Protective Resemblance in the Insecta.

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By

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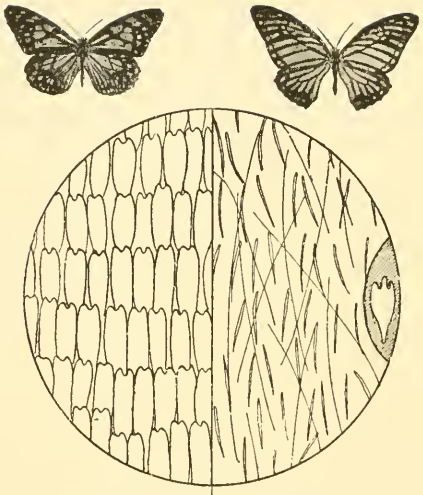

VI 1		VI 5	
Sub fam	Danainae	Sub fam.	Papilioninae
Gen	Lirumala	Gen	Paranticopsis
Sp	Limniaca	Sp	Xenocles

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PROTECTIVE RESEMBLANCE IN THE INSECTA.

I. *The theory of Natural Selection.*

The theory of the origin of species by means of natural selection, first brought before the scientific world by Charles Darwin more than 40 years ago, is now more or less familiar to all biologists. It is based upon a few well known facts; 1st, that the offspring of all animals and plants are more numerous than the parents: 2nd, that there is no proportionate increase in numbers of living things which reach maturity: 3rd, that variations from the parental forms occur in the young.

Briefly stated, the theory is that the increase in the numbers of young, whilst the total number of adults remains practically stationary, shows that a continual contest takes place for existence; that those individuals who vary in a direction which is best adapted to the struggle for life, are the most likely to survive, and that the hereditary transmission of favorable variations, with changing conditions of life, lead to structural modifications and to the evolution of new species.

The young of each generation are always much more numerous than the parents, in all orders, classes and families throughout the animal and vegetable kingdoms. There is consequently a rapid and continuous increase in the numbers brought into existence. Some plants are much more prolific than others, but whatever the proportions

may be the offspring are always the most numerous. Seeds of all kinds are immeasurably greater in numbers than the plants which produce them; in some cases hundreds of thousands being furnished by a single plant. In animals also this prodigality of reproduction obtains in the quantities of ova and of young which are brought into existence.

An instance of this prolific reproductive faculty is found in the common ghost moth (*Hepialus humuli*), which deposits upwards of 800 eggs. If it is assumed that half these ova produce female moths: that these in turn each lay the same number of eggs and that the generations be continued for five years without check or interruption, the fifth generation from a single pair of these insects would number more than eighty millions of millions of millions of moths. It has been shewn that if the average offspring of one oyster could by any possibility breed and accumulate without hindrance for only five generations their numbers would be represented by the figure 6 with 33 noughts behind it, and that the mass of their shells would be equal to eight times that of the earth.

Notwithstanding, however, the rapid increase of all forms of life the total number of living things is practically stationary, and in a case where there may be a temporary or permanent addition to the numbers of an animal or of a plant, the increase is made at the expense, and sometimes at the complete sacrifice, of some other animal or vegetable, or possibly of both, which would be deprived of the share of the room and the food necessary to existence.

There arises, therefore, amongst all living things, a constant struggle, for life first and for supremacy afterwards, and this warfare is continually in progress throughout the biological world. Every plant and every animal appears to be doing its utmost to increase its numbers, the struggle

being the keenest between closely allied, or members of the same species, as they are dependent upon the same conditions for the means of subsistence.

In many cases the difficulties of early life are met, as stated above, by the production of offspring in enormous quantities, with a better chance of some of them finding a suitable position in which to live than if only a small number were produced, although the vast majority cannot possibly arrive at maturity. In others a comparatively small number only are brought into existence, but where this is the case the young have generally advanced further in their development towards maturity, or are furnished with a generous supply of food, or are stronger, or otherwise better fitted for the battle of life; and, in the case of animals, receive protection through the guarding care and instruction of their parents until they are themselves fitted for an independent existence. But in any case the struggle must take place, the battle for life has to be fought; for whatever the number may be of those which enter into the competition comparatively few only survive it.

Generally speaking, no two animals or plants are absolutely alike. Variations are the rule in both the animal and vegetable kingdoms, and differences of a greater or lesser degree are found in every species, and even in the offspring of the same parents.

The causes of variation are not always quite clear. The fact of the parents being dissimilar will induce variations in their young, some inheriting features or peculiarities of either or of both in modified degrees, varying in intensity and in form. Ancestral characters, dormant in either parent, may appear and produce marked differences in the progeny. Through numerous causes new and peculiar variations may and do arise. "We seem" says Mr. Francis

Galton "to inherit, bit by bit, this feature from one "progenitor, that from another . . . . while the "several bits are themselves liable to some little change "during the process of transmission." The conditions of environment, heat or cold, an absence or excess of moisture, change of food supply, or any circumstance which affects the conditions of life of the parent, influence and lead to variations in the offspring, and these variations may be transmitted through successive generations.

As animals are generated and produced under mutable conditions the variations which arise may take almost any direction. There are limits of course to their extent, as whatever the differences may be which occur they are governed and restricted in the individual by the laws of heredity. But by the same laws, a variation arising in an individual will probably be transmitted to its offspring in a modified or intensified degree, the variation itself varying in the next generation. It may in many cases disappear altogether, or be so modified as to produce no appreciable effect either detrimental or advantageous to its possessor, and may persist in its modified form, or even be emphasized to a certain extent and still remain what may be termed a passive variation.

But should a modification or deviation take, and persist in, a form which is in any way, however little, prejudicial to the animal or plant in which it arises, it will lead sooner or later, but inevitably, to its destruction.

On the other hand variations in any direction, whether of colour, size or form ; keenness of sight, scent or hearing ; swiftness of foot, of flight, or of swimming ; or which, in any way, gives the individuals a distinct advantage over their fellows in the struggle for life, will tend to preserve them from a fate which the others may prematurely meet. And these favoured individuals transmitting the advantageous

variations to their young, some of the latter may possess the favourable difference in a more marked and pronounced form than the parents, and these again transmit the increased favourable variation to their offspring.

There thus arises from these premises, *i.e*, the facts of the struggle for existence and that variations occur and are transmitted from parent to offspring, the inevitable consequence that those which possess any advantageous variation in the most marked degree will most surely arrive at maturity and be able to perpetuate their kind. They, in fact, will survive because they are the most fitted to do so. Being better protected against cold or heat, drought or flood ; provided with better sight or hearing, or keener scent, or greater powers of locomotion to enable them to procure food or escape from their enemies ; with modifications of colour or of form which enable them to escape detection by their foes, or to lie concealed whilst waiting for their prey ; it is they who are the best adapted for the battle of life, for its changing conditions, its competitions, struggles and difficulties.

And as the conditions of life alter, as environments change or as migrations to new surroundings and localities take place, so will the variations which are best adapted to circumstances be preserved, perpetuated and accumulate until in the course of time new species, new genera and new families are evolved, which may eventually be so unlike their remote ancestors that the recognition of phylogenetic connection between them may be not only extremely difficult but even impossible.

The fact that small differences which arise in animals and plants can be transmitted from parent to offspring, and that by selection of peculiar features through a succession of generations they will be intensified to an extreme extent and new specific characters produced, has been taken

advantage of by man. Artificial selection of varieties has long been resorted to for breeding purposes. The judicious selection and transmission through successive generations of small individual differences has resulted in the production of many of the varieties of domestic animals and plants with which all are familiar.

Nature, with precisely the same effect, has preserved the favoured varieties in the fact that those animals and plants which have not been adapted to changing conditions, or have not been prepared to successfully meet the never ceasing contest for existence, or which have varied in a direction unfavorable for the strife, have succumbed ; whilst their better favoured rivals have survived and been preserved. In every geological formation which contains organic remains and in all parts of the world, the unimpeachable testimony of the rocks supports and confirms this great truth.

But it must be remembered that although new species may be the result of natural selection it does not follow that natural selection shall of necessity always produce new species. This is evidenced by the persistence of some forms of both animal and vegetable life through long periods of geological time, during which little or no structural modifications have taken place, as is especially the case amongst some of the lower forms of both kingdoms.

The fact that variations occur and persist which do not give the varying forms any special advantage has been raised as an objection to the theory of natural selection. There does not however seem to be any real difficulty in the matter, variations do and must take place which are merely passive or negative, neither advantageous nor detrimental and which yet persist. The remarkable modifications which occur in the colour bands and markings on the shells of the mollusca are indicative of this. In the

Helices for example the variations amongst some species are so diverse, the banding and colouring so variegated and manifold, that occurring in many groups of animals such wide superficial differences would be classed as separate species, and even as distinct genera.

So long however as variations in an animal do not produce any disadvantage, so long, in fact, as they are merely passive, they may persist and continue to an almost indefinite extent.

But even when a species has varied in such a manner and to such an extent that it seems to have acquired, so far as is possible, complete protection from its enemies and to be exactly adapted to its surroundings and mode of living, variations do not cease to take place.

That this is the case is shewn in one of the most remarkable of known instances of protective resemblance to natural surroundings; that of the "leaf butterflies." In the *Kallimæ*, and many other genera of the *Lepidoptera* the resemblance of the wings to leaves when the insects are at rest is so great as to deceive the most practised and critical eye. (Fig. 4.) But although the simulation is so close and the likeness so near, and although all have the appearance, marking and colours of decaying and dead leaves the divergence in the individual is very considerable. "The colour" says Mr. A. R. Wallace writing of the *Kallimæ* "is very remarkable for its extreme amount of variability: from deep reddish green to olive and pale yellow, hardly two specimens being exactly alike but all coming within the range of leaves in various stages of decay."

This divergence in the *Lepidoptera* is not confined to the *Kallimæ*. In the *Doleschallieæ*, *Anæinæ*, and in other cases where protection is secured through resemblance to environment, and the animal is hidden from its enemies

Fig. 4. Leaf Butterflies. *Kallima paralekta*, shewing upper surface, in centre, surrounded by several species of *Kallimæ* and *Doleschalliæ* with the wings folded and shewing leaf like markings of under surfaces.

by being lost amongst its surroundings when at rest, the deviations in markings and colours are often considerable, and the variations in a single species are sometimes as great as between members of different species.*

*Variations are also found in numerous species of the inedible *Danainæ*, *Heliconinæ*, &c., and are repeatedly referred to by writers. Bates for instance says that *Mechanitis polymnia* "varies not only in general colour and pattern, but also very considerably in "the shape of the wings," and again of *Heliconius numata* "the species is so variable "that it is difficult to find two examples exactly alike, it varies in structure as well as in "colours." Wallace also describes *Ceratinia ninonia* (illustrated in fig. 8, No. viii.) as "another of those very mutable species, exhibiting many local varieties," and Shelford says "the females of *Eurypus halithurses* are extremely variable, in fact no two "specimens of the five series of this species in 'the Sarawak (Borneo) museum collection' "are exactly alike and almost every specimen deserves a varietal name of its own." "Ten distinct varieties are described" writes Bates of *Heliconius melpomene* "all more "or less connected by intermediate forms."

II. *The Colours of Insects.*

The most striking feature of the *Insecta* is the extreme brightness and diversity of colour which they display, in all the orders into which they are divided. In no other class in the animal kingdom are such remarkable brilliancy and variety to be found. Even the birds, the most beautiful and charming of the vertebrates, cannot rival them in this respect.

All the orders of insects share in this pre-eminence of beauty, but it is the *Lepidoptera*, the great order which includes the butterflies and moths, that can claim to be the most wondrous animals in the world for brilliance of colouring and diversity of marking, and that far outshine all the other animals in their display of elegant adornment. No colour or pattern seems to be impossible, no contrast of hue unsuitable or discrepant, and no harmonious or fantastic marking unattainable, amongst these frail and delicate creatures. Brilliant metallic blues and greens, luminous crimson and gaudy red, bright orange and yellow and lustrous shining white or deep black, resplendent silver and refulgent copper, all possible combinations of colour, gay and luxurious, of every hue and tint and shade are found in a thousand combinations in the butterflies and moths.

Not in colour only are these insects remarkable ; their patterns and figures are as varied and beautiful as the colours which they exhibit. Perfect symmetry is almost universal amongst them, although the markings may be very elaborate ; the finest lines and curves and tracery of ornament being displayed with almost geometrical accuracy and the more minutely the details are examined the more perfect they appear to be.

In many cases, as in the *Heliconinæ*, the bright colours

appear on both upper and under surfaces of the wings and the markings are nearly the same on both sides. In others, as in the *Callicorinæ*, *Catagramminæ*, &c., although the insects are extremely brilliant and richly coloured on both the upper and under sides, they are quite different in both design and colouring on the two surfaces of the wings. Sometimes the display of colour appears only on the upper surfaces, as in the gorgeous *Morphinæ*, *Ornithopteræ*, *Papilioninæ*, &c., which are luxuriously adorned in iridescent blues and greens, crimson and orange, with combinations of other colours equally attractive to the eye, whilst the under surfaces are comparatively dull and inconspicuous.

In others of the *Lepidoptera* the upper surfaces of the fore wings are much less highly coloured than those of the hind wings, for instance in the *Catocalæ* and many other of the diurnal moths; which rest with the upper surfaces of the wings exposed, the grey fore wings folded over and concealing the brightly coloured hind wings.

On the other hand there are thousands of species of butterflies and moths the appearances of which are quite the opposite of those considered above. In place of the gay and showy colours they are clothed in subdued grey and drab, dun and umbre and dull brown, nearly uniform over the whole surfaces of the wings, almost without pattern, or marked with few and generally inconspicuous and often obscure spots and bands. Many again are of a greenish hue, or mottled in green and grey and are seen indistinctly, or perhaps not at all, in the obscurity of their natural surroundings.

III. *Insects as Food for other Animals.*

The increasing ratio of successive generations of insects is so great that were it unchecked and all the young

animals allowed to arrive at maturity, their numbers would quickly be such as to make the earth uninhabitable; as there would soon be neither food nor room for themselves, much less for other animals. The increase is checked however in many ways. Extremes of temperature and climate, dearth of food, disease, fungi, and bacteria destroy countless numbers of them every season. They serve largely as food for other animals which could not themselves live if deprived of the abundant supply furnished by the surplus progeny of the insecta.

Many insects feed upon others, the larvæ of one living in and upon another, as in the case of the *Ichneumonidæ;* the perfect forms consume the larvæ and pupæ of other species and often feed upon the imagines of other kinds.*

Birds subsist largely upon insects in all stages of their metamorphosis, many living almost entirely upon them and destroying incredible numbers. Frogs, toads and lizards, feed upon them, as do also the monkeys and many other tropical vertebrates. The soft and juicy larvæ are particularly attractive morsels to the *Insectivora*, the fat grub and unctuous caterpillar being eagerly sought for in every crack and crevice in field, hedge and wood.

That insects constitute a staple part of the food of other animals is very well known to every naturalist. Many experiments have been made with the object of testing the selective faculty and appetency of animals in this respect; especially by Professors E. B. Poulton, Lloyd-

*The word 'imago' as representing the final stage in insect metamorphosis is objectionable and its plural 'imagines' is particularly so. It was used by Linnæus, as he says, "because, having laid aside its mask and cast off its swaddling bands, (the insect) "being no longer disguised or confined, or in any respect imperfect, is now become a true "representative or image of its species and is qualified to fulfil the laws of nature in "propagating its kind"—Mr. J. T. Lingard suggests instead 'matura' (*maturo* = to ripen) "as it would indicate at once the state reached, whilst its termination, both singular "and plural, would accord with both larva and pupa." I quite agree with this happy suggestion and shall be glad to see it adopted to represent the perfect insect. M.L.S.

Morgan, Romanes, and later by Mr. Guy A. K. Marshall: and the works of Belt, Bates, Müller, Wallace, Swinhoe, Trimen, Butler, Beddoe and many other well known naturalists bear indisputable testimony to the fact.

So many and so persistent are the enemies to insect life that even with the prolific reproductive capabilities which insects possess it is almost a matter of surprise that so many survive. The liability to attack and destruction appears to be greatest in the case of those which are highly coloured and conspicuously marked, and more especially in the showy and brightly adorned *Lepidoptera*, which appear to be so entirely defenceless against the attacks of their numerous enemies.

It is known, however, that many of these highly attractive and brilliant butterflies and moths possess some peculiar repellent feature. Many of them are highly scented, others are tough, dry and hard, some exude nauseous and evil-smelling secretions, and bitter or acidulous fluids, whilst others are clothed in part with irritating hairs and loose fluffy scales, which render them disagreeable and offensive to the insect-eating animals.

Amongst the attractively embellished and gaily adorned butterflies are the *Heliconinæ*, *Danainæ*, *Aeræinæ*, and *Euplœinæ*, all of which are beautifully coloured and conspicuously marked. Their wings are often nearly alike on both the upper and under surfaces. They seem to have no sense of fear or avoidance of danger, fly without regard to concealment, and rest in any exposed and open situation. But it is known that they all possess in one or other form that repellent feature which renders them distasteful and obnoxious to the *Insectivora*. "They all "have juices which exhale a powerful scent" said the late A. Milnes Marshall. "This odour is not very offensive to "man, but it has been shewn by experiment to be so to "birds and other insect-eating animals."

It is here where the value of the adornment is shewn Being brightly coloured and easily recognized they cannot be mistaken ; and the shining blues and crimsons, and gay reds and yellows serve as danger signals, warning colours ; notifying by an easily recognized sign that the wearers are inedible, thus affording them immunity from attack and safeguarding them from destruction

All observations shew that young animals have no instinctive knowledge as to what is good for food and what should be rejected, but that it is a matter which must be learned either by instruction or by experience. There is no intuitive acquaintance in the selection of edible material.

Professor Lloyd-Morgan in his work "Habit and Instinct" records the results of a large number of experiments which he made with the object of satisfying himself upon this question by personal observation. He says his experiments were conducted with the sole object of ascertaining if there was any instinctive avoidance of distasteful, or selection of edible, material, and of this he "never found a single instance." "There can be no "question" he says "that experience plays its part "and practice makes perfect." "That which is outside "experience can afford no data for the conscious guidance "of future behaviour." Mr. Guy Marshall's recent experiments with monkeys, birds and other animals in South Africa all point to the same conclusion, as do those of Professor Poulton and other observers.

Nor is the lesson long in being learned. A nauseous black and yellow banded larva, or a bitter, crimson winged moth, a beetle which on being disturbed exudes a nasty fluid, a yellow hornet or a stinging bee, are very quickly recognized by a young bird which has once had experience of its objectionable characteristic, and it is amusing to watch the emotions of a young animal which is placed in

the situation of repeating a recently learned disagreeable experience of this nature.

Bright and conspicuous colours in insects are then a source of safety rather than of danger, and the more highly a distasteful caterpillar or butterfly or beetle is adorned, the more easily and quickly it is recognised when once its inedibility has been tested, and the greater will be its chances of escaping destruction.

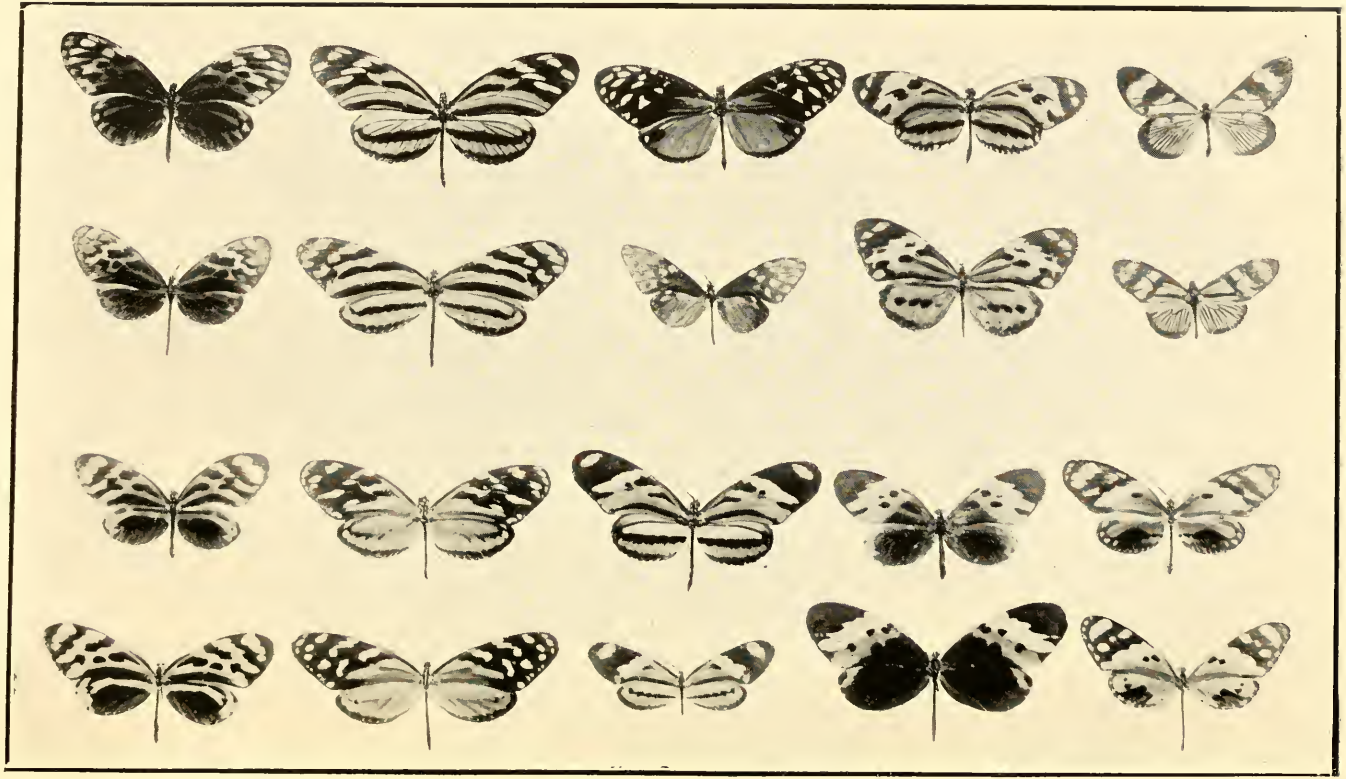
IV. *Mutual Protection: Müller's theory.*

There are in many parts of the world a number of highly coloured and inedible butterflies of entirely different sub-families and genera, which are so similar in outward appearance, markings, colours, shape of wings and peculiarity of flight that they may be very easily mistaken one for another.

A considerable number of cases are known in which two entirely different butterflies, or a butterfly and a moth, exactly alike in appearance, are found flying in concert, or in the same locality. This similarity is often seen between three or four different kinds, and occasionally within a limited area there are found six or seven or even a larger number of different species of butterflies, of two or more different sub-families, in which the likeness of each to the others is remarkably close ; and the probability of mistaking them is especially great when the insects are on the wing.

It was for some time a problem to students of this branch of biology why this superficial resemblance amongst the inedible *Lepidoptera* should exist, and the explanation which is now accepted is due to the observations of Fritz Müller.

As the young insect-eating animals have to learn by experience what food to select and what to avoid, there must be a certain number of the inedible insects attacked



Mark L. Sykes, nat. MUTUAL PROTECTIVE RESEMBLANCE OF INEDIBLE BUTTERFLIES. *Plate III.*

DESCRIPTION OF PLATE III.

Fig.	1	2	3	4	5
Sub-Fam.	*Heliconinæ.*	*Heliconinæ.*	*Heliconinæ.*	*Heliconinæ.*	*Acræinæ.*
Gen.	*Heliconius.*	*Heliconius.*	*Heliconius.*	*Heliconius.*	*Acræa.*
Sp.	*Pardalinus.*	*Telchinia.*	*Zuleika.*	*Numata.*	*Thalia.*
Habitat	S. America.	Cent. America.	Cent. America.	S. America.	S. America.
Locality	Upper Amazons.	Honduras.	Honduras.	Para.	Brazil.
Sex	Female.	Female.	Female.	Female.	Female.

Fig.	6	7	8	9	10
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Heliconinæ.*
Gen.	*Melinæa.*	*Melinæa.*	*Callithomia.*	*Tithorea.*	*Eueides.*
Sp.	*Pardalis.*	*Imitata.*	*Hezia.*	*Harmonia.*	*Povana.*
Habitat	S. America.	Cent. America.	Cent. America.	S. America.	S. America.
Locality	Upper Amazons.	Honduras.	Honduras.	Para.	Brazil.
Sex	Male.	Male.	Male.	Female.	Female.

Fig.	11	12	13	14	15
Sub-Fam.	*Heliconinæ.*	*Heliconinæ.*	*Heliconinæ.*	*Heliconinæ.*	*Heliconinæ.*
Gen.	*Heliconius.*	*Heliconius.*	*Heliconius.*	*Heliconius.*	*Heliconius.*
Sp.	*Aurora.*	*Ismenius.*	*Eucrate.*	*Messene.*	*Sylvana.*
Habitat	S. America.	S. & Cent. America.	Cent. America.	S. America.	S. America.
Locality	Upper Amazons.	Colombia.	Rio Janeiro.	Colombia.	Lower Amazons.
Sex	Female.	Female.	Female.	Female.	Female.

Fig.	16	17	18	19	20
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Melinæa.*	*Melinæa.*	*Mechanitis.*	*Melinæa.*	*Melinæa.*
Sp.	*Lucifer.*	*Messatis.*	*Lysimnia.*	*Messenina.*	*Egina.*
Habitat	S. America.	S. America.	S. America.	S. America.	S. America.
Locality	Upper Amazons.	Colombia.	Brazil.	Colombia.	Lower Amazons.
Sex	Male.	Male.	Male.	Male.	Male.

and destroyed before the lesson is acquired. The closer this resemblance between two or more species, the more probably will one be mistaken for another; the number of each kind sacrificed to inexperience will be reduced, and the amount of protection afforded to the different species will be greater as the total destruction will be divided amongst them; for a young bird, for instance, having experienced the nauseousness of one of these attractive and easily recognized insects, will avoid attacking another of similar appearance, although it may not be of the same species or even of the same genus.

Many of the *Heliconinæ*, for example, of different species, are very similar in shape, marking and colours; and there are often found in the localities which they frequent several different species of the *Danainæ* which very closely simulate them in every way. A few of these are illustrated in Plate III. There are shewn ten pairs of butterflies, each pair (one insect above and the other beneath it) very closely alike but of different sub-families, having no relationship whatever to each other. All the insects shewn in this plate are highly coloured and strongly marked in black, orange, yellow, brown and white, and are large and strikingly handsome insects; all are known to be distasteful to, and avoided by, the *Insectivora* and they afford an interesting series of examples of the mutual protection due to simulation and superficial resemblance in inedible insects.

Tropical South America, where Müller made his observations, is rich in producing, from numerous regions, instances of this kind of protection in butterflies. In Honduras there are found several species of *Heliconinæ* and *Danainæ* each of which resembles the others. The fore wings are coloured a deep sepia, almost black, with white or pale yellow spots, the hind wings being light chocolate with lines, spots and borders of sepia (Fig. 5). In the

Fig. 5. Heliconinæ and Danainæ. (Honduras.)
1. *Heliconius zuleika.* 2. *Thyridia melantho.*
3. *Eueides thyana.* 4. *Tithorea irene.*
5. *Callithomia hesia.*

same region of South America there is another group of butterflies of the same sub-families but quite different in appearance from those named above. In all these the ground colour of both fore and hind wings is a bright

Fig. 6. Heliconinæ and Danainæ. (Honduras.)
1. *Heliconius telchinia.* 2. *Lycorea atergatis.*
3. *Melinæa imitata.* 4. *Eueides dynastes.*
5. *Mechanitis doryssus.*

brown with strong sepia bands and margins, and the fore-wings are in all cases marked with spots and bands of clear pale yellow (Fig. 6). In Bolivia and the upper Amazons there is another series entirely unlike either of those already described. The prevailing colour is black with clear lemon-yellow spots on the forewings, the hind wings being strongly marked with bright crimson radiating lines; the group being a handsome and conspicuous one. Four of these butterflies belong to the *Heliconinæ* and the last to the *Nymphalinæ* (Fig. 7). An even more remarkable group

Fig. 7. Four HELICONINÆ and One (No. 5) NYMPHALID, from Bolivia.
1. *Heliconius venestus.* 2. *Heliconius vesta.*
3. *Eueides thales.* 4. *Eueides heliconides.*
5. *Eresia cornelia.*

is seen in Fig. 8 which illustrates eight simulating butterflies from Brazil, each of which might very easily be mistaken for any of the others if seen alone; yet all are of different species and belong to three sub-families, including the *Heliconinæ, Danainæ* and *Pierinæ.*

Instances of multiple protection, due to resemblances between inedible butterflies of different species and genera, although so abundant in the neo-tropical regions are by no means confined to that part of the world. In the eastern hemisphere they are both numerous and diverse in character.

In Africa several species of the *Danainæ* and *Acræinæ*, two entirely different sub-families, with very marked superficial likeness, are found flying in company or

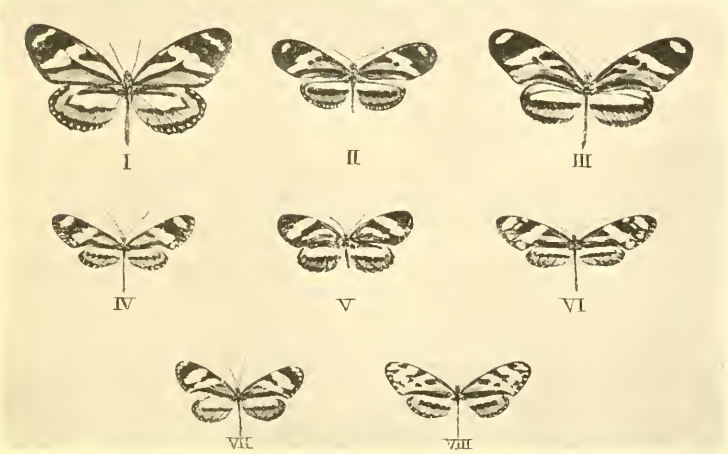


Fig. 8. Heliconinæ and Danainæ from Brazil.
I. *Lycorea halia*, II. *Eueides dyanasa*, III. *Heliconius eucrate*, IV. *Mechanitis lysimnia*, V. *Eresia sp.*, VI. *Mechanitis nesea*, VII. *Ceratinia metphis*, VIII. *C. ninonia*.

in the same localities, the ground colours of the wings together with the chocolate or black and white spots making them very much alike ; and in some of the *Danainæ* and *Lycænidæ* and also between certain *Acræinæ* and *Nymphalinæ* a similar portraiture is found.

Many of the different genera and species of the *Acræinæ* exhibit these mutually protective features to a large extent. This sub-family is widely distributed over the continent of Africa and possesses the repellent features of the *Danainæ;* the resistent vitality of its members is very high and they are strongly marked and easily recognized insects. Most of them are of a fulvous colour, prominently marked with lines and bands of dark brown and chocolate, sometimes dashed with white, and many are dotted with conspicuous dark coloured and black spots

and lines and patches; their wings are rather long and narrow and they bear an easily recognized and common likeness. Fig. 9 illustrates a pair, ♂ and ♀, of *Acræa acara* from East Africa, together with two, ♂ and ♀ of *A. Natalica*

Fig. 9. ACRÆINÆ, (Africa.)
Acræa acara ♂ *Acræa acara* ♀
A. Natalica ♂ *A. Natalica* ♀

from the same locality; the prevailing colours, markings, spots, shape, and general appearance being remarkably alike and beautiful.

V. *Mimicry or Simulism: Bates's theory.*

It is to the late H. W. Bates that we owe the term 'mimicry' in relation to insects. The word is rather unhappily chosen as it implies conscious and even voluntary imitation, which certainly do not exist in the insect world. It has however, been in use so long that its intended significance is generally recognized amongst entomologists

and other biologists, although it is misleading to those who are less intimately acquainted with the subject.*

Edible insects are found in all orders and families, and their best means of protection lies in concealment or in some method of deceiving their numerous enemies.

There are amongst the butterflies and moths many edible species which are quite brightly and gaily coloured, with markings on the wings almost as emphatic and distinct as those of the *Danainæ* and *Heliconinæ* already considered. In all regions where the inedible *Lepidoptera* are found, there are also found certain edible butterflies and moths which bear a strong superficial likeness to them. The distasteful *Heliconinæ* and *Danainæ* of South America, the *Danainæ* and *Acræinæ* of Africa, and the *Danainæ* of Asia, are copied and simulated in many cases by edible *Lepidoptera*, which are so like them in every way that even collectors sometimes fail to distinguish between them.

The edible mimics or simulators are found in all families of butterflies from the *Papilioninæ* downwards through the *Nymphalinæ*, *Pierinæ*, and so on, to and including some of the diurnal moths; the resemblance extending to colour, size, shape, peculiarity of flight and habits of life. The similarity is often so close that the insects themselves are sometimes deceived. Fritz Müller says "I have repeatedly seen the male (mimicker) pursuing "the female of the mimicked species till after closely "approaching and becoming aware of his error he suddenly "returned."

The simulation is not however confined to butterflies and moths; for not only do some of the *Lepidoptera*

*The word 'mimicry' has always appeared to me to be an unfortunate one for the reasons stated above. I would suggest in preference the word 'simulism' as being much more suitable for expressing the superficial resemblance of some insects to others or to their environment and as avoiding the implication of conscious imitation. 'Simulism,' 'Simulation,' 'Simulating,' &c., seem to me to be at once expressive, explanatory and euphonious, and to be free from the inference of designed and cognitive resemblance. I have adopted this nomenclature in this paper. M. L. S.

resemble wasps, bees, beetles, and other insects, and even some of the small tropical birds, but some beetles are like insects in other orders, flies have the appearance of stinging *Hymenopteræ*, and indeed this copying or simulation is found to occur in all orders of insects.

Amongst the most remarkable of the simulating *Lepidoptera* is the African *Papilio merope* and its varieties of females. *P. merope* is found nearly all over the African continent, and it is singular that not only are all the various females entirely unlike the males, but that the sexes are possessed of quite different means of protection.

Fig. 10. *Papilio merope*, ♂, at rest on leaf of an African grass.

The wings of the male *merope* are of a creamy white on the upper surfaces, with black markings which are of somewhat different patterns in the several varieties of the butterfly, and all possess the characteristic "tailed" extension of the hind wing found in the *Papilioninæ*. The undersides of the wings are also of a creamy white colour with various brown markings and lines of different shades. When the insect is at rest the wings are folded over the back, the under sides only are exposed, the darker shaded hind wing being only seen, and the insect presents a very close appearance to a broad leaved grass, to the faded ends of which the butterfly habitually hangs suspended with the wings hanging downwards. (Fig. 10)

The numerous female varieties of *P. merope* (Fig. 11) are very diverse in different localities, and have deviated not only from the shape, size and colours of the males to which they bear no resemblance whatever, but from each other; and have acquired in the respective regions in which they are found the appearances of various species of the inedible *Danainæ*. (Fig. 12.)

In the Cape the female of *P. merope* is similar to the type form of the Danaid, *Amauris echeria*, with black wings, all of which are spotted with yellow and marked with a large yellow patch on the centre of each hind wing. In Natal the female *merope* var *cenea* is like a local form of *A. echeria* var. *albimaculata*, which differs from the Cape type, the spots on the fore wings being white instead of yellow. In East Africa the female *merope* again varies in *tipulus* and assumes the type form of *Amauris niavius*, which is a black butterfly marked with large pearly patches on both fore and hind wings. There is also found in Natal another variety, *hippocoon*, which simulates the southern form of *A. niavius*, viz., *dominicanus*, on the wings of which the pearly patches are much larger than on those of *niavius*. In the Cape again there is still another even

more remarkable but rare form of *merope* var. *trophonius*, which is closely similar to the brown and chocolate with

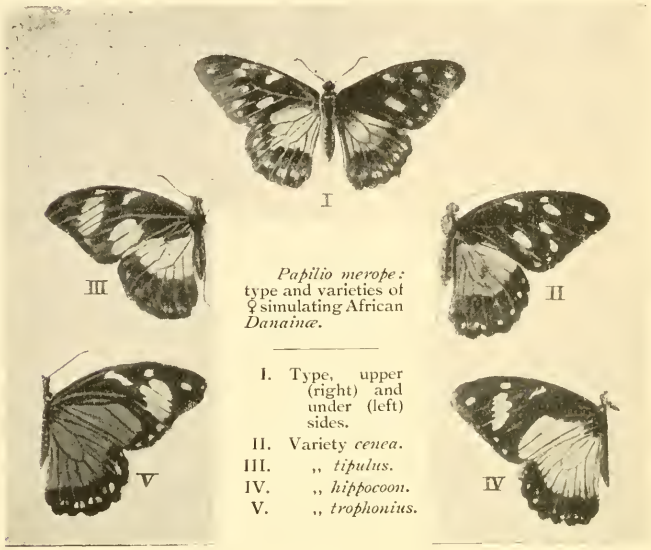


Fig. 11.

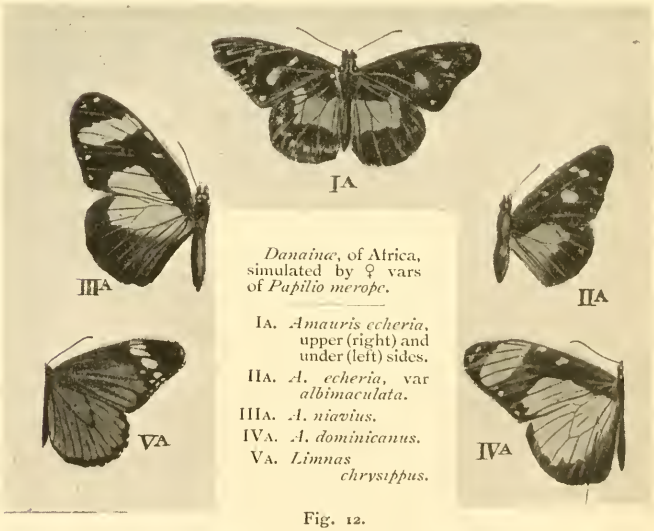


Fig. 12.

black and white markings and spots of the well known Danaid *Limnas chrysippus*. All these species and varieties are illustrated in Figures 11 and 12.

Another instance of the tendency of unprotected butterflies to follow varieties which may arise in a protected species, occurs in the several female forms of *Hypolimnas misippus*, belonging to the sub-family *Nymphalinæ*.

The Danaid, *Limnas chrysippus*, already referred to, has a very wide geographical range, extending over the whole of the African continent, Southern Asia and into the Malay Peninsula and islands. The colouring of the type is a yellowish brown deepening into chocolate on the fore wings; the bodies are black with small white spots, and the apices of the fore wings are black with large white spots across. In East Africa there is found a variety of the female, (var. *dorippus*), in which the chocolate, black and white of the fore wings do not appear, all the wings being of a light ochreous brown with very dark brown, almost black, margins. In West Africa, in another female variety of this butterfly (var. *alcippus*), the fore wings are the same as in the type, but the hind wings are suffused with white. At Aden the type of *chrysippus* and its two female varieties are all found.

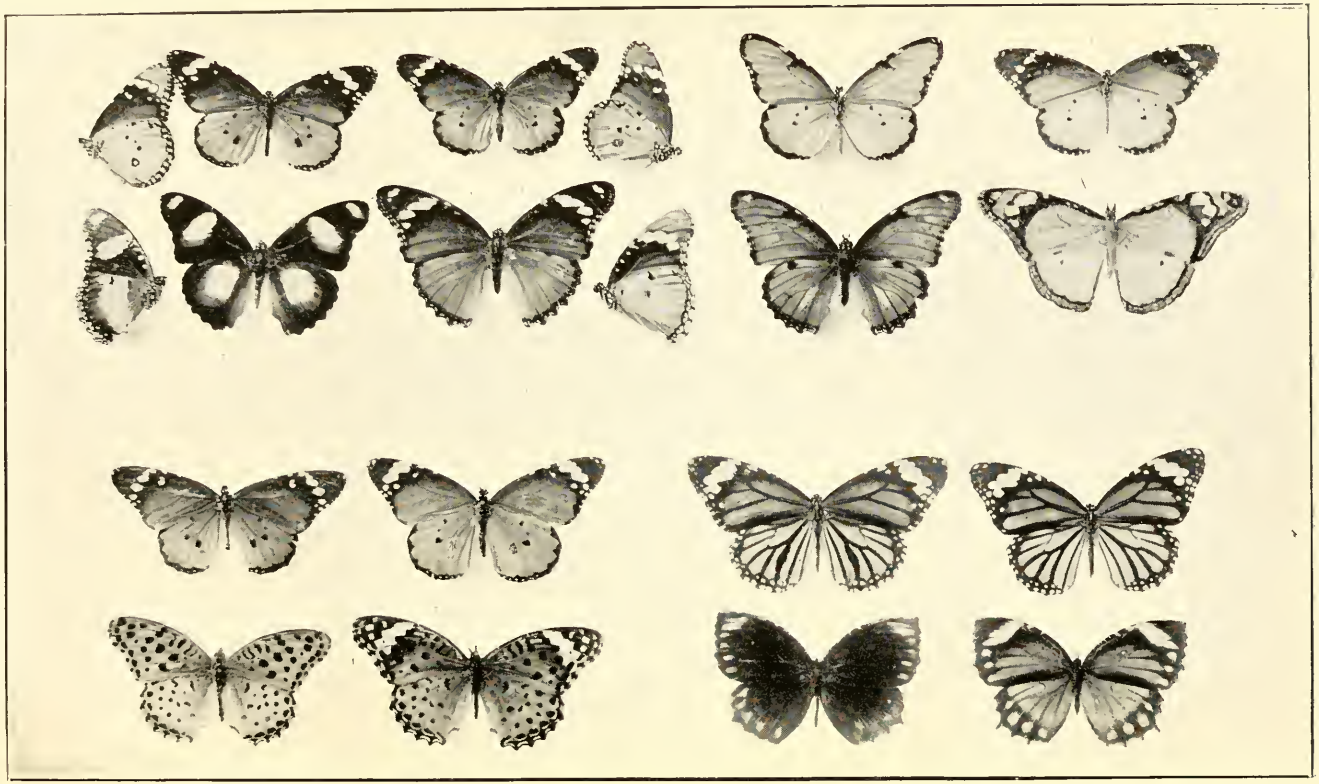
All these varieties of *chrysippus* are simulated in the above regions by females of the Nymphalid, *Hypolimnas misippus*. The male of this butterfly is black, with a large white patch in about the centre of each wing, the patches being bordered with deep shot blue. The females are however quite dissimilar. In nearly the whole of the great area over which the type female of *Limnas chrysippus* ranges, it is simulated by the female of *H. misippus*, the brown and chocolate with white and black markings and margins being closely copied. But in some localities where the *dorippus* variety of *chrysippus* occurs, the female *misippus* varies also and resembles it, and in var. *inaria* the

chocolate white and black are absent and the comparatively uniform colouring of *dorippus* is assumed. In other areas where the female *chrysippus* takes the form of *alcippus*, the female of *H. missipus* also varies in the same direction taking the form *alcippoides*, the hind wings being nearly all white, whilst the black and white of the fore wings are retained. The types and varieties of these butterflies are illustrated in Plate IV.

H. misippus is not, however, confined to the regions where *L. chrysippus* is found. The type form of *misippus* is established, for instance, in some parts of tropical South America and in the West Indies, where *chrysippus* does not occur. It may perhaps be assumed from this fact that the protection which these two species derive from mutual resemblance is due, where it occurs, rather to the Müllerian than to the Batesian form of simulation.

Of *L. chrysippus* there are simulating butterflies in many of the localities where it and its varieties are found. One of these, *Argynnis niphe*, from Burma, is illustrated on Plate IV. The upper surfaces of the wings of both male and female are a rich golden bronze colour with deep black spots distributed over their whole area. In the female, however, the apices of the fore wings are black with white patches and spots, and the insect bears a strong resemblance to the female *chrysippus*, for which it might easily be mistaken.

Salatura genutia is another of the brownish yellow *Danainæ* which has a wide range in the East. This butterfly is marked with broad black lines which follow the neuration of the wings, the tips of the fore wings being, like *chrysippus*, black, with white patches and spots. In the same regions, India, Burma, &c., is found another butterfly, *Elymnias undularis*, the female of which is very similar to *genutia* in colours and markings, although the latter are not so close as in the two cases last referred to. (See Plate IV.) It appears to be an instance of a transitional



Mark L. Sykes, nat. SIMULATION OF INEDIBLE BY EDIBLE BUTTERFLIES. *Plate IV.*

DESCRIPTION OF PLATE IV.

Fig.	1	2	3	4
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Limnas.*	*Limnas.*	*Limnas.*	*Limnas.*
Sp.	*Chrysippus* (Linn.)	*Chrysippus* (Linn.)	*Chrysippus.*	*Chrysippus.*
Var.			*Dorippus* (Klug.)	*Alcippus* (Cram.)
Habitat	Africa, India, Burma, &c.	Africa, Burma, Japan, &c.	E. Africa, Arabia.	W. Africa.
Locality	Barrakpoor, Calcutta.	Sierra Leone.	Aden.	Sierra Leone.
Sex	Male. (Upper and under sides shewn.)	Female. (Upper and under sides shewn.)	Female.	Female.

Fig.	5	6	7	8
Sub-Fam.	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*
Gen.	*Hypolimnas.*	*Hypolimnas.*	*Hypolimnas.*	*Hypolimnas.*
Sp.	*Misippus* (Linn.)	*Misippus* (Linn.)	*Misippus.*	*Misippus.*
Var.			*Inaria* (Cram.)	*Alcippoides.*
Habitat	W. Africa, India, Japan, &c.	W. Africa, India, Japan, &c.	E. Africa.	W. Africa.
Locality	Sierra Leone.	Sierra Leone.	Aden.	Sierra Leone.
Sex	Male. (Upper and under sides shewn.)	Female. (Upper and under sides shewn.)	Female.	Female.

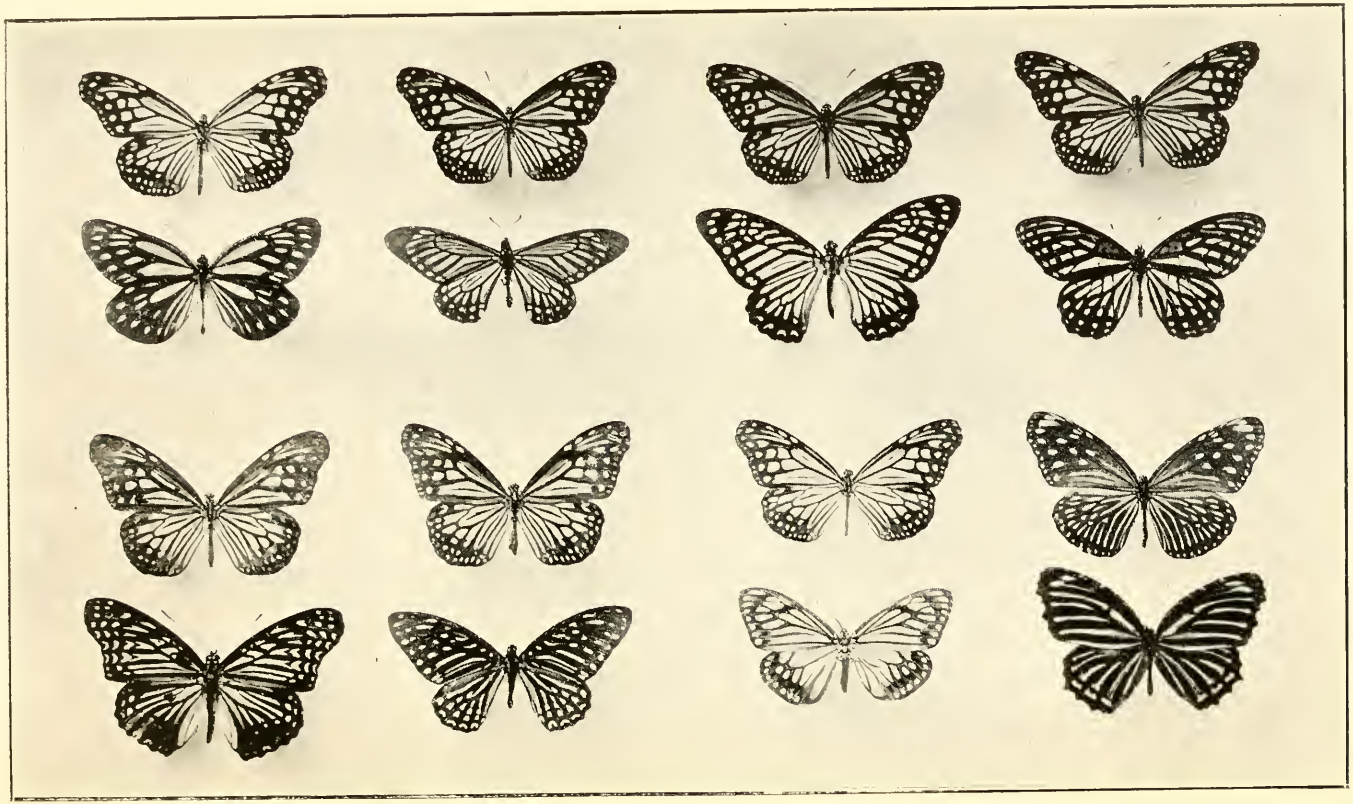
Fig.	9	10	11	12
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Limnas.*	*Limnas.*	*Salatura.*	*Salatura.*
Sp.	*Chrysippus* (Linn.)	*Chrysippus* (Linn.)	*Genutia* (Cram.)	*Genutia* (Cram.)
Habitat	Africa, India, Japan, &c.	Africa, India, Japan, &c.	India, Burma, Ceylon, &c.	India, Burma, Ceylon, &c.
Locality	Burma.	Calcutta.	Assam.	Poona.
Sex	Male.	Male.	Male.	Female.

Fig.	13	14	15	16
Sub-Fam.	*Nymphalinæ.*	*Nymphalinæ.*	*Elymniinæ.*	*Elymniinæ.*
Gen.	*Argynnis.*	*Argynnis.*	*Elymnias.*	*Elymnias.*
Sp.	*Niphe* (Linn.)	*Niphe* (Linn.)	*Undularis* (Drury.)	*Undularis* (Drury.)
Habitat	Eastern regions.	Eastern regions.	N. E. & C. India, Burma.	India, Burma, &c.
Locality	Burma.	Burma.	Cherrapunji, Assam.	Assam.
Sex	Male.	Female.	Male.	

stage, where the female is departing from the ancestral purplish black and brown, still retained by the male, and acquiring a close resemblance to the protected Danaid. This species is further interesting in the fact that the under sides of the wings of both males and females are marked and coloured very much like brown and withered leaves, to which they bear a close resemblance when they are folded and the insects are at rest.

There are found in Africa, India and many parts of the Oriental regions a large number of butterflies belonging to the *Danainæ* which are of a general black or very dark brown colour, variously marked with yellow, cream, or pearly-tinted white: large and handsome insects, more or less similar in general appearance. They are very plentiful in the regions where they are found, are slow-flying and apparently fearless insects, are possessed of the toughness and nauseousness which characterize the *Danainæ* and are generally avoided by the birds, monkeys, lizards and other animals whose food consists partly or wholely of insects.

Amongst these *Danainæ* are *Amauris niavius*, *A. dominicanus*, and *A. echeria*, already referred to, with other species such as *A. inferna*, *A. ochlea*, and *A. damocles;* and associated with them are a number of other butterflies of the sub-family *Nymphalinæ*, including several species of *Euralia*, *Hypolimnas*, *Pseudacræa*, and other genera, all of which closely resemble the various *Danainæ* in the company of which they are found. There are also seen in the same regions others of the *Danainæ* of somewhat similar colouring to those last named, but with the markings more in the shape of broad lines and spots than in large patches of colour. Included in these are several species of *Parantica*, which have a wide distribution in India, from Assam to the south. The simulators of these butterflies are found in several sub-families, including the *Papilioninæ*, *Nymphalinæ*, *Pierinæ*, &c., and even amongst the moths.



Mark L. Sykes, nat. SIMULATION OF INEDIBLE BY EDIBLE BUTTERFLIES. *Plate V.*

DESCRIPTION OF PLATE V.

Fig.	1	2	3	4
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Parantica.*	*Parantica.*	*Parantica.*	*Parantica.*
Sp.	*Melanoides* (Moore.)	*Aglea* (Cram.)	*Aglea* (Cram.)	*Aglea* (Cram.)
Habitat	Throughout Oriental regions	India, Ceylon, &c.	India, Ceylon, &c.	India, Ceylon, &c.
Locality	Bombay.	Ceylon.	N. W. India.	Trivandrum.
Sex	Male.	Male.	Male.	Male.

Fig.	5	6	7	8
Sub-Fam.	*Pierinæ.*	*Papilioninæ.*	*Papilioninæ.*	*Satyrinæ.*
Gen.	*Metaporia.*	*Cadugoides.*	*Paranticopsis.*	*Orinoma.*
Sp.	*Agathon* (Gray.)	*Epycides* (Hew.)	*Macareus* (Godt.)	*Damaris* (Gray.)
Habitat	India.	India.	India.	India.
Locality	Assam.	Assam.	N. W. India.	Assam.
Sex	Female.	Female.	Male.	Female.

Fig.	9	10	11	12
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Euplœinæ.*
Gen.	*Parantica.*	*Parantica.*	*Parantica.*	*Trepsichrois.*
Sp.	*Aglea* (Cram.)	*Aglea* (Cram.)	*Melanoides* (Moore.)	*Clauda* (Fabr.)
Habitat	Indian regions.	Indian regions.	India.	India.
Locality	Sikkim.	Assam.	Assam.	Pulo Nias.
Sex	Male.	Male.	Male.	Female.

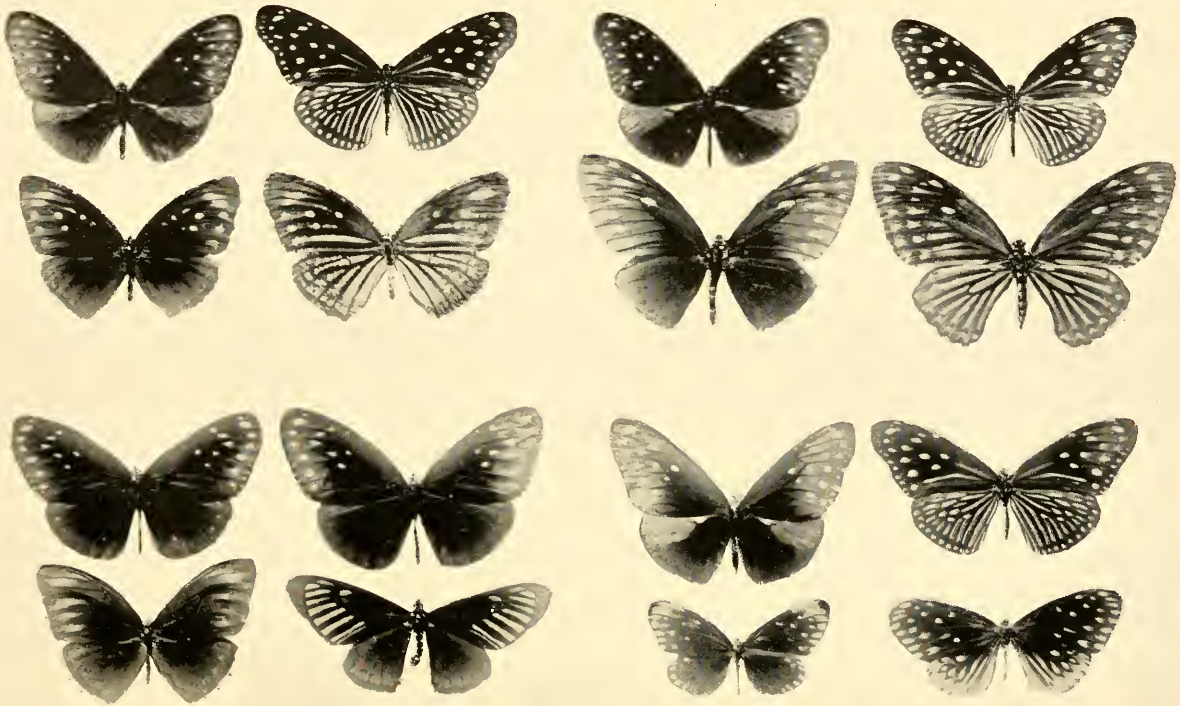
Fig.	13	14	15	16
Sub-Fam.	*Nymphalinæ.*	*Papilioninæ.*	*Bombycinæ.*	*Elymniinæ.*
Gen.	*Hestina.*	*Paranticopsis.*	*Isbarta.*	*Elymnias.*
Sp.	*Nama* (Doubl.)	*Megarus* (Westw.)	*Imitatans* (Butl.)	*Lais* (Cram.)
Habitat	Indian regions.	India.	India.	India.
Locality	Sikkim.	Cherrapunji.	Cherrapunji.	Pula Nias.
Sex	Male.	Male.	Female.	Male.

An examination of the figures in the illustrations (Plate V.) will reveal better than any description how close these resemblances are.

The *Euplœinæ* have not so wide a geographical range as some of the *Danainæ*, being confined to the Oriental and Malayan regions, but they also are characterized by a repellent nauseousness, which gives them considerable immunity from attack and destruction. They are an exceedingly handsome sub-family, many of them having large black wings spotted and lined with white, and strongly suffused with a very rich deep blue, which varies in different angles of light, as shot-silk does, and which sometimes spreads over nearly the whole surface of the wings, giving the butterflies a superb and exceedingly attractive appearance.

The *Euplœinæ* consist of numerous genera, including *Trepsichrois*, *Stictoplœa*, *Danisepa*, *Crastia* and others. Numerous species in these genera are simulated by butterflies of several sub-families, including the *Papilioninæ*, *Nymphalinæ*, *Elymniinæ*, &c., and by some of the *Chalcossinæ* and *Bombycinæ* amongst the moths.

On Plate No. VI. are illustrated three pairs of the *Euplœinæ; Trepsichrois Linnei*, from northern India, with three pairs of mimics, *Elymnias leucocyma*, *Isamiopsis telearchus*, and the moth *Calamesia midama*, all of which bear the closest resemblance to the *Euplœinæ*. On the same plate are also shewn two females of another *Euplœa*, *Stictoplœa binotata*, with their simulators *Dyctis patnoides*, and one of the Papilios, *Isamiopsis Slateri*. The similarity is in all cases very striking, and it is remarkable that in the first three cases mentioned above the males and females of both simulated and simulating butterflies differ from each other in each species, but are in all instances similar to the respective males and females to which they bear so near a resemblance.



Mark L. Sykes, nat. SIMULATION OF INEDIBLE BY EDIBLE BUTTERFLIES. *Plate VI.*

DESCRIPTION OF PLATE VI.

Fig.	1	2	3	4
Sub-Fam.	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*
Gen.	*Trepsichrois.*	*Trepsichrois.*	*Trepsichrois.*	*Trepsichrois.*
Sp.	*Linnei* (Moore.)	*Linnei* (Moore.)	*Linnei* (Moore.)	*Linnei* (Moore.
Habitat	India.	India.	India.	India.
Locality	Khasia Hills, Assam.	Khasia Hills, Assam.	Assam.	Assam.
Sex	Male.	Female.	Male.	Female.

Fig.	5	6	7	8
Sub-Fam.	*Elymniinæ.*	*Elymniinæ.*	*Papilioninæ.*	*Papilioninæ.*
Gen.	*Elymnias.*	*Elymnias.*	*Isamiopsis.*	*Isamiopsis.*
Sp.	*Leucocyma* (Boisd.)	*Leucocyma* (Boisd.)	*Telearchus* (Hewt.)	*Telearchus* (Hewt.)
Habitat	India.	India.	India.	India.
Locality	Khasia Hills.	Khasia Hills.	Khasia Hills.	Khasia Hills.
Sex	Male.	Female	Male.	Female.

Fig.	9	10	11	12
Sub-Fam.	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*
Gen.	*Stictoplœa.*	*Stictoplœa.*	*Trepsichrois.*	*Trepsichrois.*
Sp.	*Binotata* (Butl.)	*Binotata* (Butler.)	*Linnei* (Moore.)	*Linnei* (Moore.)
Habitat	India.	India.	India.	India
Locality	Assam.	Perak.	Assam.	Assam.
Sex	Male.	Female.	Male.	Female.

Fig.	13	14	15	16
Sub-Fam.	*Elymniinæ.*	*Papilioninæ.*	*Bombycinæ.*	*Bombycinæ.*
Gen.	*Dyctis.*	*Isamiopsis.*	*Calamesia.*	*Calamesia.*
Sp.	*Patnoides* (Moore.)	*Slateri* (Hewt.)	*Midama* (Boisd.)	*Midama* (Boisd.)
Habitat	India.	India.	India.	India.
Locality	Assam.		Assam.	Assam.
Sex	Female.	Female.	Male.	Female.

The wings of the butterflies and moths are composed of a double membrane, itself transparent and colourless, but covered on both the upper and under surfaces with a great number of minute feathers or scales. It is to the colour and arrangement of the scales that the brilliancy and variety of the wings are due. The colours are owing sometimes to pigments in the scales and sometimes proceed from the refraction of the light from the striations and spots on the scales, from their formation and arrangement, or from fine hairs which are found amongst them.

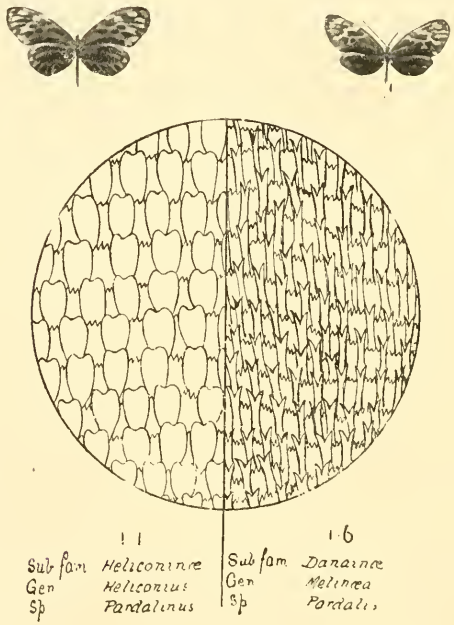


Fig. 13.

The scales are of great variety in shape and size, arrangement and quantity, but are generally very numerous, in some cases more than 100,000 being found in one square inch of wing-surface It is not surprising therefore that the combination of such minute detail with every colour,

hue and shade, should produce the extreme diversity in markings and patterns which are found in the *Lepidoptera*, the less so when it is seen, as revealed by the microscope, that the separate scales are often of more than one colour.

It is through the means afforded them by the diversity and variety of scales that some butterflies have assumed a superficial resemblance to one another.

Fig. 13 illustrates two of the inedible South American butterflies, one of the *Heliconinæ*, *Heliconius pardalinus*, and one of the *Danainæ*, *Melinæa pardalis*. Beneath them

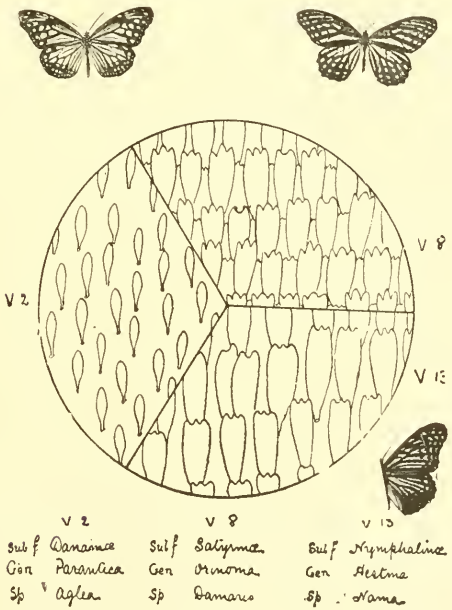


Fig. 14.

1.1 and 1.6 are shewn respectively, magnified portions of the wings of these insects, and it will be seen how very different in pattern, size, shape and arrangement the wing-scales are, whilst the butterflies are closely alike in

every way. These butterflies are illustrated in Plate III., figs. 1 and 6.

In fig. 14 are shewn three butterflies from India, *Parantica aglea*, *Orinoma damaris* and *Hestina nama*, belonging to the sub-families *Danainæ*, *Satyrinæ* and *Nymphalinæ* respectively. These insects are in no way related, although found together or in the same localities, and of very much the same appearance in every way. (See also illustrations in Plate V.) But the wing scales are quite different in all three cases, as are also those of two other butterflies, a *Pierid* and a *Papilio*, which simulate them in the same region.

Fig. 15 illustrates two butterflies of remarkably similar appearance, a Danaid, *Caduga tytia*, and one of the *Papilioninæ*, *Cadugoides agestor*. They are both light grey and pearly, with black lines on the fore wings, and deep chocolate markings on the hind wings. But the resemblance is produced in quite a different manner; in one the scales are thinly dispersed, light chocolate, and shaped like long thin skittles; in the other they are thickly placed, even overlapping, rounded and pure white, with a sprinkling of dead black scales amongst them. The effect is, however, an exact similar appearance in every detail, of colour, and markings.

The conclusion to be drawn from these differences in detail producing such striking resemblances is, that the attribution of simulation to natural selection is the correct one. Variations are constantly occurring in all directions, and the scale-varieties which result in the remarkable outward likenesses with protective results to the insects which possess them, can be the result of no other process. "For it seems manifest that these striking resemblances "which are arrived at by such widely divergent means, can "be reasonably explained on no other hypothesis than "natural selection. . . . Under the weaning influence

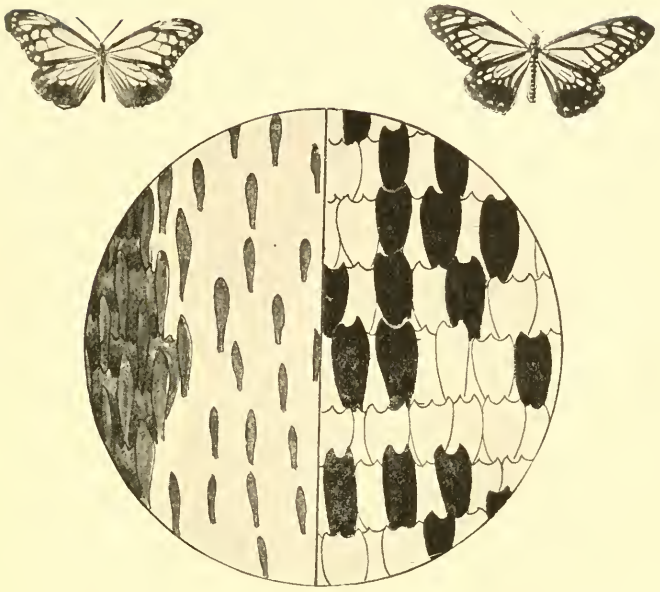


Fig. 15

"of elimination and selection of variations we should "expect to find those essentially different methods of "arriving at a common end which are here found to exist, "and in natural selection only is a reasonable basis found "for the various and devious means by which these "remarkable simulations and picture likenesses are reached "by so many separated species in nearly all geographical "areas."*

* "Evolution in Butterfly Scales," by M. L. Sykes (Proc. Manch. Micro. Socy., 1901.)

VI. *Protective Resemblance.*

Of the many means of protection found amongst insects none are perhaps more interesting, or of greater diversity, than those by which concealment is effected by similarity of the insects to their surroundings. In every order, from the *Coleoptera* to the *Diptera*, and in all stages of metamorphosis, there are found almost endless examples of this kind of protection. Leaves, twigs and flowers; grass, moss and lichen, root and bark, soils and stones, in every field and hedgerow, are copied in great variety by insects which live and shelter upon them.

Fig. 16. *Ancylecha lunuligera* (Borneo.

This form of simulation is of two kinds, or rather serves two purposes; firstly to render the animal less conspicuous and hide it from its enemies; and secondly to enable it to capture its own prey by waiting in concealment, or by its being mistaken for something else.

Caterpillars brown and green, plain and spotted, banded and striped, lie concealed everywhere, or project stiff, brown and bent from the branches and stems, exactly like the twigs upon which they rest rigid and motionless. They are to be found almost everywhere during the summer months, but so closely do they resemble their surroundings that they are very seldom seen, at least by the human eye, and are often most difficult to detect even when specially sought for.

Fig. 17. *Charagia daphnandrae* (Queensland), with the wings expanded, and at rest on bark. The fore wings are green, and the hind wings a rosy red. The insect is effectually concealed when at rest upon green bark as illustrated.

The butterflies and moths which are protected in this manner are very numerous; amongst the beetles also are a great many species which owe their safety to this means.

The *Orthoptera* are amongst the largest contributors to this class of simulism: 'leaf-insects,' 'walking-sticks,' and

simulators of mosses, fungi and lichens, being very numerous in this order.

Fig. 18 illustrates some of the *Phasmidæ* from Ceylon, Java, and Queensland, brown, dried-up looking animals, much more like sticks than living creatures, and with them are four small twigs upon which four of the insects are placed.

Fig. 18. A group of "Stick" insects from Queensland, Borneo, Ceylon, &c.

A number of the simulating *Orthoptera* are shewn in the next illustration, Fig 19. They include several species of *Mantidæ; Mantis religiosa*, *M. viridis*, and others; some of the *Truxilidæ* from Africa, with both open and closed wings, a young *Phyllium siccifolium* with brown crumpled wings like dead and dried leaves, and two of the large green coloured *Trepidodera* from Queensland. One of these insects, *T. Childreni*, that on the right, shews the transparent gauze-like hind wings partly exposed; the other is in the position of rest, with the wings closed and

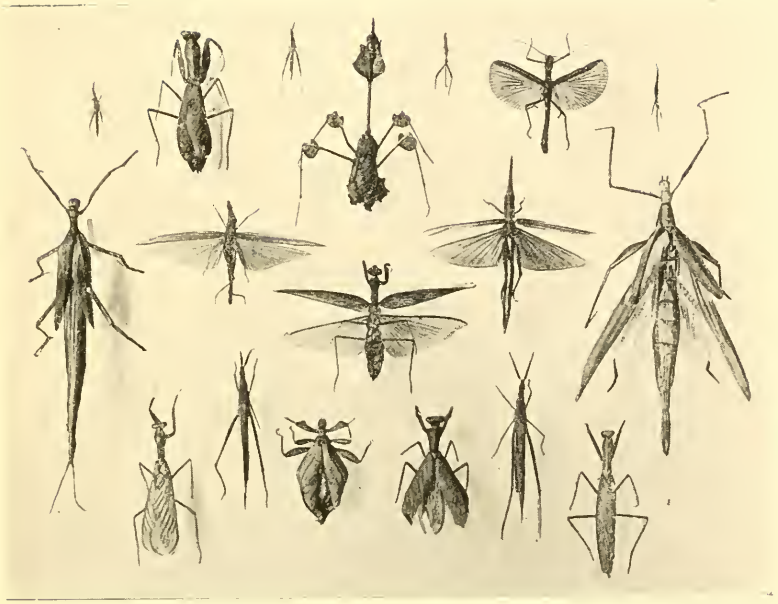


Fig. 19. A group of "Stick" and "Leaf" insects from Australia, the Malayan islands, &c.

folded over the back, and having the exact appearance of a young plant with two bright green leaves and a pink based green stem.

Fig. 20 illustrates a few more of these remarkable leaf-like insects, most of them being from Africa. The six specimens with the wings expanded have a beautiful leaf-like appearance when the wings are closed, and the insects are in repose. The fore wings are either green or brown, the nervures are exactly like the veins of leaves in both colour and pattern; and the concealment amongst vegetation is complete when the gauzy hind wings are folded away and the insects are resting. In one of these, *Arantia*, the wings are studded all over with yellow spots, in precisely the same way as a fungus-spotted leaf is often found. In the centre of the same illustration is a very

stick-like Phasmid, *lonchodes* from Queensland, and above are two of the *Mantidæ*, green and brown respectively, in the attitude of quiescence.

All the *Mantidæ* are carnivorous, feeding upon insects of other kinds, and sometimes upon their own species ; and their method of securing their food is the same. Crouching upon some plant, or upon the ground, the *Mantis* raises

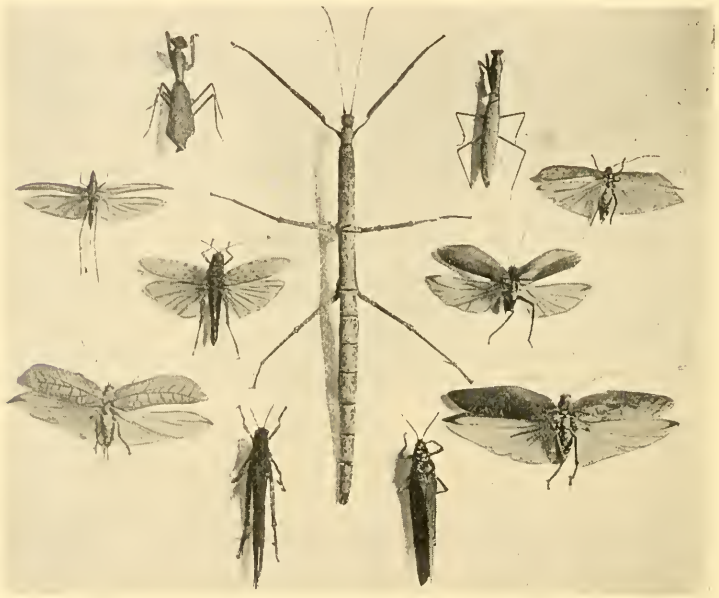


Fig. 20. A group of "Leaf" and "Stick" insects from Queensland, Africa, &c.

the fore part of the body, folds the long fore limbs together, and remains motionless, some times for hours, but always ready to grasp any unwary insect which may approach close enough to be secured. All the different species are coloured to harmonise with their surroundings, and their wings have the appearance of green or faded and crumpled leaves. The protective resemblance serves here a two-fold purpose ; to hide the insect from other animals which feed upon the *Mantidæ*, and to conceal it from the insects upon

which it feeds; the brown, or green, or rosy colouring, venation of the wings, and the twig-like appearance of the legs effectually concealing the animal during repose. Fig. 21 shews the *Mantis religiosa* in the act of seizing a fly.

Fig. 21. *Mantis religiosa*, in the attitude of seizing prey.

The *Mantis* shewn in the next illustration, a species of *Phyllocrania* from Ceylon, is even more leaflike than the last named insect (Fig. 22). The wings are varied, green and brown, and are folded over the abdomen in exact imitation of a rolled up leaf, whilst the expansions on the thorax and the legs add still further to the simulation of the foliage amongst which the insect rests.

Phyllium siccifolium is another excellent example of protective resemblance. The fore wings are of large area, completely covering the body of the insect when at rest; they are somewhat rounded, and strongly veined and marked with numerous lines. The young insect is of a

Fig. 22. *Phyllocrania sp.* (Ceylon.)

yellowish brown colour, and has a decided resemblance to a brown and withered leaf; but as it grows older its colour gradually changes from brown to a bright green, and the perfect insect, the matura, acquires a wonderful resemblance to some of the vivid and shining green leaves of tropical forests (Fig. 23).

Amongst the many curious and interesting insects which are found in Ceylon, *Empusa gongylodes*, is one of the most singular. It is a brown insect. The thorax is like a long thin twig, with a wide leaflike expansion immediately behind the head. The wings are broad, veined and crumpled, like dried leaves; and the long legs, which are spread out in any direction as the animal is at rest, harmonise so closely with the twigs to which they cling, that it is difficult to see where one begins and the other ends. Fig. 24 illustrates this insect in the attitude in which it was resting before being captured.

Fig. 23. *Phyllium siccifolium* (Fiji.)

Fig. 24. *Empusa gongylodes* (Ceylon,) at rest on twig.

Another interesting insect from Ceylon is one of the moths, *Eurybrachis Westwoodii*. The fore wings of this insect are marked in a mottled pattern of green, grey and brown; the hind wings being white, with deep claret-coloured marks near their base; and when it is on the wing the moth is an attractive looking creature. But its appearance alters when it is at rest, with the mottled wings folded over the back. In Fig. 25 it is shewn with the wings expanded as it appears when flying, and below is a piece of bark with the same insect resting upon it, and

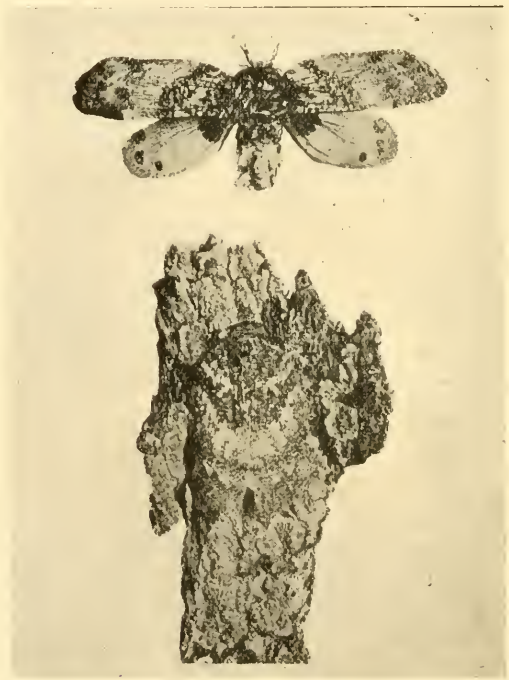


Fig. 25. *Eurybrachis Westwoodii* (Ceylon,) with the wings expanded, and at rest upon a piece of bark.

where it was discovered by the keen sight of the collector; a clever capture, as will be admitted, when it is noticed

how excellently the colours harmonize, and how the insect and the bark seem almost to merge one into the other.*

There is found in Madagascar a small beetle, which, looked at apart from its natural surroundings, has nothing specially interesting about it, except that it is a conspicuous, rugged looking, pure white and black insect, about three-quarters of an inch long. It feeds upon a species of fungus, which grows upon the bark of trees in mixed cream and black coloured patches. The beetle is shewn at the top of Fig. 26, and beneath it a piece of twig with the

Fig. 26. *Lithinus nigrocristatus* (Madagascar.) The upper figures shew beetle and bark separately, and in the lower figure *the beetle is on the bark.*

fungus growing upon it. At the bottom of the same illustration the same piece of fungus-covered twig is shewn,

* I am greatly indebted to my friend Colonel W. G. Clements for many beautiful and remarkable specimens of Protective Resemblance, including those illustrated in Figs. 22 to 26.

but here the beetle is resting right in the middle of the fungus, effectually concealed amongst the vegetation upon which it feeds. There is a very fine group of these beetles shewn in one of the 'Mimicry' cases in the Natural History Museum at South Kensington.

The leaflike Orthopteron, shewn in Fig. 16, illustrated on page 218, is from Borneo, which, like other Malayan and Australasian islands, has afforded a wealth of interesting material for the entomologist. The fore wings are green, with leaf-like veins and nervures, and there are two spots upon them which are exactly like the fungus spots so often found upon leaves, whilst the stiff-set legs have the appearance of thorn-clothed brown twigs. Another very similar insect, also from Borneo, is shewn in the next illustration (Fig. 27,) the leaflike green wing having a small round transparent patch, like a hole in a leaf.

Fig. 27. *Cleandrus neritifolius* (Borneo.)

Of the many butterflies and moths which have the

appearance of leaves when the insects are at rest, none are more perfect than the various species of *Kallimæ*, found in the palæotropical regions. Reference has already been made to these butterflies on page 189, and in Fig. 28 the upper surfaces are shewn of several species, including *Kallima paralekta*, *K. inachis*, *K. albofasciata*, *K. philarchus*, *K. Buxtoni* and *K. rumia*, together with several *Doleschalliæ* and *Anææ*, and in the upper centre a pair of *Zeuxidia amethysta*. All these insects are highly coloured, generally

Fig. 28. "Leaf butterflies": shewing upper (brightly coloured) surfaces of wings. (See Fig. 29.)

in various shades of bright blue, some varied with black, some with orange or white bands across the fore wings, some shot with heliotrope or purple; all are handsome butterflies, conspicuously coloured on the upper surfaces of the wings.

The next illustration (Fig. 29) shews exactly the same butterflies, but arranged, unfortunately, in somewhat different order. In this case the undersides only of the insects are shewn, the wings being in every case shaped and marked like leaves in various stages of decay, many

Fig. 29. "Leaf butterflies": shewing under (leaf like) surfaces of wings. (See Fig. 28.)

with blotches and patches of brown or yellow, like the mildew and fungus found on dead or decaying vegetation, and some with small transparent spots upon them, which give the appearance of small holes in dead leaves. These butterflies always rest with the wings folded over the back, the undersides only being exposed, and as they habitually settle amongst the decaying vegetation of the tropical forest the simulation to their environment possesses

a measure of almost extreme protective value. One of these insects, *K. paralekta*, is seen in the attitude of repose in Fig. 30.

Fig. 30. *Kallima paralekta*, at rest on twig.

Most of the subjects illustrated and described above are selected from amongst the tropical fauna, as being comparatively little known ; but the British insecta include amongst their numbers, in all stages, larvæ, pupæ and maturæ, many varied and beautiful examples of the interesting and attractive subject of Protective Resemblance.

(Three additional plates are inserted here in further illustration of the resemblances between edible and inedible butterflies, viz., Plates VII., VIII., and IX. ; also a plate giving additional illustrations of differences in the shape, size, and arrangement of the scales of some butterflies having superficial resemblances to each other, viz., Plate X.)

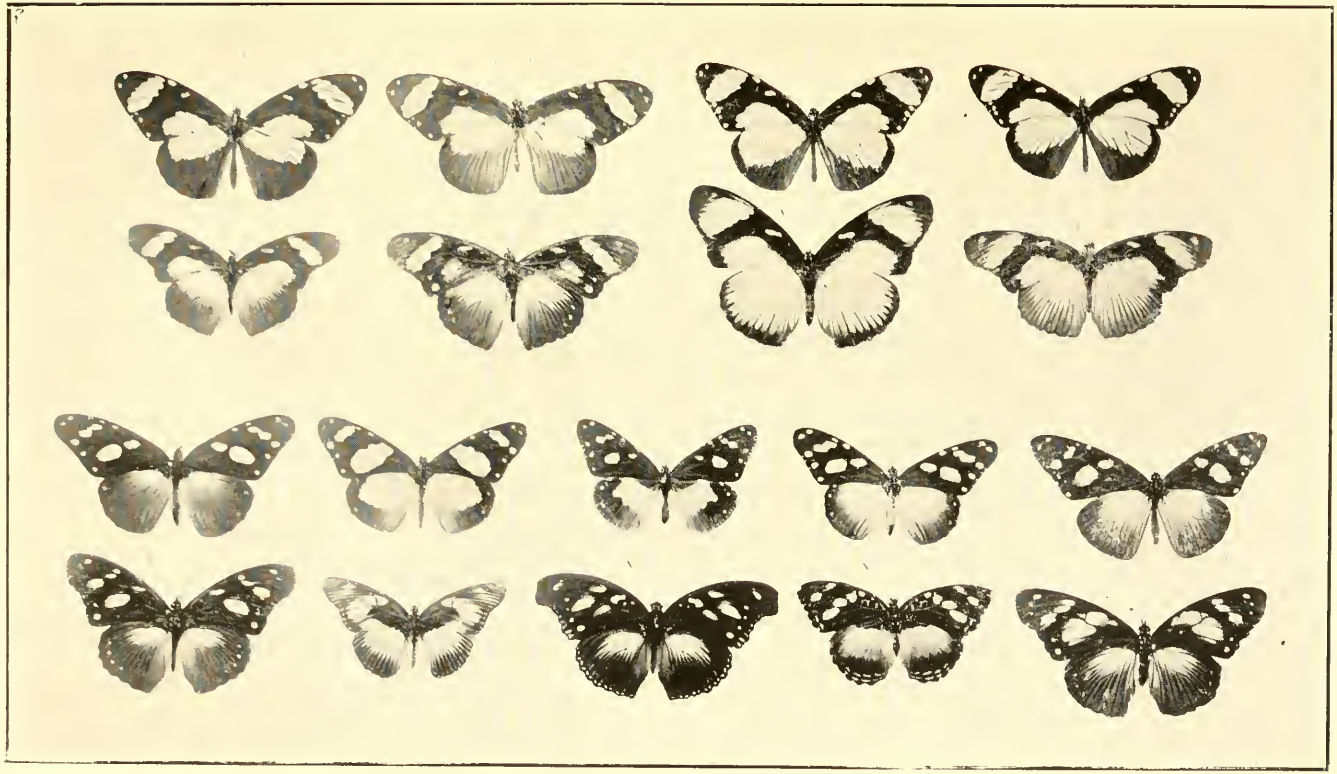
DESCRIPTION OF PLATE VII.

Fig.	1	2	3	4
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Amauris.*	*Amauris.*	*Amauris.*	*Amauris.*
Sp.	*Niavius* (Linn.)	*Niavius* (Linn.)	*Dominicanus* (Trim.)	*Dominicanus* (Trim.)
Habitat	Africa.	Africa.	Africa.	Africa.
Locality	Sierra Leone.	Gaboon.	Dar es Salaam.	Dar es Salaam.
Sex	Male.	Female.	Male.	Male.

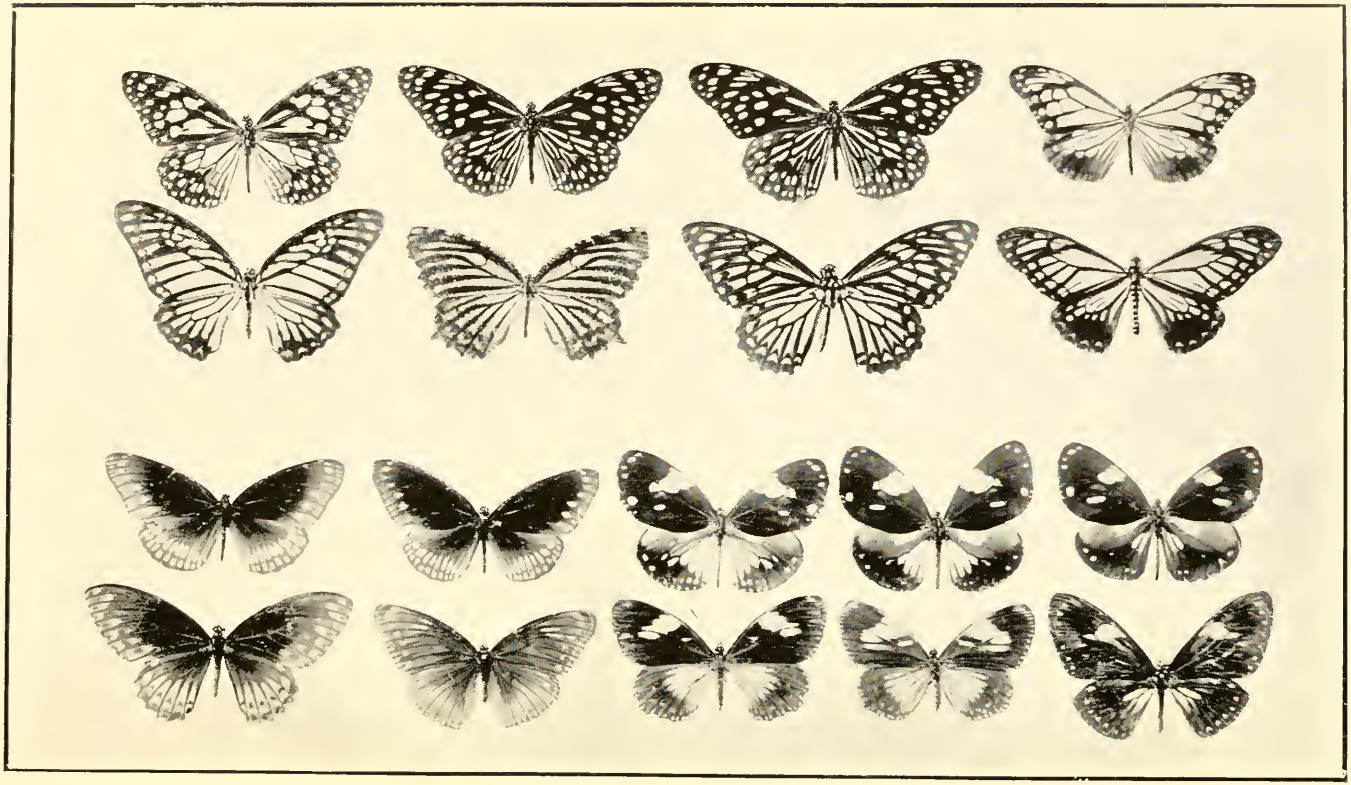
Fig.	5	6	7	8
Sub-Fam.	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*
Gen.	*Euralia.*	*Euralia.*	*Euralia.*	*Euralia.*
Sp.	*Anthedon* (Doub.)	Sp.	*Wahlbergii.*	Sp.
Habitat	Africa.	Africa.	Africa.	Africa.
Locality	Sierra Leone.	Gaboon.	Dar es Salaam.	Gaboon.
Sex	Female.	Female.	Male.	Female.

Fig.	9	10	11	12	13
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Amauris.*	*Amauris.*	*Amauris.*	*Amauris.*	*Amauris.*
Sp.	*Inferna* (Butler.)	*Ochlea* (Boisd.)	*Echeria* (Stall.)	*Egialea* (Crom.)	*Damocles* (Beauv.)
Var.			*Albimaculata.*		
Habitat	W. Africa.	Africa.	S. Africa.	W. Africa.	W. Africa.
Locality	Old Calabar.	Dar es Salaam.	Natal.	Sierra Leone.	Sierra Leone.
Sex	Male.	Female.	Female.	Male.	Male.

Fig.	14	15	16	17	18
Sub-Fam.	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*
Gen.	*Hypolimnas.*	*Pseudacrea.*	*Euralia.*	*Aterica.*	*Hypolimnas.*
Sp.	Sp.	*Lucretia* (Cram.)	Sp.	*Cupavia.*	*Dubius* (Beauv.)
Habitat	W. Africa.	E. Africa.	S. Africa.	W. Africa.	W. Africa.
Locality	Old Calabar.	Dar es Salaam.	Natal.	Sierra Leone.	Gold Coast.
Sex	Male.	Male.	Male.	Female.	Female.



Mark L. Sykes, nat. RESEMBLANCE OF EDIBLE TO INEDIBLE BUTTERFLIES. *Plate VII.*



Mark L. Sykes, nat. RESEMBLANCE OF EDIBLE TO INEDIBLE BUTTERFLIES. *Plate VIII.*

DESCRIPTION OF PLATE VIII.

Fig.	1	2	3	4
Sub-Fam.	*Danainæ.*	*Danainæ.*	*Danainæ.*	*Danainæ.*
Gen.	*Tirumala.*	*Tirumala.*	*Tirumala.*	*Caduga.*
Sp.	*Limniace* (Cram.)	*Septentrionis* (Butl.)	*Septentrionis* (Butl.)	*Tytia* (Gray.)
Habitat	Assam, India, Ceylon.	India, Assam.	India.	India, Assam.
Locality	Ceylon.	Cherrapunji.	Cherrapunji.	Cherrapunji.
Sex	Male.	Male.	Male.	Female.

Fig.	5	6	7	8
Sub-Fam.	*Papilioninæ.*	*Elymniinæ.*	*Papilioninæ.*	*Papilioninæ.*
Gen.	*Paranticopsis.*	*Elymnias.*	*Chalasa.*	*Cadugondes.*
Sp.	*Xenocles* (Doubl.)	*Timandra* (Wall.)	*Dissimilis* (Swains.)	*Agestor* (Gray.)
Habitat	India.	Assam.	India, Assam.	Assam.
Locality	Northern India.	Cherrapunji.	Cherrapunji.	Cherrapunji.
Sex	Female.	Female.	Male.	Male.

Fig.	9	10	11	12	13
Sub-Fam.	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*	*Euplœinæ.*
Gen.	*Crastia.*	*Crastia*	*Danisepa.*	*Danisepa.*	*Danisepa.*
Sp.	*Core* (Cram.)	*Core* (Cram.)	*Rhadamanthus* (Fabr.)	*Rhadamanthus* (Fabr.)	*Lowei* (Butl.)
Habitat	India.	India.	India.	India.	Oriental Archip'l'go
Locality	Bombay.	Bombay.		Assam.	Borneo.
Sex	Female.	Female.	Female.	Male.	Male.

Fig.	14	15	16	17	18
Sub-Fam.	*Papilioninæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Papilioninæ.*
Gen.	*Chalisa.*	*Hypolimnas.*	*Euripus.*	*Hestina.*	*Papilio.*
Sp.	*Panope* (Linn.)	*Anomala* (Wall.)	*Halithurses* (Doub.)	*Ida.*	*Caunus* (Westw.)
Habitat	India.	Malayana.	India.	India.	Oriental Archip'l'go.
Locality	Bombay.		Khasia Hills.	Assam.	Borneo.
Sex	Female.	Male.	Female.	Female.	Male.

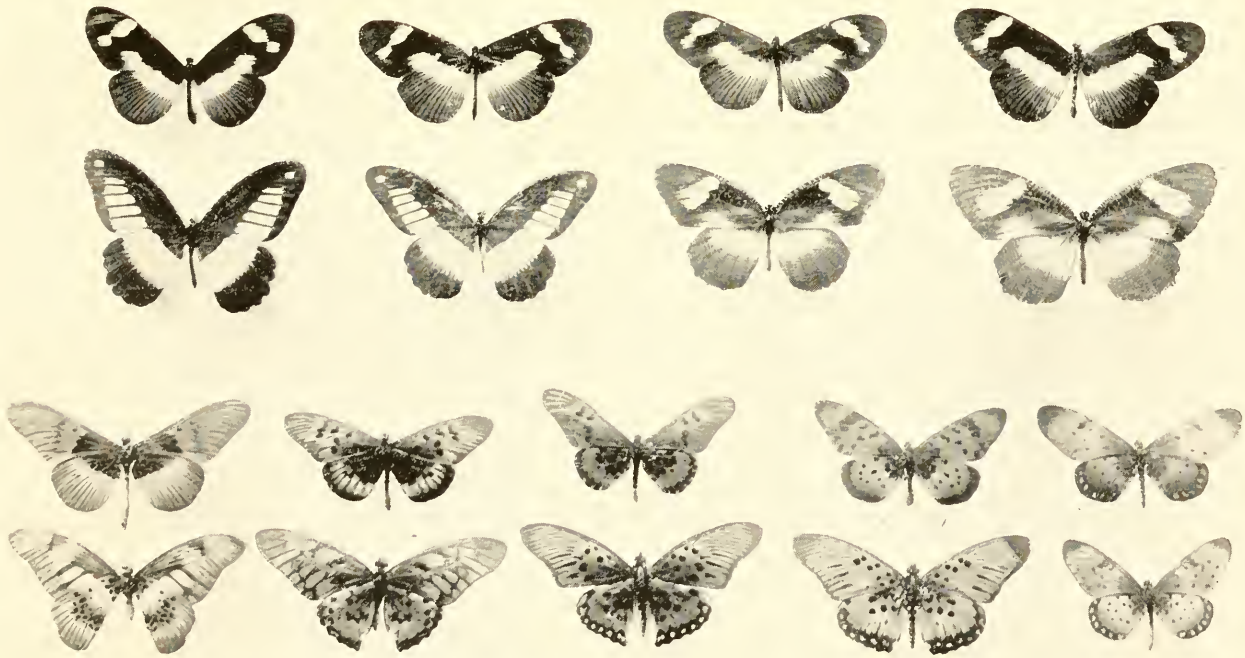
DESCRIPTION OF PLATE IX.

Fig.	1	2	3	4
Sub-Fam.	*Acræinæ.*	*Acræinæ.*	*Acræinæ.*	*Acræinæ.*
Gen.	*Planema.*	*Planema.*	*Planema.*	*Planema.*
Sp.	*Gea* (Fabr.)	*Gea* (Fabr.)	*Gea* (Fabr.)	*Gea* (Fabr.)
Habitat	Africa.	Africa.	Africa.	Africa.
Locality	Sierra Leone.	Sierra Leone.	Sierra Leone.	Sierra Leone.
Sex	Male.	Female.	Female.	Female.

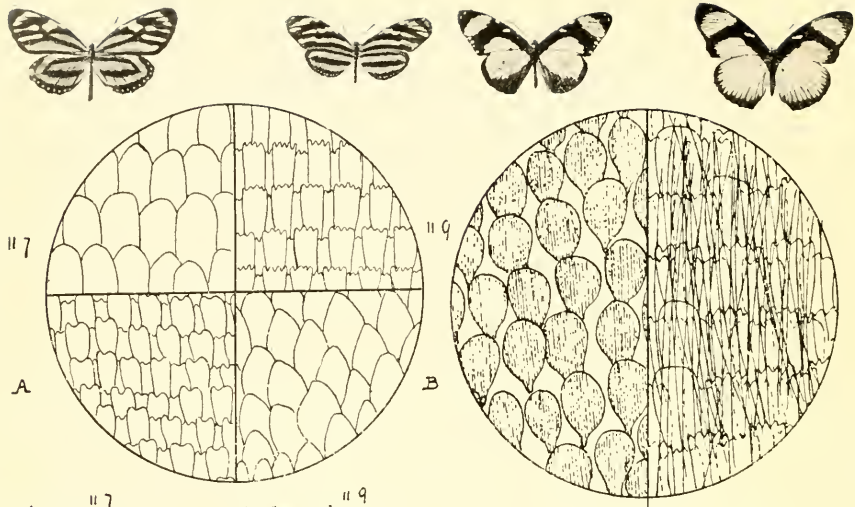
Fig.	5	6	7	8
Sub-Fam.	*Papilioninæ.*	*Papilioninæ.*	*Elymniinæ.*	*Elymniinæ.*
Gen.	*Papilio.*	*Papilio.*	*Elymnias.*	*Elymnias.*
Sp.	*Cynorta* (Fabr.)	*Cynorta* (Fabr.)	*Bammakoo=phegea* (Fabr.)	*Bammakoo=phegea* (Fabr.)
Habitat	W. Africa.	W. Africa.	W. Africa.	W. Africa.
Locality	Sierra Leone.	Sierra Leone.		
Sex	Male.	Male.	Male.	Female.

Fig.	9	10	11	12	13
Sub-Fam.	*Acræinæ.*	*Acræinæ.*	*Acræinæ.*	*Acræinæ.*	*Acræinæ.*
Gen.	*Planema.*	*Acræa.*	*Acræa.*	*Acræa.*	*Acræa.*
Sp.	*Euryta* (Linn.)	*Egina* (Cram.)	*Zetes* (Linn.)	*Acara* (Hew.)	*Acara* (Hew.)
Habitat	W. Africa.	Africa.	Africa.	E. Africa.	E. Africa.
Locality	Sierra Leone.	Sierra Leone.	Sierra Leone.		
Sex	Male.	Male.	Male.	Male.	Female.

Fig.	14	15	16	17	18
Sub-Fam.	*Papilioninæ.*	*Papilioninæ.*	*Nymphalinæ.*	*Nymphalinæ.*	*Acræinæ.*
Gen.	*Papilio.*	*Papilio.*	*Pseudacræa.*	*Pseudacræa.*	*Acræa.*
Sp.	*Latreillianus* (Godt.)	*Ridleyanus* (White.)	*Boisduvalii* (Doubl.)	*Trimenii* (Butler.)	*Natalica* (Boisd.)
Habitat	W. Africa.	W. Africa.	W. Africa.	E. Africa.	E. Africa.
Locality	Sierra Leone.	Sierra Leone.	Sierra Leone.		
Sex	Female (underside.)	Male.	Male.	Female.	Male.

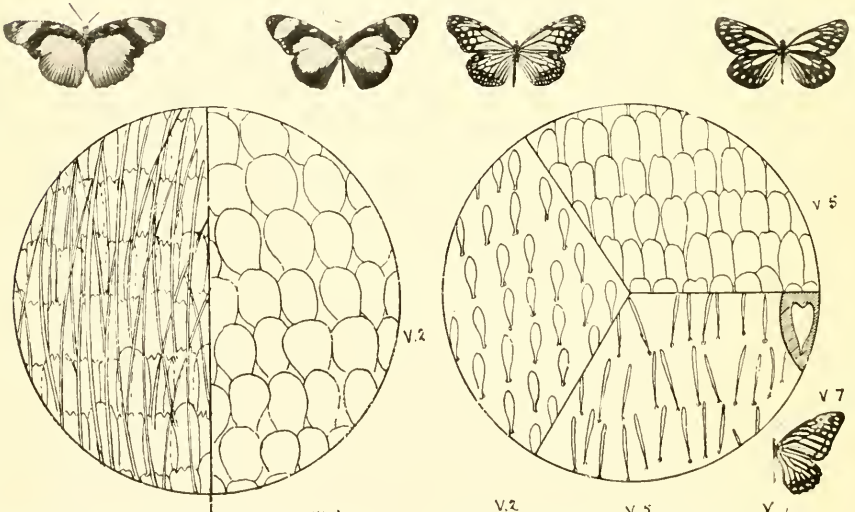


Mark L. Sykes, nat. RESEMBLANCE OF EDIBLE TO INEDIBLE BUTTERFLIES. *Plate IX.*



II 7		II 9	
Sub fam.	Danainæ	Sub fam	Heliconiinæ
Gen	Lycorea	Gen	Eueides
Sp	Atergatis	Sp	Dynastes
	A		B
Sub fam.	Pierinæ.		Moth.
Gen.	Dismorphia	Gen	Pericopsis
Sp	Praxinoe	Sp	Angulosa

IV 3		IV 7	
Sub fam	Danainæ	Sub fam	Nymphalinæ
Gen	Amauris	Gen	Hypolimnas
Sp	Dominicanus	Sp	Wahlbergii



IV 5		IV 1	
Sub. fam.	Nymphalinæ	Sub fam	Danainæ
Gen	Hypolimnas	Gen	Amauris
Sp	Antheam	Sp	Niavius

V.2		V 5		V	
Subf	Danainæ	Subf	Parinæ	Subf	Papilioninæ
Gen	Parantica	Gen	Melàpoma	Gen	Papilio Cresphontes
Sp	Aglea	Sp	Agathon	Sp	Malacum

Mark L. Sykes, del ad nat.

Plate X.

The illustrations on Plate X and on pages 214, 215 and 217, of magnified scales on the wings of Butterflies, are from camera lucida drawings of portions of the discoidal cells in the hind wings of the Butterflies shewn in the same illustrations.

See page 214 *et Seq.*

SIMULATING DANAINÆ, from Venezuela.

Melinæa lilis. *Mechanitis veritabilis* ♂

Mechanitis veritabilis ♀ *Tithorea Doubledayi.*

Ceratinia dionæa.

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