements of sea-level in forming and modifying these features and the coastline as a whole were illustrated.

Abstract of Proceedings, 31st May, 1948.

A Special Meeting of the Society was held in the Geology Department of the University on Monday, 31st May, at 7.50 p.m., with the President (Professor H. C. Webster) in the chair. Business of the meeting concerned the appointment of a Trustee to fill the vacancy caused by the death of Dr. A. J. Turner. Professor W. A. Bryan was appointed.

A Special Meeting was held in the Geology Department of the University on Monday, 31st May, at 7.55 p.m., with the President (Professor H. C. Webster) in the chair. Business of the meeting concerned proposed amendments to Rules 4 and 12. It was resolved to amend these rules to read as follows:—

Rule 4. "Life Members are such Ordinary Members as have commuted the ordinary subscriptions on payment of fifteen guineas."

Rule 12. "Ordinary Members may at any time commute the Annual Subscription on payment of fifteen guineas. (See Rule 4.)"

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 31st May, at 8 p.m., with the President (Professor H. C. Webster) in the chair. About twenty-five members and friends were present. The minutes of the previous meeting were read and confirmed. The following were elected to Ordinary Membership:—Mr. C. L. W. Berglin, Mr. G. R. M. Grant, Mr. J. W. Morrison, Mr. W. F. Machin, Mr. I. A. Evans, Mr. N. M. Haysom, Miss P. R. Pennycuick, and Mr. F. S. Colliver. The following were nominated for Ordinary Membership:—Mr. T. J. Beckmann, Mr. R. W. Clark, Mr. B. J. Phillips, Dr. C. N. Sinnamon.

Mr. Arthur R. Riddle gave an address entitled, "Beef, The Industry, and the State."

He pointed out the seriousness of the current relatively static condition of the beef-cattle industry. Keeping population-increase of the Australian people in mind, the time would seem to be not far distant when there would be only sufficient beef to meet domestic needs, with no exportable surplus, unless very active steps were takn to increase cattle population.

The recent visit of Sir Henry Turner, of the British Food Mission, on the meat side, revealed the big opportunity presented to Australia in respect of the United Kingdom market for beef and other meats, and meat products.

The current situation demanded, in addition to greatly increased production, the ability to turn off cattle for meatworks treatment of better quality, earlier maturity, and more uniform weight conformation, and quality. It was also essential that much greater continuity of supply be striven for. A block diagram of surplus cattle, prepared by the late Mr. E. F. Sunners, plotted from yearly averages over the period 1939 to 1945, vividly demonstrated the seasonal nature of the industry.

The activities in Queensland of the C.S.I.R. Divisions of Soils and Plant Industry in connection with pastures, of Animal Health and Production, and Economic Entomology, were briefly discussed, and the problems of the Division of Food Preservation and Transport handled in more detail.

The desirability of experimental work to determine the possibility of evolving one or more cattle types, more suited to the various Australian environmental factors than the present English breeds, was discussed.

Associated problems of transport and water, and the use of the Channel country after the streams come down in flood, received attention. To make use of this channel country it appeared very necessary to have such transport as would enable young cattle to be shifted in quickly from breeding areas, such as the Northern Territory, immediately the prolific feed following floods in the Cooper country was available, and to shift fattened cattle out to meatworks equally quickly, when diminishing feed was likely to cause them to lose condition if they stayed there.

The problems of the Division of Food Preservation and Transport were then discussed in greater detail, these being concerned chiefly with microbiological investigations on meatworks hygiene and storage, the highly technical problems of bloom, both physical and chemical, and those of shipboard transport.

In conclusion, reference was made to inland abattoirs and the transport of chilled and frozen meat, the problems of the tenderising of meat, and the great need of a well-organised co-operative attack by producers, meatworks, railways, and shipping, and by scientific and technical men whether Commonwealth or State, research or extension, on the whole beef-cattle and beef industry problems.

Abstract of Proceedings, 28th June, 1948.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 28th June, with the President (Professor H. C. Webster) in the chair. About thirty-five members and friends were present. The minutes of two Special Meetings and of the previous Ordinary Meeting were read and confirmed. Mr. T. J. Beckmann, Mr. R. W. J. Clark, Dr. B. J. Phillips, and Dr. C. N. Sinnamon were elected to Ordinary Membership. Mr. P. Healy, Mr. W. M. Jones, and Mr. T. E. Hunt were nominated for Ordinary Membership.

The following exhibits were made:—

"A specimen of finely folded sandstone from the Landsborough Series near Nambour," and "A 'mineral glass ruler' presented to the Department of Geology by Mr. W. O'Brien, of Yungaburra," by Professor W. H. Bryan.

"Glass to metal seals used in high vacuum work," by Dr. A. L. Reimann.

"Some recent additions to the Queensland Museum," by Mr. G. Mack.

"Life history of a moth fly (Diptera: Psychodinae)," by Miss E. N. Marks.

"A Conway unit," and "Deionizing resins," by Mr. J. M. Harvey.

"Specimens of Molybdenite from aplite veins associated with the Noosa granodiorite," by Mr. O. A. Jones. The granodiorite intrudes the Lower Mesozoic sediments, and the occurrence of molybdenite is evidence in support of an Upper Cretaceous Metallogenetic epoch in the region about Maryborough and for at least 100 miles south.

"Triassic conifers riddled by borers, from Herston," by Dr. F. W. Whitehouse.

"Geiger counter tubes," by Professor H. C. Webster.

"A poisonous vine from New Britain," by Mr. S. T. Blake; with frog's heart tracings of the vine extract, by Miss M. Scott.

"Tympanic bones and Pterodic bones and teeth of Tertiary whales from various localities in Victoria," by Mr. F. S. Colliver.

"A specimen of *Neocalamites carrerei* collected by Mr. F. S. Colliver from Petrie's Quarry, Albion," by Mr. O. A. Jones.

Abstract of Proceedings, 26th July, 1948.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 26th July, with the President, Professor H. C. Webster, in the chair. About fifty members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. P. Healy, Mr. W. M. Jones, and Mr. T. E. Hunt were elected to Ordinary Membership. Dr. L. P. Sapsford, Mr. A. S. Gehrmann, and Mr. G. S. Gloe were nominated for Ordinary Membership.

A symposium on "Genetics" was held.

The subject was introduced by Mr. G. Mack, who made reference to the cell, cell division, and sex determination.

The next speaker was Mr. W. W. Bryan. He said that genetics, the study of heredity, has two aspects:—(1) the unknown agents in the germ-cells have to be identified and their reactions studied. (2) There is the action of the gene in controlling development. The material with which we are concerned is the cell, the nucleus, the chromatin material, the chromosomes, and the genes. Genes are highly active substances, present in very small quantities. The substance is doubled before each cell-division and is thus capable of assimilation and growth. The gene is able to undergo sudden and often reversible changes called mutations. The mutated gene is as stable as the original gene and is perpetuated in the same way. The existence of the normal and wild-type gene is assumed only on the basis of the mutant genes. The best estimates of gene-numbers have been made in *Drosophila*. Bridge gives 4,000–6,000 based on bands in salivary chromosomes. Gowen gives a minimum of 14,400 based on proportion of lethal to non-lethal genes. An organism inhibits not characters but modes of reaction, which depend on the whole genetic constitution and the external conditions. For example, the sun-red character in maize is only developed in sunlight. Direct gene-interaction was dealt with, both as regards inhibitors and modifiers. The multiple effects of genes were also mentioned, the sun-red gene in maize giving a 2 per cent. higher yield. Genes show different effectiveness for different phenotypic actions; they have a time of action and often a threshold. The position of the gene on the chromosome may have an effect on the phenotype. The gene in different doses may affect the intensity of the effect. Mutations may be either gene-changes or chromosomal changes. In gene-changes only one gene of a pair mutates at a time. Most changes are to the recessive form and are deleterious. The rates are very low.

Changes with slight effects are far more frequent than those with large effects. Lethals are most common of all. Chromosomal changes may involve parts of chromosomes, single chromosomes, or sets of chromosomes known as polyploids. No attempt was made to cover the whole field of genetics, the aim being to give a brief introduction to the subject and to give some indication of the nature of the genes, their effects, interactions, and changes in these.

Abstract of Proceedings, 30th August, 1948.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 30th August, with the President, Professor H. C. Webster, in the chair. About forty-five members and friends were present. The minutes of the previous meeting were read and confirmed. Mr. C. S. Gloe, Mr. A. S. Gehrmann, and Dr. L. P. Sapsford were elected to Ordinary Membership.

Mr. S. R. Mitchell exhibited Geometrics Victorian showing the range of forms and materials used.

Mr. F. S. Colliver exhibited *Phascolonys mitchelli* from Victoria, *Phascolonys ursinus* from King Island, and *Phascolonys pliocenus* from Victoria.

Professor W. H. Bryan gave a lecture on "Submarine Canyons." After discussing the differences between subaerial and submarine topography generally, he pointed out that, largely as a result of the use of echo-sounding apparatus, there had been accumulated a sufficient number of soundings to enable the construction of submarine contour maps for many parts of the world. Such maps show that, while the continental shelves present few irregularities, the neighbouring continental slopes are deeply indented by numerous large submarine valleys similar in shape and extent to the canyons of the land. Attempts have been made to explain these spectacular gorges as due to tectonic disturbances of the sea-floor, as formed by land-streams when the continents were thousands of feet higher than at present, or as resulting from the submarine activities of land-slides, tidal waves, density, currents, and sapping by submarine springs. It was shown that some of the submarine canyons were coaxial and continuous with submerged valleys on the continental shelf which in turn were continuous with present-day rivers, but in many more instances there was no noticeable relationship between the canyons and the coastal streams. After referring to the newly discovered submarine canyons off the mouth of the Murray River and those of the Morobe Coast of New Guinea, Professor Bryan gave us his opinion that no hypothesis yet advanced is capable of explaining all the known facts concerning submarine canyons. Finally, he suggested that a study of the continental shelf off the Queensland coast should be of especial interest, as an understanding of the relationship in time and space of the canyons (if such exist) and Barrier Reefs might well help to explain the origin of each.

Abstract of Proceedings, 27th September, 1948.

A *Special Meeting* of the Society was held in the Geology Department of the University on Monday, 27th September, with the President, Professor H. C. Webster, in the chair.

The President explained that the business of the meeting was to consider the financial position of the Society and to decide the advisability of raising the annual subscription.

The Hon. Treasurer compared the total cost of Vol. 50, published in 1939, and Vol. 58, published in 1947, the cost of the latter being almost 50 per cent. greater though they were practically identical in size and number of plates. She pointed out that printing costs might rise further and that stationery costs had also risen. The costs of the 1946 and 1947 volumes plus running expenses had exceeded the income for those years, and the Society must take action to ensure that it lived within its income and had a reasonable amount in reserve for contingencies. This could be done by keeping the cost of the volume within a fixed limit, in which case the number and length of papers accepted for publication would necessarily be restricted; alternatively, the income might be increased: 1, By increasing the membership; figures were given showing the distribution of members among professions and institutions, and indicating that there was scope for greatly increased membership from these in Brisbane; the increase of 23 new members this year had been offset by the removal for arrears of 20 names from the list; 2, by obtaining an increased subsidy from the Government; 3, by increasing the subscription; a large increase might lose the Society one-third of its members; a small increase should lose very few; an increase to 25s. should bring in approximately £40 more per year, which, if used for printing, on the basis of £ for £ subsidy, would allow another 10 pages in the volume.

The Hon. Treasurer then moved, "That this meeting recommend to the Council that the subscription for Ordinary Members of the Society be increased to 25s. per annum and of Associate Members to 12s. 6d. per annum, and that a Special Meeting be called to consider altering Rule 11 accordingly."

Dr. O. A. Jones then proposed an amendment to the motion that "a Fellowship of the Society be instituted."

Dr. I. M. Mackerras proposed an amendment to the amendment that "the annual subscription for Ordinary Members be £1 11s. 6d., and for Associate Members 12s. 6d., and a Fellowship be not instituted."

Dr. O. A. Jones withdrew his amendment after some discussion.

Dr. I. M. Mackerras also withdrew his amendment.

On the suggestion of Dr. O. A. Jones, the Hon. Treasurer then agreed that her motion be modified as follows:—

"1. A Special Meeting be called to consider a proposal to modify Rule 11 to make the annual subscription for Ordinary Members twenty-five shillings, and for Associates twelve shillings and sixpence.

"2. The cost of printing the Volume be reduced, as far as possible, by printing the list of members and exchanges once every five years only.

"3. The Council then approach the Government for a further subsidy, preferably in the form of a grant.

"4. The extracts be prepared in a more attractive form suitable for country members."

The motion was put to the meeting and carried.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 27th September, with the President, Professor H. C. Webster, in the chair. About thirty-five members and friends were present. The minutes of the previous meeting were read and confirmed. The following papers were presented:—

"The Genus *Embothrium* Forst. (Family Proteaceae) in Australia," by C. T. White, presented by S. T. Blake.

"New Species and New Records of Australian Scolyptidae," by Karl E. Schedl, communicated by A. R. Brimblecombe, with comments on the economics of some species by N. E. H. Caldwell.

"The Rare Gempylid Fish, *Lepicocybium flavo-brunneum*," by I. S. R. Munro, presented by E. J. Reye.

"Notes on Australian Cyperaceae VIII," by S. T. Blake.

"Review of the Genus *Bulbophyllum* (Orchidaceae) in Australia," by T. E. Hunt and H. M. R. Rupp.

"Westringia—An Australian Genus of Labiatae," by Bernard Boivin, communicated by C. T. White, and presented by S. T. Blake.

Abstract of Proceedings, 25th October, 1948.

A Special Meeting of the Society was held in the Geology Department of the University on Monday, 25th October, with the President (Professor H. C. Webster) in the chair. About forty members were present. It was moved by Miss E. N. Marks that—

"Rule 11 be amended to read as follows:—

Each Ordinary Member shall pay an annual subscription of twenty-five shillings, and each Associate shall pay an annual subscription of twelve shillings and sixpence. The year's subscription is due on the 1st of January in each year."

The motion was seconded by Dr. O. A. Jones, and carried.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 25th October, with the President (Professor H. C. Webster) in the chair. About sixty members and friends were present. The minutes of the previous Special and Ordinary Meetings were read and confirmed.

Professor T. G. H. Jones addressed the Society on his impressions of a trip abroad.

Abstract of Proceedings, 29th November, 1948.

The Ordinary Monthly Meeting of the Society was held in the Geology Department of the University on Monday, 29th November, with Mr. E. M. Shepherd (Vice-President) in the chair. About forty-five members and friends were present. The minutes of the previous Special and Ordinary Meetings were read and confirmed.

Mr. C. C. Ball exhibited the following, which are illustrative of concretionary structures in rocks recently collected near Brisbane:—

(1) Cemented half-inch concentric aluminous "iron-shot" from 10 feet depth in loose post-tertiary sands beyond Codwynpin bridge, on the Redlands Bay road.

(2) Aligned one-fiftieth-inch, supposedly bauxite spheres in pseudo-agglomeratic kaolinised tertiary basalt from the Capalaba bluff, above the old Tingalpa bridge, on the Cleveland road.

(3) Structureless quarter-inch indurated clay nodules in stratified Brisbane tuff at the Upper Tingalpa bridge, on the Mount Gravatt road.

(4) Disseminated one-hundredth-inch spherical cavities with concentric linings and fillings in early palaeozoic shales on Mount Taylor, at Kingston. (There is a remote possibility that these may be organic remains.)

Dr. I. M. Mackerras delivered a Memorial Lecture entitled "Alfred Jefferis Turner and Amateur Entomology in Australia."

ANNOUNCEMENT.

Because of the increased cost of printing, it has been decided to omit from this and future volumes of the Proceedings the customary list of Publications Received and the List of Members. New members and losses through resignation or death will, however, be recorded. Any further information concerning either membership or publications may be obtained from the Honorary Secretary.

New Members.

Basire, A. H.	c/- Shell (Q.) Development Pty., Ltd., Shell House, Ann Street, Brisbane.
Beckmann, T. J., B.Sc.	Department of Agriculture and Stock, Brisbane.
Berglin, C. L. W., B.E.	"Yungaba," Main Street, Kangaroo Point.
Clark, R. W. J., B.Sc.	Department of Agriculture and Stock, Brisbane.
Colliver, F. S.	Geology Department, University, Brisbane.
Cribb, A. B., B.Sc.	Biology Department, University, Brisbane.
Evans, I. A., B.Sc.	Mathematics Department, University, Brisbane.
Exley, Miss E., B.Sc.	Biology Department, University, Brisbane.
Gehrmann, A. S., B.E.	c/- Gibbs Bright & Co., 406 Queen Street, Brisbane.
Gloe, G. S., B.Sc., ...	Edith Street, Enoggera.
Grant, G. R. M., B.E.	Engineering Department, University, Brisbane.
Hayson, A. M., B.Sc.	Biology Department, University, Brisbane.
Healy, P.	48 Roy Street, Ashgrove.
Hunt, T. E.	15 Challinor Street, Ipswich.
Jones, W. M.	161 James Street, Toowoomba.
Machin, W. F.	131 Russel Street, Toowoomba.
Morrison, J. F., B.Sc.	Physiology Department, University, Brisbane.
Noyes, Miss M. M., B.Sc.	Biology Department, University, Brisbane.
Pennycuik, Miss P. R., B.Sc.	Biology Department, University, Brisbane.
Phillips, B. J., M.B., B.S.	Mareeba Road, Ashgrove.
Sapsford, L. P., M.B., B.S.	Glen Road, Toowong.
Sinnamon, C. V., M.B., B.S., ...	Ryan Road, St. Lucia.
Tonge, J. I., M.B., B.S.	Health Department, Brisbane.

Resignations.

Richard, E. L.

Whalley, T., B.Sc.

Deaths.

Dixon, G. P., C.B.E., M.B., Ch.M.

Goddard, E. J., B.A., D.Sc.

Hawken, R. W. H., B.A., M.E., M.Inst.C.E.

McDonald, S. F., M.D., M.R.C.P.

Richards, H. C., D.Sc.

Turner, A. Jefferis, M.D., F.R.E.S.

A. H. Tucker, Government Printer, Brisbane.

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