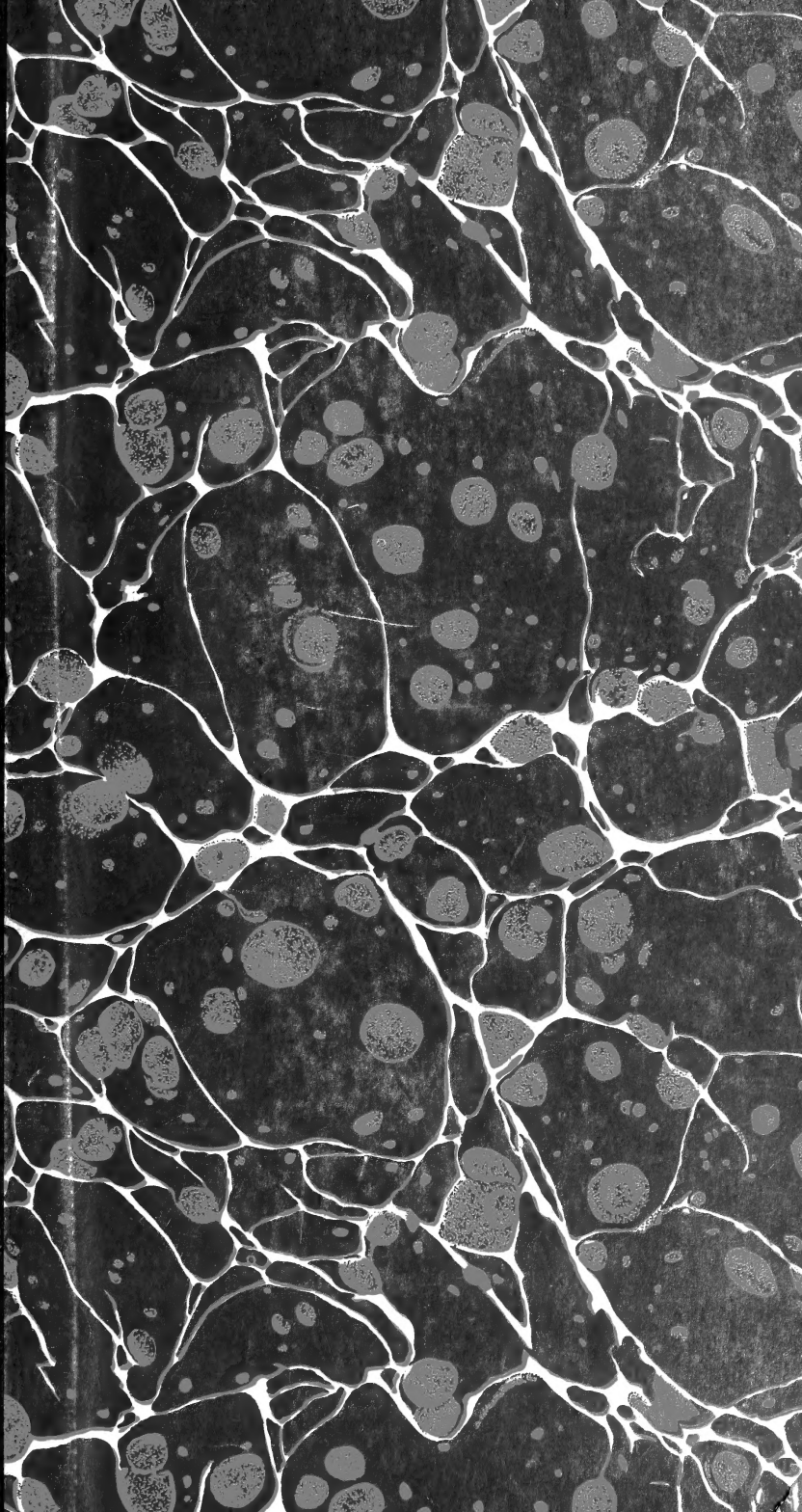

PROCEEDINGS

OF THE

Bristol Naturalists' Society

FOURTH SERIES, VOLUME VIII, 1935–1939

EDITED BY H. W. TURNER, M.A., F.G.S.
ASSISTED BY A COMMITTEE

"Rerum cognoscere causas."—Virgil.

Authors alone are responsible for the accuracy of their articles.

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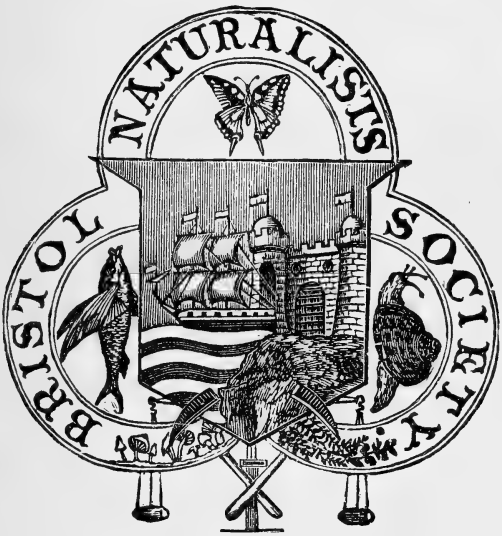

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Bristol Naturalists' Society's Proceedings

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ERRATA

Page 19 (seventh paragraph): for "Rose Bay Willow" read "Rose-Bay Willowherb."

Page 27 (last line): for "Sir Roland Austin" read "Mr. Roland Austin, M.A., F.S.A."

Page 97 (line 19): for "feet" read "inches."

Page 97 (last line): for "tracks" read "packs."

Page 128 (line 2): The names "White" and "Bentham and Hooker" respectively refer to the fact that these plants appear under those names in White's *Flora of Bristol* and Bentham and Hooker's *Handbook of the British Flora*, 7th Edition.

Page 128 (Review): for "Lower Lias" read "Lower Silurian."

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	Yonge, Prof. C. M., D.Sc. ..	The University, Bristol, 8	
A.	Zealand, Mrs. H. W.....	Brecon Lodge, Westbury-on-Trym, Bristol	*F.*

Honorary Members

Prof. C. Lloyd Morgan, LL.D., F.R.S., F.G.S., 23 Elphinstone Road Hastings.
R. M. Prideaux, F.R.E.S., Brasted Chart, near Sevenoaks, Kent.
Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64 Victoria Street, Westminster, S.W.1.
Prof. W. J. Sollas, M.A., LL.D., F.R.S., F.R.S.E., F.G.S., University Museum, Oxford.
Prof. Sydney Young, D.Sc., F.R.S., The Ferns, Stoke Bishop, Bristol, 9.
Sir Ernest Cook, D.Sc., 40 Alma Road, Clifton, Bristol, 8.
H. Womersley, F.R.E.S., A.L.S., 36 Wattle Street, Fullerton Estate, Adelaide, S. Australia.

REPORT OF COUNCIL

TO DECEMBER 31ST

1935

IT so often happens that nations, societies and individuals move in calm waters for such long periods that they completely forget not only the disadvantages of rough seas, but also the advantages of the quiet and smoothness of still waters. The year 1935 has been one of many changes and unrest for the Society.

In June, your Society suffered an irreparable loss by the death of Miss Ida M. Roper, F.L.S., who had been an official for such a long period that many members cannot remember the Society apart from her cheery presence. For the past 19 years she had held the offices of Hon. Secretary and Librarian; she was its efficient Editor until 1934; she was the first and only woman President; and only those who have been intimately connected with her know the untiring zeal and energy with which she pursued any matter that was for the well-being of the Society. It is no exaggeration to say that since the Great War she had devoted at least half her life to the Society, and members, both individually and collectively, sincerely mourn her death. The Society was fully represented at the funeral, and a scheme is to be launched early in 1936 which will serve as a memorial to her memory.

During the early part of the year, Miss T. Shaw kindly undertook the duties of Acting Hon. Secretary and Librarian, and the Society is deeply indebted to her for all the work which she carried out during that period. Miss Roper officially resigned in March when Miss M. D. Hiley was appointed Hon. Secretary, and Mr. J. V. Pearman became Hon. Librarian.

In January, Mr. G. E. J. McMurtrie was elected President, and with his business instincts he quickly secured the appointment of a Reorganisation Committee so that the pioneer work of the late Professor O. V. Darbishire should be consolidated and new members obtained. This Committee, with the approval of Council, has carried out a programme of wider publicity for the activities of the Society, and has prepared a leaflet which briefly states the organisation, advantages, and types of membership. It is gratifying to note that a small but steady response to the work of this Committee has been obtained. The same Committee has completely revised the rather out-of-date rules and these will be presented to the Annual General Meeting in 1936.

The summer meeting of the Society was, according to custom, under the auspices of the officers of the Field Section. A delightful run in northern Somerset brought the members to the charming Orchardleigh Church. After tea the never-failing interests of Vallis Vale occupied the attention of members and their friends.

At the Open Meeting, an entirely new departure was undertaken by the exhibition of natural history films. A crowded house denoted the popularity of this venture, and your Society is indebted to Professors Macgregor Skene and C. M. Yonge for their running comments, and to Mr. T. V. T. Baxter for his excellent scheme of publicity.

The chief guest at the Annual Dinner was Dr. A. B. Rendle, F.R.S., who delighted the members and their friends by an informal talk concerning his botanical work in Bermuda and St. Helena.

The Sections still continue to hold their Open Meetings, but the limited attendance of other members necessitates a complete review of the position by Council in the near future.

The work of the old Publications Committee has been absorbed into the wider sphere of the Publications and Library Committee. The annual publication of the Society is now known under the abbreviated title of *Proceedings*, and Council would congratulate the Editor, Mr. H. W. Turner, on the excellence of his first annual part.

M. D. HILEY, *Hon. Secretary.*

Report of Delegate to British Association Meeting

1935

I HAD the honour to represent the Bristol Naturalists' Society at the meetings of the British Association held at Norwich in September, 1935. Although the attendance was not so high as is usual when meetings are held in more densely populated districts, the Norwich meeting was a great success in many ways, and members warmly appreciated the attractions of Norfolk.

At the Conference of Delegates of Corresponding Societies, the most important matter was contained in the address by the President, Professor P. G. H. Boswell, D.Sc., F.R.S., who spoke on "The Preservation of Sites of Scientific Interest in Town and Country Planning." In particular, he asked delegates to draw the attention of the Societies which they represented to the fact that the Ministry of Health has given opportunity to scientific societies (through the British Association) to advise as to when action ought to be taken to preserve sites of scientific interest or natural beauty. The areas in which planning schemes are proposed are notified to the British Association, but effective action can only be taken when local societies supply information regarding sites. We are, therefore, urged once more to begin "the compilation of a list of sites and objects of exceptional botanical, zoological or geological character," and to communicate the results at frequent intervals to the central office of the Association. Such a reference list will thus be available for consultation as each scheme of planning is notified; where necessary the Association will then consult with experts on the panel already drawn up for the purpose. It is not advice as to nature reserves that is invited by the Ministry. Professor Boswell instanced certain old gravel and clay pits of great geological and archæological interest in Norfolk as suitable objects for preservation.

A. E. TRUEMAN.

The Hon. Treasurer in Account with the Bristol Naturalists' Society

Dr. RECEIPTS AND PAYMENTS FOR THE YEAR ENDING 31st DECEMBER, 1935 *Cr.*

1934 £ s. d.		£ s. d.	£ s. d.
	To Members' Subscriptions :—		
10 0	Ordinary : Arrears from 1934 ..	1 10 0	
54 15 0	„ 1935	49 0 0	
3 0 0	„ in advance, 1936 ..	2 0 0	
	Associate : Arrears from 1934 ..	10 0	
15 10 0	„ 1935	15 10 0	
	„ in advance, 1936 ..	15 0	
15 0	Junior : 1935	10 0	
			69 15 0
11 5 0	„ Subscriptions to Sections received by Treasurer (per contra) ..	.. ..	20 0 6
1 0 0	„ Members' Donations to Bookbinding Fund		
			89 15 6
5 0 0	„ Donation to Publishing Fund ..	.. ..	5 0 0
4 11 0	„ Sale of Publications	.. ..	2 11 0
19 10 6	„ Sale of Dinner Tickets	.. ..	12 13 0
	„ Donation to Dinner Fund ..	.. ..	2 11 9
	„ Sale of Tickets : Field Meeting ..	.. ..	14 14 0
2 5 3	„ Interest on Deposit	.. ..	2 9 11
114 4 1	„ Balance from last Account ..	.. ..	139 16 4
232 5 10			£269 11 6

1934 £ s. d.		£ s. d.	£ s. d.
	By Subscriptions :—		
1 1 0	Ray Society	1 1 0	
2 10 0	Zoological Record (Vol. 71) ..	2 10 0	
18 0	S.W. Naturalists' Union, 1935		
	British Empire Naturalists' Association	5 0	
			3 16 0
46 7 6	„ Cost of *Proceedings*, 1934 ..	.. ..	42 10 3
	„ Do. (Reprints of papers) ..	.. ..	6 7 6
9 5 1	„ Printing, Postages, Stationery, etc.	.. ..	18 0 6
1 19 0	„ Lecture Expenses	.. ..	7 10 3
1 11 0	„ Rent and Fire Insurance ..	.. ..	1 11 0
16 12 5	„ Dinner Expenses	.. ..	15 4 9
1 0 6	„ Bookbinding		
	„ Field Meeting, Charabancs, teas, etc.	.. ..	13 15 0
	„ Wreath (the late Miss I. M. Roper)	.. ..	15 0
11 5 0	„ Subscriptions to Sections paid over by Treasurer (per contra) ..	.. ..	20 0 6
139 16 4	„ Cash at Bank	.. ..	140 0 9
232 5 10			£269 11 6

Bristol, 11th January, 1936.

F. W. EVENS, *Hon. Treasurer.*

Audited and found correct.

ERNEST H. COOK,
CHAS. BARTLETT, F.C.A. } Auditors.

LIBRARIAN'S REPORT

FOR THE YEAR 1935

ON the resignation of the late Miss Roper, the care of the library was undertaken by Miss T. E. Shaw, and the Society is deeply indebted to her for clearing up much of the disorder that had resulted from a number of causes. In March, Mr. J. V. Pearman agreed to accept office as librarian, subject to certain limitations.

During the year there have been one hundred and six borrowings of books for home reading. No figures are available of the number of visits for reference purposes only.

Gifts of books have been received from Miss A. Morley and Mr. L. Harrison Matthews, and the thanks of the Society have been conveyed to the donors.

An exchange was effected with Professor J. W. Carr of Nottingham, who desired to receive a number of parts of our *Proceedings* to complete the series he was presenting to University College, Nottingham. In return, he has sent bound copies of his " Invertebrate Fauna of Nottinghamshire " and the " Supplement " thereto.

The annual volumes of the Ray Society and of the Zoological Record, for which this Society subscribes, have been received, and the usual exchange of publications with British and foreign societies and institutions has been made.

As hitherto, the Entomological, Geological and Ornithological Sections have presented the leading journals dealing with their respective interests.

Under the bequest of the late Miss I. M. Roper, several books from her library have been received. These will shortly become available for consultation and will be of especial interest to the Botanical Section.

The condition of the library is, in many respects, not so satisfactory as could be desired.

There is need for up-to-date works on various subjects. In 1923 Council was able to make a grant of £30 for the purchase of volumes for which a demand had arisen in the Sections, but since then no funds have been available for restocking, and additions of books, other than periodicals, have been due to the generosity of individual members.

On the other hand, the influx of scientific periodicals and memoirs received from societies and institutions to which we send our *Proceedings* shows no abatement, and it is becoming difficult to find shelf-room for them. Apart from their monetary worth, which exceeds the cost of our part of the exchange, these publications, in their subject matter, form a very valuable part of our library. But their value is diminished if they cannot be made readily available to members by being properly bound and displayed. The provision of additional shelving will have to be considered seriously in the near future.

Bookbinding is much in arrear ; over two hundred volumes await binding. For many years past most of the expense of binding has been met by donations from members, particularly the late Mr. Horace Gummer. These funds are now exhausted, and a means of replenishing them should be found.

Stocktaking, re-arrangement and re-cataloguing are all desirable. The general manuscript catalogue is complete and comprehensive, but the entries are becoming crowded. A classification under subject headings, in addition to the orthodox arrangement under authors' names, would facilitate reference to the books. The card index, on which much labour was expended, has been compiled on mistaken lines and is practically useless.

Now that a standing Library Committee is in being, it will be possible for better consideration to be given to the improvement of conditions. But the primary needs are for increased financial aid and for the services of a self-sacrificing librarian who can find time to devote, not only to the current routine of his office, but also to the labours of re-organisation, which the present *locum-tenens* is unable to do.

J. V. PEARMAN, *Hon. Librarian.*

REPORT OF BOTANICAL SECTION

1935

THE Section has continued to hold monthly meetings on the third Monday in each month, except August, in the Botanical Department of the University.

Professor M. Skene was elected President, and Mrs. Bell was invited to occupy the chair at meetings in the place of Miss Roper, who resigned on account of ill-health.

The number of members has been maintained and now stands at 29. The practice of having short papers during the winter, when the number of exhibits is lower than in the summer, has been continued.

At the February meeting, Mr. Glasspool dealt with Biblical Plants, and this was followed by an account of the Flora of present-day Palestine by Dr. Druce, published in the Report of the Botanical Society and Exchange Club, 1925. This latter account was read by Mrs. Bell.

"Liverworts" formed the subject of the paper given by Miss Bowen at the March meeting. Fresh and mounted specimens were exhibited and prepared microscope slides were shown by means of the micro-projector.

During the summer, the exhibits were sufficiently numerous to occupy the whole of the meetings, and short papers were not re-introduced until 21st October, when the first of the Open Sectional Meetings was held. Of the eighteen members present, only three were visitors from other sections.

Short papers were given and were illustrated by fresh and dried specimens, diagrams and photographs. The papers given were as follow :—

Mrs. Sandwith : Unprincipled Plants.

Mr. Evans : Reseda.

Miss Bowen : Lycopodium.

Mrs. Bell : Wolffia.

Mr. Luckwill : The Ecology of Blackdown.

A paper by Mr. Glasspool on Potamogetons was held over until the November meeting owing to lack of time. At the end, the visitors expressed their appreciation of the work carried out by the Section.

Professor Skene exhibited a number of living specimens on Dec. 16th, and, in his unavoidable absence, a description of them was given by some of the members present.

The Section has sustained a great loss again this year by the death of Miss Roper, who, with very few exceptions, had occupied the Chair at the Section meetings since 1925. An appreciation of the work done by Miss Roper, not only for the Section, but for Natural History generally, was expressed by Mrs. Bell at the July meeting.

F. F. GLASSPOOL, *Hon. Secretary.*

REPORT OF ENTOMOLOGICAL SECTION

1935

SEVEN meetings were held during 1935 as follow :—

29 *Jan.* Seventy-first Annual General Meeting. Mr. C. Bartlett was re-elected President and Hon. Secretary.

Mr. A. H. Peach exhibited a varied series of specimens of the family *Lycænidæ.*

20 *Feb.* The meeting was held at the University and was open to members of the Society who were not members of the Section, the President, Mr. G. E. J. McMurtrie, and four others attending.

The following members gave notes and exhibited specimens, many being displayed on a screen by the epidiascope :—

Mr. H. Tetley, *Tabanidæ* ; Mr. J. V. Pearman, *Psocidæ* ; Mr. W. R Taylor, illustrations of protective resemblance, mimicry and warning colours, and the association of Ants with *Macrolinea arcin,* the Large Blue ; Mr. H. Audcent, *Oncodes* ; Mr. C. Edwards, *Bombus* ; Mr. J. W. Norgrove, *Saturnia carpini* and *Orgyia antiqua* ; Dr. E. B. White, *Xylina conformis,* with notes upon its occurrence in South Wales ; Mr. C. Bartlett, examples and coloured drawings of seven orders of British Insects.

12 *March.* Mr. W. R. Taylor read a paper upon British Hunting Wasps.

9 *April.* Mr. C. Bartlett, Notes upon the genus *Agrotis,* with examples of all the British species.

15 *Oct.* Mr. C. Edwards, Notes on British Ants.

5 *Nov.* Dr. E. B. White, Notes upon the History of *Lygris reticulata* and *Penthina postremana,* formerly associated with the local yellow balsam, *Impatiens noli-me-tangere,* in the Lake District.

10 *Dec.* Mr. C. Bartlett, Paper on the History of the Genus *Luperina,* illustrated by varied specimens.

The members have in addition contributed a large number of notes and exhibits of interesting specimens and aberrations.

In addition to the loss the Society and Section have suffered through the death of Miss I. M. Roper, F.L.S., who was a constant attendant at our meetings, the Section regrets to report the death of Preb. A. P. Wickham, M.A., F.R.E.S., of East Brent, President of the Entomological Section of the Somerset Archæological and Natural History Society, who was an honorary member of the Entomological Section of B.N.S.

CHAS. BARTLETT, *Hon. Secretary.*

REPORT OF FIELD SECTION

1935

AN American is credited with saying that "a report is the essence of statistical dullness." Notwithstanding, annual reports are traditionally an important part of any Society, and even the cynic must admit that they serve several useful purposes.

The year has witnessed the consolidation of the new classes of membership initiated by the late Professor O. V. Darbishire.

At the Annual Meeting, Dr. F. S. Wallis and Mr. G. H. Beacham were re-elected President and Vice-President respectively. Mrs. H. F. Barke was elected Hon. Treasurer in succession to Miss T. Shaw, and Miss M. D. Hiley continued to serve as Hon. Secretary. The President made reference to a recently published novel entitled "The Search," by Dr. C. P. Snow. He said that the principle that science is a quest for truth formed the ever recurring background of the book, and this principle, he felt, should form the basis of all work undertaken by the Field Section. He then proceeded to elaborate details of the theme.

Although she was never an officer of this Section, members, in common with the members of the parent Society, acutely feel the irreparable loss of Miss Ida M. Roper. Her sympathetic help was always available, and many remember her aid when the original Field Club became the Field Section of the Bristol Naturalists' Society.

Following the practice of recent years, a definite district was selected for study, and members concentrated their attention on the well-defined ridge of hills which stretches from Leigh Woods through Failand to Clevedon and thence along the coast to Portishead. The usual inset of descriptive notes accompanied the programme, and the Section is indebted to Professor S. H. Reynolds and Messrs. Charles Bartlett, H. Stuart Thompson and H. Vicars Webb, who kindly supplied the manuscript for this purpose.

The opening meeting in May, under the leadership of Mr. Ivor Evans, was held in the Abbots Leigh and Failand area. Bird-life was fairly quiet, but members were able to observe the following: Blackcap, Willow Warblers, Whitethroat, Cuckoo and Hedge Sparrows. The relationship of the scenery to the underlying rock structure and composition was stressed at many places.

In July, the Clapton-in-Gordano and Cadbury Camp districts were visited under the leadership of Mr. and Mrs. H. F. Barke. Mr. G. H. Beacham acted as co-leader in botany, and amongst the plants seen may be mentioned Viper's Bugloss, Rose Bay Willow, St. John's Wort, Black and White Bryony and several Thistles and Orchids.

East Clevedon, with Mr. G. E. J. McMurtrie as leader, was the centre of investigations in September. A very instructive time was spent on the flanks of Salt House Hill, and members were interested in the architectural features of the old church. The botanists at this meeting were active under the guidance of Mr. Ivor Evans.

Mr. G. H. Beacham concluded the scheme in October by leading members along the main portion of the Clevedon-Portishead ridge. Mr. H. F. Barke explained the principal geological features, and many instructive cliff sections were noted.

The average attendance for these meetings was 26.

Again the Section was responsible for the arrangements in June when the Society visited Orchardleigh Park and Vallis Vale. At Orchardleigh Church, the Rev. H. Vaughan-Johnson, M.A., kindly met the party consisting

of over 50 members. The Murtry Hill Stones were examined, and, as usual, Vallis Vale provided a wealth of material for all naturalists.

This year, the Section was officially asked to contribute notes to the *Proceedings* of the Society. Several members helped in this way, and it is hoped that this feature of the Section's activities will be continued.

Mr. H. Vicars Webb again made himself personally responsible for several meetings for the purpose of ornithological observations, and has contributed the following notes :—

Saturday, 4 *May*. Newton St. Loe District. A fairly good time for birds. The movements of a female Cuckoo watched at close quarters. Songsters included Willow Warblers, Chiff-chaff, Whitethroats, Blackbird, Thrush and Robins. Swallows and Martins on the wing.

Wednesday, 15 *May*. Norton Malreward. Dry, but cold wind did not favour songsters. A family of Waterhen chicks seen in a wayside pool. Others heard or seen were Cuckoo, migrant Warblers, Swallows, Martins and Swifts, and a Dipper on a stream.

Saturday, 25 *May*. Blagdon Lake. At the lake, where Mr. Donald Carr was met, were scores of Swallows, Martins and Swifts eagerly taking flies. Two beautiful pairs of Great Crested Grebes were seen, also a Little Grebe or Dabchick, a Coot's nest with seven eggs in the reeds, active Lapwings, Warblers and resident species in song. On the forward journey, Rickford Glen revealed all its Maytime beauty.

Wednesday, 12 *June*. From Filton to Stapleton. A gloomy evening, and songsters were few. A Blackcap heard in song from a wood covert. At the Duchess Pond, Swans and a Coot on the islet.

There was an average attendance of 11 members at these meetings.

Mr. Ivor Evans has similarly supplied the following in reference to the botanical meetings :—

Saturday, 27 *April*. Brislington to Hanham. The route taken was through fields to River Avon, crossing the ferry, returning via river side and Trooper's Hill. Following observed :—Bush Vetch, Hairy Rock Cress, Vernal Whitlow Grass, three varieties of Forget-me-nots, Crosswort, Ivy-leaved Crowfoot, etc. *Trees :* Barberry, Pear, Sycamore, Oak, Hornbeam, and various grasses.

Saturday, 25 *May*. Blaize Castle. The party was personally conducted by the Head Forester, and grounds, woods and nurseries were inspected. Various trees and shrubs were noted, amongst them being Rhododendrons, Maidenhair Fern tree, and species of Pinus ; also woodland plants in season. Special notice was drawn to magnificent colonies of Hartstongue Fern.

Saturday, 8 *June*. Visited the Forest and Orchard nurseries at Milbury Heath and were personally conducted over the spacious grounds by the manager, Mr. E. J. Ingleby. Various stages of fruit tree growth were explained and other botanical specimens examined. The party returned to the Ship Inn, Alveston, and were the guests of their guide.

Saturday, 6 *July*. Pensford and Keynsham. Train was taken to Pensford, and the Chew Valley inspected, returning from Keynsham. Following botanical observations :—Water Parsnip, White Stonecrop, Cudweed, Vervain, Goatweed, Ivyleaved Toad Flax (white), Water Ragwort, Spear Plume Thistle, Stone Parsley, trees, grasses and ferns of various types noted.

Saturday, 10 *August*. Bitton to Upton Cheney. Mr. G. H. Beacham deputised for the leader. Route to Upton Cheney was along the River Avon, where riverside plants were noted, and then the upland lanes and fields were inspected with various plants and trees in seasonal abundance.

The average attendance at these meetings was eleven.

M. DORIS HILEY, *Hon. Secretary.*

REPORT OF GEOLOGICAL SECTION

1935

IT is gratifying to be able again to report that our numbers continued to increase, though slightly. During the year five members resigned, but six new members were admitted ; so we are one up on balance, the present roll containing 61 names.

We continued to subscribe to the *Geological Magazine*, but the Hon. Secretary would like it to circulate among more members.

At the Annual General Meeting of the Section in January, the following were elected as Officers for the year 1935 :—Professor A. E. Trueman, President, in place of Professor S. H. Reynolds, who had held the office since 1901, and now felt obliged to retire ; Dr. F. S. Wallis, Vice-President ; Mr. H. C. Shilstone, re-elected Hon. Secretary ; Mr. G. E. J. McMurtrie, re-elected Hon. Auditor ; Mrs. M. Marsden, Hon. Treasurer ; and Committee—Mr. H. F. Barke, Mrs. H. F. Barke, Mr. G. A. Kellaway, Mr. J. W. Tutcher, Professor S. H. Reynolds and Dr. S. Smith.

At the conclusion of business, Professor Reynolds lectured on "The Musk Ox in Britain."

In February, Professor A. E. Trueman lectured on "The Geology of Southern Norway," fully illustrated by lantern slides and by specimens collected by the lecturer in Norway.

In March, we held an "Open Meeting" to all B.N.S. Sections, and three papers were read and discussed :—(*a*) Mr. F. B. Tombleson, "Some Notes on Fossil Bryozoa" ; (*b*) Dr. F. S. Wallis, "Some Carboniferous Cephalopods from Shipham, Somerset" ; (*c*) Dr. Stanley Smith, "The Portishead Borehole."

A presentation to Professor S. H. Reynolds, to mark the great appreciation of the members of this Section of his valuable services, and the close of his unusually long tenure of office, extending over no less than 34 years, formed an interesting feature of this meeting.

During the summer session, three Field Meetings of the Section took place :—

(*a*) In April we visited Uphill and Bleadon, and inspected the Carboniferous Limestone quarries at Uphill Wharf, the quarries and fossiliferous Pleistocene breccia deposit at Bleadon, and the extensive exposure in the new cutting for the by-pass road at Uphill. Mr. G. A. Kellaway, who had read a paper last year on the work he and Dr. K. P. Oakley had done on this cutting, was present to describe the results of their labours. (Their joint Paper was printed in 4th Ser., Vol. VII, Pt. VI, of the *Proceedings*.)

(*b*) In June we made an interesting early evening charabanc tour of the northern part of the Bristol Coalfield, under the direction of Professor A. E. Trueman.

(*c*) In September we visited the great quarry at Chipping Sodbury, under the leadership of Professor Reynolds. The Carboniferous Limestone here is overlain by Rhætic and later deposits ; the unconformability of the latter to the Limestone is most marked.

In October, Professor A. E. Trueman again lectured, his subject being "The Geological History of Welsh Scenery." A most interesting and instructive lecture.

In November, Professor S. H. Reynolds lectured on "The Geology of the Belfast District." The visit to Belfast was made by Dr. Reynolds in connection with the Geologists' Association, and the lecturer exhibited many entirely new lantern slides, and a large collection of rock specimens gathered there by himself.

The Hon. Secretary wishes to call attention to the Tutorial and Discussion Class which precedes each ordinary winter meeting. The class is fairly well attended but many more members could find it of the greatest use and interest, and their future attendance is especially invited. Moreover, we have not enough members whose special interest is Mineralogy. I hope we shall improve in this direction.

Early in the autumn, a letter from Professor Trueman appeared in *The Times* calling public attention to the lack of systematic Geological teaching in the national scheme of Education. Since then, a popular two-term Saturday morning class in Geology has been started at Bristol University. The class is well attended and has been successful from the start, and several of our members are attending the course.

HY. CUTHBERT SHILSTONE, *Hon. Secretary.*

REPORT OF ORNITHOLOGICAL SECTION, 1935

THE number of members has fallen slightly after the reorganisation scheme of the Society, but still remains at a satisfactory total. There have been the usual six meetings as well as a visit to Steep Holm in May, and observations on this and other occasions have been contributed to *British Birds* and the *Annual Report of the Somerset Archæological and Natural History Society.*

The meetings have been varied: Mr. K. B. Rooke gave a full account of observations on Birds of Newfoundland made while he was Ornithologist to the Public Schools Exploring Society in 1934; Mr. Savory, details of a visit to a bird reserve in North Holland; Mr. W. B. Alexander, at the Open Meeting in November, described the work being done by the British Trust for Ornithology at Oxford under his direction, but only three members were present, apart from members of the Section. This was a poor compliment to him, as he had come specially from Oxford to give an account of work that is of great importance to Ornithology. Several members paid visits to East Anglia during the summer and described, at the December meeting, the many interesting birds seen there.

As in the past two years, a visit was paid to Steep Holm; the number of Cormorants nesting there had increased to about 16 to 19 pairs, and the Great Black-backed Gulls also showed an increase. A full list was made of all birds seen.

The autumn migration brought to Barrow Gurney a bird new to Somerset, the American Pectoral Sandpiper, which was seen there from September 28th to October 3rd inclusive. The normal migration of this species is from North to South America, but about forty have occurred in the British Isles. Its presence may have been due to the S.W. to W. gale earlier in the month, which provided many birds of interest on the Somerset coast. Details of this, as of the remarkable numbers of duck seen at the reservoirs in December, will be found later in this issue of the *Proceedings.*

H. TETLEY, *Hon. Secretary*

Account of the Annual and General Meetings

THE 72ND ANNUAL MEETING was held at the University on 17 January, 1935, with Dr. F. S. Wallis, Vice-President, in the chair. Mr. G. E. J. McMurtrie was elected President, and Mr. H. Savory Vice-President. Miss T. Shaw was appointed Acting Secretary and Librarian during Miss Roper's illness. The other officers were re-elected, and there were minor changes in Council. The usual annual reports were presented and adopted. Owing to the death of the retiring President, Professor O. V. Darbishire, M.A., Ph.D., Dr. F. J. North gave a paper on "Coal."

Dr. North explained that the object of the lecture was to show the bearing which research into the constitution of coal had upon its utilisation. Although coals were so variable in their chemical and physical properties, they all belonged to one great series of natural products and were more or less related. Researches that appeared purely academic in their outlook, and in some cases were undertaken with a view to determining the origin of coal and the conditions that obtained in the forests where the coal substance occurred, had often proved to be of great importance as leading to a better understanding of the properties of the substance. They also formed the basis of further work with a view to the better utilisation of coal as a fuel, and its treatment as a raw material for the manufacture of other fuels and material of totally different application.

THE 575TH GENERAL MEETING was held on 7 February, 1935, taking the form of the Eighth Annual Dinner. This was held under the Presidency of Mr. G. E. J. McMurtrie at Bright's Restaurant, Queen's Road, and over 50 members and friends were present. Dr. A. B. Rendle, F.R.S., late Keeper of Botany at the British Museum (N.H.), was the guest of the evening and proposed the toast of "The Society." Dr. Rendle mentioned the valuable aid which he had received from the material lent him by the Bristol Museum and Art Gallery, and also gave an interesting account of his visit to Jamaica and the Bermudas, drawing special attention to the local plants. He said that many of the beautiful native shrubs had been threatened by the preponderance of introduced species. The President replied on behalf of the Society, after which a programme of songs and recitations was provided.

THE 576TH GENERAL MEETING was held at the University on 8 March, 1935, with the President, Mr. G. E. J. McMurtrie, in the chair. The resignation of Miss I. M. Roper as Hon. Secretary and Librarian was received with regret, and a special vote of thanks and sympathy was accorded to her. Miss M. D. Hiley was elected Hon. Secretary. Mr. H. Tetley, B.Sc., then gave an account of Zoology in a modern museum. He explained the general system of the arrangement of the exhibits in the Bristol Museum and Art Gallery and stressed the need for provision of habitat groups. He said that museums now concentrated on small exhibits illustrating special points, whilst they built up reserve stores of material available for the student and specialist. The lecture was illustrated by lantern slides and provoked a discussion.

THE 577TH GENERAL MEETING on 15 June, 1935, was held at Orchardleigh Park and Vallis Vale, Frome. The members were met at Orchardleigh Church by the rector (Rev. H. Vaughan-Johnson, M.A.), who pointed out the chief features of this 13th century island church. Several water-birds were noted by the lakeside; members passed on to the Murtry Hill Stones, which consist of the fragmentary remains of a long, chambered barrow.

After tea, Vallis Vale was visited and here Mr. Vicars Webb, Mr. B. W. Weddell and Dr. F. S. Wallis respectively described the birds, moths and butterflies, and rocks.

During the meeting Mr. G. E. J. McMurtrie referred to the great loss which the Society had sustained in the death of Miss Roper.

THE 578TH GENERAL MEETING was held in the University on 3 October, 1935, Dr. F. S. Wallis, Vice-President, being in the chair. Many members showed exhibits and gave short talks.

Mr. H. Savory showed a series of photographic enlargements which included Spoonbills and Sandwich Terns in Holland and various sea birds at Lundy Island. Mr. H. Tetley exhibited various skulls of Gorilla in the collections of the Bristol Museum and Art Gallery and commented upon their historical associations. Mr. F. C. Coombs exhibited photographs of Rooks in a rookery near Bristol.

The Botanical section provided a luxuriant display of living plants, the majority of which were wild and were collected by Mrs. A. G. Bell. Mr. H. Stuart Thompson gave a brief survey of some of the varieties exhibited, and showed a series of selections from his herbarium of Hornbeam and Whitebeam trees. Mr. Ivor Evans showed examples of the Sea Spleenwort from Flat Holm and the Wild Peony from Steep Holm, whilst Mrs. Sandwith exhibited living water plants and a series of detailed diagrams illustrative of their life history.

In the Geological Section, Professor S. H. Reynolds showed a series of reptilian vertebræ with photographs; Mr. J. W. Tutcher a series of fossil plants with photographs of Somerset mines; Mr. B. A. Baker a specimen of celestine; Mr. H. W. Turner an example of Dalradian schist showing faulting; Dr. Stanley Smith rocks from the Portishead borehole, and Cornish Devonian fossils, and Mr. L. R. Moore a fossil Eurypterid. Mr. G. A. Kellaway spoke on the correlation of coal seams by means of microspores, illustrating his remarks by experiments and microscopic slides.

THE 579TH GENERAL MEETING was held in the Lecture Theatre of the Bristol Museum and Art Gallery on 7 November, 1935, the President, Mr. G. E. J. McMurtrie, being in the chair. This was an Open Meeting, and there was a large attendance which included many pupils from local schools. During the evening, four natural history films were shown, which were described by Professors Macgregor Skene and C. M. Yonge. Professor Yonge dealt with the Amœba and described the life history of this simple form. Professor Skene followed by supplying comments on the films of the Filter, the Roots of a Plant, and the Life Cycle of a Plant. The occasion was the first on which films were used at a meeting of the Society, and the members present felt that it was eminently satisfactory.

THE 580TH GENERAL MEETING was held at the University on 5 December, 1935. The President, Mr. G. E. J. McMurtrie, was in the chair, and the evening was devoted to a discussion on the Wegener theory of drifting continents.

Professor A. E. Trueman, in opening, said that the hypothesis of moving continents was welcomed by some scientists as offering an easy explanation of many awkward facts of distribution, and was condemned at once by others because it was so contrary to so many earlier views. This period of ready acceptance or wholehearted condemnation was now over, and geologists and others were seeking to re-examine the position in a more scientific mood. He emphasized the fact that geophysical considerations appeared to indicate that continents and ocean floors were of different structure, and that no part of a continent had ever been an ocean floor.

The similarity of eastern America to the west coasts of Africa and Europe, and the comparison of underlying structures, supported the view that there may have been no Atlantic Ocean when many European rocks were laid down. Whilst drift on the lines suggested by Wegener may not be demonstrable, many mountain chains had resulted from the movement of one continental mass towards another, and it was certain that in the past the relative positions of the continents had been at least somewhat different from those of the present.

Many members took part in a spirited debate.

M. DORIS HILEY, *Hon. Secretary.*

Ida M. Roper (1865-1935)

AMONG the many activities of the late Miss I. M. Roper, F.L.S., who was born in Bristol in 1865 and died June 8th, 1935, perhaps the most important was her interest in and official connection with this Society. Although she had been in ill health for nearly a year, it was chiefly for the B.N.S. that at times she bravely continued her work. She had been Hon. Secretary and Editor for nineteen years, Hon. Librarian a long time, and was President 1913-1916.

Her first and most important Presidential Address was on "Some Historical Associations of Flowers." It showed considerable research. The next was entitled "Permanency in the Growth of Plants," and that in 1916 on "Mistletoe" indicated wide observation on the host-trees of that parasite. Miss Roper also wrote a "Report on the Condition of *Spartina Townsendi* below Clevedon, Somerset" (*Proc.* for 1919). This explained "the experiment made on this exposed and tide-swept shore" by the planting of Cord-grass against coast erosion.

Apart from her ordinary work in the Society's Library, she made a Catalogue of most of the botanical papers and books there. In the preface to the late J. W. White's excellent "Flora of Bristol," 1912, he pays a well-earned tribute to Miss Roper to whom he "owes much, not only for field-work but for assistance in literary research and in revision and correction of the press."

A most helpful and greatly appreciated piece of work was her thirteen years' collecting and exhibition of local wild plants at the Bristol Museum. Her own herbarium of British flowering plants and ferns was given to the University of Leeds shortly before her death, together with many of her botanical books.

Miss Roper was considerably interested in British Violets; and in 1917 she found near Wickwar a new variety of *Nitella mucronata,* which Messrs. J. Groves and Bullock-Webster described as var. *gracillima* in *Journ. Bot.*, 1917, p. 324. Though over a dozen short notes by her appeared in the *Journal of Botany,* these and a few longer articles were of less real importance than the great help she gave in furthering a love of field botany in Bristol and in connection with Societies in several parts of England. Her frequent attendance at British Association and other meetings, e.g., those of the British Bryological Society, made her widely known and her energetic personality much appreciated. At the Bristol Meeting of the British Association in 1930, she acted as Local Hon. Sec. for Section K.

Photo: Veale & Co., Bristol]

Miss Ida M. Roper, F.L.S.

[*To face p.* 26

In the late Col. Jermyn's "Notes on the Diptera of Somerset" Pt. V (Appendix) in *Somersetshire Arch. and N. H. Soc. Proc.*, for 1922, Miss Roper's work on Plant Galls is acknowledged. She was from 1920 a member of that Society and of its Botanical Section Committee. Her paper on "The Earliest British Herbal" was published in that Society's *Proceedings* for 1921 (1922). She also served on the Council of the Bristol and Gloucestershire Archæological Society, for she had done some useful work in Archæology. Monumental effigies had long been a hobby, and she had visited most of the churches in Gloucestershire and Bristol and many in Somerset to collect information and make rubbings. In 1930 was published her handsome volume on "The Monumental Effigies of Gloucestershire and Bristol," with an Introduction by Sir Roland Austin.

H. S. T.

EDITORIAL

LAST year it was our pleasant duty to pay tribute to the long and devoted work of the former Editor, Miss I. M. Roper, but scarcely was the *Proceedings* in the hands of members before they received the news of her lamented death. In several places in the present issue—notably in Mr. H. Stuart Thompson's obituary of her—reference is made to Miss Roper's work for the Society, and we hope to be able to give an account in our next issue of the manner in which the Society will perpetuate her memory.

The Society has also during the year lost the services of another who, though not a member, nevertheless assisted the Society in many ways over a long period. As Steward of the Geological Department of the University for so many years, Mr. J. E. Livingstone was brought into intimate contact with the Society, and a great many members will long cherish a recollection of his cheery and unselfish readiness to assist them whenever he was asked. His services as a lanternist have been in constant demand, and his skill as a photographer has frequently been seen in these pages. To his painstaking work also we owe the lists of Geological publications compiled in the Geological Department of the University and published in the *Proceedings*.

It is a matter for much satisfaction that the Society is able in this issue to republish in revised form the late Dr. Vaughan's paper on the Avonian. That this has been possible without infringing upon the space required for other matter is due to the generosity of those who have enabled us to produce on this occasion a much enlarged part; a list of the names of contributors to the special fund for this purpose appears with the paper. The Society's thanks are also due to Professor S. H. Reynolds who is primarily responsible for the revision of the paper and for the new matter which it contains.

We welcome in this issue also the reappearance as a feature of the notes on Bristol Botany for which the late Mr. J. W. White was so long responsible. We now owe their compilation to Mrs. Sandwith.

THE CARBONIFEROUS LIMESTONE SERIES (AVONIAN) OF THE AVON GORGE

BY

ARTHUR VAUGHAN, B.A., D.Sc., F.G.S.

Revised with certain additional sections by

S. H. Reynolds, M.A., Sc.D., F.G.S.

PREFACE

The late Dr. Vaughan's paper on the Avonian of the Avon Gorge has been for some years out of print, and the frequent enquiry for copies points to the desirability of a new issue.

Much consideration has been given to the question of what modifications should be made in the original paper. It consisted of four parts: (1) Introduction; (2) The Section on the Clifton side; (3) The Section on the Leigh Woods side; (4) Notes on the Genera of Carboniferous Corals and Brachiopods. The Introduction is reprinted practically as it stands. As regards parts 2 and 3, the construction of Portway and the destruction of the Hotwells section of the Avonmouth railway have altered the topography and made it necessary to introduce many small changes in the text, but, in the main, parts 2 and 3 remain much as they were originally. On the other hand, a considerable amount of fresh matter, particularly as regards the lithology, has become available. It would be difficult to work this in with Vaughan's original description and it has, on the whole, seemed best to print it separately although this procedure causes a certain amount of repetition. It forms part 2B of the present paper.

In the Palæontological portion of parts 2 and 3, Vaughan's original names are retained, but the table on p. 43 shows the present-day equivalents. Dr. Helen M. Muir-Wood has kindly drawn up the part of this table which has reference to the Brachiopods, and Dr. Stanley Smith that which is concerned with the Corals.

Vaughan states that part 4 was intended for the use of students who already have a general acquaintance with the structure of fossil Corals and Brachiopods but are unacquainted with the generic distinctions which have been made in recent years. Experience has, however,

shown that the demand for the paper is quite as great among more advanced workers on the Carboniferous Limestone as among other students. Dr. Helen Muir-Wood, as regards the Brachiopods, and Dr. Stanley Smith, as regards the Corals, consider that these sections are now out of date, and had best be omitted. Vaughan's original part 4, therefore, finds no place in the present issue.

The photographic illustrations have been remodelled and, though the actual number of plates is reduced, the number of illustrations is increased. Lettering on the photographs themselves has been adopted in place of the transparent tissues. S.H.R.

January, 1936.

The Society desires to record its thanks for the generous assistance given in defraying the cost of re-publication of this paper. But for the donations received from those geologists and others mentioned in the subjoined list, it is extremely doubtful if the paper could have appeared in its present form with the many illustrations from Professor Reynolds' photographs.—Ed. *Proc. B.N.S.*

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CONTENTS

I. INTRODUCTION

THIS paper is intended to serve as a geological guide to the grand section of Carboniferous Rocks which is exposed in the Avon Gorge. It is hoped that a visitor who is interested in the geology of the Gorge will, without further aid than this manual, be able to recognize the various phenomena to which attention is drawn, and to test the interpretations which are here suggested.

The technical knowledge which is postulated is of the most elementary kind, for I deem it more useful to attempt to arouse the interest of the student than to set out a concise disquisition for the delectation of the Carboniferous specialist.

Since the paper deals mainly with the establishment and analysis of the faunal succession, it has been necessary to introduce a brief statement of the biological principles upon which the zoning of the Lower Carboniferous Rocks has been carried out, and also to point out certain fundamental phenomena which characterize faunal variation.

Lastly, since this manual is confessedly a compilation, I have seen no reason for nicely allotting the credit for each fact, and for each law, to its first discoverer.

History It would be a laborious, if not an unprofitable, task to collect all the references which have been made by earlier writers to the rocks and scenery of the Avon Gorge. I shall consequently content myself with references to the work of those few geologists who have examined the section systematically and with the purpose of some definite line of research.

Nearly a century ago, in a paper entitled "On the Limestone Beds on the River Avon, near Bristol,"[1] George Cumberland gave a minute

[1] *Geol. Trans.* (1811 *and* 1818).

description of each bed in the Avon Section and, although the old-time terminology sounds strange, it is not difficult to recognize certain of the best known horizons from the writer's descriptions.

Some sixty years later,[1] W. W. Stoddart undertook a detailed examination of the Carboniferous Limestone Series of the Avon, with the view of compiling an exhaustive record of the fossils found in each bed. An analysis of Stoddart's paper, in so far only as it deals with Corals and Brachiopods, will be found, set forth at considerable length, in my paper on the Bristol Sequence.[2]

In 1885,[3] Prof. C. Lloyd Morgan, LL.D., F.R.S., F.G.S., published an extremely suggestive account of the Avon Gorge in which he pointed out the broad principles which have governed the formation of the Gorge itself and of its tributary depressions. The magnitude of the "Great Fault" and its extension on the Leigh Woods side of the river are also discussed in the same paper. The present communication will, it is hoped, serve as a necessary complement to the work of Prof. Lloyd Morgan by filling in detail, where he has already firmly sketched the broad outline.

Mr. E. B. Wethered, F.G.S.,[4] has dealt with the micro-structure of the rocks which form the Avon Sequence and has classified the local development of the Lower Carboniferous Rocks into broad lithological divisions.

From 1902 to 1905, I was engaged upon the detailed examination of the Carboniferous Limestone sequence in the Bristol Area, with the special object of determining the faunal sequence and of setting out a series of life-zones. The results of this investigation are described in my paper, "The Palæontological Sequence in the Carboniferous Limestone of the Bristol Area," to which reference has already been made. In this paper the Avon Section is described in considerable detail and is adopted as the type-section for the Avonian of the South-Western Province.

[1] *Proc. Bristol Nat. Soc. n.s. vol. i.* (1875), p. 313.

[2] *Quart. Journ. Geol. Soc.* (1905), *vol. lxi.* p. 200.

[3] "Subaerial Denudation and the Avon Gorge." *Proc. Bristol Nat. Soc. n.s. vol. iv.* p. 171.

[4] "On Insoluble Residues obtained from the Carboniferous Limestone Series at Clifton." *Quart. Journ. Geol. Soc. vol. xliv.* (1888), p. 186.

Fossil Notation The following definitions explain the precise meaning which is to be attached to the conventional symbols employed in the designation of fossils throughout this paper.

A SPECIES is a form so completely described that the characters of two individuals, both of which are correctly referred to the same species, can only differ in degree of expression; furthermore, all the individuals which constitute a species must be continuously connected in time. (An individual in which all the characters of a certain species are reproduced, but which came into existence long after that species had died out, cannot be correctly assigned to the same species.)

The whole assemblage, which is composed of the ancestors, descendants and collateral relatives of a given species, constitutes the GENS of that species and is denoted by prefixing "aff." to the specific name. Thus, *Productus* aff. *semireticulatus* denotes *any* member of the gens, of which *Prod. semireticulatus* (Martin) is a well-known member.

In the case of a long-lived gens, an early member usually differs sufficiently from a late one to constitute a new species. All such time-variants of a given gens are here referred to as MUTATIONS of the gens, and the time at which a given mutation flourished is indicated by the addition of a zonal or subzonal symbol to the abbreviation "mut." Thus, *Spirifer* aff. *bisulcatus*, mut. C. implies a species which existed at the time indicated by the zonal symbol C. and is a member of the gens containing *Spirifer bisulcatus*, J. de C. Sow.

A HOMŒOMORPH is a form which strongly resembles the species with which it is compared, although it is presumably not a member of the same gens. Homœomorphy is indicated by inserting "cf." before the specific name of the form with which comparison is made. Thus, *Orthotetes* cf. *crenistria* bears a strong resemblance to "*Spirifera*" *crenistria*, Phillips (as typified by the specimen preserved in the Gilbertson Collection), but the two species are presumably not members of the same gens since Phillips' species appears to be a *Derbya*, whereas the form which is here denoted by *Orthotetes* cf. *crenistria* is a true *Orthotetes*.

The Theory of Zoning Stratigraphical Zones are subdivisions which succeed each other always in a definite order; they may be defined by

the occurrence of a particular rock-type ("Lithozones"), or by some faunal particularity ("Biozones").[1]

Lithozones, by their very nature, can only determine horizons within a very limited area and must always be employed with great caution.

For example, the "*laminosa*-dolomites," the "*Caninia*-oolite" and the "*Caninia*-shales" and "-dolomites" succeed one another in ascending order throughout the Bristol Area, but their relative thicknesses vary considerably from point to point, and the sequence cannot be recognized in the Mendip Area which lies only a short distance to the south.

On the other hand, a sequence of biozones may be of world-wide application and, however ill-chosen, must always express some portion of the truth, seeing that the definition of a biozone must always be the record of part of the fauna which existed during a definite interval of relative time.

It is, however, easy to understand how a series of biozones, defined by the successive faunas of a particular locality, may appear to fail when applied to a more extended area.

For, let us suppose that three successive zones at a certain locality indicate oscillatory succession of conditions, as expressed by the ascending sequence :—

A, containing a normal shallow-water fauna ;
B, containing a normal fauna of moderate depth ;
C, containing a normal shallow-water fauna.

The faunas of A and C will be essentially similar, and that of B markedly different, since the life-assemblage at different bathymetric levels is distinct.

If, now, the fauna of C, while presenting the same broad generic facies, differs from that of A in the introduction of new species in place of old ones, it will be perfectly legitimate to select the faunas of A and C as defining two successive biozones. In so doing, we implicitly adopt shallow-water conditions as our standard conditions for purposes of zoning and, consequently, the complete series of biozones must express the successive shallow-water faunas throughout the whole interval which is to be zoned.

[1] Dr. W. J. Arkell kindly points out that Vaughan uses the term "Biozone" in the sense of "Faunizone" as defined by Buckman in 1902, and also that the term "Biochron" (H. S. Williams, 1901) should be used as the time equivalent of a "Biozone." (See W. J. Arkell, *The Jurassic System in Great Britain*, pp. 21-23, 34).

The fauna of B would be very incorrectly set down as constituting a zonal assemblage intermediate between those of A and C, for it is impossible to discover, either how early in the zone of A the fauna of B became established, or how late it persisted into that of C. Hence B must be regarded as an interruption of the zonal sequence.

Any such interruption of a zonal sequence, by deposits formed under conditions distinct from the standard conditions which have been selected for the purpose of zoning, is termed a "Phase."

In the South-Western Province the standard conditions must be chosen to be those which, under normal circumstances, existed at moderate depth, for these are the conditions which prevailed during the greater part of Avonian time throughout the Province. Two "phases" are co-extensive with the Province:—the *Modiola*-Phase of the *Cleistopora*-Zone characterized by shallow-water conditions, and the S_2-Phase of the *Seminula*-Zone, which was deposited in shallow water containing an excess of carbonate of lime.

Certain phases are purely local within the Province, and the most important of these is the dolomite-phase of the *Syringothyris*-Zone which is characterized by abnormal shallow-water conditions. Since, however, this phase is undeveloped in part of the area (for example, in the Mendips) the faunal succession under standard conditions can be satisfactorily filled in.

In the Bristol Area, the Brachiopods and Corals are the only two classes which are sufficiently abundant throughout the sequence to render a system of zones, founded upon faunal variation, both reliable and useful.

It has been found advisable to study the variations of at least two classes in order that the zones constructed from Coral-variation may be checked by the simultaneous Brachiopod-variation. For if, at each of two distant points within the Bristol Area, two time-scales be graduated in terms of the variation-incidents which are exhibited by the Corals and Brachiopods separately, it is found that the same variation-incident, which is marked on both Brachiopod scales, does not occupy exactly the same position with reference to the graduations of the two Coral scales at the two localities. (In fact, in passing from south to north, the entrances of the Coral gentes occur later and later, as measured over a considerable segment of the Brachiopod scale, whereas the *sequence* of variation-incidents, which form the graduations, remains constant for both the Brachiopod and Coral scales.)

This irrationality of two time-scales, constructed from the variations of two different classes, represents a relative acceleration of the one class upon the other, and its existence puts a definite limit to the smallness of useful zonal divisions; for the size of a zone or subzone must necessarily be large when compared with the error which may be introduced by relative acceleration.

We have now to tabulate the successive species or mutations of each gens of the two classes we have selected and to express the relative times at which each mutation was dominant.

It has been pointed out by several observers that a species, during its period of dominance, retains its distinctive characters without appreciable change, and that transitional forms connecting it to other species are relatively scarce.

This general principle is strikingly exemplified in the variation of a gens. Each new mutation arrives almost unannounced and is usually never more abundant than at the time of its first establishment. (Careful search usually results in the detection of a few early forerunners of each mutation and, in a small number of cases, the maximum development of a species does not take place until some time after its first establishment.)

Each gens may be conveniently represented graphically by a line upon which stations are marked which represent the maxima of successive mutations, and the distance between two stations is measured proportional to the actual thickness of strata in the Avon Section which intervenes between the maxima of the two mutations. (Where a station cannot be fixed from the occurrence of a mutation in the Avon Section itself, its position must be approximately fixed by correlation.) This method is of more practical use than the attempt to plot accurate time-intervals by reducing the thicknesses of various deposits, by estimation, to one uniform rock-type.

A Range-diagram is now constructed by plotting all the gens-lines parallel to one another, and at arbitrary distances apart, in such a manner than any transverse line which cuts all the parallels at right angles is an isochrone, and the aggregate of the mutations which lie upon it represents the faunal assemblage of a particular instant of zonal-time.

The Range-diagram is the complete expression of the faunal succession, and upon it every system of zoning must be founded.

It is not, however, an entirely simple matter to draw up a series of zones from the mere inspection of a Range-diagram.

Theoretically, any one of the long gens-lines upon which several stations are marked would serve as a time-scale, but the longer the life of a gens, the greater is its stability and, consequently, the greater are the distances between successive mutations, and the smaller the actual difference between them (in other words, a long-lived gens has a low variation-gradient). *Orthotetes* cf. *crenistria* affords an excellent example of the practical difficulty in employing this method.

Again, a long-lived gens is usually dominant only during a limited part of its existence and is relatively unimportant during the remainder of its life.

The practical stratigrapher naturally desires to fix his zonal position by the aid of fossils which are at once easily found and easily recognised (in fact by a system of "spot-zoning") and this method leads to absolutely accurate results, so long as it is only relied upon within a small area. There are, however, several weighty objections to this method if its intrinsic limitations are not fully appreciated.

(1) It usually happens that the various species of a gens, or of closely allied gentes, are not all dominant *throughout* a large area, but that an earlier species is dominant in one part and rare in another, whereas a later species may be rare in the first locality and dominant in the second. Hence, the field worker, who is not specially trained to the appreciation of variational differences, may confuse the later for the earlier variant if he pass immediately from the first locality to the second.

The case of *Zaphrentis* aff. *Phillipsi* which characterizes Z, and *Zaphrentis* aff. *Enniskilleni* which marks the upper part of D, may be cited as an excellent example.

(2) A particular area may, during a certain period, have been subject to peculiar conditions and, consequently, exhibit a peculiar faunal assemblage. If a dominant fossil of such an assemblage be selected as a zonal fossil, it will probably be of value only in areas which were subject to the same conditions during the same period, and the absence of the fossil will not denote the absence of deposits of that particular age in areas which do not exhibit the special conditions.

(3) If a species which exhibits very exaggerated characters be selected as a zonal fossil, there is a danger of confusing the local extinction of a mutation of a gens with the total and general extinction of the gens itself.

Extinction is frequently accompanied by the development of excrescences, such as spines and exaggerated ornament in the Brachiopods, roots and the excessive development of vesicles in the Corals, and these striking moribund characters almost completely conceal the less pronounced mutational differences upon which we rely for fixing zonal positions. If, then, a gens becomes extinct in a particular area, owing to the incoming of unfavourable conditions, the individuals which stayed on in the area until it became uninhabitable may exhibit the same moribund characters which are to be seen in the last stages of the gens itself at a much later time.

For example, the temporary extinction of the gens of *Productus semireticulatus* at the top of S_1, in the Bristol Area, is signalized, in the last representatives, by the extraordinary development of spines and marginal accretions.

On the other hand, the structural complexity or specialization which heralds the general extinction of a group affords an extremely valuable measurement of time-intervals; for, in such cases, the variation-gradient is abnormally large, and appreciable variation takes place in small intervals of time. Among the Corals, the Clisiophyllid group exhibits this rapid variation in the most striking manner, and the degree of specialization affords a valuable guide to zonal position.

There is one other natural law which assists very materially in the determination of time-level.

At any one period, there is a general tendency among the gentes of the different genera of the same class to adopt some particular character which is possessed by the particular group of that class which is dominant at the time.

For example, in *Dibunophyllum*-time, (1) the *Cyathophylla* and the Lithostrotions adopt, more or less completely, a Clisiophyllidan type of structure.

(2) *Productus* aff. *giganteus* and *Chonetes* aff. *comoides* become closely assimilated.

In the working of this law, genera lose their distinctness, and their artificiality is often strikingly displayed.

Characters which are common to several genera at the same time may be termed time-traits, and the general law itself may be entitled convergence or coeval assimilation.

To sum up :—

A natural system of zonal indices must be based upon the variation of the gens, those gentes being best adapted for our purpose whose variation-gradients are large.

In practice, dominant species must be relied upon for purposes of zoning and, consequently, we are frequently forced to change from one gens-line to another.

The presence of a zonal fossil suggests a zone but does not fix it; for it is, by nature, impossible to select a series of indices which shall be exactly conterminous.

In fine, the zonal index merely connotes the whole faunal assemblage which is the ultimate expression of a biozone.

The Zonal System The faunal assemblages which characterize the successive zones and subzones in the Carboniferous Limestone Series of the South-Western Province will be sufficiently understood from the fossil lists which are given under each division in the descriptive portion of this paper, and the zonal and subzonal indices are set forth in the same place. It is only necessary, here, to draw attention to the implication of certain new terms which are employed in the zonal scheme.

Avonian denotes the whole interval of time during which the Carboniferous Limestone Series of the South-Western Province was being laid down. It is divided into two main periods, the *Clevedonian* and the *Kidwellian*, which are characterized by essentially distinct faunas.[1]

[1] The terms Clevedonian and Kidwellian have not been generally adopted, most geologists using the Belgian terms Tournaisian, as practically equivalent with Clevedonian for the Lower Carboniferous Limestone, and Visean, as practically equivalent with Kidwellian for the Upper Carboniferous Limestone.

The dividing line between Upper and Lower Carboniferous Limestone is now drawn, not at the base, but in the middle, of the *Syringothyris*-Zone as originally defined by Vaughan.

The Clevedonian is subdivided into three zones, namely the *Cleistopora*-Zone, the *Zaphrentis*-Zone and the *Syringothyris*-Zone.

The Kidwellian is divided into two zones, namely the *Seminula*-Zone and the *Dibunophyllum*-Zone.

Each zone is again divided into subzones, and, for local use only, into Phases.

The highest portion of one zone and the lowest portion of the next usually exhibit a mingling of the two faunas which are respectively characteristic of the two zones; such levels of faunal overlap are termed Horizons.

The use of a new term, Avonian, in place of the old and well-established Carboniferous Limestone, is a necessary outcome of the knowledge acquired by recent zonal work. A deposit is Lower Avonian, for example, because it contains a definite faunal assemblage; it is Lower Carboniferous Limestone, merely because it happens to occur at the base of a local series of limestones. For example, Dr. Wheelton Hind has recently shown that the base of the "Carboniferous Limestone" in the North Wales area is of Upper Seminula age and belongs, therefore, to a very much later date in the earth's history than the base of the Carboniferous Limestone in the Avon sequence.

The statement that a particular species occurs at a certain level in the "Carboniferous Limestone" of one locality affords no clue to its position in the "Carboniferous Limestone" of a second locality. On the other hand, the statement that a certain fossil occurs in a particular zone of the Avonian fixes its relative position for all localities.

Example of an Avonian Time-Scale

It will not, I hope, be wasted space to close this short outline of zonal method with a tabular summary of some of the more important incidents which marked the progress of Avonian time.

The particular incidents which I have elected to present are the times of *first establishment* of certain important genera and gentes of Corals and Brachiopods; but, to avoid overcrowding, I have selected only one Brachiopod genus, namely, Productus.

An Avonian Time-scale, Graduated by the Entrances of well-known Corals and Producti.

Producti.	Zones, Subzones and Horizons.	Corals.
P. scabriculus and *P. costatus*	D_3	[*Cyathaxonia rushiana*][1]
	ϵ	Zaphrentis aff. Enniskilleni
P. longispinus	D_2	*Cyathophyllum regium*
Choneti-Productus		Lonsdalia and *Acrophyllum*
	D_1	*Aulophyllum* Dibunophyllum and *Koninckophyllum*
P. aff. *giganteus*		*Lithostrotion irregulare* and *L. junceum* *Cyathophyllum Murchisoni*
P. corrugato-hemisphericus	S_2	
P. aff. *punctatus* and *P.* aff. *fimbriatus*	S_1	*Alveolites* *Carcinophyllum*
P. aff. *hemisphericus*		LITHOSTROTION
P. cf. *concinnus* *P.* aff. *pustulosus*	C	Cyathophyllum ϕ *Campophyllum*
	γ	
P. aff. *corrugatus*	Z_2	Caninia *Zaphrentis* aff. *cornucopiæ*
P. aff. *semireticulatus*	Z_1	*Michelinia*
P. cf. *burlingtonensis*	β	Zaphrentis aff. Phillipsi
	K_2	
P. bassus	K_1	*Cleistopora*

[1] Not yet recorded from the South-Western Province.

[After careful consideration it has seemed best to retain the old nomenclature of the fossils in the text of the present issue. The following table shows in the right hand column the present-day names, the

original names being given in the left hand column. Dr. Helen M. Muir-Wood has kindly revised the nomenclature of the Brachiopods, and Dr. Stanley Smith that of the Corals.]

Alveolites septosus	*Chaetetes septosus* Fleming
Athyris aff. *glabristria*	*Cleiothyridina* aff. *glabristria* (Phillips)
Athyris cf. *planosulcata*	*Actinoconchus* cf. *planosulcatus* (Phillips)
Athyris Royssii	*Cleiothyridina royssii auctt.*, not necessarily *roissyi* (Léveillé)
Campophyllum aff. *Murchisoni*	*Caninia juddi* Thomson emend. Lewis
Caninia cylindrica mut S_1	*Caninia bristolensis* Vaughan
Chonetes cf. *buchiana*	*C.* (*Plicochonetes*) *stoddarti* Vaughan
Chonetes cf. *comoides*	*Daviesiella* cf. *comoides* (Sowerby)
Chonetes cf. *crassistria*	*C.* (*Plicochonetes*) *failandensis* Smith
Cleistopora geometrica	*Vaughania vetus* Smyth
Cyathophyllum Murchisoni	*Palæosmilia murchisoni* Edwards and Haime
Cyathophyllum regium	*Palæosmilia regium* (Phillips)
Cyathophyllum ϕ	*Cyathoclisia tabernaculum* Dingwall
Cyclophyllum pachyendothecum	*Aulophyllum fungites* Fleming
Cyrtina carbonaria	*Davidsonina carbonaria* (M'Coy)
Dibunophyllum θ	*Dibunophyllum bourtonense* Garwood and Goodyear
Dibunophyllum ψ	*Dibunophyllum bristolense* Garwood and Goodyear
Discina	*Orbiculoidea sp.*
Eumetria carbonaria	*Hustedia carbonaria* (Davidson)
Lithostrotion ensifer	*Orionastræa ensifer* (Edwards and Haime)
Lonsdalia floriformis	*Lonsdaleia floriformis crassiconus* (M'Coy) Smith
Martinia ovalis	*Brachythyris ovalis* (Phillips)
Orthotetes crenistria	*Schellwienella crenistria* (Phillips)
Productus bassus	*P.* (*Avonia*) *bassus* (Vaughan)
Productus cf. *burlingtonensis*	*P.* (*Dictyoclostus*) *vaughani* (Muir-Wood)
Productus corrugato-hemisphericus	*P.* (*Linoproductus*) *corrugato-hemisphericus* (Vaughan)
Productus hemisphericus	*P.* (*Linoproductus*) *hemisphaericus* (Sow.)
Productus latissimo-giganteus	*P.* (*Gigantella*) *giganteus* (Martin)
Productus punctatus	*P.* (*Echinoconchus*) *punctatus* (Martin)
Productus scabriculus	*P.* (*Buxtonia*) *scabriculus* (Martin)
Productus subpustulosus	*P.* (*Pustula*) *subpustulosus* Thomas
Productus θ	*P.* (*Linoproductus*) θ (Vaughan)
Productus semireticulatus	{ *P.* (*Dictyoclostus*) *multispiniferus* (Muir-Wood) { *P.* (*Productus*) *garwoodi* Muir-Wood
Reticularia lineata	*Phricodothyris lineata* (Martin)
Seminula ambigua	*Composita ambigua* (Sow.)
Seminula ficoides	*Composita ficoides* (Vaughan)
Spirifer clathratus	*Spirifer tornacensis* de Kon.
Spirifer planicosta	*Brachythyris planicostata* M'Coy
Spiriferina cf. *octoplicata*	*Spiriferellina perplicata* mut. K (North)
Syringothyris cuspidata (of K)	*Syringothyris principalis* North
Syringothyris cuspidata (of Z_1)	*Syringothyris cuspidata* North
Syringothyris cuspidata (of Z_2)	*Syringothyris cuspidata* mut. *exoleta* North
Syringothyris laminosa	*Tylothyris laminosa* (M'Coy)
Zaphrentis aff. *cornucopiæ*	*Zaphrentis konincki* Edwards and Haime
Zaphrentis aff. *phillipsi* (K_2-Z_1)	*Zaphrentis delanoui* Edwards and Haime
Zaphrentis aff. *phillipsi* (Z_2)	*Zaphrentis omaliusi* Edwards and Haime

Table of Classification of the Avonian Rocks of the Avon Section

The classification of the Avonian rocks is somewhat confusing owing to certain terms not being always used consistently. This is particularly the case with the term *Caninia*-zone introduced in Vaughan's later work. It has sometimes been used to include only the rocks classed in the following table as Lower *Caninia*-zone, sometimes to include both the Upper and Lower *Caninia*-zones of the table. The term *Syringothyris*-zone is retained in the table and throughout the paper although it is not now much used.

DIBUNOPHYLLUM ZONE (D)	D_3 represented by the base of the local Millstone Grit and by horizon ϵ D_2 Upper *Dibunophyllum* zone D_1 Lower *Dibunophyllum* zone
SEMINULA ZONE (S)	S_2 Upper (main) *Seminula* zone
UPPER CANINIA ZONE	S_1 Lower *Seminula* zone C_2 (Upper *Syringothyris* zone)

(In Vaughan's latest work the Upper *Caninia* zone, characterized by the overlap of *Lithostrotion* and *Caninia*, is termed horizon δ.)

LOWER CANINIA ZONE (C_1) (Lower *Syringothyris* zone)

γ horizon of overlap of *Caninia* and *Zaphrentis*.

ZAPHRENTIS ZONE (Z)	Z_2 Upper *Zaphrentis* zone Z_1 Lower *Zaphrentis* zone

β horizon of overlap of *Zaphrentis* and *Cleistopora*.

CLEISTOPORA ZONE (K)	K_2 Upper *Cleistopora* zone K_1 Lower *Cleistopora* zone K_m (base of K_1) forming passage to the Old Red Sandstone.

II. THE SECTION ON THE CLIFTON SIDE

A. TOPOGRAPHICAL, LITHOLOGICAL AND STRUCTURAL CHARACTERS*

ALTHOUGH there is no exposure south of the entrance to the Rocks Railway, now (1935) closed, we shall, for completeness, commence our traverse about 300 yards south of that point.

If we start from the "General Draper" public-house, near the end of the Hotwell Road, we are at the junction of the Carboniferous Limestone Series with the Millstone Grit above; from this point, we shall have to cover a distance of a little more than $1\frac{1}{2}$ miles downstream before we reach the junction of the Carboniferous Limestone Series with the Old Red Sandstone below.

Behind the "General Draper" there was, formerly, a good exposure of the highest level in the Limestone Series, D_3 (Horizon ϵ); this level is, however, no longer exposed on either side of the Avon.

The upper subzone (D_2) of the *Dibunophyllum*-Zone (D) is fronted by a row of houses and cannot be examined.

The lower subzone (D_1) is, in its higher portion, also concealed and lies behind the Colonnade; its lower portion is, however, well exposed in the lofty vertical face of rock which includes the entrance to the Rocks Railway. The D_1 subzone extends northward to a point a little beyond the steps at the bottom of the Old Zig-zag (a steep path which winds up the side of the gorge).

Between the "General Draper" and this point, the whole of the *Dibunophyllum*-Zone is comprised.

We now enter the *Seminula*-Zone, and the section rises to a height of more than 200 feet above us; we proceed under the Suspension Bridge past the former site of the Hotwell Station till we reach the bottom of Bridge Valley Road. Here the massive grey *Seminula*-Limestone ceases abruptly where it abuts against a contorted mass of red rocks, and where the height of the section drops suddenly.

The massive limestones which compose this portion of the sequence all belong to the Upper *Seminula*-Zone (S_2), whereas the red rocks against which they end belong to the upper part of D_2, and the S_2

* In this section of the paper the later classification set forth in the table on p. 44 and involving the use of the term *Caninia*-zone has been adopted. For the remainder of the paper it has been thought best to retain Vaughan's original classification of the strata.

limestone-mass is sharply separated from the subjacent D_2 beds by a reversed fault whose plane hades southward with the dip.

The under surface of the limestone is strongly slickensided, and the contortion in the soft D_2 rocks (Pl. 9 *b*), due to the overthrust of the massive S_2 limestone, is finely shown, although it extends only a short distance north of the fault. The vertical displacement produced by the fault amounts to about 1,100 feet, calculated as follows :—The lowest portion of the limestone-mass is composed of "*Seminula*-Oolite," a rock which we shall see again in the middle of the "Great Quarry," and there is a perfectly continuous sequence from the "*Seminula*-Oolite" of the "Great Quarry" up to the D_2 beds immediately below the fault. Hence, knowing the average dip and the horizontal distance from the "*Seminula*-Oolite" of the "Great Quarry" to the "*Seminula*-Oolite" just above the fault, the upthrow can be estimated.

Having noticed the crumpling of the soft D_2 beds by the overthrust of the great limestone-mass, and also the smoothing of the under surface of the limestone, it is worth while to retrace our steps a few yards in order to study the effect of the overthrust upon the limestone-mass itself.

The piece of ground, access to which is now shut off by a fence, was formerly the yard of the Hotwells Station. Above its northern end the surfaces of the beds are sharply bent and smoothed, thus indicating the immense force behind the overthrust and marking how the limestone-mass was held back by friction at the fault plane, while the upper beds were sheared over the lower.

We must now return to the bottom of Bridge Valley Road and continue our walk downstream.

From this point to the bottom of the Carboniferous Limestone Series, a distance of a little more than 1 mile, we continuously descend in the sequence, and whereas we have contented ourselves with a rather hurried examination of the rocks south of the fault, knowing that we should meet the same beds again north of the fault, we shall study the rest of the section more leisurely and shall pause at frequent intervals to consider what were the circumstances under which the beds were laid down.

The beds dip southward under one another at a uniform dip of nearly 30°, without a break in the succession, and the rocks can be examined, practically bed by bed.

The Avon section is probably the most complete section of the Carboniferous Limestone Series to be met with anywhere in the British Isles.

UPPER AVONIAN OR VISÉAN

Dibunophyllum-ZONE (D)

Upper subzone (D_2).

No part of the Avon Section has been so much changed by the construction of Portway as that between the bottom of Bridge Valley Road and the New Zig-zag path. There is a fine section of Lower D_2 by Portway, north of the end of Bridge Valley Road, but Upper D_2 is completely hidden by a great wall. A section of Upper D_2 may, however, be reached by climbing up above and behind the great wall. This section is seen from the other side of the river but is not fully visible from Portway. The D_2 beds consist of limestone, sometimes coarsely oolitic, sometimes rubbly, with abundant fossils, especially near the top. These limestones overlie strata which include massive beds of red grit associated with quartz-conglomerate or pebble beds. Such a variation in lithic structure indicates considerable movement of the sea floor, the total variation amounting to a change from clear water conditions, at a moderate depth, to the circumstances of an actual beach. We may also notice that the variation was oscillatory, for the same succession of rock types is repeated, as shown in the descending sequence :—

Grit.
Limestone.
Quartz Conglomerate or Pebble Beds.
Grit.
Limestone.

The line dividing D_2 and D_1 may be drawn here.

Lower subzone (D_1).

For about 70 yards northward from the outcrop of the quartz conglomerate there are now no exposures, this part of the section being the upper part of D_1.

The lower and better-exposed portion of the D_1 subzone can be examined by the road south of the New Zig-zag path ; it consists of thick-bedded, fossiliferous limestones which, like most of the *Dibunophyllum* beds in the Bristol Area, are stained red. To the north of the New Zig-zag, the surface of the ground rises rapidly, on an irregular dip-slope, until it reaches a height of 200 feet above the road. The limestones forming this slope constitute the base of the *Dibunophyllum*-Zone ; they can be examined by ascending the New Zig-zag path and

clambering up the slope on the left-hand side. Many fossils were formerly obtained here but the exposures are now much overgrown.

The rubbly limestones which recur so frequently throughout the *Dibunophyllum*-Zone may best be studied in the roadside exposure of the D_2 beds, but are also well seen in D_1 south of the New Zig-zag. Examined in a clean cut face, the rubbly limestone (Pl. 14, *b* and *c*) is seen to be made up of large numbers of rounded portions composed of comparatively pure limestone, separated by softer material which is usually very rich in iron; to this structure the face owes its "mottled" appearance. The hard portions offer a relatively large resistance to weathering, and consequently the surface of the rock has become extremely irregular. Possibly the structure is, to a limited extent, concretionary, for, occasionally, the harder portions exhibit true "shell-structure" near their surface; the greater number of these masses, however, seem to be due to the patchy accumulation of carbonate of lime, for the corallites of a large *Lithostrotion*-corallum can often be seen to pass from one hard portion to another.

The oolitic limestones which occur at various levels throughout the D series can usually be easily distinguished from the oolites which occur in lower zones. The oolite grains are larger and more scattered, and the rock has usually a red tint. (The deep red, coarse oolite which was formerly polished and sold as a characteristic Clifton rock was derived from beds in the D series.)

Seminula-Zone (S)

Upper subzone (S_2).

Returning to the road and resuming our walk northward along it, the lofty wall of *Seminula*-limestone lies at some little distance to the right. The upper beds of the *Seminula*-Zone cannot be easily examined on this side of the river; we may, however, note in passing the thin capping of D_1, which we have already examined on the slope north of the New Zig-zag and, immediately beneath it, a band of thinner-bedded rock which constitutes the uppermost portion of S_2.

The rocks of this band are remarkable for a very peculiar structure, and they are here referred to as the "Concretionary Beds" (Pl. 13 *c*). (This term is used merely to describe the appearance of the rock, without definitely suggesting a particular mode of origin.) The "Concretionary Beds" occur only at the very top of the *Seminula*-Zone, where, in certain parts of the Bristol Area (notably at Sodbury and near West-

bury), they form a thick and extremely striking band. In the Avon Section, these beds cannot be examined at the point which we have now reached, but they can be made out at the same level on the other side of the river and also in the repetition of the *Seminula*-Beds south of the "Great Fault," at a point which we have already passed, a short distance north of the bottom of the Old Zig-zag path. The structure of these rocks is almost identical with that of "Cotham or Landscape Marble," but on a very much larger scale.

The upper surface of a typical bed consists of very numerous tall ridges, usually discontinuous, separated by equally deep narrow valleys. A cross-fracture of the bed shows that these surface wrinkles are underlain by several thin layers in parallel undulations. Below this concretionary upper portion comes the main thickness of the bed, which consists of a very fine-grained, pale argillaceous limestone, mottled by black patches. In many cases these black patches can be seen to extend as continuous pipes, from beneath the concretionary top-layer down to the under surface of the bed, and it is probable that most of the apparently isolated patches are merely cross-sections of similar, continuous, but flexuous pipes. These pipes appear to be themselves concretionary and to be built up of thin layers which are convex upward. The under surface of the bed is scored by sharp grooves in such a way that the bottom line of a cross section of the bed is notched at regular intervals. Beneath such a typical bed lies a thin black under-layer, which is almost entirely made up of small black nodules.

Compared with "Landscape Marble," the black under-layer represents the "hedges and bushes," the pipes correspond to the "trees," and the undulating upper-layer represents the "sky."

The origin of the peculiar structure described above has not yet been satisfactorily explained, although several theories have been advanced to account for it. It seems probable that such beds could only be laid down under water undisturbed by waves and charged with abundant carbonate of lime, and it seems a fair deduction from the remarkable character of the rock that the occurrence of these beds marks a datum level of absolute time, almost comparable in exactitude with that marked by a continuous lava sheet.

We will now proceed to the "Great Quarry" (Tennis Court quarry), where S_1 and the greater part of S_2 are splendidly exposed (Pl. 6).

The beds, which come down to the floor of the quarry near its southern

end, consist largely of a fine white oolite, the "*Seminula*-Oolite." This Oolite is seen as a conspicuous thick band in the face of the Quarry and, like the similar band lower down in the sequence, is characterized by the vertical joints which traverse its whole thickness, and by the weak development of bedding planes. (These characters are, however, much more striking in the "*Caninia*-Oolite" lower down, and we shall consequently defer, for the present, an inquiry into their origin.)

The base of the Upper *Seminula*-Zone in the "Great Quarry" is marked by a good development of a very peculiar type of limestone which is here referred to as "pisolite." This rock recurs at frequent intervals throughout the S_2 series. It can be studied in the Avon Section at various levels, but nowhere is it so strikingly displayed as in the basal beds of the S_2 subzone, in the middle of the "Great Quarry." The rock has the aspect of a conglomerate or breccia in which the "fragments" are of white limestone, cemented in a limestone matrix. When the "fragments" are examined they are seen to have, in all cases, a concretionary structure, although this structure may only be evident in the outermost layers. The greater number of the "fragments" are large concretions which have been formed round shells and other organic débris; the rock may consequently be broadly described as a pisolite. In certain seams of *Seminulæ* the majority of the shells are surrounded by concretionary crusts and, occasionally, comparatively large pieces or coral (such as *Syringopora*) are seen to be similarly included in a concretionary envelope. Other points to be noticed are that a great many of the "fragments" are merely broken pieces of concretions and that many complete concretions occur broken across, with the component parts displaced.

Lastly, the S_2 series in which these pisolites occur contains numerous beds which are almost entirely built up of continuous coral masses (*Lithostrotion* and *Syringopora*).

Hence, the most probable explanation of the origin of the pisolite appears to be the following:—The large coral masses grew in clear shallow water near the shore line and presented the general characters of a fringing reef. In the water between the shore and this coral fringe, the percentage of lime was necessarily maintained at a high level, and the shells and coral débris which accumulated on the floor were consequently thickly coated with carbonate of lime. Many of the concretions were probably broken up almost as soon as formed, and the whole accumulation of débris, coated and uncoated, broken and

unbroken, was rapidly cemented by the interstitial deposit of carbonate of lime.

Upper *Caninia*-Zone
including *Lower Seminula subzone* (S_1), and *Upper Syringothyris subzone* (C_2).

Lower Seminula subzone (S_1).

Thick limestones, mostly dark in colour but of very varying texture, build up the greater part of this subzone; they are separated by shales whose thickness increases more and more as we approach the end of the quarry.

One of the most striking of the limestone-types is termed "China-stone"; this rock has a perfect conchoidal fracture and is as compact in texture as a hone; a fresh fracture is black, but, by weathering, the surface becomes coated with a thin white "skin." This peculiar type is found at various levels throughout the *Seminula*-Zone of the South-Western Province.

Another noteworthy feature of the beds near the north end of the quarry is the fact that they are, in several places, stained black by petroleum.

Upper Syringothris subzone (C_2).

Leaving the "Great Quarry" at its extreme corner and returning to the road, a fine section (Pl. 5) of the next horizon, the "*Caninia*-dolomite," C_2b, may be examined by the roadside. Here shales predominate but thick beds of pure dolomite are intercalated at frequent intervals and there are one or two beds of oolitic limestone.

LOWER AVONIAN or TOURNAISIAN

Lower *Caninia*-Zone = *Lower Syringothyris subzone* (C_1)

The road section ends in the striking white oolite of the "Gully Quarry" (Pl. 4). Much of the upper part of this quarry consists of a thick band of pure white oolitic limestone in which bedding planes are very inconspicuous but in which vertical joints, traversing the whole thickness of the band, present a striking feature. The highest beds of the quarry are the basal beds of the "*Caninia*-dolomite," shaly, thin-bedded limestones which form a striking cap to the massive band of oolite beneath.

The oolitic band rests upon a series of limestones which are rich in carbonate of magnesia; this series has been termed the "*laminosa*-dolomite."

If we examine the two slopes of the broad depression known as the "Gully," we shall find that, at the bottom of the Gully, the Oolite lies wholly on the south side, whereas the northern slope is a dip slope in the "*laminosa*-dolomite." Near the top of the Gully, however, there is a fine exposure of the white Oolite on the northern side, and the screes from this crag extend for a considerable distance along the floor of the Gully.

The massive white Oolite forms so striking a feature in the scenery of the Gully that its local title, "Gully Oolite," is well deserved. Since, however, it is essential to emphasize the zonal position of any particular rock-type, in order to distinguish it from the same rock-type occurring at a different level, I have named this Oolite the "*Caninia*-Oolite." (Compare the terms "*laminosa*-dolomite," "*Seminula*-Oolite.")

We now enter the Black Rock Quarry. The thick bed which underlies the north slope of the Gully can be examined between the Gully and the Black Rock Quarry. It is a dull, yellowish-brown dolomitic limestone and forms the base of the "*laminosa*-dolomite"; as seen in the face of the quarry, it forms a conspicuous cap, distinct in colour and texture from the pure limestones beneath.

With this bed we reach the bottom of the *Caninia*-Zone.

Reviewing the whole zone, it is clear that the circumstances of deposit were peculiar and comparatively local.

Judging by similar deposits of recent age, the "*Caninia*-Oolite" indicates perfectly clear and shallow water conditions such as are associated with the growth of coral reefs. Further, deposition must have been sufficiently continuous to prevent the formation of well marked bedding planes, and consequently, when the mass consolidated, the cross joints traversed the whole mass.

The dolomites point to the same conditions, for it is found that the dolomitization which affects recent coral masses is initiated at the surface of the mass, and therefore practically at sea-level.

The conclusions thus arrived at, as to shallow water conditions during the deposition of the rocks of the *Caninia*-Zone, are confirmed by an

examination of the strata of the same age in other parts of the South-Western Province :—

At Weston-super-Mare, the rocks of this age contain inter-bedded lava and ash, of such a nature as to indicate shallow water and proximity to land. Farther west at Pendine, north of Tenby, there is a gap in the succession and the *Caninia*-Zone is absent, indicating that, locally, the sea floor emerged and became land during this period.

Zaphrentis-Zone (Z)

All the beds in the Black Rock Quarry (Pls. 2 and 3) below the "*laminosa*-dolomite" belong to the *Zaphrentis*-Zone and are of essentially the same rock-type, namely a highly-fossiliferous, crinoidal limestone. The divisions are consequently entirely palæontological.

The uppermost part constitutes Horizon γ, and the steep slope, just below the "Cave," may be taken as the dividing plane between the upper and lower subzones of the *Zaphrentis*-Zone (Z_2 and Z_1).

The basal beds of the "Black Rock" massif constitute Horizon β and are exposed in the small quarry north of the Black Rock Quarry. (This small quarry, here named Press' Quarry, is now closed and forms part of a private estate.)

The whole of the *Zaphrentis*-Zone, including Horizon γ at the top and Horizon β at the base, may be considered to have been deposited under standard conditions.

Cleistopora-Zone (K)

Upper subzone (K_2).

Just to the north of Press' Quarry, a roadside cutting, now largely built up, exposes a highly fossiliferous series of thin-bedded limestones and shales. These beds are the top of K_2. But north of this exposure, for a distance of about 270 yards, the rocks are entirely hidden. A short distance, however, to the north of a gate giving access to a path leading up to the railway line, a fine section commences.

Lower subzone (K_1) [including the "*Modiola*-Phase" (K_m)].

If we now examine the section (Pl. 1) which commences beyond the gate, we are at once struck by the massive red bed which is termed the "Bryozoa Bed." Resting on it, a thickness of about 35 ft. of thin-bedded limestones with shales is seen.

These beds, the lower part of K_1, are the only part of that horizon which was deposited under "standard conditions."

The whole of the lower portion of K_1, i.e. the "*Modiola*-phase" K_m, consists of sediment accumulated under special conditions in extremely shallow water. The separation of K_1 into an upper and a lower division, characterized respectively by standard and special conditions, is much sharper in the Avon sequence than in any other part of the South-Western Province. The "Bryozoa Bed" marks the junction of the two divisions, and the "Palate Bed," which lies some three or four feet above the top of the "Bryozoa Bed," may be taken as the base of the upper and normal development of K_1.

The "Palate Bed" is a thin, very hard conglomeratic bed, full of coprolites, and containing the teeth and spines of fish in considerable abundance. As with all "bone beds," the horizontal distribution of this bed is extremely patchy (at one spot the bed is well developed, whereas at another, only a short distance away, it is practically absent); nevertheless, the bed occurs at widely separated points of the Bristol area and always at approximately the same level, (for example, a "Palate Bed" of exactly the same type as the Avon bed occurs at practically the same level near Sodbury, 10 miles to the north). The very shallow water conditions under which this bed was formed are demonstrated alike by its conglomeratic characters and by the included mollusca.

The "Bryozoa Bed," a massive red crinoidal limestone, forms a very striking feature in the road and railway at this point. The rock is built up of vast numbers of small, *rounded* crinoid fragments, which are cemented together by coarsely-crystalline calcite. It seems probable that the crinoid fragments were rounded by rolling in very shallow water and that the crystalline matrix has been produced, by solutional agency, at a time subsequent to the original cementation of the rock.

The Modiola-Phase (Lower $K_1 = K_m$).

The "Bryozoa Bed" and the rocks below it, down to the base of the Carboniferous Series, can be studied both by the roadside and in the cutting of the Avonmouth line which here emerges from the tunnel through the Downs. The following is a general description which applies to either section, but much of both sections is now in a poor condition for examination, the railway section being partly bricked up, and that by the road much overgrown.

Grouping under the term "Bryozoa Bed" the whole series of massive

red beds which form such a conspicuous feature of this part of the section, this rock-band has a thickness of 25 feet. Only the upper 8 feet, however, form the "Bryozoa Bed" proper; the lower 17 feet, though in the main equally red and massive, are more gritty. Below these red gritty beds are 20 feet of thin-bedded limestones, separated by highly fossiliferous shale partings, the fauna of the shales indicating shallow water conditions.

Descending in the sequence, we next come upon 30 feet of thick shales in which a few thick beds of limestone and calcareous grit are intercalated.

The section ends with 15 feet of thin slabby argillaceous limestones, separated by shale partings. These beds exhibit very clearly their shallow water origin, both in their lithic characters and in their faunal contents. Several of the thin slabby limestones have undulating surfaces and exhibit sun cracks. Other beds are built up of angular fragments of thin shaly limestone cemented together in a fine-grained matrix. These beds were probably formed by the breaking up of thin limestone beds shortly after their deposition, and by the immediate cementation of the fragments.

The actual base of the Carboniferous Limestone Series cannot be definitely fixed, for there is a complete passage down, from the calcareous series above, into the marls and sandstones which are regarded as constituting the uppermost portion of the Upper Old Red Sandstone.

In the roadside section the junction is concealed by a wall, north of which the marls, sandstones, and quartz-breccias of the Upper Old Red Sandstone are typically exhibited.

B.—FURTHER ACCOUNT OF THE TOPOGRAPHY AND LITHOLOGY (S.H.R.)

The section as repeated by the Observatory Hill fault (Pl. 8)

A fossiliferous exposure of D_1 is seen just north of the entrance to the Rocks Railway, now (1935) closed; the strata belonging to this horizon extend to a point about 40 yards north of the Old Zig-zag path. Here they are underlain by the highest S_2 beds, the "Concretionary beds" (S_2d), which are better seen here than in the main Avon Section. Several bands of the peculiar algal limestone, to which the term "Concretionary beds" alludes, are well exposed.

The steep but easily climbable rock-face which opens out just south of the Bridge includes many good exposures of algal and other types of limestone.

Massive limestone (S_2c) with numerous *Lithostrotion* bands extends on to the little parking place just beyond the Bridge. Here we reach the spot formerly occupied by the Hotwells Railway Station, and from this point nearly as far as the bottom of Bridge Valley Road the fine section is inaccessible, being shut off by a fence. Almost the whole of it is S_2c. The most interesting feature of this part of the section concerns the disposition of the rocks—while those on which the Suspension Bridge pier has been erected obviously succeed one another uniformly and regularly, the underlying strata are clearly much disturbed and are repeated by a series of small overthrusts. Owing to this repetition, a comparatively small thickness of limestone has a wide outcrop. The rounded soles or surfaces of five of the overthrusts are conspicuous (see Pl. 9, *a*). Some of the overthrust masses are bounded by powerful joints along which the iron in the limestone has become oxidized, giving a red colour.

The massive white limestone forming the precipice of Observatory Hill at the bottom of Bridge Valley Road is the "*Seminula*-Oolite" (S_2b), and is perhaps the best exposure of this horizon in the Avon Section. The presence of a cherty layer near the base may be noted.

The section from the Observatory Hill fault to the southern end of the "Great Quarry" (Pl. 7)

The cutting back of the rocks at the bottom of Bridge Valley Road exposed a remarkable section of grit and limestone crushed and slickensided by the movement of the overthrust, but this has been partly obscured by bricking up.

Vaughan[1], p. 46, gives a full account of the fault. Prior to the construction of Portway, a considerable section of D_2 could be seen in the lower part of Bridge Valley Road, by the side of the towing path which preceded Portway, and by the riverside. These exposures are now much modified, and that of the lower part of Bridge Valley Road is entirely walled up. With the railway, other landmarks alluded to in earlier papers, such as Point Villa, have disappeared.

[1] In all the references to Vaughan in this section of the paper the pagination referred to is that of the present edition.

The cutting back of the rocks to widen the road has, however, given rise to a very fine section of lower D_2 which commences about 100 yards north of Bridge Valley Road. The beds here are largely reddish and grey limestone, often coarsely oolitic and sometimes full of corals. But the most marked lithological feature is probably the occurrence of numerous bands of rubbly limestone and "pseudobreccia." The coral limestone is best seen at the commencement of the section, where *Lithostrotion portlocki* and *L. irregulare* are very conspicuous. Just below this layer is the highest "pseudobreccia" bed. This rock (Pl. 14, *a*) has the appearance of a breccia consisting of pale patches—"fragments"—in a red or dark "matrix." Recrystallization has led to the concentration of the colouring matter in the "matrix" and its removal from the "fragments." Probably this rock-type is nowhere so well seen in the Bristol district as in this relatively recently made section, as it readily weathers, and the contrast between "fragments" and "matrix" becomes obscured.

A related rock-type, often highly fossiliferous and frequently alluded to as "rubbly beds," is also admirably seen (Pl. 14, *b*). In this case, the "fragments" are larger, more rounded and more irregular, and the "matrix" includes more argillaceous material. It may be noted that sometimes a band is "rubbly" in one part of its outcrop but becomes compact a short distance further on (Pl. 14, *c*). There is a complete passage from "pseudobreccia" proper to "rubbly beds." Vaughan (p. 48) describes the character of the "rubbly beds." At the northern end of this section of D_2, three massive bands of red grit become conspicuous. Associated with the grits are three thin bands of limestone containing numerous quartz pebbles, the only example of this rock-type in the Carboniferous beds of the Avon Section. Vaughan alludes (p. 47) to these pebble beds as proof of variation in the depth of the water in which the strata accumulated. The dividing line between D_2 and D_1 is drawn at this level.

North of the grit bands there are no exposures for about 70 yards, and then follows a section of D_1 about 115 yards long and extending almost to the Zig-zag path. The southern part of this section is in a very poor state for examination, the rocks being much weathered and hidden by walling. It includes, however, some good "rubbly beds" showing the passage along the strike of the rubbly into the non-rubbly limestone. In the northern part of the section the limestone is much better exposed and shows early stages in the production of "pseudo-

breccia" as well as fully developed examples of this rock-type. D_1 beds, with exposures few or poor, extend on to the Zig-zag path, but the first strata exposed north of the wall bounding its lower end are seen, by the occurrence of *Seminula* bands and algal ("Concretionary") layers, to be S beds.

A distance of about 200 yards separates the Zig-zag path from the fence bounding the "Great Quarry." The rocks (Upper S_2 and Lower D_1) are in a very unsatisfactory state for examination. Their outcrop near the road is hidden by a great mass of talus and, higher up the side of the valley, they are very badly weathered. There is, however, a good development of the "Concretionary beds" with algal limestone and a *Chonetes papilionacea* band in a riverside exposure reached by a flight of steps.

The "Great" or Tennis Court Quarry (Pl. 6)

Access to the rocks is now (1935) shut off by a railing, but permission to reach them is commonly easy to get. The whole of the "Great Quarry" is in S beds, which are everywhere admirably exposed. This horizon is probably the most interesting one in the whole sequence as regards the lithology. The rocks exposed at the southern end are limestones full of *Lithostrotion* (S_2c). The massive "*Seminula*-oolite" (S_2b), which is about 60 ft. thick, is well seen in the quarry face, its base lying just above a small cave. On the floor of the quarry it is well exposed near the northern end of the outcrop. It is in the main a rather fine-grained white oolite quite devoid of *Lithostrotion*, but containing a considerable number of brachiopods. At about the middle of the oolite there is a rather conspicuous band of breccia well exposed near the floor of the quarry. This breccia is penecontemporaneous, i.e., the fragments are of approximately the same age as the matrix enclosing them. The fragments probably represent pieces of the surface layer, brecciated perhaps by desiccation under shallow water conditions, which sank a short distance into the still unconsolidated layer beneath them.

The "*Seminula*-oolite" rests on a band of grey dolomite 4½ feet thick, which is well exposed at the commencement of a projecting talus-covered mass in the middle of the quarry. Immediately below the dolomite is a band of chert nodules.

The succeeding section of limestone (S_2a), which forms the whole of

the projecting mass, extends on to within about 20 yards of the grassy bank near the northern end of the main quarry. The rocks commonly have a patchy appearance, part of the limestone being very white, while part is replaced by brown dolomite. *Seminula* and *Lithostrotion* bands occur, but fossils are not very conspicuous. The most marked feature is the development of "*Seminula*-pisolite" (Pl. 14, *d*), a rock-type fully described by Vaughan (p. 50). This rock-type occurs at two main levels, an upper one exposed high up the sloping bank already alluded to and a lower and more conspicuous one at the level of the quarry floor. The *Seminulæ* in the pisolite are sometimes silicified. A band of cherty nodules occurs just below the lower band of pisolite. The underlying limestone, extending as far as the grassy bank alluded to, is noteworthy for the great masses of *Lithostrotion*. The base of S_2 may be drawn here.

After ascending the grassy bank, the observer is faced by a shaly bedding plane covered with *Seminulæ*. This is the "front slope" of Vaughan's account (see p. 73). The rocks just above and below this level include several fossil bands of which Vaughan gives a full description (p. 73).

The northern end of the main part of the quarry is formed by the "back slope" of Vaughan, ~~a large~~ irregular bedding plane extending high up the quarry end. The upper part of the precipitous side of the quarry overlooking the "back slope" is traversed by a small overthrust fault. The northern segment of the quarry shut off from the rest by the "back slope" is formed by the series formerly alluded to as the Middle Limestone Shale. It consists of alternating bands of shale and limestone; the shale, which is very dark, being sometimes full of *Lithostrotion*. Below the more conspicuous shaly series the limestone is largely of the very compact type alluded to by Vaughan (p. 51) as "China-stone." Another rock-type seen near this horizon has a mammillated surface and is possibly algal. A band of *Lithostrotion* (*Diphyphyllum*) exposed high up the bank in the road-cutting just beyond the limit of the quarry may be taken as marking the base of S_1 and the top of C_2.

The Section from the "Great Quarry" to the Black Rock Quarry (Pls. 4 and 5)

Immediately north of the "Great Quarry" commences a fine roadside section of the "*Caninia*-dolomite," the finest in the Bristol District and,

previous to the making of Portway, only to be approached by trespassing on the railway. The "*Caninia*-dolomite" consists of bands of grey, yellow, or more rarely, pink dolomite alternating with shale. Occasionally there is a little oolite. In the upper part of the section, where the exposures are best, the dolomite bands are usually about 12 to 18 inches thick, but lower down the section both dolomite and shale occur in thicker bands. Crinoids may sometimes be seen in the dolomite and, very rarely, a gasteropod, but macroscopic fossils are very scarce. When examined microscopically, ostracods, foraminifera, and calcareous algæ are seen to be plentiful in some bands.

Near the end of the section, the "*Caninia*-oolite" comes on below the "*Caninia*-dolomite," the contrast between the two rocks being very marked and suggesting non-sequence. The "*Caninia*-oolite" is a massive white or sometimes pinkish fine-grained oolite in which it is difficult to find any fossils. The upper beds are well exposed by the roadside and in the southern part of the Gully Quarry. The northern end of the Quarry is in the "*laminosa*-dolomite."

The base of the "*Caninia*-dolomite," the "*Caninia*-oolite" and part of the "*laminosa*-dolomite" are seen in a riverside exposure reached by a ladder.

The Black Rock Quarry (Pls. 2 and 3)

In the Black Rock Quarry the lower part of the "*laminosa*-dolomite," γ and nearly the whole of Z are exposed. Horizon γ is a very massive bed of limestone, and the top of Z_2 is marked by three limestone bands each about $4\frac{1}{2}$ ft. thick. These are the "fish beds" (see Vaughan, p. 70) from which numerous teeth and spines of Elasmobranchs have been obtained.

The base of the "*laminosa*-dolomite" is seen at the extreme southern end of the quarry resting on γ; it is unfossiliferous save for numerous crinoids; γ is still more crinoidal and shows plentiful Zaphrentid corals.

In the middle of the Black Rock Quarry the rocks are in an unsatisfactory state for examination, the surface being much weathered and access being difficult. Towards the northern end the exposures become better and the limestone differs from that higher up the sequence in the fact that brachiopods are much more conspicuous than any other fossils. All the main part of the quarry is in Z_2. Vaughan drew the base of Z_2 at about the top of the irregular grassy dip-slope

at the northern end of the main quarry, 30 ft. or more below the "cave."

Beyond the grassy dip-slope the quarry becomes much narrower, though about 50 yards have still to be traversed before it actually ends. This part of the quarry is not bounded by precipitous cliffs but shows numerous bedding planes covered with brachiopods. There is a chert band in the limestone at the extreme northern end of the main quarry.

Beyond the quarry rises the great cliff of Sea Walls, access to the base of which is prevented by a wall which shuts off a small enclosure alluded to in Vaughan's paper as Press' Quarry. The southern part of the base of the cliff, which is shut off from the road merely by a fence, exposes a highly fossiliferous development of Z_1, fossils perhaps being more plentiful than anywhere else in the Avon Section, though not easily collected. Press' Quarry, which can be reached by climbing over the rocks, is in the lowest member of the Z beds, horizon β. One—possibly more—small overthrust faults may be seen near the northern end of the Black Rock Quarry. In Press' Quarry there is a rather more conspicuous overthrust. These overthrusts all come from the south and start by cutting the strata, but as they are followed up the cliff they are seen to pass into the bedding planes. There is a fine riverside section of γ and Upper Z_2.

The section north of Black Rock Quarry (Pl. 1)

The top beds of K_2—thin-bedded, highly crinoidal and brachiopodal limestone with shaly partings—are exposed by the roadside just north of Press' Quarry, but much of what was formerly a very fine section is now hidden by walling. For the next 275 yards there are no exposures, almost the whole of K_2 and the greater part of K_1 not being seen. From the point where the section recommences—about 150 yards north of the tunnel through the Downs—to the base of the Carboniferous Series there are two sections, an upper one in the Clifton Down Railway and a lower one formerly seen by the side of the Hotwells Railway, but now, owing to the removal of the railway, by the roadside. In the upper section, the "Bryozoa Bed," about 5 ft. of the overlying K_1 and about 30 ft. of the underlying K_m are seen, but all the lower part of K_m—well exposed when Vaughan's paper was written—is now hidden by walling. In the roadside section about 25 ft. of K_1—thin-bedded limestone and shale—is poorly exposed. The "Palate

Bed" (see Vaughan, p. 54) may be recognised. The "Bryozoa Bed," which he describes fully, and perhaps 15 ft. of shale below are well exposed, but the rest of K_m is in a very poor state for examination. Vaughan gives a full description of the succession. A wall hides the actual passage from K_m to the Old Red Sandstone. The exposures of the "Bryozoa Bed," which formerly existed by the old towing path and riverside, have been destroyed by the construction of Portway.

C.—PALÆONTOLOGICAL CHARACTERS

We shall now turn back and study the fossils which are to be found at each successive level.

In this palæontological survey our attention will be directed along two main lines of inquiry:

(1) The possibility of making divisions which shall be based upon the occurrence of certain distinctive fossils ("Diagnosis").

(2) The registration and study of the important and abundant fossils which are associated at each level ("Fauna").

The Corals and Brachiopods are the only two groups which will be dealt with in detail, but attention will be drawn to the genera of other groups wherever they form an important constituent of the fauna.

Upper Old Red Sandstone

The green and red marls and grits, which immediately underlie the lowest beds of the Carboniferous Limestone, are almost entirely concealed on the Clifton side of the Avon, but, on the Leigh Woods side, these beds are well exposed for examination. They have there yielded, in considerable abundance, scales of a Rhizodont fish which is most probably a species of *Strepsodus*, a genus which has only been previously recorded from rocks of Carboniferous Age.

Cleistopora-Zone: $K \begin{cases} K_2 \\ K_1 \\ K_m \end{cases}$

Zonal Index: *Cleistopora* cf. *geometrica*.

Diagnosis:

The occurrence of *Cleistopora* and the absence of *Zaphrentis* are the essential facts.

CHARACTERISTIC FOSSILS :

Productus bassus, *Eumetria* aff. *carbonaria*, *Chonetes* cf. *Buchiana*, and *Spiriferina* cf. *octoplicata* are all abundant within the zone, and are rare or absent above.

LOWER LIMIT :

The *Modiola*-Phase constitutes the basal portion of the zone and presents a transitional stage between the conditions prevalent during the deposition of the uppermost Old Red Sandstone and the standard conditions which became established in the main portion of the *Cleistopora*-Zone.

UPPER LIMIT :

The fauna of the uppermost beds of the zone only differs from that of the succeeding *Zaphrentis*-Zone in the presence of *Cleistopora* and the absence of *Zaphrentis*.

Km = Phase of *Modiola lata*.

From the base of the Carboniferous series up to the "Palate Bed" the majority of the fossils are forms characteristic of shallow water, and very incomplete information can be obtained concerning the fauna which was then living in water of the depth which we have selected as our standard. This portion of the sequence, therefore, presents us with a special phase, and the change of fauna which takes place at its termination does not indicate the extinction of an earlier fauna and its replacement by a new, but merely introduces us to the life of a lower bathymetric-zone.

DIAGNOSIS :

The abundance of shallow-water fossils (Modioliform Lamellibranchs, Ostracods, *Spirorbis*, etc.), associated with Brachiopods, which are characteristic of the Lower *Cleistopora*-Zone (*Athyris Royssii*, *Eumetria*, etc.).

FLORA :

Plant fragments are common.

FAUNA :

Spirorbis (?), Ostracods, Crinoid fragments, Lamellibranchs of the genera *Modiola*, *Sanguinolites*, etc., and Gasteropods, especially small forms belonging to the genera *Murchisonia* and *Bellerophon*.

Bryozoa belonging to the genera *Rhabdomeson*, *Rhombopora* and *Fenestella*.

Fish scales occur somewhat rarely.

The Brachiopods include shallow-water forms, such as *Lingula* and "*Discina*," together with a limited number of species which also belong to the fauna of standard depth :—

Athyris Royssii (abundant).

Eumetria sp.

Eumetroid Rhynchonellid.

Spiriferids (fragments, probably, of both *Spirifer* and *Syringothyris*).

Chonetes cf. *hardrensis*.

LOCAL DETAIL :

N.B.—The beds are dealt with in ascending order and the particular section which has yielded the best results is indicated at the side. The original description is printed practically unaltered in spite of the fact that owing to bricking up and growth of vegetation the exposures have greatly deteriorated.

Road section.

(*a*) In the lowest 15 feet of the sequence, thin slabs can be seen whose surface is covered with *Spirorbis* (*?*), small Gasteropods and Ostracods, with an occasional specimen of *Modiola*.

(*b*) The next 30 feet is very poor in fossils, but a thick bed, near the top, contains the small Eumetroid Rhynchonellid in some abundance. Resting upon this bed is a thick band of shale.

(*c*) The upper part of this shale-band, and the limestones and shales above (some 20 feet in thickness), are highly fossiliferous ; all the shales yield abundant Ostracods and Modioliform Lamellibranchs (*Modiola lata* being extremely common), while the weathered surfaces of the limestones are covered with Bryozoa and with fragments of Brachiopods and Crinoids.

The lowest hard bed in this series is a black, compact, somewhat nodular limestone, rich in *Leperditia* (one of the largest forms in the Ostracod group).

Railway section.

At the base of this series, *Athyris Royssii* is extremely abundant in the railway section. (This is a striking instance of the patchy distribution of individual forms.) A little above the *Athyris Royssii* level, hunt should be made for a remarkable branching Bryozoan (*Rhombopora ?*), which, at first glance, resembles *Lithostrotion junceum*.

The "Bryozoa Bed" is best examined in a thin slice under the microscope. Bryozoa, belonging to the genus *Rhabdomeson*, are always to be seen, but they are relatively scarce in comparison with the great number of small rounded sections of crinoid fragments which constitute the main portion of the slide. These crinoid sections exhibit a finely reticulate structure, suggestive of the transverse sections of dendroid Bryozoa, and it is to their great abundance that the rock owes its misnomer. [There are several beds in the upper part of the *Cleistopora*-Zone, to which the title of "Bryozoa Bed" might be much more aptly applied.]

The index fossil *Modiola lata* is to be found throughout the *Modiola*-Phase, but it is most abundant in certain of the shales included in Division *c*. The horizon at which it is most prolific is a shale bed in the railway section, 30 feet below the top of the "Bryozoa Bed," where it is associated with enormous numbers of small Ostracods.

K_1 = Subzone of *Productus bassus*.

DIAGNOSIS;

Productus bassus, *Chonetes* cf. *Buchiana* and *Eumetria* aff. *carbonaria* are abundant at certain levels.

FAUNA:

Productus bassus.
Chonetes cf. *Buchiana.*
Chon. cf. *crassistria.*
Chon. cf. *hardrensis.*
Orthotetes cf. *crenistria.*
Leptæna cf. *analoga.*
Eumetria aff. *carbonaria.*
Camarotœchia mitcheldeanensis.

LOCAL DETAIL:

The K_1 section includes the "Palate Bed" and about 30 feet of overlying strata, but the rocks are now ill-exposed.

The basal limestones, 2 or 3 feet in thickness, are crowded with fossils and, from them, all the forms cited above have been obtained, with the exception of the three species of *Chonetes* which are rare at the bottom of the subzone. The index fossil *Productus bassus* is also somewhat rare here, although it is remarkably abundant at the same level on the opposite side of the river. The thin limestones at the top of the exposure contain the three types of small *Chonetes* cited above. With the *Chonetes* are associated Rhynchonellids, Spiriferids and the tails of a small species of *Phillipsia*.

The Spiriferids include both *Spirifer* aff. *clathratus* and *Syringothyris* aff. *cuspidata*, but they do not yet play a dominant part in the faunal assemblage.

The zonal coral, *Cleistopora*, has not, as yet, been recorded from K_1 in the Avon Section (right bank), but further search will doubtless result in its discovery, for it has been found at this level on the left bank of the Avon and in other parts of the South-Western Province, as, for example, at Skrinkle, south of Tenby.

K_2 = Subzone of *Spiriferina* cf. *octoplicata*.

DIAGNOSIS :

Spiriferina cf. *octoplicata* and *Cleistopora* cf. *geometrica* occur somewhat abundantly at certain levels.

The Brachiopods cited as diagnostic of K_1 are rare or absent. *Zaphrentis* is absent.

FAUNA :

CORALS :

Cleistopora cf. *geometrica*.

BRACHIOPODS :

Chonetes cf. *hardrensis*.
Orthotetes cf. *crenistria*.
Leptæna cf. *analoga*.
Spirifer aff. *clathratus*.
Syringothyris aff. *cuspidata*.
Athyris Royssii, mut. *β*.
Camarotœchia mitcheldeanensis.

BRYOZOA :

Rhabdomeson.
Monticuliporids.
Fenestellids.

CRINOIDS :

Three or four species are represented by fragments which build up the greater part of the limestones, but their identification awaits further work.

LOCAL DETAIL :

As already remarked, the exposures in this subzone are very poor.

A special search should be made for the zonal and subzonal indices, *Cleistopora* cf. *geometrica* and *Spiriferina* cf. *octoplicata*, at the side of the road just north of Press' Quarry ; good specimens of both fossils have been obtained from this level.

The Brachiopods above cited are abundant in the thin limestones throughout the subzone and, near the top, the Spiriferids form the dominant feature of the fauna.

The characteristic K_1 forms, such as *Productus bassus* and *Eumetria* aff. *carbonaria*, have not, as yet, been recorded from this subzone in the Avon. On the other hand, the characteristic Lower-

Zaphrentis Brachiopods (such as *Productus* cf. *burlingtonensis*, *Athyris* aff. *glabristria*, *Athyris Royssii* mut. β, *Reticularia* cf. *reticulata* and *Rhipidomella* aff. *Michelini*) become more and more abundant as we approach the top of the *Cleistopora*-Zone.

$$\textit{Zaphrentis}\text{-Zone}: \; Z \begin{cases} \gamma \text{ horizon of overlap} \\ Z_2 \\ Z_1 \\ \beta \text{ horizon of overlap} \end{cases}$$

Zonal index :—*Zaphrentis* aff. *Phillipsi*.

DIAGNOSIS :

At the base, *Zaphrentis* enters and *Cleistopora* has become extinct.

At the top, *Caninia* becomes abundant.

Horizon β

DIAGNOSIS :

Spiriferina cf. *octoplicata*, the index fossil of the Upper *Cleistopora* Zone, occurs in association with *Zaphrentis* aff. *Phillipsi*, the index of the *Zaphrentis*-Zone.

FAUNA :

This horizon, though characterized by a fauna essentially the same as that of the *Zaphrentis*-Zone, contains one or two survivors from the fauna peculiar to the *Cleistopora*-Zone.

LOCAL DETAIL :

In the Avon Section, this extremely fossiliferous level forms the base of the Black Rock Limestone-massif and, on the Clifton side of the river, it can only be examined in Press' Quarry.

The Brachiopods, with the two principal exceptions mentioned below, are characteristic Lower-*Zaphrentis* forms and, in fact, at Horizon β, the Z_1 fauna is already typically developed ; hence it is unnecessary to enumerate the forms which are most abundant since they are equally abundant throughout Z_1 and will be sufficiently dealt with in the general account of that subzone which immediately follows.

The two Brachiopods worthy of special notice are *Spiriferina* cf. *octoplicata* and *Athyris Royssii*, mut. β.

In the Bristol Area, *Spiriferina* cf. *octoplicata* is not found above

Horizon β; it is the index fossil of K_2, but reaches its maximum abundance at, or just below, Horizon β.

Athyris Royssii, mut. β, agrees very closely, in range and distribution, with *Spiriferina* cf. *octoplicata*; it is an abundant and characteristic fossil at Horizon β and is common throughout K_2, but it ranges on into the Z_1 subzone.

The only coral which occurs at this horizon is *Zaphrentis* aff. *Phillipsi* which here makes its earliest appearance; it is not uncommon, and good specimens, showing the calyx, can be picked out of the weathered partings.

Cups and stems of Crinoids, spines and plates of a Palæchinid, and Bryozoans of several types can be collected at this level, but their accurate determination awaits much-needed research.

Z_1 = Subzone of *Spirifer* aff. *clathratus*.

DIAGNOSIS:

Zaphrentis aff. *Phillipsi* is the only *Zaphrentis*.

Spirifer aff. *clathratus* is enormously abundant.

FAUNA:

CORALS:

Zaphrentis aff. *Phillipsi*.

BRACHIOPODS:

Productus cf. *burlingtonensis*.
Chonetes cf. *hardrensis*.
Orthotetes cf. *crenistria*.
Leptæna cf. *analoga*.
Rhipidomella aff. *Michelini*.
Spirifer aff. *clathratus*.
Syringothyris aff. *cuspidata*.
Reticularia cf. *reticulata*.
Athyris aff. *glabristria*.
Camarotœchia mitcheldeanensis.

Bryozoa and Crinoids are abundant.
Palatal teeth of Elasmobranchs (*Psammodus*, etc.) are not uncommon.

LOCAL DETAIL:

The beds are exposed at the side of the road in the northern extension of the Black Rock Quarry, and most of the fossils cited above can be seen weathered out on the bedding planes. *Camarotœchia mitcheldeanensis* abounds in one of these beds, and this is the highest level in the Avon sequence at which this Brachiopod is an important fossil.

The best hunting-ground is, however, in the beds which form or underlie the broad dip-slope at the northern end of the Black Rock Quarry.

Orthotetes cf. *crenistria* and the two varieties of *Spirifer* aff. *clathratus* occur in thousands; *Leptæna* cf. *analoga* and *Syringothyris* aff. *cuspidata* are their commonest associates.

Just below the slope, at the top of the Z_1 subzone, the surfaces of the beds are often completely covered with the valves of *Chonetes* cf. *hardrensis*. Associated with this small species of *Chonetes* are the earliest examples of the group of papilionaceous *Chonetes*. *Rhipidomella* aff. *Michelini* reaches its maximum near the top of Z_1, and specimens should be looked for on the surfaces on which *Chonetes* cf. *hardrensis* is abundant.

Z_2 = Subzone of *Zaphrentis* aff. *cornucopiæ*.

DIAGNOSIS:

The association of *Zaphrentis* aff. *cornucopiæ* with *Zaphrentis* aff. *Phillipsi*, the rarity of *Caninia*, and the gradual decline of the Z_1 Brachiopod-fauna.

The lower part of the subzone is marked by the entrance of *Schizophoria* aff. *resupinata* and by the abundance of *Athyris* aff. *glabristria*; the upper part is characterized by the great abundance of the two species of *Zaphrentis*, and by the entrance of *Caninia* and of the large form of *Syringothyris* aff. *cuspidata* which is so important a fossil of the *Syringothyris*-Zone.

FAUNA:

CORALS:

Zaphrentis aff. *cornucopiæ*.
Zaph. aff. *Phillipsi*.
Amplexus cf. *coralloides*.
Syringopora θ
Michelinia, spp.

BRACHIOPODS:

Productus cf. *burlingtonensis*.
Prod. aff. *semireticulatus*.
Chonetes cf. *hardrensis*.
Papilionaceous *Chonetes*.
Orthotetes cf. *crenistria*.
Schizophoria aff. *resupinata*.
Rhipidomella aff. *Michelini*.
Syringothyris aff. *cuspidata*.
Syr. cf. *laminosa*.
Athyris aff. *glabristria*.

Bryozoa, Crinoids and *Palæchinus*.

ELASMOBRANCHS:

Psammodus, *Orodus*, *Helodus*, etc.

LOCAL DETAIL:

Within the main Black Rock Quarry, namely that portion which lies south of the broad dip-slope below the "Cave," the whole of the Z_2 subzone is comprised.

The "Fish Beds" occur about the middle of the subzone and separate two rather distinct faunal assemblages :—

(1) Below the "Fish Beds."—

Zaphrentis aff. *Phillipsi* is the only common species of *Zaphrentis*.

Athyris aff. *glabristria* and *Orthotetes* cf. *crenistria* are the most abundant fossils.

Schizophoria aff. *resupinata* makes its first appearance, and is rather common, in the beds immediately above the slope.

(2) Above the "Fish Beds."—

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiæ* are both very common and account for the greater number of coral sections which can be seen in the rock-faces, but *Amplexus*, *Michelinia* and *Syringopora* can always be recognized if carefully looked for.

The large papilionaceous *Chonetes* is already firmly established as the dominant *Chonetes*, and the gens of *Syringothyris* aff. *cuspidata* is represented for the first time by the large form, *Syringothyris cuspidata*, which is characteristic of the succeeding zone.

Horizon γ

DIAGNOSIS :

Caninia cylindrica is, for the first time, abundant and is associated with *Zaphrentis*, which is still extremely common.

N.B.—In the Avon section, Horizon γ appears to be inseparably linked with the Z_2 beds below and to be sharply marked off from the *Syringothyris*-Zone above, but this phenomenon is due to the incoming of peculiar physiographic conditions (the "dolomite phase"). Where the standard conditions persisted into the *Syringothyris*-Zone, as was the case in the Mendip Area, Horizon γ presents its true character as a level of faunal overlap which links the zones above and below, and is placed with equal justice in either.

FAUNA :

Syringothyris cuspidata and papilionaceous *Chonetes* are the most striking of the Brachiopods, and there are few survivors of the Z_1 fauna.

Corals abound :

Zaphrentis (both species), *Caninia*, *Amplexus*, *Michelinia*, *Syringopora*.

LOCAL DETAIL :

Horizon γ is represented by the massive bed which immediately underlies the "*laminosa*-dolomite" at the extreme southern end of the Black Rock Quarry. Sections and weathered calices of *Caninia*

cylindrica can be seen in the rock-faces, and *Zaphrentis* is extremely abundant.

Syringothyris-Zone : $C = \begin{cases} C_2 \\ C_1 \end{cases}$

GENERAL CHARACTERS of the zone in those areas in which the standard conditions obtained :—

Lithostrotion is typically absent and *Caninia* abundant.

FAUNA :

CORALS :

Michelinia cf. *megastoma* can be found throughout.

Cyathophyllum ϕ is especially characteristic of the upper half.

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiæ* pass up from the *Zaphrentis*-Zone below, but are only abundant in the lower half of the *Syringothyris*-Zone.

BRACHIOPODS :

Syringothyris cf. *laminosa* and *Syringothyris cuspidata* are characteristic fossils. *Chonetes* cf. *comoides* and papilionaceous *Chonetes* crowd certain beds, especially in the lower part of the zone where they are associated with equally abundant specimens of the C mutation of *Orthotetes* cf. *crenistria*.

GASTEROPODS :

A large species of *Bellerophon* is very abundant in association with *Cyathophyllum* ϕ in the upper part of the zone.

LOCAL DETAIL :

Owing to the peculiar conditions of deposition, the *Syringothyris*-Zone in the Avon section exhibits very few of the above characters and, in fact, it is at the present time useless to attempt the study of the fauna in the section on the Clifton side of the river; a fossiliferous level in C_1 is exposed on the opposite side of the river and will be described later.

From the "*laminosa*-dolomite," at the foot of the Gully, good specimens of *Orthotetes* cf. *crenistria* have been obtained and, from the "*Caninia*-Oolite" Quarry, specimens of *Michelinia* cf. *megastoma* and *Syringopora* cf. *reticulata* were formerly collected in fair numbers.

The upper portion of the zone, the *Caninia*-shales and-dolomites,

has yielded hardly any fossils on either side of the Avon Section. There is, however, a fossiliferous development of C_2 as near as Failand.

Seminula-Zone : $S = \begin{cases} S_2 \\ S_1 \end{cases}$

Zonal index :—*Seminula ficoides.*

DIAGNOSIS :

The first abundance of *Lithostrotion* occurs at the base of the zone.

The first abundance of *Dibunophyllum* occurs above the top of the zone, at the base of the succeeding zone.

Lithostrotion Martini is the dominant coral throughout the zone and no *Zaphrentis* or *Dibunophyllum* has yet been recorded from the zone.

Seminula ficoides is the dominant Brachiopod.

S_1 = subzone of *Caninia cylindrica*, mut. S_1.

DIAGNOSIS :

The S_1 subzone is characterized by the establishment of a dominant Viséan fauna (*Lithostrotion, Seminula*, etc.) with which are associated several mutations which are the direct descendants of Tournaisian forms (*Caninia cylindrica*, certain *Producti*, etc.).

FAUNA :

CORALS :

Caninia cylindrica, mut. S_1.
Lithostrotion Martini.
Lith. bristolense.
Syringopora cf. *reticulata.*
Syr. cf. *distans.*

BRACHIOPODS :

Productus θ.
Prod. semireticulatus, mut. S_1.
Athyris cf. *planosulcata.*
Syringothyris cf. *laminosa.*

Trepostomatous Bryozoa.

GASTEROPODS :

Bellerophon, Loxonema, etc.

LOCAL DETAIL :

At the northern end of the "Great Quarry" where the fence bounding the tennis courts swings round towards the road, rises a large irregular bedding plane extending high up the quarry end. This bedding plane is alluded to in the original issue of this paper as the "back

slope." About 15 yards further south a second conspicuous bedding plane covered with small brachiopods (*Seminula*) is seen; this is the "front slope." The quarry bank still further south is a recently constructed feature. Several interesting horizons may easily be recognized from their position relative to the "back" or "front" slope.

The dendroid coral *Lithostrotion Martini*, which abounds throughout the *Seminula*-Zone, often builds up entire beds.

The massive coral, *Lithostrotion bristolense* is only abundant in a thick bed just above the "back slope." Specimens were formerly obtained from a petroleum-stained patch at this level and are common in old collections, where they are usually labelled *Lithostrotion aranea*.

Syringopora cf. *reticulata* is, locally, a valuable diagnostic fossil as it is not known, in the Bristol area, above S_1 or below the *Syringothyris*-Zone.

The subzonal coral, *Caninia cylindrica*, mut. S_1, is only abundant in a thick bed a few feet above the "front slope."

Seminula ficoides is enormously abundant at frequent intervals throughout the *Seminula*-Zone.

The shaly partings in the S_1 subzone are frequently crowded with crushed *Seminulæ* and, resting immediately upon the "back slope," is a massive bed which teems with uncrushed specimens. All the characters of the fossil can be readily made out in the numerous cross sections exposed in the rock-face, but solid specimens are very difficult to extract.

Productus θ is a common fossil but is difficult to determine from the specimens seen *in situ*, which are usually mere cross sections or partially exposed valves. Specimens can, however, often be picked up from among the débris which is littered over the slopes. (The same level on the opposite side of the river is, however, a better hunting-ground.)

Productus semireticulatus, mut. S_1, is represented by crushed valves and long spines in the shaly partings. The best collecting level is just above the "front slope," where the weathered surfaces are covered with the spines of this Productus,[1] associated with the

[1] This level has often been referred to as the "longispinus bed," but the designation is unfortunate since the *Productus*, whose spines have suggested the name, is very different from *Productus longispinus*. The term "Trilobite Bed" is to be preferred.

tails of a small "*Phillipsia*" and with abundant specimens of a trepostomatous Bryozoon.

Athyris cf. *planosulcata* is common at the same level on the opposite side of the river.

Trepostomatous Bryozoa are abundant at several levels in the shaly partings, and good specimens can be obtained from the "Trilobite Bed." Fenestellids are common associates.

Gasteropods belonging to several genera can be seen cross-sectioned in the rock-faces, especially at the top of the subzone.

S_2 = Subzone of *Productus corrugato-hemisphericus*
(= *Prod.* aff. *Cora*, mut.)

FAUNA:

Throughout the South-Western Province very few gentes are represented in this subzone, but those which occur are remarkably rich in individuals. *Lithostrotion*, *Syringopora*, *Seminula*, papilionaceous *Chonetes*, and variants of *Productus hemisphericus* build up thick bands and recur again and again.

CORALS:

In addition to *Lithostrotion* and *Syringopora*, which are extremely abundant, *Carcinophyllum* and *Alveolites* occur somewhat sparingly, and *Cyathophyllum* has been recorded from the uppermost bed in a single locality (Sodbury). These are the only corals found in this subzone throughout the South-Western Province; *Zaphrentis*, *Caninia*, *Dibunophyllum*, etc., being all absent.

BRACHIOPODS:

Productus hemisphericus (abundant).
Prod. corrugato-hemisphericus (abundant).
"*Prod. giganteus*" (from the uppermost beds only).
Prod. punctatus (rare).
Orthotetids (rare).
Cyrtina carbonaria and var. (especially abundant near the base).
Athyris (rare).
Seminula ficoides and vars. (abundant).

The above list comprises practically *all* the Brachiopods which have as yet been recorded from the S_2 subzone throughout the South-Western Province. *Spirifer*, *Syringothyris*, *Schizophoria* and *Leptæna* are all absent and, although *Seminula* is so remarkably abundant, *Athyris* is very rare.

The limited nature of the fauna points clearly to the existence, during Upper-*Seminula* time, of very special conditions throughout the whole of the South-Western Province.

The groups which are unrepresented in the S_2 fauna either migrated from the Province during S_1 time, before the establishment of the new conditions, or lived on in the area until they suffered local extinction. (*Productus* aff. *semireticulatus*, mut. S_1, in its profusion of spines and in its marginal extensions, exhibits very convincingly the moribund characters which indicate approaching extinction.)

LOCAL DETAIL:

Seminula ficoides, *Lithostrotion Martini*, *Chonetes* cf. *papilionacea*, *Syringopora* cf. *distans* and *Productus corrugato-hemisphericus* build up distinct and recurring seams.

Carcinophyllum and the Bryozoan, *Chætetes* cf. *radians*, can always be detected by careful searching.

Cyrtina carbonaria, which is so extremely abundant at the base of S_2 in certain parts of the South-Western Province (e.g., Wickwar), has not been recorded from the Avon section.

In the repetition of the series, south of the "Great Fault," the entire S_2 subzone, with the exception of the pisolites at the base, is well exposed between the bottom of Bridge Valley Road and a point a few yards north of the foot of the Old Zig-zag. The repeated seams of *Lithostrotion*, *Seminula*, *Productus* and *Chonetes* can be readily examined, but very few other fossils have, as yet, been recorded.

Dibunophyllum-Zone: $D \begin{cases} \epsilon \\ D_2 \\ D_1 \end{cases}$

Zonal Index :—The *Dibunophyllum* group of the Clisiophyllidan Corals.

DIAGNOSIS:

CORALS:

In general, the abundance of Clisiophyllidan Corals is remarkably striking, both as regards species and individuals; in particular, the predominance of the *Dibunophyllum* section and the occurrence of the *Aulophyllum* section are noteworthy features.

Narrow-tubed *Lithostrotions* such as *Lithostrotion irregulare* and *L. Portlocki*, are the dominant forms of that genus.

BRACHIOPODS :

In general, the abundance of *Producti*, both as regards species and individuals, is a salient feature, and in particular, the predominance of the giganteid section and the entrance of the scabriculate and longispinous groups are the facts of chief importance.

Of the *Spirifers*, *Sp. bisulcatus* is the dominant species.

D_1 = Subzone of *Dibunophyllum θ*.

DIAGNOSIS :

The entrance of *Dibunophyllum* and the predominance of those species of the genus which have a simple type of structure.

The absence of highly specialized Clisiophyllids, such as *Lonsdalia*.

The maximum abundance of *Cyathophyllum Murchisoni* and of *Productus hemisphericus*.

FAUNA :

CORALS :

Dibunophyllum θ, *Dib. ϕ*, *Carcinophyllum θ* } abundant.
Cyclophyllum pachyendothecum (rare).
Koninckophyllum θ (common locally, e.g. at Sodbury).
Campophyllum aff. *Murchisoni*.
Cyathophyllum Murchisoni (very abundant).
Diphyphyllum.
Lithostrotion irregulare.
Lith. Martini.
Lith. junceum.
Syringopora cf. *geniculata*.
Syr. cf. *ramulosa*.
Syr. cf. *distans*.
Alveolites septosa (abundant).

BRACHIOPODS :

Productus giganteus, *Prod. hemisphericus*, *Prod. corrugato-hemisphericus* } abundant.
Chonetes (*Daviesiella*) aff. *comoides*.
Orthotetids, especially *Derbyia* (rare, except locally, e.g. at Westbury).
Cyrtina septosa (rare, except locally, e.g. at Lydstep).

LOCAL DETAIL :

This subzone can be examined in the roadside exposures immediately south of the bottom of the New Zig-zag.

In the repetition of the series, south of the "Great Fault," the fossils characteristic of the D_1 subzone can be readily recognized in the rock-face between the Colonnade and the foot of the Old Zig-zag, as well as in the exposures by the side of that path.

D_2 = Subzone of *Lonsdalia floriformis*.

DIAGNOSIS :

The presence of highly specialized Clisiophyllids, such as *Lonsdalia*, and *Dibunophylla* of the type of *Dib.* ψ.

The entrance of compound *Cyathophylla* and the importance of the *Martinia* section of the Spiriferids.

FAUNA :

CORALS :

Lonsdalia floriformis (abundant).

Dibunophyllum ϕ } common.
Dib. ψ }
Aulophyllids (rare).
Campophyllum.

Cyathophyllum Murchisoni } common.
Cyath. regium }

Lithostrotion irregulare (very abundant).
Lith. junceum.
Lith. Martini with Clisiophylloid and Diphyphylloid variants (abundant).
Lith. Portlocki and *Lith. M'Coyanum* (abundant).
Lith. ensifer.
Petalaxis Portlocki.
Alveolites septosa (common).
Syringopora cf. *distans.*

BRACHIOPODS :

Productus latissimo-giganteus. (abundant).
Choneti-Productus.
Prod. hemisphericus (common).

Spirifer striatus.
Sp. bisulcatus.
Sp. planicosta.
Martinia ovalis.
Reticularia lineata.
Athyris planosulcata.
Seminula ambigua.
Dielasma.

The above lists include only those species which have been recorded from D_2 in the Avon section.

LOCAL DETAIL :

The only exposures of D_2 beds on the Clifton side of the Avon are those by the roadside north of the bottom of Bridge Valley Road ; those which formerly existed in Bridge Valley Road itself are now hidden by a wall. *Lithostrotion portlocki* is very common, while *Lithostrotion martini* and *irregulare* build up the greater part of several beds. Many of the species cited in the foregoing lists can be detected by careful search in the roadside section. It was in widening the river channel at this spot, formerly known as Round Point, that most of the " Clifton Corals," so common in collections, were originally obtained.

Horizon ϵ.

Passage beds from the Carboniferous Limestone into the Millstone Grit.

In the Avon section, this horizon consists chiefly of massive calcareous grit and was formerly included in the "Millstone Grit" series.

FAUNA:

Productus scabriculus (extremely abundant).

Prod. corrugatus and Orthotetids (common).

In the repetition of the series, south of the "Great Fault," this horizon is concealed behind the "General Draper" Public House and is no longer accessible; in the main section, north of the Fault, the sequence is cut short near the top of D_2, before this horizon is reached.

In other parts of the South-Western Province, the calcareous development extends above Horizon ϵ, and includes a small portion of the subzone D_3 which is so important a subdivision of the Lower Carboniferous in the Midland and Yoredale Provinces.

Hence it is impossible to avoid the conclusion that "Millstone Grit" conditions did not commence at the same time over even so small an area as the South-Western Province and that, consequently, the "Millstone Grit" of one locality is the time-equivalent of part of the "Carboniferous Limestone" of another.

"Millstone Grit."

The massive quartzite-like grits, included under this title, immediately succeed Horizon ϵ in the Avon section without any break, and, since the upper part of D_2 contains several bands of grit which herald the incoming of prolonged grit conditions, we may fairly assume the conformity of the "Millstone Grit" with the underlying "Carboniferous Limestone" in the immediate neighbourhood of Bristol.

III. THE SECTION ON THE LEIGH WOODS SIDE

Seeing that the sequence on the right bank of the Avon has been so fully dealt with, it will be unnecessary to give so detailed an account of that on the left bank. The descriptive account which follows consists, therefore, of a series of short notes explanatory only of the most striking facts, and especially of those which cannot be so satisfactorily observed on the Clifton side of the river.

We may conveniently start from Clifton Bridge Station, and, before entering on the riverside traverse, it will be advisable to visit the quarry on Rownham Hill, though this has now (1935) been used for many years as a depository for refuse. If the hill be ascended as far as the fork in the road, the left-hand branch must be taken, and the quarry then lies a short distance farther along, on the right hand side of the road. (If Clifton Bridge Station is reached from the Suspension Bridge, the quarry should be examined on the way down.)

"Rownham Quarry" lies in the upper part of the *Dibunophyllum*-Zone (D_2), and in the repetition of the Carboniferous Series, south of the "Great Fault." The lowest beds exposed in the quarry are massive limestones poor in fossils; these beds were formerly worked for road metal. Resting upon these massive beds is a thick bed of rubbly limestone which contains numerous patches of clay, and it is from these patches that the finest specimens of D_2 corals have been obtained.

Subjoined is a complete list of the Corals and Brachiopods which have been collected from Rownham Quarry:—

CORALS:

Lonsdalia floriformis.
Lithostrotion irregulare.
Lith. Portlocki.
Lith. M'Coyanum.
Lith. ensifer.
Dibunophyllum ψ.
Cyathophyllum regium.
Cyath. Murchisoni-regium.
Campophyllum Murchisoni.
Alveolites septosa.
Syringopora cf. *distans.*

Lonsdalia, Lithostrotion irregulare and *Cyathophyllum regium* are the most abundant Corals.

BRACHIOPODS:

Productus latissimo-giganteus.
Choneti-Productus.
Spirifer bisulcatus.
Sp. planicosta.
Spiriferina cf. *biplicata.*
Martinia ovali-glabra.
Athyris planosulcata.

Giganteid *Producti* are the only Brachiopods which are abundant; Spiriferids and Athyrids are rare.

Bryozoa are not uncommon, and *Calamites* occurs in a thin grit band.

Returning to Clifton Bridge Station, we will now commence our walk downstream along the river side.

The *Dibunophyllum*-Zone is poorly exhibited in the rail-side cutting, the beds which we have just examined in "Rownham Quarry" cropping

out again at the southern end of this exposure, while at the northern end the "Concretionary beds" (S_2d) are seen.

As we pass under the Suspension Bridge, the strata (S_2c) which separate the "Concretionary beds" from the "*Seminula*-oolite" are well exposed in the cliff-face but present no new points of special interest. Between the northern end of the little tunnel and Nightingale Valley, the "*Seminula*-oolite" is exposed in the railway cutting and by the riverside.

Nightingale Valley, which lies immediately north of the Suspension Bridge, is just to the south of the continuation of the "Great Fault" as traced by Professor Lloyd Morgan.

At this point, therefore, we enter upon the main Avon Section, which includes, without a break in the sequence, all the zones, from the upper part of the *Dibunophyllum*-Zone down to the base of the *Cleistopora*-Zone and its conformable junction with the Upper Old Red Sandstone.

D_2.

North of Nightingale Valley, the D_2 beds form a high mural exposure which can be examined in Quarry 6. (See Pl. 15). This quarry has been long disused and will scarcely repay a short visit. Most of the fossils obtained at "Rownham Quarry" can also be found here, and *Fistulipora* cf. *incrustans*, a Monticuliporoid characteristic of D_2, is somewhat abundant, as are also the narrow-tubed massive forms of *Lithostrotion*. The fossils occur, as on Rownham Hill, in a thick rubbly limestone; this bed can be followed up the slopes, and is well exposed on the sides of Stoke Leigh Camp.

No further exposures are seen till the second tunnel is approached.

D_1.

A short cutting just south of the tunnel affords a good section of D_1, and, coincident with this, a fine riverside section of D_1 about 100 yards long commences. "Rubbly beds" ("pseudobreccia") are well exposed at the southern end. Many bedding planes covered with *Cyathophyllum murchisoni* and *Productus giganteus* are conspicuous, these two fossils reaching their maximum of abundance at this level. D_1 beds are also well exposed by the roadside, and weathered out corals can, or formerly could, readily be collected on the dip-slope of the rubbly limestone overlooking the southern end of the tunnel.

The following fossils have been found in these exposures of D_1 :—

CORALS :

Dibunophyllum θ.
Dib. φ.
Carcinophyllum, θ.
Campophyllum aff. *Murchisoni.*
Cyathophyllum Murchisoni.
Diphyphyllum.
Lithostrotion irregulare.
Lith. junceum.
Lith. Martini and a Clisiophylloid variant.
Syringopora cf. *geniculata.*
Syr. cf. *ramulosa* and *S.* cf. *distans.*
Alveolites septosa.

BRACHIOPODS :

Productus hemisphericus.
Prod. giganteus.
Chonetes cf. *papilionacea.*
Ch. aff. *comoides.*

S_2.

Although there is no stratigraphical break between the base of D_1 and the top of S_2, yet the faunal break (as also the lithological break) is remarkably striking and, at first sight, well-nigh complete. In the Avon sequence, the D_1 beds, with their rich coral fauna, are underlain by the S_2 " Concretionary beds " which contain few fossils beyond recurrent seams of *Seminula.* (Although the sharpness of the faunal break between the *Dibunophyllum* and *Seminula*-Zones is seen to be less perfect the more closely we examine any one locality, and the more widely we extend our observations, it yet remains a striking feature of the sequence throughout the South-Western Province, and undoubtedly indicates a very considerable change of conditions.)

The strata forming the roof of the tunnel are the " Concretionary beds " (S_2d), and the scarp overlooking them is D_1. The exposures of the " Concretionary beds " are in the main poor, though the characteristic algal layers are well seen in some of the roadside exposures.

The riverside exposure of S_2, which extends as far as Quarry 5, is in the main in the " Concretionary beds " (S_2d), but includes part of the underlying S_2c. It affords one of the best developments of upper S_2 in the whole of the Avon Section.

Quarry 5 is in upper S_2-beds which are, however, poorly exposed. *Seminula ficoides* and *Lithostrotion Martini* are both abundant. A thin band of Dolomitic Conglomerate rests on the limestone at the top of the quarry and its character can be studied in blocks on the quarry floor. The northern boundary of the quarry is formed by a large and conspicuous bedding plane. Between quarries 5 and 4, both of which have long been abandoned, " *Seminula*-Oolite " (S_2b) is exposed by the side of the railway and also by the riverside. In

Quarry 4, the upper part of the wall is formed of "*Seminula*-Oolite" in poor condition. The main part of the quarry is in "*Seminula*-pisolite" (S_2a), also very poorly exposed and much calcite-veined. The large blocks of *Lithostrotion*-limestone, and of "China-stone" showing brecciation, which lie about on the floor of the quarry, are from this horizon.

S_1.

The main interest of Quarry 4 centres, however, in the exposure of the S_1 subzone.

The slope which forms the north end of the quarry lies immediately above the level of the "Trilobite Bed" (see footnote, p. 73) of the "Great Quarry." There is, in fact, a small exposure of this bed in the north-eastern corner of Quarry 4 where a few trilobite tails can be recognised on the bedding-surface; a frilled Athyrid, with the form of *Athyris planosulcata*, is not uncommon, but *Productus semireticulatus*, mut. S_1, has not been detected.

If we now climb the main slope and examine the exposures of bare rock which lie in position upon it, *Caninia cylindrica*, mut. S_1, is seen to occur abundantly, with *Lithostrotion Martini* and *Seminula ficoides*. In the débris scattered over the highest part of the slope, at the extreme north end of the quarry, *Productus* θ may be found; this Productus can be seen, *in situ*, in a bed a few feet above the slope where *Athyris* cf. *planosulcata* is also not uncommon.

C_2.

After leaving Quarry 4, the C_2-dolomites and -shales can be recognized, both in the river bank and also by the side of the line, but the exposures are unsatisfactory, and there is nothing to delay us until we reach Quarry 3 (the "Oolite Quarry").

C_1.

The thick band of "*Caninia*-Oolite" forms a striking feature in the wall of this quarry (Plate 11). The well-bedded shales and thin limestones capping the thick massive oolite, in which the bedding is difficult to recognize, give a momentary suggestion of unconformity which is heightened by the vertical jointing of the oolite-mass, but the impression is immediately corrected by the obvious bedding to be seen in the rocks below the Oolite, and by the traces of bedding which can be made out in the oolite-mass itself.

The oolite grains are usually very much smaller than is the case in the oolitic bands at higher levels, and the amount of interstitial cement is relatively less; the concretionary structure of the grains extends almost from surface to centre.

Fossils are rare in the Oolite but *Syringopora* cf. *reticulata* and *Michelinia* cf. *megastoma* occur sparingly.

The beds below the Oolite form the uppermost portion of the "*laminosa*-dolomite," a division of C_1, in which recurrent shell seams form a characteristic feature. One of these seams can be examined on the bare slopes at the northern end of the quarry.

Orthotetes cf. *crenistria* and papilionaceous *Chonetes* occur in great numbers, and a few specimens of the subzonal index, *Syringothyris laminosa*, may be seen.

There is a good section by the side of the railway just north of Quarry 3; the highest beds are "*Caninia*-Oolite," the lowest 30 feet are γ, the remainder "*laminosa*-dolomite" (Pl. 11); a duplicate section is seen by the side of the road. After a gap of about 50 yards, exposures by the railway recommence and there is a section of Z_2, but the rocks are rather badly weathered. There is a better section by the roadside, the upper beds being very fossiliferous. There is also a riverside section which extends from a point a little north of Quarry 3 almost as far as the wharf of Quarry 2, and exposes the whole of the "*laminosa*-dolomite," γ, and Z_2. Z_2 and γ are very easily examined, but much of the "*laminosa*-dolomite" is not easily accessible.

We may now pass on to Quarry 2, which till 1935 has been in continuous work. The southern face consists of γ with Z_2 below and a capping of "*laminosa*-dolomite."

γ and Z_2.

Horizon γ is exposed at the southern end of the quarry, and fossils can readily be made out on the rock-faces.

Caninia cylindrica, *Zaphrentis* aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiæ* are the most abundant forms.

The "Fish Beds" have yielded large numbers of palatal teeth (*Psammodus*, *Orodus*, etc.).

In the lowest beds, at the northern end of the quarry, Brachiopods are abundant and constitute a characteristic *Zaphrentis* assemblage. The commonest forms are:—

Spirifer aff. *clathratus*, *Orthotetes* cf. *crenistria*, *Chonetes* cf. *hardrensis*,

Athyris aff. *glabristria*, *Syringothyris* aff. *cuspidata*, *Reticularia* cf. *reticulata* and *Rhipidomella* aff. *michelini*.

The earliest occurrence, in the Bristol Area, of a corrugate Productus is recorded from these beds.

We now proceed to Quarry 1, no exposures being seen either by the road or riverside between it and Quarry 2. The characteristic fossils of Z_1 are easily obtainable from the blocks of rock on the floor of the quarry.

Z_1, β, *and* K_2.

The most interesting portion of the quarry is, however, the northern end, which is shut off by a rise from the main part of the quarry. Here the lowest part of Z_1 and β are exposed. Horizon β owes its differentiation to the fact that at this level several of the fossils which are characteristic of the *Cleistopora*-Zone occur in association with a typical *Zaphrentis*-fauna.

The following Corals and Brachiopods have all been collected from Horizon β in Quarry 1 :—

(*a*) Brachiopods which may be considered to be characteristic of the *Cleistopora*-Zone :

Spiriferina cf. *octoplicata*.
Chonetes cf. *Buchiana*.
Athyris Royssii and its variant, mut. β.
Camarotœchia mitcheldeanensis.

(*b*) *Productus* cf. *burlingtonensis*, mut. β is common and may be considered to be equally indicative of the uppermost part of K and the lowest part of Z.

(*c*) *Zaphrentis* aff. *Phillipsi* is less common in Quarry 1 than it is on the Clifton side of the river, in Press' Quarry.

(*d*) The general *Zaphrentis*-assemblage of Brachiopods which has already been specified in the description of the lowest beds of Quarry 2.

A small excavation visible from the main entrance of Quarry 1 is in K_2, the beds being now much overgrown. They consist of shale and thin limestone bands in which Brachiopods are abundant. The zonal fossil *Cleistopora* has been obtained here.

For rather more than two hundred yards northwards from Quarry 1

there are no exposures. Then there commences a fairly good rail-side section of the "Bryozoa Bed" and the whole of K_m. The rocks are, however, still better seen by the riverside.

K_1.

In the riverside section, the K_1 subzone is finely exposed and there is a satisfactory sequence from the normal development of K_1, down through the "*Modiola*-Phase K_m," into the uppermost beds of the Old Red Sandstone.

As we walk along this exposure, the red "Bryozoa Bed" is easily recognized and is seen to separate the normal K_1 beds to the south from the "*Modiola*-Phase" to the north.

In the K_1 beds, *Orthotetes* cf. *crenistria*, mut. K_1, *Leptæna* cf. *analoga*, *Productus bassus* and *Camarotœchia mitcheldeanensis* occur in great abundance.

Eumetria aff. *carbonaria* and *Athyris Royssii* are common.

Bryozoa are very abundant, especially the genera *Rhabdomeson* and *Rhombopora* and certain members of the Monticuliporoid group.

Small Gasteropods (*Bellerophon*, *Capulus*, etc.) are common, and appear to be characteristic of the level.

Small palatal teeth occur sparingly as we approach the "Bryozoa Bed."

The "Bryozoa Bed" is well developed but calls for no special notice.

The "*Modiola*-Phase," immediately north of the "Bryozoa Bed," contains thick bands of shale which are practically unfossiliferous; a few imperfect specimens of *Modiola lata* have been discovered but Ostracods appear to be absent. The lowest beds of the "*Modiola*-Phase" contain obscure Modioliform lamellibranchs, small *Spirorbis*-like tubes which are weathered out on the surfaces of certain beds, and algal layers, one of them brecciated.

O. R. S.

The lowest beds of the "*Modiola*-Phase" pass down with perfect conformity into the coloured marls and grits which characterize Old Red Sandstone conditions.

From certain beds near the top of the Old Red Sandstone were obtained the scales of *Strepsodus* (*?*) to which reference has already been made.

IV.—TABLE SHOWING THE CHIEF EXPOSURES OF THE SUCCESSIVE HORIZONS (S. H. R.)

	Right Bank.	Left Bank.
D_2	*Highest beds* visible but not easily accessible just below the fault.	Not seen.
	Upper beds poorly seen above great wall at bottom of Bridge Valley Road.	*Upper beds* formerly well exposed in "Rownham Quarry" which is now used as a rubbish tip.
	Lower beds well seen in Portway roadside section.	*Lower beds* poorly exposed by the railway and in quarry 6.
D_1	*Upper beds* well exposed in Portway roadside section and poorly in Bridge Valley Road.	*Upper beds* poorly exposed by the railway.
	Lower beds seen : 1. In the main Portway section. 2. By the roadside from just north of the Rocks Railway to the Old Zig-zag path (series repeated by the fault).	*Lower beds* finely exposed in the riverside section. Seen high up above the tunnel slope south of quarry 5.
S_2	(*d*) "*Concretionary Beds.*" Very poorly exposed in main section. Best seen : 1. In the series as repeated by the fault. 2. By the side of the pavement leading to the Suspension Bridge. 3. In a riverside exposure near the New Zig-zag path.	Well seen in the riverside exposure. Poorly exposed in quarry 5 and in the tunnel slope to the south.
	(*c*) *Strata between the "Concretionary Beds" and the "Seminula*-Oolite." Seen : 1. Near the northern end of the "Great Quarry." 2. By the side of the pavement leading to the Suspension Bridge. 3. In the great rock-face just south of the Bridge (series repeated by fault).	Upper beds well seen in the riverside exposure. Poorly seen in quarry 5.

	(*b*) *The* "*Seminula*-Oolite." Well exposed near the northern end of the "Great Quarry." Also at the bottom of Bridge Valley Road (series repeated by fault).	Poorly seen in quarry 4.
	(*a*) "*Seminula*-pisolite." Finely exposed in the "Great Quarry."	Poorly seen in quarry 4.
S_1	Finely exposed at the northern end of the "Great Quarry.'	Fairly well seen in quarry 4.
C_2	"*Caninia*-dolomite." Finely exposed by the roadside between the "Great" and Gully Quarries. Seen in the adjacent riverside section.	Base well seen in quarry 3, but inaccessible.
C_1	(*b*) "*Caninia*-Oolite." Upper beds seen in roadside section south of Gully Quarry. The whole horizon is seen in the Gully Quarry and in the adjacent riverside exposure.	In quarry 3 the upper beds are well seen but inaccessible. The lower beds are seen in relation to the dip-slope of quarry 3 and in the adjacent rail and riverside exposures.
	(*a*) "*laminosa*-dolomite." Upper beds seen in the Gully Quarry, north end, and in the riverside exposure; lowest beds in the Black Rock Quarry, south end.	The whole horizon is well exposed in the railside section north of quarry 3. The lower beds are exposed but inaccessible high up in quarry 2.
γ	Finely seen in the Black Rock Quarry, and in the adjacent riverside exposure.	Seen by the railway north of quarry 3 and in the adjacent riverside exposure. Exposed but inaccessible high up in quarry 2.
Z_2	The whole horizon is seen in the Black Rock Quarry, but the exposures are not very good. There is a good riverside exposure.	The whole horizon is exposed in quarry 2, and the greater part in the adjacent riverside exposure. The top beds are also seen in the railside exposure south of quarry 2.
Z_1	Well exposed in the northern part of the Black Rock Quarry.	Well exposed in quarry 1.

β	Exposed in Press' Quarry.	Well exposed in the northern part of quarry 1.
K_2	Top beds exposed by the roadside just north of Press' Quarry. Main part of the horizon not seen.	Top beds ill exposed in a little excavation in the wood just north of quarry 1 ; main part of the horizon not seen.
K_1	Main part of the horizon not seen. Lowest beds exposed by the roadside just south of the "Bryozoa Bed" outcrop.	Upper beds not seen. Lower beds well exposed by the riverside north of quarry 1.
a	"Bryozoa Bed." Finely exposed by the roadside. Good exposures also in the Avonmouth railway north of the tunnel.	Well exposed in the railway cutting and still better in the riverside exposure.
K_m	Exposed both by the roadside and by the Avonmouth railway, but the exposures are becoming overgrown and are partly bricked up.	Seen in the railway cutting and well exposed by the riverside.

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EXPLANATION OF PLATES

Pl. 1. The northern end of the section showing the succession from the Old Red Sandstone nearly to Z_1.

Pl. 2. The Black Rock Quarry.

The whole of the Zaphrentis beds except lower Z_1 is seen, together with the "*laminosa*-dolomite," C_1 (*a*). The photograph was taken prior to the destruction of the Hotwells and Avonmouth railway.

Pl. 3. General view of the Avon Section, right bank, from near Sea Walls.

The southern end of the Black Rock Quarry is seen in the lower part of the photograph, the gap between it and the Gully Quarry not being apparent. The freedom from quarrying of C_2 and of the D-beds is conspicuous. The photograph was taken before the destruction of the Hotwells and Avonmouth railway.

Pl. 4. The Gully Quarry and part of the Black Rock Quarry. The woods in the upper part of the photograph are growing on the "*Caninia*-dolomite."

5. The section from the southern end of the Black Rock Quarry to the northern end of the "Great Quarry." The woods in the right half of the photograph are growing partly on the "*Caninia*-dolomite," C_2, partly on S_1.

C.D. = "*Caninia*-dolomite."

Pl. 6. The northern and major part of the "Great Quarry." Almost the whole *Seminula*-zone is seen, but the upper beds do not reach the floor of this part of the quarry.

Pl. 7. The "Great Quarry" and section almost as far as the bottom of Bridge Valley Road. The photograph was taken from above the gorge on the left bank.

The wooded character of the D-beds is conspicuous. Point Villa was formerly situated approximately where D is written in the photograph just above the "Point." The fine new section of lower D_2 is seen in the right hand corner.

Pl. 8. Observatory Hill, the Suspension Bridge and the section as repeated by the fault.

All the S-beds save the lowest section, S_2 (*a*), are seen. The base of D, which comes on just south of the Old Zig-zag path, is also seen.

Pl. 9. (*a*) Looking north from the Suspension Bridge.

The photograph shows the soles of several of the minor overthrusts in relation to the "Great Fault" of Observatory Hill. In the distance is seen the Black Rock Quarry below Sea Walls.

(*b*) Near view of the disturbed upper D_2-beds below the overthrust S_2-beds of Observatory Hill.

Pl. 10. (*a*) Quarry 5 and the tunnel slope to the south (lower D_1- and upper S_2-beds). Quarry 5 is terminated on the right by a conspicuous bedding plane.

(*b*) Quarries 5 and 4 both in the Upper S-beds.

Pl. 11. Quarry 3 and the railway section to the north. Quarry 3 is in the "*Caninia*-oolite" capped by the "*Caninia*-dolomite," which is well seen but inaccessible. In the railway section to the north and in the riverside exposures, the section extends from the base of the "*Caninia*-oolite" to the top of γ.

Pl. 12. (*a*) Quarry 3 and the southern part of Quarry 2. In Quarry 3 the "*Caninia*-dolomite" and "-oolite" are seen; in the southern part of Quarry 2 the "*laminosa*-dolomite" and Upper Z_2.

(*b*) Quarries 2 and 1. The series from the "*laminosa*-dolomite" to Z_1 is seen.

Pl. 13. Weathered surfaces of algal limestone.

(*a*) Brecciated algal limestone, K_m. Riverside exposure, northern end of section, left bank.

(*b*) Algal limestone, K_m. Riverside exposure, northern end of section, left bank.

(*c*) Algal limestone ("Concretionary beds"), $S_2(d)$. Quarry 5, left bank.

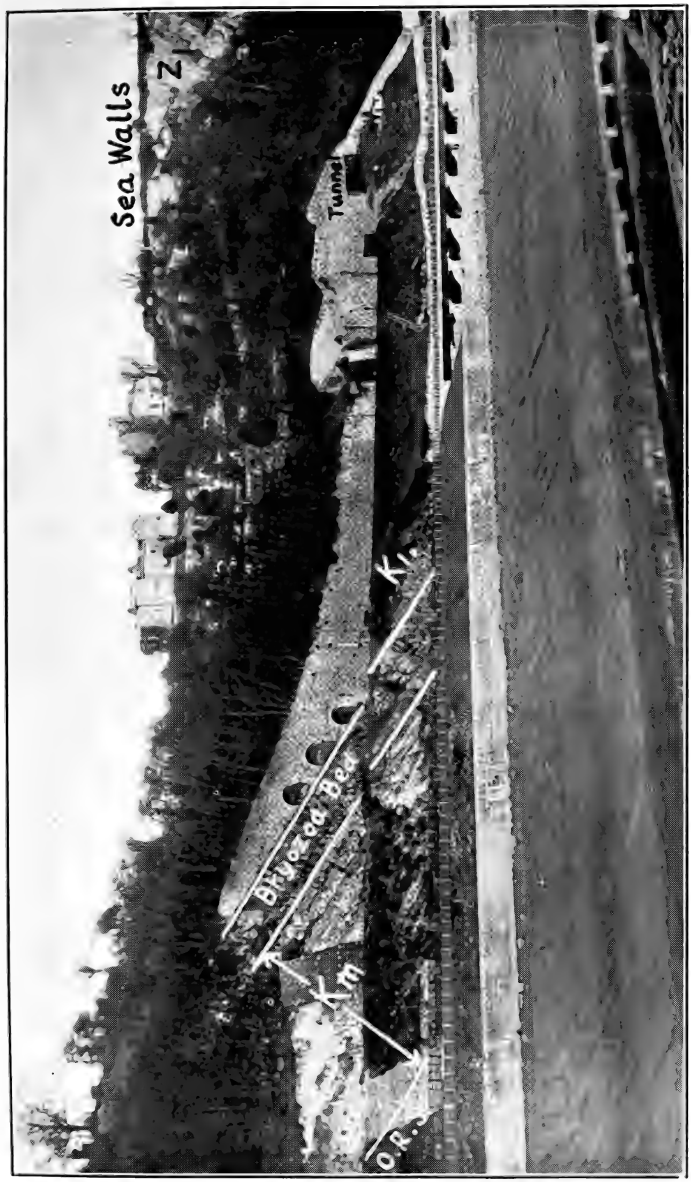
Pl. 14. "Pseudobreccia" and "*Seminula*-pisolite."

(*a*) "Pseudobreccia," D_2, Portway.
The rock is relatively little weathered. The "fragments" are pale, the "matrix" dark. Penny gives scale.

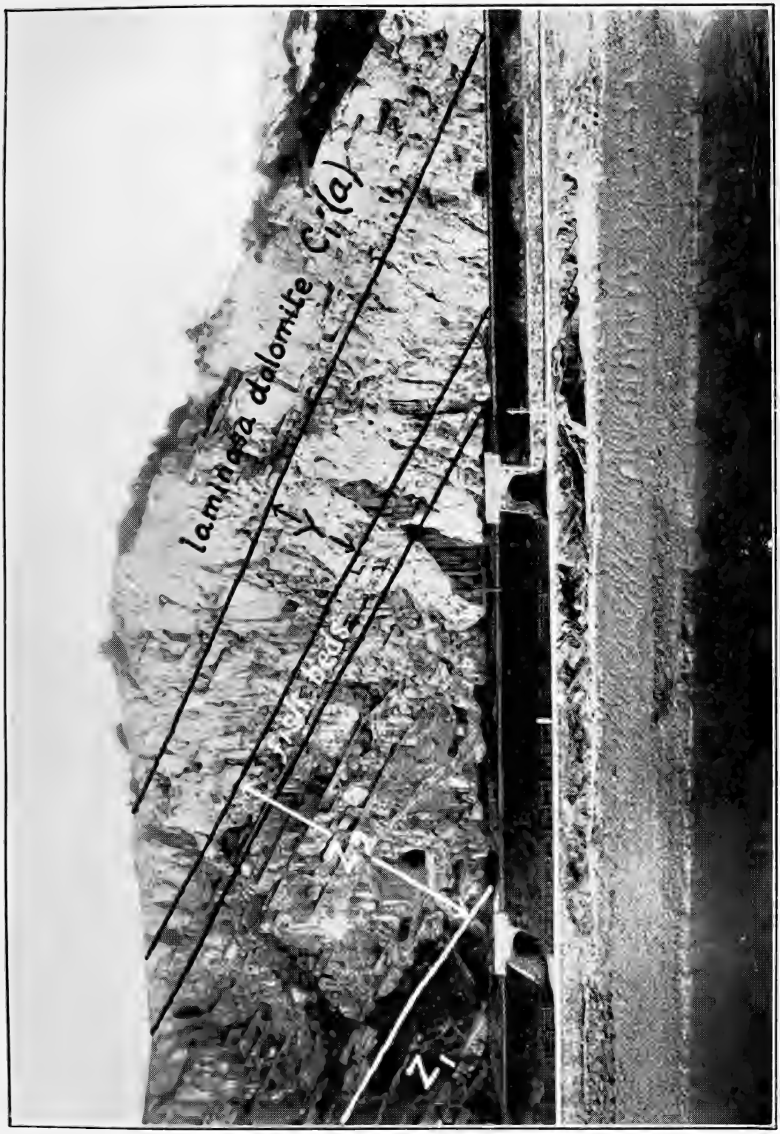
(*b*) "Pseudobreccia" ("rubbly-beds"), D_2, Portway.
The rocks are more weathered, and the proportion of clay in the "matrix" is greater than in (*a*). Penny gives scale.

(*c*) "Pseudobreccia," D_1, Portway.
Shows a band of "pseudobreccia" interrupted by a mass which is not pseudobrecciated. Length of hammer handle, $10\frac{1}{2}$ inches.

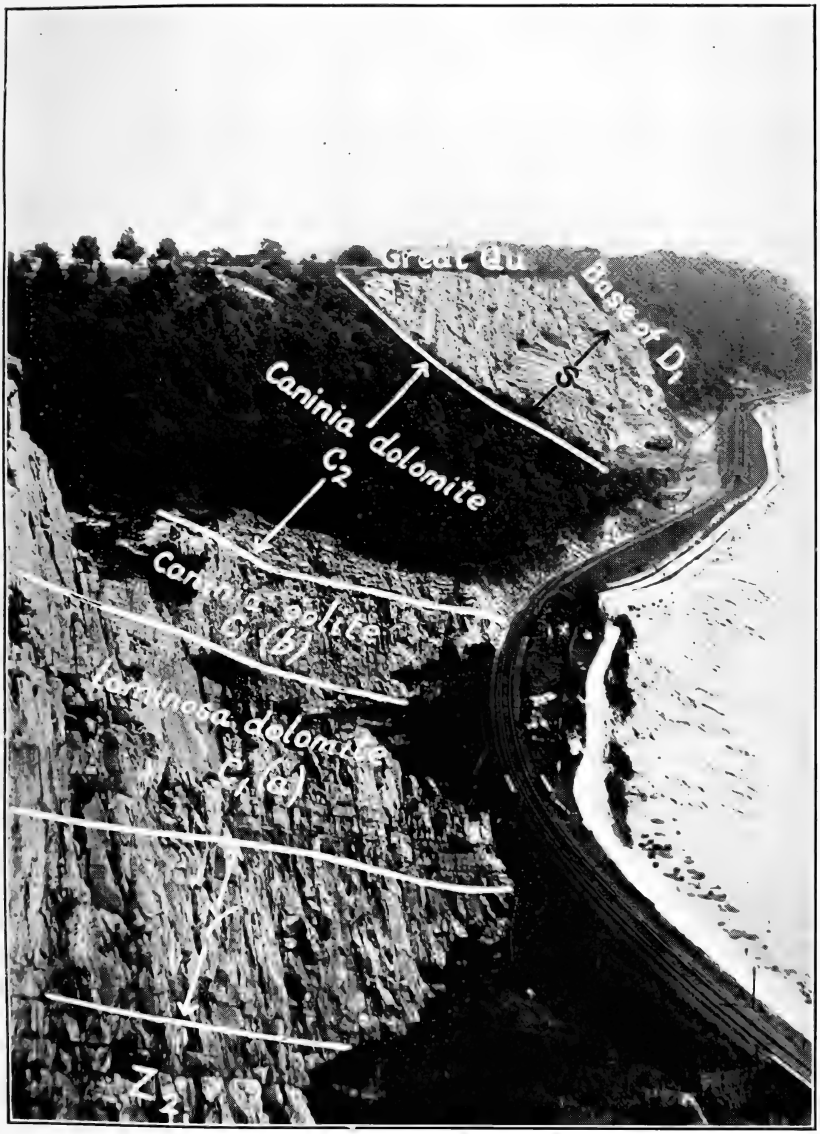
(*d*) "*Seminula*-pisolite," $S_2(a)$, "Great Quarry." Two pisoliths (one broken) show concentric structure clearly. Numerous sections of *Seminulæ* visible. $\times$ about $\frac{1}{2}$.



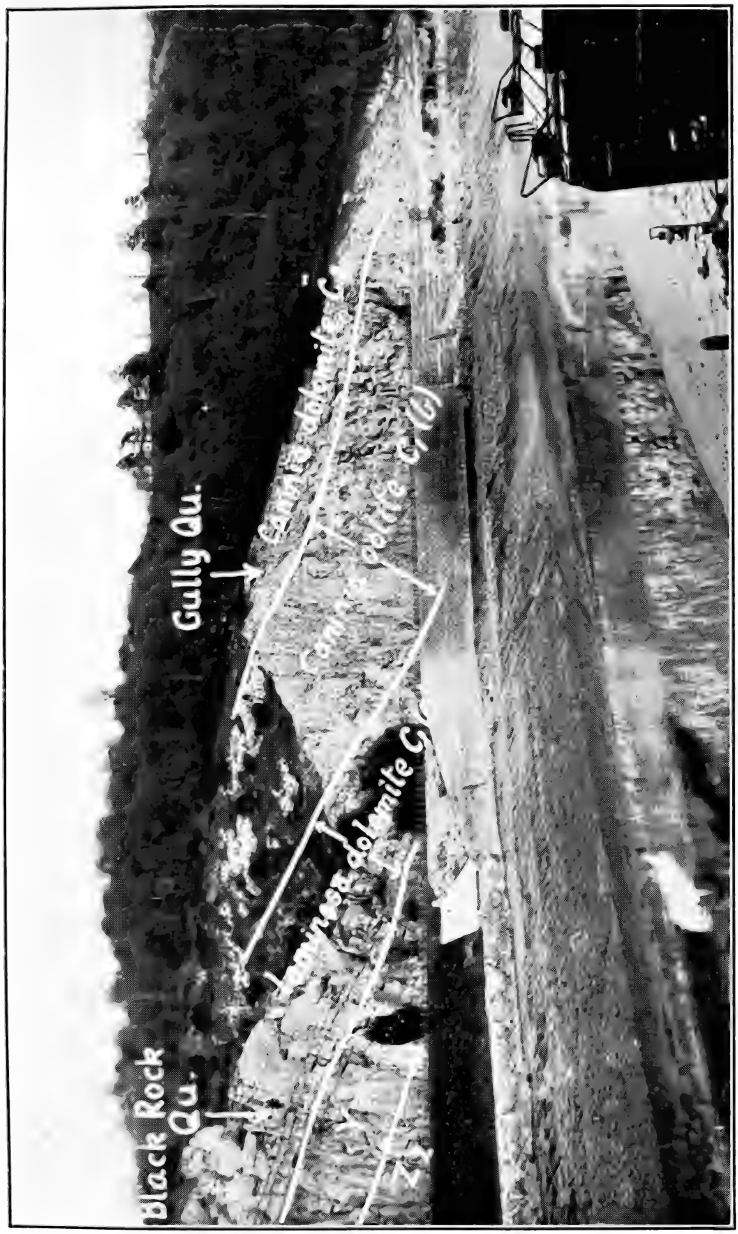
The Northern End of the Section, Right Bank



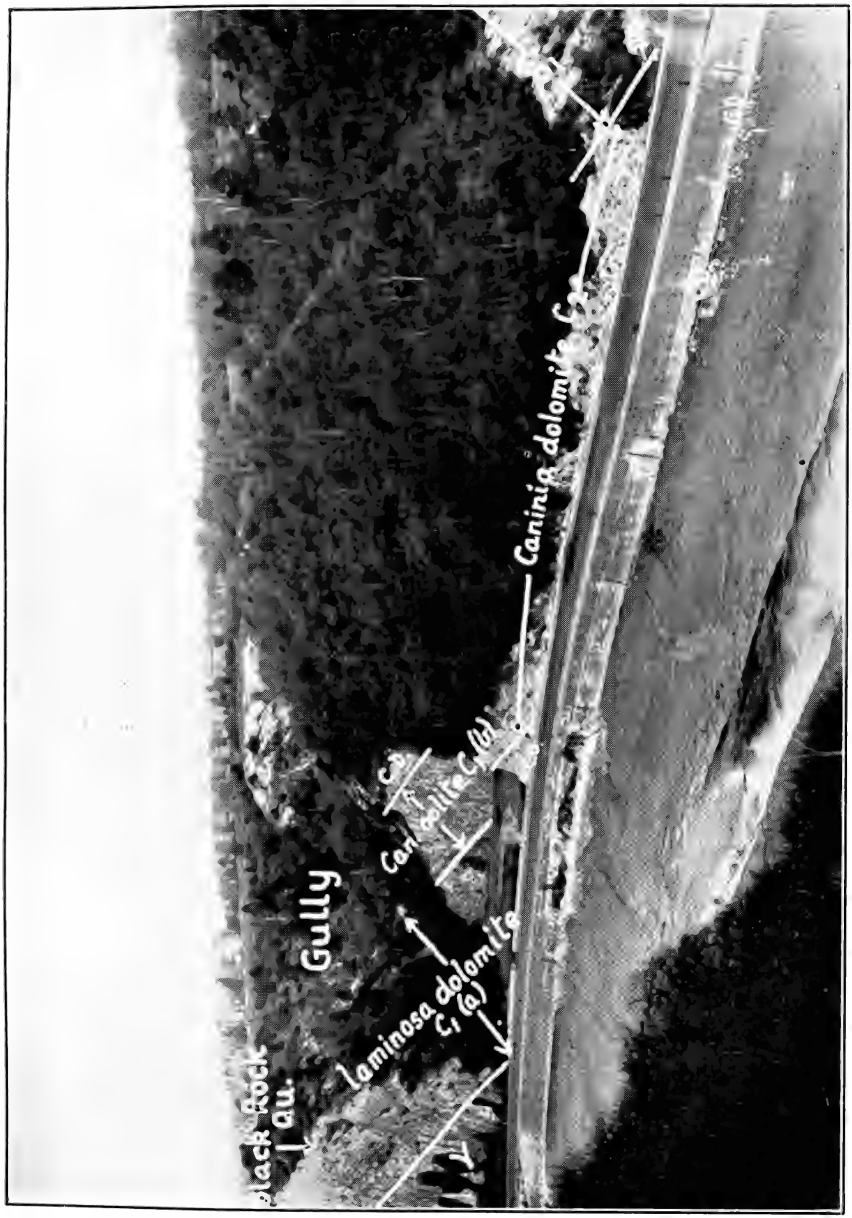
The Black Rock Quarry



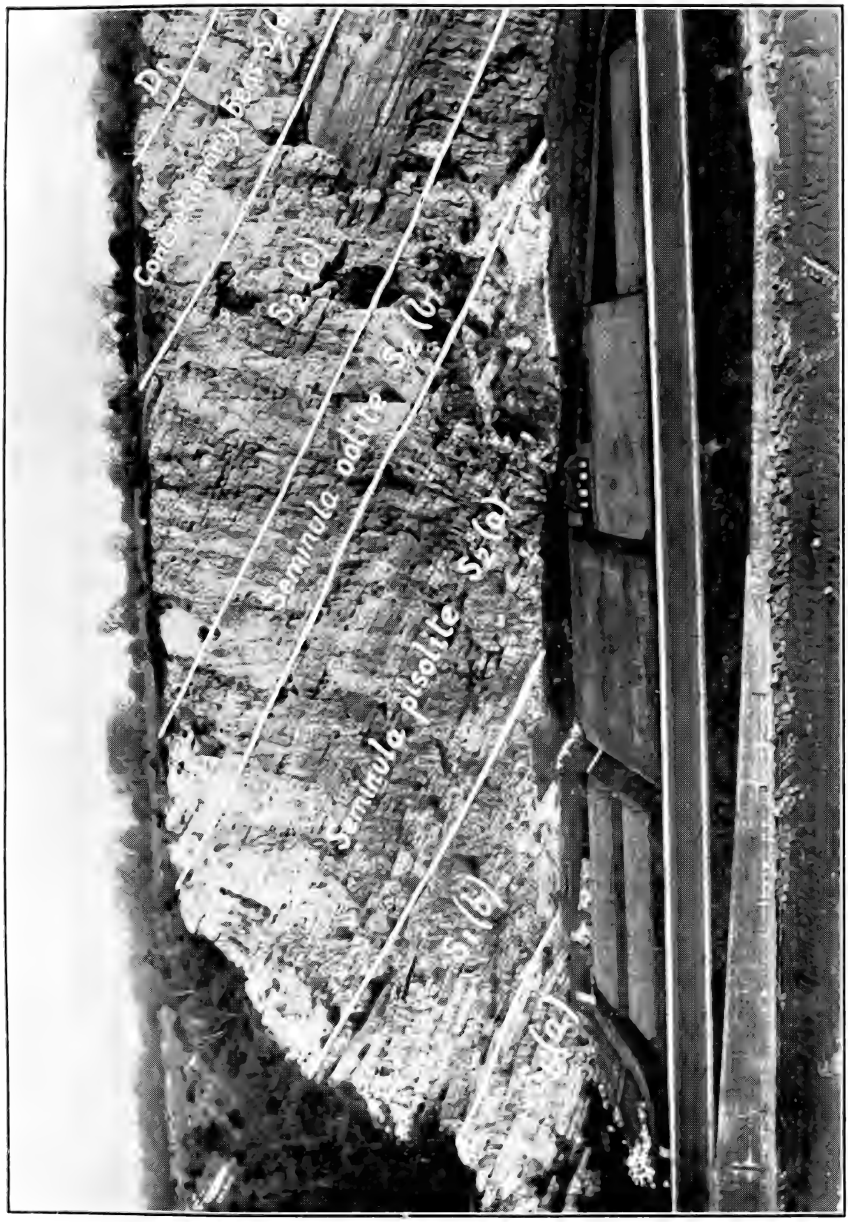
General View of the Avon Section, Right Bank, from near Sea Walls



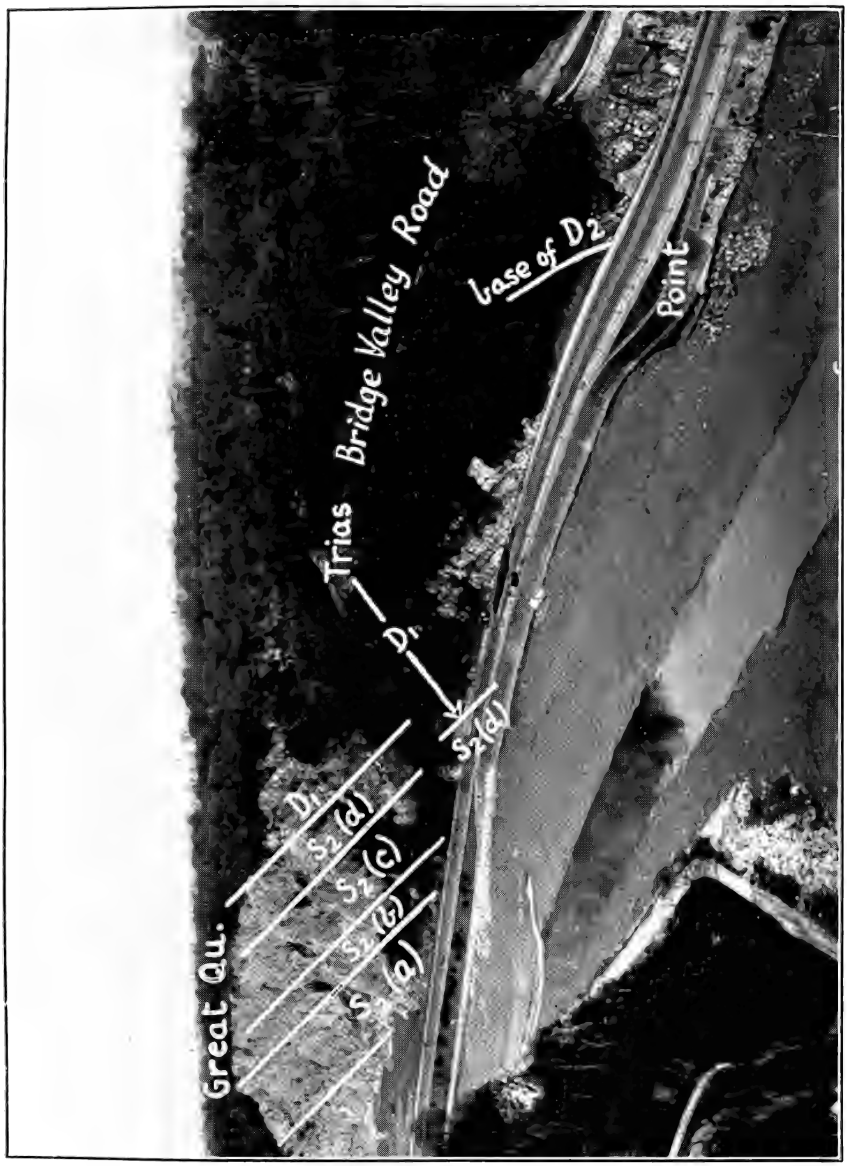
The Gully Quarry and part of the Black Rock Quarry



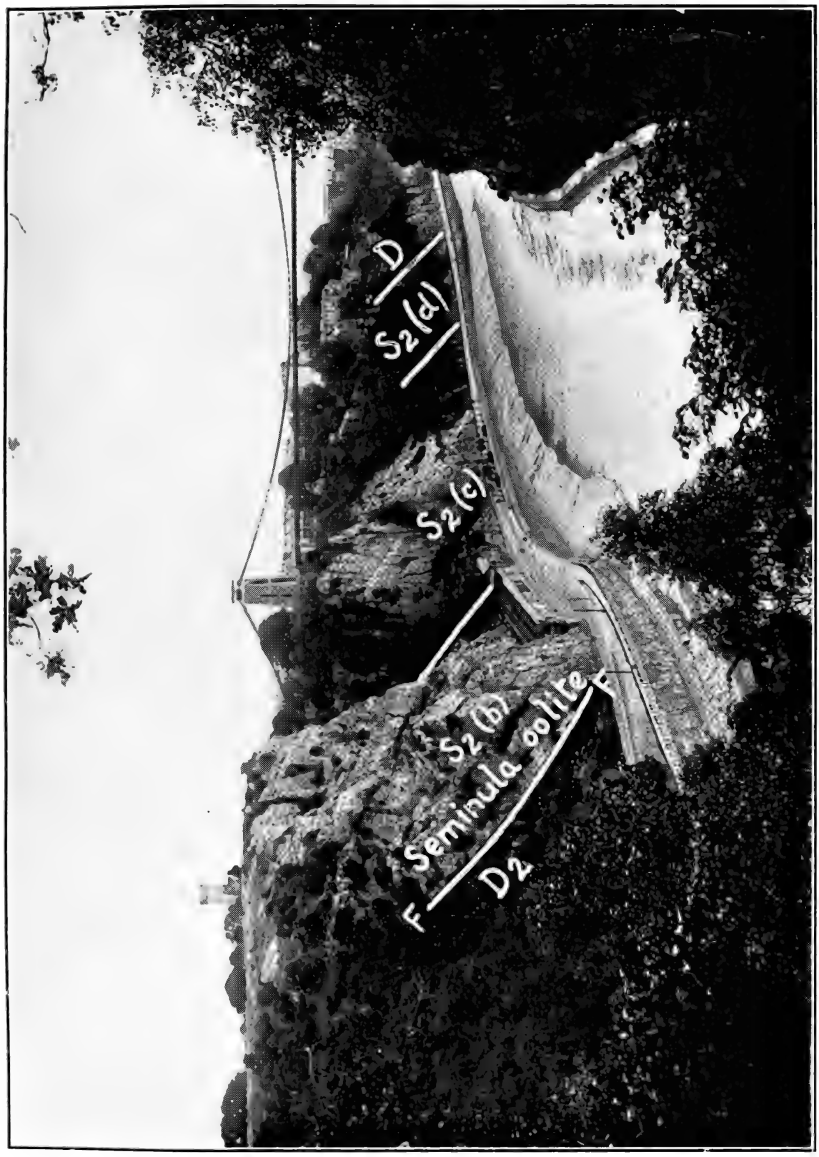
The Section from the S. end of the Black Rock Quarry to the N. end of the "Great Quarry"



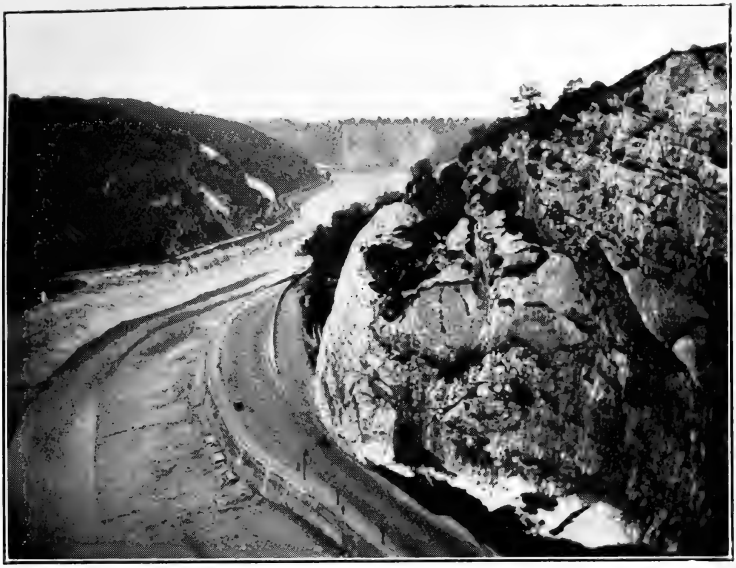
The Northern and Major Part of the "Great Quarry"



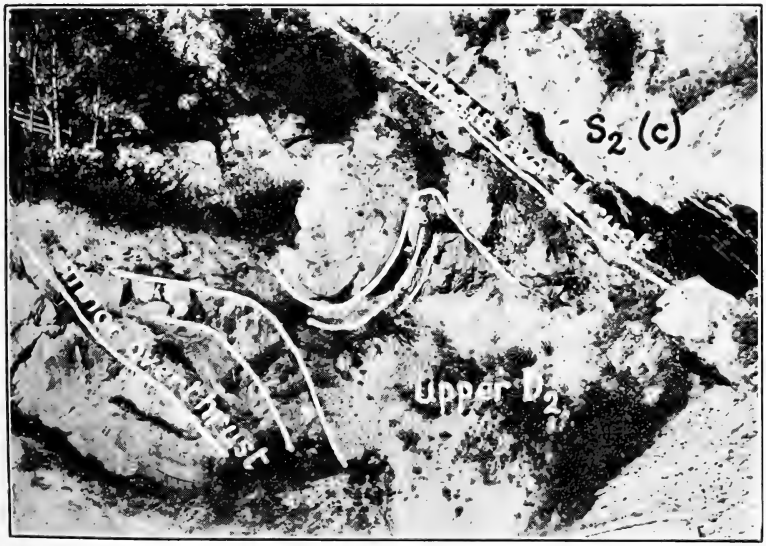
The Section from the "Great Quarry" to Bridge Valley Road



Observatory Hill, the Suspension Bridge and the Section as repeated by the Fault



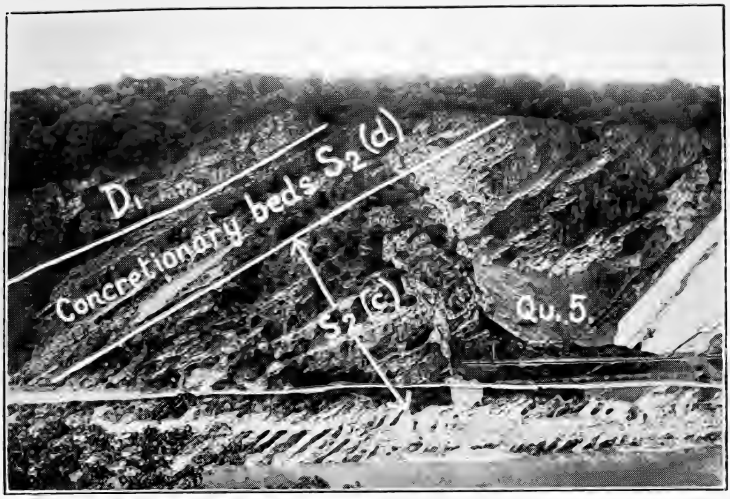
(*a*)



(*b*)

(*a*) LOOKING NORTH FROM THE SUSPENSION BRIDGE.

(*b*) NEAR VIEW OF THE DISTURBED UPPER D_2 BEDS BELOW THIN OVERTHRUST S_2 BEDS OF OBSERVATORY HILL



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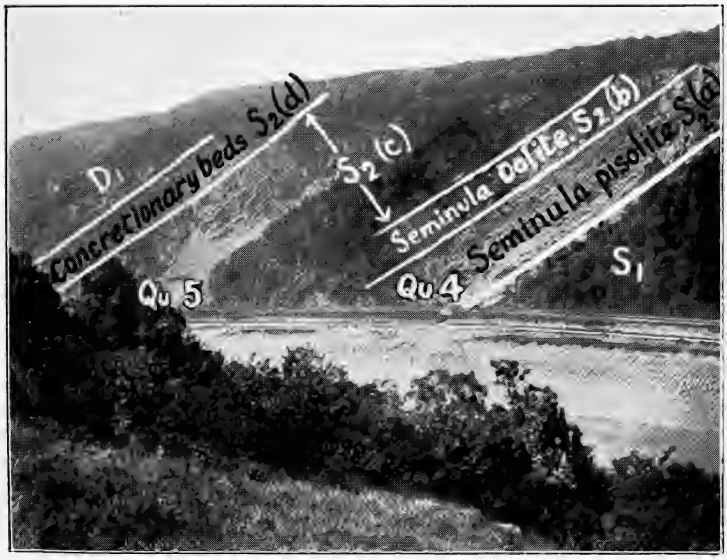
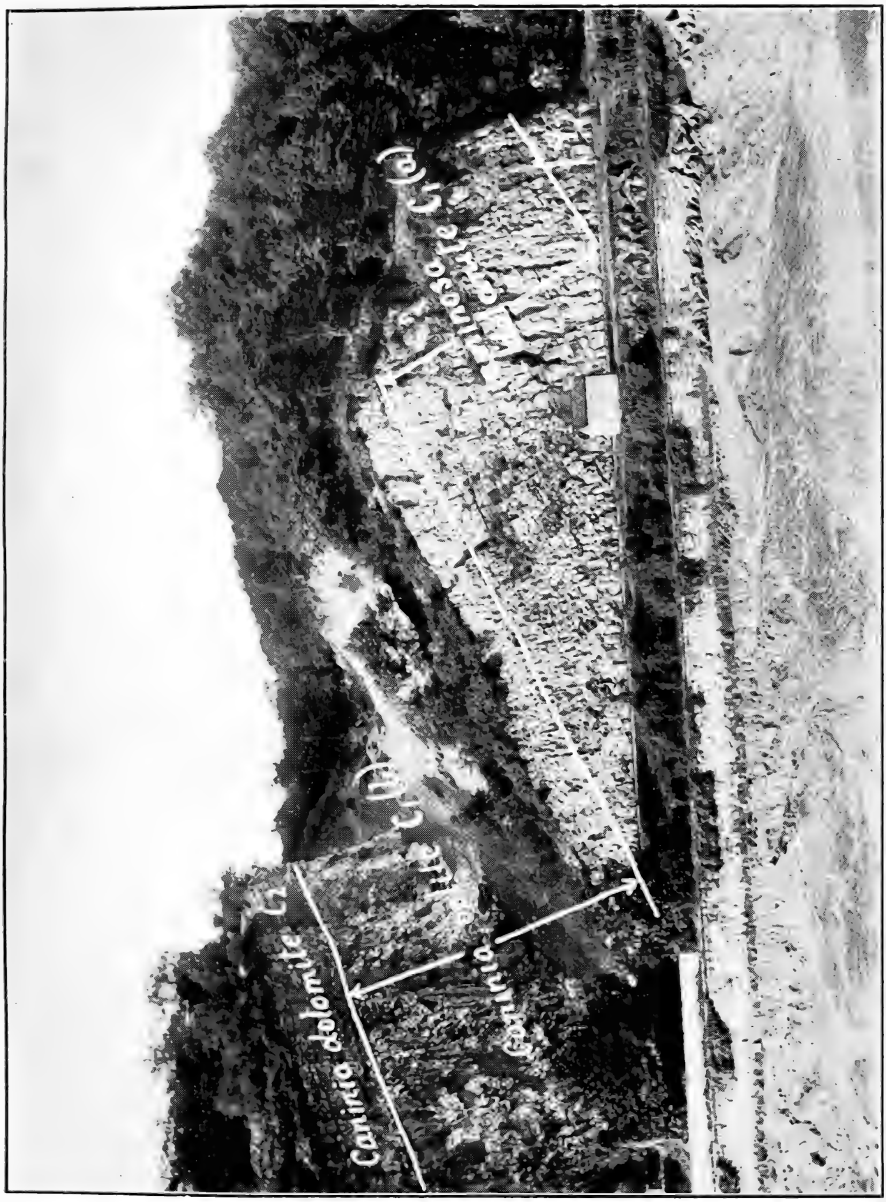
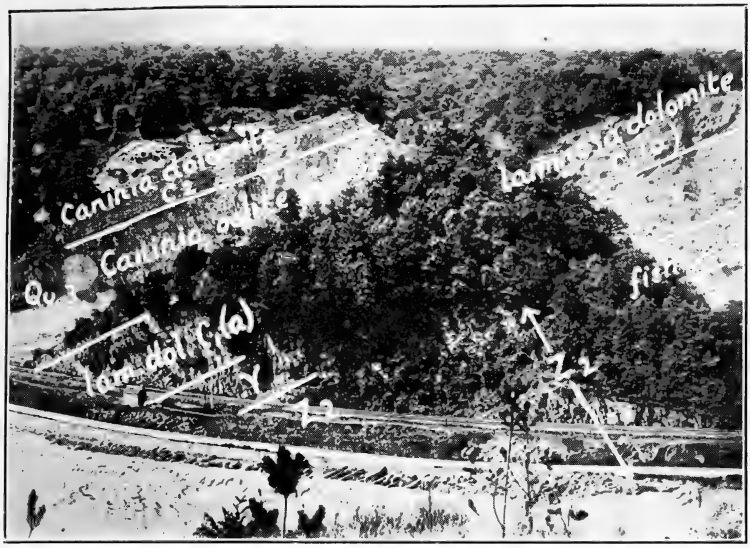


(*b*)

(*a*) QUARRY 5 AND THE TUNNEL SLOPE TO THE SOUTH
(*b*) QUARRIES 5 AND 4



Quarry 3 and the Railway Section to the North



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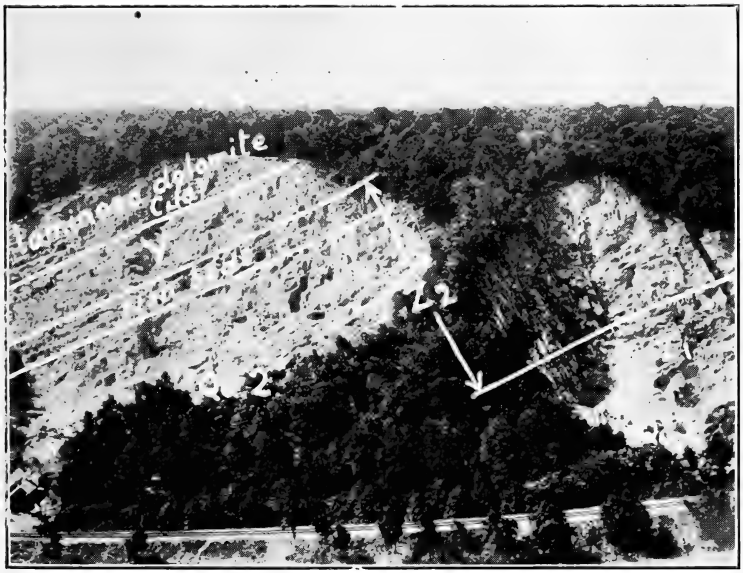
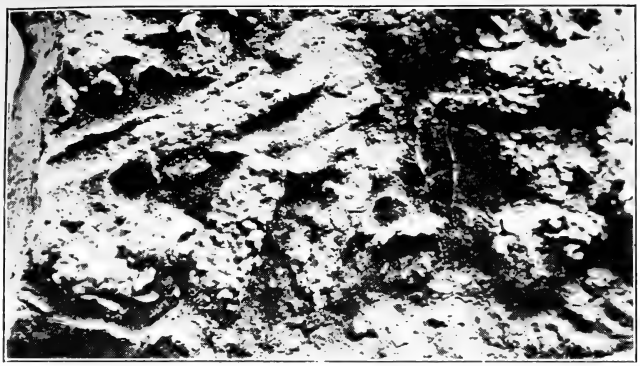


(*b*)

(*a*) Quarry 3 and the Southern Part of Quarry 2
(*b*) Quarries 2 and 1



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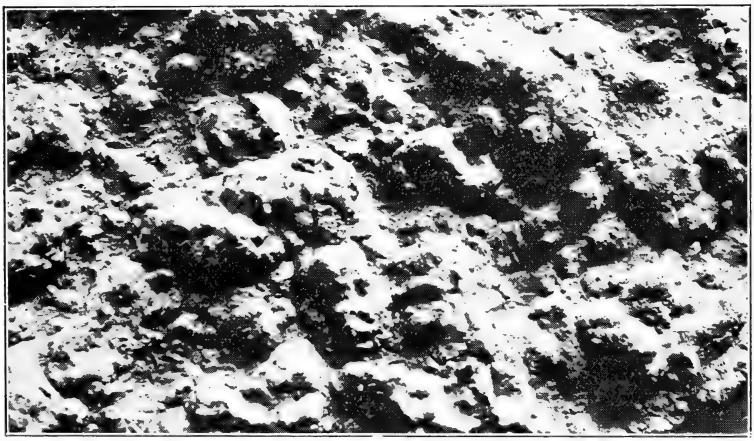


(*b*)

(*c*)

Weathered Surfaces of Algal Limestones

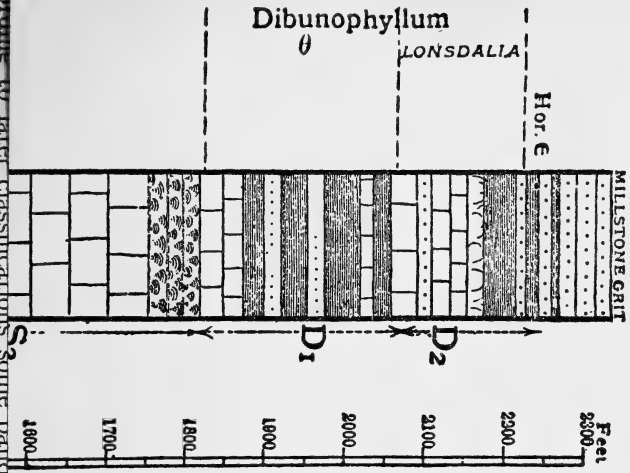
(a)

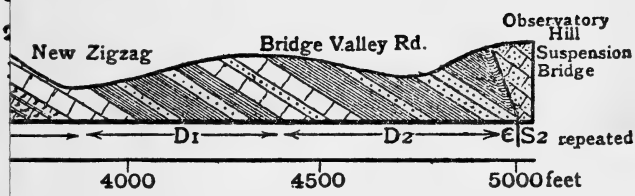
(b)

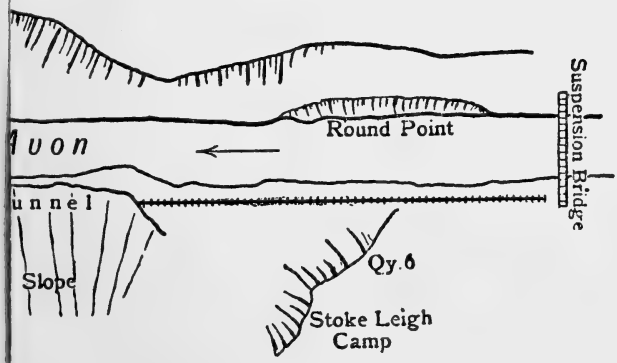
(c)

(d)

(*a*, *b*, *c*) "PSEUDOBRECCIA," (*d*) "*Semionula*-PISOLITE."







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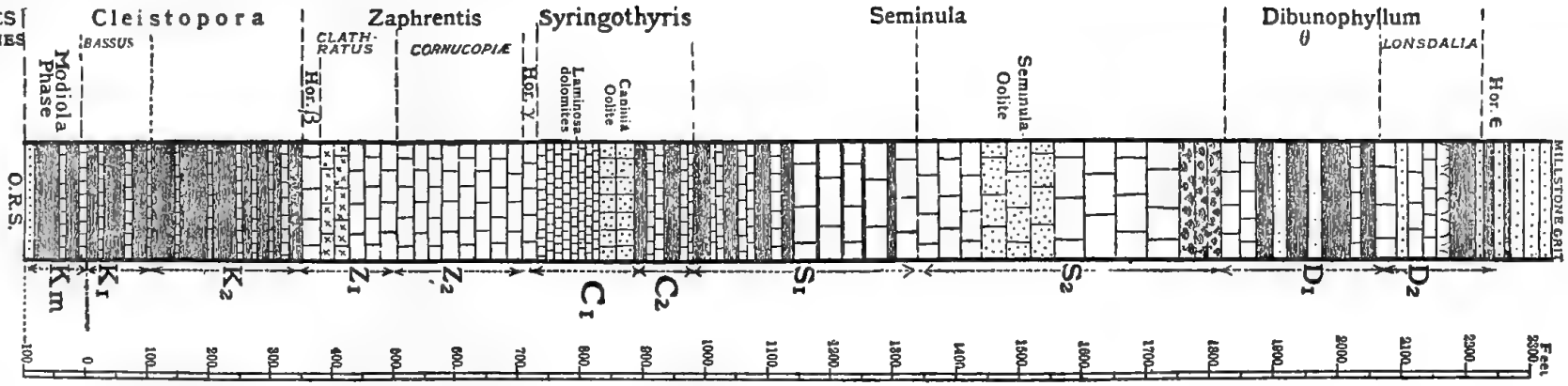
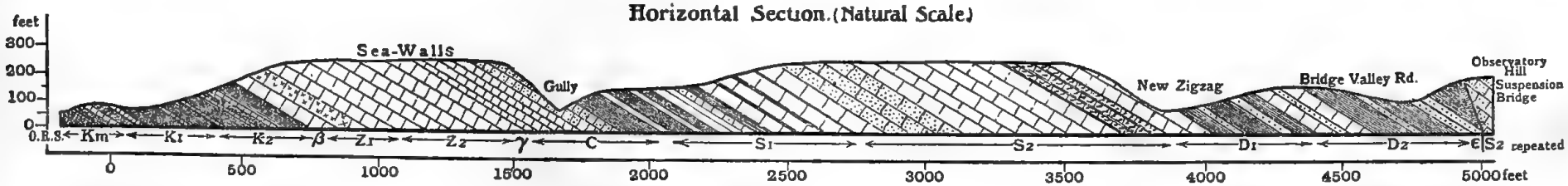
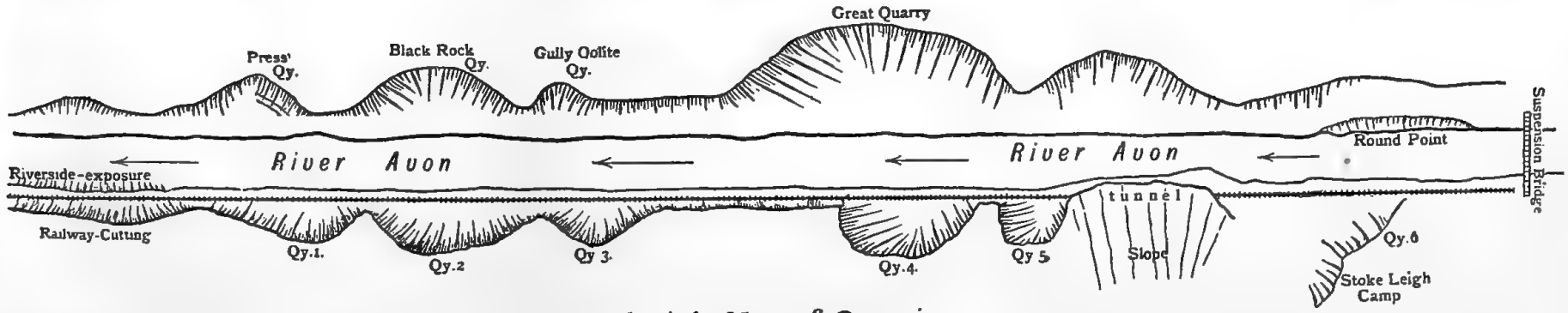


VERTICAL SECTION
Showing the Thickness and Lithic Characters of the
ZONES and SUBZONES in the AVON Sequence.
(according to later classifications some bands should be thicker and others thinner than in the above table.)

THE AVON GORGE

Horizontal Section. (Natural Scale)





Sketch Map of Quarries

PRESIDENTIAL ADDRESS, 1935

(*Read* 16*th January*, 1936)

Description of Former and Present Methods of Cutting, Loading and Conveying Coal

By G. E. J. McMurtrie

I TRUST that the following description of the great alterations that are being made in the getting and delivery of coal, from the coal face to the pit top, may not be without interest, although necessarily they must be described without too much detail.

As you are aware, coal is found in seams or veins of thicknesses varying from 1 ft. or even less to as much as 30 ft. in the celebrated thick coal of Staffordshire. It is interbedded with considerable thicknesses of shale or sandstone, generally, in Great Britain, in what is spoken of as the Coal Measures, which lie immediately above the Mountain Limestone, the principal Geological deposit of the neighbourhood of Bristol. Originally, no doubt, coal formed level layers, but owing to various earth movements, seams are now generally more or less inclined.

To win the coal, a vertical shaft is sunk through the Coal Measures, and any higher strata that may cover them, to what is in any district regarded as the lowest, or possibly the most workable, seam, and the main haulage roads are driven in the seam from the shaft bottom, on what is called " water level," i.e., roads rising ½ in. or so per yard from the shaft, so that any water met with may flow out to the shaft, and to neutralise the friction of the coal tubs.

Many of you have visited local collieries and have some rough idea of what goes on both below and above ground. You all know that the coal is wound up a shaft or shafts, fitted with two cages and guides. The early shafts were generally very small in Somerset ; in fact, they were little better than wells, often 4 ft. or 4 ft. 6 ins. diam. only ; even to-day 1,500 tons a week are being wound up such a shaft at a Somerset colliery. This small diameter enabled them to keep out the large quantity of water generally met with in passing through the New Red Sandstone, by simple ashlar walling set in hydraulic mortar. To-day shafts are, in the larger districts, generally 18 ft. to 22 ft. diam., and, even in the thin-seam districts, 12 ft.

A daily output of 100 tons in a 10-hour day, or longer, was formerly reasonable in thin-seam districts; to-day, 500 to 600 tons is wound in 8 hours, and in the thick seam districts as much as 4,000 tons in 8 hours.

The headgears, formerly of pitch-pine timber, are now universally either steel lattice work or girders. Their early height of 30 ft. is now 75 to even 90 ft., and when we remember that a very usual top speed of coal winding is 50 miles an hour, and the average 33, this is none too high, although practically all winding engines are fitted with over-winders, to prevent excess of speed at midway, when approaching the top, when landing, and when the engines are reversed. The engine drivers are a fine class of men too, and fatal winding accidents are extremely rare, although on the basis of 500,000 men being raised and lowered daily, four times a week for 50 weeks, some 100,000,000 men are raised and lowered yearly.

Guides, which were originally wood, and first introduced into Great Britain at Radstock in Somerset, are now wire ropes, which allow of a greater speed of winding.

The haulage of the coal from the coal face to the shaft was formerly entirely done by horses, ponies, or youths called runners. Ropes have long ago replaced all three of these on what are called the primary haulages, that is, the main roads from the shaft bottom to a main siding.

The secondary haulage, i.e., the means of conveying the coal from the different districts to the main siding, is still in some cases done by horses, ponies, or runners, but of late years small supplementary haulage engines and ropes, driven by compressed air or electricity, have largely replaced them. Such an engine can, by a suitable arrangement of ropes, bring the coal from two or even three districts to the primary haulage siding; or, if the tonnage warrants it, two or three small engines may be necessary to do this work. Although these secondary haulages are extended as the workings advance, and are kept as close to the face as possible, what may be termed tertiary haulage is still necessary from the individual roads of each district to the sidings at the end of the secondary haulages; this, till lately, was again universally done by horses, ponies, or runners. A great change is taking place here under what is called "intensive mining," to which I will refer later. A result of this is that the use of horses and ponies underground is much reduced; indeed, at many collieries there is not a horse or pony underground.

To have economical haulages it is essential that they should be

properly laid out from the very start of working the coal seam, and kept straight on definite angles, regularly extended by the surveyor.

As everyone knows, the coal itself was, where possible, cut in the "underearth" with picks by the collier, and the coal supported on short pieces of wood called "sprags," till ready to be dropped; when the sprags were knocked out the coal dropped or was blown down. Boys collected this coal along the face and conveyed it to the stall road itself, where it was loaded into tubs.

The distance between stall roads varied in different districts and at different collieries, from 25 to 30 yards; in S. Wales the distance is generally 16 yards. This distance is dependent upon the ease with which the coal can be loaded and conveyed along the face, and is very largely governed by the height of the seam. Where possible, rails are laid, and the tub itself taken along the face; where this cannot be done, smaller boxes are used, possibly running on rails or on the hard floor. Two or three of these load a tub.

Intensive mining is altering all this. For many years past at many collieries, machine cutting has been gradually replacing the collier with his pick, and of late years has increased rapidly.

There are various types of cutters; formerly, a revolving wheel with a series of picks attached to the circumference was used, having much of the appearance of the ordinary circular saw used for cutting timber to lengths, etc.; this has largely been replaced by a rapidly revolving bar, with again a series of picks let into its circumference at regular intervals, or by a revolving chain with picks again attached.

The machine now runs on rails, and can draw itself along the face by a rope passing round a pulley attached to a steel prop fixed some yards ahead. Such a machine is capable of cutting at least 90 yds. per shift, to a depth of 4 ft. 6 ins., and even 6 ft., and in the latter case, in a 4 ft. seam, would produce 240 tons a day.

Three men man the machine; the driver, a man in front and another behind, to move and erect timber and clean out the dust produced by the cutter.

Where there is no gas, and even in some cases where there is gas, electricity is the motive power, the motor being attached by a trailing cable to the power main. In the early days, compressed air alone was used, and most colliery managers to-day will not use electricity in fiery collieries, preferring compressed air with its lower efficiency on

the ground of safety. For this trailing cable, though armoured, even with care is exposed to much rough usage, and short circuits do occur.

The usual practice is for the coal to be cut at night, filled out on the day shift, and the machine taken back by the afternoon shift to the other end of the face for a fresh cut, timber set to allow the machine to pass between the row of props next the face and the coal, and odd bits of face straightened off, etc. As you will at once see, the success of this system is entirely dependent upon each operation being completed with clockwork regularity. It compels a high standard of efficiency on the part of all concerned, and good supervision, which latter is obtained by an official being placed in charge of two coal-cutter faces every shift ; for failure to complete any of the three operations within its shift throws everything behind, and will probably prevent the coal cutting being completed at night. In practice, the trouble generally arises in clearing the face of coal, either from slackness on the part of the fillers, or through the coal not falling properly, or from want of tubs. To meet this, an odd filler or two may have to be added to clear up on the afternoon shift, but this is a poor arrangement. The best practice to-day is for the surveyor to draw a straight chalk line from end to end of the face, and for all the face props to be set at a certain distance from this line, to ensure the machine cutting an absolutely straight line, as the breaking off of the coal very largely depends on this. This system in the past has been applied to districts laid out as described earlier.

To get over this difficulty of completing the picking up of the coal on the day shift, conveyors are now being carried along the coal face or faces to a central haulage road. This has entailed an entirely different lay-out of the coal face. In place of stall roads being driven every 25 to 35 yds. apart, it is usual to have one central haulage road with at least a 90 yard face on either side, and conveyors to each 90 yd. face. Faces in many cases exceed this length of 90 yds., and, in some very long faces, they have tandem conveyors, really two conveyors in line, the one delivering on to the second, and this to the haulage road. A panel, or width, of coal 180 yards long, or whatever distance the conveyors may clear, is carried up by itself with, in the case of the 180 yd. face, three stall roads only, in place of at least seven under the old system. These stall roads will be cut off on either side every 100 or 200 yards by cross roads, to reduce cost of repairs.

The delivery of the coal from a minimum length of face of 180 yards

into one road, at once raised the fresh difficulty of how to get this accumulation of coal away, so as to prevent delay. A constant supply of tubs is essential to prevent any stoppage; this entails a double track of some length to hold a stream of empty tubs, which automatically serve towards or away from the face, and when loaded are collected later on the parallel or full road. A haulage engine is essential to convey the tubs to the primary haulage, and for pulling the loaded tubs to the siding. Even this arrangement is often superseded by the laying of a long conveyor along this central haulage road (the face conveyor delivering on to it), to take the coal to the primary haulage siding where it is loaded into tubs. This arrangement obviously cuts out the possibility of haulage delays on the secondary haulage, and as the conveyor works in a large road, under ideal conditions, there is little likelihood of delay being caused. A transport official, too, is frequently kept in charge of the haulage.

To cut out still further the human element, mechanical loaders, largely used in the U.S.A., are being tried, which mechanically gather and deliver the fallen coal on to the face conveyor. Machines even are on the market to-day which cut and deliver the coal on to the face conveyor. This part of mechanisation is still possibly in the experimental stage, but it is assuredly coming in many collieries, and appears to be the only way to prevent colliery owners from being constantly held to ransom by strikes, and the driving away of their trade.

The results of machine cutting and face conveying are astonishing. In Scotland, 340 tons have been loaded by 52 men from a 4 ft. 2 in. seam and a 200 yd. face, or nearly 7 tons per man per day; and again 260 tons by 20 men from a 4 ft. seam and 160 yd. face, or 13 tons per man per day. In the Midlands, 450 tons by 32 men from a 6 ft. seam and 180 yd. face, or 14 tons per man per day. In this case the 32 men replaced 86. In a 2 ft. clean seam the tons loaded per man range from 5.3 to 12.9. In a 2 ft. 9 in. clean seam the tons loaded per man range from 7.2 to 13. In a 4 ft. clean seam, from 10 to 17. These figures compare with, at most, 3 tons per man on the old lines.

A 26 in. gateway conveyor transported 1,000 tons in 2 shifts for 755 yds. In America, the Frick Company convey 6,000 tons per day four miles underground along ten separate belts, and deliver the coal into barges on the river.

Coal may be cut on the strike or level line of the seam, or on the full dip, or at any intermediate angle to the strike.

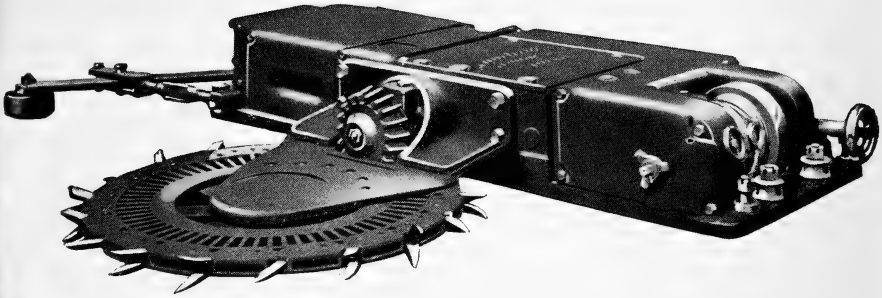
The earliest form of conveyor was the shaker, which was compressed-air driven by a short stroke engine, attached to it by a cam which gave the necessary chuck forward to the continuous band of short steel troughs, rollers being placed at intervals beneath it to reduce friction and keep it off the floor. Troughs are 7 ft. 6 in. to 9 ft. long, bolted together, and generally 2 ft. wide. This type of conveyor has the advantage in thin seams of requiring little height, and is most advantageous on a slightly dipping face, as it will not deliver uphill except against a slight gradient, but it requires more power than the lighter belt conveyor.

The belt conveyor is a continuous canvas belt loaded with gutta-percha and faced with india rubber, very generally 26 in. wide in the face, but anything up to 4 ft. in the haulage road, driven by an engine at the one end, and running on rollers attached to a light frame. The neccessary friction or grip for the belt is given by running it round three rollers or drums, one of which has springs attached to allow for the varying load. They are flat in the face and troughed in the haulage roads. The newer forms have also an arrangement, "the loop take-up joint," by which the belt can be lengthened in conveyor roads as the haulage road advances, without putting a piece into the belt.

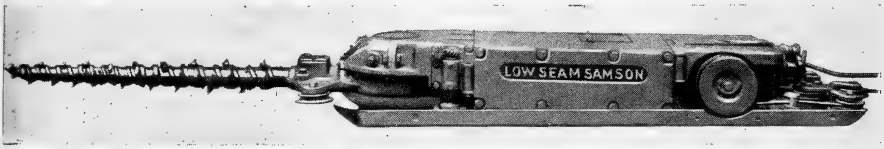
Belts are generally used to bring coal up a dipping face, even if the gradient be small, as there is practically no slip back of the coal. They require rather more height than the shaker but absorb less power, are noiseless and should reduce breakage of the coal.

Arrangements are generally made on the haulage road for the face conveyors to deliver on to a short chute, so as to load the tub endways rather than sideways.

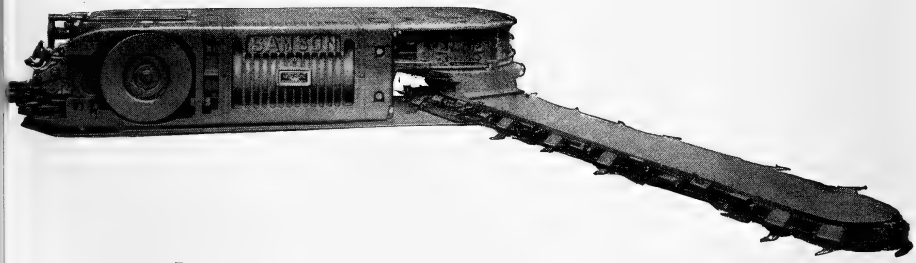
The double track, or long sidings for loading in the haulage roads, and the use of long conveyor belts in many cases have necessitated larger roads 10 to 12 ft. wide. Timber has been found unsatisfactory, both as regards strength and life, necessitating frequent repairs and renewal. Where taken to the face, a second ripping down of the roof with its attendant heavy cost was very usual. The earliest step forward was the use of light steel girders on Norway props, or possibly side walls in bad ground. Light steel arches have largely replaced the steel girder and props, the straight sides being splayed outwards to offset the push of the sides, possibly set on foot-pieces of timber, and with a circular top. They are sent into the pit in halves, and connected together by patent fish plates of fully the same strength as



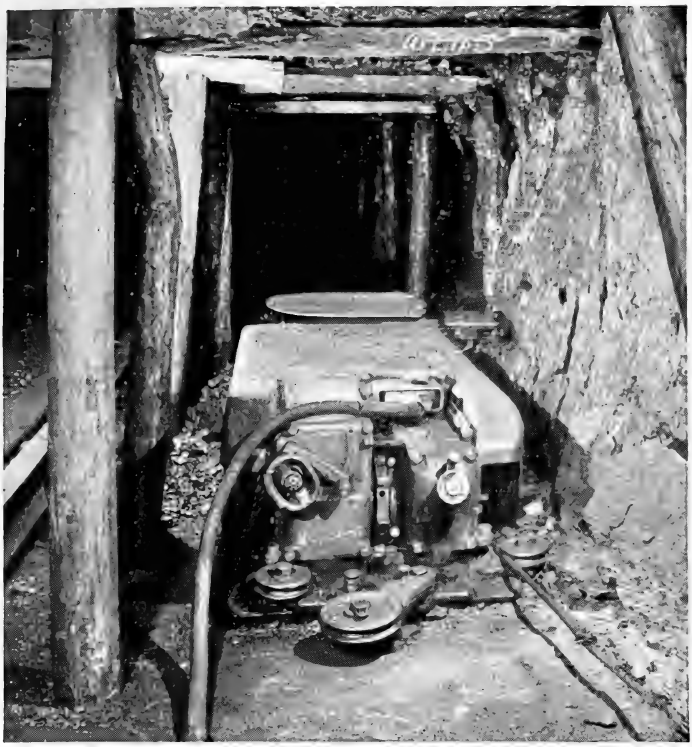
Disc or revolving wheel coal-cutter



13 in. high bar coal-cutter



Longwall Samson chain coal-cutter. Undercutting



Longwall Samson chain coal-cutter. Overcutting

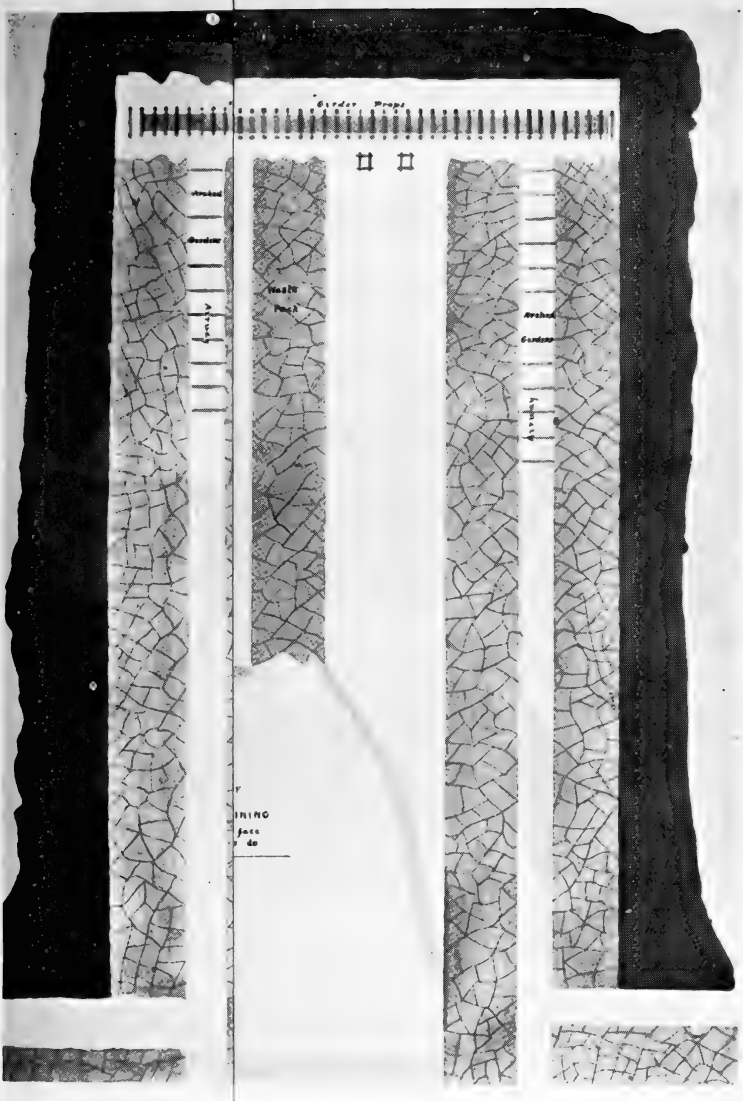
Shaker conveyor coal face

Mavor & Coulson shaker conveyor delivering into a gate-end loader

Gate-end loader delivering on to belt conveyor

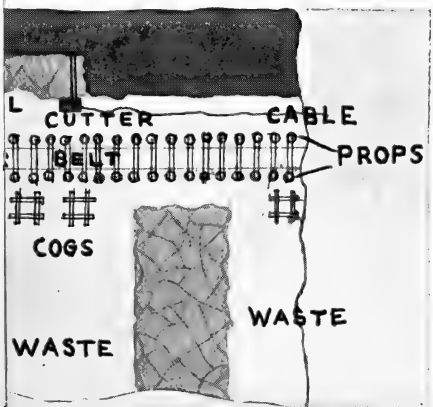
Belt conveyor bringing coal from face to loading station

Loading coal brought by M. & C. troughed belt conveyor from 300 yards in-bye

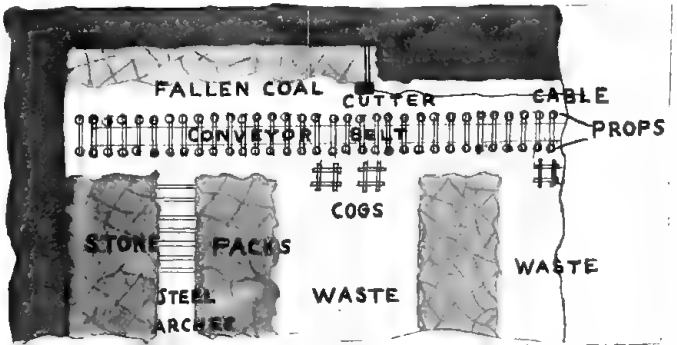


LID COAL

SKETCH



SOLID COAL



SKETCH PLAN OF INTENSIVE MINING

The Smaller Drawing Shows an Enlarged Portion of the Larger.

the arch itself. These are set every yard in the road, and lined by old tub sides and bottoms, old rails, thin black plate and, in bad ground, by $4\frac{1}{2}$ in. brickwork. To prevent endway movement, and to attach the arches together, wooden distance pieces are set, sometimes level, but more usually at an angle or diamond wise, the ends of the props being cut at the necessary angle to butt against one another. These are now added every yard at the coal face as it advances. Serious falls of roof on such roads in normal strata are now exceptional, little or no repair is required, and no second ripping as before. After the 1926 Coal Strike of over five months, there were few if any cases of falls of strata in lengths of two miles and over, and the coal faces were restarted in a day or two at most.

Steel again is largely taking the place of timber in the coal face, on account of the variation in the strength of apparently similar props. The old custom was to fix wooden props with a flat piece of timber called a "lid" on the top, and possibly another flat piece below the prop, if the floor was soft, to prevent it sinking into the floor. The lid on the top was primarily to allow for the settlement of the roof as the coal was abstracted, and may be 2 to 3 ft. thick. There have been a large number of patent props designed, with the object of allowing for the settlement of the strata, but the one most generally used to-day is of a simple light-girder section, with the web cut away at either end and the flanges turned inwards, with a 3 in. lid over the top to take up the roof settlement. They maintain height better in the face and prevent falls.

Regularity of coal cutting largely depends on control of the roof. The best practice is to allow a road for the machine cutter against the coal face, a second road for the conveyor between the first and second row of props, with corrugated iron stretchers reaching from prop to prop, possibly a third row of props with stretchers, and the waste behind filled with the rubbish got in making the roads, or from the seam itself. Both machine and conveyor should be moved forward daily, a fresh row of props added in front, the back row drawn, and this space filled daily with rubbish. This causes a gradual settlement of the roof on this rubbish. Where sufficient rubbish is not obtainable to fill the ground from which the coal has been abstracted, then what are called packs, i.e., stone walls 5 to 6 yds. or so thick, are built against both sides of the roads as they advance, and along the face between the roads, with empty spaces or wastes 5 to 20 yds. between them, all tracks being parallel with the road walls. In such a case, the third

row of props may be replaced by cogs of wood, i.e., an arrangement of wooden sleepers built in twos, every layer crossing the last at right-angles. To save labour at the face, these may be built up at land and sent underground threaded on light iron rods, and then require only the addition of a few light pieces on the top to tighten them to the roof. Where wastes are necessitated, the object of the packs is to cause the roof to break off beyond the wooden cogs or last row of props, to relieve the pressure on the coal face, and provide material for the packs. The face conveyor is now often utilized to take the rubbish from the roads, etc., to where it is required for packing, either by running the conveyor belt in reverse, or by delivering rubbish at the upper end of the shaker belt, or even in some cases by a special shaker or conveyor belt.

This matter of roof control has been receiving special attention of late years. Committees with well qualified investigators and assistants have been appointed in several districts. Their visits to different collieries, working possibly the same seam under different conditions or on slightly different lines, enable them to make valuable practical reports and offer suggestions, and their advice is often experimentally tested under the joint supervision of the colliery manager and the investigator. The result should show how better the forces of nature can be utilized to get the coal down and prevent falls of roof in the coal face and roads, with consequent increased safety and economy. As these reports are later very fully discussed at district meetings of mining engineers and managers, a very keen interest is created in this important matter.

From the above it will be realised that great changes are taking place in coal mining, the result of patient experiment for many years, for British machine cutting dates back 40 to 50 years, and the adaptation of American methods.

The newer system entails larger capital expenditure, and capital expenditure in the past has at all times been large, but a much shorter face produces more coal, on account of the quicker advance of the coal face; undoubtedly less labour will be required, and unless a much larger export trade is obtained fewer collieries will be needed. Against this must be set a more cheaply produced coal and higher paid labour.

For the plates accompanying this paper, the blocks have been very kindly lent by Messrs. Mavor and Coulson of Glasgow, who specialise in coal-cutting and conveying machinery.

Gulls in the Bristol District

By H. Tetley, B.Sc., F.Z.S.

(*Read in title 5th March,* 1936.)

THE attraction of the river and the proximity of the coast combine to make Gulls a conspicuous feature of the bird-life at all seasons of the year, and the movements of these birds in the region of the docks and the Avon provide a number of points of interest. Here seven species have been recorded, viz.: Common Gull (*Larus c. canus*), Herring Gull (*Larus a. argentatus*), Great Black-backed Gull (*Larus marinus*), Scandinavian Lesser Black-backed Gull (*Larus f. fuscus*), British Lesser Black-backed Gull (*Larus fuscus graellsii*), Iceland Gull (*Larus leucopterus*) and Black-headed Gull (*Larus r. ridibundus*).

Of these, the largest is the Great Black-backed Gull, a very handsome bird in the adult plumage of black and white, and with a wing-span of about five feet. Smaller than this bird are the Herring, Lesser Black-backed and Iceland Gulls which are all about the same size. The Iceland Gull can be distinguished by its white primaries or flight feathers, which are black or dark brown in all the others; the Herring Gull has a grey back in the adult plumage. Next in size comes the Common Gull which is distinctly smaller than the Herring and distinctly larger than the Black-headed Gull; in the adult plumage it has a blue-grey back, bluer than that of the Herring Gull, and conspicuous white tips to its wings. Lastly, the Black-headed Gull is the smallest and the commonest Gull on the water; its dark head is a phase of the breeding plumage and is mainly replaced by white in winter, though birds with this summer feature may be seen occasionally as early as January. Its bright red legs and bill serve to distinguish it, but in flight the broad white border to the front edge of the wing, a feature which applies to any plumage, serves to mark it out with ease.

Some difficulties of identification may arise as the larger gulls take four or five years to reach their full plumage. The Herring Gull, for instance, in its first plumage is speckled brown in colour, but at each successive moult it becomes greyer above and whiter beneath; it is thus possible to see examples of these gulls in several different plumages, representing different ages and not just varieties. The same applies

to the Lesser Black-backed Gull which, though when young indistinguishable in the field from a young Herring Gull, becomes well marked-off the following year by the much darker back due to the slaty-grey feathers of the mantle and wings beginning to appear.

As regards their habits and distribution, the Iceland Gull, unfortunately, can only be looked upon as a chance visitor. It breeds in the Arctic regions and comes further south in winter, and by some chance, very fortunate for the Ornithologist, a young one wandered up the Avon and was first discovered in February, 1933 ; here it remained for more than two years, being seen at sufficiently frequent intervals to make certain it was the same bird. It was usually about Rownham Ferry or Cumberland Basin, but on two occasions it was seen at Barrow Gurney reservoirs and once at Blagdon. Its strikingly white plumage was the feature that first drew attention to it, and when flying it looked like a broad-winged white owl passing over the water. This effect was no doubt partly due to its white primaries. At rest it was longer-winged, more slender, and not so upright in carriage as a Herring Gull and it was evidently able to look after itself, as on several occasions it was noticed that when on the mud, there was a clear space around the bird, and any intruder, even as large as a Black-backed Gull, was promptly sent off. It seems unlikely that another bird may turn up, but there is now always the possibility and the hope that it will.

The Great Black-backed Gull is not common up the Avon above the Suspension Bridge. During the winter months there may often be one or two at Sea Mills, but higher up they are rarely seen, though there seems to be a tendency for them to come up more frequently in recent years. In all plumages they may be distinguished by their size ; size is often a very difficult, if not impossible, criterion, but as there will almost certainly be a Herring Gull close at hand with which the other may be compared, comparison should be easy as any gull markedly larger is certain to be a Great Black-backed. A few pairs nest on Steep Holm, the nearest breeding-station to Bristol.

The two Lesser Black-backed Gulls are smaller than the last and in addition, have yellow, and not pink, legs and feet. The British form has a paler mantle than the Great Black-backed Gull (slate-grey and not slate-black) which is particularly noticeable in flight, when the much darker primaries stand out very distinctly from it. In the Scandinavian form, the mantle is almost as dark as in the larger bird, and in flight there is no distinction between the colour of the mantle and the

primaries. It has only been definitely identified once, at Sea Mills on July 21st, 1934. The British Lesser Black-backed Gull is mainly a summer visitor to this district. It has actually been recorded in every month of the year, but the bulk of the birds are seen from March to October, the rest being stragglers from the main body of this species which migrate to western Europe and N.W. Africa. From about March to August or September there may be from ten to twenty adults on the Avon between Ashton Swing Bridge and Sea Mills ; in the other months only one or two, but it is difficult to say if these are wintering or stragglers.

Barrow Gurney reservoirs are a very noticeable gathering ground for this bird in spring and autumn. Here, on several occasions, as many as 30 to 40 adults have been seen on the large (no. 3) reservoir, and it is quite evident that this is a distinct line of migration. This is all the more interesting as on the coast the bird is rarely seen, even though, on Steep Holm, there is a large breeding colony, and they are much commoner on the Avon in the summer than on the Severn flats. There is still plenty to find out as regards bird-life in the Bristol district, and the lines of flight of these gulls, whence they come and whither they go, would well repay investigation. It may be noted that there is some evidence of east to west movement, e.g., six over Clifton, Queen's Road—May 21st, 1935, going towards Hotwells, and sixteen Herring Gulls over Elmdale Road—November 28th, 1935, in the same direction.

The Herring Gull, in adult plumage, has pink legs and feet and a grey mantle, and is, with the Black-headed Gull, the commonest Gull on the Avon at all times of the year. The numbers increase in winter considerably, and young birds come up the river in late summer, no doubt from Steep Holm, the nearest breeding-colony where large numbers breed about equal to those of the Lesser Black-backed Gull, of which bird it is also the equal in size.

The Common Gull, a very neat bird, is a winter visitor. With the exception of a few pairs in Kent, it nests nowhere in England or Wales, but from Scotland northwards it is a "common" breeding Gull. From August to April there are usually some on the Avon, and it is a noticeable point that a good place to find them is on the stretch of water immediately above Ashton Swing Bridge. Here they seem to predominate whereas lower down they are far outnumbered, except that, in 1934, at Sea Mills, there was a great preponderance of these birds in March and April, as many as 200 being seen at once. These

were evidently on migration northward. This was a very marked movement, not at all noticeable the following year, and probably they do not occur normally in anything like these numbers. Stragglers have been seen in June and July, evidently non-breeding birds. The adult is somewhat similar to the Herring Gull in flight, but is more buoyant, distinctly smaller and has a pale green bill and pale green legs and feet. The distinctive white patch at the tip of the wing has already been mentioned, but any Gull that is distinctly intermediate in size between the Herring and Black-headed Gull may, in this district, be safely called a Common Gull. It is very often seen inland in flocks on ploughed ground in the winter, particularly near the Cotswolds.

Within the last thirty years, a great change has come over the Black-headed Gull in Bristol. At one time it was not a common bird, but it has increased greatly in numbers. There is no breeding colony anywhere near Bristol, probably the nearest one being in Dorset. But these birds are always to be seen on the river at any time of the year, the numbers fluctuating from very large in winter to much smaller in summer. The details of their distinctive adult plumage have already been given, but it may be added that the immatures of this Gull can be told by the dark band at the end of the tail feathers, the tail of the adult being pure white.

The sequence to adult plumage only takes two years and so is not so protracted as in the larger Gulls, but it is quite easy to distinguish between the two years. Non-breeding adults are about during the summer and these are reinforced about July by young birds. From that time the numbers increase rapidly and the winter maximum is reached. A number of notes made between November and March show a great preponderance of adults over immatures on the river, while round the docks and Tramways Centre this is much less marked, though immatures never seem to be in greater numbers than the adults.

No attempt has been made to estimate the numbers of gulls using the Avon in winter as a feeding ground, but probably there are several thousand when the higher reaches of the river are also included. When evening draws in they all move off down to the coast, and small parties are continually passing down and above the river until none are left.

The Black-headed and Herring Gulls are easily the most numerous, the others being, at any time of the year, very much fewer, and of these two the former preponderates over the latter.

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Weather Movements in the Bristol Area, 1935

By H. Tetley, B.Sc., F.Z.S.

(*Read in title 5th March,* 1936.)

THE stormy weather of September, 1935, had an obvious effect on bird-life in the Bristol district. There was a great gale from the west or south-west on the night of September 16th-17th over a wide area. The weather continued stormy and unsettled, and culminated, in the immediate neighbourhood of Bristol, in a heavy thunderstorm on the night of September 21st-22nd.

Two Manx Shearwaters were picked up inland on the 18th, one at Fishponds, Bristol, and the other at Clutton, Somerset, these places being respectively about 8 and 9 miles from the coast. An adult Gannet was found on Old Sodbury Common, 12 miles north-east of Bristol and 14 miles from the Severn, about the 21st. All these birds were brought alive to the Clifton Zoological Gardens where the Gannet is still living.

Further down the coast, off Burnham-on-Sea and Berrow, Mr. F. H. L. Whish informs me of a great movement of birds. On the 18th and 19th he saw more than 50 Terns, 2 Skuas (probably Richardson's Skua), several Grey Phalaropes, Manx Shearwaters, and Fork-tailed Petrels, and one Gannet. There were, in addition, great numbers of Shelldduck.

At Barrow Gurney reservoirs there were, on the 21st, two Terns which, but for their habits, would have been put down as Common or Arctic Terns. They were, however, looping down to the water in wide U-shaped loops, never plunging in and very rarely, if ever, touching the water. In this they resembled Black Terns but were probably one of the other two.

Two days later there were 3 Terns, two undoubtedly adult Black Terns, and the third probably a juvenile of the same species though it lacked the dark patches on the sides of the chest normally characteristic of that species.

On the morning of the 22nd, Mr. H. H. Davis saw, on, or over, ground heavily flooded by the thunderstorm of the previous night, about 25 Common or Arctic Terns. This was at Stoke Gifford, about 6 miles from the Severn. Eighteen or nineteen of these were high up in the air, moving from east to west, the remainder flying low over

the water. A Common or Arctic Tern was flying over the Severn above Sharpness bridge on the 25th, and a juvenile of the same species over the canal at Slimbridge, Glos., on the 29th. The movement of Terns has been particularly noticeable during September, much more so than in recent years.

A young Puffin was found on the roof of some works at Filton, just north of Bristol, on October 25th. This is about 6 miles from the Severn. The weather had been unsettled but not as stormy as in the previous month.

From gales we passed to severe cold, and in December a spell of hard frost and snow swept over Britain, particularly from the Midlands and Eastern Counties northwards. Hard frost occurred in the Bristol district but little snow. The somewhat milder conditions combined with the floods on the Somerset levels no doubt helped to provide the most striking feature of bird-life. Great numbers of different species of duck were to be seen. Teal have been present in thousands on the levels and elsewhere, and on Barrow Gurney reservoirs no such numbers have been recorded before.

The maximum was reached on December 28th, when more than 2,300 duck were present; this number was composed of 300 Mallard, 400 Teal, 250 Wigeon, 65 Shoveler, 50 Tufted Duck, 1,200 Pochard and adult males of Scaup and Golden-eye. On December 15th, 1,000 Teal were seen.

Waders in the Bristol District

By H. H. Davis

(*Read in title 5th March,* 1936.)

THE Bristol Channel and the mouth of the Severn, the Blagdon and Barrow Gurney reservoirs, and considerable areas of low-lying marshy country all combine to make the neighbourhood of Bristol an attractive district for the *Limicolæ*, or as they are generally known, the Waders. This does not, however, apply to the breeding season—for the only nesting species are the Lapwing and a few pairs of Oyster-catchers, Redshank, Curlew and Common Snipe; indeed, it is during the autumn and spring passages and the intervening winter months that the Wader population is at its height. Even the banks of the Avon, as far up as the Suspension Bridge, are, in the winter, sometimes frequented by Ringed Plover, Dunlin and Redshank, and this in spite of the near-by road and rail traffic. The Common Sandpiper is a regular visitor along the Avon banks in late summer and autumn.

On the coast from Aust Cliff to Brean Down, the various expanses of mud, left bare by the receding tides, are both attractive feeding grounds to winter visitors and convenient halting places to passage migrants. It is to be regretted that much of this coastline is not watched with greater frequency. Regular observations on the mud-flats off Portbury Wharf, Kewstoke and Weston-super-Mare would probably show results very similar to those obtained in recent years on the north side of Avonmouth.

The large numbers of Ringed Plover, Lapwing, Turnstone, Dunlin, Redshank and Curlew that appear in late summer and autumn along the Avonmouth-Severn Beach mud-flats are undoubtedly one of the chief features of bird-life in the locality. Golden Plovers, Sanderlings, Knots, Curlew-Sandpipers and Godwits may also be expected in the autumn though usually in small numbers. That single instances of the Ruff and Little Stint have recently been observed suggests that these may not infrequently occur. The winter population on this stretch of mud is often enormous and consists chiefly of Ringed Plover, Turnstone, Dunlin, Redshank, Curlew and usually a few Purple Sandpipers. The Dunlin, however, is the predominating species, and the well ordered flight of a large flock of these birds when seen under favourable conditions is a spectacle not easily forgotten; turning and twisting as one, and alternately showing their almost invisible grey

backs and their conspicuous white underparts, give to the observer the impression of rapidly appearing and disappearing silvery flakes.

During the autumn migration, the Blagdon and Barrow Gurney reservoirs are in some years visited by a few individuals of the Ruff, Greenshank, Black-tailed Godwit and, occasionally, by the Spotted Redshank and Grey Phalarope. Much, however, depends on seasonal conditions; prolonged spells of dry weather—as in 1933 and 1934—cause a low water level with a consequent increased area of mud, which prove a great attraction to wading birds. The Common Sandpiper is a regular visitor on spring and autumn passage, while solitary examples of the Green Sandpiper frequently occur and sometimes remain through the winter. Common coastal Waders such as Ringed Plover and Dunlin are only occasional visitors in small parties. With the exception of the Lapwing, no species visit the reservoirs in large numbers.

An event of considerable ornithological interest was the visit in late September, 1935, of a Pectoral Sandpiper to Barrow Gurney. It was first observed on September 28th, at the No. 1 reservoir, where it remained and was seen daily until October 3rd. This species is a little larger than the Dunlin, has longer legs, and is more slender in build, while the distinct line of demarcation between the dark streaky breast and the pure white underparts is an outstanding characteristic. Breeding in western N. America and wintering in S. America, the Pectoral Sandpiper is a rare straggler to the British Islands, and it has not previously been recorded for Somerset. The occurrence of this bird at Barrow—full details of which were published in *British Birds*, Vol. XXIX, p. 183—was perhaps due to heavy storms and westerly gales during the latter half of September.

The following list of thirty species is in no way intended as a complete historical account of Bristol Waders, but rather as a guide in the light of observations in recent years. For the purpose of comparison between observations made to the South and to the North of the City, each species has been separated under two headings, viz., S. and G., representing respectively Somerset and Gloucestershire. Much information has been gleaned from the annual reports on Somerset Birds from which fuller details may be obtained. Gloucestershire particulars—some of which have from time to time been published in *British Birds*—are almost entirely the result of observations by members of the B.N.Soc. Ornithological section.

1. STONE-CURLEW. *Burhinus œ œdicnemus* L.

S. In the 1925 Report on Somerset Birds, a pair is stated to have been clearly identified on December 3rd in Woodspring Bay. (A summer visitor to England, this species has occasionally been known to winter in the S.W. Counties.)

G. Not recorded.

2. OYSTER-CATCHER. *Hæmatopus ostralegus occidentalis* NEUM.

S. Resident on the coast but more numerous in winter. Breeds at Woodspring. Occasional inland. One seen at Barrow reservoirs in February, 1929, and is reported to have occurred at Blagdon in the autumn of 1933.

G. Recent observations suggest that this species is uncommon to the north of Avonmouth although it may occur more often than is supposed. (Has been seen on St. Tecla's Isle.)

3. DOTTEREL. *Charadrius morinellus* L.

S. A very occasional visitor on migration. A specimen was shot on Steep Holm in May 1869 and at about the same time a small trip was seen near Weston-super-Mare, since when there have been no authentic records.

G. Not recorded.

4. RINGED PLOVER. *Charadrius h. hiaticula* L.

S. Common on the coast particularly in autumn and winter. Small parties sometimes visit the Blagdon and Barrow Gurney reservoirs in autumn.

G. A very abundant species along the Severn mud-flats where it is common at any time from August to May. A few—probably non-breeding birds—occur in June and July.

5. GOLDEN PLOVER. *Charadrius apricarius* L.

S. A regular autumn and winter visitor to the coast and inland, sometimes appearing in large numbers.

G. A few are sometimes observed on the Avonmouth-Severn Beach mud-flats in autumn and winter. Occurs more frequently inland. During severe weather in February, 1932, a large flock appeared at Stoke Gifford.

6. GREY PLOVER. *Squatarola s. squatarola* L.

S. Occurs on the coast in winter, but usually only in small numbers. Fairly frequent in Woodspring Bay. Scarce inland. Has been recorded near Blagdon.

G. Apparently a scarce winter visitor to the Severn mouth. Has

been observed twice recently—single birds—on the Avonmouth-Severn Beach mud-flats.

7. LAPWING. *Vanellus vanellus* L.

S. and *G.* A common resident. Breeds freely in suitable places. As an autumn and winter visitor it occurs in large flocks inland and to a lesser extent on the coast.

8. TURNSTONE. *Arenaria i. interpres* L.

S. That little is known of this species on the Somerset side of Avonmouth is perhaps due to lack of observation, as it occurs regularly in autumn and winter on the Severn flats. Has been seen at Clevedon.

G. The presence at almost all times of the year of this rock-loving species on the Avonmouth-Severn Beach mud-flats is of particular interest. As many as 150 or more have sometimes been observed there in the autumn.

9. RUFF. *Philomachus pugnax* L.

S. Occurs fairly frequently on autumn passage—either singly or in two's or three's—at the Blagdon and Barrow Gurney reservoirs.

G. A single bird on the Avonmouth-Severn Beach mud-flats in September, 1935, is the only recent record of this species.

10. SANDERLING. *Crocethia alba* PALL.

S. A visitor in late summer and autumn to the coast, but apparently not in large numbers. Has been seen off Portbury Wharf. Although records are lacking it probably also occurs in spring. Scarce inland. Three were observed at the Barrow Gurney reservoirs in September, 1930.

G. An autumn and spring visitor in small numbers to the Avonmouth-Severn Beach mud-flats.

11. KNOT. *Calidris c. canutus* L.

S. That there are no records of this species on the coast is curious and may perhaps be due to lack of regular observation as it has been noticed fairly frequently in autumn and early winter on the Gloucestershire side of Avonmouth. Rarely seen inland. One at Barrow reservoirs in September, 1935.

G. Chiefly an autumn visitor to the Avonmouth-Severn Beach mud-flats. Although usually in small numbers, as many as 100-150 have been seen.

12. DUNLIN. *Calidris alpina* L.

S. and *G.* An abundant coastal species from late summer to spring.

A few—probably non-breeding birds—occasionally seen in summer. The departure of the large flocks of wintering birds is followed by an influx of spring passage migrants in full breeding dress. Small parties sometimes visit the Blagdon and Barrow Gurney reservoirs, usually in autumn.

13. Curlew Sandpiper. *Calidris testacea* Pall.

S. A visitor to the coast on autumn passage. Probably occurs more often than is supposed since, being frequently in company with Dunlin, it may easily be overlooked. Has occurred at the Blagdon and Barrow Gurney reservoirs; 8 or 10 were seen at Barrow Gurney in September, 1923.

G. An autumn visitor to the Severn flats. Has been observed on several occasions in September between Avonmouth and Severn Beach.

14. Little Stint. *Calidris minuta* Leisl.

S. Probably visits the coast more often than is supposed during the autumn passage. Owing to its small size it may easily be overlooked. Reported as having been observed at Blagdon in 1922 and 1933.

G. Very little information available, but perhaps an overlooked passage visitor. A single bird was seen on the Avonmouth-Severn Beach mud-flats in September, 1935.

15. American Pectoral Sandpiper. *Calidris melanotos* Vieill.

S. A single example of this species was observed daily at the No. 1 reservoir, Barrow Gurney, from September 28th to October 3rd, 1935 (cf. *British Birds,* Vol. XXIX, p. 183.)

16. Purple Sandpiper. *Calidris m. maritima* Brünn.

S. Scarcely any information from the coast, but probably often occurs, as it is a regular winter visitor to the Severn mouth. One observed on the Brean Down flats in March, 1925.

G. A regular winter visitor in small numbers to the Avonmouth-Severn Beach mud-flats, usually in company with Turnstones and Dunlin.

17. Common Sandpiper. *Tringa hypoleucos* L.

S. A common spring and autumn visitor, the autumn passage sometimes beginning early in July. Occurs regularly at the Blagdon and Barrow Gurney reservoirs. An unusually large flock of about 100 was seen off Portbury Wharf in May 1922.

G. A regular visitor on passage to the Severn and Avon banks. Occasionally seen inland.

18. GREEN SANDPIPER. *Tringa ochropus* L.

S. Frequently observed—usually singly—in autumn and spring at Blagdon and Barrow Gurney reservoirs, and occasionally winters. Has occurred at Abbots Leigh, Woodspring and on Kenn Moor.

G. Scarcely any authentic records, but undoubtedly occurs in suitable places. Has been seen at Dyrham in autumn.

19. COMMON REDSHANK. *Tringa totanus* L.

S. Occurs chiefly as an autumn and winter visitor to the coast. Has frequently nested at Blagdon reservoir and breeding has been reported from several suitable localities near the coast. A scarce autumn visitor to the Barrow Gurney reservoirs.

G. A common autumn and winter visitor to the Severn mouth mud-flats. A few—apparently non-breeding birds—sometimes seen in summer. Occasional inland.

20. SPOTTED REDSHANK. *Tringa erythropus* PALL.

S. A scarce and irregular autumn visitor. One observed at the Blagdon reservoir in September, 1923. In September, 1933, two were seen at Blagdon and one at Barrow Gurney. One was identified at the mouth of the River Yeo in January and February, 1935, and two were seen there in the following November. As this species is rarely observed in the British Islands in winter these latter records are of considerable interest.

G. Not recorded.

21. GREENSHANK *Tringa nebularia* GUNN.

S. Frequently occurs, either singly or two or three birds, at the Blagdon and Barrow Gurney reservoirs, during the autumn passage. A larger number were seen at Barrow Gurney in 1933, than in any year previously recorded. Has been observed at Blagdon in January (1922).

G. Not recorded.

22. GREY PHALAROPE. *Phalaropus fulicarius* L.

S. An irregular autumn visitor ; usually seen singly inland. Has several times occurred at Blagdon. One visited a small pond at Barrow Court in late October, 1935, where it remained for about ten days.

G. Probably occurs at irregular intervals in autumn. There are, however, no authentic records since two were obtained and two others seen at Avonmouth in September, 1896.

23. Red Necked Phalarope. *Phalaropus lobatus* L.

S. A scarce autumn visitor. Two were seen and one of them shot at Blagdon in September, 1921. A Phalarope, said to be of this species, visited Blagdon in the autumn of 1931.

G. Not recorded.

24. Bar-Tailed Godwit. *Limosa l. lapponica* L.

S. A visitor to the coast in autumn or winter. May occur more frequently than is supposed.

G. Occurs—perhaps regularly—in autumn on the Avonmouth-Severn Beach mud-flats. Has been seen there in December (1934).

25. Black-Tailed Godwit. *Limosa l. limosa* L.

S. Apparently a scarce autumn visitor to the coast. One observed on the Portishead mud-flats in September, 1922. One or two were present at the Barrow Gurney reservoirs in late September, 1933, and it has occurred at Blagdon on several occasions in autumn and once in spring. Twenty-three were seen at Blagdon reservoir on the last day of September, 1934, some of which remained until early November.

G. An uncommon visitor on autumn passage. A single bird was seen on the Avonmouth-Severn Beach mud-flats in September, 1934. (One observed at the mouth of the River Wye, September, 1933.)

26. Curlew. *Numenius a. arquata* L.

S. Common on coastal mud-flats from autumn to spring, some remaining through the summer. Occasionally seen in small numbers at Barrow Gurney and has visited Blagdon. Has nested on the Mendips on several occasions since 1912.

G. A common species at the Severn mouth especially in autumn and winter. Frequently occurs inland.

27. Whimbrel. *Numenius ph. phœopus* L.

S. A visitor to the coast on migration. Although regularly seen in spring there are but few autumn records.

G. An autumn and spring passage migrant. Has been observed on the Avonmouth-Severn Beach mud-flats and inland.

28. COMMON SNIPE. *Capella g. gallinago* L.

S. Resident but more numerous in winter. Breeds—perhaps regularly—on the Clapton, Nailsea and Kenn Moors and on other suitable ground. Occurs regularly in varying numbers at the Blagdon reservoirs in autumn and winter. Less frequent at Barrow Gurney.

G. A common autumn and winter visitor to marshy ground and streams. Occasional in summer but no evidence of breeding.

29. JACK SNIPE. *Lymnocryptes minimus* BRÜNN.

S. A winter visitor. Probably frequent in some years but records from the district are few. Has been observed at Blagdon and Barrow Gurney.

G. Little information available but probably a regular winter visitor in small numbers. One was shot at Stoke Gifford in December, 1935.

30. WOODCOCK. *Scolopax r. rusticola* L.

S. An autumn and winter visitor to suitable places in the district. As many as twenty or more have been shot on some estates in one winter. Records kept in recent years show, however, that in most cases the average number obtained on any one estate in a season is no more than six or seven birds.

G. Undoubtedly a regular autumn and winter visitor but to what extent is uncertain. A few are seen in most winters in the Tockington district where it has also been observed in summer and is reported to have bred on one or two occasions. Has been shot at Stoke Gifford.

The Moulting of Chirocephalus diaphanus

By K. W. Nicholson, M.Sc.

(*Read in title 5th March*, 1936.)

WHILE carrying out research on the Fairy Shrimp (*Chirocephalus diaphanus*) in the Department of Zoology, University of Bristol, under the direction of Prof. C. M. Yonge, I had occasion to study the moulting of these and similar animals. No previous observations on moulting in *Chirocephalus* appear to have been published, although good accounts exist of ecdysis in various Crustacea, including a detailed description by Cunnington (1930) of the process in *Simocephalus sima*. My observations will be compared with his.

To ascertain the frequency of moulting, I followed Cunnington's method, isolating individuals in small vessels and examining the water frequently for cast skins. The animals were kept in pond water, and food material supplied by the introduction of a few slightly decayed portions of leaves. The animals were roughly divided into three groups, small, medium and large, according to size. I found that, as in *Simocephalus*, moults occurred at regular intervals. Generally speaking, the smallest animals moulted every second day, those of medium size every third day, while the largest would live for three or four days without moulting. There was no difference between the behaviour of the two sexes. Cunnington found that intervals of four to five days elapsed between the moulting of a mature female *Simocephalus*.

The behaviour of the two animals prior to a moult appears to be similar. Cunnington describes the integument as being loose fitting and the animal sluggish in its movements. This is also the case in *Chirocephalus* which I found to be usually pale in colour at this period. The animal lies on its back at the bottom of the vessel and moves its appendages very slowly. At intervals it shakes itself and lashes with the tail. The first sign of actual moulting is a median ventral slit in the integument. The entire animal assumes a ragged appearance. The appendages are withdrawn one at a time, apparently without any definite sequence. Sometimes animals were observed to take firm hold of a piece of weed or similar object, the purchase so obtained apparently assisting in the pulling off of the integument. A tendency was also

observed for the animal to scrape itself against any foreign body as an aid to the process.

The two animals differ widely in the time occupied by the moulting process. Cunnington states that in *Simocephalus* the entire process is completed in less than a minute. He states that the animal splits the carapace above the head region with one jerk. The old integument comes away laterally from the thoracic region but the animal remains attached to it ventrally, anteriorly in the region of the first antennae, and also posteriorly. Through the opening in the old integument are pushed out first the head, then the thorax and finally the abdomen. This is assisted by an apparent springing apart of the two sides of the old carapace.

I have watched an individual *Chirocephalus* showing the preliminary stages of moulting for as long as a day without observing much apparent progress, and I have never been so fortunate as to observe the process from start to finish. That the final emergence from the cast integument is sudden is indicated by the fact that, after observing an animal struggling to free itself for hours, I have left it for the space of a few minutes and, on my return, found the moult completed. This suggests agreement with conditions in *Simocephalus* so far as the final stages of ecdysis are concerned.

It still remains to consider the condition of the animals when the moult is completed. Cunnington describes *Simocephalus* as being transparent, soft and quiet in behaviour for half an hour after the moult and says that the animal is still passive after nine hours. It does not become active and feed until the day following the casting of the old integument. A similar quiescent period during the hardening of the shell occurs in the Decapod Crustacea. *Chirocephalus*, on the other hand, exhibits unusual activity almost immediately after the integument is shed, swimming about with great vigour, while the colours are as bright as, or brighter than usual. Another interesting point is that, whereas *Simocephalus* shows a sudden, marked increase in size, this is not so apparent in *Chirocephalus*.

It would appear, therefore, that though the time taken in the actual casting of the integument is so widely different in the two animals, the process of ecdysis, considered as a whole, takes essentially about the same time. Whereas *Simocephalus* rids itself of the old integument and then proceeds to complete, possibly the secretion, and certainly the hardening, of the new one, in *Chirocephalus*, the old integument

is retained as a protective coat during these processes. The latter, by the protection provided during the most delicate stage in the life of these animals, would appear to be more efficient. In any case, this difference between the process of ecdysis in two such members of the Branchiopoda, *Chirocephalus* being included in the Order Anostraca and *Simocephalus* in the Cladocera, is of interest.

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Bristol Botany in 1935

By Cecil I. Sandwith

(*Read in title 5th March,* 1936.)

It has been generally felt that "Bristol Botany" should no longer remain unrepresented in the *Proceedings*. When reading over the late J. W. White's notes for so many past years, and realizing the immensity of the botanical work done in the fifty-eight years, 1874-1932, it seems an impossible task to approach such a standard. The notes are so alive, and full of interesting information and detail, showing the enthusiasm of the author for the country and the flowers he loved. I would call attention to the fact that these notes and records have been of supreme importance in the past, and should be equally valuable in the future for another generation called to work on the Bristol flora. This can only be done with the help and co-operation of all members of our Society who are actively engaged in any form of field botany. One cannot always expect new county records, but the observation of how rare plants are holding their own, which new ones are establishing themselves and becoming naturalised in certain places, and which are disappearing or have already disappeared, is a matter of interest and importance, and would provide a good object for study and recording.

The systematic botanist must not be regarded as one who merely collects and classifies plants. The object of collecting should be to know and understand more about them, and when the collection is made the work begins. Fortunately, all are not collectors, and dried goods do not appeal to the majority of flower lovers; besides, the space required, the contingent expense, and the constant care which is necessary to preserve the herbarium of any useful size, make it prohibitive for those who are otherwise busily engaged, and in most cities at the present day there are herbaria which can be consulted, so that personal observations in the field are often more useful and attractive. The plant in its natural surroundings, the soil and situation which are suitable to some and avoided by others, the changes which take place in summer and winter, variations of form in species, times of flowering, the struggle for existence in weak communities, and the inroads of an aggressor, so much can still be done without any specialised knowledge.

Our manuals of botany are inadequate for these days, and still follow one another in meagre descriptions and occasionally doubtful state-

ments. One book states that *Scilla verna* is never white, but this is not a fact, as herbarium specimens prove. Species which normally produce blue flowers often have white forms, and the *Scilla* is no exception. Four books describe the Hornbeam as "a small tree" although one of them adds that it sometimes grows to 70 ft. high. The Bristol Flora tells of one 50 ft. in height, "the head as much, or more in diameter," and the one in a copse near Sea Mills held its own in size amongst Elms and Beeches. There still exists a large old Hornbeam in a field below Blaise Castle Woods which could never be described as small. Gerard says of the Hornbeam, "it growes great, and very like the elme, having a great body, the timber whereof is better for arrowes, shafts, and such like devices than elme." There must be some reason why so many authors have described the Hornbeam as small. Except in gardens where it is often clipped, it appears to be local, at any rate in this part of the country, and when left to itself becomes a fine tree. It is with relief that we turn to Gilbert-Carter's little book and find that "It is somewhat rare to find an unmutilated tree in England." His photograph shows the fine bole of an old Hornbeam in Essex. The moral is surely that descriptions should not be made from the victims of circumstances over which they have no control, and personal observations must be careful and accurate. Careful observations and notes made by members of our Society should be of value.

Ranunculus sardous Cr. var. *inermis* Babey. Waste ground, formerly meadow-land, at Ashton Gate, S., July, 1932, *C. Sandwith.* Plentiful and looking native. In this variety the carpels are either quite destitute of tubercles or show only a faint irregular row near the margin. Mr. J. W. White's specimen from Ashton Avenue, Nov., 1909, is also to be referred to this ; and so is another collected by him in St. Philip's Marsh, G., in June, 1906.

Barbarea intermedia Bor. Yard near Cheddar Station, S., 1935, *J. P. M. Brenan.*

Geranium pusillum L. Edge of limestone rock in a quarry near Wickwar, G., June, 1935, *C.* and *N. Sandwith.*

Trifolium filiforme L. Grassy bank in a quarry at Wickwar, G., June, 1935, *C.* and *N. Sandwith.*

Vicia bithynica L. In spite of, or because of, the widening of the lane and the consequent disturbance of the soil, this species appeared

in extraordinary abundance last summer in the old locality between Stoke Gifford and Winterbourne, G.

Valerianella eriocarpa Desv. Slopes above Cheddar, S., a quantity in one spot, but probably of recent introduction, June, 1935, *C.* and *N. Sandwith* and *H. W. Pugsley.* A new vice-county record for North Somerset, and hitherto found in the area only as a casual at St. Philip's Marsh (1904, *C. Bucknall*). This is a rare British species, mainly confined to the south-western counties of Dorset, Devon and Cornwall.

Senecio Jacobaea L. A dwarf " hen-and-chicken " form on a hillside near Wotton-under-Edge, G., *J. P. M. Brenan.*

Cirsium acaule (L.) Weber × *lanceolatum* Scop. Pasture at Marshfield, G., Aug., 1935, *J. P. M. Brenan.*

Calystegia sepium (L.) R. Br. var. *colorata* Lange. This pink-flowered form is occasionally found, as on a railway bank at Weston, Bath, S., 1935, *J. P. M. Brenan.*

Verbascum nigrum L. A single plant on a wall near Longwood, Failand, S., 1935, *C. Sandwith.*

Veronica Beccabunga L. A patch with very pretty lilac flowers, with purple spots near the centre, was seen on the border of a wood near Wickwar, G., 1935, *C.* and *N. Sandwith.*

V. aquatica Bernh. and *V. Anagallis-aquatica* L. These two species, now generally recognised by British and continental botanists, were not separated in the *Bristol Flora.* Their occurrence and distribution in the area should therefore be investigated. At present it appears that *V. aquatica* (with pinkish flowers on fewer, thicker, more or less horizontal pedicels) is the common plant of our dykes and lowland marshes. *V. Anagallis-aquatica* (with bluish flowers in dense racemes, on slender ascending pedicels, and usually a more robust plant with larger leaves) has been seen in a rhine on Tickenham Moor, and by the Chew near Publow, S., *J. P. M. Brenan.* The characters of these two species have been discussed in recent years in various papers in the *Journal of Botany*, and the *Reports of the Botanical Society and Exchange Club of the British Isles.* Among other characters which should be tested, in addition to those mentioned above, are the length of the bracts in relation to the pedicels, the size of the corolla, the shape of the leaves, sepals and fruit, and the seeds. The two species frequently grow together, and a hybrid has been recorded.

Mentha cardiaca Baker. By farm buildings on the Glastonbury peat moor, S., Sept., 1933, *C.* and *N. Sandwith.*

Ballota ruderalis Sw. Outside a gate on Ursleigh Hill, Pensford, S., July, 1935, *H. S. Thompson.*

Mercurialis annua L. var. *ambigua* (L.) Black Rock Quarry and Marshfield, G., Twerton, S. All records made in 1935 by *J. P. M. Brenan.*

Salix undulata Ehrh. (*S. alba* L. × *triandra* L.). By ditches in the flats between Berrow and Lympsham, S., 1932, *C. Sandwith.* Det. J. Fraser. First record for the district.

Ophrys Trollii Reichb. Still under Leigh Woods, S., June, 1935, *Ivor Evans.* The present tendency of British botanists is to regard this as a mere state of *O. apifera.*

Alisma lanceolatum With. Canal near Bath, and between Claverton and the Aqueduct, S., 1935, *J. P. M. Brenan.*

Sparganium neglectum Beeby. Peat moor near Shapwick, S., 1935, *J. P. M. Brenan.*

Eriophorum vaginatum L. Certainly rare at the present day on the peat moors (see *Bristol Flora,* p. 622), but seen in one spot last July by *C. Sandwith* and *H. S. Thompson.*

ALIENS. Numerous casuals from the city tips and docks are recorded annually in the *Reports of the Botanical Society and Exchange Club of the British Isles.* Among the more interesting additions to the " Adventive Flora of the Port of Bristol " (1932) are *Clematis Flammula* L., *Vicia grandiflora* L. and *Orlaya grandiflora* (L.) Scop. (*H. J. Gibbons*) ; and *Malva nicæensis* All., *Falcaria vulgaris* Bernh., *Inula graveolens* L., *Hemizonia Fitchii* A. Gray, *Stachys Ocymastrum* (L.) Briq. and × *Rumex Bontei* Danser (*R. crispus* × *obovatus*). The two last are first records for Britain. In addition, Mr. J. P. M. Brenan has found *Matthiola bicornis* DC. on the Burnham sand-dunes ; and the remarkable African grass, *Brachiaria Isachne* (Roth) Stapf, on a roadside at Walton-in-Gordano, S. Finally, Mr. T. H. Green was the first to note the establishment by the river Avon at Bath of a bush of the Pomegranate, *Punica Granatum* L. ; this is now 4-5 ft. high, and is an interesting addition to the British alien list.

Note on a Boring Near Winford, Somerset

By A. E. Trueman, D.Sc., F.G.S.

(*Read in title 5th March,* 1936.)

IN 1934, a boring for water was made in a field on the western side of the lane leading to Winford from the Bridgwater road, at a point about 370 yards north-north-west of Grove Farm (on the six-inch map it is near the borders of two sheets, Somerset XI N.E. and XII N.W.). A well was dug for about 20 feet in limestones and shales of the Lower Lias, and boring was then continued for a further 170 feet. The supply of water being inconsiderable, the scheme was then abandoned. No detailed record of the boring was available and only an approximate section can be compiled from a study of the cores and the material from the well. Unfortunately, the cores from the upper part of the section were badly weathered and afforded only scanty information concerning the clays and shales. The evidence available, however, made it possible to obtain details of the more important parts of the sequence, and the results appear to be of sufficient interest to justify a record.

The section commenced in Lower Lias (*angulata* zone) and passed completely through the Rhaetic, before penetrating about a hundred feet of Keuper The details are as follow :

		ft.	ins.	
Lower Lias	Limestones in thick beds ..	18	0	*Schlotheimia* spp. *Nautilus* sp. *Oxytoma inaequivalvis* (Sow.) *Calcirhynchia calcaria* S. S. Buckman.
	Clay, about	2	0	
	Massive grey limestones, some crinoidal	19	0	
	Thin limestones and dark shales	8	0	*Ostrea liassica* Strickl.
	Compact brownish limestone (? Sun Bed) ..	1	0	Fish scales.
White Lias	Thin limestone and marl, seen	1	6	
Upper Rhaetic	Cotham Marble		6	
	Light coloured marl, seen	2	0	
Lower Rhaetic	Black shales with some slightly harder bands, seen	6	0	*Chlamys valoniensis* (Defrance). *Protocardium rhaeticum* (Mer.).
Tea Green Marl	Soft, badly weathered, seen	6	0	

		ft.	ins.
Red Marl	Red Marl	5	0
	Gypsum		3
	Red marl with green bands	6	0
	Brown sandstone	1	0
	Gypsum		4
	Red and green marls with a little gypsum	18	6
	Red marl with films of gypsum, often in vertical veins	15	0
	Green sandstone with calcite veins	1	0
	Red marl with green band and irregular gypsum. Some conglomerate ..	20	0
	Green bands with sandstone and disturbed chocolate-coloured marl	3	0
	Red marl and sandstone, with thin beds of conglomerate and some gypsum	21	0

The above record accounts for only just over 155 feet of the 190 feet known to have been passed through. In view of the nature of the core in the Red Marl it is not likely that much is missing from this part, although some proportion of the core is no doubt lost. The greater loss probably occurred in the softer shales of the White Lias, the Rhaetic, and in the Tea Green Marls. The figures given in the table can therefore only be regarded as minima.

While the section shows a fairly normal sequence, there are several interesting features which are best considered in relation to the position of the borehole. To the west, the ground rises to Broadfield Down where Carboniferous Limestone outcrops and is overlain directly by massive Lias limestones in many places, especially on Felton Hill. Carboniferous Limestone actually outcrops in Rocks Wood, on the hill immediately above the borehole, and only about 300 yards to the west. The considerable thickness of the Keuper found in the boring is thus rather unexpected, and indicates a very rapid westerly overlap by the Lower Lias. The surface of Carboniferous Limestone on which the Mesozoic rocks rest on this face of Felton Hill must, therefore, fall away rapidly eastwards, and they must be banked against a comparatively steep slope. On the other hand, exposures of Keuper occur both to the south of Winford and to the north of Barrow Gurney, and a much more gradual overlap by the Lias may suggest a more gentle slope in these directions.

The occurrence of some conglomeratic layers in the upper part of the Lower Lias is not surprising in view of the these facts, but the pebbles of Carboniferous Limstone present in these beds do not exceed about a half-inch in length. The massive Lias limestones in part of this sequence and the thinness of the intercalated shale bands are presumably due to the presence of finer débris from the Carboniferous Limestone, and the lithology somewhat recalls the Sutton Stone of Glamorgan, which was deposited under similar conditions.

So far as could be determined, there are no conglomeratic layers in the Rhaetic, which preserves its usual characters and has no noticeable calcareous beds.

The Keuper Marl has layers of conglomerate at several horizons, but these are rather thin and inconspicuous, and the included fragments of limestone are rarely half an inch in length. The marl is unusually calcareous, however. There is no trace of a conglomerate in the lowest beds reached, and it is uncertain what thickness of marl exists in the area.

Possibly faulting may have led to a slight increase in the thickness shown, for at about 75 feet below the Rhaetic there is some evidence of disturbance. The dip is normally less than 5 degrees, but at this depth it suddenly increases to over 30 degrees, and the marl is broken and slickensided. One bed of peculiar chocolate marl occurs here. In this, as in other layers at about that level, numerous tabular crystals of celestine about half an inch long are abundant.

Notes and Memories, 1935 (Stapleton)

By G. Mogg

(*Read in title 5th March,* 1936.)

SWIFTS usually arrive here early in May, and my records shew that in the last four years their stay has averaged approximately 91 days. In 1932, they appeared on the 13th of May and disappeared on or about the 19th of August; in subsequent years the dates are as follow: 30th April, 4th August; 9th May, 17th August; 4th May, 4th August.

Exceptionally, a Swift was seen here on the 5th September, 1934, accompanied by a number of House Martins, all flying in a northerly direction in pleasant, sunny weather. The Swift seemed uncertain as to its whereabouts and direction, and zigzagged a good deal in its flight. On the 10th of the same month, I am pretty certain that a Swift flew over in the company of a Swallow. On or about the 5th, wintry weather, including snow, was reported from the Continent.

On the 19th of May, last year, my attention was attracted to a pied Swift flying low in the company of other Swifts over the Duchess' Pond. An unusual sight to me; a ring of white feathers encircled its neck, the top of its head and a part of its back were also white. This bird seemed particularly odd as it shot to and fro among its normal-coloured companions. In the early mornings of the 10th to 12th July, a dozen Swifts attracted attention by screeching very loudly as they chased each other along the fronts of houses facing east, and catching insects, probably flies, close against the wall. Some of them would cling to the wall, and appeared to take the flies directly from the stones. What untiring creatures Swifts are; their three months' stay in the hottest period of the year seems to be spent in unremitting energy, feeding, drinking, and even mating whilst on the wing; from the earliest to the latest moment of visibility during the long days they may be seen; now at a great height, now flashing and screaming along the eaves of houses, never tiring, never colliding, seldom resting—finally suddenly departing—a very crowded, exciting life indeed. These birds have whizzed closely around me whilst I have stood near the stream at the old mill.

The Duchess' Pond, the river Frome and the adjacent fields and coppices are most interesting places for observing wild life all the year round. The Pond is much favoured by Seagulls for cleaning purposes after foraging for food on the land and refuse heaps. Scores of them splash and dip together there, and as they alight on the Pond, each one takes a sip of water even before it has recovered from the slight momentum due to landing. Recently about ninety per cent. were birds of immature plumage, a mixed company including Black-headed and Herring species. One day a Carrion Crow watched the Gulls taking their bath, and after a while decided to follow suit. He flew to the Gulls, alighted in the deep water and splashed and dipped himself in true Gull fashion; soon he became waterlogged and alarmed, and only with considerable difficulty was he able to regain the bank—a wetter and wiser crow. Birds observed at the Pond include Teal, Tufted Duck, Little Grebes which nest there, Common Sandpipers, Mallards, Herons, Coots and Waterhens.

On the 7th of May, fully fledged young Carrion Crows were being fed by their parents in the adjoining meadow. Grey Wagtails, Kingfishers and Dippers are among waterside birds that have their nests along the banks of the Frome. Even on the lower reaches of the river, a Kingfisher and a Lesser Spotted Woodpecker appear to have nested last summer. I was shewn circumstantially the actual sites of the nests, too late in the season, however, to see their contents. The Kingfisher's nest was in a hole in the bank, and the Woodpecker's nest in a willow tree close by. The Grey Wagtails usually nest in an old wall, ivy-covered or draped with the pretty ivy-leaved toadflax; and although Dippers are rarely seen now in the Stapleton area, they have nested there in recent years; and once I heard the delightful song of the Dipper, and also that of the Grey Wagtail near the ruined mill.

Otters still roam the banks and feed from the river. On one occasion I witnessed a "kill" at Hambrook. The hunt seemed to be quite a one-sided affair; some twenty dogs with the aid of fifty persons of both sexes, having driven the creature by divers means from its holt in the half submerged roots of a tree, scared it into shallow waters, and virtually surrounded it; there, yielding gamely, it was crushed by the powerful jaws of the dogs. The carcase was eventually thrown to the dogs on the bank where it was mauled and tugged at for some time; subsequently I examined the pelt—all that was left of a brave little animal—and found it to be absolutely intact. Just previously a small

terrier of the hunt had found a Vixen at home with her cubs in a drain and retired hurt.

I had a surprise on the 18th March last whilst I was engaged in gardening operations; a Hedge Sparrow was singing on some pea sticks when a Sparrow Hawk dashed for it, making a great noise with its wings; the Hedge Sparrow flew towards me and hid in an old tin lying upon the ground; the Hawk alighted beside the tin, and with outspread wings and tail, waited expectantly with fierce and terrifying gaze, until I approached closely to it. It was a thing of great beauty, even in its seemingly horrifying quest. I withdrew the Hedge Sparrow and held its frail and panting frame in both hands for a while before setting it free, when it immediately returned to the sticks, and sang out as blithely as ever. A nest, with greenish blue eggs, was in the sticks.

On another occasion, a dead Chaffinch fell at my feet; its skull was broken and bleeding, but its body was still warm; on looking up quickly, I saw a Sparrow Hawk making off, no doubt much disappointed at the unexpected interruption of its meal.

Once a Hawk chased and took away a Song-thrush from under a seat on which I and my family were resting—the tragedy was enacted suddenly, and was over before we realised what had happened.

Recently, mixed companies of Linnets, Greenfinches, Chaffinches, Bramblings and Goldfinches have fed together on the various weed seeds in the gardens; and I noted that Bullfinches and Greenfinches fed on the dried-up fruit of blackberries—they actually ate the hard seeds, or achenes.

Wood Pigeons, Starlings and Thrushes feed in late winter on ivy berries, and Thrushes on holly and yew berries. In autumn and winter Starlings seem to cry pathetically, "Dear me, Dear me," and one of their common imitations is of the enchanting cadences of Willow Warblers, interspersed with the call of the Green Woodpecker.

During 1934, Hares were numerous in some allotment gardens at Fishponds, and bred freely there; being too confiding, however, they were almost exterminated. Still, it has been my pleasure since to handle tiny Leverets, each too small to cover the palm of one's hand; the distinctive white spot on the forehead, black eartips, together with appealing dark eyes, make Leverets especially attractive. Mother Hares appear to remain within sight or hearing of their young at all

times, and remove them from danger to a place of safety at the first opportunity.

" Our " Blackbird of last spring and summer was a particularly rich and tuneful bird. It began to sing in February and continued attractively into August, quite a long period for a Blackbird. At times it seemed languid or lazy, and on such occasions would yawn, and whistle only in a suppressed manner—just crooning to itself with closed mandibles.

Housesparrows are interesting, and have the virtue of being always with us and doing much good. A Tree Sparrow, with a perfect ring of greyish white feathers around its neck, fed with them all last winter on a table placed outside a window suitable for observation. In August, a company of Housesparrows congregated in a lilac bush and twittered so sweetly together as to pardon one for believing they actually sang a continuous and pleasing melody. A hen Housesparrow once sang a very quiet little song at close quarters to myself, leaving no doubt about the matter—there was a caged Canary singing, intermittently, in an adjoining garden, and the Sparrow's song seemed to be imitative of that of the other bird.

In July, several colonies of Mason Wasps, invaded the red sand banks near the Duchess' Pond, and were a source of much interest for weeks afterwards.

At the end of June, I stood on an eminence and watched Peregrine Falcons flying to and fro below and above me ; a most thrilling experience. They eventually flew inland directly towards the city. In the evening, just after sunset, is a good time to watch the Peregrines, as they almost invariably return just before dark.

On the 11th of December, a Great Crested Grebe visited a disused clay-pit directly adjoining the Fishponds Road, and within a few yards of almost incessant noise. The morning was misty, but the sun broke through and shone on the Grebe's silky white neck in a most pleasing way, whilst the bird moved quietly about with a dignity that was both charming and fascinating to see.

A Query

VERY soon after Portway was constructed, scented coltsfoot (*Petasites fragrans* White; *Tussilago fragrans* Bentham and Hooker) established itself on the bank of the Avon and has now taken possession of large stretches, almost exterminating all other plants.

At first it was of the ordinary pink colour, nearly as dark as Butterbur, (*Tussilago petasites*) with which it is frequently confused, except in one place near the foot of the Gully where it was much paler, having only faint pink petals contrasting with the darker stamens; the leaves also were of a lighter shade of green. But now, along the whole distance it is nearly all the light colour and only a few heads here and there approach the darker tint.

Can any explanation be given for this change? It appears to be a definite change of colour and not the supplanting of one variety by another.

H. O. EDMONDS.

Review

THE FLOWERING PLANTS AND FERNS OF CARDIGANSHIRE.

By J. H. SALTER, D.Sc. Cardiff: University Press Board, 1935. 5s.

Want of space precludes more than a brief note on this useful book. Many of the author's personal observations are of great interest in illustrating peculiar features of the Cardiganshire flora. There the Poppy of the corn-fields is *P. Lecoquii*; and the Daisy is said to grow only on enclosed pasture-fields and not on open sheep-walks. In the Preface we are told that the flora is by no means a rich one. "This is largely accounted for by the absence of variety as regards soil and geological formation, the latter being everywhere grits, shales and imperfect slates of the Ordovician or Lower Lias Series." Nevertheless, about 890 native or naturalised species are dealt with in addition to (in square brackets) aliens, casuals and natives either wrongly recorded or extinct.

H. S. T.

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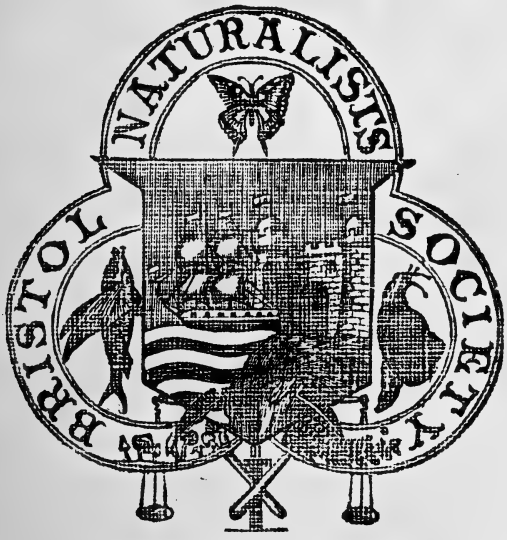
EDITED BY H. W. TURNER, M.A., F.G.S.

ASSISTED BY A COMMITTEE



"Rerum cognoscere causas."—Virgil.

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*	Baxter, T. V. T., M.A., B.Sc.	25 Clyde Road, Redland, Bristol, 6	*G.*
	Beacham, G. H.	18 Raglan Road, Bishopston, Bristol, 7	*B.F.G.*
A.	Bell, Mrs. A. G.	25 St. Michael's Park, Bristol, 2	*B.F.*
A.	Berry, K. C.	120 City Road, Bristol, 2	*O.*
	Bishop, H. C.	43 Elton Road, Bishopston, Bristol, 7	*B.F.G.*
A.	Blake, W. R.	50 Aiken Street, Barton Hill, Bristol, 5	*F.*
A.	Blathwayt, Rev. F. L.	Dyrham Rectory, Chippenham	*O.*
†	Boley, A. E.	508 Stapleton Road, Bristol	
	Boley, Mrs.	508 Stapleton Road, Bristol	*B.*
	Bowen, Miss M., B.Sc.	13 Redland Park, Bristol, 6	*B.*
*	Bracher, Miss Rose, Ph.D.	The University, Bristol, 8	
	Bush, Miss M.	20 Cornwallis Crescent, Clifton, Bristol, 8	*F.*
A.	Butterworth, Miss D. G.	31 Bedminster Down Road, Bristol, 3	*F.G.*
	Chamberlain, W.	157 Whiteladies Road, Bristol, 8	
	Clarke, Miss E. L.	17 Elmdale Road, Bristol, 8	*F.*
A.	Cleeve, R. E.	80 Beauley Road, Southville, Bristol, 3	*G*

	Clothier, G. E.	The Research Station, Long Ashton, Bristol	*O.*
A.	Clough, Miss A. M.	30 Henleaze Avenue, Bristol	*F.*
	Clough, J. W. S.	Bourton House, Flax Bourton, near Bristol	*O.*
	Clough, Mrs.	Bourton House, Flax Bourton, near Bristol	*O.*
A.	Cockcroft, John A.	103 Cranbrook Road, Redland, Bristol, 6	*G.*
	Cole, H. S.	37 Wick Road, Brislington, Bristol, 4	
A.	Cook, Miss G.	Hampton House, 7 Cotham Park, Bristol	*F.G.*
A.	Cook, Miss G. M.	9 Belvedere Road, Bristol, 6	*B.F.*
A.	Coombs, C. J. F.	14 Southfield Road, Westbury-on-Trym	
	Cratchley, Rev. W. J., Ph.D., M.A., B.Sc., F.C.S.	Ripon Hall, Boars Hill, Oxford	
†	Daniels, F. L., F.G.S.	Stringer's Court, Rodborough, Stroud, Glos.	
†	Darell, R. D. S., F.G.S., F.L.S., F.Z.S.	Hillfield House, near Dartmouth	
	Davies, T. H.	Down House, Stoke Bishop, Bristol, 9	
*	Davis, H. H.	Little Stoke, Patchway, near Bristol	*O.*
	Davis, Mrs.	Little Stoke, Patchway, near Bristol	*B.O.*
A.	Davis, Mervyn J. L.	8 Osborne Road, Clifton, Bristol, 8	*E.*
	Daws, Miss H.	109 Forest Road, Fishponds, Bristol	*F.*
A.	Dobbin, G. M.	12 Eaton Crescent, Clifton, Bristol, 8	*G.*
A.	Dunnicliff, H.	10 Effingham Road, St. Andrew's, Bristol, 6	*O.*
	Dunscombe, Miss A.	55 Clarendon Road, Redland, Bristol, 6	
A.	Eddolls, Miss E. S.	32 Freemantle Road, Eastville, Bristol, 5	*F.*
*	Edmonds, H. O.	33 Wellington Park, Clifton, Bristol, 8	*F.*
A.	Edwards, C.	50 Elton Road, Bishopston, Bristol, 7	*E.*
	Evans, I. W.	46 Horfield Road, St. Michael's, Bristol, 2	*B.F.*
	Evens, F. W., A.C.A.	Stretton, 77 Manor Road, Fishponds, Bristol	*F.*
	Fitzjohn, Miss A., M.Sc. ..	Malton, Chelwood, nr. Bristol	*B.*
*	Flemming, A. L., M.B., Ch.B.	48 Pembroke Road, Clifton, Bristol, 8	*O.*
	Ford, Roger	Hartfield, Cotham Park, Bristol	*F.O.*
	Fox, Mrs. A.	Brislington House, near Bristol	
A.	Fry, Miss Lena E.	20 Hill View, Henleaze, Bristol	*F.*
A.	Fry, T. R.	59 Air Balloon Hill, St. George, Bristol, 5	*G.*
	Gardner, D. A.	30 Gloucester Road North, Horfield, Bristol, 7	*B.F.G.*

	Glasspool, F. F., M.Sc., F.C.S.	6 Southfield Road, Cotham, Bristol, 6	*B.*
	Goodall, Rev. Canon R. W.	19 Elmdale Road, Tyndall's Park, Bristol, 8	*G.*
A.	Gorham, Major A.	Avonside, Limpley Stoke, Som.	*G.*
A.	Gowan, Miss J. E.	26 Woodstock Road, Redland, Bristol, 6	*F.*
A.	Green, Mrs. M. B., L.L.A.	Dyrham, nr. Chippenham, Wilts	*O.*
A.	Green, T. L., B.Sc.	The University, Bristol, 8	
A.	Green, Mrs. T. L.	The University, Bristol, 8	
A.	Grignon, Miss A. E.	41 Filton Avenue, Horfield, Bristol, 7	*B.F.G.*
A.	Hallam, A. D., D.Phil., B.A., B.Sc., F.G.S.	16 Cheddon Road, Taunton	*G.*
A.	Hallam, Mrs. A. D., B.A...	16 Cheddon Road, Taunton	
A.	Hartley, Miss M. C.	22 College Road, Clifton, Bristol, 8	
	Hayman, Mrs. E. S.	3 Chatford House, Clifton Down, Bristol, 8	*B.E.F.G.O.*
	Hayward, Miss E.	31 Manor Road, Bishopston, Bristol, 7	*O.*
	Hiley, Miss M. D.	9 Vyvyan Terrace, Clifton, Bristol, 8	*F.*
	Hiley, Miss W. F.	9 Vyvyan Terrace, Clifton, Bristol, 8	*F.*
A.	Hodder, Mrs. N. F.	11 Beaufort Road, Clifton, Bristol, 8	*F.*
A.	Hudson, F. G.	The Elms, Stinchcombe, Dursley, Glos.	*G.*
	Humphries, Lady	Eastfield Lodge, Westbury-on-Trym, Bristol	*O.*
A.	Hurst, G. W. S.	34 Upper Belgrave Road, Clifton, Bristol, 8	*F.*
A.	Hurst, Mrs.	34 Upper Belgrave Road, Clifton, Bristol, 8	*F.*
	Hutchinson, G. W., M.A..	Williscot, Winscombe, Som.	
A.	Hutchinson, Miss M. I. ..	57 Oakfield Road, Clifton, Bristol, 8	*F.*
	Hutton, Miss H. M., F.G.S.	The Manor, Dursley, Glos.	*G.*
J.	Iles, J. F.	26 Leonard Road, Redfield, Bristol, 5	*B.*
	Ivens, H. P.	18 Alexandra Road, Clifton, Bristol, 8	*F.*
A.	Jacobs, A. C.	65 Fremantle Road, Cotham, Bristol, 6	*F.*
	Jeffcoat, Rev. R., M.A. ..	5 Berkeley Square, Clifton, Bristol, 8	*E.F.G.*
	Jenkins, F. G., M.B., Ch.B.	51 Redcliff Hill, Bristol, 1	
	Jones, W. M.	3 Imperial Walk, Knowle, Bristol, 4	*O.*
	Jones, Mrs.	3 Imperial Walk, Knowle, Bristol, 4	*O.*
*	Kearns, H. G. H., Ph.D., B.Sc., F.R.E.S.	The Research Station, Long Ashton, Bristol	
*	Kellaway, G. A., B.Sc. ..	125 Howard Road, Westbury Park, Bristol, 6	*G.*
	Knight, Miss L. S.	7 Alma Road, Clifton, Bristol, 8	
A.	Kromler, A. A.	45 Summerleaze, Fishponds, Bristol	*E.*

*	Leach, A. C.	11 Percival Road, Clifton, Bristol, 8	*O.*
J.	London, Miss G. M.	26 Woodcroft Avenue, Whitehall, Bristol, 5	*B.*
*	Lovell, G. E.	24 Islington Road, Southville, Bristol, 3	*F.*
A.	Lucas, H. J., F.S.L., F.I.S.A.	14 Walcot Parade, Bath	*G.*
A.	Luckwill, L. C.	36 Lower Redland Road, Bristol, 6	*B.*
	Macdonald, D.	Hill View, Barrow Road, Burnham-on-Sea	*O.*
	Macpherson, Miss B. B. ..	14 Victoria Square, Clifton, Bristol, 8	*F.*
A.	Madkins, W. E., B.A., F.R.G.S.	Fairfield Secondary School, Bristol	*G.*
	Mappin, S. W.	100 Pembroke Road, Clifton, Bristol, 8	*G.*
	Marples, B. J., M.A., M.Sc.	208 Henleaze Road, Bristol	
	Marples, Mrs. B. J., B.A...	208 Henleaze Road, Bristol	
	Marsden, A., F.I.C.	161 Bishop Road, Bishopston, Bristol, 7	*G.*
	Marsden, Mrs.	161 Bishop Road, Bishopston, Bristol, 7	*F.G.*
*A.**	Mathews, P. M.	Wharfedale, Pulteney Road, Bath	*G.*
*	Matthews, L. H., M.A. ..	2 Adelaide Terrace, Portishead	*O.*
	Maxwell, H. W.	10a Downfield Road, Clifton, Bristol, 8	*F.O.*
	Maxwell, Mrs.	10a Downfield Road, Clifton, Bristol, 8	*F.*
	Mead, Miss C. E., B.A. ..	16 Quadrant West, Hillfields Park, Bristol	*F.G.*
A.	McErvel, Miss N.	Westonbirt School, near Tetbury, Glos.	*O.*
*	McMurtrie, G. E. J.	Eastfield House, Westbury-on-Trym, Bristol	*F.G.*
	McMurtrie, Mrs.	Eastfield House, Westbury-on-Trym, Bristol	*F.*
A.	Merryweather, Miss M. D.	11 St. John's Road, Clifton, Bristol, 8	*F.*
	Milton, Mrs. I. C.	10 Randall Road, Bristol, 8	*F.O.*
	Mogford, C. J.	13 Park Grove, Westbury Park, Bristol, 6	*F.G.*
*A.**	Mogg, G.	483 Fishponds Road, Bristol	*F.*
A.	Morley, Miss A.	17 The Avenue, Clifton, Bristol, 8	*O.*
	Morris, D. G.	Clifton Zoological Gardens, Clifton, Bristol, 8	
A.	Morrison, Miss A. M. C...	8 Richmond Hill, Clifton, Bristol, 8	*F.*
A.	Neal, H. W.	70 Trymside, Sea Mills, Bristol, 9	*O.*
A.	Nettle, Miss E. C.	3 Beaufort Road, Kingswood, Bristol	*F.*
J.	New, R. S.	38 Norton Road, Knowle, Bristol, 4	*B.*
	Norgrove, J. W.	22 Alma Road, Clifton, Bristol, 8	*E.*
	Nuell, F. H.	63 Springfield Road, Cotham, Bristol, 6	

A.	Paterson, Miss K. M. Noel	Windyridge, 17 Greendale Road, Redland, Bristol, 6	*O.*
	Peach, A. H.	5 Hanbury Road, Clifton, Bristol, 8	*E.*
	Peach, A. N. H.	5 Hanbury Road, Clifton, Bristol, 8	*O.*
*	Pearman, J. V., F.R.E.S.	56 Clifton Park Road, Clifton, Bristol, 8	*E.*
A.	Pepperell, Mrs.	16 Westfield Park, Redland, Bristol, 6	*G.*
A.	Potter, Miss E. A.	Westonbirt School, near Tetbury, Glos.	*O.*
	Powell, J. J., M.D.	18 Elgin Park, Redland, Bristol, 6	*G.*
A.	Pratt, Miss D. L.	1 Hughenden Road, Clifton, Bristol, 8	*B.F.*
A.	Preston, Miss G. J.	Stapleton Road Gas Works, Bristol, 5	*F.*
A.	Price, Miss M. R., B.A.	1 Richmond Park Road, Clifton, Bristol, 8	*O*
	Purchon, R. Denison	Mortimer House, Clifton, Bristol, 8	*O.*
*	Rafter, J., M.A.	228 Shirehampton Road, Westbury-on-Trym, Bristol	
	Reed, F. N.	18 Stackpool Road, Southville, Bristol, 3	*B.F.G.*
	Reed, W. N.	18 Stackpool Road, Southville, Bristol, 3	*F.G.*
A.	Rex, Miss F.	4 Upper Belmont Road, Bishopston, Bristol, 7	*F.*
*	Reynolds, Prof. S. H., Sc.D., F.G.S.	13 All Saints' Road, Clifton, Bristol, 8	*G.*
	Richards, G.	Pensylva, Cecil Road, Weston-super-Mare	*F.G.*
	Richardson, Frank	21 Pembroke Road, Clifton, Bristol, 8	*G.*
	Ross, F. Stenhouse	25 Tugela Road, Uplands Estate, Bristol, 3	*G.*
	Ross, James, F.L.A.	Central Library, Bristol, 1	
	Rudge, Miss D. M.	6 Elgin Park, Bristol, 6	
	Rudge, Miss E. L.	6 Elgin Park, Bristol, 6	
	Rutter, Miss E. M.	32 Henleaze Gardens, Bristol, 9	*B.*
A.	Salmond, P. W.	22 Tyndall's Park Road, Clifton, Bristol, 8	*F.G.*
	Sanders, Miss L. M.	Redroofs, Downs Cote Park, Westbury-on-Trym, Bristol	*F.G.*
*	Sandwith, Mrs.	26 Canynge Square, Clifton, Bristol, 8	*B.*
	Savory, J. H.	Windyridge, Abbots Leigh, near Bristol	*O.*
J.	Scase, R. P.	Wills Hall, Stoke Bishop, Bristol	*O.*
	Selley, A.	116 Coronation Road, Bristol, 3	*G.*
*	Shaw, Miss T.	12c Kingsdown Parade, Bristol, 6	*B.F.G.*
A.	Shield, E. H.	78 Sefton Park Road, Bishopston, Bristol, 7	*F.*
	Shilstone, H. C.	124 Victoria Avenue, Redfield, Bristol, 5	*F.G.*
*	Skene, Prof. Macgregor, D.Sc., F.L.S.	The University, Bristol, 8	*B.*
*	Smith, Stanley, M.A., D.Sc., F.G.S.	The University, Bristol, 8	*G.*

A.	Smith, Mrs. W.	Greenhills, Redcliffe Bay, Portishead	*B.*
J.	Stainer, J.	Endcliffe, Henbury, nr. Bristol	*E.*
	Statton, A. G.	2 Auburn Road, Redland, Bristol, 6	
A.	Strudwick, Miss F. E., M.A.	26 Woodstock Road, Redland, Bristol, 6	*B.F.*
	Sully, H. T.	Elmside, Julian Road, Stoke Bishop, Bristol, 9	*F.*
	Swain, Miss R.	Wyndham House, Easton-in-Gordano, Som.	*F.O.*
	Tarring, E.	Mimosa, 196 Bishop Road, Bristol, 7	*B.F.*
	Taunton, W. C.	70 Halsbury Road, Westbury Park, Bristol, 6	*E.O.*
A.	Taylor, R. J.	12 Claremont Avenue, Bishopston, Bristol, 7	*F.*
	Taylor, W. R., M.A.	5 Pembroke Vale, Clifton, Bristol, 8	*E.O.*
*	Tetley, H., B.Sc., F.Z.S. ..	4 The Avenue, Sneyd Park, Bristol, 9	*E.O.*
	Tetley, Mrs.	4 The Avenue, Sneyd Park, Bristol, 9	*O.*
A.	Thomas, Miss K. M., N.F.U.	17 Upper Belgrave Road, Clifton, Bristol, 8	*O.*
A.	Thomas, Richard	131 Cumberland Road, Redcliff, Bristol, 1	*G.*
*	Thompson, H. S., A.L.S. ..	11 Buckingham Place, Clifton, Bristol, 8	*B.F.G.*
	Tombleson, F. B.	Shirley, Briercliffe Road, Westbury-on-Trym, Bristol	*F.G.*
*	Trueman, Prof. A. E., D.Sc. F.G.S.	The University, Bristol, 8	*G.*
	Trueman, Mrs. A. E.	44 Redland Court Road, Bristol, 6	*G.*
	Tucker, B. W., M.A., M.B.O.U.	9 Marston Ferry Road, Oxford	*O.*
	Turner, H. W., M.A., F.G.S.	The University, Bristol, 8	*G.*
	Turner, Mrs. H. W.	Mortimer House, Clifton, Bristol, 8	*B.*
*	Tutcher, J. W., M.Sc.	57 Berkeley Road, Bishopston, Bristol, 7	*F.G.*
	Veal, Mrs. G. C.	Lower Hazel House, Rudgeway, nr. Bristol	*O.*
A.	Verhey, Miss D. E., B.Sc...	Stanmore House, Royal Crescent, Weston-super-Mare	*B.*
	Vizard, Miss E. S.	25 Logan Road, Bishopston, Bristol, 7	*B.*
A.	Waight, Miss F.	Beeches, 47 Kewstoke Road, Bristol, 9	*O.*
	Waight, Miss M.	Beeches, 47 Kewstoke Road, Bristol, 9	
A.	Wallace, Miss N.	17 Upper Belgrave Road, Clifton, Bristol, 8	*O.*
*	Wallis, F. S., D.Sc., F.G.S.	The Museum and Art Gallery, Bristol, 8	*F.G.*
	Walton, C. L., Ph.D., M.Sc.	34 Northumberland Road, Redland, Bristol, 6	*O.*
	Walton, Mrs. C. L.	34 Northumberland Road, Redland, Bristol, 6	*O.*

	Webb, H. M., B.Sc.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*G.O.*
	Webb, Mrs. H. M.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*O.*
	Webb, H. Vicars	58 Belmont Road, St. Andrew's, Bristol, 6	*F.O.*
A.	Weetman, Miss M. J.	60 Ashley Road, Bristol, 6	*F.*
A.	Wheeler, Miss K. E.	Hillside, Watchet, Som.	*F.*
*	White, E. Barton, M.D., F.R.E.S.	St. Merryn, Braunton, N. Devon	*E.*
	White, Mrs. E. Barton....	St. Merryn, Braunton, N. Devon	*E.*
A.	Willcox, F. R.	Stoke Hill Cottage, Stoke Bishop, Bristol, 9	*O.*
†	Wills, W. Melville	Bracken Hill, Leigh Woods, Bristol	
A.	Wools, Miss F. R.	5 Hamilton Road, Easton, Bristol, 5	*B.*
A.	Yeates, G. K.	Sherborne School, Sherborne, Dorset	*O.*
	Yonge, Prof. C. M., D.Sc...	The University, Bristol, 8	
A.	Zealand, Mrs. H. W.....	Brecon Lodge, Westbury-on-Trym, Bristol	*F.*

Honorary Members

R. M. Prideaux, F.R.E.S., Brasted Chart, near Sevenoaks, Kent.
Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64 Victoria Street, Westminster, S.W.1.
Prof. Sydney Young, D.Sc., F.R.S., The Ferns, Stoke Bishop, Bristol, 9.
Sir Ernest Cook, D.Sc., 40 Alma Road, Clifton, Bristol, 8.
H. Womersley, F.R.E.S., A.L.S., 36 Wattle Street, Fullerton Estate, Adelaide, S. Australia.

REPORT OF COUNCIL

TO DECEMBER 31ST

1936

YOUR Council reports that the reorganisation of the Society and its Sections begun in 1935 has now shown the completed results of its first full year of working. Although minor adjustments will probably be made in the future, it is gratifying to note that already an increased membership has resulted. During the year one member has compounded for life membership. Your Council would wish to stress this provision in the rules.

At the Annual General Meeting in January the past Officers were re-elected. Mrs. A. G. Bell was appointed Assistant Secretary and Miss F. E. Strudwick succeeded Mr. J. V. Pearman as Librarian. Professor S. H. Reynolds and Professor Macgregor Skene were elected to fill vacancies on Council.

Council was represented by Professor A. E. Trueman at the Conference of delegates of Corresponding Societies at the British Association Meeting at Blackpool.

The rules of the Society, which had been thoroughly revised by a small sub-committee, were finally sanctioned at the Annual Meeting. These have been printed and circulated to all members.

Your Council regrets to record the death of two honorary members—Professor C. Lloyd Morgan and Professor W. J. Sollas ; an ordinary member, Mr. A. W. Cottle, and a past member, Dr. Herbert Bolton.

Council also wishes to report that a total of nearly £44 has been collected for the Ida Roper Memorial Fund. A small sub-committee is now investigating the most effective means of dealing with this sum in accordance with the issued appeal.

The ninth Annual Dinner was held in February when Professor E. Fawcett, F.R.S., gave a lecture on "The Bristol Giant." The Exhibition night in October provided an unusual quantity of local material, and at the open meeting in November three films of botanical interest were shown and explained by Professor Macgregor Skene.

The Summer Field Meeting at Cherhill and Avebury was again under the satisfactory auspices of the Field Section.

M. DORIS HILEY, *Hon. Secretary.*

The Hon. Treasurer in Account with the Bristol Naturalists' Society

Dr. RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDING 31st DECEMBER, 1936 *Cr.*

1935 £ s. d.		£ s. d.	£ s. d.
	To Members' Subscriptions :—		
	Life Subscription	5 0 0	
1 10 0	Ordinary : Arrears from 1935 ..	3 10 0	
49 0 0	,, 1936	48 15 0	
2 0 0	,, in advance, 1937 ..	17 6	
10 0	Associate : Arrears from 1934 and 1935	1 10 0	
15 10 0	,, 1936	14 0 0	
15 0	,, in advance, 1937 ..	10 0	
10 0	Junior : 1936	5 0	
69 15 0			74 7 6
20 0 6	,, Subscriptions to Sections received by Hon. Treasurer	.. ..	21 9 3
89 15 6			95 16 9
	,, Memorial Fund to late Miss I. M. Roper : Contributions received	.. ..	43 5 6
5 0 0	,, Donation received towards *Proceedings*	.. ..	10 0 0
	,, Special Publications Fund : Contributions received towards republication of late Dr. A. Vaughan's paper, *The Avonian of the Avon Gorge*	.. ..	38 5 6
2 11 0	,, Sale of Publications	.. ..	2 19 0
12 13 0	,, Sale of Dinner Tickets	.. ..	14 0 0
2 9 11	,, Interest on Deposit	.. ..	3 2 7
2 11 9	,, Donation to Dinner Fund		
14 14 0	,, Sale of Tickets : Field Meeting		
139 16 4	,, Balance from last Account ..	.. ..	140 0 9
269 11 6			£347 10 1

1935 £ s. d.		£ s. d.	£ s. d.
	By Subscriptions :—		
1 1 0	Ray Society	1 1 0	
2 10 0	Zoological Record		
	S.W. Naturalists' Union, 1936 ..	18 0	
5 0	British Empire Naturalists' Association, 1936 and 1937 ..	10 0	
			2 9 0
42 10 3	,, Cost of *Proceedings*, 1935, including revision of late Dr. A. Vaughan's paper, *The Avonian of the Avon Gorge*	.. ..	87 12 11
	,, Reprints of 250 copies of *The Avonian of the Avon Gorge* ..	.. ..	15 10 0
6 7 6	,, Reprints of other Papers	.. ..	6 1 6
	,, Index to previous series of *Proceedings*	.. ..	4 3 0
	,, Printing Rules after Revision ..	.. ..	6 9 6
18 0 6	,, Printing, Postage, Stationery, etc.	.. ..	17 19 0
7 10 3	,, Lecture Expenses	.. ..	7 7 3
1 11 0	,, Rent and Fire Insurance	.. ..	1 11 0
15 4 9	,, Dinner Expenses	.. ..	14 19 9
	,, Bookbinding and Librarian's Expenses	.. ..	15 5 0
13 15 0	,, Field Meeting (printing)	.. ..	1 4 6
	,, S.W. Naturalists' Union : Reception	.. ..	2 12 6
15 0	,, Wreath (the late Miss I. M. Roper)		
20 0 6	,, Subscriptions to Sections paid over by Hon. Treasurer	.. ..	21 4 9
140 0 9	,, Cash at Bank, as under :—		
	Sectional Subscriptions in hand	4 6	
	Ida M. Roper Memorial Fund ..	43 5 6	
	General Fund	95 10 5	
			139 0 5
	,, Cash in hands of Hon. Secretary	.. ..	4 0 0
269 11 6			£347 10 1

Bristol, 20th January, 1937.

F. W. EVENS, *Hon. Treasurer.*

Audited and found correct.

ERNEST H. COOK,
CHAS. BARTLETT, F.C.A. } Auditors.

LIBRARIAN'S REPORT

FOR THE YEAR 1936

ON the resignation of Mr. J. V. Pearman, who occupied the post of Librarian till the end of 1935, the work was taken on by Miss F. E. Strudwick.

During the year a considerable amount of time has been spent on the Library; additional space having been found, it has been possible to sort and re-arrange the books, during which process both volumes and shelves have undergone a good "spring-clean," and stock-taking has begun.

The Library Sub-Committee met twice, and a very careful revision was made of the Exchange list; certain unprofitable exchanges, chiefly foreign, were cancelled and a few new ones accepted.

Twenty pounds having been voted by Council for binding and casing, estimates were obtained for the binding of 60 selected volumes and for ten dozen pamphlet cases in three different sizes, all of which are now in place on the shelves.

The following books were added to the library in 1936:—

1. *Wookey Hole, its Caves and Cave Dwellers*—Balch—presented by Mr. J. H. Savory.
2. *Monograph of the Genus Erebia*—Warren.
   Mosquitoes of the Ethiopian Region—Hopkins.
   Flora of Jamaica. Vol. 7—Fawcett and Rendle.
   Guide to the Galleries of Geology and Palæontology.
   } All presented by the British Museum of Natural History.

Also the Entomological, Geological and Ornithological Sections, as formerly, have presented the current periodicals taken by them.

Certain early *Proceedings of the B.N.S.* have been asked for, and there has been a considerable demand for copies of the *Avonian of the Avon Gorge.*

During the year one hundred and twenty entries have been made for books borrowed from the Library.

The great need at the present time is more money for the binding of additional volumes, and the compilation of an efficient catalogue and card index, a piece of work which will entail considerable time and labour.

F. E. STRUDWICK, *Hon. Librarian.*

EXCHANGE AND GIFT LIST

BRITISH SOCIETIES

Ashmolean Natural History Society of Oxfordshire.
Belfast Naturalists' Field Club.
Birmingham Natural History and Philosophical Society.
British Association for the Advancement of Science.
Cardiff Naturalists' Society.
Royal Cornwall Polytechnic Society.
Cotteswold Naturalists' Field Club.
Coventry Natural History and Scientific Society.
Croydon Natural History and Scientific Society.
Edinburgh Royal Botanical Society.
Society for British Entomology.
Essex Field Club.
Geologists' Association.
Geological Society of London.
Geological Society of Glasgow.
Royal Geological Society of Cornwall.
Glasgow and Andersonian Natural History and Microscopical Society.
Hertfordshire Natural History Society and Field Club.
Linnean Society of London.
Liverpool Geological Society.
Llandudno and Colwyn Bay Field Club.
Manchester Literary and Philosophical Society.
Manchester Microscopical Society.
Royal Microscopical Society.
Norfolk and Norwich Naturalists' Society.
Northamptonshire Natural History Society.
Plymouth Institution and Devon and Cornwall Natural History Society.
Quekett Microscopical Club.
Southport Scientific Society.
North Staffordshire Field Club.
Swansea Scientific and Field Naturalists' Society.
Torquay Natural History Society.
Isle of Wight Natural History Society.
Yorkshire Geological Society.

School Societies

Cheltenham College Natural History Society.
Clifton College Scientific Society.
Eton College Natural History Society.
Marlborough College Natural History Society.
Rugby School Natural History Society.

Public Institutions, etc.

Bodleian Library.
Bristol Museum and Art Gallery.
Bristol Public Library.
Bristol University Library.
British Museum (Natural History).
British Museum—Copyright Office.
Cambridge University Library.
Geological Survey and Museum, London.
Royal Irish Academy.
Manchester Museum Library.
Marine Biological Association.
National Library of Scotland.
National Library of Wales.

Patent Office Library.
Science Museum, London.
Trinity College Library, Dublin.

EUROPEAN SOCIETIES, ETC.

Belgium.—The Royal Natural History Society.
Belgian Geological Society.
France.—Linnean Society of Lyons.
The University of Rennes.
Holland.—The Dutch Geological Bureau.
Latvia.—The Zoological Institute, Riga.
Norway.—The University, Oslo.
Poland.—The Zoological Museum, Warsaw.
Sweden.—The Royal University Library, Upsala.
Switzerland.—The Central Library, Zurich.
The Vaudois Natural Science Society, Lausanne.

DOMINION SOCIETIES, ETC.

Australia.—Australian and New Zealand Association for the Advancement of Science.
Queensland Museum, Brisbane.
Canada.—Canadian Institute.
National Museum of Canada.
Nova Scotian Institute of Science.
India.—Imperial Department of Agriculture.
Geological Survey of India.

UNITED STATES SOCIETIES, ETC.

American Museum of Natural History.
Boston Natural History Society.
Brooklyn Institute of Arts and Sciences.
University of California, Berkeley.
California Academy of Sciences, San Francisco.
University of Colorado.
Denison Scientific Association.
Michigan Academy of Science.
Missouri Botanic Gardens.
Philadelphia Academy of Natural Sciences.
San Diego Society of Natural History.
Smithsonian Institution.
St. Louis Academy of Science.
United States National Museum.
Vanderbilt Oceanographic Museum.
Wisconsin Academy of Sciences, Arts and Letters.
Yale University.
Museum of Natural History, Yale University.
New York Zoological Society.

REPORT OF BOTANICAL SECTION

1936

THE work of the Section during the year has continued as in previous years with exhibits of botanical interest and short papers or talks on botanical subjects.

Eleven meetings have been held in the Botanical Department of the University.

The Section is fortunate in having the continued presence of Prof. Skene at its meetings and would like to take this opportunity of expressing its appreciation and sense of gratitude to him for the use of the Department and for the material support which he has given both generally and specifically.

At the February meeting, Dr. Campbell gave a lecture on Fungi and showed specimens of species of *Lycoperdon, Stereum, Corticum, Xylaria, Ustulina, Armillaria* and *Auricularia.*

The Open Meeting of the Section in October was attended by seventeen members and five visitors. The agenda included two papers of a popular nature on " Plant Life in the Service of Man," by Miss Pratt, and " Plant Superstitions," by Mr. Glasspool. In addition there were more technical talks on " *Cochlearia* " by Mr. H. S. Thompson, " Gymnosperms " by Mrs. Bell, and " The Germination of Iris Seeds " by Mrs. Sandwith.

Prof. Skene showed a number of greenhouse plants at the December meeting. Amongst these were *Ardisia crenata* and *Psychotria* with nitrogen fixing bacteria in their leaves, *Albizzia, Euphorbia fulgens* and *Euphorbia pulcherrima, Bouvardia* and two Liverworts, *Conocephalus* and *Dumortiera.*

Fresh and preserved specimens have been brought in by members for the remaining meetings. These have been named, examined and discussed, and in some cases have given rise to further investigations.

Mrs. Sandwith has continued to collect and collate records of new plants and plants in new habitats in order that the Botanical Notes may be brought up to date and continued.

F. F. GLASSPOOL, *Hon. Secretary.*

REPORT OF ENTOMOLOGICAL SECTION

1936

14th January. 72nd Annual Meeting. After the usual business Mr. A. H. Peach read notes upon his excursions to various districts during 1935 and exhibited many interesting species of Lepidoptera including extended series of British *Lycænidæ* and *Cœnonympha tullia*, and Mr. N. A. Watkins showed some aberrations of British Butterflies.

19th Feb. Meeting held at the University and open to general members of the Society. This was attended by the President and twelve others. All the sectional members present read notes and brought exhibits, and for some of these the epidiascope was used.

28th April. Mr. J. V. Pearman described and demonstrated apparatus used in microphotography, including special microscope mountings and lamp for projection on to a photographic plate, turntable and mediums for preservation of specimens and ringing slides.

13th Oct. Exhibits of several Orders were made by Messrs. C. Edwards, A. Kromler and C. Bartlett, and a discussion took place on the occurrence of *Danaus plexippus* in England.

17th Nov. Mr. C. Edwards read a paper on "Variation," especially with reference to climate, altitude, temperature, and seasonal forms, and a discussion took place thereon. Exhibits were made by Messrs. C. Edwards, A. H. Peach and C. Bartlett. Mr. M. J. L. Davis reported his extraordinary experience at Weston-super-Mare on 25th, 26th and 27th August when he saw very large migratory swarms of *Plusia gamma*, Silver Y Moth.

8th Dec. Mr. J. W. Norgrove exhibited a portion of his collection of British Lepidoptera, and Mr. C. Bartlett read notes upon the history of the black race of the Peppered Moth, *Amphidasis betularia* v. *doubledayaria*, in England, and its spreading to the Continent in the 19th century.

Interest in Entomology in Bristol is confined to a very small and reducing number of individuals; the present membership is only sixteen, of whom only half a dozen regularly attend the meetings.

The destruction of the countryside with its plant life, cutting of woodlands, drainage of fens and marshes, malicious or careless damage by fire to heaths, afforestation of large areas with conifers, beneath whose shade no plant or wild life can survive, are all destructive to the fauna and flora, and having their inevitable result on those who admire their beauty and study nature.

CHAS. BARTLETT, *President and Hon. Sec.*

REPORT OF FIELD SECTION

1936

DR. WALLIS, in his retiring Presidential address, dwelt upon the Englishman's instinctive love of the countryside, which he traced from early times, through its eclipse during the Industrial Revolution, to the present-day revival. It is for the fulfilment of this instinct that the Field Section exists, and in field meetings one finds a common bond of union, however diverse our natures and stations in life.

At the Annual Meeting held in January, Dr. F. S. Wallis resigned the presidency, which he had occupied for five years, and was succeeded by Mr. H. F. Barke, F.I.C., a past president of the Section. Mr. Ivor Evans was elected Vice-President, and the remaining officers were re-elected. Mrs. Hayman and Mr. F. N. Reed were elected to fill two vacancies on the Committee. Mr. H. Stuart Thompson exhibited dried specimens of the Common Ragwort, showing fasciated stem, found at Cadbury Camp, near Tickenham, and the President showed examples of Neolithic greenstone axes which had been discovered in the Bristol district.

The area selected for special observation during 1936 comprised an upland district to the north-west of Bath, an area which is essentially the south-western portion of the Cotswolds. The usual field notes which now form such a feature of the Summer programme were again ably supplied by members of the Section.

The first meeting was held in May when members met at Saltford and by a circuitous route walked to Lansdown under the joint leadership of Mrs. E. S. Hayman and Mr. H. C. Bishop. The church at North Stoke was visited and the exposure of Cotteswold Sands at Upton Cheyney noted.

In July an experiment was made whereby members divided into all day and half-day parties. The earlier party left Bristol by the Marshfield road and then worked in a southerly direction, meeting the second party in St. Catherine's Valley. Mr. H. O. Edmonds was the general leader for the day, and under his guidance members were able to collect aquatic plants from Doncombe Brook.

The Pucklechurch, Hinton, Tolldown and Dyrham district was visited in September, with Mr. Ivor Evans as leader. The botanists were able to distinguish a great variation in vegetation as the slope of the hills was ascended, and members were interested in the relationships of surface relief and the underlying rock. By permission of the owner, the late Squire Blathwayt, members walked through Dyrham Park and visited the church where the Rev. F. L. Blathwayt met the party.

At the concluding meeting in October, Dr. F. S. Wallis led the members to Swainswick and Woolley. In addition to dealing with the particular features shown in this district, the opportunity was taken to sum up the whole of the observations collected during the season. Canon H. C. England conducted members over the church at Swainswick and fully explained the architectural features.

In accordance with recent custom, the President and Secretary of your Section (Mr. H. F. Barke and Miss M. D. Hiley) were responsible for the arrangements in June of the Annual Field Meeting of the Society in the neighbourhood of Cherhill and Avebury. The meeting was particularly interesting in that members were able to compare and contrast the flora, fauna and rocks of the Chalk Downs with those of the Bristol district. At Cherhill the ascent was made to the White Horse and the following plants were noted on the Downs: Bee Orchis, Butterfly Orchis, Burnt-stick Orchis, Lesser Burnet, Common Milkwort and several species of Carex. A bore-hole for water in course of construction was interesting to the geologists. After tea the Saxon

Church at Avebury was visited, and the Vicar, Rev. V. Mason-Pooley, M.A., pointed out the details of special interest. Members afterwards walked round the Great Circle and inspected the Avenue. A halt was made at Silbury Hill during the return journey.

The thanks of your Section are due, not only to the efficient leaders enumerated above, but to the numerous co-leaders who so ably assisted them.

Mr. H. Vicars Webb again kindly conducted the special ornithological meetings, and reports as follows :—

April 22*nd*. Wickham and Stapleton Glens. The only migrants were Swallows, House and Sand Martins over the Duchess Pond, Moorhen on nest near the margin. Resident birds in good view. Garden and rockery at the old mill bright with Spring flowers.

May 2*nd*. Frenchay District. Chiff-chaff and Willow Warblers in song ; Cuckoo heard ; brief sight of a Kingfisher. At the Duchess Pond two broods of Water Hens successfully reared. Two Yellow Wagtails (migrants) near the water.

May 23*rd*. Blagdon Lake. Abandoned, wet.

May 27*th*. Hanham Woods. A favourable evening for hearing three or four Nightingales answering each other. One clearly seen on an oak branch. Blackcaps and Willow Warblers in good voice. Cuckoo seen on the wing.

June 10*th*. Keynsham District. Birds heard and seen : Chiff-chaff, Blackcap, Whitethroat, Pied Wagtail, Cuckoo, Wing Doves, Swallows, House Martins and Swifts. Also a pair of Spotted Fly Catchers taking insects over the river Chew.

Mr. Ivor Evans kindly conducted the special botanical meetings, and reports as follows :—

May 25*th*. Flax Bourton and Wurple Pool. Visited Flax Bourton Combe and Wurple Pool. Plants observed : Lady's Mantle, Leopard's Bane, Pencilled Geranium, Columbine, Tway Blade, Adder's Tongue, Fern (G. Winged O.), Spring Potentilla, Field Scorpion Grass, Wood Sanicle, Dog Bean, Squinancy Wort. Trees : Oak, Elm, Ash, Maple, Spindle, Guelder Rose, Wayfaring Tree. Grasses and Carex in variety.

June 24*th*. Charfield and Nibley Monument. Footpath across the fields from Charfield to the Monument was full of plants of interest, the following being recorded : Prickly Poppy, Water Veronica, Ragwort, Evergreen Alkanet, Marsh, Tway, Frog and Bee Orchis, Dog Wood, Spindle, Elder, Yellow Chestnut, and grasses and rushes in variety.

August 22*nd*. North Woods and Winterbourne. Leaving Filton cars the party proceeded to Winterbourne ; the following plants were noted on the return journey : Hemp Nettle, Field Pansy, Celery Leaved Crowfoot, Honeysuckle, Vetches in several varieties, and the commoner cornfield plants, including Field Mint, Scabious, Betony, Harebell, Hemp Agrimony, etc. Trees and shrubs were noted.

M. DORIS HILEY, *Hon. Secretary.*

REPORT OF GEOLOGICAL SECTION

1936

THE year just closed has been a satisfactory one. The general interest in all our meetings has been well sustained, and the few lapses in membership have been more than made good by an ingress of newcomers.

At the Annual General Meeting of the Section in January, all the old officers were re-elected *en bloc*, a recognition of their efficiency. It was decided to continue to subscribe to the Palæontological Society and to the *Geological Magazine*. At the second meeting on the same evening, Mr. J. W. Tutcher read a paper on "The Mouth Borders of Ammonites," and Mr. G. A. Kellaway read a paper on "The Rivers of the Cotswolds."

In February, Mr. Arthur W. G. Kingsbury lectured on "Some Mendip Minerals," and showed some remarkable and rare specimens which he has collected in the Priddy district.

In March, the special lecturer was Dr. Emily Dix. She lectured on "Fossil Plants of the Coal Measures." Respectful reference was made at this meeting to the recent death of Professor C. Lloyd Morgan.

The next three meetings were Summer Excursions. In April, Dr. Stanley Smith conducted a party to Beachley and Chepstow; the weather was somewhat unsettled, but the excursion was enjoyed. The Gorge at Chepstow is considered to be the finest British example of an incised river gorge.

At Midsummer we made an early-evening trip to the Kingswood Anticline in the Coal Measures, under the joint leadership of Mr. L. R. Moore and Prof. A. E. Trueman. "Thrusting" on a large scale is much in evidence there.

The last of the Summer Field Meetings was in September, at Higher Pitts Farm, Priddy-on-Mendip, under the guidance of Mr. Kingsbury who lectured to us in February. This very interesting visit to a charming district concluded with a descent of the Ebbor Gorge to Wookey; there was a good attendance at this meeting.

Our Winter session opened with a meeting in October, when Professor S. H. Reynolds gave us a lantern lecture on "A Geological Trip to Northern Scotland." The lecturer gave an interesting account of a visit to Caithness and the Orkney and Shetland Islands which he made the previous Summer on an excursion of the Geologists' Association of London.

The last meeting of the season was held in November, when Dr. Stanley Smith lectured on "Geological Rambling in Rhineland and in Bohemia." The lecture dealt with a scientific holiday that Dr. Smith had taken in the Summer to Czecho-Slovakia via the Rhineland.

In conclusion, it is pleasant to report also that Professor Trueman's Saturday morning special Geology Class at the University resumed in September, and is well attended; and also that Dr. F. S. Wallis started a "Workers' Educational Association" Evening Course of lectures in elementary Geology at the University Buildings this Autumn, and has a satisfactory attendance. Geology, as an essential basic subject in any complete school curriculum, is sadly neglected in our national scheme of Education; and these courses of systematic adult instruction are important steps in the right direction. Several of our members have joined the classes and find them of much use in their studies.

HY. CUTHBERT SHILSTONE, *Hon. Secretary.*

REPORT OF ORNITHOLOGICAL SECTION
1936

EIGHT meetings have been held during the year at which the average attendance has been over 22, and a variety of useful papers have been read. These have not been confined to the British Isles, for Mr. L. H. Matthews gave at the Open Meeting in November an account of "Birds of the South Atlantic," dealing principally with South Georgia from his own observations made there during the "Discovery" expedition. Mr. A. M. Champion, C.M.G., at a special meeting held at Clifton College, described "Administration and Ornithology in the Lake Rudolf District," and Mr. B. W. Tucker, on another occasion, dealt with "Birds of Southern Spain."

Coming nearer home, members have heard three papers on Scottish birds. In January, Dr. O. H. Wild described "Some Hebridean Birds"; in October, Mr. G. K. Yeates, "Bird-life in Northern Britain"; and in December, Mr. D. Macdonald, "Birds of Jura and Ailsa Craig." Mr. W. R. Taylor, at the September meeting, gave a talk on "Birds of Flamborough Head," the noted sea-bird resort on the Yorkshire coast, and Mr. C. J. F. Coombs, in March, described "Breeding-habits of Rooks" from observations made at a rookery a few miles north of Bristol.

The Open Meeting held in November was very successful; 25 members came and, in addition, 30 members of the Parent Society, not members of the Section, were present. This was no doubt due to the special notices sent out and to the fact that all members of the Parent Society were circularised.

Another visit to Steep Holm was paid by some of the members on May 2nd and useful observations were made. These will be incorporated in the Annual Report of the Ornithological Section of the Somerset Archæological and Natural History Society.

Fifteen new members have been elected during the year and, though one or two have resigned, the total at the end of 1936 stood at 53, the highest recorded for this Section. This large number raises two problems, one being accommodation, for if, as is the case, the numbers go on increasing, members' houses of sufficient capacity for holding meetings will be very limited in number, and some other arrangements may have to be made. The other problem is that, although in the past few years there has been such an influx of new members, the list of members who contribute papers to the meetings or articles to the *Proceedings* remains almost stationary. It is to be hoped that this may be remedied, as much useful work, which does not require expert knowledge, remains to be done.

Unfortunately, I find that, owing to pressure of other zoological work, I am unable to continue the secretaryship of this Section. I would like, therefore, to express my thanks to the members for their indulgence during the past nine years, and to say that the office is being transferred to the very capable hands of Mr. H. H. Davis, who is an excellent ornithologist in every way.

H. TETLEY, *Hon. Secretary.*

Account of the Annual and General Meetings

THE 73RD ANNUAL MEETING of the Society was held at the University of Bristol on 16 January, 1936, with the President, Mr. G. E. J. McMurtrie, in the Chair. The President was re-elected for 1937, and Mr. F. W. Evens became Junior Vice-President. Professor S. H. Reynolds and Professor MacGregor Skene were appointed new members of Council, and the other officers were re-elected with the addition of Mrs. A. G. Bell as Assistant and Reporting Secretary. The annual reports were presented and adopted. After certain minor amendments the Rules of the Society were accepted, and it was recommended that they be printed and circulated to members. Mr. McMurtrie in his presidential address compared past and present methods of coal mining, and illustrated his remarks with lantern slides.

The 581ST GENERAL MEETING took the form of the Ninth Annual Dinner and was held at the Royal Hotel on 6 February, 1936, under the Presidency of Mr. G. E. J. McMurtrie. Professor E. Fawcett, F.R.S., the guest of the evening, gave a lecture on "The Bristol Giant." The lecturer said that his interest in Patrick Cotter O'Brien dated back to 1906 when changes were being made at the Roman Catholic Chapel in Trenchard Street where the giant was buried. From measurements of the skeleton, the giant's height was estimated at 7 ft. 10½ ins.

The 582ND GENERAL MEETING was held at the University on 5 March, 1936, when Mr. G. E. J. McMurtrie was in the Chair, and several papers were read in title. Miss F. E. Strudwick was unanimously elected to the post of Honorary Librarian. Mr. H. St. George Gray, F.S.A., gave a lecture on Archæological Excavations in Somerset, and at the outset paid tribute to the early pioneers in this work. He reviewed the chief sites of interest in chronological order, including remarks on barrows at Stoney Littleton, Murtry Hill, and Wick near Stogursey; Glastonbury and Meare lake villages; Kingsdown camp near Mells, and, finally, the excavations at Taunton Castle. A wealth of lantern slides illustrated the lecture.

The 583RD GENERAL MEETING was held on 20 June, 1936, under the auspices of the Field Section, at Cherhill and Avebury. The flora of the untilled Chalk Downs of Cherhill was outlined by Professor Macgregor Skene. The members were conducted over the Norman Church at Avebury by the Vicar (Rev. V. Mason-Pooley, M.A.) and subsequently visited the Great Circle and the Avenue. Silbury Hill, the largest man-made and yet most problematical mound in Europe, was inspected.

The 584TH GENERAL MEETING was held in the University on 1 October, 1936, with the President, Mr. G. E. J. McMurtrie, in the Chair. The following members exhibited and gave short talks:—

BOTANICAL

The University—Bouvardia, propagation of colour forms.
Mrs. Sandwith—The Iris, from seed to flower.
Mr. L. Luckwill—Ecology of the Bilberry.

Mr. Ivor Evans—Herbaria; Geraniums of the Bristol District.
Mrs. Bell—Grasses and American Hickory nuts.
Mr. H. Stuart Thompson—The difference between our Spring and Autumn Crocus.
Mr. G. E. J. McMurtrie—Eucalyptus leaves, showing why the forests of Australia are shadeless.

ENTOMOLOGICAL

Mr. J. V. Pearman—Models illustrating the hatching and oviposition of Psocids.
Mr. T. L. Green—Life history of the Locust with living specimens.

GEOLOGICAL

Mr. Stenhouse Ross—Ammonites from the Dundry district.
Mr. J. H. Savory—Collection of stalactites collected on Mendip now in the Museum and Art Gallery.
Mr. H. C. Shilstone—Some common forms of calcite.
Prof. A. E. Trueman—Carboniferous arthropod, etc.
Mr. G. A. Kellaway—Pre-cambrian rocks of Charnwood Forest.

ORNITHOLOGICAL

Mr. L. H. Matthews—Photographs of Sea Elephants taken in South Georgia and Lions in Tanganyika.
Mr. J. H. Savory—Photographs of Sea-birds.

The 585TH GENERAL MEETING was held in the Lecture Theatre of the Museum and Art Gallery on 5 November, 1936. This was an Open Meeting, with the President, Mr. G. E. J. McMurtrie, in the Chair. There was a large attendance, and Professor Macgregor Skene, by a running commentary, enhanced the value of the films shown—The Thistle, Fungi, Mushrooms and Cabbage.

The 586TH GENERAL MEETING was held at the University on 3 December, 1936. Mr. G. E. J. McMurtrie was in the Chair, and nominations for Officers and Council for 1937 were received. Professor S. H. Reynolds, M.A., Sc.D., then gave a lecture on Palestine. This consisted of an account of a visit to that land during the early Spring of 1936, and included interesting remarks concerning Easter functions and a visit to Transjordania, Petra and Akaba at the northern end of the Red Sea.

M. DORIS HILEY, *Hon. Secretary.*

Report of Delegate to British Association Meeting

1936

THE British Association meetings of 1936 were held in Blackpool from September 9th to 16th.

The President of the Conference of Delegates of Corresponding Societies was Dr. A. B. Rendle, F.R.S., who spoke on September 11th on "The Preservation of our Native Flora." He asked how far it was desirable to attempt to preserve a native flora, which itself results from changes of the past and represents merely a stage in a continuous progress. He illustrated these remarks by references to his experiences in St. Helena and the Bermudas, and urged the desirability of preserving the floras in the interests of science.

Methods by which this could be brought about were then discussed, both legislation and education being commented on. Bye-laws prohibiting the uprooting of plants, adopted by many County Councils, have been criticised by botanists and by herbalists.

Later, Sir Albert Kitson spoke on the Dumping of Rubbish in Places of Natural Beauty. He referred particularly to the Dorset Coast, where Dr. W. D. Lang reported that much refuse was being tipped over cliffs, which besides being of great natural beauty were classic geological exposures. The importance of collecting and disposing of rubbish in rural areas was emphasized.

A. E. TRUEMAN.

OBITUARIES

DURING the year 1936, the Society lost by death two of its honorary members :—

DR. C. LLOYD MORGAN

Dr. Lloyd Morgan died at St. Leonard's on March 6th, 1936, at the age of 84. A biographical notice with a portrait was published in the *Proceedings of the Bristol Naturalists' Society* in 1900,[1] on the occasion of his election to the Royal Society, and the matter contained in this earlier notice will not be repeated here.

During the ten years following the publication of the notice, a very large part of Dr. Lloyd Morgan's time was spent over the arduous negotiations which ended in the establishment of the University of Bristol in 1910. He became the first Vice-Chancellor, but on the understanding that it was merely an interim appointment, and after a few months' tenure he resigned, becoming Professor of Psychology and Ethics, a post which he held till his retirement in 1919. At the date of the publication of the earlier notice, he still held the Chair of Zoology and Geology in addition to the Principalship of University College, Bristol, and was still carrying on geological investigation. This, however, gradually came to an end as he became more absorbed in his work on the mental processes of animals, a subject on which he became the leading authority. His chief publications not alluded to in the former notice were *Animal Behaviour* (1900), *Instinct and Experience* (1912), *Emergent Evolution* (1923), *Life, Mind and Spirit* (1926), and *The Mind at the Crossway* (1930). *Emergent Evolution* and *Life, Mind and Spirit* were based respectively on the first and second course of Gifford lectures at the University of St. Andrews.

No account of Dr. Lloyd Morgan should fail to record the great part he played locally in encouraging the study of Natural History and Archæology by his lectures, intra- and extra-mural, and as a leader of field excursions. Few men can have had a knowledge of so many subjects, for, in addition to the subjects he taught at Bristol, he had also, when in South Africa, taught Chemistry and English Literature. He was, too, deeply interested in the drama and in music.

In his younger days a good athlete and mountaineer, he never, while his health permitted it, neglected regular exercise. Though he took up golf relatively late in life he learnt to play a good game. But it was as a cyclist that he was best known, and to the end of his stay at Clifton might be seen in all weathers taking his daily run of some

[1] Vol. IX, Pt. 1 (1900 issued for 1898), p. 1.

half a dozen miles. His annual mileage when well on in the sixties amounted to several thousand.

His former pupils and colleagues at the University of Bristol retain a vivid recollection of his wise, kindly and humorous personality, and the writer of the present notice, who came to Bristol as his assistant in 1894, is deeply sensible of his good fortune in having been associated with such a man.

S. H. R.

PROFESSOR W. J. SOLLAS

William Johnson Sollas was born in Birmingham on May 30th, 1849, so that, at the time of his death on October 20th last, he was 87 years of age.

For practically the last 40 years of this long life, Sollas lived and worked in Oxford, but there was a period of five years when his work was in Bristol, and he always continued to regard Bristol as a centre of outstanding geological interest and importance ; the present writer has heard him declare that Bristol was the place above all others in this country for a Geological School.

It was from 1878 to 1883 that Sollas was occupied in Bristol. In July, 1878, he was appointed Lecturer in Geology in University College, Bristol, and Curator of the Bristol Museum ; these were really his first important posts. Less than two years later, in May, 1880, he became Professor of Geology and Zoology at University College and continued to hold the Curatorship of the Museum also until June, 1882, when he resigned that appointment. Little more than a year later, in December, 1883, he also resigned the Professorship at University College on being appointed to the Chair of Geology in the University of Dublin.

Numerous obituaries of Sollas have appeared in various journals, e.g., *The Times, Nature, Proceedings of the Geologists' Association,* etc., dealing at some length with his eminence and fame as a scientist as well as with his personality. A very brief record, however, of his career after leaving Bristol must suffice for our pages. From Dublin he went in 1897 to Oxford to succeed the late Professor Green in the Chair of Geology ; he was elected a Fellow of University College, Oxford, in 1901, a Fellowship now associated with the Chair, and he held both the Chair and the Fellowship until his death. Sollas held degrees of several Universities, and he was elected F.R.S. in 1889.

Although Sollas was primarily a geologist, it was perhaps the breadth of his scientific interests to which his fame was largely due. Thus we find treated among his many writings not only geological subjects

in the widest sense, but also zoological and anthropological subjects. Moreover, his grasp of the physical sciences was always evident in his approach to his studies.

It was to anthropology that he turned most in his later years, and he was recognised as a leading authority on the subject, and in March, 1925, he lectured to the Bristol Naturalists' Society at its 515th General Meeting on "Men and Apes." He showed also much interest in the Spelæological Society of the University of Bristol, and perhaps his most famous publication was his *Ancient Hunters*.

During his early connection with Bristol, Sollas was President of the Geological Section of the Bristol Naturalists' Society from 1880-1883, and he also contributed to these *Proceedings*. In New Series, Vol. II (1877-79), appears an abstract of a paper "On the Silurian district of Rhymney and Pen-y-lan, Cardiff"; in N.S., Vol. III (1879-82), we have his illustrated paper on "The Structure and Life-history of a Sponge," and in N.S., Vol. IV (1882-85), we find his report (reprinted —with additions—from the *Journal of the Psychical Society*), "On Wells sunk at Locking, Somerset, to Test the alleged Power of the Divining Rod." During this period also, Sollas contributed articles concerning the Bristol district to other publications, e.g., on the "Geology of the Bristol District," in the *Proc. Geol. Assoc.*, Vol. VI, and on "The Severn and its Tributaries," in the *Quart. Journ. Geol. Soc.*, Vol. XXXIX.

It seems to the present writer that all who knew Sollas must have been impressed not only by the power of his intellect and the extent of his erudition, but also by his amazing vivacity and the perseverance which he ever showed in the pursuit of knowledge, as witness his expedition to the Pacific to investigate the question of the origin of coral atolls, or his journey to the Kalahari Desert to study the Bushmen, or his adventures, late in life, in the caves of the Pyrenees, where a dive into the cold waters did not come amiss to one who was, even in advanced years, accustomed, until late in the year, to take his daily plunge in the Cherwell at Oxford. In all these undertakings he was assisted, of course, by his bodily vigour, for though short of stature, with the leonine head that hinted at his strength of mind and character, yet he was physically tough and wiry as became a geologist.

Sollas' love for his subject was seen at the last in the provision which he made in his Will for the eventual endowment of a Fellowship at University College, Oxford, for the furtherance of the study of geological science.

H. W. T.

PRESIDENTIAL ADDRESS, 1936

By G. E. J. McMurtrie

(*Read* 21*st January*, 1937)

AS you are aware, in my Presidential Address last year I made a comparison of past and present methods of cutting, loading and conveying coal. This year I propose to follow this coal further, and describe its modern treatment after it has reached the surface.

Later I want to refer to the lighting of the underground roads and faces, a matter of considerable importance, as better lighting should mean fewer accidents, and in several experiments it has been proved that nystagmus is largely reduced, possibly entirely prevented, by better lighting, owing to the lessened strain on the eye.

PAST AND PRESENT SYSTEMS OF SCREENING AND CLEANING COAL

As many of you have seen, coal is loaded underground into wooden or steel tubs just as it is cut, large and small being shovelled up together, hauled to the shaft and wound to land.

Formerly it was then taken to a tipping platform called a "Tippler," and tipped on to fixed screens of sloping steel bars, with 1 inch to 1¼ inch spaces between them. The coal was shovelled down these, the large or house coal passing forward over the bars into trucks on No. 2 road, and the small coal falling between the bars into trucks on No. 1 road. What cleaning was done was done as they shovelled.

Possibly in those days the seams worked were cleaner, there was less shovel filling underground, and certainly there was more time to clean the coal both below and above ground. It was usual to pick off the larger blocks of coal and load them separately as a special quality of higher price. The obvious result of this system was that the average householder promptly broke up these large lumps into more handy pieces for the fire-grate, making as much small as he or she could in the process. This produced a demand for ready broken coal of cobble and nut sizes, and to-day in every district there is quite a long list of varying descriptions and sizes.

Machine cutting and conveying, with its larger tonnage, and the increased independence of labour, have undoubtedly produced dirtier coal, and have to-day compelled most elaborate and expensive plants for cleaning the coal.

The first step to produce coals of more varied size was *the jigging screen.* This consisted of a heavy frame containing a number of what may be described as riddles; the upper one might be a solid plate with 6 inch diam. holes, or a very coarse riddle of strong woven wire, with a second below it, dipping in the opposite direction, of a closer mesh, to take out the cobbles, with a third again below this, dipping in the same direction as the first and of a smaller mesh to take out the nuts, allowing only the small below $1\frac{1}{4}$ inch or 1 inch to pass through.

These jiggers were suspended by four swinging hangers of iron or wood, and were attached at one end by two rods to eccentrics on a rapidly rotating shaft, which shook them to and fro, chucking the coal forward down the dipping riddles, and at the same time dividing the coal up into the required sizes. (See Fig. 1.)

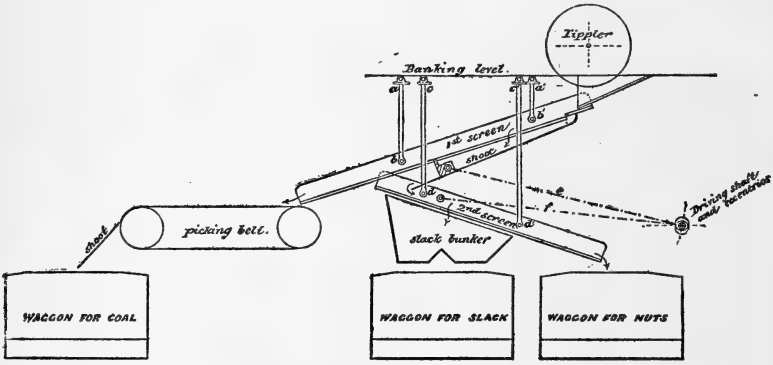


FIG. 1

At a later date some jiggers were driven by similar means crossways in place of end ways, the effect of which was to hold the coal longer on the riddles to ensure a more complete separation of the sizes. In my experience the endway jiggers are quite sufficient, and the obvious result of holding coal longer on the riddles, i.e., shaking it more, is disastrous to a tender coal.

No cleaning is done on these jiggers, but the coal from each riddle is led on to a travelling belt, which takes it to its truck. These belts travel slowly, and the coal should be deposited upon them in a thin layer so as to enable the men and boys stationed on either side to pick out any stone loaded with the coal. The snouts, or ends, of these belts are mechanically lowered or raised to reduce the drop into the truck with its consequent breakage.

The small coal that passes through the lowest riddle cannot be

cleaned under this system and is sold as actually filled underground, for it is practically impossible to clean coal below $1\frac{1}{4}$ inch or 1 inch by manual labour.

The modern demand is for clean small coal and for its division into a number of thoroughly screened and cleaned sizes, such as small nuts, beans, peas and dust, etc. To ensure this, the machinery has to be automatic, reliable, and, as far as possible, free from the human element.

Naturally, the earliest attempt was wet cleaning of the small coal by the trough system. This consisted of a dipping double trough, each having a series of stops in it, and with a door at the lower end to discharge the dirt washed out. The one side is filled with the coal to be washed, which is delivered and carried forward by the stream of water. When the trough is full, the water carrying the coal is diverted to the other trough, and a supply of clean water is turned into the upper end of the first trough, and the mixture agitated with rakes by manual labour. As a result, the coal floats off and the dirt settles at the stops. Later, these are raised and the water sweeps forward the dirt which drops through the opened door at the lower end. If proper care was exercised this gave a very clean coal at a somewhat high labour cost. (See Fig. 2.)

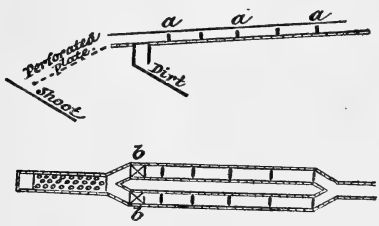


Fig. 2

To reduce this labour cost the Robinson washer was introduced, consisting of an inverted cone in which a central vertical shaft revolves with four horizontal arms attached crossing at right angles. To these arms in turn a series of vertical strips are attached. Water is introduced at bottom under pressure, through a series of perforations round the cone, and the coal itself at the top. The revolving arms keep the coal in suspension, and the water is regulated so as to float off the pure coal and allow stone and intermediate pieces of coal with adhering dirt, or inferior coal below a certain specific gravity, to drop to the bottom, whence it is discharged from time to time by opening valves. The process is very simple, and the capital and labour costs

small, but it is dependent for its efficiency on the regulation of the water, and it appears to me that a considerable loss of coal might follow a slight drop in pressure. (See Fig. 3.)

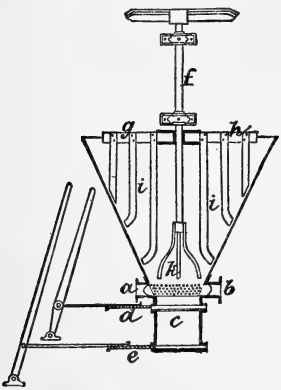


Fig. 3

The next step, in the Coppée or Lührig, was the adoption of a double compartment washer, in one compartment of which a piston is made to rise and fall, forcing water through a perforated strainer in the other. The coal is introduced above the strainer, and when the piston falls in the one compartment it forces water through the strainer in the other, lifting the bed and continuously floating off a little coal, while, on the return stroke, the rubbish falls quicker than the lighter coal and forms a layer which also is gradually discharged by an endless worm.

In these washers the small coal is separated before washing into at least nuts, above say $\frac{3}{8}$, and fines from this to dust. The fines machines are really double or treble washers with two or three pistons and two or three compartments, and have a 2 inch or 3 inch layer of felspar above the strainer. The nut washers are single piston compartments. To prevent coal passing through the strainer, the nuts are kept of larger size than the holes, while the felspar is larger than the fines. The fines enter one end of the three boxes and pass through all three, discharging at the far end. The specific gravity of the felspar is greater than that of the fines and less than that of the rubbish, and so forms a clear cut line of division. Any number of qualities can be thus made, but each quality must be separately washed. The capital and wear and tear costs of this method are heavy, but the labour cost is very small. (See Figs. 4 and 5.)

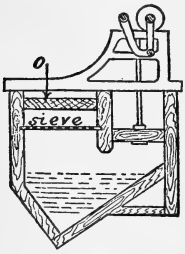


Fig. 4

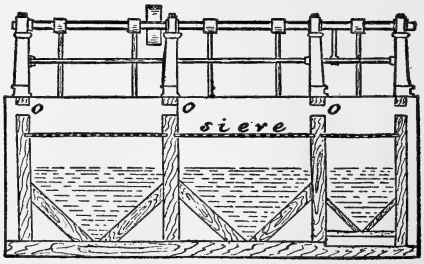


Fig. 5

A further system, and one largely used to-day, is that of the Baum machine, in which air at a pressure of about 2 lbs. takes the place of the ascending and descending piston. Again we have a two-compartment box; the coal is generally brought to the larger by the water-feed; in the other is a small piston valve which alternately admits or draws out air. This keeps the water in a state of agitation, lifting and dropping the coal to be washed; the coal floats off, and the lower portion of the shale on the sieve is removed by lifting doors which drop it into an outer shell, whence it is carried off by an endless worm. (See Fig. 6.)

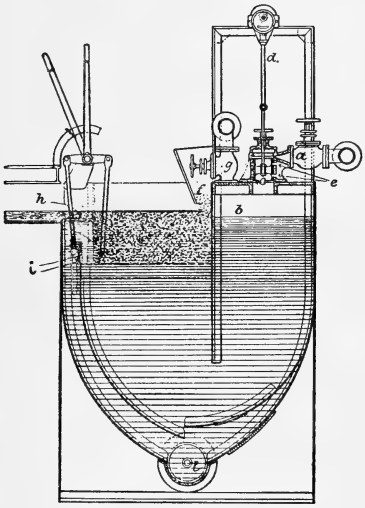


Fig. 6

In this case the separation is largely dependent on the number of strokes, which may be 50 to 70 for the coarser sizes and 75 to 110 for the finer.

The main claim for this machine is that, while the return strokes of the piston machines do not help separation and tend to fix the bed of material and thus prevent separation, the air keeps the material in a fluid state the whole time, and in the case of the fines jigging machine, the coal does not even rest on the sieve at all but is floating through all the time.

At Coalpit Heath Colliery, now the last in the Bristol Coalfield, there is a most compact little Baum washery with special features.

The coal is first tipped on to a double-decked jigger screen with $4\frac{1}{2}$ and $2\frac{1}{4}$ holes, making large, cobbles and small. The large is taken

to a breaker on a conveyor that stops at fixed intervals. At every stop a series of pickpoints attached to a crossbar are lowered and pierce any coal on the band. The picks then rise and simultaneously the conveyor restarts. This broken coal is taken back to the jigger and rescreened.

All that passes through the $2\frac{1}{4}$ holes is conveyed to a shaking screen which takes out the dust up to $\frac{1}{16}$. This dust is not washed. The remaining $2\frac{1}{4}$ to $\frac{1}{16}$ coal goes to the Baum washer of a pair of double compartment boxes. The air receiver is very compactly placed over the wash box, and a valve automatically regulates the depth of bed.

The coal after washing is dewatered on another jigging screen and divided into nuts and small.

The washery water goes to a settling tank where the slurry is deposited and later carried away by scrapers for use at the boilers.

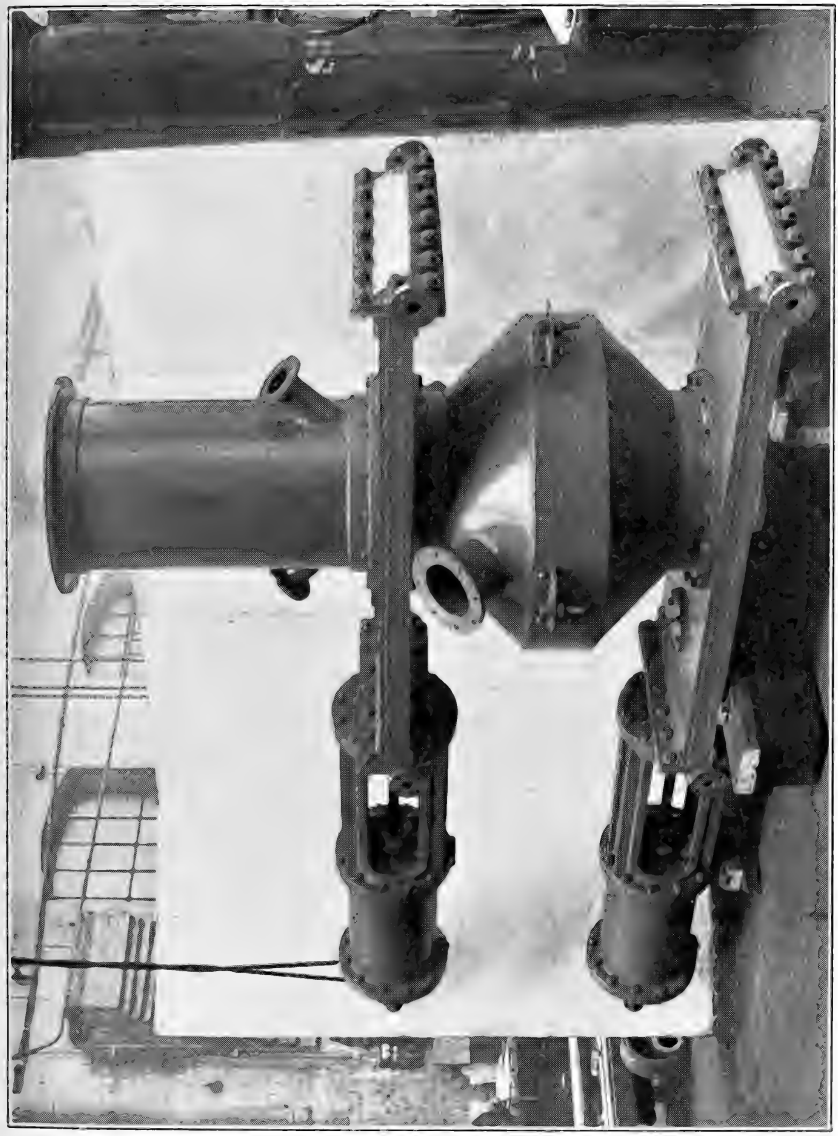
The most recent type of washer is the Chance, a machine that is largely used in the U.S.A., and is being introduced into both the north of England and S. Wales. In this process the whole of the coal that will pass through a shaking screen, with holes up to, say, 6 inches diam., is treated as one unit, that above 6 inches passing over the riddle and being cleaned on a travelling band as usual. (See Figs. 7 and 8.)

All the undersize is conveyed to a double-decked jigger screen which shakes through all the coal below $\frac{3}{8}$ inch and passes it to a pair of Sherwin vibrating screens which take out all the dust below $\frac{1}{16}$ inch which is not washed. These vibrating screens are electrically driven, are made of phosphor bronze wire, and make 3,000 short strokes per minute and are in a constant shiver.

The coal above the $\frac{1}{16}$ inch is returned to the over $\frac{3}{8}$ inch coal from the shaker and together passed to the washing cone.

The cone is not unlike the Robinson washer, but the medium in this case is sand to increase the specific gravity of the water, the density being regulated by four valves which admit water at different levels. By varying the valves, i.e., by opening or closing them, the specific gravity is lowered or increased. The water keeps the sand in a fluid state, but in addition there is a mechanical agitator attached to a central revolving shaft to keep the sand and water mixed and to prevent its banking up on the side of the cone.

The coal floats over the top with some sand, and the rubbish drops through the sand to the bottom, where there is a chamber with top and bottom slides, alternately opened and closed by air, to discharge it. (See Plate 22.) The upper part of the cone contains practically pure water, but to clear off any sand that may still adhere to the clean coal



Arrangement of Valves to Discharge Dirt

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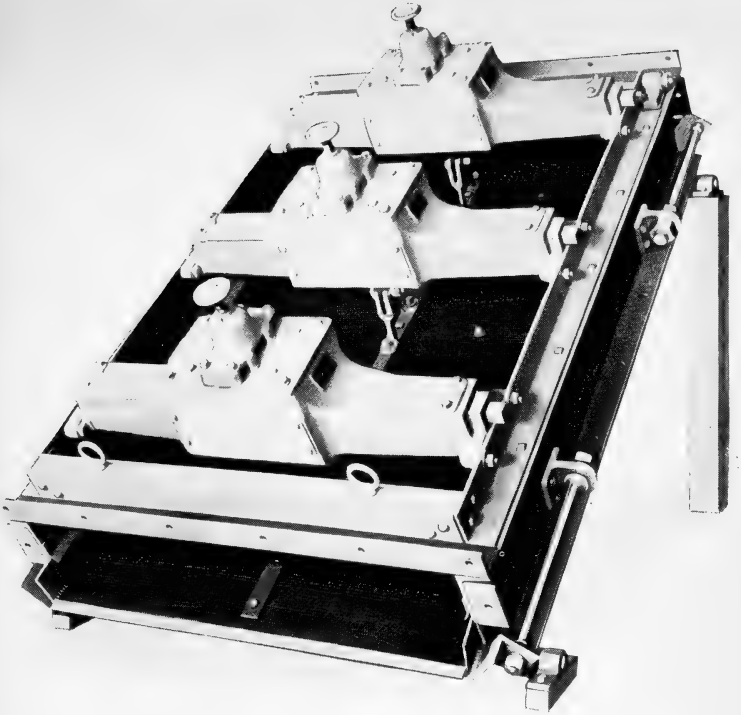
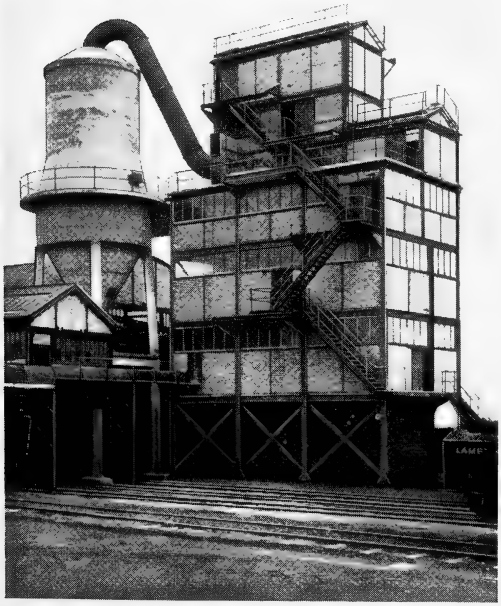
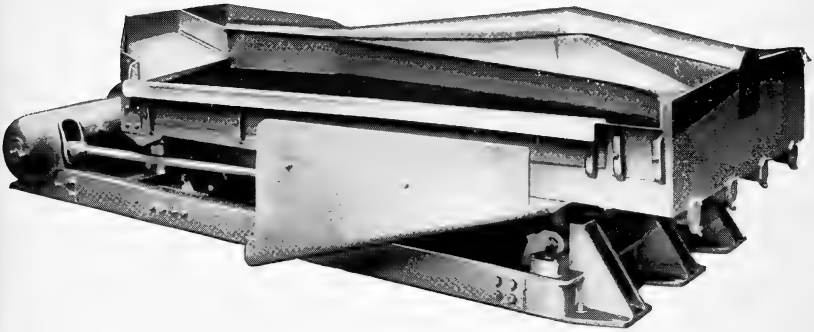


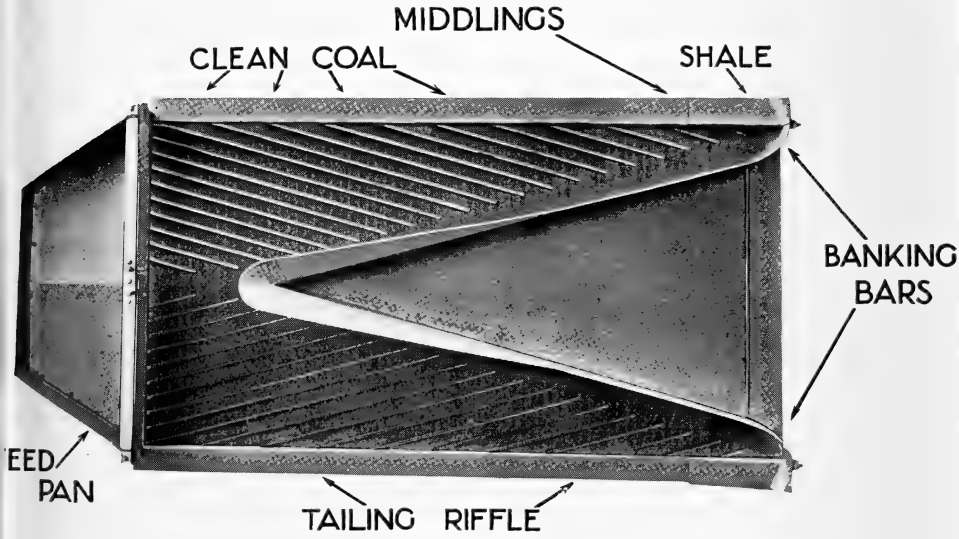
Hummer Vibrating Screen



Typical Pneumatic Coal Cleaning Plant



Vee Type Separator, Showing Separation of Shale from Coal



Separator Deck

Separator Floor with Machines in Position

that is floated off and carried by the water to a double-decked jigging screen, which divides it into the various sizes, cobbles, nuts, fines, etc., that the market requires, water sprays are added on the screens.

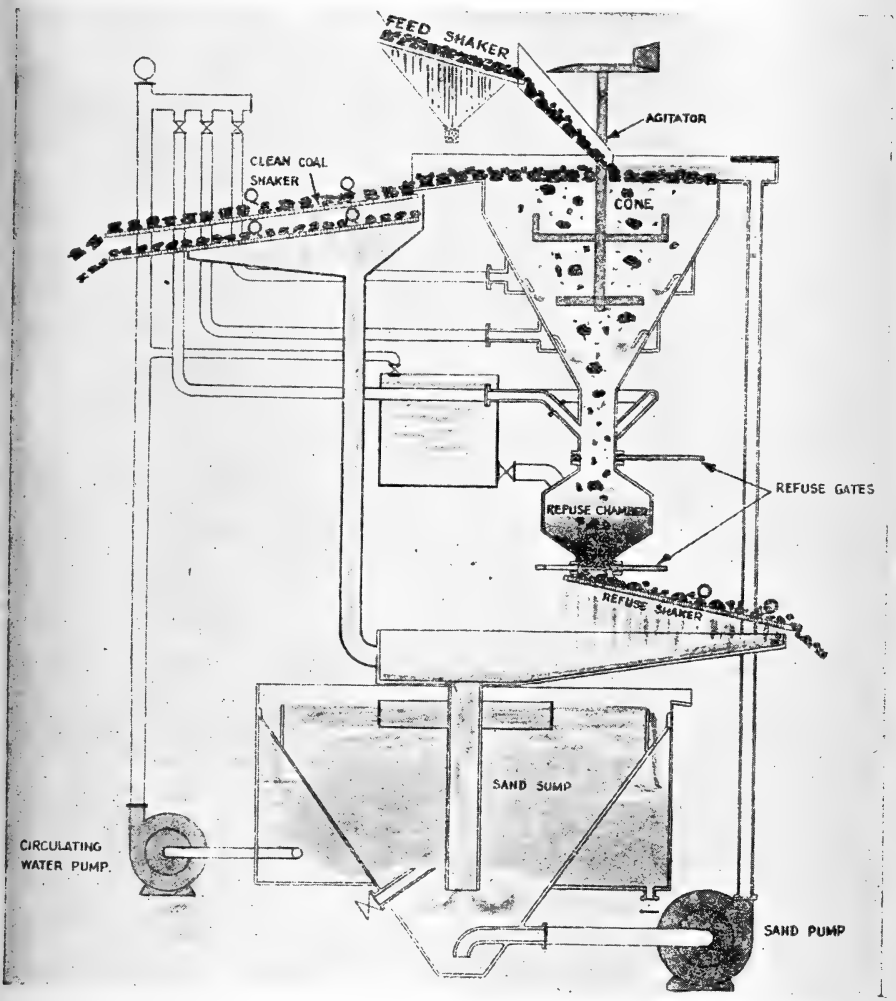


FIG. 8.—SECTION OF CHANCE WASHER

Actually the first part of this screen almost entirely dewaters and desands the washed coal. The sand lost in circulation is collected in another cone and pumped back to the main cone, and a second pump deals with the water.

Constant tests of the washed coals are made throughout the day in a 1.5 specific gravity mixture of tetrachloride in benzine contained in a tank. A perforated steel basket, with upper and lower decks that open and close, is dipped in this, the coal floats and the dirt drops. By closing the deck the two portions are kept separate and can be weighed in turn on a spring balance attached. If the percentage of ash aimed at is exceeded more sand is at once added.

This plant again requires a considerable capital expenditure, but the labour cost is small—at one large plant twenty-four men were reduced to nine on replacing cleaning bands by this plant—and probably the maintenance also.

The principal difficulty of all washeries is the "slurry," i.e., the fine dust that floats off with the water, and at some collieries forms as much as 10 per cent. of the landings. It is difficult to collect, settle and dry. It has generally to be run to settling beds, mechanically recovered from here and added to the washed small. Even then it is very difficult absolutely to free the water of it, and it may cause a material loss of tonnage.

The newest method is by flocculation. Lime is first added to the water to make it alkaline, and then starch. The thickened water is then filtered, and the cakes formed are used at the colliery boilers.

To-day it is largely unwashed, as in the Chance machine, and used for firing the colliery boilers until there is a ready market found for it. For, what is known as pulverised fuel, which it actually is, is gradually being applied to boilers, to copper smelting, heavy and light forge furnaces, etc.

The difficulty of dealing with "slurry" has produced a process of dry cleaning the fine coal by air, brought out by the Birtley Co., and largely adopted in the North of England. It deals with coals from 4 inches down to zero. The coal is first passed over ordinary jigging screens which divide it into over and under 1 inch. That over 1 inch is taken to two-compartment wash boxes fitted with Birtley type plungers. A valve regulates the feed of water to the box, the coal floats off, and the rubbish drops down and is automatically discharged by another valve driven from the main washer shaft. The opening and closing of this valve is ingeniously controlled by a float resting on the rubbish, which rises and opens further the valve if the bed thickens and *vice versa*. The idea, of course, is to maintain a constant depth of bed automatically and not by the judgment of the man in charge. This should prevent loss of coal which happens with a thin bed. The 4 inch to 1 inch coal is afterwards dewatered and

taken to further jigging screens to be divided into cobbles, large and small nuts, etc. That under 1 inch is conveyed to high-speed vibrating Hummer screens and divided into 1 inch to $\frac{1}{2}$ inch and $\frac{1}{2}$ inch to 0. (See Plate 23.) The larger size is taken to pneumatic separators, where a thin stream of coal is fed into a series of louvres, and air pumped through. (See Plate 24.) The smaller size ($\frac{1}{2}$ to 0) is conveyed to the dedusting plant of a pair of Birtley Aspirators which suck out all dust up to $\frac{1}{32}$ inch. This dedusted coal is again divided into $\frac{1}{2}$ inch to $\frac{1}{8}$ inch and $\frac{1}{8}$ inch to $\frac{1}{32}$ inch by high-speed vibrating screens, and each size cleaned by pneumatic separators. Each Separator and Aspirator has its own fan, and dusthoods cover the separators, and trunking takes the dust-laden air to the dust collector.

The dust collectors are of the combined cyclone and bag filter type; the heavier dust is deposited in the cyclone, the lighter is collected in the bags. These bags are periodically cleaned by opening valves to the atmosphere when the bags collapse and the dust falls to the cyclone and the filtered air is discharged to the atmosphere. (See Fig. 9.)

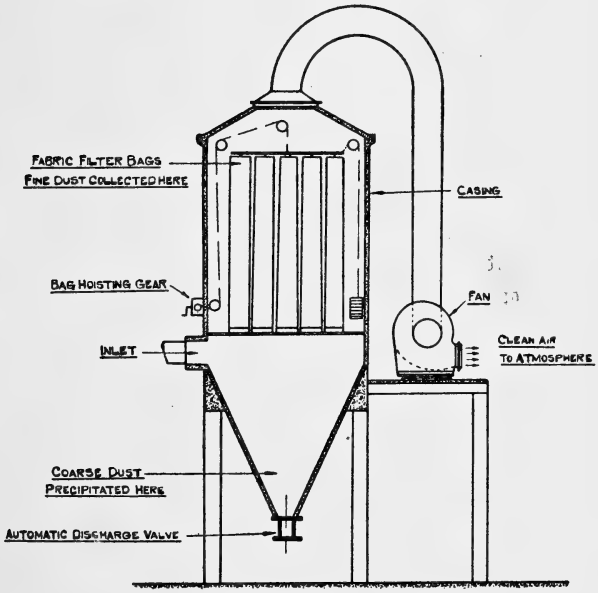


FIG. 9.—DIAGRAM OF DUST FILTER

The $\frac{1}{32}$ inch to 0 dust collected by the Aspirators is taken to an Elmore vacuum flotation plant and divided into clean coal and tailings or refuse. Both clean coal and tailings are water-conveyed to Birtley

Henry clarification and filtration plants, where the solids are deposited by flocculation and the clean water overflows and is recirculated. The solids are picked up, filtered and made into cakes, and the water drawn off by air suction.

The $\frac{1}{2}$ inch to 0 smalls got from this flotation concentrate and "slurry" are next taken to a rotary drier with $8\frac{1}{2}$ ft. diam. drum 32 ft. long, fired by dust from the filters. The now dry and cleaned coal, 1 inch to 0, can finally be mixed and screened into whatever sizes the market requires or can be sold as already prepared. Even the exhaust gases from the drier are passed through a dust collector.

The description of this very complete process may sound very complicated, but it deals fully with cleaning and drying everything from 1 inch to 0, recovering all "slurry" and discharging clean air and pure water. In many cases, of course, the complete process may not be adopted or required.

To summarise the process: after a preliminary screening, all coal of 1 inch and below is divided by high-speed vibrating screens into 1 inch to $\frac{1}{2}$ inch and $\frac{1}{2}$ inch to 0 sizes. The 1 inch to $\frac{1}{2}$ inch goes to a pneumatic separator. The $\frac{1}{2}$ inch to 0 goes to a dedusting plant of Aspirators, where all dust up to $\frac{1}{32}$ inch is drawn off, collected, filtered and clean air discharged.

This dedusted coal is again divided into $\frac{1}{2}$ inch to $\frac{1}{8}$ inch and $\frac{1}{8}$ inch to $\frac{1}{32}$ inch by high-speed vibrating screens and cleaned by pneumatic separators. The $\frac{1}{32}$ inch to 0 dust is dealt with wet by a flotation plant and divided into clean coal and tailings. Both are then clarified and filtered by a flocculation plant with the addition of lime and caustic soda.

The various smalls, $\frac{1}{2}$ inch to 0, are then dried and can be finally sold as 1 inch to $\frac{1}{2}$ inch and $\frac{1}{2}$ inch to 0, or rescreened into any sizes required. (Plate 23 shows the elevation of a typical plant.)

The labour cost of such a plant is small but the capital and upkeep costs must be high, and only a large tonnage can warrant the complete plant.

Actually, for boiler firing, small coal containing 8 to 10 per cent. of ash is most suitable, but gas and electric light works demand cleaner coal, and some manufacturers find a coal containing only 3 to 4 per cent. of ash essential; which is the only justification for such elaboration.

The pity, from a colliery point of view, is that very seldom can the necessary increased price be obtained.

However, from the above it will be seen that both colliery owner and mechanical engineer have done and are doing their utmost to

produce clean coals, suitable for the varying needs of their customers, at large capital expenditures and with more than possible losses to the colliery owner.

PAST AND PRESENT METHODS OF UNDERGROUND LIGHTING

The earliest form of lighting was the ordinary tallow candle, carried by both officials and colliers, either in a metal candlestick or lump of clay. No doubt, at first, this was the rush dipped at home in tallow or some fat. Candle cotton replaced the rush, and as late as 1905 I kept a candle maker regularly at work.

The oil lamp was then introduced, and found to give a better light, to be cheaper, and to stand a higher air velocity.

Oil, in turn, was replaced by wax, made from the Scotch coal shales, which gave a clearer light, largely owing to the smoke given off by the adulteration of oil with paraffin.

For some years now acetylene has been universally used and gives a most excellent light of at least 10 c.p.

The above is a summarised history of lighting in collieries free from gas.

In gassy collieries the candle, too, was the earliest form of lighting, but the frequent gas explosions brought about attempts to isolate the light.

The first of these to take practical form was Sir Humphrey Davy's lamp which confined the flame within a cylinder of iron gauze with 784 apertures to the square inch. It was made safer later by a short second cylinder of gauze at the top, and a short metal shield around two-thirds of the flame at bottom, to prevent the flame being driven through. This lamp, of course, gave a very poor light compared with the naked candle.

This lamp was succeeded by Dr. Clanny's, which consisted of a short cylinder of glass surrounding the flame, with a gauze cylinder above, and later a metal shield or bonnet. As the air entered at the top of the glass cylinder, and got mixed with the products of combustion, this lamp again gave a very poor light, in spite of the replacement of part of the gauze cylinder by glass.

Sir Robert Stephenson's lamp consisted of an entire glass cylinder inside the gauze cylinder, but the air entered below the glass and thus gave a better light.

A much safer lamp was the Mueseler, which continued the short lower glass of the Clanny with a wire gauze above and a central metal chimney and external shield. The air descends between the metal chimney and glass directly to the flame, and gives a much better light.

With the exception of the Mueseler, all these lamps would pass the flame through the gauze at velocities of 6 ft. per second, and the Mueseler at 12 ft.

As a result of a Royal Coal Commission we have the modern oil safety lamp.

The Marsaut is typical of these and has the usual glass cylinder at bottom, with two gauzes above, and a sheet-iron shield or bonnet around them, and will stand the present high velocities of underground air currents.

This lamp is in general use with colza oil or benzine spirit, with slight modifications possibly.

For gas testing purposes and official use a very useful lamp is the Hepplewhite Gray. This has three tubes of the height of the lamp, with a short conical glass cylinder at bottom, and gauze cylinder above with bonnet or metal shield around this, and cover at top to protect the three tubes. Fire damp or carburetted hydrogen gas is lighter than air, and floats against the roof, and this lamp draws its air from the top of the lamp down the three tubes, in place of, as usual, above the short glass cylinder. The air right against the roof can therefore be tested, and a very small percentage of gas is shown by the lengthening of the flame. At other times shutters can be lifted at the bottom of the tubes and the normal air burnt.

All these lamps, while safe and essential for testing for gas before and during the working shifts, give a relatively poor light, at the best that of a candle. Moreover, an oil lamp, if accidentally turned over, and often if only tilted, is put out by the products of combustion, and can only be relighted at some distant station or at land.

Electric handlamps are undoubtedly the lamps of the future and are very largely used to-day. Their great fault at present is their excessive weight, the electricity being produced from a contained lead-acid or alkaline battery. Two-volt lamps were originally used, but 4-volt are now replacing them. The weight of such a lamp is 9 to 10 lbs.

As regards light, the oil lamp makes a very poor showing. A lamp is generally hung 4 ft. 6 ins. from where the man is working, and comparative tests made with a photometer towards the end of a collier's shift gave :—

Ordinary Marsaut using oil or spirit	·3 c.p.
Lead acid 2 volt lamp	·8 c.p.
„ „ 4 „ „	1·6 c.p.
Alkaline 4 c.p. „	1·6 c.p.
„ 6 c.p. „	4·5 c.p.

In Scotland, more especially, a small and much lighter electric lamp is worn in the cap, the electricity being produced by a small lead acid battery strapped to the back or side. Unquestionably this is the best portable system, as the light is thrown directly on to the place where the man is working.

Similarly tested, these lamps showed :—

2 volt cap lamp, 2 ft. 6 in. from face	$1\frac{1}{4}$ c.p.
4 „ „ „ „ „ „	2·45 c.p.

The Edison electric safety cap lamp has a nickel iron alkaline battery of two cells, rubber jacketed for protection and insulation, weighs 63 oz. and gives a maximum of 26 c.p. 1 ft. from the photometer. A 3-cell battery weighing 87 oz., yielding 55 c.p. 1 ft. from the photometer, is also made. The headpiece is made of bakelite, a light weight insulating material, and has a 2 filament gas-filled bulb, the larger of which would be used for work, and when this failed, the smaller would ensure a light.

The use of electricity for power underground has brought about the general lighting of pit bottoms and main and secondary haulage roads by small incandescent lamps with generally metallic filaments, yielding 25 c.p., the voltage being 110. They give, of course, an excellent light, especially if the walls are white-washed and the lamps placed 50 yards apart.

In some collieries in this country, and more extensively in Germany, coal faces are also lit by electricity, particularly where machine coal cutting and conveying are adopted. Many English colliery managers, however, will not risk carrying electric lighting beyond the main intake air current, for fear of short circuiting in a possibly gassy atmosphere.

In the case of a coal cutter face with conveyors, a flexible trailing cable is taken along the road in which the coal is loaded and conveyed, and up and down the faces to the right and left of this road. The current is transformed in the haulage road to 110 volts, and 60 watt gas-filled lamps attached every 10 yards.

In some cases, to ensure safety, each lamp contains a small cut-out which, if the glass bulb is broken, interrupts the current.

On the Continent sometimes an ordinary sparklet, such as is used in the making of soda water in syphons, is introduced into the fitting, and the well glass surrounding the lamp is filled with CO_2 gas which, on the lamp breaking, puts out the light.

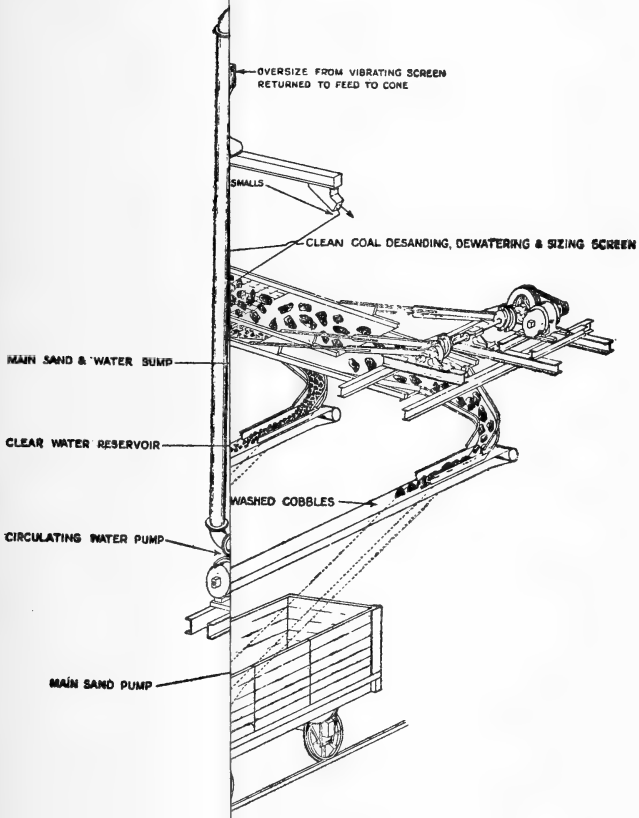
Frequently all current-carrying parts are surrounded with compressed air, the cable itself being carried in a compressed air pipe, which keeps any gas from the lamps and fittings.

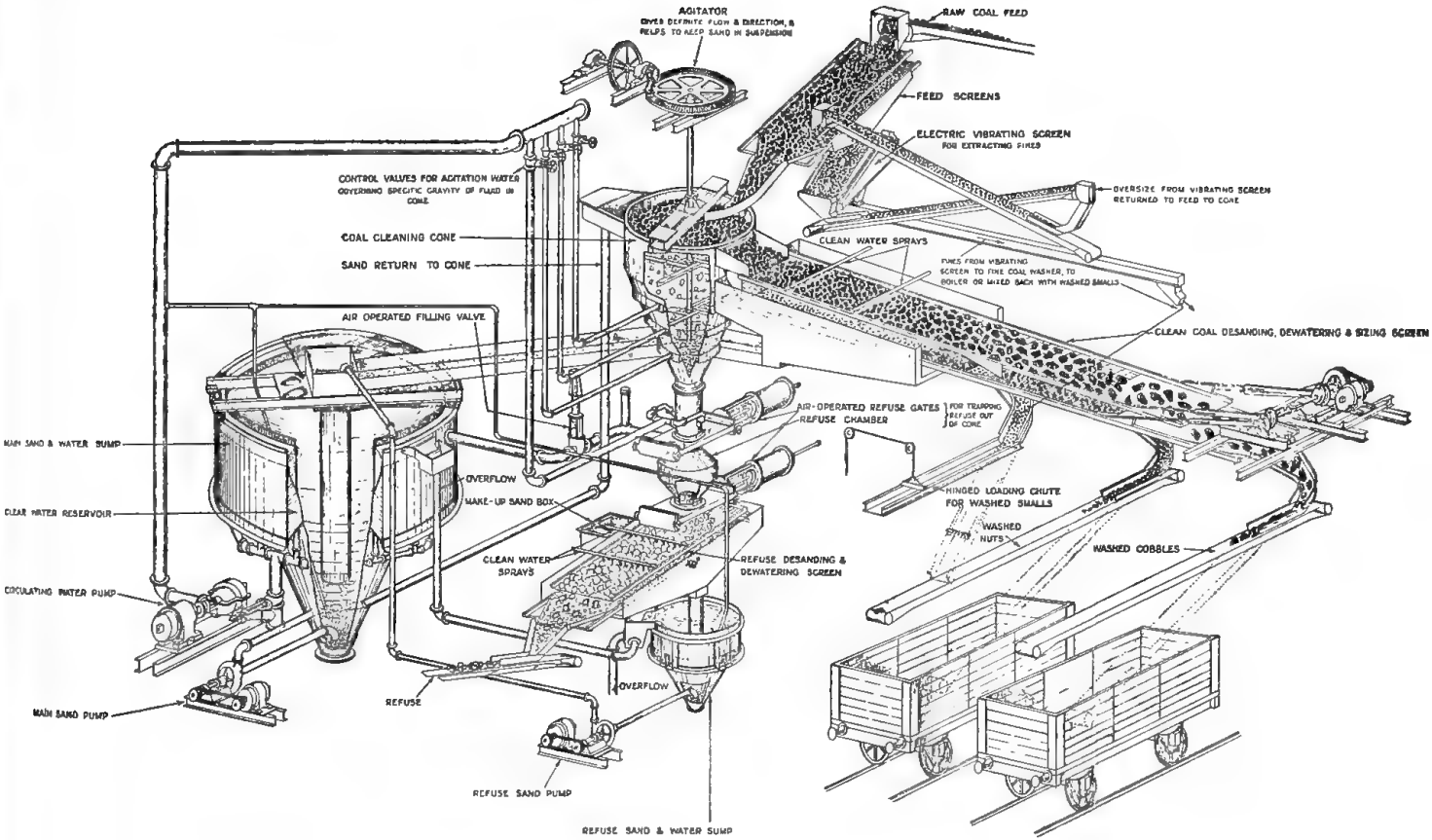
Opaque or preferably prismatic glasses should always be used to prevent glare from the light, though this reduces the light considerably.

From the above it will be clear to you that much thought has been given for many years to the improvement of the portable oil safety lamp, as regards both safety and light, and of late years to the portable electric safety lamp, and that the permanent lighting of pit bottoms and the various roads leading to the coal face may be regarded as satisfactory.

The lighting of the coal face, where most of the danger is, is, however, in a very unsatisfactory state. What is required, viz., the introduction of electric light, is recognized, but the difficulty is to instal it with absolute safety in what at times may be an unsafe atmosphere, and in coal faces that, in the case of machine mining, are daily moving forward.

The writer is indebted to Messrs. Chas. Griffin & Co., publishers of Mr. H. W. Hughes' *Textbook on Coal Mining*, for the loan of Figs. 1 to 6; to Messrs. Fraser & Chalmer of Erith, Kent, the producers of the Chance Washer, for Figs. 7 and 8 and Plate 22; and to the Birtley Co., Durham, producers of the pneumatic process of cleaning fine coal, for Fig. 9 and Plates 23 to 25. He has also to thank Messrs. Thomas & Williams, safety lamp manufacturers of Aberdare, for the loan of lamps that illustrated the notes on underground lighting when read.


OVERSIZE FROM VIBRATING SCREEN
RETURNED TO FEED TO CONE
SMALLS
CLEAN COAL DESANDING, DEWATERING & SIZING SCREEN
MAIN SAND & WATER SUMP
CLEAR WATER RESERVOIR
WASHED COBBLES
CIRCULATING WATER PUMP
MAIN SAND PUMP



PICTORIAL LAYOUT
OF
THE CHANCE SAND FLOTATION PROCESS FOR COAL WASHING
MANUFACTURED BY
FRASER & CHALMERS ENGINEERING WORKS
(PROPRIETORS - THE GENERAL ELECTRIC CO LTD)
ERITH — KENT

Fig. 7.

Caves, Natural and Artificial

By S. H. Reynolds, M.A., Sc.D., F.G.S.

(*Read in title, 4th March,* 1937)

THERE are two chief groups of natural caves—sea-caves, formed by the battering action of the waves, and inland caves, formed by the dissolving action of rain water. A third class of caves, produced in some cases when, at the edge of a lava flow, the still liquid lava runs out from beneath a roof formed by the consolidation of the surface layers, is comparatively rare and unimportant, though there are many caves in the lavas of Iceland. Shelters, formed when a softer band of rock overlain by a harder band is worn away by wind or water action, leaving a verandah-like projection, are not uncommon.

Sea-caves may be worn in any hard rocks, inland caves as a rule only in limestones and related rocks.

Sea-Caves.

These are formed in fairly hard and compact rocks along lines of weakness, most commonly along joints, frequently along fault-lines, and sometimes, where sedimentary rocks are highly inclined, along bedding planes. Dykes also, when intruded into rocks more resistant than themselves, are frequently worn into inlets and caves.

The Old Red Sandstone rocks of the Orkneys and Caithness illustrate the formation of sea-caves in a remarkable manner. The sea working along a powerful divisional plane may erode a narrow inlet (goe or voe), which, starting as a cave, becomes progressively unroofed, producing a gully, the inner end of which may form a cave, or, after passing underground for a certain distance, may finally open to the surface by a blow-hole.

Columnar basalt presents a series of well-marked divisional planes to the erosive action of the sea and, particularly where the columnar rock is roofed over by non-columnar, sea-caves may arise. A classical example is afforded by Fingal's Cave, Staffa.

The formation of sea-caves may be well seen on almost any rocky coast. (Pl. 26, *a*, *b*.)

Inland Caves.

Inland caves are far more important than sea-caves owing to their number, beauty and great scientific interest dependent on the fact

that they so frequently contain the remains of their former inhabitants, human and non-human.

They are formed by the dissolving action of rain water containing CO_2 in solution. The surface drainage in limestone countries is interrupted by openings—sink-holes or swallets—into which the water passes, and in course of time produces a system of passages and chambers, often of great length and complexity. Eventually, new channels are opened out at a lower level and the earlier ones may be left dry, as is well seen at Cheddar.

The most numerous and important limestone caves in the British Islands are those in the Carboniferous Limestone, and include those of the Bristol District and the Mendips, of North and South Wales, of Derbyshire and West Yorkshire and of Ireland. The caves of Torquay, Brixton, Plymouth and elsewhere in South Devon are in Devonian Limestone, while those of Creswell Crags in Derbyshire are in Magnesian Limestone. The once famous Kirkdale Cave in East Yorkshire was in Upper Jurassic Limestone (Corallian), but has long since been destroyed by quarrying. It yielded the remains of over 300 hyaenas.

In Scotland there are caves in the Cambrian Limestone of the North West Highlands.

Of the numerous caves in the Carboniferous Limestone of Ireland, those of Shandon near Dungarvon, of Ballynamintra, co. Waterford and of Kesh, co. Sligo are among those of which the contents have been most fully studied, while the caves of Mitchelstown ($1\frac{3}{4}$ miles) and Slieve Elva, both in co. Clare, are probably the most extensive in the British Isles. Explorers have traversed the latter cave for two miles from the entrance, and it continues still further. Other extensive Irish caves are those of Banteer, co. Cork, Dunmore, co. Kilkenny, Knockmore and Florencecourt, co. Fermanagh, and Aille, Westport, co. Mayo.[1]

In the face of the precipitous or highly sloping limestone cliffs of Gower in South Wales occurs a series of caves which combine some of the characters of sea-caves and of inland caves. They apparently originated like other limestone caves by solution but were enlarged by marine action. Subsequently they were raised to their present height of 20-40 feet above sea level. They include some of the most important bone-caves of the British Isles.

The Bristol District is particularly rich in bone-caves and fissures which contain deposits ranging in date from Middle Palæolithic

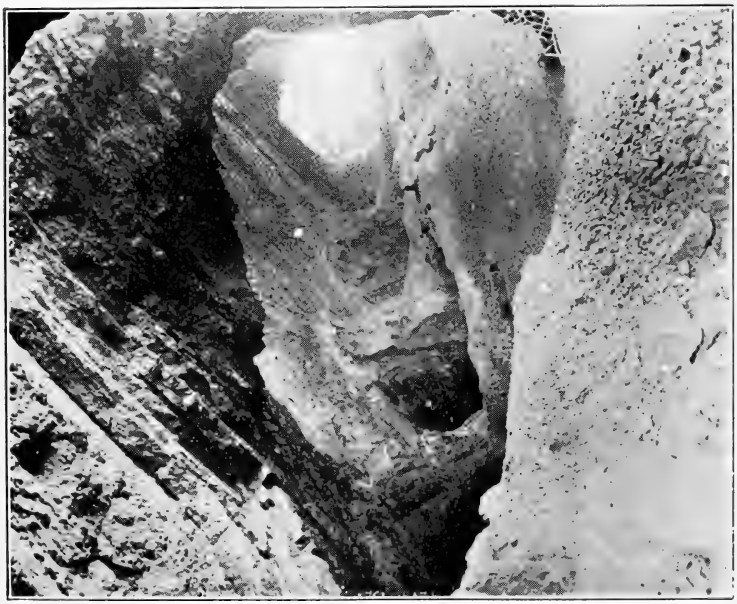
[1] The above information regarding Irish caves was kindly supplied by Professor J. Mitchell of Galway.

(*a*) SEA-CAVES WORN IN HORIZONTALLY-LYING CARBONIFEROUS SANDSTONE. COAST N. OF BERWICK-ON-TWEED. (1931)

(*b*) SEA-CAVES WORN ALONG THE BEDDING PLANES OF HIGHLY INCLINED FLAGSTONES AT SYBIL HEAD, CO. KERRY. (1900)

[*To face p.* 170

(b) FAÇADE OF A THREE-STORIED BUDDHIST CAVE TEMPLE CUT IN A BASALTIC ROCK AT ELLORA, WESTERN INDIA. (1897)



(a) CAVE (UNDERGROUND QUARRY) IN HIGHLY INCLINED WENLOCK LIMESTONE, WREN'S NEST, DUDLEY. (1935)

(Mousterian) to Iron Age.[1] The great majority are in Carboniferous Limestone, but a few, including Rowberrow and the superficial Wookey caves, are in Dolomitic Conglomerate. Several of these were explored in early days by the late Sir William Boyd Dawkins, while an immense amount of work has been carried out during recent years by the members of several Somerset societies for the study of caves and of the University of Bristol Spelæological Society. The Hyaena den at Wookey, studied by Boyd Dawkins, has long been famous as one of the first places in England yielding proof of the co-existence of Man and the extinct Mammalia. Attention may be drawn to Mr. H. E. Balch's splendidly illustrated volume, *Wookey Hole, its Caves and Cave Dwellers*, published in 1914.

The following classification of some of the caves of the Bristol district was supplied by Mr. E. K. Tratman :—

Iron Age - - - - - - - -	Wookey Cave.
	Read's Cave, Burrington.
Early Bronze - - - - - - -	Rowberrow.
Magdalenian - - - - - - -	Aveline's Hole, Burrington.
	Gough's Cave, Cheddar.
Solutrean - - - - - - - -	Uphill Cave.
Solutrean (probably) and Aurignacian	Hyaena den, Wookey.
Early Aurignacian to late Mousterian	Walton Cave, near Clevedon.

The British caves as a whole, great though the archæological interest of some of them is, yield in importance to those of Southern France and Northern Spain, where the late Palæolithic races of men (Aurignacian to Magdalenian) have left an astonishing series of wall-paintings of animals, sometimes in monochrome, sometimes in polychrome. The animals most commonly shown in the paintings are the bison and the horse, but many other contemporary animals, such as the mammoth and woolly rhinoceros, the lion and the cave bear, are represented in the work left by the late Palæolithic cave-dwellers. In one of the caves of the South of France, bison modelled in the round in clay were found.

The only cave paintings comparable in merit to these are those of the modern Bushmen of South Africa, though cave paintings are also known in Australia.

[1] For a short summary of the results obtained, see L. S. Palmer in the *Handbook to the Geology of the Bristol District*, prepared for the 1930 meeting of the British Association for the Advancement of Science, p. 52.

Among European regions where extensive caves occur may be mentioned :—

The Belgian Ardennes	(Carboniferous Limestone)
Central France	(Jurassic)
Westphalia	(Devonian)
Bavaria and Franconia	(Jurassic)
Istria	(Cretaceous)
Moravia	(Devonian)
Sicily	(Cretaceous)
Malta	(Miocene)
Gibraltar	(Jurassic)

Some of the most extensive and remarkable caves in Europe are those of Postumia near Trieste.

Among extra-European caves most famous for their size and beauty are those of Oudtshoorn (Cretaceous) in the Cape Province, South Africa, of Jenolan in New South Wales, and, in particular, of Kentucky, U.S.A. The Mammoth Cave of Kentucky is probably the most extensive in the world.

There are great numbers of caves in the limestone districts of the Eastern Mediterranean, several of the Greek caves such as those of Parnassus playing an important part in Greek mythology.

In Palestine the abundance of caves contributed materially to the difficulties in dealing with the recent disturbances. It is a remarkable fact, in view of the subsequent religious importance of caves, that there is nothing to show that in early times any caves in Palestine were regarded as sacred or were used for worship, but all through Jewish history they served merely as places of refuge. Thus we have the caves where the Israelites took shelter from the Midianites in the times of Gideon,[1] and the Philistines in the time of Saul,[2] David's Cave of Adullam[3] and Saul's of Engedi,[4] the cave where Obadiah[5] hid the prophets of the Lord in the time of Jezebel, and the caves of the Gadarene demoniacs.[6] But when the Christian religion came to be established in Palestine, it is scarcely incorrect, as Dean Stanley remarks in his *Sinai and Palestine*, to say that it became a religion of caves. Whenever a sacred tradition had to be fixed, a cave or grotto was immediately selected or found as its home, even if there is nothing in the biblical account of the event commemorated to show

[1] Judges vi. 2. [2] 1st Sam. xiii. 6. [3] 1st Sam. xxii. 1.
[4] 1st Sam. xxiv. 3. [5] 1st Kings xviii. 4. [6] Matt. viii. 28.

that it took place in a cave. First in antiquity is the grotto of Bethlehem, already, in the second century, considered to be the scene of the Nativity. Next comes the grotto on the Mount of Olives selected as the scene of Christ's last words to His disciples before His Ascension. Then followed the cave of the Holy Sepulchre at Jerusalem, that of the Annunciation at Nazareth, and that of the agony at Gethsemane, and many others.

Caves wholly or partly artificial.

Of the innumerable caves large and small which have been formed by solution in limestone regions a considerable proportion have been artificially enlarged. This is particularly the case in Palestine, where the Tombs of the Kings at Jerusalem, the cave of Macpelah at Hebron, which Abraham bought, and many of the caves at Beit Jabrin, between Hebron and Gaza, have been enlarged for burial purposes. The latter group forms the most remarkable series in Palestine and, in addition to numerous smaller sepulchral caves, includes a large one, 100 feet across and 30 to 40 feet high. Some of these caves, in early Christian times, were adapted for use as churches. The great Egyptian tombs of Luxor were hollowed out in soft Eocene limestone, and are entirely artificial, as Dr. W. F. Hume informs the writer.

Quarrying operations are sometimes carried on underground and may result in extensive artificial caverns such as those of Tilly Whin near Swanage (Portland Stone), of various places near Bath (Great Oolite) and of Solomon's quarries, Jerusalem. Extensive "caves" have also been made by quarrying operations in the Wenlock Limestone of the Wren's Nest at Dudley. Owing to the high dip, these pass steeply underground and have a distinctly forbidding aspect. (Pl. 27 *a*). The dene holes in the Chalk of the South and East of England, excavated for the purpose of extracting flints, may be alluded to here. Limestone, however, with the exception of chalk, is too hard a rock for cave-making by artificial means to be carried out easily. Far more satisfactory is sandstone if it be fairly hard, thickly-bedded and well-jointed.

Petra, which lies some 50 miles to the south of the southern end of the Dead Sea, is probably the most remarkable locality in the world for sandstone caves. The rock—the Nubian sandstone—is generally a thickly-bedded ferruginous stratum of doubtful—possibly Carboniferous—age. The caves, large and small, natural and artificial, which are scattered in hundreds over the steep sides of the Petra ravines, are, in the main, sepulchral in character (Pl. 28 *a*). The earliest are

believed to have been made by the Edomites, a Semitic people, who were in possession of the country prior to the invasion of Palestine by the Jews under Joshua. In the fourth century before Christ, the Nabateans, another Semitic people, overcame the Edomites, made Petra their capital, and excavated certain of the large cave temples as well as innumerable tombs. The most remarkable of the temples at Petra were, however, made by the Romans after Trajan, in A.D. 106, had extinguished the Nabatean kingdom. (Pl. 28 *b*.)

At various places in the Triassic area of the English Midlands, examples of caves hollowed out in the massive red sandstone occur. Professor A. E. Trueman has contributed the following note regarding those of Nottingham :—

> "The Bunter Sandstone around Nottingham has long been famous for its caves. The readiness with which it can be excavated was probably a factor in the location of the early Saxon settlements. The so-called Robin Hood's caves in Nottingham are of some antiquity, while in the older parts of the city, which are built on Bunter Sandstone, are extensive cellars hewn out of the sandstone. The famous old inn, the 'Trip to Jerusalem,' which is built up against the steep Bunter cliff, immediately under the Castle, has rooms as well as cellars cut right into the rock."

Cave dwellings are found at various places in the western territories of the United States, including the Grand Canyon of the Colorado river, Arizona. (Pl. 29 *a*.)[1]

The peculiar *loess*, an unstratified loam of æolian origin which occurs in central Europe and covers vast areas of China, is so firm and compact as to give rise through stream erosion to deep precipitous gorges, in the sides of which elaborate cave dwellings have been hollowed out by the Chinese.

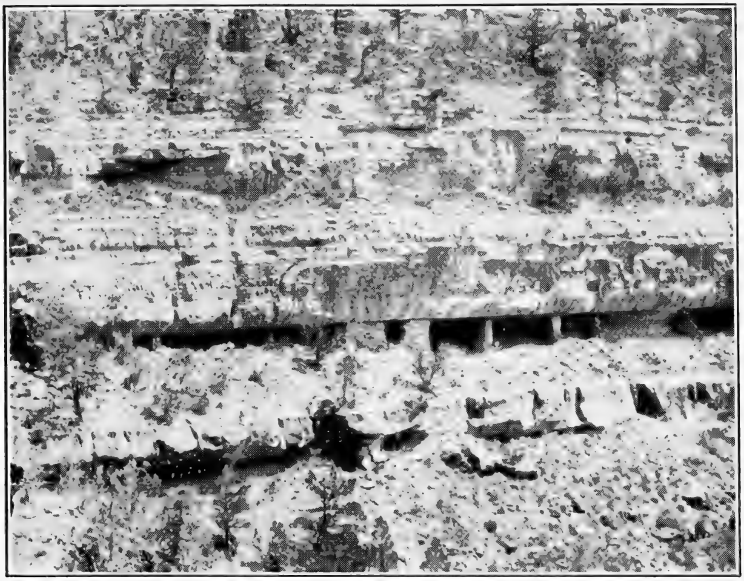
Probably, however, the most remarkable artificial caves are those in igneous rocks, particularly lavas and tuffs. Of the lava caves, the Indian examples of the Deccan at Ellora, Ajanta, Elephanta, Karli and Nassik are the most important. The most famous series, that of Ellora, some 30 in number, are all carved in the steep slopes of a basaltic hill. They belong to three religions, Buddhism, Brahmanism (Hinduism), and Jainism. The earliest and most numerous are Buddhist (Pl. 29 *b*), some of them probably dating from the fifth century, the latest and fewest are Jain. Most of the caves are one-

[1] Pl. 29, *a*, is from a photograph by the late W. H. Banks, the remainder are from photographs by the writer.

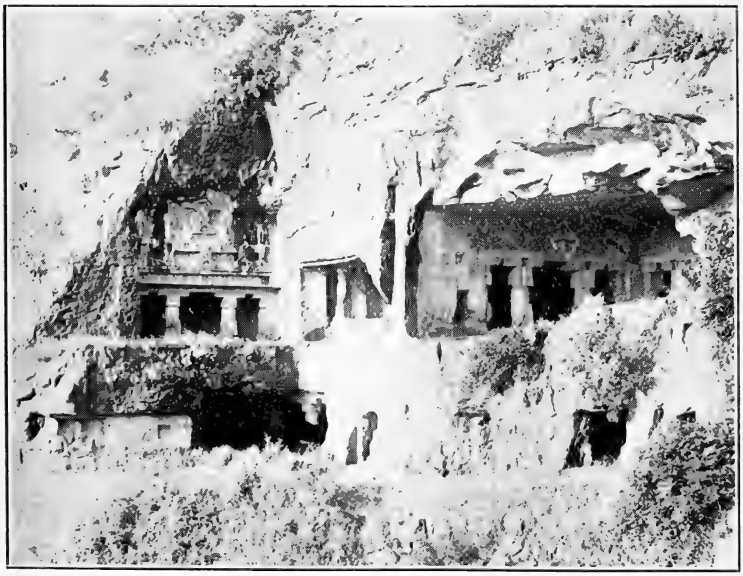
(*a*) SMALL SEPULCHRAL CAVES IN NUBIAN SANDSTONE, PETRA. (1936)

(*b*) TEMPLE CUT IN NUBIAN SANDSTONE, PETRA. (1936)

[*To face p.* 174



(*a*) CAVE-DWELLINGS, GRAND CANYON OF THE COLORADO, ARIZONA, U.S.A.



(*b*) BUDDHIST CAVES CUT IN BASALTIC LAVA AT ELLORA, WESTERN INDIA. (1897)

storied, but some may have two and others three stories. (Pl. 27 *b*.) Sometimes there is a carved facade, sometimes a courtyard with subsidiary features is excavated at the entrance. In one case, that of the famous Kailas, the rock has been cut away externally as well as internally, so that a complete temple has resulted standing in a pit. It is believed to date from the second half of the eighth century.

Plutonic and gneissic rocks are too hard for the excavation of extensive caves but, at the Seven Pagodas near Madras, a series of small cave temples with carved facade and reliefs have been cut in a coarse granitic rock. They are Brahminical in character and may date from the second half of the eighth century. In Ceylon the gneissic rocks are unfavourable for cave production, and the Buddhist cave temples, which are not very numerous or extensive, seem in the main to be partly closed-in rock-shelters.

Compact tuffs afford excellent material for excavation, the most famous examples being the Roman catacombs, but these can hardly be termed caves.

Even more remarkable are the cave dwellings of Cappadocia, cut in an immensely thick deposit of soft pumiceous tuff which has been worn by subaerial erosion into an extraordinary series of conical peaks varying in height from 50 to 300 feet. In these cones and in the adjacent cliffs, dwellings of several stories and even churches and monasteries have been hollowed out. Access to the upper stories is by means of ladder holes, either external or cut in the walls of vertical chimney-like passages. Some of the caves are natural ones artificially enlarged, many thousands are purely artificial and are said to be of all dates from about 2000 B.C. to the present time. Some of the larger caves show architectural features of Classical, others of Byzantine, character. Cave dwellings are alluded to by several classical writers, including Herodotus and Xenophon.

Bristol Botany in 1936

By Cecil I. Sandwith

(*Read in title, 4th March,* 1937)

THE notes for this year show satisfactory work. The Botanical Section owes a debt of gratitude to Mr. Ivor Evans for his " labour of love " in undertaking voluntarily the arduous task of making a complete copy of the notes made by the late Miss Ida M. Roper in her interleaved volume of White's *Bristol Flora,* which, by misfortune, was lost to Bristol. It is hoped that these valuable notes will be typed and kept in the Society's Library.

Mr. N. Y. Sandwith, having first-hand knowledge of the history of the new *Epilobium* in this country, has kindly contributed a note, and has also dealt with some of the complicated nomenclature of the Willows referred to. It is interesting to note that the Willow-herb, like the Oxford Ragwort, is travelling and has already reached our Docks. It may be looked for anywhere, and is already hybridising with other well-known species.

Hutchinsia petræa (L.) R. Br. Near Charterhouse-on-Mendip, S., *W. S. Parry,* see *Proc. Som. Arch.* and *Nat. Hist. Soc.,* lxxxi (1935). A very interesting discovery, perhaps confirming the old records (*J. C. Collins* in *New Bot. Guide,* 1837) from Cheddar given in the *Bristol Flora.*

Astragalus glycyphyllos L. In a large lime quarry at Cromhall, G., *Ivor Evans.*

Lathyrus tuberosus L. Disused railway bank, Hallen, G., flowering in Oct., 1936, *Miss M. Bowen.*

Agrimonia Eupatoria L. forma *albiflora* Caspary. About a score of plants on a grassy roadside bank of a deep rhine, Oldbury Lane, G., 1927-9, *E. Nelmes.* Not previously recorded outside E. Prussia. Albinos of yellow-flowered species are always uncommon, but are well known in such genera as *Ranunculus* and *Verbascum.* The above plant has been grown at Kew and breeds true to the white colour, see *Journ. Bot.,* lxvii, 341 (1929). A similar plant, labelled " *Agrimonia leucantha.* Origin unknown," has been cultivated at Kew for some years.

Pyrus Pyraster Bor. A tree with orbicular or ovate-orbicular leaves, rounded-truncate or slightly cordate at the base, and bearing

a few spines, has been known since 1920 in a wild part of Leigh Woods, S., *C.* and *N. Sandwith.* The tree flowers but no fruit has yet been seen, so that no varietal name can be assigned to it.

Sorbus bristoliensis Wilmott in *Proc. Linnean Soc.*, Session 146, part ii, p. 76 (1934). Mr. A. J. Wilmott has shown that British *Sorbus latifolia* (Lam.) Pers. cannot be identified with the true *latifolia* of Fontainebleau. He distinguishes the plants of the Wye Valley, Avon Gorge, Minehead and Lynton as four distinct, uniform "lineages" intermediate between *S. Aria* (or one of its allies) and *S. torminalis*, from which they probably arose at some period, and gives new specific names to the first three. Thus our Bristol *S. latifolia*, which has sometimes been known as *S. latifolia* var. *decipiens*, receives the new name of *S. bristoliensis*, and is the first species of flowering plant to commemorate our city and to be described as an endemic of our area.

Cratægus monogyna Jacq. var. *stricta* Loddiges. Nupdown, G., July, 1932, "looking like a hedgerow pear tree," *E. Nelmes.*

Epilobium adenocaulon Hausskn. Avonmouth Docks, G., 1935, *C. Sandwith.* Portishead Dock, S., 1936, new to v.c. 6, *N. Y. Sandwith* and *J. P. M. Brenan.* New to the district. For a full account, with description and plate, of the appearance of this North American species in Britain and on the Continent, see G. M. Ash and N. Y. Sandwith in *Journ. Bot.*, July, 1935, pp. 177-184, pl. 609. It occurs in abundance over wide areas in S.E. England, being found in woods and other perfectly natural localities, and hybridising with several of our native species ; and was found many years ago by Rev. H. J. Riddelsdell in Woodchester Park, W. Glos. It may, therefore, be expected to spread in the neighbourhood of Bristol, although up to the time of writing it has been found only as a casual on our docks. Hybrids with *E. montanum* and *E. parviflorum*, named by Mr. G. M. Ash, have been collected at Avonmouth. *E. adenocaulon* is near *E. tetragonum* and its allies, the salient characters being the rosulate innovation leaves, the spreading gland-tipped hairs on all the upper parts, the oblong-lanceolate, petiolate, almost glabrous leaves, the peculiarly small pale pink corolla, and the pellucid apical beak of the seed. *E. roseum* is immediately distinguished by the colour of the flowers and the much longer petiole of the leaf, as well as by the seed, which has no apical beak.

Œnothera stricta Ledeb. This is the correct name for the Berrow and Burnham sandhill *Œnothera*, which has been passing for many

years (both in the Bristol district and in other British localities) as *O. odorata* Jacq. The latter, according to a recent revision by P. A. Munz, has more glaucous and more crisped leaves.

Apium inundatum (L.) Rchb. In the Hill district, G., 1933, *E. Nelmes.*

Lysimachia nemorum L. With primrose-coloured flowers in an open broad ride in Michaelwood, Damery, G., 1929, and flowering freely in 1936, *E. Nelmes.*

Verbascum nigrum L. On a wall in Hinton Lane, Granby Hill, Clifton, G., July, 1936, *Ivor Evans.*

Linaria repens (L.) Mill. × *vulgaris* Mill. = *L. sepium* Allm. Disused railway bank, Hallen, G., Oct., 1936, *Miss M. Bowen.* The first record for the district.

Veronica Anagallis-aquatica L., sensu stricto. Ditch between Rangeworthy and Yate Lower Common, G., 1936, *C.* and *N. Sandwith.*

Nepeta hederacea (L.) Trev. Plentiful and persistent with pure white flowers near South Stoke, Bath, S., *Ivor Evans.*

Rumex conglomeratus Murr. × *maritimus* L. = *R. Knafii* Čelak. In a shallow part of a pond at Hill, G., with the parents, Sept., 1936, *E. Nelmes.* Mr. Nelmes writes, "This has apparently been recorded for Britain as it is included in Druce's List, but I cannot find any published record." Certainly new to the district.

Salix alba L. × *fragilis* L. = *S. viridis* Fr., sens. lat., ♀. Streamside below Ashley Hill, G., June, 1936, *C. Sandwith.* Confirmed by Dr. B. Floderus, of Stockholm. A first record for the district, although noted by Mr. White (*Bristol Flora*, p. 535) as very likely to be present. It should be added that certain trees with male catkins, many of which are curiously forked, occurring in several spots (Keynsham, Pensford, Brent Knoll and Berrow, S.) are apparently to be referred to the forma *monstrosa* of the male condition of this hybrid.

S. atrocinerea Brot. On a recent visit to this country, the world's leading salicologist, Dr. B. Floderus of Stockholm, pointed out that British *S. cinerea* L. differs from the Continental plant bearing this name and from the specimens in the Linnean herbarium. He refers all British material to *S. atrocinerea* Brot., which is a strictly "Lusitanian" species occurring in Portugal, Spain and Britain, being rare and little known in France. *S. atrocinerea* has a fine pubescence with a mixture of reddish or rust-coloured hairs, whereas the indumentum of *S. cinerea* is wholly ashy-grey. See *Rep. Bot. Soc. Exch. Club*, 1932, p. 369 (1933). Bristol *S. cinerea* must, therefore, be known in future as

S. atrocinerea; and a specimen at Kew, collected by Mr. White, of the Walton-in-Gordano *S. rugosa* Leefe (see *Bristol Flora*, p. 537) has been determined as *S. atrocinerea* × *viminalis* by Dr. Floderus.

S. repens L. Similarly, Dr. Floderus has shown that pure *S. repens* should have glabrous ovaries and pedicels, and is perhaps unknown in this country at the present day; he would refer the bulk of our material to *S. arenaria* L. × *repens* L., the theory being that these two species have been crossing and back-crossing for thousands of years, and may not even have entered this country in a pure condition.

Populus italica Mœnch × nigra L. Trees bearing female catkins, and with the branches slightly more spreading than those of the Lombardy Poplar, were noticed in April, 1936, between Keynsham and Saltford, S., by *C. Sandwith* and *J. P. M. Brenan*. *P. italica* is said by specialists to be invariably staminate, and "Female Lombardy Poplars" are referred by them to hybrids between *P. italica* and *P. nigra*, or, as some would put it, between *P. nigra* var. *italica* and *P. nigra* var. *typica*.

Spiranthes spiralis (L.) C. Koch. Still occurs sparingly on Durdham Down, G. Three or four flowering spikes were seen in 1934, and two in 1936, by Mr. H. O. Edmonds.

Potamogeton trichoides Cham. et Schl. Near Weston-super-Mare, S., 1934, *Miss M. Taylor*, det. *W. H. Pearsall*, see *Rep. Bot. Soc. Exch. Club*, 1934, p. 845 (1935). New to the district and to North Somerset. It is hoped that this record of a rare and critical species will be confirmed.

Carex Hudsonii Ar. Benn. Very sparingly in a rhine on Weston-in-Gordano moor, S., June, 1936, *C.* and *N. Sandwith*. Identified by Mr. E. Nelmes of Kew. This is the second station in N. Somerset for this local species.

Bromus madritensis L. In *Journ. Bot.* for August, 1936, pp. 240-241, Mr. H. S. Thompson calls attention to the great increase of this species on the Downs during the last two years.

B. lepidus Holmb. Old quarry near Twerton-on-Avon, S., May, 1936, *C.* and *N. Sandwith*.

ALIENS. Singularly little of interest was collected during 1936 on the city tips and docks. *Carum copticum* Benth. et Hook. f. occurred at Avonmouth in 1935-6; and *Axyris amarantoides* L. was found in allotment ground by Weston-super-Mare Station

in Sept., 1936. Mr. Ivor Evans records *Bromus inermis* Leyss. from the Filton railway at Stoke Gifford, G.; *Hesperis matronalis* L. from a quarry at Cromhall, G.; *Lactuca macrophylla* (Willd.) A. Gr., a garden outcast, in a lane leading from Sea Walls to the Avon, G.; *Clematis Flammula* L. on rocky ground in Bourton Combe, S.; and two very interesting aliens on waste land above Oldfield Park, Bath, S., viz., *Glaucium grandiflorum* Boiss. et Huet, a first record for Britain, and *Reseda inodora* Reichb. In the last-named locality he also found *Althæa hirsuta* L.

Review

ECOLOGY IN TOWN AND CLASSROOM

By Rose Bracher, M.Sc., Ph.D. Bristol: J. W. Arrowsmith, Ltd., 1937. 2s. 6d. net.

In 1934 Dr. R. Bracher's useful little book on *Field Studies in Ecology* was published by J. W. Arrowsmith, Ltd. This has been suitably followed in May, 1937, by her *Ecology in Town and Classroom*—a companion volume at the same moderate price, "containing observations and experiments especially suitable for the town worker." This handbook deals with those types which, "being in or near a town, come directly under human influence and, as such, may be termed artificial." Therefore, to those living in or near Bristol this book should be particularly helpful and interesting; for the number of flowering plants, ferns and mosses growing on our walls, banks, and in some of the Bristol streets is remarkable.

The three chapters on The Vegetation of the Street, Waste Ground, and the Vegetation of Coal Tips are apt and to the point. Chapter V, on Tidal River Banks, is particularly well done. Its sections on Physiographic, Edaphic and Biotic factors respectively are helpful and clear. Indeed, Miss Bracher has had practical experience of the ecology of no less than ten of the chief tidal rivers of England, extending from the Thames, Severn and Bristol Avon to the Mersey, Ribble, Lune, Humber and Ouse in the North. As is well known, she has made a special study of that little organism the flagellate *Euglena limosa*, which inhabits tidal mud and often gives it a bright green colour.

The chapter on Colonization and Succession is also important and helpful, and is clearly divided into sections, e.g., a "Street succession" starts with minute algæ; stage 2 shows protonema and young plants of the moss Bryum and seedlings of the tiny green flowering plant *Sagina procumbens*; and stage 3 shows half a dozen flowering plants.

Among the excellent illustrations are some very clear and unusual ones of underground root-systems. Except for the full Index, the volume ends with a useful and ample bibliography, in which, of course, is found Mrs. Sandwith's important work on *The Adventive Flora of the Port of Bristol.*

H. S. T.

Ornithological Notes, Bristol District, 1936

By H. H. Davis, M.B.O.U.

(*Read in title, 4th March,* 1937)

THE increased interest taken in the bird-life of the Bristol district during recent years has been well maintained in 1936, and as the succeeding pages will show, a number of noteworthy observations have been reported.

It is pleasing to know that so wary a species as the Raven can become sufficiently indifferent to the presence of man as to nest immediately overlooking the road, river and rail traffic of the Avon Gorge. That a pair have now done so seems to indicate a spread from one of the two long established breeding sites in the Bristol Channel.

The continued presence of Crossbills early in the year, as a result of the 1935 invasion, was not unexpected, while the visit of Pied Flycatchers on Spring passage, and a Sandwich Tern in Autumn are events which, although probably occurring more frequently than is supposed, do not often come under the notice of observers.

In spite of the Bristol area being on the border-line of its westerly range in Britain, that graceful little falcon, the Hobby, can still be numbered among our Summer visitors.

A Common Scoter, Goosanders, and Slavonian Grebes have been seen at the North Somerset reservoirs, while the visit of a Sheld-Duck, two Little Stints, and a Kittiwake to Barrow constitute three additional species to the list of Birds at the Barrow Gurney reservoirs.[1] Owing to the abnormally wet Summer and the consequent high water level at both Blagdon and Barrow, very few waders were observed at either place in September, and at no time has there been a repetition of the unprecedented number of Duck as recorded at Barrow in December, 1935 (cf. *Proc. Bristol Nat. Soc.*, 1935, p. 105).

Among more familiar waders at the Severn mouth in Autumn, Grey Plover, Curlew Sandpipers, a Little Stint and Bar-tailed Godwits were identified, and a party of eighteen of the latter was seen there in Spring.

The following classified notes represent the more important observa-

[1] A complete list of Barrow Gurney Reservoir Birds is given in the *Proceedings of the Bristol Nat. Soc.*, 1933, pp. 467-9. To this list must also be added the Knot (*Calidris c. canutus*) and the American Pectoral Sandpiper (*Calidris melanotos*), both of which were identified at Barrow in September, 1935 (cf. *British Birds*, Vol. XXIX, p. 183).

tions made during the year by various members of the B. N. Soc. Ornithological Section.

Raven (*Corvus c. corax*). The breeding of a pair in the Avon Gorge for the only time on record was an event of considerable interest. The birds were first noticed on February 19th, and within a few days were seen carrying sticks to a site on the Gloucestershire side. It is most satisfactory to relate that three young were successfully reared, although unfortunately two of these came to grief a few weeks after leaving the nest.

On several previous occasions Ravens have been observed in the vicinity of the Gorge; that they remained to breed in the present year was certainly some recompense for the fact that for the first time since 1928 the Peregrines' eyrie was untenanted. It is now to be hoped that the Avon cliffs, like those of Brean Down and Steep Holm, will become an annual stronghold of both Raven and Peregrine, and that the attractions of the Gorge may be still further enhanced by aerial combats such as are often witnessed wherever the two species are close neighbours.

Crossbill (*Loxia c. curvirostra*). In common with other areas in southern Britain, an immigration occurred on the Somerset side of Bristol during the latter half of 1935, and, in consequence, Crossbills were still tolerably abundant in the early part of 1936. They were frequently seen at Long Ashton from January to mid-March, while in the Leigh Woods and Failand districts, flocks, varying in size, were noticed until the second week in May. Although nesting has previously taken place in the above localities (cf. *Reports on Somerset Birds*, 1930, p. 7, and 1934, p. 7) there is no evidence to show that any remained to breed during the present year.

Corn Bunting (*Emberiza c. calandra*). A single bird was frequenting a vetch field near Stoke Gifford for a short while on the evening of July 16th, but was not seen afterwards. Although occurring and breeding locally on the Cotswolds, it is apparently not often noticed in close proximity to the city.

Pied Flycatcher (*Muscicapa h. hypoleuca*). Several visited Leigh Woods during the Spring migration. Two males seen there on April 15th remained until the 20th. A single bird was reported at the Abbots Pool on the 22nd, and another in Leigh Woods on May 2nd. One—female or immature—was observed in a copse on the outskirts of Tortworth Court on August 2nd.

Hobby (*Falco s. subbuteo*). On July 10th a pair was watched at

close quarters on the Gloucestershire side of Bristol where the species has been noticed each summer since 1932. No information, however, is yet forthcoming regarding an eyrie in the district.

On a recent occasion, and almost within sight of the city boundary, Mr. J. H. Savory and the writer were fortunate in being able to obtain a telescopic view, at 150 yards range, of a Hobby plucking a kill.

Sheld-Duck (*Tadorna tadorna*). Two were seen at Blagdon on February 1st, and one on No. 3 reservoir, Barrow Gurney, on the 2nd. Although common on the coast, it is seldom seen at the reservoirs, and there is no previous record of its occurrence at Barrow.

Pintail (*Anas a. acuta*). A pair was observed at Blagdon on April 5th. Recorded at the North Somerset reservoirs fairly frequently but only in small numbers.

Scaup (*Nyroca m. marila*). An adult male was again present on Barrow Gurney reservoirs where it remained from January until the third week in April or later. That a single male should be the sole representative of this species each winter at Barrow during the last four years suggests the probability of its always being the same bird (cf. *Reports on Somerset Birds*, 1933-36).

Goldeneye (*Bucephala c. clangula*). Although not of infrequent occurrence it may be of interest to record that among seven or eight Goldeneye at Blagdon on December 26th was one very fine adult male.

Common Scoter (*Oidemia n. nigra*). A single male was seen on No. 3 reservoir, Barrow Gurney, on September 26th but it had departed by the following day. This sea-going duck is an occasional visitor to the North Somerset reservoirs, more often in Spring, but at no time in anything but small numbers.

Goosander (*Mergus m. merganser*). A pair at Blagdon on April 5th were, for a few moments, under observation from a car at no more than twenty yards range. Has been fairly frequently recorded, usually in Winter, at the North Somerset reservoirs.

Great Crested Grebe (*Podiceps c. cristatus*). For the third successive year a pair bred on the lake at Tortworth Court. Two broods were reared, the first being hatched late in April, and the second on or about August 16th. The colonization of this water in 1934 corresponds with the noticeable east to west extension of the breeding range of this species, and it is interesting to relate that during the progress of the Great-Crested Grebe enquiry, 1931 (cf. *British Birds*, Vol. XXVI), no nesting pairs were reported from the Gloucestershire side of the Bristol area.

There were no less than fifty-three at Barrow Gurney reservoirs on August 9th, all of which were adults.

Slavonian Grebe (*Podiceps auritus*). One, in almost full breeding plumage, was observed on No. 3 reservoir, Barrow Gurney, on April 7th and 10th, but it had departed by the 19th. Another, in a similar state of dress, was clearly identified at Blagdon on April 11th. This species is of rare occurrence at the North Somerset reservoirs.

In Winter some difficulty may be experienced in distinguishing the Slavonian from the Black-necked Grebe, at which time both present a decidedly black and white appearance when on the water ; in Summer plumage the chestnut lower-neck of the former should prevent any confusion. Distinguishing characters at all times, however, are the slender up-turned bill and the arched forehead of the Black-neck as compared with the stout, straight bill, and the comparatively flat forehead of the Slavonian.

Golden Plover (*Charadrius apricarius*). A flock of about seventy were in company with Lapwings in a field at Little Stoke on January 24th. Although not an uncommon Winter visitor to this locality, it is usually only seen in small numbers.

Grey Plover (*Squatarola s. squatarola*). A party of twenty-one were frequenting the river bank between Avonmouth and Severn Beach on October 4th. When watched in flight, the black axillary feathers were plainly visible. This is the largest number yet recorded at the Severn mouth.

Curlew Sandpiper (*Calidris testacea*). Observed on the Avonmouth-Severn Beach mud flats on several dates in September. Three were there on both the 20th and 22nd. Although of regular occurrence on this stretch of mud in Autumn, it has not yet been reported there in Spring.

Little Stint (*Calidris minuta*). One was seen in company with Dunlin along the Avonmouth-Severn Beach mud flats on September 20th, while at Barrow Gurney reservoirs on the 26th two extremely tame birds were identified. The Barrow birds had left by the following day. These occurrences are of interest in that there appears to have been an unusual number of Little Stints passing through the British Islands at this time (cf. *British Birds*, Vol. XXX, pp. 195, 230).

Purple Sandpiper (*Calidris m. maritima*). Twelve, with Turnstones, on the Avonmouth-Severn Beach mud flats on March 29th is the largest number yet noticed there on any one day. A single bird on May 10th provides the latest date yet recorded for this species at the Severn mouth.

BAR-TAILED GODWIT (*Limosa l. lapponica*). A flock of eighteen between Avonmouth and Severn Beach on May 10th is the first Spring record of this bird at the Severn mouth. Of these, three were in partial and one in full red dress. As early as July 26th two were seen on the mud flats off Littleton-on-Severn.

BLACK TERN (*Chlidonias n. niger*). A fairly frequent visitor to the North Somerset reservoirs in Autumn, though less often in Spring, this Tern was again observed in September. At Barrow Gurney there were two or three on the 12th, while four were seen at Blagdon on the same date, and two on the 13th.

At Blagdon, on September 12th, there were also about six Common (or Arctic) Terns.

SANDWICH TERN (*Sterna s. sandvicensis*). One, an adult assuming Winter plumage, was identified by Mr. H. Tetley and the writer between Avonmouth and Severn Beach on September 30th. A clear telescopic view of the bird was obtained when the black bill and legs placed its identity beyond reasonable doubt. This Tern has rarely been noticed in the Bristol district and there is apparently no authentic record of its previous occurrence at the Severn mouth.

KITTIWAKE GULL (*Rissa t. tridactyla*). A single specimen, in the "tarrock" state of dress, was seen at No. 3 reservoir, Barrow Gurney, on August 9th. It was extremely tame and allowed an approach to within eight or ten yards. Another was picked up on the river bank near Severn Beach on November 15th. Typically a Gull of the open sea, the Kittiwake only visits the district occasionally, usually storm driven, or as a lost wanderer.

RED-LEGGED PARTRIDGE (*Alectoris r. rufa*). As in 1935, at least one pair bred near Stoke Gifford. In neither year, however, were more than two or three young reared. The heavy clay soil of this particular locality is probably unsuited to a bird, the natural habitat of which is reputed to be sandy or stony ground.

One, found dead at the water's edge of No. 1 reservoir, Barrow Gurney, on March 8th, may, from its head injuries, have been struck down by a hawk.

The Coast of Somerset (1)

By O. D. Kendall, M.A.

(*Read in title, 4th March,* 1937)

THE coast of Somerset is bordered chiefly by recent rocks, such as alluvium, and this is particularly true of the area surrounding the mouth of the River Parrett. In the south older rocks make up the coast line, and to the north Carboniferous rocks are seen at Clevedon, at Swallow Cliff, Worle and Brean Down. Patches of shingle are comparatively rare, and those found are usually of insignificant proportions.

The area immediately under review is an interesting one from many points of view, but although a good deal of attention has been given to it on the historical side, little seems to have been written on its morphological aspects. That there have been coastal changes is evidenced by a study of maps of the area, and some of these appear to have been of comparatively recent date.

It is proposed in this paper to make some mention of the evidence of change which can be traced from an examination of various map issues and other historical evidence, and from a series of plane table sketches which have been drawn recently. In the first place, this will be restricted chiefly to the area surrounding Stert and Fenning Islands and Stert Point, all standing at the mouth of the River Parrett. It is hoped to carry on observations and to collect further evidence concerning these.

It must be remembered that evidence from early maps can only be treated with reserve. A map may make no mention of a particular island, not of necessity because the island did not then exist, but possibly because it was relatively unknown and probably not easy of access and survey. It is not necessary in this place to detail the geography of the area under review. At the same time there are several geographical facts which are very striking and in certain cases exceptional. These may be briefly mentioned.

1. The range of the tide is greater in this area than in any other place in Europe. Some of the figures for Spring Tides are :—

Bridgwater Bar	35 ft.
Weston-super-Mare	40 ft.
Avonmouth	42 ft.

At low tide, the Parrett and the Brue rivers are fringed with mud banks which are often over 10 ft., and occasionally up to 20 ft. in vertical extent.

2. The Severn Estuary is renowned for its excessive muddiness. Sollas[1] regarded this as the result of "a storage of suspended sediment, the accumulation of days, weeks or even months. This accumulation is always being diminished by withdrawals seaward and as constantly renewed by fresh accessions provided by the denudation of the land." The sediment is finally carried some distance out to sea, but not until many journeys have been made with the tide. The muddiness has been estimated as being, in shallow parts of the channel, 35 grams per gallon.

3. The following figures are taken from the *West Coast of England Pilot*[2] and show the area as being very liable to gales.

Average number per year :—

England, S.W.	32·0
Bristol Channel	37·5
St. George's Channel	30·1
Irish Sea	35·3

In Neolithic times this area was undoubtedly affected and suffered considerable subsidence. Ussher,[3] discussing the submerged forest at Stolford, three miles west of the Parrett, suggested that, when this forest flourished, the land must certainly have stood forty feet higher. Boyd Dawkins,[4] writing of the same forest along Bridgwater Bay, considered that "the land then stood sixty feet above present level." This was probably the last important movement along this coast. Following that period, the coastline almost certainly had a very irregular outline in marked contrast to its present even contour. It must also have been cut back relatively quickly, since it is made up, at any rate in the Bridgwater area, of soft rocks. The outlet of the Parrett may have been considerably changed owing to the formation of spits and bars which would accompany the cutting back of the coast.

The bay into which the River Parrett flows is in itself an impressive feature, and is hemmed in to the north by the Brean Down limestone massif and bordered to the south by the lower slopes of the Quantock Hills. A line connecting these two points encloses an area along the coast made up of Stert Flats in the south and the Gore Sand and Berrow Flats in the north. These are very extensive and, at their

[1] All references are to the list on p. 207 and 208.

greatest extent, up to four miles in width. The Gore Sand at its highest points is not covered except at high tides. The five fathom line is a considerable distance further out into the channel, and the only deeper water is that of the Parrett itself, which, after hugging the shore to a point north of Burnham, makes a big sweep and finds its way out to sea between the Gore Sand and Stert Flats.

The course of the river as it nears the channel is a remarkable one, and there seems to be no obvious reason why it should not have continued on its course at Combwich and entered the sea in the Stolford district. Actually it runs for six miles beyond Combwich before swinging away from the coastline. South of Fenning Island, the channel winds a good deal and is almost dry at low tides. Admiralty instructions point out that considerable alterations in its depths are constantly taking place. The present position of Stert Point suggests that it has built up in a north-easterly direction and prevented the river from reaching the sea at a more southerly point. The break between Stert Island and Stert Point suggests further that the river has from time to time succeeded in breaching the point and forming subsidiary channels to the sea. Those occasions have probably witnessed a critical combination of winds and storm waves.

Greswell[5] mentions a scheme dated 1723 which concerned "the making of a new cut through a narrow neck of land about three-quarters of a mile across, near Combwich, from and out of Parrett river into the Severn Sea, to empty itself into Stolford Bay." No evidence of the scheme being actually attempted has been found. Another story relates that the cut between Stert Island and Stert Point was originally made by fishermen, and subsequently enlarged by the action of the tides. Other evidence suggests that Stert has become an island in comparatively recent times, and measurements of erosion which have been made in the last few years clearly demonstrate that the possibility of a breach between the sea wall and Stert Point must at many times have been a very real one.

Sandy beaches, which occasionally are broken by very small collections of shingle, are almost continuous between Brean Down and Burnham. A noticeable feature of the sands from Burnham to Berrow is their muddy surface. Over wide stretches there exists a kind of earthy top layer, while the sand itself appears to be impregnated with mud. The Stert Flats are very largely mud covered and there is little sand bordering the coastline in that district.

In some areas, such as Burnham, blue Lias clay may be seen, and this becomes more marked along and to the west of Stert Point. Along

the Point itself there is a very definite shingle formation, many of the pebbles of which are derived from the Lias to the west. As in so many other districts, the shingle was formerly used for road repair work. The shore formations are invariably the result of the prevalent drift from the west, and Stert Point itself has been the result of this. The shape of the Parrett mouth must also be largely influenced by the strong tides of the Bristol Channel and the very fine material which is drifted by them. Owing to the accumulation of sediment in the surrounding waters, there is a constant movement of mud. Sollas showed that quantities of sediment are supplied to the tributary streams during flood tide. Where any marked decrease in velocity takes place, there will be considerable sedimentation. Therefore, some of the silt will remain behind in the estuaries, although the greater portion is carried seaward. The mouth of the River Parrett gives clear evidence of this, both along the banks themselves and in the mud banks which are so pronounced. The same is true of the River Brue and the channel between Stert Island and the Point, as also along the coast of the Stert mainland.

Many parts of the levels of Huntspill and Burnham are below the level of high water. In places, also, the land nearer the sea is higher than that further inland, owing to the deposit of mud by the tides. This accretion has been aided by the construction of embankments which probably date back to Roman times.

On this stretch of coast the inhabitants have carried on a ceaseless warfare against the sea. In the last few years new defences have been completed between Stert and Stogursey. These have been described as a new kind of sea wall, consisting of piles with heavy planks across the areas between them, almost in the form of a net. It is hoped that the force of the waves will drive rock and sea through the gaps in this, and thus build up a solid wall.

At this point the value of the dunes, which stretch from Brean to Burnham, in protecting the land from the sea, may be mentioned. In such a district, where so much land behind them is low lying, they are very important and prevent floods during exceptionally high tides. Several of the dune ridges are stable. North from Burnham, however, there are very recent formations, and in other cases definite effects of wind erosion. Sand is constantly blown inland and occasionally the dune ridge is pierced during exceptional storms.

Near Berrow Church the dunes are definitely making, and a new dune line has been added since the 1904 edition of the six-inch map of the Ordnance Survey. The church itself is almost surrounded by the

dunes. A further stretch in front of this is building up rapidly and now covers a considerable area.

North of Burnham, however, a severe storm during the winter of 1935-36 caused much anxiety, and severe erosion resulted. The outer dune line was badly cut and, immediately north of the town, the foreshore was almost stripped of sand.

Immediately north of the Burnham Light a marsh has also been established since the edition mentioned.

In keeping with other rivers opening into the Bristol Channel, the River Parrett is subject to a slight bore, which is about two feet in height, at Spring Tides in March and September. If these are accompanied by gales from the south or south-west, the bore may be an impressive sight. At neap tides it is scarcely perceptible. Writing with reference to an unusual flood and tidal wave of September, 1903, Mr. Lunn[6] remarked: "I was informed that the tide of the night of September 10th last rose to 20 ft. 4 ins. on the gauge at Bridgwater Bridge (the gauge is 5·62 ft. above Ordnance Datum, Liverpool), instead of the predicted height of 15 ft. 4 ins. The tide ebbed and flowed four times at Bridgwater and two or three times at Highbridge. At the latter place, at the first ebb, the water sank 6 ft. and then flowed up higher than before. The flooding was not caused, below Combwich at any rate, by the might of the tide, but by the waves, which at times ran up for long distances in a solid body, one or two feet deep over the banks and walls. The high tide was caused by the wind, which at first blew from the south-west and heaped up the sea at the entrance of St. George's Channel and then, at the time of high water, veered round to the north-west, and in so doing drove the water up the Bristol Channel.

One of the earliest definite references to the area occurs on Speed's map of 1610[7] where the instructions for sailing up the mouth of the river were as follows: "To sail into the River Parrett from the westward from the port of Bridgwater you will first make a high round hill called Brent Knoll (500 ft.), nearly over Burnham Church which you must keep due east, and then sail along until you open Bridgwater Steeple. There you are to keep the north side of Burnham Church till you open the river to the eastward of the Warren House of Steart Point."

The Victoria History of Somerset[8] quotes from a survey of the coast dated 1625. "Along Somersetshire there is no coming near the coast with vessels of any burthen except it be for seven or eight miles west of Purshot (Portishead) Point, the rest is all almost flat ground whereon

is only two fathoms water even to Porlock a little creek the march between Somerset and Devon."

Before the days of lighted coasts, the task of approaching the mouth of the Parrett must have been a really perilous one, and to-day it is by no means simple.

The Burnham Lights, immediately to the north of Burnham, which are still used, have a rather interesting legendary history. It is suggested that they began as a lamp carefully tended by the wife of a fisherman and shown from her window to light her husband safely to his anchorage. The light must have been found really useful, for after the death of these people, their primitive lamp was succeeded by a more efficient light. Another story relates that in the days before the Burnham lighthouse, the spire of East Brent Church was kept white-washed to serve as a guide.

Historical Evidence.

Several writers have mentioned, rather incidentally, inundation and subsidence on this coast. Major[9] suggested that subsidence was in progress at any rate up to the time of the Roman occupation, and Poole[10] called attention to extensive sand-banks in the Bridgwater Level in which marine shells occur. He was further of the opinion that two successive subsidences had occurred, and that two former land surfaces could be recognised.

Billingsley[11] draws attention to the constant flooding of areas near the sea and the establishment of a commission of sewers in 1304. He says, "from Stert Point northward, the coast is flat and composed of vast sandbanks repelling the inundation of the sea, which, in ancient times, flowed up into the country covering with its waters that extensive territory now called Brent Marsh."

One of the early records of this area describes floods which occurred in 1607.[13] These are stated to have covered an area of twenty miles in length and at least five miles in breadth, and occurred over wide stretches of country to a depth of twelve feet. The sea reached Bridgwater and there were heavy losses of life and animals. Several villages were "buried in salt water" or "quite consumed." There are many other vague references to similar floods, but a manuscript called *Old Parish Records of Huntspill*[12] gives a very interesting summary of such happenings from 1703: "On Nov. 27, 1703, the sea broke into Huntspill and broke down the seawall and houses with a great wind." The village of Huntspill was originally mostly round and to the west of the parish church. The latter part was almost completely

destroyed by this flood and not rebuilt. Many traces of old buildings are still to be seen.

Many other floods are mentioned in the nineteenth century, and in all cases many hundreds of acres of land seem to have been covered.

Other evidences shows that before 1739[14] the Parrett had two outlets, separated by an island of about 80 acres. Of these the smaller and more northerly one was on the east side of the Gore Sand. In 1739, however, it was dammed by an accumulation of ice, and the current was diverted into the main channel. This led to a rapid deposit of mud, and this outlet became permanently blocked. There are many other interesting references to changes in this area, though, unfortunately, these are often vague and difficult to interpret accurately.

Speaking of the "strand" in 1851, Stradling[15] says, "I recollect when, for a few years it was nearly double its present width. When a boy I was taken in a chaise by my mother from Bridgwater to Stert Point, where there was a small inn for the accommodation of parties who visited the spot. That point is become an island, and at high tide, large vessels can now pass over what was once the carriage road." Other evidence, however, suggests that Stert Island was already in existence when Stradling made this trip. The carriage road was in some sort of use until very recent times, for Mr. Govett, who has farmed on Stert Point for the last thirty-five years, informs me that he used to take animals over to Stert Island, and his route may have been the old carriage way.

A record of the rapid accumulation of alluvial deposit was given by Phelps[16] writing in 1853. He states that an old channel of the River Brue at Highbridge was filled up in about 25 years to a depth of nearly 20 ft.

The best and most complete account of the erosion at Stert appeared in 1877.[17] That paper gave very detailed evidence, and the following extracts are taken from it.

"Along the edge of the common near Steart, there used to be a raised pebble beach, called the Chesil, of which very few traces remained when I saw it last (1871). Just at the end of the common on the road to Steart, there used to be, when I knew the place first (1851) a house inhabited. There was a gate on the north of it, and a low stone wall beyond the gate, through which passed the road to Steart, with the house on its right hand. All long since vanished. In 1869 a series of gales and high tides tore up the pavement and foundation of the house. Strewed fragments of the wall heaped up a shingle beach in what had once been the fireplace." The writer goes on to give further

THE MAIN SHINGLE RIDGE ALONG STERT LOOKING NORTH

EROSION ON STERT, ON THE BANK OF THE PARRETT AND NEAR THE EXTREME END OF THE POINT

THE LAST GROYNE TO THE NORTH ON STERT. NOTE EROSION

[*To face p.* 192

details which he had gleaned from old inhabitants. "In 1869, an old man told me he well remembered a farm house with its buildings and barton, far out to the north-west of Stert. I have also heard from old men that there was in those days (some sixty years ago) an island of considerable size near the mouth of the river, on which stood a house of entertainment which drove a roaring trade in the days of high protective duties. Brandy and foreign wines could be run with ease and safety upon this island. Now the place has been swept away. I am not sure whether this was the same island of which a small piece still remains and is used (or was six or seven years ago) as pasture for sheep. That island was once much larger and had cornfields on it. This I have been told by an old man who had in his youth helped to reap and carry the corn." Some of these remarks undoubtedly refer to Stert Island, but others may apply to Fenning Island. Knight,[18] writing in 1909, although not naming Fenning Island, seems to place both the "notorious inn" and the "cornfields" upon it. At that date, however, this island was definitely a part of Stert Point, and it apparently ceased to be an island on some date between 1891 and 1904, following the evidence of the six-inch map of the Ordnance Survey, as mentioned later in this paper.

Writing in 1922, Stuart Thompson[19] described a new marsh off Berrow of an area of 100 acres and nearly a mile in length. He suggested that the marsh had been built up as a result of a new channel running on its seaward side and so diminishing the force of scour over the flat between it and the sand dunes. He also noted at that time that there was an expanse of clean sand on the seaward side of this channel which was about two feet higher than the mud on its landward side.

The same writer quotes the harbour-master of Bridgwater as reporting a good deal of recent coast erosion between Stert Island, a mile from the end of Burnham Pier, and Stert Point on the west side of the Parrett mouth. At the same time the River Parrett was becoming gradually silted up. The erosion mentioned is still going on rapidly, and Mr. Govett, who is farming the land in question, has observed it for a considerable time.

Minor changes here are of constant occurrence. One definite proof of this may be quoted from a further paper by Stuart Thompson, 1923. A second examination of the area he described in the previous year revealed that the channel of which he spoke had become much silted up and that its north end had disappeared, and that the marsh itself had changed in form and area. A survey in 1936 showed the marsh

to have an approximate length of 1,300 yards and a maximum width of rather less than 300 yards. In shape it resembles a flattened crescent. At the Burnham Low Lighthouse end the marsh is very wet, and a channel on its landward side appears to be kept full by the sea. At the Berrow end, however, the marsh is drier and sand-logged, finally passing into dunes. As a consequence, the vegetation at the Burnham end is dense, while at the Berrow end it is in open patches only amid the sand.

About a quarter of a mile beyond Berrow Church and towards Brean, there is a small isolated marsh of about 300 square yards in area. This surrounds a small pool of about 50 yards diameter and is a recent formation which will probably be quickly incorporated in the dune belt.

Map Evidence.

An examination of old maps bears out the suggestion that there have been many changes in the navigable channels leading from the River Parrett, and in the positions of small islands at its mouth. It is probable that the river itself formerly flowed out to sea along a different course. Greswell[20] speaks of a rough sketch map dated about 1550 which suggests that the Parrett at that time flowed out to Stolford and Botestall, and, therefore, in a much more direct line than at present.

Stanford Cole[21] mentions a violent storm of 1798. This "was accompanied by a high tide, and drove the sea through a new channel that had opened in the River Parrett directly against the seawall, which from time immemorial had protected the level of Huntspill." Did this finally separate Stert Island from the Point? Apparently no map was produced in support of his statement. No map before that date has been seen which shows the island, and if it had existed in 1610, then Speed must have noted it in his celebrated sailing instructions. Bowen, 1720, Collingson, 1791, and Cary, 1793, do not show it, though Bowen depicts two small islands on the east side of the river, and Cary names both Stert Point and the Warren. Billingsley, 1794 (surveyor White), definitely marks the island, as also does Greenwood, 1822, though Murray, 1930, in a map "projected on the basis of the Trignometrical Survey," which shows two islands in this area, gives no name to either of them. There appears to be a connection between the Dunball Island of Cary, 1793, and the "Slime Batches" of White, 1794, which are shown south of the mouth of the River Brue. In a map of the Moors in 1853, Clark[22] shows and names both Stert and Fenning Islands.

There remains the more reliable evidence of the various map issues as published by the Ordnance Survey.

Fenning Island.

The first map of this area, published by the Ordnance Survey, is dated 1802, and is on a scale of three inches to one mile. This, the original survey, shows Jennings Island, which is about 600 yards in length. A search has not revealed any evidence for this name. The map shows a building on the island which was apparently well established.

The six-inch map appeared in 1891, and shows Fenning Island, which is presumably the Jennings Island of the 1802 map. The Ordnance Survey, commenting on the change of name, state that the name Fenning was authorized at the large scale survey of 1886 by three local residents. On this map the island is of much greater area, but no buildings of any kind are marked on it. It is shown as being roughly triangular in shape with approximately equal sides of 440 yards. It has a very regular outline on its sheltered sides, but its seaward side was at that time obviously subject to severe erosion.

The 1904 edition of the six-inch map again shows considerable change. Fenning Island, as an island, has disappeared, but the name is still retained for this particular area. A small creek seems to mark what was formerly the division line between the island and the mainland of Stert.

On more modern maps the name Fenning Island is still shown. It is also used on the Admiralty charts and in the *West Coast of England Pilot*[23] (page 103). This reads: "Stert Flats fill the whole of the southern portion of Bridgwater Bay, between Inkley and Stert Point. The channel edge of this flat is composed of rock covered with sand and a detached bed of shingle shown as Chesil rocks, which dry 3 ft.; from thence Lark Spit and eastward and southward to Fenning Island, the Shoal edge is of sand drying 1 to 11 feet: all southward of Fenning Island is mud."

Stert Island.

Early evidence is vague, and Neville Grenville[24] suggests that it became an island about 1780. This date is roughly in accord with map evidence and the storm of 1798, which has already been mentioned. It will be remembered that Cary (1794) showed a name "The Warren" on his map. In the original survey by the Ordnance Survey, a building "Warren House" is shown on Stert Island. Is this the Warren of

Cary? If he is correct, then the island was not cut off from the mainland until after 1794. White, however, shows the island in that year. A small discrepancy of a few years may well be accounted for by an interval between actual field work and the printing of a map.

The 1802 Ordnance Survey map shows Stert Island immediately north of Fenning Island, the two islands being separated by a channel connecting the River Parrett with the sea, and directly opposite to the mouth of the Brue (Fig. 10). The latter fact is rather significant,

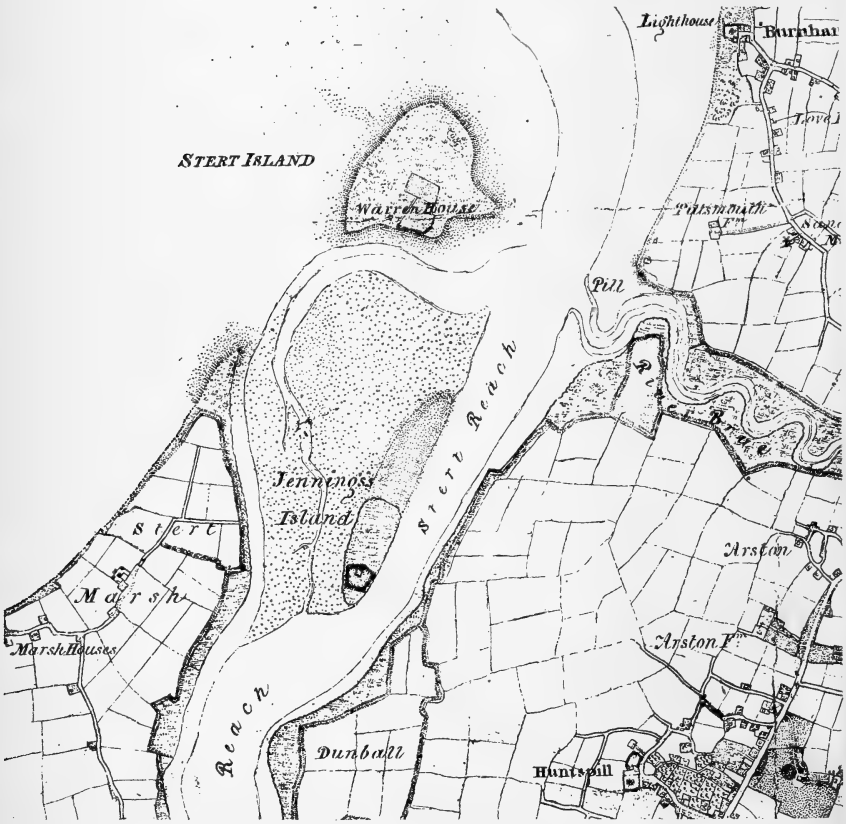


FIG. 10

PHOTOGRAPHED FROM A PORTION OF A THREE INCHES TO ONE MILE SCALE MANUSCRIPT DRAWING DATED 1802, AT THE OFFICE OF THE ORDNANCE SURVEY, WITH THE SANCTION OF THE CONTROLLER OF H.M. STATIONERY OFFICE.

and the even alignment of the West Coast of Stert Island with that of the coast of the Stert mainland is also worthy of note.

The 1891 edition of the six-inch map shows the island in greater detail. There are several well marked shingle patches, especially that

which borders the entire east coast. These are succeeded away from the island by swamp and marsh. The main stream of the Parrett is some distance to the east of the island. Warren House is no longer shown but drainage channels are clearly marked, and a trigonometrical station appears on the west coast near them. These persist on the 1904 edition, but erosion is marked on the west coast, and there is considerable change in the general form of the island. The Parrett has also developed an off channel which borders the east coast.

The old road, running out from the Stert mainland to the island, has already been mentioned. This has now disappeared, but the shallows around the point and the island are very marked, and the channel between them dries out completely at low water. It was apparently the custom for some time to drive over cattle to the island from the mainland, although this is not now done.

The maps (Figs. 11 and 12) are tracings from the six-inch maps of the Ordnance Survey published in 1891 and 1904 respectively. These reveal rather striking changes over a relatively short period and demonstrate very clearly that observations in this area will be untrustworthy if covering a few years only. On the 1904 map, Fenning Island is shown as a definite part of Stert Point. Its south shore remains practically the same as on the earlier map, suggesting that little, if any, change had taken place in the main stream of the River Parrett. A new reach of the river, however, stretches almost in a straight line from Fenning Island alongside the eastern side of Stert Island. It is approximately a quarter of a mile more to the west than Stert Reach as shown in 1891, and is remarkable for its regular direction. To the north, the coastline westward from Stert Point has suffered erosion, but at the same time the point has been making in a north-easterly direction and has swung round so as to embrace Fenning Island. This growth of the point seemingly gave the necessary protection for the establishment of the area between the point itself and the island. Measurements taken from the maps (H.W.O.T.) show that the point has moved approximately 500 yards from its position in 1891, or 587 yards to its junction with the island at its south-east corner. Although the shingle on the sheet was probably not adequately mapped at that time, there is evidence of the development of the customary recurved end of the main shingle ridge forming the point and a protection for the saltings to the south.

A comparison of these two sheets shows little change on Stert Island. Large patches of marsh, however, which bordered the island on both east and west sides in 1891 have been replaced by shingle in 1904,

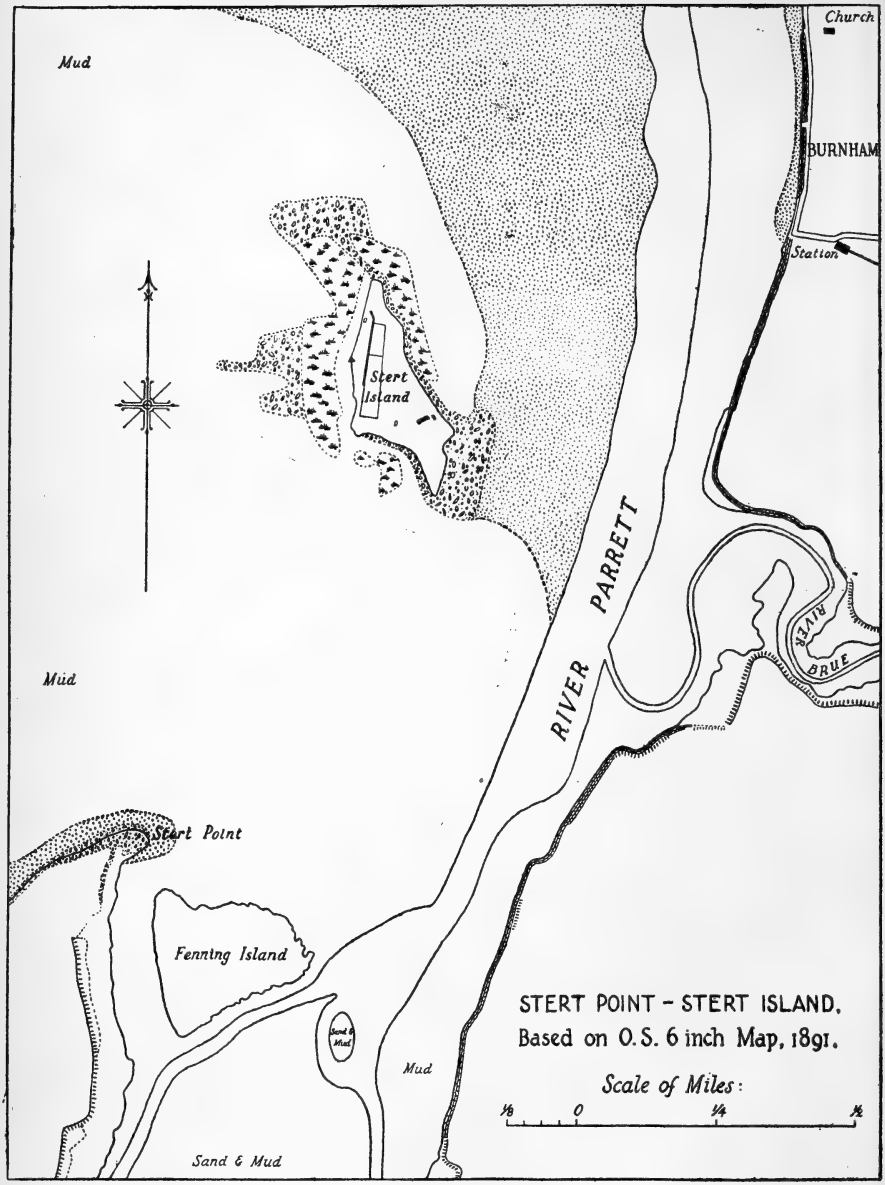


FIG. 11

PRODUCED WITH THE SANCTION OF THE CONTROLLER OF H.M. STATIONERY OFFICE

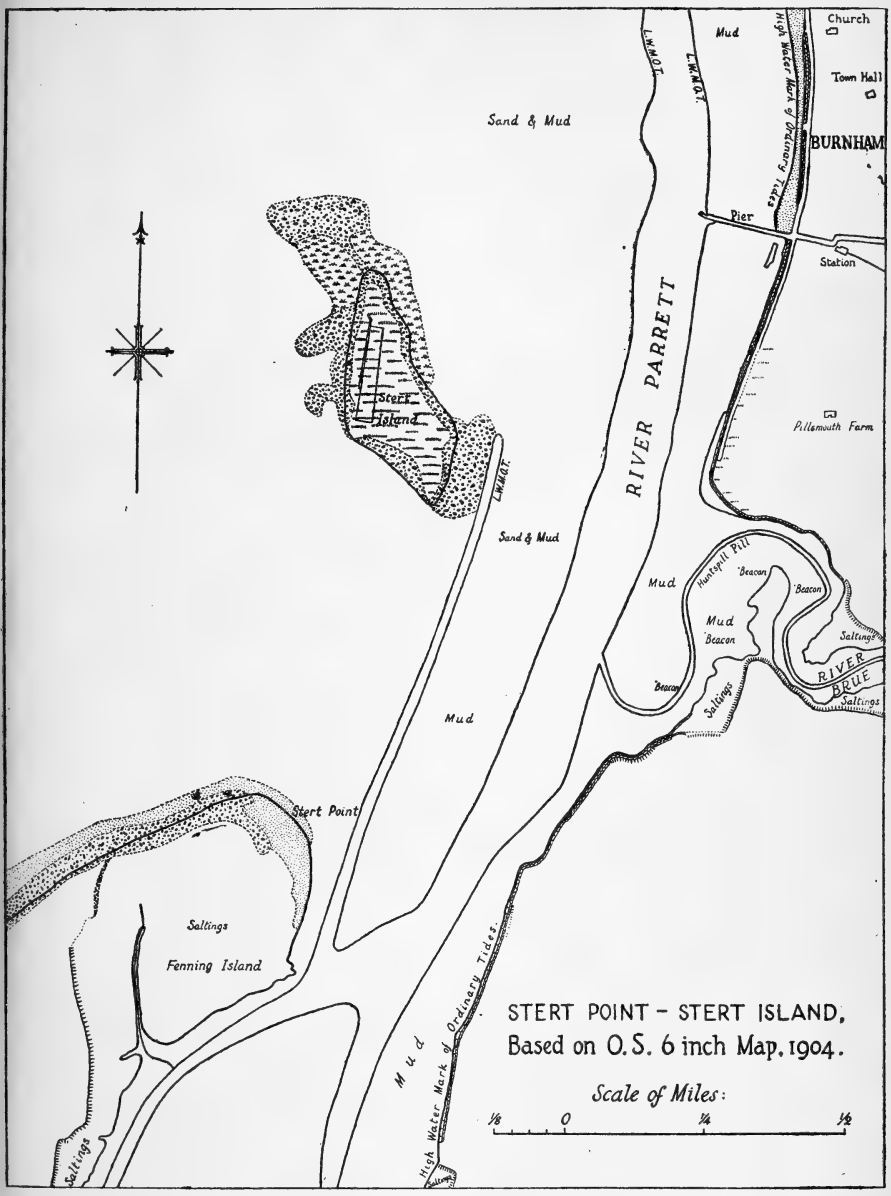


FIG. 12

PRODUCED WITH THE SANCTION OF THE CONTROLLER OF H.M. STATIONERY OFFICE

and at several points the shingle has been piled above high-water mark on to the island itself. The new reach of the River Parrett, bordering the south-eastern side of the island, has already been mentioned.

Summary.

Fenning Island.

1802 A small island; named Jennings Island on the Ordnance Survey map. This gradually increased in size until

1891 and was then a well defined island, named Fenning Island. Some time between this date and 1904 it became a definite part of the Stert mainland. Mr. Govett, who is still farming on Stert Point, informs me that Fenning was definitely an island about forty years ago according to his own observations.

1904 The six-inch map shows it as a part of the Stert mainland, and so it continues up to the present. As will appear later, there is now considerable erosion on both its seaward and river sides.

Stert Island.

1790 (about). Separated from Stert Point.

Stert Point.

1802 Shingle ridge No. 1 probable position of the Far Point at that date (Fig. 13).

1936 Present position as determined by plane table survey. Therefore, the point has advanced a distance of approximately 515 yards in 134 years. This assumes that the southern end of Stert Island has remained steady.

Stert Point.

The point is made up of a remarkably level grass-covered marsh, bordered to the north and east by a well-defined shingle ridge. Observations have been carried out for several years, and surveys were made by plane table in the years 1935 and 1936. The latter show that the shingle is being pushed over on to the sand, and that the Far Point is making towards Stert Island. There is also evidence of erosion along the bank of the Parrett.

The map (Fig. 13) brings out the manner in which the point has moved to the north-east, and its former positions are shown.

The outer of the two drainage channels on Stert Island.
Now below High-Water Mark

Clay Balls on the west coast of Stert Island

Clay Balls on the west coast of Stert Island.
A half-crown gives an idea of relative sizes

[*To face p.* 200

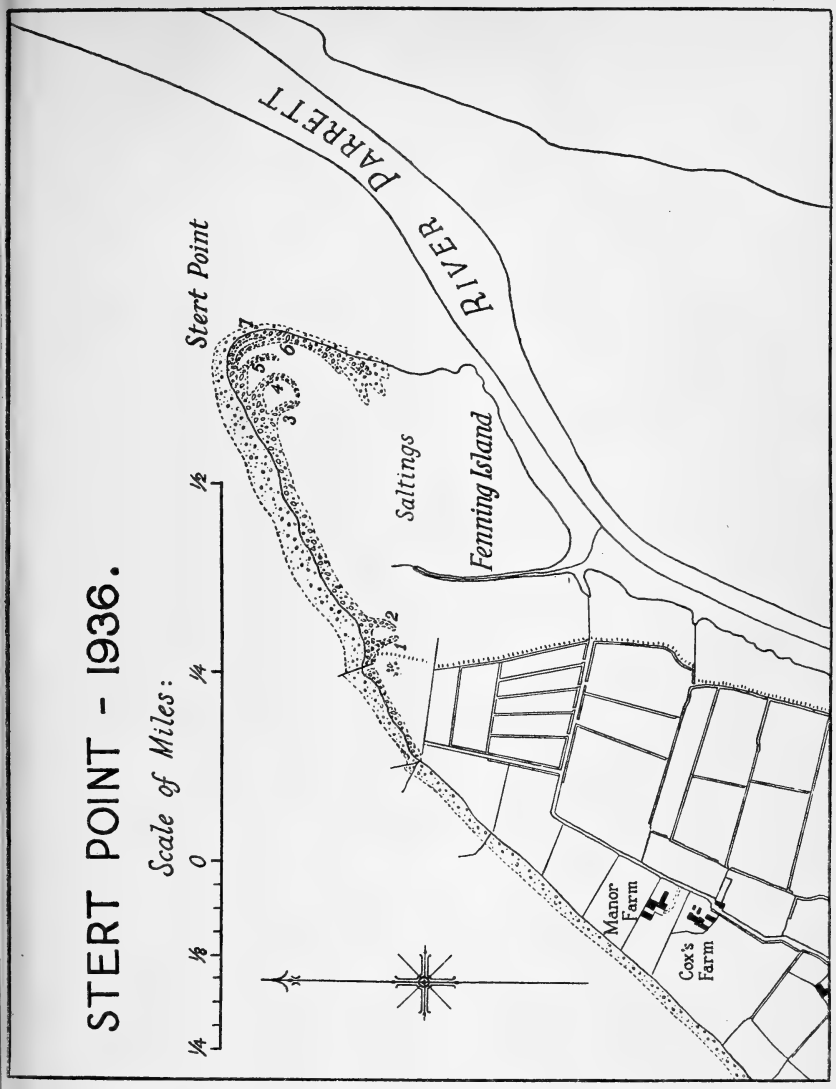


FIG. 13

BASED UPON THE ORDNANCE SURVEY MAP WITH THE SANCTION OF THE CONTROLLER OF H.M. STATIONERY OFFICE

Five individual ridges, each with the characteristic recurved end, are distinguished; the last of these, with a sharp right-angled bend, being the present Far Point. The most severe erosion appears to have taken place immediately east of the last groyne, where there is a well-defined cut into the land. On its landward side the main ridge affords evidence of the gradual encroachment of the shingle in a series of small curves over the vegetation. On the river side, almost

immediately south of the distal end of the point, erosion is probably considerable. Many cracks extend for several yards inland, and blocks of the marsh are endangered by every high tide. There is no sand or shingle in this area.

If No. 1 ridge is taken as the position of the end of the point in 1802 (see Fig. 13), then four further ridges (2, 3, 4 and 5) have been added since that date, and show positions of the point at intermediate dates. The ridge of the present Far Point is beautifully curved, after leaving the main ridge by a right-angled bend, and two much smaller subsidiary ridges may be noted (6 and 7.)

In the 1935 survey of the point, six fixed stations were set up, as shown on the map. In August, 1936, only two of these were located, one on the Far Point and the other at the junction of that ridge with the main ridge. Little change was apparent at the extreme end of the ridge, though the bank of shingle was rather higher than in 1935.

Along the main ridge, severe erosion had occurred during the year, and in one area there was a pronounced curve inland of the shingle bank. The main spread of shingle was flatter and wider, and along practically its entire length the shingle had been pushed an appreciable distance over the land, the maximum advance being of the order of 45 feet. This fact accounts for the disappearance of the fixed marks which were placed some yards from the landward edge of the shingle. Definite cliffing into the old marsh soil was also very evident, particularly to the north of the groynes. It is probable that the major part of these changes occurred during the severe storm of September, 1935, which has already been mentioned.

Distances calculated from the Ordnance Survey six-inch map show that, in 1891, Stert Point was separated from Stert Island by 1,400 yards, and in 1904 by 1,050 yards. In 1936, however, these distances have been reduced to 910 yards.

Stert Island

A series of plane table sketches of Stert Island have been carried out during the last five years, and continuous observation has thus been maintained. In 1934, six permanent points were established, but in 1935, only four of these were identified. The two missing ones were those on the west side of the island, a fact which suggests definite erosion in that area. In 1935, six fixed points were again established, but a visit to the island in August, 1936, gave evidence of further severe erosion, and only two of the points were located. In general, during these years, there has been very severe erosion on the west side of the

island. This is clearly evidenced by the position of the old drainage lines shown by straight lines on the original (1891) large scale survey of the Ordnance Survey. In 1904 these were, at their northern end, 170 feet, and at their southern end, 80 feet away from the high-water mark. The 1936 survey shows that the outer drain, although still visible, is almost entirely below high-water mark (see Fig. 14). Its northern end is now almost identical with the high-water mark, so that, at this point, the sea has advanced by 170 feet since 1904. Further, each survey has shown more definite piling up of the shingle over the vegetation on the northern part of the west coast. Immediately south of the north-west corner of the island, cliffing is more conspicuous, and steps of clay and the old marsh soil are now very prominent. To the south and almost immediately west of the hut, new patches of shingle have become conspicuous. The line of shingle along the high-water mark is piled with a dip from the land to the sea, the pebbles being distinctly flat on this side of the island.

On other parts of the coastline there is little change to describe with the exception of slight increases of shingle at some points and of marsh at others. These are shown on the map (Fig. 14). The most recent shingle formation is that at the south-west corner of the island. This is well marked up to a height of six feet at the distal end of the spit. The only dune formation is to the south-west of the hut. This is prominent on the west side, becoming less so towards the east and tapering out gradually to the south. Marram grass is well established here, and the island, except at its southern end, is well covered with coarse grasses.

On the higher ground, close by the hut, there are what seem to be the foundations of old buildings. These are composed of pebbles and mortar in the main, and may be the remains of the building, Warren House, to which attention has been drawn on some of the earlier maps.

The channel between the island and Stert Point is layered with deep mud, and no water remains in it at low tide. The long straight side channel of the Parrett, which is shown on the six-inch Ordnance Survey map of 1904 as bordering the east side of the island, has disappeared, and the Parrett now keeps to one main channel between the island and Burnham.

Possibly the last survey (August, 1936) gave the clearest evidence of erosion, and it is probable that this was the result of the severe storm of September, 1935, when considerable damage in the Burnham area on the mainland was reported. There were signs that a great part of the island, particularly the north end, has been awash quite recently,

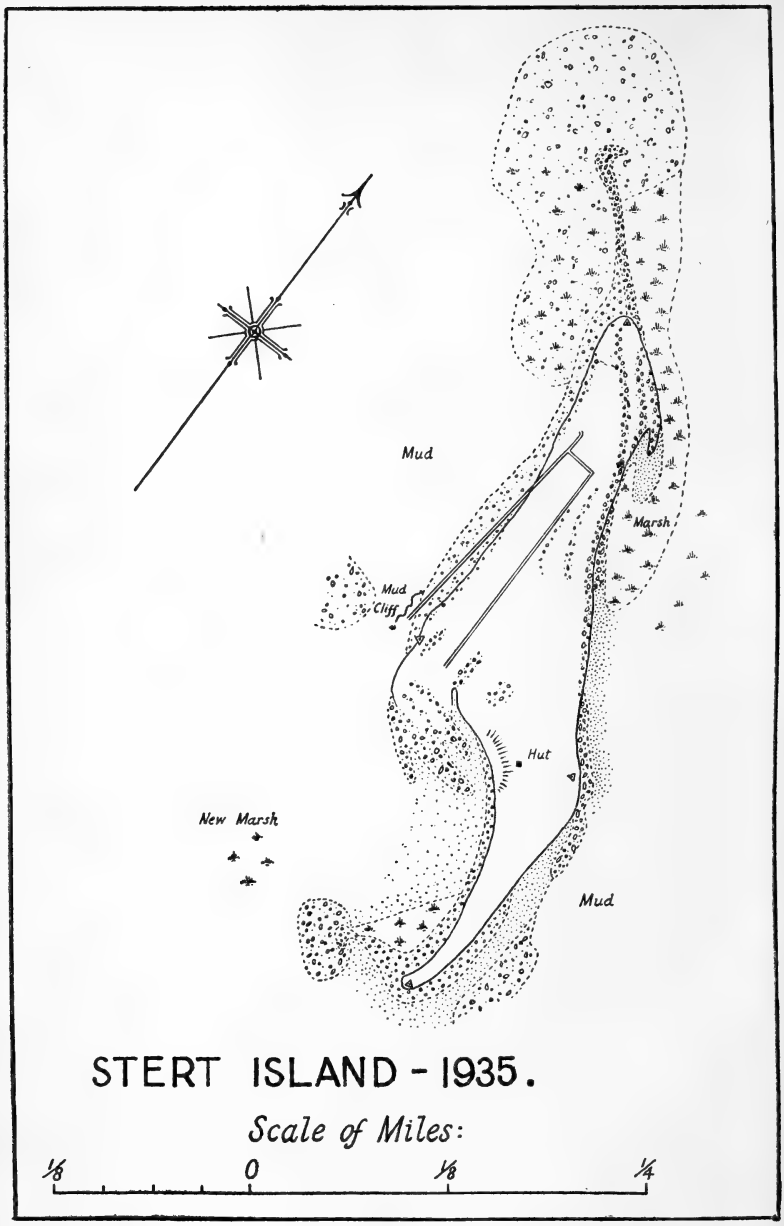

Mud
Marsh
Mud
Cliff
Hut
New Marsh
Mud
STERT ISLAND - 1935.
Scale of Miles:
1/8
0
1/8
1/4

FIG. 14

and erosion has been active on both the east and west coasts. The spread of shingle to the south-west has continued to grow, and cliffing on the west coast has become more pronounced, especially in the area of the drainage lines.

In the period 1802-1936, both the area and shape of the island have changed considerably. In 1802 the area was approximately 750 yards × 880 yards, whereas in 1936 it was approximately 300 yards × 750 yards. The island is being constantly reduced on its western side, and this is to be expected from a study of the winds and storm waves.

BALLS OF CLAY (blue mud).

These were first observed in the summer of 1934, but have only been noticed on rare occasions, on Stert Island. They occurred on the west side of the island and were in considerable numbers, varying in size from a diameter of one inch up to one of six inches. Their composition is of fine blue clay, mixed with small pebbles, and they are beautifully rounded. Probably the rounding effect is due to rolling by water. It would seem that they can be formed in quickly moving water only, and that normally they will not be preserved.

In April, 1936, between the end of the promenade and the Lower Lighthouse at Burnham, more of these clay balls were seen. Although in considerable number, they were only very crudely rounded, and many had almost a sausage form. In this area the beach was very severely denuded of sand during the winter of 1935-36, and the underlying clay thus exposed. Apparently this has been subjected to wave erosion, grooves have been worn in it, and from the edges thus exposed, pieces of clay have been torn away. These pieces are constantly rolled to and fro by the waves and are seemingly the origin of the clay balls as seen.

No previous mention of them has been found in this country. An American reference,[25] however, describes apparently similar balls in the gravels of the tributaries of the Upper Illinois:

> "An interesting feature to be seen in the gravel of most of the tributaries consists of the so-called 'clay balls.' These are pieces of till rounded by being rolled by water.
>
> "They seem to be found only in very rapid streams, and preserved only where speedily covered by other deposits."

They have been mentioned by another American writer[26] as occurring along the beach of Lake Michigan, along which there is "considerable slumping" during continued wet weather, within reach of waves.

Views are put forward to account for their formation by both accretion and corrasion. The writer suggests their origin as "similar to that of clay balls or rolls formed where lake waves are actively cutting. . . . The chief requirement that would seem necessary would be a slumping of stiff tenacious clay into moving water."

Cushing[27] has pointed out that the Indians have noticed the connection of the clay balls with running water. Consequently, they are collected and put in irrigation ditches to encourage the flow of water in their primitive irrigation—a kind of sympathetic magic.

In August, 1936, they were seen again on the west side of the island, in considerable quantities and of a variety of sizes up to six inches in diameter. There is a good deal of miniature cliffing on this side of the island, and the balls usually occur just below this, at the junction of the clay step and the sand. It was confirmed that many of them contain numbers of pebble fragments. Others have a pebble as a nucleus. Further observations supported earlier impressions that they are formed by rolling in water, and that they are probably derived from a more or less recent mud.

Conclusions.

The formations discussed, Stert Point, Stert Island and Fenning Island, seem to show a constant struggle between the waves and the winds on the one hand and the point itself on the other. Under ordinary circumstances the point gradually makes to the north-east. The longshore drift is along the coast in that direction, and the constant supply of shingle, though rather small in quantity, undoubtedly enables it to build up, and has afforded protection for the inclusion of such areas as Fenning Island in the mainland. Further, the prevailing winds are westerly. The tidal currents in the area, however, are strong, and there must be a constant danger of severe erosion by storm waves if these coincide with high tides. Such circumstances would seriously interfere with the normal progradation of the point, and on occasion might result in a definite breach. There is clear evidence that shingle is being piled up over the land on the seaward side of Stert, and there is considerable erosion between the last groyne and the Far Point. This is probably due to storm waves, and was thus demonstrated during the gale of September, 1935. A material factor also is the extensive fetch of open water. It is suggested that the separation of Stert Island from the mainland was a result of a critical combination of these elements. It is perhaps also significant that the break between the

island and the point occurred immediately opposite the mouth of the River Brue.

The meeting of the currents of the Parrett and the Brue may be expected to lead to the formation of mud barriers in the Parrett in the neighbourhood of their junction, especially if the unusual amount of sediment carried by them is considered. Many old maps give evidence of these, and also show the way in which they are constantly changing in both position and size. Their formation is also influenced by the constant shifting of the main channel of the Parrett. One of these was gradually enlarged and ultimately became Fenning Island. Later, this was enveloped by Stert Point and became a part of the mainland.

Both the Point and Stert Island are unstable structures, have undoubtedly changed in form many times, and will continue to do so. At the moment, the Point is pushing out towards the island, and the channel between the two dries out at low water. Silting in the latter is reported to be appreciable, though no definite observations are so far available in support of this suggestion. The island itself, however, is suffering severe erosion, and it may disappear before a junction can once again be made with the Point. A relatively new spread of shingle to the south-west of the island must be noticed here, as it may materially assist in the closing of the present channel.

New defences have recently been constructed to the west of Stert. If these are effective in holding up an appreciable amount of shingle, then the progradation of the point may be slowed down, and erosion along its western side may become more severe.

My grateful thanks are due to the Colston Research Society, who have made grants in aid of this work, and to a number of my old students without whose help the succession of surveys could not have been carried out.

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Additions to Bristol Insect Fauna (Diptera) Since 1934

By H. L. F. Audcent

(*Read in title, 4th March,* 1937)

Itonididæ (Cecidomyiidæ).

Anarete coracina Zett. S. Shapwick (A.), 7.ix.25 (see Ent. Mo. Mag., for 1929, p. 15).

Fungivoridæ (Mycetophilidæ).

Docosia sciarina Mg. G. Frenchay (A.), 14.iv.35.

Tipulidæ.

Tipula montium Egg. S. Vallis Vale (A.), 31.v.36.

Tipula peliostigma Schum. S. Tickenham (A.), 21.vi.36.

Syrphidæ.

Sphegina clunipes Fall. S. Vallis Vale (A.), 31.v.36.

Cnemodon latitarsis Egg. S. Banwell (J.), 25.vii.22.

Eumerus tuberculatus Rond. G. Filton (A.), 22.v.35.

Larvævoridæ (Tachinidæ).

Compsilura concinnata Mg. S. Long Ashton (J. V. Blachford), ex: *Acronycta psi* L., 3.v.35.

Panzeria nielseni Vill. S. Shapwick (A. H. Peach), ex: *Tœniocampa populeti* Fab., 21.iv.36.

Mehria (*Sarcophaga*) *rosellei* Böttch. S. Curry Rivel, *vide* Paton and Wainwright, *Ann. Trop. Med. and Paras.*, Vol. 29, No. 4, p. 523, Dec., 1935.

Thyrsocnema (*Sarcophaga*) *teretirostris* Pand. G. Filton (A.), 29.v.35.

Anachætopsis ocypterina Zett. S. Sharpham (St.), 31.v.36.

Muscidæ (Anthomyiidæ).

Hydrotæa tuberculata Rond. G. Pilning (A.), 12.v.35.

Cœnosia humilis Mg. S. Sharpham (A.), 6.ix.25.

Tetanoceridæ (Sciomyzidæ).

Sciomyza austera Mg. (*lata* Schin.) S. Shapwick (A.), 1.v.27.

Notes on the Development of Some Upper Lias Ammonites

By C. C. Yü, B.Sc., Ph.D.

(*Read in title, 4th March,* 1937)

WHILE working in the Geological Department of the University of Bristol I have had the opportunity to investigate the development of a number of ammonites from the Upper Lias, and as there are few records of the ontogenies of many of these forms it appears desirable to place some of my observations on record. The value of evidence gained from the study of ontogeny as a key to phylogeny has lately been called in question. It may be said, however, that whether the stages in ontogeny are regarded as affording indications of ancestry or as showing possible lines of future changes, they are of distinct importance in the study and classification of ammonites. A knowledge of the development of all ammonites is therefore desirable.

Many of the specimens on which I have worked were in the collections of the Geological Department of the University of Bristol; some of these were included in the T. Fry Collection. Mr. J. W. Tutcher also kindly gave me many specimens to study, while to Dr. F. S. Wallis of Bristol Museum, Dr. C. J. Stubblefield of the Geological Survey, and Dr. L. F. Spath of the British Museum (Natural History) I am grateful for facilities in the study of material in their charge. This work has been carried out with the assistance of Professor A. E. Trueman and with help from the Colston Research Society.

In working out the developments, some specimens have been cut vertically through the centre, and others have been dissected. All drawings, including those of the sutures, have been made by means of the camera lucida.

1. *Harpoceras falcifer* (J. Sow).

The specimens were from the *falcifer* zone, Pennard, Somerset. Dimensions of adults, 115 mm., 42, 22, 29; 90 mm., 45, 20, 28.[1]

This species is characterised in the adult stage by a well-developed septi-carina, the keel in the cast being inconspicuous. The sides of the whorls are nearly flat, and marked by simple, broad, falciform ribs

[1] The dimensions given are according to the scheme used by Buckman:—Diameter in mm., followed in order by whorl height, whorl thickness, and breadth of umbilicus, as percentages of the diameter.

visible on both inner and outer parts of the whorl. About two-fifths of the way across the whorl (from the inner or umbilical border) is a well-marked spiral furrow. The umbilical margin of the whorl is deeply undercut.

The development of the shells remains smooth until it has a diameter of about 10 mm., but a faint keel is already seen, even on the cast, before this stage is reached, though there is not a septi-carina. At this stage the umbilical margin slopes gently into the umbilicus, but by the diameter of 13 mm. the margin is almost upright (Fig. 15). Ribs are present at this stage, but not very distinctly, the inner portion of the whorl being nearly smooth.

Fig. 15
Vertical section of *Harpoceras falcifer* (J. Sow) × 1½

At a little over 20 mm. diameter there is a strong keel, scarcely seen at all in the cast; a well-marked septi-carina is present by this stage. The ribs are less falciform than those of the adult; only a few of the ribs extend to the inner part of the whorl, two or three shorter ribs being present on the outer portion of the whorl between each pair of them. There is a tendency to form a low knot-like projection at the position of the sharp bend in the ribs. No furrow is present at this stage and the umbilical margin is not undercut.

In the development of the suture the external saddle shows the beginnings of a bipartite character at an early stage (before 4 mm.), when the sutural elements are otherwise undivided (Fig. 16). This feature (characteristic of *Harpoceras* and related genera) becomes very pronounced before the adult stage is reached. From an early stage also the first lateral lobe is deeper than the external lobe, and the first lateral saddle is very narrow.

2. *Harpoceras exaratum* (Young and Bird).

The specimens were from the Upper Lias of Whitby. The adult shell had the following dimensions: 18 mm., 44, 29, 25 keel. Mr. S. S. Buckman pointed out (in *Yorkshire Type Ammonites*, Vol. I, p. 51, 1909) that it differs from the typical *Harpoceras* " by not having

an undercut umbilical edge and by beginning to lose the strong falciform character of the ribbing." Buckman pointed out that a more falciform stage occurs in the development.

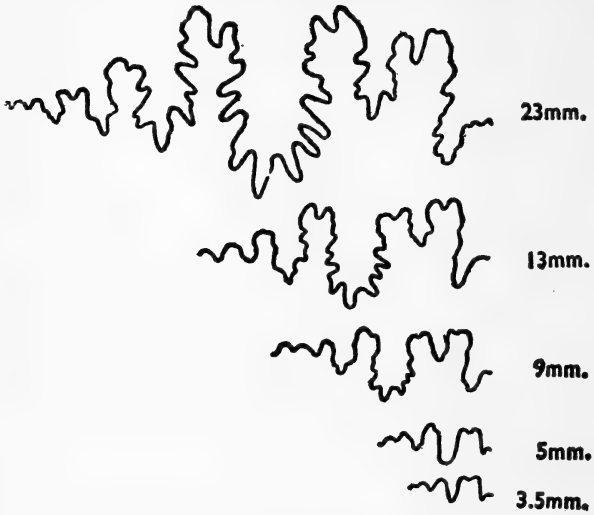

FIG. 16
SUTURAL DEVELOPMENT OF *Harpoceras falcifer* (J. SOW). THE NUMBERS INDICATE THE DIAMETERS AT WHICH THE SUTURES WERE DRAWN

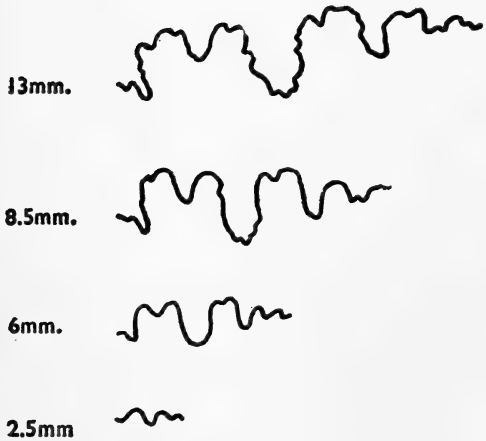

FIG. 17
SUTURAL DEVELOPMENT OF *Harpoceras exaratum* (Y. AND B.)

FIG. 18
VERTICAL SECTION OF *Harpoceras* (*Phaularpites*) *exiguum* BUCKMAN × 1½

A feeble keel appears very early in development, being first recognisable at 3 mm. diameter: ribs also appear early. The umbilical margin becomes upright at about 13 mm., but does not become undercut.

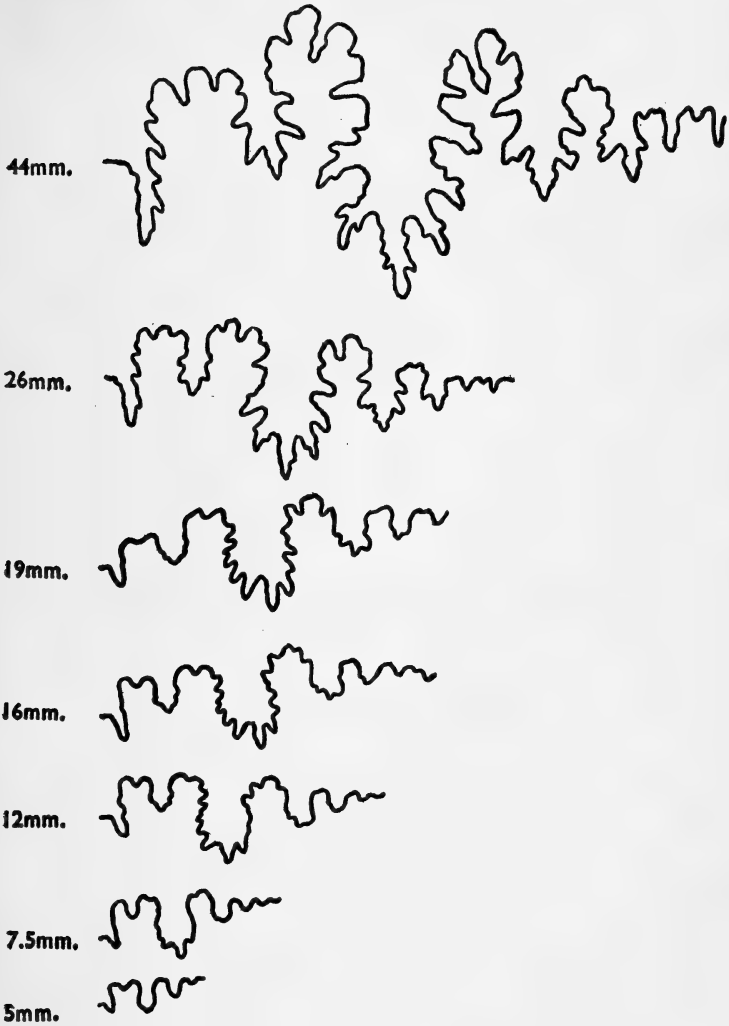

FIG. 19
SUTURAL DEVELOPMENT OF *Harpoceras* (*Phaularpites*) *exiguum*

The sutural development shows the early accentuation of the bipartite external saddle (Fig. 17), but the other features are much less pronounced than in *Harpoceras falcifer*.

3. *Harpoceras* (*Phaularpites*) *exiguum* Buckman.

The specimens were topotypes from Moolham, Somerset. The dimensions of the adults were similar to those given by Buckman (*Type Ammonites*, VII, 1928, DCCLXXIV); for instance, 21·5 mm., 38, 28, 32·5.

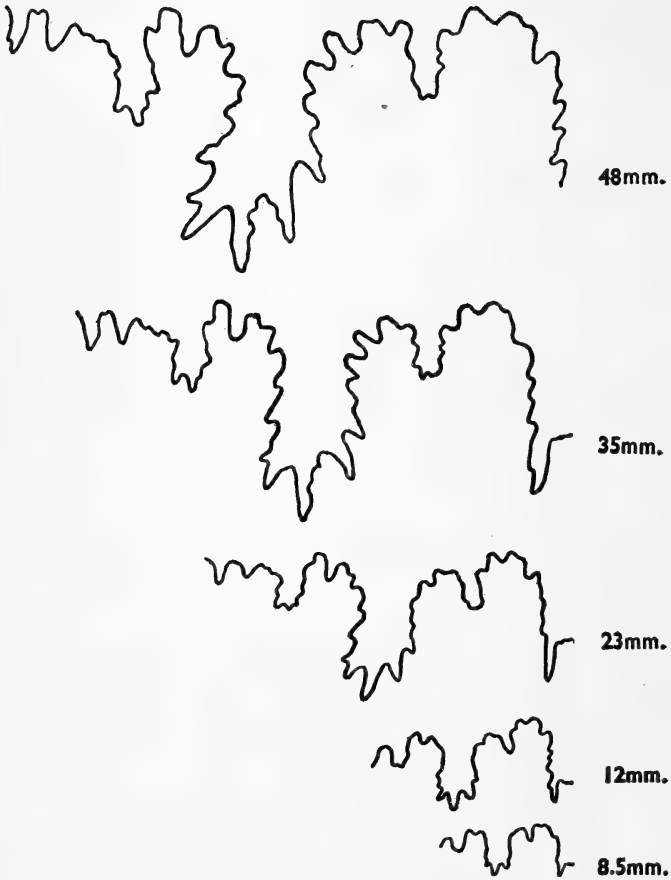

FIG. 20
SUTURAL DEVELOPMENT OF *Hildoceras walcotti* (J. SOW)

A very low carina is shown on the cast of the adult, but it is more noticeable than in the adult of *Harpoceras falcifer*. Only the stronger primary ribs reach the inner edge, the secondary ribs being in some cases united to them about a third of the way across the whorl. The umbilical margin is practically upright (Fig. 18).

An extremely faint carina is present at 4·5 mm. diameter, at which stage ribs were not observed. The shell remains smooth for several whorls but inconspicuous ribs are present at 7·5 mm., and are only gently curved; they are distinctly sigmoid at about 16 mm.

The sutural development shows the early importance of the bipartite external saddle, but in many ways the suture resembles *H. exaratum* rather than *H. falcifer*, especially in the wider external saddle. This latter feature appears to tilt outwards in both these species owing to the greater height of the inner portion (Fig. 19).

4. *Hildoceras walcotti* (J. Sow).

The specimens were from the Upper Lias of Whitby. The dimensions of an adult form were 76·5 mm., 31, 21·5, 44·5. The adult features are well known, but the absence of a septi-carina and the sloping inner edge may be mentioned here.

These characters may be observed from a very early stage in the development, for they are already present by the diameter of 8 mm., when the shell has a keel bordered by faint sulci, and when ribs are present, though confined to the middle parts of the whorl. Before the diameter of 20 mm. the ribs are wider and are extending towards the outer margin of the whorl, bending sharply backwards from the borders of the spiral furrow which appears early and remains prominent.

The sutural development is shown in figure 20.

5. *Hildoceras* sp. nov.

A number of specimens of *Hildoceras* from the Upper Lias of Moolham appear to represent an undescribed species. The following gives the normal dimensions: 45·5, 32, 30, 45.

The whorl is almost square in section, with prominent keel and sulci (Fig. 21). The ribs are much less distinctly sigmoid than in *H. walcotti* and related species, being slightly arched backwards on the side of the whorl: the smooth inner portion of the whorl is quite narrow, and there is no distinct furrow.

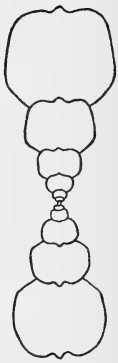

FIG. 21 VERTICAL SECTION OF *Hildoceras* SP. × 2

The development of the ribs shows some interesting features (Fig. 22). They are prominent by 6 mm. diameter, and bend very sharply, getting stronger near the outer margin where they tend to form a knob. This condition persists for some time, the ribs becoming

fainter on the inner part of the whorl and less reclined on the outer part. In some cases two of the ribs appear to unite at the sharp bend.

FIG. 22

CHANGES IN ORNAMENTATION IN *Hildoceras* SP.: *a*, AT 45 MM; *b*, AT 30 MM.; *c*, AT 17 MM.; *d*, AT 10 MM.; *e*, AT 6 MM.

The sutural development closely resembles that of *H. walcotti*.

Further Notes on Carboniferous Mollusca from Shipham, Somerset

By F. S. Wallis, D.Sc., F.G.S.

(*Read before the Geological Section*, 18*th Feb.*, 1937)

IN the *Proceedings* of this Society for 1934, pp. 538-541, an account was given of some cephalopods collected from a quarry on the east of Shipham-Cheddar road about 1 mile S.S.E. of Shipham Church. The quarry is owned by Messrs. L. W. Bryant (Quarries) Ltd., and strata of both horizon γ and subzone C_1 are included. Through the kindness of the owners and others interested in the quarry, especially Mr. H. W. Smith, a further series of mollusca has been deposited in the Museum and Art Gallery collections, and the object of the present note is to record and describe briefly these additions.

The more common fossils found in the quarry and constituting the usual faunal assemblage have been already noted in the previous paper. The only addition in this category worth recording is *Palæosmilia* (*Cyathophyllum*) θ (Vaughan).

Cardiomorpha corrugata (McCoy). An excellent example of this species has recently been found by Mr. R. F. Parry of Cheddar, and deposited in the Wells Museum. Through the courtesy of the Curator, Mr. H. E. Balch, M.A., it has been possible to examine it. The lamellibranch is complete and agrees with the description and measurements given in Hind's *Palæontographical Society's Monograph.* This agreement is especially pronounced in regard to the compression which forms a well-marked excavation below the umbo. The specimen measures antero-posteriorly 7·2 cms., dorso-ventrally 6·1 cms. and the thickness of the two valves is 4·2 cms.

Pleurotomaria carinata (J. Sowerby). A gasteropod, almost wholly in the form of a worn cast, is clearly referable to this species. It consists of about four whorls, the apex being absent. The raised ridge at the edge of the whorls is well shown in the cast but the apparently tuberculate appearance is solely inorganic and due to differential weathering. The umbilicus is deep with angular edges, and the lines of growth are indicated near the aperture. The maximum height and width are 4·8 cms. and 5·2 cms. respectively. The specimen is in the collections of the Bristol Museum and Art Gallery (Reg. No. Cb 2584).

Platyschisma helicoides (J. Sowerby). A fine internal cast collected

by Professor A. E. Trueman, D.Sc., and now in the collections of the Museum and Art Gallery (Reg. No. Cb. 2630) is referable to this species.

The cast is evidently that of a smooth thin-shelled organism, although here again weathering has produced a pseudo-tuberculate appearance on one whorl. The shell is flattish and has a depressed, low spire of four convex whorls. The aperture is lunate and the umbilicus is relatively narrow and deep with rounded edges. The base of the shell is distinctly tumid. The maximum height and width of the shell are respectively 5·4 cms. and 6·5 cms.

Actinoceras striatum (J. Sowerby). In the previous paper, op. cit. p. 539, a specimen (Reg. No. Cb 2412 in the Bristol Museum and Art Gallery collections) consisting of portions of four gas chambers is identified as *Aipoceras gibberosum* (de Koninck). Further development and examination of the specimen shows that it is *Actinoceras striatum* (J. Sowerby). The shell is oval in section and the septa are moderately spaced. There is a shallow sinus in the septa on the side of the longest diameter and nearest to the siphuncle ; the latter is excentric and placed at a point about 2/5 along each diameter of the oval. Owing to the weathered character of the shell, there are no signs of the exterior decoration which is such a feature of this species.

Actinoceras sowerbyi (McCoy). A specimen in the collections of the Bristol Museum and Art Gallery (Reg. No. Cb 2585) shows the base of the body-chamber and clearly indicates the position of the siphuncle in this species. The section is ovate in shape and the siphuncle is situated about half-way between the centre and the margin. The septa are markedly arched on the shorter side and form a shallow sinus on the longer diameter. The measurements of the diameters of the body-chamber are 8·5 cms. and 7·9 cms.

Solenocheilus conspicuus (de Koninck). A nautilus-like, tumid shell, consisting of about three gas chambers and part of the body-chamber, is referred to this species. The section is almost semi-circular and the zone of impression is shallow and indistinct. The aperture is not present ; the sides are broad and flat and finally merge imperceptibly into the periphery. The siphuncle is situated close to the ventral margin, just beneath the smooth test. The maximum height of the whorl is 7·9 cms. The specimen is in the collections of the Bristol Museum and Art Gallery (Reg. No. Cb 2586).

Aipoceras compressum (Foord). The specimen (Reg. No. Cb 2537), in the collections of the Bristol Museum and Art Gallery, consists of part of a body-chamber and shows the characteristic change in curvature of the periphery. The section is roughly triangular. The

sides are flattened and gradually merge into the narrowly-rounded periphery. The siphuncle is near the ventral margin of the shell; no trace of surface ornamentation can be detected. The maximum diameter of the body-chamber is 10·0 cms.

Adding the organisms described in this and the previous paper, it may be stated that the following mollusca occur in Bryant's quarry at Shipham :—

Cardiomorpha corrugata (McCoy).
Pleurotomaria carinata (Sow.).
Platyschisma helicoides (Sow.).
Actinoceras giganteum (Sow.).
Actinoceras striatum (Sow.).
Actinoceras sowerbyi (McCoy).
Meloceras apicale (Foord).
Meloceras arcuatoseptatum (Foord).
Poterioceras fusiforme (J. de C. Sow.).
Vestinautilus paucicarinatus (Foord).
Aipoceras gibberosum (de Kon.).
Aipoceras compressum (Foord).
Solenocheilus conspicuus (de Kon.).

Considering that such fossils are almost unknown in other parts of the South-Western province, it is difficult to account for such a rich faunal assemblage in one quarry. The question was briefly discussed in the previous paper and although these notes add considerably to the number of known forms, the reason for their presence is still no further explained. A partial solution of the problem may lie in the fact that, as in other parts of the Bristol area, fossil collectors have concentrated on the more usual brachiopods and corals. In that case the absence of these forms in beds of the same age in neighbouring localities is more apparent than real.

On a Boring for Coal at Farrington Gurney, Near Bristol

By L. R. Moore, B.Sc., Ph.D., and A. E. Trueman, D.Sc., F.G.S.

(*Read in title, 4th March,* 1937)

A BORING was made for the Marsh Lane Colliery Company of Farrington Gurney, Somerset, in order to ascertain the position of the Rudge seam, formerly worked at the Rudge Colliery, near Clutton.

The authors are indebted to Mr. Cottle, the manager of the Marsh Lane Colliery, who kindly gave particulars of the boring and also further data from sections in his possession concerning the Rudge and Greyfield Collieries (lying some two miles to the north of Farrington Gurney).

The site of the boring lies immediately west of the main Bristol to Wells road and on the slope of Rush Hill. It is approximately 90 yards west of the milestone shown on the six-inch Ordnance Survey sheet (Somerset XIX, S.E.). It is about 400 yards due west of the Marsh Lane Colliery where the lowest member of the Jubilee group of seams is worked to its sub-Mesozoic outcrop. The Jubilee group of seams on this western border of the Radstock basin represents the lowest worked horizon in the Farrington Group of the Upper Coal Series. As the strata are dipping almost due east, the borehole section apparently provides important evidence of the sequence commencing some 350 feet below the Jubilee seams.

Boring started at 428 feet above ordnance datum and reached a depth of 291 feet. A section was kept at the Marsh Lane Colliery offices, and the cores, though confused, were examined by the authors.

Section :—	*Thickness* ft.	in.
Trias.		
Keuper Marls	60	0
Dolomitic Conglomerate	90	0
Coal Measures.		
Coal Seam	2	0
Soft blue shales with plant remains	18	0
Coal Seam—soft shaley coal	2	6
Red and mottled shales : "Dicey"	117	6
Hard sandstone band		
Soft blue shale		
Red strata—disturbed and slickensided	1	0

The abnormal thickness of the Dolomitic Conglomerate is of considerable interest. The limestone pebbles are large and suggest derivation from a source at no very great distance. The nearest Carboniferous Limestone would appear to be two miles away. Shaft sections of the Farrington Gurney and Old Mills Collieries show thicknesses of Dolomitic Conglomerate of only 12 and 16 feet respectively.

The coal seam cut at 150 feet proved to be of good quality; the roof of the seam was not, however, cut in the borehole. The soft shaley coal cut at 170 feet carried a strong shale roof in which plant remains were abundant. The following species were identified:—

Sphenopteris sp.
Neuropteris cf. *nikolausi* Goth.
N. scheuchzeri Hoff.
N. cf. *macrophylla* Brongt.
N. cf. *tenuifolia* (Schloth.)
Linopteris sp.
Asterotheca cyathea (Schloth.)
A. miltoni (Art.)
Pecopteris dentata (Brongt.)
Sphenophyllum emarginatum Brongt.
S. cf. *majus* Bronn
Lepidodendron lycopodioides Sternb.
L. cf. *wortheni* Lesq.
Lepidostrobus sp.
Lepidophyllum majus Brongt.
L. triangularis Zeiller
Annularia radiata Brongt.
Cordaites sp.

The occurrence of *Linopteris* sp. and the forms of *Neuropteris* cf. *tenuifolia* provide an interesting feature of the assemblage. *Neuropteris* cf. *nikolausi* and *Asterotheca cyathea* are species which are common only in the lowest known strata of the Farrington Group. The specimens of *Pecopteris dentata* listed above bear close resemblance to forms of *Dactylotheca plumosa* (Art.).

Below the seam cut at 170 feet, red and mottled strata were encountered and passed into a harder sandstone band, further soft shales continuing the sequence. The boring ended in red strata strongly slickensided, suggesting the presence of faulting. Specimens of *Alethopteris serli* were obtained from these strata.

This sequence is of particular interest in that strong sandstones are practically absent. The Marsh Lane Colliery workings east of the borehole are free from disturbance, and though sandstones may occur in the strata between the colliery and the borehole, the presence of a

shale belt containing coal seams at this horizon in the Pennant Series is of considerable importance.

McMurtrie[1] mentioned a level branch driven across the deeper measures of the now disused Greyfield Colliery some two miles north of Farrington Gurney. It was intended to cut the Rudge Seam previously worked near by. A section of this branch shows the Bantam seam and two coals below it (regarded as equivalent to the Jubilee Group) to lie 155 feet below the New Seam of Greyfield Colliery. Below the Bantam Seam, a shale belt 140 feet thick, containing an unworkable coal seam, passed into a group of massive sandstones termed " Pennant " at a point 850 feet along the branch from the New Seam. A further shale belt, with a soft coal seam 2 feet 6 inches thick, was proved below the sandstone. The branch was closed before the Rudge Seam was cut. The Rudge Seam was estimated to lie 1,370 feet along the branch from the New Seam.

The disused Rudge Colliery at Clutton lies east of the bridge carrying Marsh Lane over the Bristol and North Somerset Railway (six-inch Ordnance Survey, Somerset XIX, N.E.). A shaft section of this colliery shows the Rudge Seam to occur at a depth of 102 yards, with red mottled strata described as " Red dicey " below it. It is thought that this horizon may be represented in the Farrington Gurney borehole. The surface features exhibited near the Rudge and Greyfield Collieries suggest the presence of softer shaley bands of considerable thickness lying above the massive Pennant Sandstone which is quarried near by.

The evidence provided by the borehole section and by the data from the Rudge and Greyfield Collieries suggests the presence of a shale belt containing coal seams, and lying below the Farrington Group proper.

[1] McMurtrie, J. " The Geological features of the Somerset and Bristol Coalfield, with special reference to the Geology of the Somerset Basin."—*Trans. Inst. Min. Eng.* (1900), Vol. XX, p. 14.

Further Recent Exposures in the Rhætic and Liassic Rocks of the Bristol Area

By G. A. Kellaway, B.Sc.

(*Read in title, 4th March*, 1937)

SEVERAL new sections have been made in the Liassic and Rhætic rocks since the important temporary exposure near West Town Lane, Brislington, was described in these *Proceedings* in 1935 (Vol. VII, Pt. VII). It is desirable that these new sections should be recorded.

1. Section at Red Lion Hill, Knowle. This section, of which the details are given below, was exposed during road-widening operations on the main Bristol-Wells road at a point just east of the Knowle Tram Terminus. The rocks were seen to be dipping at 4° in a W.N.W. direction.

Upper Rhætic. 6 feet 6 inches.

	ft.	in.
24. Rubble with Cotham Marble.		
23. Clay. Laminated, greenish (seen)	2	0
22. Limestone. Fine-grained, grey	0	2
21. Clay. Laminated green and yellow, with an impersistent limestone bed	1	0
20. Limestone. Banded—with "sun-cracked" layers ..	1	4
19. Clay. Greenish-yellow—with a band of limestone nodules (0-1 in. thick)	2	0

Lower Rhætic. 7 feet 11 inches.

18. Shale. Black, rusty-stained—with *Schizodus ewaldi* ..	2	0
17. Shale. Ochreous—with *Protocardium rhæticum* and *Pleurophorus elongatus*	0	2
16. Shale. Soft black—with *Pteria contorta* and *Schizodus concentricus*	0	7
15. Limestone and ochreous sandy shale	0	3
14. Shale. Soft black—with *Myophoria emmerichi*, *Pteria contorta* and *Schizodus ewaldi*	1	8
13. Shale. Ochreous and pyritic	0	3
12. Shale. Soft black—with *Protocardium rhæticum*, *Pteria contorta*, *Schizodus ewaldi*	1	4
11. Shale. Hard, black—base ochreous; with a few fish scales in the bottom inch. *Schizodus ewaldi* ..	1	8

Red and Green Marls. Approx. 50 feet.

10. Marl. Soft, greenish, jointed	1	3
9. Marl. Hard, calcareous	1	0
8. Marl. Green, jointed—with some limestone	9	2

		ft.	in.
7.	Marl. Red	8	0
6.	Marl. Green—with black joint faces	2	6
5.	Marl. Hard, yellowish-green, partly crystalline ..	0	1
4.	Ochreous parting	0	½
3.	Sandstone. Soft yellow friable	2	10
2.	Marl. Hard red and green, variegated	4	0
1.	Marl. Red—with irregular green patches (seen) ..	20	0

In the clays of Bed 19 was a nodule of limestone containing bands of a small but abundant *Protocardium*. This was in a vertical position and was associated with patches of black shale (containing *S. ewaldi*) of undoubted Lower Rhætic age. Both the nodule and the black shale were completely surrounded by the greenish-yellow clay. The following forms were collected from the Lower Rhætic :—

Pelecypoda :—

Myophoria emmerichi (Winkler).
Pleurophorus elongatus (Moore).
Protocardium rhæticum (Merian).
Pteria contorta (Portlock).
"*Schizodus*" *concentricus* (Moore).
"*Schizodus*" *ewaldi* (Bornemann).

Gastropoda :—

"*Chemnitzia*" *henrici* (Martin).

2. A further section was exposed on the site of the new Public Baths adjoining the Water Tower at Knowle. Here, White Lias was seen to be resting on the Upper Rhætic clays which were capped by a bed of Cotham Marble. The dip was in a direction 5° S. of W. at 8°. It is thus apparent that in the neighbourhood of Knowle Hill the Lias and Rhætic rocks have a westerly or west-north-westerly dip.

The Lias and Rhætic rocks of Knowle form part of the Dundry mass, while the sections described below are situated on the west side of the City in the district of Henleaze, and consequently fall within the North Bristol outlier.

3. The following exposures have been seen on the Northumberland House Estate, which is now in process of development. The estate lies within the area bounded by Howard Road, Holmes Grove Road, Henleaze Road and Downs Park East.

Exposure A. Half mile due E. of the L-bend in Henleaze Road.

	ft.	in.
20. Limestone. *Psiloceras* seen in section	0	2
19. Clay. Ochreous	0	3
18-13. Alternating Shales and thin limestones	2	0
12. Shale. Brown, laminated—with *Ostrea* sp.	0	4-5
11. Limestone. Hard grey—with *Lima* sp.	0	3-5
10. Shale. Brown—many broken *Ostrea* shells	0	7
9. Limestone. Granular pink and grey	0	2-5
8. Shale. Brown calcareous	6	4
7. Limestone. With *Pleuromya tatei* R. and T.	0	6
6. Clay	0	3-4
5. Limestone. Hard grey—with *Pleuromya tatei* and *Ostrea liassica*	0	4
4. Shale and limestone parting	0	4-6
3. Limestone	0	4
2. Shale. Dark-coloured	0	3
1. Limestone. A hard grey limestone resting on a few inches of more rubbly beds	0	6

Exposure B. Half mile S.W. of A.

The gap between the bottom beds seen in section A and the top beds of section B is probably about two feet.

	ft.	in.
10. Limestone	0	4
9. Clay	0	6
8. Limestone with *Modiola langportensis* R. and T. ..	0	2
7. Clay. Greenish grey	0	2
6. Cotham Marble	0	4-5
5. Clay. Laminated grey—with small concretions ..	1	9
4. Limestone. Grey, blue-hearted, banded	0	3
3. Clay. Grey laminated	0	9
2. Limestone. Grey, impersistent—with *Estheria minuta*	0	4
1. Clay. Laminated grey. (Seen.)	1	0

A short distance from Exposure B a trench was cut in the Upper Rhætic clay, below which an impersistent limestone appeared. The sides of the trench were boarded up when it was examined by the writer, so that the sequence could not be determined. However, it seems almost certain that this limestone, which is rich in well-preserved specimens of *Naiadites lanceolata*, is at about the same horizon as, or possibly a little lower than, that of the *Estheria*-nodules.

PLANT REMAINS FOUND IN THE *Naiadites*-BED

The following notes have been very kindly supplied by Professor T. M. Harris, of Reading University.

LIVERWORTS AND MOSSES

Naiadites lanceolata Brodie. In most of the plant-bearing layers the specimens are very broken, but the preservation of fine details of structure is unusually good. All the known organs of the plant were found, gemmæ and archegonia are remarkably common.

Hepaticites solenotus M.S. sp. Fragments of this liverwort are fairly frequent. They are recognisable by their clear brown colour.

Moss rhizoids. Fine branching filaments agreeing in all their characters with moss rhizoids are common in this locality.

ALGÆ

Botryococcus brauni Kütz (known as *Pila* and *Reinschia* as fossils). This alga is very common in this locality, often occurring as one or two colonies to each square centimeter. It is a pinkish to rust-red colour and is occasionally difficult to distinguish from ferric oxide concretions without chemical tests. The colonies can be cleared very satisfactorily with concentrated nitric acid and potassium chlorate. This alga is much commoner here than elsewhere.

Stenixys cosmarioides M.S. gen. et. sp. A rather rare alga in this and other localities. It is recognisable by its shape and its blackish brown colour.

The new genera and species mentioned above are to be described by Professor Harris in a forthcoming publication by the British Museum.

Exposure C. Half mile E. of the junction of Henleaze Road and Henleaze Gardens and just S. of Holmes Grove Road.

	ft.	in.
12. Limestone.		
11. Clay. Brown.		
10. Limestone with *Pholadomya fraasi*	0	4
9. Shale. Hard pyritic	0	6
8. Limestone with *Pleuromya tatei*	0	3
7. Shale. Dark coloured, shelly	0	3
6. Limestone	0	10
5. Clay. Greenish-grey (4 ins.)		
4. Limestone. Hard grey (4 ins.)	0	10
3. Clay. Soft greenish (2 ins.)		
2. Cotham Marble	0	6
1. Clay. Yellowish-green.		

4. Section at the Electricity Sub-Station, Downs Park East, Henleaze. The following series of beds were seen during excavations

at a point adjoining the junction of Downs Park East and Henleaze Road.

	ft.	in.
Upper Rhætic—Yellow clays and limestones (seen) ..	11	0
Lower Rhætic—Black shale	9	0
Carboniferous Limestone (*Caninia*-Oolite)		

Black limestones with "Beef" occurred at 1 ft. 6 ins., 3 ft. 6 ins., and 8 ft. 0 ins. above the base of the Black Shale. The bottom eighteen inches of shale was much harder than the overlying portion and was strongly laminated. The surface of the *Caninia*-Oolite on which the Black Shale was resting was very smooth and even, while there was no evidence of any littoral deposit at the base of the Rhætic. The absence of a littoral facies is characteristic of the Rhætic and Lias along the W. margin of the N. Bristol outlier, and in this respect these rocks contrast strongly with those of the Mendips where silicified and conglomeratic Rhætic and Liassic rocks are of constant occurrence whenever they are adjacent to the Palæozoic land-mass.

5. Exposure at the junction of Etloe Road and North View, Westbury Park. At this point a pit some 10 to 15 feet deep was made, and from here the road was trenched as far as the top of Parry's Lane. In the pit about 10 feet of greenish-yellow clay could be seen at the E. end, resting on the rather uneven surface of the Carboniferous Limestone (*laminosa*-Dolomite). The surface of the limestone rose rapidly and reached ground level about ten yards from the E. end of the pit. From this point onwards to the top of Parry's Lane, small, impersistent patches and infillings of Rhætic clay could be seen resting on the surface of the Limestone. Another trench, which ran from North View to Coldharbour Road by way of Etloe Road and Bayswater Avenue, proved Upper Rhætic in Etloe Road and basal Lias (pre-*planorbis* beds) in the neighbourhood of Westbury Park Council School.

It has become apparent that here the line of junction of the Rhætic and the Carboniferous Limestone is an extremely irregular one and that, in the portion of the Downs which lies E. of Westbury Road, the Limestone is hidden by an impersistent cover of U. Rhætic clay.

The writer is indebted to Mr. H. M. Webb, B.Sc., for drawing his attention to the exposure at Red Lion Hill.

Fossil Shells from the Nailsea Coalfield

By E. W. Seavill

(*Read in title before the Geological Section* 18*th Feb.*, 1937)

When searching on the old tip of the colliery immediately south of Nailsea Station, I discovered a number of small slabs of black shale containing crushed examples of a non-marine lamellibranch which Prof. A. E. Trueman has kindly identified as *Anthraconauta phillipsi* (Will.). This, I believe, is the first shell to be recorded from the Coal Measures of the Nailsea basin.

A note by Prof. Morris (in the *Geol. Mag.*, 1868, p. 357) tells of the finding of *Estheria striata* var. *Beinertiana* from a pit at Nailsea, whilst he also mentions that from the roof of the White Seam of Young Wood pit, he obtained the ostracods *Kirkbya costata* and a well-preserved specimen of a species of *Cythere*. Young Wood pit lies about 590 yards due west of the tip from which I obtained the non-marine lamellibranchs.

It appears from the Geological Survey map that the colliery at Nailsea Station was situated near the outcrop of two seams which were probably worked there and also probably corresponded to the Golden Valley seams shown in the Survey vertical section of the area (Sheet 49). The Young Wood pit, on the other hand, was situated on a higher group of seams, not far beneath the Pennant Sandstone.

The finding of *A. phillipsi* at the Station pit proves conclusively that some part of the coal worked there must have occurred in the *phillipsi* Zone. Dr. L. R. Moore and Prof. A. E. Trueman have recently shown ("The Coal Measures of Bristol and Somerset," *Abstracts Proc. Geol. Soc.*, No. 1324, March 5th, 1937, p. 75) that the *phillipsi* Zone includes the highest strata of the New Rock Group (the top of the Lower Coal Series) and the main part of the Pennant Sandstone. It follows, therefore, that the coal worked at Nailsea Station must have been within these strata. It is surprising to find that, according to the Geological Survey map, it represents what may be described as the middle group of seams in the Lower Coal Series of the Nailsea basin, and it is possible that the structure is more complicated than the map suggests. Otherwise, it appears that the sequence of the Lower Coal Series below the Golden Valley seams is very incomplete; according to Anstie's figures it would leave only just over 800 feet for the whole of the *lenisulcata*, *ovalis*, *modiolaris* and *similis-pulchra* Zones in this area, if they are represented there.

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"Rerum cognoscere causas."—Virgil.

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*	Reynolds, Prof. S. H., Sc.D., F.G.S.	13 All Saints' Road, Clifton, Bristol, 8	*G.O.*
	Richards, G.	Pensylva, Cecil Road, Weston-super-Mare	*F.G.*
A.	Riddle, Miss H. E.	20 Banwell Road, Ashton Gate, Bristol, 3	*Bi.F.*
	Ross, F. Stenhouse	25 Tugela Road, Uplands Estate, Bristol, 3	*G.*
	Ross, James, F.L.A.	Central Library, Bristol, 1	
	Rutter, Miss E. M.	32 Henleaze Gardens, Bristol, 9	*B.*
A.	Salmond, P. W.	22 Tyndall's Park Road, Clifton, Bristol, 8	*F.G.*
A.	Sampson, Miss A. M.	Bristol Road, Congresbury, near Bristol	*Bi.*
	Sanders, Miss L. M.	Redroofs, 6 Downs Cote Park, Westbury-on-Trym, Bristol	*F.G.*
*	Sandwith, Mrs.	26 Canynge Square, Clifton, Bristol, 8	*B.E.*
	Savory, J. H.	Windyridge, Abbots Leigh, near Bristol	*O.*
A.	Scase, R. P.	Wills Hall, Stoke Bishop, Bristol, 9	*O.*
	Selley, A.	116 Coronation Road, Bristol, 3	*G.*
*	Shaw, Miss T.	12c Kingsdown Parade, Bristol, 6	*B.F.G.*
A.	Shield, Miss M., B.Sc.	The Laundry House, Filton, Bristol	*Bi.*
	Shilstone, H. C.	124 Victoria Avenue, Redfield, Bristol, 5	*F.G.*
A.	Simmons, Miss L., L.R.A.M.	47 Grosvenor Road, St. Paul's, Bristol, 2	*F.O.*
*	Skene, Prof. Macgregor, D.Sc., F.L.S.	The University, Bristol, 8	*B.F.*
A.	Smith, Miss M. de Lattre ..	The School House, High Ham, Taunton, Som.	*G.*

*	Smith, Stanley, M.A., D.Sc., F.G.S.	The University, Bristol, 8	*G.*
A.	Stanhope, Rev. A. J.	"Jesmond," 182 Bishop Road, Bristol, 7	*F.G.*
	Statton, A. G.	2 Auburn Road, Redland, Bristol, 6	
A.	Strudwick, Miss F. E., M.A.	26 Woodstock Road, Redland, Bristol, 6	*F.*
	Sully, H. T.	Elmside, Julian Road, Stoke Bishop, Bristol, 9	
	Tarring, E.	Mimosa, 196 Bishop Road, Bristol, 7	*B.F.*
	Taunton, W. C.	70 Halsbury Road, Westbury Park, Bristol, 6	*E.O.*
A.	Taylor, R. J.	12 Claremont Avenue, Bishopston, Bristol, 7	*F.*
	Taylor, W. R., M.A.	5 Pembroke Vale, Clifton, Bristol, 8	*E.O.*
*	Tetley, H., B.Sc., F.Z.S.	4 The Avenue, Sneyd Park, Bristol, 9	*E.O.*
	Tetley, Mrs.	4 The Avenue, Sneyd Park, Bristol, 9	*O.*
A.	Thomas, Richard	131 Cumberland Road, Redcliff, Bristol, 1	*G.*
*	Thompson, H. S., A.L.S.	11 Buckingham Place, Clifton, Bristol, 8	*B.F.G.*
A.	Tombleson, F. B.	Shirley, Briercliffe Road, Westbury-on-Trym, Bristol	*G.*
J.	Trenerry, G. G.	Windover, 54 Kellaway Avenue, Bristol, 6	*O.*
*	Trueman, Prof. A. E., D.Sc. F.G.S.	The University, Glasgow.	*G.*
	Trueman, Mrs. A. E.	c/o The University, Glasgow	*G.*
	Tucker, B. W., M.A., M.B.O.U.	9 Marston Ferry Road, Oxford	*O.*
	Turner, H. W., M.A., F.G.S.	The University, Bristol, 8	*G.*
	Turner, Mrs. H. W.	Mortimer House, Clifton, Bristol, 8	*B.*
*	Tutcher, J. W., M.Sc.	57 Berkeley Road, Bishopston, Bristol, 7	*F.G.*
	Veal, Mrs. G. C.	Lower Hazel House, Rudgeway, nr. Bristol	*O.*
A.	Verhey, Miss D. E., B.Sc.	Stanmore House, Royal Crescent, Weston-super-Mare	*B.*
	Waight, Miss F.	Beeches, 47 Kewstoke Road, Bristol, 9	*O.*
	Waight, Miss M.	4 Park Lane, Dartington Hall, Totnes, Devon	
*	Wallis, F. S., D.Sc., F.G.S.	The Museum and Art Gallery, Bristol, 8	*F.G.*
A.	Walsh, Miss C. L. B.	8 Alma Vale, Clifton, Bristol, 8	*F.*
	Walton, C. L., Ph.D., M.Sc.	34 Northumberland Road, Redland, Bristol, 6	*O.*
	Walton, Mrs. C. L.	34 Northumberland Road, Redland, Bristol, 6	*O.*
	Webb, H. M., B.Sc.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*G.O.*
	Webb, Mrs. H. M.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*O.*

	Webb, H. Vicars	58 Belmont Road, St. Andrew's, Bristol, 6	*F.O.*
A.	Weetman, Miss M. J.	60 Ashley Road, Bristol, 6	*Bi.F.*
A.	Wheeler, Miss K. E.	Hillside, Watchet, Som.	*F.*
+	Wills, W. Melville	Bracken Hill, Leigh Woods, Bristol	
A.	Woolls, Miss F. R.	14 Russell Grove, Westbury Park, Bristol	*Bi.B.*
A.	Yeates, G. K.	Sherborne School, Sherborne, Dorset	*O.*
	Yonge, Prof. C. M., D.Sc. ..	The University, Bristol, 8	
A.	Zealand, Mrs. H. W.	Brecon Lodge, Westbury-on-Trym, Bristol	*F.*

* * * *

Honorary Members

R. M. Prideaux, F.R.E.S., Brasted Chart, near Sevenoaks, Kent.
Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64 Victoria Street, Westminster, S.W.1.
Sir Ernest Cook, D.Sc., 40 Alma Road, Clifton, Bristol, 8.
H. Womersley, F.R.E.S., A.L.S., 36 Wattle Street, Fullerton Estate, Adelaide, S. Australia.

REPORT OF COUNCIL

TO DECEMBER 31st

1937

THE main feature of this year has undoubtedly been the addition of a new section entitled the Biology Teachers' Section which, while adding another branch of work, will also add to our membership.

The Annual Meeting was held on January 21st at 7.30. Mr. McMurtrie was re-elected as President, Professor C. M. Yonge became Vice-President in place of Mr. J. H. Savory, and the Rev. R. Jeffcoat and Messrs. A. C. Leach and H. Savory were elected to the Council in the places of Professor C. M. Yonge and Messrs. F. F. Glasspool and H. Vicars Webb. Miss Hiley being unable to continue the Secretaryship, Mr. F. Stenhouse Ross was appointed in her stead.

The Annual Dinner held in the Royal Hotel was most successful as there was the innovation of an entertainer, which was appreciated by the members.

The Society has suffered loss by the deaths of Professor Young, an Hon. Member and a past Vice-President, Mr. D. Darell of Dartmouth, and Miss H. M. Hutton of Dursley.

The President of the Geological Section, Prof. A. E. Trueman, has accepted the Chair of Geology in Glasgow University. We shall miss his kindly and helpful services. We welcome Professor W. F. Whittard in his stead.

The open night was most successful; excellent films of Marine Life were shown with explanations by Professor Yonge. These were fully appreciated by the large audience whose presence was due in part to the able work of Mr. T. V. T. Baxter among the schools.

The quality of the exhibits was maintained in the Exhibition meeting in October, but we hope to increase the attendance because this is, I feel, a very useful meeting.

It is pleasant to report that there is an increase in membership both as regards the Society and the Sections.

The Summer Field Meeting, held on June 19th, at Whatley, Holwell and Nunney was, as usual, arranged by the President and Secretary of the Field Section.

As a Memorial to Miss Ida Roper an Epidiascope has been purchased, and an addition is being made to the Library.

We regret that Miss Strudwick, the Librarian, acting under doctor's orders, tendered her resignation; Mr. H. Gorvett has accepted the position.

F. STENHOUSE ROSS, *Hon. Secretary.*

The Hon. Treasurer in Account with the Bristol Naturalists' Society

Dr. RECEIPTS AND PAYMENTS FOR THE YEAR ENDING 31ST DECEMBER, 1937 *Cr.*

1936 £ s. d.		£ s. d.	£ s. d.
	To Members' Subscriptions :—		
5 0 0	Life Subscription		
3 10 0	Ordinary : Arrears from 1935 ..	10 0	
	,, ,, 1936 ..	6 17 6	
48 15 0	,, 1937 ..	50 10 0	
	,, 1937 (new)	5 5 0	
17 6	,, in advance, 1938	3 15 0	
1 10 0	Associate : Arrears from 1936 ..	1 2 6	
14 0 0	,, 1937	16 15 0	
10 0	,, in advance, 1938 ..	17 6	
	Junior : Arrears from 1936 ..	2 6	
5 0	,, 1937	7 6	
	,, in advance, 1938 ..	2 6	
			86 5 0
74 7 6			
21 9 3	,, Subscriptions to Sections received by Hon. Treasurer		28 3 0
95 16 9			114 8 0
43 5 6	,, Memorial Fund to Miss I. M. Roper		
10 0 0	,, Donations received towards *Proceedings*		10 0 0
38 5 6	,, Special Publication Fund		
2 19 0	,, Sale of Publications		1 16 6
	,, *Avonian*		3 2 9
14 0 0	,, ,, Dinner Tickets		13 15 0
	,, ,, Tickets for Field Meeting		12 0 6
3 2 7	,, Interest on Deposit		1 12 0
140 0 9	,, Balance from last Account		143 0 5
347 10 1			£299 15 2

1936 £ s. d.		£ s. d.	£ s. d.
	By Subscriptions :—		
1 1 0	Ray Society	1 1 0	
	Zoological Record	2 10 0	
18 0	S.W. Naturalists' Union, 1937 ..	18 0	
10 0	Bristol Empire Naturalists' Assn.		
			4 9 0
87 12 11	,, Cost of *Proceedings*, 1936		70 3 4
21 11 6	,, Reprints of Various Papers		10 3 0
4 3 0	,, Index to previous series of *Proceedings*		
17 19 0	,, Printing, Postage, Stationery, etc.		12 0 7
6 9 6	,, Printing Rules		
7 7 3	,, Lecture Expenses		6 3 2
1 11 0	,, Rent and Fire Insurance		1 11 0
14 19 9	,, Dinner Expenses		12 19 0
15 5 0	,, Librarian's Expenses		1 6 8
1 4 6	,, Field Meeting. Expenses		12 11 9
2 12 6	,, S.W. Naturalists' Union : Reception		
21 4 9	,, Subscriptions to Sections paid over by Hon. Treasurer		28 7 6
	,, Memorial Fund to late Miss I. M. Roper. Purchase of Epidiascope		35 2 6
	,, Cash at Bank, as under :—		
	Ida M. Roper Memorial Fund Balance	8 3 0	
139 0 5	General Fund	92 14 8	
			100 17 8
4 0 0	,, Cash in hands of Hon Secretary		4 0 0
347 10 1			£299 15 2

F. W. EVENS, *Hon. Treasurer.*

Audited and found correct.

ERNEST H. COOK,
CHAS. BARTLETT, F.C.A. } Auditors.

Bristol, 16th January, 1938.

LIBRARIAN'S REPORT

FOR THE YEAR 1937

THE Society is deeply indebted to Miss F. E. Strudwick for her work as Honorary Librarian, and in particular for her contribution to the reorganization of the Library. On her resignation in April, 1937, the work was taken over by Mr. H. Gorvett.

The Library has since been entirely reorganized. Bulky and rarely used cabinets containing a herbarium, a collection of Lepidoptera, and a collection of microscope slides have been removed to the cellar behind the Library, and the cupboards rearranged to give additional space and light. The work of cleaning and rearranging the herbarium was kindly undertaken by Mr. H. S. Thompson.

All journals and books previously stacked in cupboards are now displayed on the shelves. Journals of general interest are grouped according to the countries in which they are published, while those published by British Societies are arranged in alphabetical order. Journals and books relating to special subjects are grouped under the following subject headings: Botany, Entomology, Geology, Ornithology, Zoology, and General (including books on general biology, biography, anthropology, British Museum catalogues and British Association handbooks). A list giving particulars of the new arrangement will be found on the notice board, and it is hoped that the rearrangement will make for greater efficiency and ease of reference. Recent additions are placed on a separate table, and it is suggested that reference to these would be greatly facilitated by the acquirement of a suitable rack for their display.

The Society is indebted to the British Museum (Natural History) and to Mr. H. S. Thompson for the presentation of books, and, as in previous years, journals have been received from the Entomological, Geological, and Ornithological sections.

That there is a growing awareness amongst members of the existence of a really valuable collection of books in the Society's Library is shown by the fact that one hundred and fifty entries have been made for books borrowed, an increase of nearly fifty per cent. in two years.

There is still a certain demand for copies of the reprint of the paper on the Avon Gorge by Dr. Vaughan and Professor Reynolds and also for back numbers of the Society's *Proceedings*.

It will now be possible to set to work on a new catalogue, so long overdue, and it only remains to reiterate the plea of former Hon. Librarians for increased financial aid, particularly for the purposes of binding.

H. GORVETT, *Hon. Librarian.*

REPORT OF BIOLOGY TEACHERS' SECTION

1937

THIS section was formed after a preliminary meeting held in July, 1937. For some time the Biology teachers in Bristol had been feeling the need of co-operation in their work. This especially applied to the teachers in the new Senior Schools. It was to meet this need that the Bristol Teachers' Biology Club was suggested and this has become the Biology Teachers' Section of the B.N.S. The aim is to pool the resources of the teachers of Bristol for their mutual benefit. A committee was formed which met the representatives of the B.N.S., and a programme was arranged.

In the latter part of 1937 four meetings were held. Two of these were Museum visits to familiarise members with the Library and to see more fully the possibility of the Museum as a teaching aid. In September, at a Symposium, the "Aims of School Biology Teaching" were discussed. In November, Mr. H. A. Peacock of Cheltenham Grammar School addressed the section on "The Uses and Abuses of School Biology."

The Section is anxious to form its own reference library of text books suitable for teachers of Biology. Any suggestions or gifts of text books will be welcomed by the Secretary. We are also hoping to prepare, for circulation in the Section, copies of tried syllabuses.

M. A. GIBBS, *Hon. Secretary.*

REPORT OF BOTANICAL SECTION

1937

THE Section has held eleven meetings in the Botanical Department of the University during the year. The membership of the Section is now thirty-nine, representing a net increase of eleven.

At the Annual Meeting held in January, Professor M. Skene was re-elected President, and Mr. F. F. Glasspool Hon. Secretary and Treasurer. A paper on Periclinal Chimæras, illustrated by lantern slides, was given by Professor Skene.

The subject for the February meeting was Twigs. Among the exhibits were many common trees as well as the Tulip Tree, *Liriodendron tulipifera*, Vanilla Tree, *Vanilla planifolia*, and *Azara microphylla*.

Wind pollinated flowers formed the special subject for March. A remarkably fine collection of representative types from trees, flowering plants and grasses was shown and described by Mr. Luckwill. Mrs. Bell showed a specimen of perennial wheat, together with cuttings and photographs of it collected from various sources.

During the Summer months no special subjects were selected, as fresh specimens were more easily obtainable and the number of exhibits was sufficient to provide discussion for the whole of the meetings.

In July, members inspected the Botanical Gardens of the University with Professor Skene acting as guide and lecturer. Here they saw many plants frequently mentioned, but less frequently observed, such as the Venus Fly Trap and the Pitcher Plant. A visit was afterwards paid to the Gardens in Woodland Road.

The Open Meeting of the Section, held in October, was well attended and, in addition to members, fourteen visitors from other Sections were present. Mr. H. S. Thompson read a paper on Alpine Fruits and illustrated it by means of pressed specimens. Short accounts of Teasels and Winter Buds of Frogbit were given by Mrs. Bell and Mrs. Sandwith respectively, and a collection of thirty-five plants in flower was shown by Mr. Reed.

At the November meeting Dr. Bracher gave an account of the colonization of Dungeness by Lichens, Mosses and flowering Plants. Lantern slides showing plants on the coast, together with fresh and preserved specimens, were exhibited.

In December, Professor Skene showed a number of greenhouse plants possessing features of botanical interest. They included *Rhoeo discolor*, *Ruellia*, *Bilbergia*, *Psychotria* and two peppers, *Capsicum minimum* and *Capsicum annuum*.

Mrs. Sandwith has continued the Botanical Notes in the *Proceedings* and will be pleased to receive any new records for inclusion.

F. F. GLASSPOOL, *Hon. Secretary.*

REPORT OF ENTOMOLOGICAL SECTION

1937

12th Jan. 73rd Annual Meeting. The Hon. Secretary reported that the number of members was sixteen, including two honorary members. The election of President and Hon. Secretary was adjourned until March.

Mr. A. H. Peach exhibited a large series of aberrations of British *Lycænidæ* and *Cænonympha tullia*. Thanks to the seven visitors present, viz., Col. L. Wood, Messrs. G. B. Coney, G. H. W. Cruttwell, C. Greenwood, I. P. Russell, N. A. Watkins and B. W. Weddell, an unusual number of very fine aberrations and forms of British Butterflies and a few Moths were exhibited and discussed.

9th Feb. Meeting held at the University and open to General Members of the Society, of whom the President, Mr. G. E. J. McMurtrie, and eleven others attended. Short papers were read and exhibits made by the following sectional members :—

Mr. C. Bartlett :	Migration in British Butterflies.
	British Dragon flies.
Mr. C. Edwards :	Respiration in Insects.
Mr. A. H. Peach :	Methods of collecting Lepidoptera.
Mr. J. V. Pearman :	Evolution of variation in the wings of *Psocidæ* and the egg breaker of the embryo, with models.

13th April. Mr. C. Bartlett was elected President ; the office of Hon. Secretary was not filled. Mr. J. W. Norgrove exhibited a store box of insects from the Cape of Good Hope and British Lepidoptera from his collection. Mr. A. Kromler bred specimens of *Arenipses sabella* and *Aphomia gularis* from a chocolate factory at Fishponds.

3rd July. Excursion to Shapwick. Four members attended, the day was warm but generally overcast and there was noted a great dearth of insect life, which has been the general experience this season ; the only noteworthy captures were a specimen of *Sesia culiciformis*, by Mr. Bartlett, one *Vanessa c-album*, and several *Hydrelia uncula*.

16th October. At Portishead. Mr. Audcent exhibited a specimen of the beetle *Pyrochroa coccinea* from the New Forest and reported taking the larvæ of the saw fly *Pterenidex salicis* from willow at Ashley Hill. Mr. C. Edwards exhibited specimens of British *Carabidæ*, and Mr. Bartlett various orders of interest to those present.

The year closed with fourteen members. The successful functioning of the Section has been handicapped this year by the refusal of any member to undertake the not too onerous duties of Hon. Secretary. The Section was formed in 1864 ; the late Mr. George Harding held the office from 1865 to 1896 and was succeeded by the writer, who acted from 1897 to 1924, when he was elected President, Mr. J. V. Pearman taking over the duties for the next nine years, retiring in 1933. As no member could be induced to accept office the writer again undertook the duties of both positions from 1934-1937.

CHAS. BARTLETT, *President.*

REPORT OF FIELD SECTION

1937

AT the Annual Meeting held in January, Mr. H. F. Barke, F.I.C., Miss M. D. Hiley and Mrs. H. F. Barke were re-elected President, Hon. Secretary and Hon. Treasurer respectively Mr. G. H. Beacham was elected to serve on the Committee in place of Mrs. A. G. Bell.

Mr. B. A. Baker, F.G.S., exhibited some interesting specimens of coniferous wood which had been washed out from the clay at Southbourne.

In his Presidential Address Mr. Barke explained that by recent regulations the Ministry of Health had greatly simplified the position in that to-day all milk was either T.T., which was clean milk from a herd free of tuberculosis, or pasteurised, which was milk previously heated to 145° F. for 30 minutes in order to kill the germs. He subsequently demonstrated some of the bacteriological tests on milk and showed how the liquid is tested in order to prove that it is of sufficient purity as demanded by the Act.

Following the practice of recent years, the Committee decided again for the Summer to concentrate on a particular area and selected the district to the south and south-east of Bath circumscribed by a line joining Bath, Farmborough, Midford, Warleigh Woods and Hampton Rocks. Various members supplied the field notes which are contained in the programme, and the Section would wish to record their thanks to them. It is believed that these notes, although expensive to print, are nevertheless a valuable feature.

In May, Mrs. E. S. Hayman and Mr. H. C. Bishop led the first field meeting. The party walked from Combe Down to Claverton, where the church was visited, then proceeded to Warleigh Woods which proved an interesting centre for observations of many kinds. The inter-relationships of scenery and underground rock structure were particularly well seen at many points.

In July, Mr. Ivor Evans was responsible for leadership in the immediate area of Bath. On this occasion members visited the Sham Castle, Hampton Rocks and the Botanical Gardens where the botanists were especially interested in the wealth of flora observed.

Mr. H. O. Edmonds was again the leader for the whole-day field meeting in September. From Odd Down the members walked down Monkton Combe to Stout Hill. An augmented afternoon party walked along the towing path of the canal from Claverton to Limpley Stoke.

The concluding meeting was held in October when members visited the Farmborough-Timsbury area under the leadership of Mr. F. W. Evens. Members alighted from the bus at the Clutton-Timsbury cross roads and a circular route was followed to the New Inn at Farmborough. During the course of this meeting there was ample opportunity to collect late flowering plants, fruits and fungi. The geologists visited several exposures and many fossils were collected.

The Annual Field Meeting of the Parent Society was held in June and as usual was under the leadership of the President and Hon. Secretary of the Field Section. The villages of Egford, Nunney and Holwell in the Eastern

Mendips formed the area for investigation, and the blending of Cotswold and Mendip characteristics was noted. Nunney Castle and Church were inspected, and the Holwell quarries, long known through the indefatigable labours of Charles Moore of Bath, were visited.

The thanks of the Section are due to all the efficient leaders and to those who assisted them.

Mr. H. Vicars Webb again kindly arranged the special ornithological meetings and reports as follows :—

April 21*st*. St. Anne's Woods. Birds in song : Willow Warbler, Blackbird, Thrush, Robin and Common Wren. The water from St. Anne's Well tested by all the party.

May 1*st*. Pensford District. Brilliant day and warm. Willow Warblers the dominant songsters. Other birds : Cuckoo, pair of Grey Wagtails, Green Woodpecker, Swallows, Martins, Chiff-chaff, Common Wren and Tits. Pensford and Publow churches were visited.

May 22*nd*. Blagdon Lake. Showery conditions. The party was welcomed by Mr. Donald Carr. Waterfowl observed were three Great Crested Grebes, Tufted Duck, Wigeon and Coot ; a nest of the latter with three eggs in a reed bed. Swallows and Swifts over the water. Other bird-life : Willow Warbler, Chiff-chaff, Blackbird, Thrush, Wren, Robin, Chaffinch and Green Woodpecker. St. Andrew's church visited.

May 26*th*. Abbots Leigh. A Turtle Dove seen and heard "cooing" from the bare top of a tree. On the Abbot's Pool a family of tiny Mallard-chicks with adults catching insects, also four handsome Canada Geese. Songsters heard : Cuckoo, Willow Warblers and resident species.

June 9*th*. Stapleton District. Birds seen or heard : Willow and Wood Warblers, long-tailed Tits, Swifts and Sand Martins, Jays and Magpies. At the Old Mill the water-wheel was in action. The flower beds and the rockeries were attractive. On the Duchess Pond were families of Swans and Moorhens.

Messrs. Ivor Evans and L. C. Luckwill kindly conducted the special botanical meetings and contribute the following reports :—

April 28*th*. Brislington and Keynsham. The field path was taken to the river at Keynsham, returning by the main road. Spring flowers and trees were remarked upon and special attention drawn to Thele Cress, Ivy-leaved Crowfoot, Hornbeam, Elms in catkin ; early foliage of trees and river-side plants was observed.

May 29*th*. Goblin Combe. The party proceeded from Cleeve via Goblin Combe and Prestow Wood to Wrington. After tea, some members inspected the church, whilst others visited a near-by quarry on the hillside. The party then proceeded by footpath to Redhill. Amongst the more interesting plants noted in the Combe itself were the limestone Polypody, Rock Stonecrop, Stinking Hellebore, Spindle, Stinking Iris, Field Maple and many fine specimens of native Ash and Yew. In the lanes leading to Wrington five species of Orchis were found, viz. : Spotted, Early Purple, Twayblade, Butterfly and Bee, and many other plants including the Rough Chervil, Carnation Grass and Black Bryony. By the river between Wrington and Redhill a number of interesting marsh plants were observed such as the Yellow Iris, Brookweed and Marsh Horsetail.

June 12th. Flax Bourton and Broadfield Down. Summer flowers in profusion including Purple Orchis and Spring Potentilla. The gardens of W. O. Gibbs, Esq., of Barrow Court, were open to members who were personally conducted around them by the owner.

July 3rd. Rowberrow and Blackdown on Mendip. After inspecting the quarries at Churchill Rocks, where some fine specimens of the Stinking Hellebore were noticed, the party proceeded round the base of Dolebury Warren, up Swiss Valley to Rowberrow Warren and Tyning's Farm. Many interesting plants were observed growing in the valley, including the Alpine Penny-Cress, the Axillary Clustered Sedge, the Bladder Fern, Marsh Horsetail, Drooping Thistle, Water Mint and Dames Violet. On the slopes of Rowberrow towards Tyning's Farm the round leaved Sundew and the Bog Pimpernel were found.

After tea at Tyning's Farm, the party inspected the heath flora on the summit of Blackdown, and descended on the other side to Burrington. The dominant plants on the summit of the hill were Ling, Cross-leaved Heath and Bell Heather, whilst the slopes were covered by a dense growth of Bracken. On the heath the following plants were found: Milkwort, Dwarf Furze, Tormentil, Heath Bedstraw, Bilberry, Lousewort, Deer's Hair Spike Rush, Decumbent Heath Grass, Purple Moor Grass, Mat Grass, Hare's Tail Cotton Grass, Narrow Leaved Cotton Grass, Bog Violet, Marsh Bird's Foot Trefoil, Bog Asphodel, together with numerous other species. Amongst the Bracken on the slopes many species of heath grasses were observed together with the upright St. John's Wort, Sheep's Sorrel and Foxglove.

July 24th. Hursley Hill and Marksbury. The party walked from Hursley Hill across wooded country to Marksbury Vale via Compton Dando. Plants seen: Wild Liquorice, Adder's Tongue, Periwinkle, Honeysuckle, Teasle, Woolly Headed Thistle, trees, ferns, grasses, etc.

August 21st. Filton, Winterbourne and Hambrook. Members walked to Winterbourne via Stoke Gifford and observed Field Pansy, Henbit, Nettle, both species of White Bryony, Corn Camomile, fruit of Guelder Rose, Maple, Dane Wort. Plants of cornfield and roadsides were examined.

M. DORIS HILEY, *Hon. Secretary.*

REPORT OF GEOLOGICAL SECTION

1937

THE Annual Meeting was held on the 28th January, 1937. The Secretary and Treasurer read their reports which were approved by the meeting. The President, Vice-President and Treasurer were re-elected. The Secretary, Mr. H. Cuthbert Shilstone, resigned on account of ill health ; his place was taken by Mr. F. Stenhouse Ross. The Chairman spoke appreciatively of Mr. Shilstone's services for the Section. Mr. Turner and Mr. Shilstone were elected to the committee in place of Dr. Smith and Mrs. Barke. This meeting was followed by a lecture by Professor A. E. Trueman on the Coal Measures of Bristol and Somerset.

In February, Dr. Wallis and Mr. G. Kellaway read most interesting papers. Professor A. E. Trueman, who was in the Chair, suggested that Mr. E. Seavill's paper should be read in title as he was absent on account of illness.

In March, Professor H. H. Swinerton of Nottingham University College gave a very interesting lecture entitled "The Palmistry of the Rocks." He demonstrated, from the position of the footprints that he had discovered in the Triassic rocks in the neighbourhood of Nottingham, the type of animal that had made them.

We opened our Summer season on April 24th with a very successful charabanc outing to Temple Cloud, Radstock and Nettlebridge, led by Professor A. E. Trueman assisted by Dr. Moore. The Coal Measures of this area were studied.

On June 30th we were led by Dr. F. S. Wallis and Mr. H. M. Webb. The deep Triassic deposits in the Hollycrome Brick Pits, and the Upper and Lower Rhætic in Crox Bottom were seen. Mr. G. A. Kellaway described the lower beds of the Lias in reference to the Oolite of Dundry Hill. The members then went to the Venture Inn where coffee was served and a presentation was made to Professor A. E. Trueman who was leaving to take the Chair of Geology at Glasgow University.

The last Summer outing was led by Professor S. H. Reynolds to Spring Cove and Woodspring, Weston-super-Mare. The exposures of lavas and volcanic tuff in the Carboniferous Limestone, and the raised beach at the former place, were noted with interest.

The Winter Session opened on October 21st with a lecture by Professor S. H. Reynolds on a visit to Iceland, with some very fine slides of the geysers and volcanic lavas and tuffs. On November 18th Dr. Wallis conducted the members round the Geological Section of the Museum and Art Gallery, which was much appreciated by the members.

The Tutorial classes preceding the lectures in the Winter Session were appreciated and found instructive by the members, and we commend them to those who have not attended.

We regret to report the death of Miss H. M. Hutton, of Dursley, in the early part of the year.

Professor A. E. Trueman, D.Sc., having accepted the Chair of Geology at Glasgow University, has left Bristol. We miss him with his clear and lucid methods of teaching.

Mr. G. A. Kellaway, B.Sc., has been appointed to the Geological Survey.

F. STENHOUSE ROSS, *Hon. Secretary.*

REPORT OF ORNITHOLOGICAL SECTION

1937

THIS Section now has a membership of 65—the largest since its revival in 1922. The marked enthusiasm shown in the past few years has in no way diminished; this, coupled with much friendly co-operation among members, augurs well for the future.

Seven meetings have taken place during the year. At those held in members' houses, seating capacity was sorely tried, and late-comers ran the risk of finding standing-room only. At the February meeting, held in conjunction with the Natural History Section of the Clifton College Scientific Society, there was a large combined gathering of College boys and members, while at the Open Meeting in November, particulars of which were circularised to the whole Parent Society, there was an attendance of 60. It is to be regretted, however, that of these no more than 10 or 12 were members of other Sections.

In January, an account of Bird-life in Pembrokeshire was given by Mr. H. H. Davis, special reference being made to the Islands of Skokholm and Grassholm. Mr. Peter Scott journeyed from East Anglia for the February meeting and gave a most entertaining talk on "Wild Geese and Ducks," illustrated by a beautiful series of slides taken from his own drawings. In March, the Rev. F. L. Blathwayt lectured on "British Breeding Terns" and dealt especially with field characters, nesting habits and distribution. The September meeting was devoted to Short Papers, among which a descriptive account by Miss K. M. Paterson of the working of the "Skokholm Bird Observatory," and notes on "Bird-life in the Port Erin district of the Isle of Man", by Mr. G. E. Clothier, were of particular interest. In October, a lecture on "Bird-life in North Argyll" by Mr. H. Tetley was augmented by some valuable observations on mammals in the district. At the Open Meeting in November, Mr. G. K. Yeates gave a vivid account of "Bird-life in the Camargue," and showed a unique series of slides depicting, among others, such interesting species as Penduline Tit, Spectacled and Fantail Warblers, Hoopoe, Hobby, Marsh Harrier, Little Egret and Black-winged Stilt. Finally, in December, Mr. H. G. Alexander came from Birmingham and gave a highly instructive lecture on "Bird Song," illustrated by Bird Song gramophone records.

A few members were fortunate in being able to attend two additional meetings in Bristol—that of the Ornithological Section of the Somerset Archæological and Natural History Society on October 14th, when Mr. H. A. Gilbert spoke on "Duck Decoys and Migrations"; and a meeting of the Bristol Photographic Society on November 10th, when Captain Oliver Pike gave a lantern lecture on "Familiar Wild Birds."

For the fifth successive year a visit was paid to Steep Holm in May, the weather, as on previous occasions, being perfect. All accessible parts of the Island were worked, and no less than 24 species were identified, of which two —Goldfinch and Chaffinch—had not previously been recorded. Good views were obtained of Ravens, Peregrines, and the Cormorant colony.

Many interesting observations have been made by various members of the Section, particularly at the North Somerset reservoirs and along the Severn mud flats. A detailed account on the more important of these will be found elsewhere in this number of the *Proceedings*.

H. H. DAVIS, *Hon. Secretary.*

Account of the Annual and General Meetings

1937

THE 74TH ANNUAL MEETING of the Society was held at the University of Bristol on January 21st, 1937, with the President, Mr. G. E. J. McMurtrie, in the Chair. The President was re-elected for his third term of office. Rev. R. Jeffcoat and Messrs. A. C. Leach and H. Savory were elected to serve on the Council in the places of Professor C. M. Yonge and Messrs. F. F. Glasspool and H. Vicars Webb. The other Officers were re-elected with the exception of the Hon. Secretary; Mr. F. Stenhouse Ross was elected to this office to replace Miss M. D. Hiley, who was retiring owing to pressure of other work. The Annual Reports were presented and adopted.

Mr. McMurtrie in his Presidential Address on "Screening and Cleaning of Coal and Underground Lighting" fully described the methods of screening coal. Thanks to a considerable exhibit of safety lamps lent by Messrs. Thomas and Williams, Cambrian Lamp Works, Aberdare, he was able to trace very clearly the development of lighting in the different types of mines. The lecture was illustrated by lantern slides. (See p. 155.)

The 587TH GENERAL MEETING took the form of the 10th Annual Dinner which was held at the Royal Hotel on February 4th, under the Presidency of Mr. G. E. J. McMurtrie; fifty-five members were present. There was a change made in the programme. Instead of a guest of the evening and a lecture, a new departure was made in the form of an entertainer, which was appreciated by the members.

The 588TH GENERAL MEETING was held at the University on March 4th. Mr. G. E. J. McMurtrie was in the Chair. Several papers were read in title. Dr. C. L. Walton gave a lecture on "The Warble fly and its Control." He gave a very comprehensive review of the Life History of the Warble Fly, also of the methods for its control; a wealth of lantern slides illustrated the lecture.

The 589TH GENERAL MEETING was held on June 19th, under the auspices of the Field Section at Whatley, Nunney and Holwell. At Whatley, in that most beautiful valley, the Botanists had a splendid opportunity of collecting specimens, and the quarries were thoroughly inspected by the Geologists. The interesting Castle of Nunney was also seen, and at Holwell the Geologists noted the planed-off surfaces of the Carboniferous Rocks, and their unconformity with the Jurassic Rocks.

The 590TH GENERAL MEETING was held in the Botanical Department of the University on October 7th, with the President, Mr. G. E. J. McMurtrie, in the Chair. The following exhibited:

BOTANICAL

Mrs. Bell and Mrs. Sandwith—Fine exhibit of fresh flowers.

Mr. Evens—Exhibit of Autumn growth collected on the last Summer outing.

GEOLOGICAL

Mrs. Marsden—Lavas and Ashes from Vesuvius with views of the mountain.

Mr. Tutcher—some very fine examples of Jurassic fossils.

Mr. F. Stenhouse Ross—Jurassic fossils from Dundry and Dorset.

Geological Department of the University—Rock and mineral specimens from Devon and Cornwall, and recently acquired books.

ORNITHOLOGICAL

Messrs. Savory, G. K. Yeates and C. J. F. Coombs—A very fine series of photographs of Bird Life.

Mr. L. H. Matthews also showed fish from the Bristol Channel, and Mr. Stuart Thompson some rare Natural History books.

The 591st GENERAL MEETING was held in the Lecture Theatre of the Bristol Museum and Art Gallery on November 4th. The President, Mr. G. E. J. McMurtrie, was in the Chair. There was a large audience. Professor C. M. Yonge described a series of cinematograph films of Marine Life.

The 592nd GENERAL MEETING was held at the University on December 2nd. Mr. G. E. J. McMurtrie was in the Chair. Nominations for Officers and Council for 1938 were received. Miss P. M. Jenkin, M.A., gave a lecture on "The Biology of the Lakes of Kenya." She described the Geological history of the Lakes, their fauna and its relationship to the alkalinity of the Lakes.

F. STENHOUSE ROSS, *Hon. Secretary.*

PRESIDENTIAL ADDRESS, 1937

(*Abridged*)

By G. E. J. McMurtrie

(*Read* 20*th January*, 1938)

At the end of my three years' term of office as President, it may not be unwise to look back and epitomise what has been attempted and done by the Council, particularly as a special effort has been made to add to the usefulness of the Society and to its membership.

The past history of the Society has been well told by Mr. J. W. Tutcher in his 1932 Presidential Address, and that of the Sections in 1914 by the following: The late Mr. J. W. White, "Fifty Years of Bristol Botany"; Messrs. A. E. Hudd and G. C. Griffiths, "Fifty Years of Bristol Entomology"; the late Mr. H. J. Charbonnier, "Fifty Years of Bristol Zoology"; and Prof. S. H. Reynolds, "Fifty Years of Geological Research in the Bristol District." The last five years, therefore, alone remain to be considered.

1933

Dr. F. S. Wallis was our 1933 President, and very early in the year he brought forward the matter of organization, and a Sub-Committee was appointed to advise the Council. More than one report was made by this Committee before the Council advised the adoption of their proposals. The final financial basis was the work of the late Professor Darbishire, but many valuable suggestions were made by Mr. T. V. T. Baxter and others. The main proposal was that Sectional members, in addition to paying their sectional fee or fees, should be either Ordinary members paying 10s. and receiving the annual *Proceedings*, or Associate members paying 5s. and not receiving the *Proceedings*. Junior members under 21 were admitted for 2s. 6d. with 1s. sectional fees.

My own feeling is that, given numbers, an annual subscription of 10s. should cover membership and admission to any and all sections. This should come in time.

Systematic advertising by lectures, leaflets, posters, circulars, etc., a Zoological section, and the use of films, were other suggestions of the

Committee accepted by the Council. A Biological section has lately possibly taken the place of the suggested Zoological section, while our November meeting for the last five years has been made an open night, with a lecture on some special subject or subjects, and the Museum Theatre well filled by members, their friends and secondary school boys and girls. Our grateful thanks are due to Professors Macgregor Skene and Yonge for giving these lectures, and to Mr. Baxter for ensuring a good attendance of pupils. It is very doubtful, however, whether sufficient systematic advertising by leaflets, posters, circulars, etc., is being done; this is a matter that should be further considered.

Notices of our meetings, General, Open and Sectional, are, it is believed, posted on the main and sectional University notice-boards, and at the Central Library. They should also be posted at the various branch libraries, the Museum, at all secondary schools, and at the Merchant Venturers' Technical College.

The open night instituted in the Autumn of 1934, and given by each section, is undoubtedly a step forward, but though the officers of each section have taken considerable trouble to provide matter of common interest to all sections, the attendance of non-members of the section has been at times disappointing, even though latterly the whole of the Society has been circularized. There seems plenty of naturalist and sectional *esprit de corps*, but it is curiously wanting on these open nights.

The first open lecture was given by Mr. John Kearton on "The Fascination of Field photography."

We had to deplore this year the loss of Mrs. Vaughan, a keen geologist, and reporting secretary for eight years.

1934

The late Prof. Darbishire was our 1934 President, but to the great loss of the Society died in October.

The scheme of reorganization was adopted at the annual meeting, and the result of it was an increased financial balance of £25 for the year. Several Sectional members became Ordinary members, and more became Associate members, but, unfortunately, there was a temporary loss of membership.

Miss Roper, on account of ill health, resigned the Editorship of the *Proceedings* and also the Librarianship. The Council considered it advisable to separate these two offices, and Mr. H. W. Turner was appointed Editor and Miss Shaw Librarian.

A new and very useful feature, "Field Notes and Observations," was added to the *Proceedings* by the new Editor, and it was printed locally, while Miss Shaw began an overhaul of the Library. There is much largely unseen work required of both Editor and Librarian.

The open lecture this year was given by Prof. Trueman.

The open sectional meetings were also introduced this year as an experiment.

1935

While 1934 was overshadowed by the death of the President, 1935 brought very great trouble in the death of the Secretary, Miss Ida Roper, who, for the long period of nineteen years, had been Secretary and Editor, and for much of this time also Librarian, and represented in the public eye the Society. She was also our President from 1913 to 1916, the only lady President as yet and a botanist of outstanding merit, with a profound knowledge of fungi, which was acknowledged by her election to the Linnean Society. For thirteen years, too, she collected and exhibited local wild plants at the Bristol Museum. As a well-known local archæologist she was on the Council of the Bristol and Gloucestershire Archæological Society, and was the author of a standard work on Monumental Effigies. A many-sided woman.

Miss Shaw was good enough to act as Secretary during Miss Roper's long illness, and later Miss M. D. Hiley accepted the appointment. Mr. McMurtrie was elected President, Miss Shaw resigned the Librarianship and Mr. Pearman was appointed in her stead. Altogether a record of much change.

As, in consequence of Professor Darbishire's death, there could be no Presidential Address, Dr. F. J. North, of Cardiff, gave a most instructive address on "The Origin of Coal."

The open meeting was held in November in the Museum Theatre, when films were exhibited on (1) The Amœba, explained to a very full house by Prof. C. M. Yonge; (2) Roots, the life cycle of a plant, and how plants feed, by Prof. Macgregor Skene.

The *Proceedings* has been much improved by the adoption of a bolder type, and an excellent work done by the Editor in the republication of the late Dr. Arthur Vaughan's standard work on *The Carboniferous Limestone Series (Avonian) of the Avon Gorge.* Prof. Reynolds revised and brought this paper up to date and improved the plates. Thanks to subscriptions collected by Mr. Turner, the

publication cost the Society very little, though it somewhat curtailed the space allotted to other papers.

It should be noted that nearly all the papers are read in title only and that no sectional papers are produced. Obviously certain very valuable records can only be dealt with in this way, but more space should be given to the excellent sectional papers read.

During the year a Presentation was made by the Geological section to Prof. Reynolds on resigning its presidency after thirty-four years of excellent service.

The President endeavoured this year to obtain the addition of an Archæological section, but though he obtained promises from over thirty members to join it, the Council did not approve of it. This is regrettable, as in many naturalist societies the Archæological or Antiquarian section is the strongest, and adds largely to their membership.

1936

Mr. McMurtrie was re-elected President, and Mr. F. W. Evens replaced Dr. Wallis as Vice-President. Mr. Pearman resigned the Librarianship and was replaced by Miss F. E. Strudwick.

Much time had been spent in 1935 in revising the rules, which were adopted at this annual meeting.

The President's address was a description of "Former and Present Methods of Cutting, Loading and Conveying Coal."

After the annual dinner Prof. E. Fawcett lectured on "The Bristol Giant."

A new feature in the syllabus was a most interesting lecture by Mr. H. St. George Gray on "Archæological Excavations in Somerset," when members of the Bristol and Gloster. and the Somerset Archæological Societies joined us.

The November open meeting was again largely attended. Films of the Thistle, Fungi, Mushroom and Cabbage were shown and explained by Prof. Macgregor Skene.

During the year, the Librarian, Miss Strudwick, thoroughly overhauled and rearranged the Library, which entailed much labour and time. The Exchange List was also revised, and certain books removed and additional shelving added.

The Council also voted £25 for bringing up to date bookbinding and for the purchase of new books. It should be noted that Mr. Ivor

Evans has copied into the Library copy of Mr. J. W. White's *Flora of Bristol* Miss Roper's notes thereon.

The sectional open nights were held and the Ornithological and Entomological were very well attended.

During the year the Society decided to purchase a Memorial to the late Secretary, Miss Roper, and the President collected over £43, with which an Epidiascope has been purchased, which it is hoped will be of use to all sections, and some botanical works to mark her sectional interest.

The Society during the year lost two of its seven honorary members, Professor C. Lloyd Morgan and Professor W. J. Sollas, as well as Mr. A. W. Cottle and a formerly well-known Bristol man, Dr. Herbert Bolton, a former director of the Bristol Museum and Art Gallery. Excellent obituaries have appeared in our *Proceedings*.

1937

Mr. McMurtrie was again elected President for his last year of office, and Prof. Yonge replaced Mr. J. H. Savory as Vice-President.

Miss Hiley, finding the work of Secretary of both the Society and the Field section excessive, resigned the former, and Mr. F. Stenhouse Ross was appointed in her stead.

The President's address dealt with "Past and Present Systems of Screening and Cleaning Coal" and "Underground Lighting." Interest was added to the latter subject by a large exhibit of safety lamps kindly lent by Messrs. Thomas & Williams of Aberdare.

The open November meeting in the Museum Theatre was noteworthy and well attended. Professor Yonge described films shewing (1) The life history of the Oyster, (2) The Jelly Fish, (3) The Sea Urchin, and (4) How Organisms adapted themselves to their surroundings.

The open sectional meetings were continued and were better attended, thirty non-members attending the Geological.

The principal feature of this year was undoubtedly the addition of a Biology Teachers' Section, with Miss Gibbs as Secretary. This has added another interest to the Society, and has already brought a useful addition to our membership.

Unfortunately, acting on medical advice, Miss Strudwick had to resign the Librarianship, after greatly improving the condition of the Library with some assistance from Mr. H. A. Edmonds. Mr. H. Gorvett was good enough to undertake the work of Librarian. Mr.

Gorvett also very kindly undertook the cataloguing of the Library, entailing much work and supplying a long-felt want.

The attention of the Council having been drawn by a member to the want of "direction posts" in parts of both Gloucestershire and N. Somerset, the Council investigated the matter. The preservation of footpaths should be an essential part of the Society's work.

We lost by death during the year Professor Sydney Young, another of our honorary members; Mr. R. D. S. Darell, a life member keenly interested in Botany, Geology and Zoology, and a "Senior Fellow" of the Geological Society of London to which he was elected in 1875; and Miss H. M. Hutton.

MEMBERSHIP

The following table is a summary of our membership for the last five years:—

Analysis of Membership

Society

Year	Life	Ordinary	Associate	Junior	Total
1933	3	97	5	—	105
1934	3	119	65	6	193
1935	3	113	66	4	186
1936	4	126	71	6	207
1937	4	124	79	4	211

Sections

Year	Botanical	Entomological	Field	Geological	Ornithological	B.T.S.	Total Sections
1933 ..	34	16	101	66	40	—	257
1934 ..	26	14	67	46	30	—	183
1935 ..	23	14	65	43	31	—	176
1936 ..	30	16	72	58	49	—	225
1937 ..	38	14	78	58	58	20	266

From this it will be seen that there has been a steady increase in the Ordinary membership, and a larger increase in Associate members

consequent on reorganization. The membership for 1937 is double that of 1933. Also that the Sectional membership largely increased in both 1936 and 1937, though the Field section has never recovered its heavy loss of one-third of its membership, due to the introduction of the Associate fee of 5s., though it will be seen that it is steadily growing again. With this exception, all the sections have held their ground or shew a slight increase.

A welcome feature is the steady increase of new members, consequent upon the broader lines on which we are working:—

1933	1934	1935	1936	1937
14	20	28	29	30

Against this have, unfortunately, to be set yearly several resignations, chiefly due to members leaving the neighbourhood.

This five years' retrospect shews a record of much work on the part of many of our members, apart from that of the Council and Officers.

In conclusion, while the reorganization of 1934 has financially greatly benefited the Society, and has strengthened both the full and sectional membership, our present total of 211 cannot be regarded with satisfaction in a population of 410,000, and points to the necessity for additional work and propaganda.

Bristol Botany in 1937

By Cecil I. Sandwith

It is regrettable that few records of interest have been noted for the past year with regard to native plants in the district. A more intensive search in the less well-known parts of the district on the W. Gloucestershire side might be profitable.

At the Exhibition Meeting of the Society in October, Mrs. Bell showed an unusual form of *Verbascum nigrum* with white flowers, from Portway, also *Dipsacus fullonum*, which had appeared there in abundance. She also noticed on Shapwick Heath in August small bushes of *Symphoricarpos* (Snowberry), which is gradually becoming naturalized on the edge of a drove. The less frequent *Chenopodium glaucum* L. was also found by Mr. H. J. Gibbons and Mrs. Bell in a field near Brent Knoll Station, and a remarkably luxuriant plant of *Cicer arietinum* L. on ground near the Avon.

Malva neglecta Wallr. is the correct name for the native Dwarf Mallow, which British botanists have for so long called *M. rotundifolia* L. Linnæus' name must be applied to the alien *M. borealis* Wallm. of *Bristol Fl.* (*M. pusilla* Sm.).

Marsh and Spotted Orchids. In *Journ. Linnean Soc. Bot.*, XLIX, Jan., 1935, Mr. H. W. Pugsley has a valuable paper on the British Marsh Orchids. He demonstrates that the name *Orchis incarnata* L. must disappear from British lists, being applicable to a variety of the Continental *O. sambucina* L., and having been misapplied to a marsh orchid since the days of Fries. The plant which British botanists have called *O. incarnata* must now be identified, according to Mr. Pugsley, with *O. latifolia* L., a name whose application has aroused controversy for many years, having been usually given in Britain to hybrids of *O. prætermissa* Druce and the Spotted Orchids, or to the new species, *O. pardalina* Pugsley, which closely resembles such hybrids. Bristol botanists should re-collect *O. latifolia* L. ("*O. incarnata*" of *Bristol Flora*) in the localities given by Mr. White in order that the identification may be checked and the distribution in the area of this, and of *O. prætermissa*, properly understood; while the distribution of the two Spotted Orchids, *O. maculata* L. (*O. Fuchsii* Druce) and *O. elodes* Griseb. (*O. ericetorum* Linton), also requires investigation. *O. pardalina* may also occur in the Bristol district;

dark-flowered forms of *O. latifolia* certainly occur on the Somerset peat moors. Fresh specimens, with full information as to date and locality, should be forwarded to Mr. V. S. Summerhayes at the Herbarium, Royal Botanic Gardens, Kew, Surrey, who will notify the writer as to identification. A specimen in Herb. Sandwith from a marshy meadow, Tickenham, Som., 1932, has been marked by Mr. Pugsley " cf. *O. pardalina* H.W.P." This plant had a hollow stem and ring-spots on the leaves. It is essential to have fresh material for identification as these characters are lost in the drying.

Potamogeton pusillus and *P. panormitanus* Biv.-Bern. In *Journ. Bot.* for April, 1938, Mr. J. E. Dandy and Dr. G. Taylor have an important paper on the nomenclature and taxonomy of the two plants which have borne the above names. They show, after a study of the history and type specimen of Linnæus' *P. pusillus*, that this name must be applied to the plant which we have known as *P. panormitanus*, while the common *P. pusillus* auct. angl. non L. must in future be named *P. Berchtoldi* Fieb., which has in the past been treated as a variety of *P. pusillus* L. in our lists. In *P. pusillus* L. (*P. panormitanus*) the stipules are closed and tubular, while in *P. Berchtoldi* they are open, split and convolute. It is suggested that Bristol botanists should pay attention to the distribution of the two in our area.

Carex vesicaria L. Pond near Breadstone, G., *E. Milne-Redhead.* Just inside the district and a welcome addition owing to the destruction of this sedge at Frampton Cotterell, and its disappearance at Iron Acton.

Agrostis L. The British species, varieties, and forms are revised by Mr. W. R. Philipson in *Journ. Linnean Soc. Bot.*, LI, Nov., 1937. This paper should be consulted by Bristol botanists. The *Agrostis nigra* With. of our manuals and county floras is maintained as a distinct species under the earlier name *A. gigantea* Roth. The alien *A. olivetorum* Gren. et Godr., a native of S. Europe, is cited from Clifton, Glos., where it was collected by Mr. A. E. Wade in 1924. Mr. Philipson remarks that it is probably a hybrid of *A. tenuis* (*A. vulgaris*) and *A. canina*; if this is so, it is possible that Mr. Wade's plant was not introduced.

Phalaris arundinacea L. var. *picta* L. A patch, 6 ft. by 2 ft., in a roadside pool at Rangeworthy, G., April, 1938, *Ivor Evans.* This form is well known in cultivation, where it is called " Gardener's Garters " as well as " Ribbon Grass."

ALIENS. After several lean years, for some reason or other, a sudden crop of remarkable Alien plants made their appearance in various places, many of them disappearing equally suddenly in the usual course of events. Amongst these were plants from the Eastern Mediterranean Region hitherto not recorded in the British lists, together with other European plants which had been recorded previously from Bristol but had not been seen for many years. Among the more interesting species were :—

Ceratocephalus falcatus (L.) Pers. *Sisymbrium septulatum* DC. *Diplotaxis erucoides* DC. *Vogelia apiculata Vierh.* *Tribulus terrestris* L. *Medicago sicula* Jackson. *M. Nöeana* Boiss. *Onobrychis squarrosa* Viv. *Vicia palestina* Bss., f. *leguminibus pubescentibus.* *V. Ervilia* (L.) Willd. *Lens esculenta* (L.) Mœnch. *Cuminum Cyminum* L. *Artemisia annua* L. *Arctium tomentosum* L. *Notobasis syriaca* Cass. *Rhagadiolus edulis* Gaertn. *Plagiobothrys procumbens* (Colla) A. Gray. *Convolvulus stachydifolius* Choisy. *Hyoscyamus albus* L. *Verbena venosa* Gill. et Hook. *Blitum capitatum* (L.) Asch. *Agrostis olivetorum* Gren. et Godr., *Wade*, 1924. *Poa persica* Trin. *Bromus Danthoniæ* Trin. *Bromus scoparius* L. *Brachypodium distachyum* Beauv. *Agropyrum Buonapartis* (Spreng.) Dur. et Schinz. *Ægilops triaristata* (Willd.) Gren. et Godr. *Nardurus maritimus* (L.) Janchen. *Elymus Delileanus* Schultes. All collected by C. I. Sandwith and J. P. M. Brenan unless otherwise stated.

I am indebted to Mr. N. Y. Sandwith for the notes on changes in nomenclature which I think will help to disentangle the confusion of names.

Ornithological Notes, Bristol District, 1937

By H. H. Davis, M.B.O.U.

OF many interesting observations recorded within the Bristol area in 1937 none will give greater satisfaction to local ornithologists than the breeding, for the second successive year, of Ravens in the Avon Gorge. The usual tenacity with which this species will cling to a favoured nesting haunt gives good reason for hoping that the Avon Gorge eyrie will long continue to be used.

Winter visitors were noted unusually early on the north side of Bristol; scarcely had Chiffchaffs departed than the first Bramblings were seen. Fieldfares had arrived by mid-October, and in contrast to 1936 were extremely abundant from early November onwards.

Of Ducks at the North Somerset reservoirs no less than fourteen species have been identified, a greater number, apparently, than in any previously recorded year. Wigeon were unusually plentiful at Blagdon late in November, as also were Shoveler in March and early April. Of particular interest are the occurrences of a Gadwall at Barrow Gurney, and Red-breasted Mergansers and Smew at Blagdon.

The visits of a Red-necked Grebe to Barrow Gurney in February, and a Red-throated Diver to Blagdon in March, were perhaps due to severe weather in northern Europe during the last days of January, following which a remarkable influx of Grebes and Divers into the British Islands took place (cf. *British Birds*, Vol. XXX, p. 370). A small flock of Dark-breasted Brent Geese on the Severn bank in February may well have been birds driven out by wintry weather in the Baltic.

Grey Plover in May, and a Curlew-Sandpiper in April, between Avonmouth and Severn Beach, provide the first Spring records of either species on the Severn mud flats, while Greenshanks, hitherto unrecorded to the north of Bristol, were seen at New Passage in August. Uncommon waders met with during the Autumn migration were a Little Stint near Avonmouth, and Spotted Redshanks at Blagdon.

Twice has the Scandinavian Lesser Black-backed Gull been identified, on both occasions there being British Lesser Black-backs close at hand for comparison. These observations are of real value in that little is known of this northern Gull in the West of England.

The following notes represent the more important records during the year, and are, except where otherwise stated, the result of observations by members of the B.N.S. Ornithological Section.

RAVEN (*Corvus c. corax*). A pair again bred on the Gloucestershire side of the Avon Gorge. Four young were successfully reared. Ravens were noticed over Long Ashton on several dates in October and November, and one was seen high overhead near Stoke Gifford on May 17th. These were probably birds from the Avon Gorge.

SISKIN (*Carduelis spinus*). A party of eighteen or twenty were, in company with Goldfinches, frequenting Alder trees along the River Yeo, near Blagdon, on March 27th and 28th. Uncommon, but probably occurs in most Winters.

BRAMBLING (*Fringilla montigringilla*). One was seen near Stoke Gifford on October 8th, the earliest date yet recorded for the district.

CHIFFCHAFF (*Phylloscopus c. collybita*). From December 4th to the 6th one was frequenting a hedgerow near Stoke Gifford, and in spite of cold weather appeared to be thriving. This was undoubtedly a wintering bird.

FIELDFARE (*Turdus pilaris*). Three were observed at Little Stoke on October 13th, an unusually early date for the district.

REDWING (*Turdus m. musicus*). Many, probably not less than two thousand, were watched going to roost in rhododendron bushes at the south end of Tortworth Court lake on January 17th. As large numbers were seen coming in to the same spot on December 5th, this is presumably a regular Winter roost.

RING OUZEL (*Turdus t. torquatus*). An adult male was seen near Stoke Gifford on November 5th and again on the 9th ; an exceptionally late bird. Occasionally noticed in the Bristol district when on passage to or from its more northerly breeding quarters.

BLACK REDSTART (*Phœnicurus ochrurus gibraltariensis*). A Redstart observed at close quarters along the Avonmouth–Severn Beach railway embankment on March 28th was undoubtedly this species. Infrequently recorded, but perhaps occurs more often than is generally supposed.

SHORT-EARED OWL (*Asio f. flammeus*). A single bird was frequenting the Severn bank near Avonmouth on November 5th. An uncommon Autumn and Winter visitor.

HOBBY (*Falco s. subbuteo*). An excellent view was obtained of one in flight at Little Stoke on August 21st.

Common Buzzard (*Buteo b. buteo*). One was seen quartering along the edge of Callow Hill between Winscombe and Axbridge on January 17th, and one over Blagdon on September 5th. Has occurred in the district fairly frequently in recent years, and breeding on the Mendips has on one occasion been proved (cf. *Report on Somerset Birds*, 1931, p. 17).

Common Heron (*Ardea c. cinerea*). A census taken in late April of occupied nests at the Brockley Coombe and Banwell Heronries showed that there were thirty nests definitely in use at Brockley, and eighteen at Banwell. Taking the two Heronries together, this represents a decrease of ten breeding pairs as compared with the average number recorded for the previous three years (cf. *Reports on Somerset Birds*, 1934-36).

Dark-breasted Brent Goose (*Branta b. bernicla*). A small flock, identified as all being of the dark-breasted race, visited the Severn bank on the north side of Avonmouth early in February, where they remained for at least a month. Three were seen on February 7th, and six on the 15th. By the 21st the number had increased to thirteen, and of these eleven were seen on various dates up to March 7th. One was still present on March 28th (cf. *British Birds*, Vol. XXXI, p. 54). There is no previous authentic record within recent years of Brent Geese near Avonmouth.

Gadwall (*Anas strepera*). An adult male was frequenting Barrow Gurney reservoirs from August 22nd to October 10th, and was again seen on several dates in December. The bird was usually in company with Mallard, from which it could easily be distinguished when in flight by its conspicuous white speculum, and when on the water by its smaller size and more dingy appearance. A scarce duck at any time in the West of England, this species has been recorded on one occasion at Blagdon, but not hitherto at Barrow.

Pintail (*Anas a. acuta*). Three, females or immatures, were observed at Barrow Gurney reservoirs on September 19th and 26th, and one, a female, at Blagdon on November 28th.

Scaup (*Nyroca m. marila*). An adult male again visited Barrow Gurney. It was frequently seen from early February to mid-April, and on various dates in December.

Common Scoter (*Oidemia n. nigra*). Two were seen at Barrow Gurney reservoirs on April 11th, and one on the Avon off Sea Mills on the 18th; all three were males. Another, also a male, was swimming off New Passage on July 19th. One, a female, was observed at Barrow Gurney on December 12th.

RED-BREASTED MERGANSER (*Mergus serrator*). Twice seen, three on February 21st and a single bird on April 4th, on Blagdon reservoir, where it is an irregular Winter visitor in very small numbers.

SMEW (*Mergus albellus*). Five "redheads" were observed close inshore at Blagdon on November 28th. Has occurred fairly frequently at the North Somerset reservoirs. Adult males, however, are seldom recorded.

RED-NECKED GREBE (*Podiceps g. griseigena*). A single bird at Barrow Gurney reservoirs on February 21st was identified by members of the Oxford Ornithological Society. There are no previous records of this Grebe at Barrow.

BLACK-NECKED GREBE (*Podiceps n. nigricollis*). One was seen at Blagdon on February 21st, and two on March 20th. Although visiting Barrow Gurney in most Winters it is of infrequent occurrence at Blagdon.

RED-THROATED DIVER (*Colymbus stellatus*). A single bird frequented the Butcombe corner of Blagdon reservoir from mid-March to April 4th or later. An occasional visitor in Winter to the North Somerset reservoirs.

GREY PLOVER (*Squatarola squatarola*). On May 2nd two were identified on the Avonmouth–Severn Beach mud flats, where it has not previously been recorded in Spring. A party of six were seen in the same place on September 26th.

TURNSTONE (*Arenaria i. interpres*). With the exception of June, has been observed between Avonmouth and Severn Beach in all months of the year. One hundred or more were seen on various dates in September and October. The feeding ground of these birds is undoubtedly the large area of pebble and stone off Severn Beach. When driven from this by the incoming tide they are usually to be found either on or close under the river bank. On August 22nd a single bird was feeding at the edge of No. 3 reservoir, Barrow Gurney, where the species has not hitherto been recorded.

RUFF (*Philomachus pugnax*). One was identified at Blagdon on August 27th and 29th and again on September 5th and 6th; perhaps the same bird on each occasion. A single bird was seen at No. 3 reservoir, Barrow Gurney, on September 26th.

SANDERLING (*Crocethia alba*). Twice observed in Spring along the Avonmouth–Severn Beach mud flats—one on May 12th, and a party of five on the 30th.

KNOT (*Calidris c. canutus*). Frequently seen along the mud flats between Avonmouth and Severn Beach from late August to early October, but only in very small numbers.

Curlew-Sandpiper (*Calidris testacea*). On April 25th a partially red bird was seen on the Avonmouth–Severn Beach mud flats. This is the first Spring record for the Severn mouth. Observed, up to four or five in number, along the same stretch of mud on several dates during the first half of September.

Little Stint (*Calidris minuta*). One was identified on the Avonmouth–Severn Beach mud flats on September 30th and again on October 1st.

Purple Sandpiper (*Calidris m. maritima*). Frequently observed, up to half a dozen in number, between Avonmouth and Severn Beach from mid-February to early May. A single bird on May 12th is the latest yet recorded on the Severn mud flats. Two were seen off Severn Beach on November 7th.

Green Sandpiper (*Tringa ochropus*). Unusually common at the North Somerset reservoirs from mid-August to the end of September. At Blagdon two or three were seen on August 29th, and four or more on September 6th.

Spotted Redshank (*Tringa erythropus*). This uncommon passage migrant was twice identified at Blagdon reservoir in August—a single bird on the 23rd, and two on the 27th.

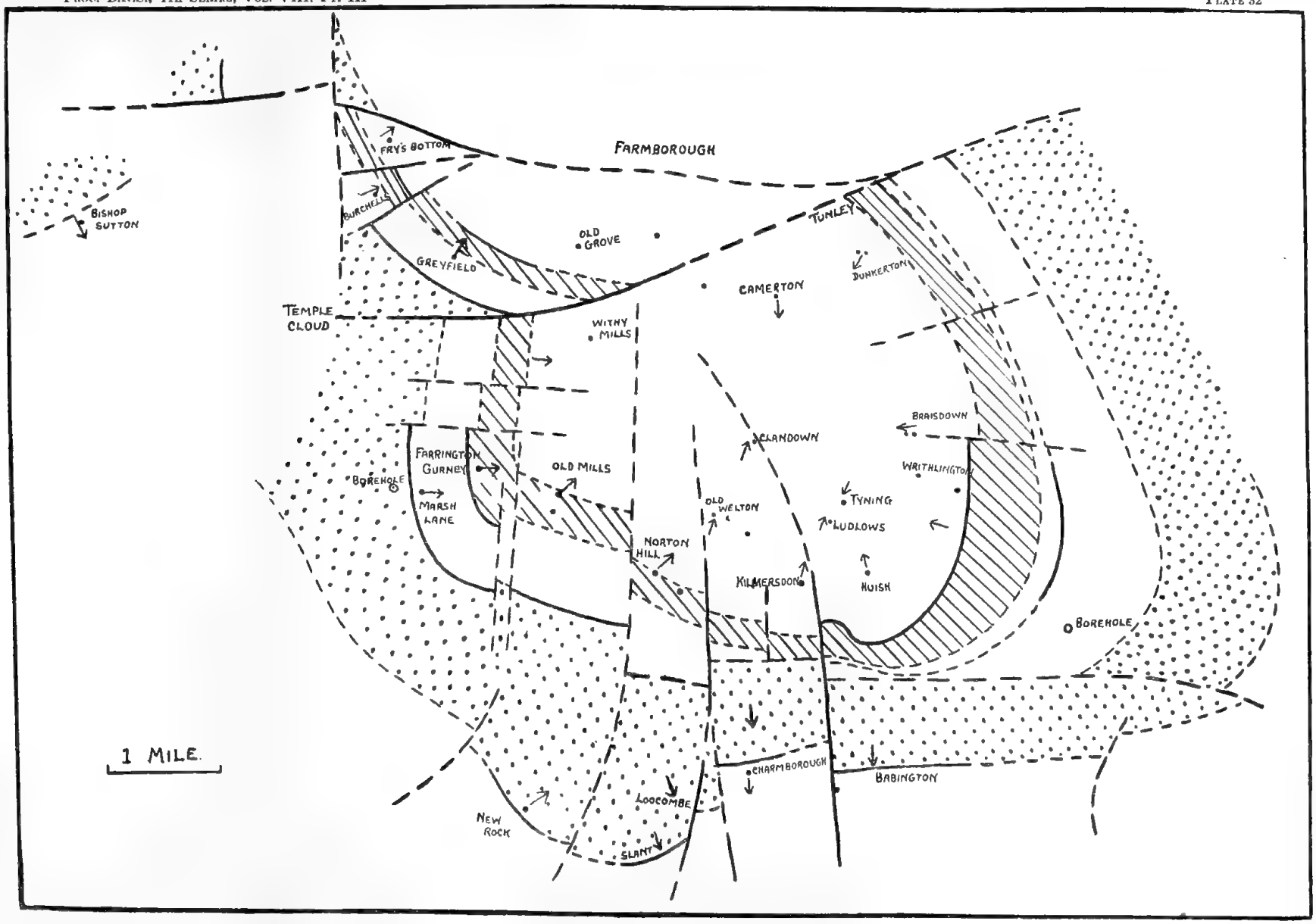
Greenshank (*Tringa nebularia*). Single birds were present at the Blagdon and Barrow Gurney reservoirs on several dates in August and September. Two seen at New Passage on August 31st provide the only record of this species at the Severn mouth.

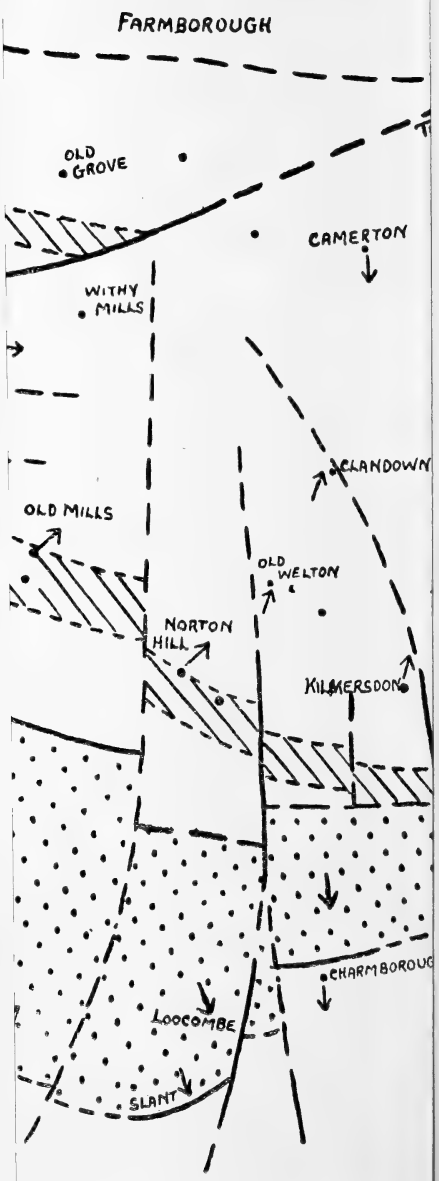
Bar-tailed Godwit (*Limosa l. lapponica*). Observed, up to three in number, on two occasions in September on the Avonmouth–Severn Beach mud flats.

Black Tern (*Chlidonias n. niger*). A single bird was seen at Blagdon reservoir on September 18th. Apparently much scarcer than usual during the Autumn migration.

Scandinavian Lesser Black-backed Gull (*Larus f. fuscus*). One was clearly identified at Sea Mills on April 20th, and another at No. 3 reservoir, Barrow Gurney, on August 22nd (cf. *British Birds*, Vol. XXXI, pp. 54, 199). Only once previously has this race been definitely recorded for the district, also at Sea Mills (cf. *British Birds*, Vol. XXVIII, pp. 117-118).

Kittiwake Gull (*Rissa t. tridactyla*). One, an immature bird, was seen between Avonmouth and Severn Beach on December 22nd.


Farmborough
Fry's Bottom
Burchells
Bishop Sutton
Old Grove
Greyfield
Tunley
Dunkerton
Camerton
Temple Cloud
Withy Mills
Braisdown
Clandown
Farrington Gurney
Old Mills
Writhlington
Borehole
Marsh Lane
Tyning
Old Welton
Ludlows
Norton Hill
Kilmersdon
Huish
Borehole
1 Mile.
Charmborough
Babington
Loocombe
New Rock
Slant


FARMBOROUGH
OLD GROVE
CAMERTON
WITHY MILLS
CLANDOWN
OLD MILLS
OLD WELTON
NORTON HILL
KILMERSDON
CHARMBOROUG
LOOCOMBE
SLANT

The Sequence and Structure of the Radstock Basin

By L. R. Moore, B.Sc., Ph.D.

INTRODUCTION

DURING the course of this investigation, attempts were made to secure information from all possible sources. Specimens have been collected chiefly *in situ*, and plans of the workings examined at many collieries. For opportunity to work underground the writer is indebted to the managements of the Somerset Collieries (Radstock), Old Mills, and Writhlington Collieries. At many collieries facilities for studying the working plans were kindly provided, and information freely given. For such facilities the writer is deeply grateful to Mr. C. Southern and Mr. H. V. Phelps of the Writhlington Collieries; Mr. C. Heal and Mr. E. Heal of the Old Mills Collieries; Mr. D. Bennett of the Camerton and Braisdown Collieries; and Mr. C. Cottle of Marsh Lane Colliery.

Valuable information regarding disused collieries was given by Mr. J. Smith, Mr. J. Parfitt, Mr. Cobb and many others, which is gratefully acknowledged here.

Many plans of disused mines were consulted at the Mines Department, where Mr. E. H. Clark provided every facility and gave much assistance in studying the plans deposited in his care. The writer is very grateful for this kindness.

To Professor A. E. Trueman the writer is deeply indebted for much valuable advice and continued help throughout the work and during the production of the paper. Dr. Dix has from time to time named many fossil plants and given important information concerning their ranges, for which the writer is indebted. Professor W. F. Whittard also has very kindly assisted in the production of the paper.

Some of the expenses of this work have been defrayed by the Colston Research Society of the University of Bristol.

A brief account of the sequence within this basin has previously been given (Moore and Trueman, 1937), whilst a general account of the structure of the basin has also been written (Moore and Trueman, 1938). However, it is thought advisable to publish a more detailed account of the sequence, and to discuss at some length the structural problems presented by the basin.

The sequence lies within the Upper Coal Series, a productive series lying above the Pennant Sandstone. The Lower or Farrington Group of seams is divided by the Barren Red Shales from the overlying Radstock Group of seams. Previous work by Kidston (1888, 1923-25) and Crookall (1925, 1929) has demonstrated the rich flora of the Upper Coal Series. This Series is probably the best known portion of the Somerset sequence, the Radstock Group being particularly well known.

THE FARRINGTON GROUP

This term is applied to the productive measures lying immediately above the Pennant Sandstone and passing upwards into the Barren Red Shales. The group name is derived from the disused Farrington Gurney Colliery where the coals of this horizon were first worked. J. Prestwich (1871, p. 33) estimated the then known thickness of this Group to have been 750 feet, and gave a correlation of the seams then worked. McMurtrie (1901, p. 13) stated that "the Farrington Group usually consists of six seams, but it is much more variable than the Upper Series (i.e., Radstock Group), sections taken at different parts of the basin differing so materially one from the other that it has been found difficult to correlate the seams, which are consequently known by different names in different parts of the district."

Since the date of McMurtrie's publication, further exploration has revealed the presence of lower seams which are at present being worked in the basin. It has been possible to examine these seams from what is regarded as the Middle or No. 5 Seam downwards at all the collieries, but only at Braisdown and Ludlow's Collieries has it been possible to see the upper part of the Group, since the seams, owing to their thinness and poor quality, are not worked; in many cases they are only known from shaft sections.

The area covered by the Farrington Group may be seen from the map (Plate 32), and in order to describe fully the sequence, flora, and correlation of this Group, the Radstock basin may be considered as divided into an eastern and a western portion by the Clandown fault. That portion east of the fault is worked by Braisdown, Ludlow's, Writhlington and Kilmersdon Collieries; to the west, Norton Hill, Old Mills, and Marsh Lane Collieries are still working these coals.

A convenient horizon which may be taken as the base of the Farrington Group for present purposes is that provided in the eastern portion of the basin by the Braisdown No. 9 Seam, Writhlington and

Ludlow's No. 9 Seam and the Kilmersdon New Seam. A comparable horizon in the western portion is provided by the Norton Hill Big Vein, Old Mills Brights Vein, and the Marsh Lane Jubilee Group of seams, formerly worked at the disused Farrington Gurney Colliery.

Below this horizon, though some exploration has taken place, the ground is relatively unknown, and, since nowhere do these beds outcrop, due to the Mesozoic cover, the presence of further seams can only be proved by exploration. Evidence already published (Moore and Trueman, 1936), concerning a boring for coal at Farrington Gurney, together with further data given below, would tend to suggest the presence of lower seams, though these may not be in a workable condition.

At the Lower Writhlington Colliery, an exploration branch proving all the coals in the Farrington Group passed down to cut a further group of seams. The position of the No. 9 Seam is estimated here and a section of the branch below this horizon given :—

No. 9 Seam.

Roof of Hard grey sandstone.
Coal 18 inches.
Hard floor.

(11) Iron banded[1] shale or "clift" continues to a thin seam (1 ft.). The dip increases and the thin coal runs almost vertically up into the roof and was found to turn over. Abundance of red stained water corroborates the presence here of a fault. 30 feet.

The following sequence, though much disturbed, is given to illustrate the character of the strata and the seams proved :—

(12) Irregularly iron banded shale passing down to strata resuming a normal dip in soft blue shale with shaly coal 10 inches thick. Approx. 35 feet.

(13) Shale and sandstone pass into massive coarse-grained sandstone or "greys," which are badly disturbed and in many places vertical. The strike changes, causing the branch to swing sharply at a point some 140 feet from the coal in (12). As repetition probably occurs within the sandstones, this thickness cannot be estimated.

(14) The normal dip of 12 degrees in the sandstone is restored and this rock forms the roof of a sulphury coal 1 foot thick. Below

[1] The term "iron banded" here and elsewhere in the paper implies the presence of thin ferruginous layers tending to weather into orange or red bands.

this seam sandy shale, becoming iron banded, merges into a dark blue very fine-grained shale forming the roof of a further sulphury coal 1 foot thick. The roof of this coal is important since it yields plant remains, amongst which

Lepidophyllum sp.
Neuropteris cf. *nikolausi* Gothan

have been recognised. A band of black mudstone here has yielded good specimens of freshwater lamellibranchs, including

Anthraconauta phillipsi (Will.).
Anthraconauta cf. *tenuis* (Davies and Trueman). 25 feet.

(15) Massive coarse sandstone passing down to a sandy shale forms the roof of a third coal, 1 foot thick. 90 feet.

(16) Very massive sandstone resembling Pennant Sandstone and containing two further sulphury black shale bands. 45 feet.

(17) Sandstone and shale were proved to a point where a seam 4 to 5 feet thick was cut; this, when followed, proved to be a swell, the coal averaging 1 foot. Approx. 50 feet.

(18) The workings were flooded at this point and could not be examined further, but the branch had been continued for a further 70 yards through disturbed ground, a large fault producing much "red ground" having been cut.

It is important to note that the shells recorded above are the only ones to be found within the Radstock Basin below the No. 1 Seam of the Farrington Group. The presence of this lower group of seams with a fauna is of considerable importance and throws light on the sequence at the Pensford and Bromley Collieries.

THE FARRINGTON GROUP WORKED TO THE EAST OF THE CLANDOWN FAULT

At Braisdown, which is the most northerly colliery at present working the Farrington seams within this part of the basin, unproductive ground has been proved below the No. 9 Seam. The latter seam shows the presence of a blue shale roof, though massive sandstones occur in the higher part of the roof. Ironstone nodules are abundant over the seam and occur in such profusion in hard bands that the miners term them "Cockle bands."

No. 9 Seam

Coal Section :—

Braisdown	*Ludlow's*
Roof blue shale, ironstone bands.	Shale overlying sandstone.
Binching 3-4 inches.	Coal 22 inches bright.
Coal 22 inches bright.	Floor soft.
Ironstone band 2 inches.	
Floor soft.	

An excellent collection from the thin shale band over the coal at Braisdown included :—

Flora—

Sphenopteris neuropteroides (Boul.)
S. cf. *pecopteroides* Kidston
Alethopteris serli (Brongt.)
A. serli forma grandini Crookall
Neuropteris flexuosa Sternb.
N. cf. *flexuosa* Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. macrophylla Brongt.
N. cf. *tenuifolia* (Schloth.)
Mixoneura (*Neuropteris*) *ovata* Hoff.
Cyclopteris obicularis Brongt.
Asterotheca cf. *cyathea* (Schloth.)
A. oreopteridia (Schloth.)
A. cf. *miltoni* (Art.)
A. cf. *daubreei* (Zeiller)
Pecopteris dentata (Brongt.)
Ptychocarpus unitus (Brongt.)
Dicksonites pluckeneti (Schloth.)
Lepidodendron lycopodioides Sternb.
L. sp.
Calamites sp.
Annularia stellata (Schloth.)
A. sphenophylloides (Zenker)
A. radiata Brongt.
Cordaites sp.

Further specimens of *Sphenopteris alata* Kidston were obtained on the tip from the roof of this seam.

The No. 9 Seam at Ludlow's Colliery to the south-west of Braisdown provides an excellent coal. A soft shale rests on the coal in places, but is probably lenticular in its distribution ; where the shale is present ironstone nodules are strongly developed. Overlying sandstones come down very near the coal, and no shale yielding fossils was obtained from this seam.

At both collieries the No. 9 Seam is separated from the overlying No. 8 Seam by hard sandstones which, at Ludlow's and Braisdown, are 40 feet and 45 feet thick respectively.

No. 8 Seam

Exploration branches, both at Ludlow's and Braisdown Collieries, have provided data giving the positions of the seams from which the thickness of strata has been estimated. This Seam is not worked at either colliery, and it was only possible to make a collection in old workings at Ludlow's Colliery where an unsuccessful attempt to work this Seam had been made. Sections of the Seam as observed at Braisdown and Ludlow's Collieries are given below together with a list of the rich flora from the latter colliery :—

Section.

Braisdown	*Ludlow's*
Roof hard blue shale.	Roof hard blue shale.
Coal 4 inches.	Coal inferior 3-4 inches.
Black shale and thin coal.	Coal—Main 18 inches.
Coal 8 inches.	Floor soft.
Thinly bedded dark shale 6 feet.	
Coal 12-18 inches.	
Floor soft.	

Flora No. 8 *Seam.*

Sphenopteris macilenta L. and H.
S. neuropteroides (Boul.)
S. cf. *pecopteroides* Kidston
S. alata Kidston
S. cf. *laurenti* Andræ
Renaultia chærophylloides (Brongt.)
Sphenopteris sp.
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
Diplotmena sp.
Alethopteris serli (Brongt.)
A. serli forma grandini Crookall
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
N. macrophylla Brongt.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Cyclopteris orbicularis Brongt.
Asterotheca miltoni (Art.) (*Pec. abbreviata* Brongt.)
Ptychocarpus unitus (Brongt.)

Sphenophyllum emarginatum Brongt.
S. cf. *majus* Bronn
Odontopteris sp.

The occurrence of *Sphenopteris macilenta* with *S. alata*, and this association with *Ptychocarpus unitus* and *Mariopteris* cf. *carnosa* is interesting and stratigraphically important. *Renaultia chærophylloides* and *Sphenopteris* cf. *laurenti* are interesting occurrences.

The New Seam of Kilmersdon Colliery to the south of Ludlow's exhibits characters which are more in common with seams worked at Norton Hill and Old Mills Collieries in the western portion of the basin. The roof of the Seam has yielded a rich flora which, with the seam section, is given below :—

New Seam Section

Roof strong massive blue shale.
Top coal 2 ft. 6 ins.
Parting thin black shale.
Bottom coal variable 1 ft. to 1 ft. 6 ins.

The section is found to vary considerably, particularly the parting of shale and the Bottom coal. The average total thickness of the section is 4 feet 6 inches.

Flora

Sphenopteris cf. *pecopteroides* Kidston
S. striata Gothan
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
Alethopteris serli Brongt.
A. serli var. *lonchitifolia* P.B.
A. serli forma grandini Crookall
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
N. cf. *macrophylla* Brongt.
N. cf. *tenuifolia* (Schloth.)
Mixoneura (*Neuropteris*) *ovata* Hoff.
Asterotheca cyathea (Schloth.)
A. cf. *oreopteridia* (Schloth.)
A. cf. *miltoni* (Art.)
A. daubreei (Zeiller)
Eupecopteris sp.
Pecopteris dentata (Brongt.)
Ptychocarpus unitus (Brongt.)
Sphenophyllum emarginatum Brongt.
Annularia stellata (Schloth.)

The occurrence of *Ptychocarpus unitus* in abundance, with a similarity in the Pecopterids, particularly the occurrence of *Asterotheca cyathea*, renders this collection similar to that from Braisdown No. 9 Seam.

It is thought that the Nos. 8 and 9 Seams of Ludlow's and Braisdown and similar seams proved in a branch (see p. 269) at the Lower Writhlington Colliery are equivalent to the Kilmersdon New Seam, and represent a splitting up of that Seam when followed northwards.

No. 7 Seam

The sequence above the No. 8 Seam has been observed both at Ludlow's and Braisdown Collieries. At the former colliery, massive grey micaceous shales often strongly iron banded in a very regular manner alternate with beds of hard sandstone, the sequence containing two inferior thin coal seams. The thickness of strata to the No. 7 Seam is estimated at 250 feet.

The following section at a comparable horizon was observed at Braisdown :—

No. 7 Seam

Massive shales strongly and regularly iron banded. About 60 feet.
Beds of hard grey sandstone passing down into sandy micaceous shale, becoming strongly iron banded at its base and resting on a thin sulphury coal. 45 feet.
Strongly iron banded shales and thin sandstones resting on 18 inches of coaly shale. 20 feet.
Massive blue shale with sandstone bands passing down to a hard grey sandstone forming the roof of the No. 8 Seam. 80 feet.

The thickness of strata, therefore, between the No. 7 and No. 8 Seams of this colliery would be approximately 205 feet.

The No. 7 Seam is not at present worked at either colliery ; it shows, however, a similar section. A collection from this horizon was made in old workings at Ludlow's Colliery ; here the roof of the seam consists of grey thinly bedded shale rich in fossil plants.

Section No. 7 Seam, Ludlow's

Roof grey shale.
Top coal 9 inches.
Band of soft black shale 12 inches.
Coal 12 inches.
Band of black shale 24 inches.
Bottom coal variable 8 inches to 2 feet.
Floor hard.

The averge thickness of the Seam is nearly 5 feet, but the coal is of poor quality.

Flora No. 7 Seam

Sphenopteris neuropteroides (Boul.)
S. pecopteroides Kidston
Mariopteris cf. *carnosa* Corsin
Alethopteris serli (Brongt.)
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. scheuchzeri Hoff.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Cyclopteris orbicularis Brongt.
Asterotheca miltoni (Art.) (*Pec. abbreviata* Brongt.)
Sphenophyllum emarginatum Brongt.
Annularia stellata (Schloth.)
A. sphenophylloides (Zenker)

No. 6 Seam

A thickness of 112 feet of strong blue shale very prominently iron banded and containing occasional beds of sandstone lies between this and the No. 7 Seam at Ludlow's Colliery. Though the thickness of strata at Braisdown is apparently greater, the character of the sequence is very similar. This Seam is only worked at the above-mentioned collieries, and what is considered to be its equivalent is found both at Writhlington and Kilmersdon Collieries to be in an unworkable condition. The roof of the Seam is peculiar in that iron banding is so pronounced as to tend towards the formation of ironstone nodules.

No. 6 Seam Ludlow's	*No. 6 Seam Braisdown*
Brown shale with ironstones.	Blue " clod " with ironstones.
Thin black coaly band.	Black coaly band.
Top coal 8 inches dirty.	Top coal 6 inches dirty.
Band variable 6 to 12 inches.	Band and black shale 3 inches.
Bottom coal 14 inches.	Bottom coal 12 inches.
Hard floor.	Hard floor.

The flora collected at these two localities includes :—

Sphenopteris neuropteroides (Boul.)
S. pecopteroides Kidston
S. cf. *artemisæfolioides* Crép.
S. sp.
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
Alethopteris serli (Brongt.)
A. serli forma grandini Crookall

A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
N. macrophylla Brongt.
N. fimbriata Lesq.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Asterotheca miltoni (Art.) (*Pec. abbreviata* Brongt.)
A. cf. *oreopteridia* (Schloth.)
A. cf. *daubreei* (Zeiller)
Sphenophyllum emarginatum Brongt.
S. cf. *majus* Bronn
Odontopteris sp.

The collection from Ludlow's Colliery, whilst showing similar species of *Alethopteris*, *Neuropteris* and *Pecopteris*, is poorly represented by Sphenopterids, *Sphenopteris* sp. being the only record. *Mariopteris* is absent from Ludlow's whilst *Ptychocarpus unitus* (Brongt.), *Asterotheca cyathea* (Schloth.), *A.* cf. *miltoni* (Art.), and *Cyclopteris orbicularis* Brongt. are not recorded from Braisdown. These specimens are represented by single occurrences at Ludlow's.

It is opportune at this point to give the upper portion of the exploration branch at Lower Writhlington Colliery which, commencing at the No. 5 Seam, is considered to have proved the sequence down to the No. 9 horizon of Ludlow's and Braisdown. That portion of the branch below the No. 9 Seam has been previously given (p. 269). Since this branch is heavily timbered, the data only give an approximation of thickness; collecting was only possible in those refuge holes containing fossiliferous strata.

No. 5 of Ludlow's

(1) From the Deep Middle Vein (or No. 6 Seam of Writhlington) the branch passed through massive blue shale, to cut a seam of inferior coal 2 feet thick. 25 feet.

No. 6 of Ludlow's

(2) Beds of massive grey sandstone giving place to massively bedded shale underlain by thinly bedded brown shale forming the roof of a thin sulphury coal. 30 feet.

This roof was fossiliferous and yielded:—

Sphenopteris cf. *pecopteroides* Kidston
Alethopteris serli (Brongt.)
A. serli var. *lonchitifolia* P.B.

Neuropteris scheuchzeri Hoff.
Odontopteris sp.
Asterotheca cf. *miltoni* (Art.)
Annularia sphenophylloides (Zenker)

(3) Thinly bedded shales passing down to dark blue massively bedded shales which become sandy and iron banded forming the roof of a thin shaly coal seam. 100 feet.

(4) Very hard and strongly iron banded shale forming the roof of a thin coal seam 1 foot thick. 30 feet.

(5) Dark blue sandstone passing into finer grained light blue "clift" with regular iron bands forming the roof of a coal of inferior quality consisting of 18 inches coal with much black sulphury shale. 12 feet.

No. 7 *of Ludlow's*

(6) Grey-blue massive "clift" prominently red stained with ironstone nodules, passing to thick sandstones irregularly bedded, which become shaly to form the roof of a coal seam 1 foot thick. 80 feet.

(7) Blue shales fine grained, passing to darker iron banded shale—ironstone bands being very regular and tending to produce ironstone nodules. This forms the roof of a coal 18 inches thick, very inferior and sulphury. 20 feet.

(8) Ironstone nodules prominent in strongly banded fine grained shale lying above a dirty sulphury coal shale 1 foot thick. 45 feet.

Alethopteris serli (Brongt.), *Neuropteris rarinervis* Bun. and *Odontopteris* cf. *lindleyana* Sternb. were obtained from the roof.

(9) Massive iron banded shales with ironstone nodules and occasional coal streaks extend down to a thicker coal seam with the following sections :— 30 feet.

No. 8 *of Ludlow's*

Roof iron banded shale.
Top coal 4-6 inches.
Black shales. 2 feet 4 inches.
Bottom coal 1 foot 4 inches.

The following collection was made from this seam :—

Sphenopteris neuropteroides (Boul.)
S. cf. *ovatifolia* Lillie
Renaultia sp.
Mariopteris sp.
Alethopteris serli (Brongt.)

A. serli var. *lonchitifolia* P.B.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Asterotheca sp.
Sphenophyllum cf. *majus* Bronn
S. cf. *emarginatum* Brongt.

(10) Beneath this coal the sequence consists entirely of hard massive standstones forming the roof of a coal seam. 30 feet.

No. 9 of Ludlow's

Roof hard grey sandstone.
Coal 18 inches bright.
Floor hard.

The correlation of this sequence with the sequence at Ludlow's Colliery is based on the available flora, on the distances apart of the seams, and on the character of the intervening strata.

The Middle Vein or No. 5 Seam

This Seam, which at Ludlow's and Braisdown Collieries occurs some 35 feet above the No. 6 Seam, is extensively worked throughout the coalfield. Thinly bedded blue shale, very regular and distinctly iron banded, lies between this and the lower seam. This coal appears to provide one of the most constant seams within the Radstock basin. It proves to be of good quality, though its average thickness is rarely greater than 18 to 22 inches. The roof of the Seam is very variable; in many instances a coarse sandstone with coaly particles rests directly on the coal, in other places a shale roof is present, whilst a "clod" of softer dark blue shale is known to occur. It is important to note that, whatever the type of roof near the coal, there is invariably a thick coarse sandstone present at no great distance above it.

This Seam has been examined in all the collieries mentioned; the extent of the collection at each locality has been considerably influenced by the lithology of the roof. Sections of the Seam at the various collieries will serve to illustrate this nature :—

Braisdown No. 5
Roof generally shale.
Coal 18 inches.
Floor hard.

Ludlow's No. 5
Roof shale and sandstone.
Coal 20 inches.
Floor hard.

Writhlington No. 6 or Deep M.V.
Sandstone or clod.
Coal 18 to 22 inches.
Floor hard.

Kilmersdon D.M.V.
Thin shale and clod.
Coal 18 to 22 inches.
Floor hard.

This Seam was best seen at the Writhlington and Kilmersdon Collieries, where it was followed over a wide area. The flora from these localities is therefore the most complete and will be given :—

Flora

Writhlington Deep Middle Vein (*or No.* 6 *Seam of the Colliery*).

Sphenopteris cf. *pecopteroides* Kidston
S. cf. *sewardi* Kidston
S. cf. *marrati* Kidston
S. cf. *artemisæfolioides* Crép.
S. striata Gothan
S. sp.
Alloiopteris sp.
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
Alethopteris serli (Brongt.)
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
N. macrophylla Brongt.
Cyclopteris orbicularis Brongt.
Asterotheca cyathea (*Schloth.*)
A. miltoni (Art.) (*Pecopteris abbreviata* Brongt.)
A. oreopteridia (*Schloth.*)
A. daubreei (Zeiller)
Eupecopteris fletti Kidston
Pecopteris dentata (Brongt.)
Dicksonites pluckeneti (Schloth.)
Sphenophyllum cf. *emarginatum* Brongt.
S. cf. *majus* Bronn
Calamites sp.
Annularia stellata (Schloth.)
A. radiata Brongt.
Aphlebia crispa Gut.

The flora from the Deep Middle Vein of Kilmersdon Colliery is essentially similar though somewhat poorer in Sphenopterids. The interesting *Sphenopteris* cf. *artemisæfolioides* Crép. is present together with *Sphenopteris* spp. and a specimen of *Sphenopteris* cf. *ovopteroides Weiss* (not recorded from Writhlington). An abundance of *Alloiopteris radstockensis* Kidston with further specimens referred to *Alloiopteris* sp., and *Corynepteris* sp. are interesting occurrences at this horizon. The presence of *Eupecopteris fletti* Kidston with *Asterotheca daubreei* (Zeiller) and an abundance of *Asterotheca oreopteridia* (Schloth.) is important. The flora from this seam at Braisdown is not so rich in Sphenopterids, *Sphenopteris neuropteroides* (Boul.) and *S.* sp. only

being present. *Mariopteris nervosa* (Brongt.) is fairly common, whilst Pecopterids are represented by *Asterotheca* cf. *cyathea* (Schloth.) with *A. oreopteridia* (Schloth.) and *A. daubreei* (Zeiller) abundant. *Alethopteris serli* Brongt. and *Mixoneura* (*Neuropteris*) *ovata* Hoff. are common; single specimens of *Ptychocarpus unitus* (Brongt.) and *Calamites carinatus* Sternb. also occur. Further specimens referred to *Dicksonites pluckeneti* (Schloth.) and comparable with similar forms from Kilmersdon Middle Vein are present.

At Ludlow's Colliery the sandy shale roof rendered collecting difficult; the collection from the No. 5 Seam contained:—

Sphenopteris cf. *neuropteroides* (Boul.)
S. cf. *artemisæfolioides* Crép.
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
Alethopteris serli (Brongt.)
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
N. cf. *macrophylla* Brongt.
Cyclopteris orbicularis Brongt.
Asterotheca cf. *oreopteridia* (Schloth.)
Sphenophyllum emarginatum Brongt.

The occurrence of *Sphenopteris* cf. *artemisæfolioides* Crép. and *Asterotheca* cf. *oreopteridia* (Schloth.) is noteworthy.

The inset levels of the shafts of Braisdown, Writhlington and Kilmersdon are at the horizon of the No. 5 or Middle Vein, that of Ludlow's being at the No. 6 Seam. Only at Braisdown and Ludlow's Collieries is it possible to study the sequence between the No. 5 Seam and the higher worked Rock Vein. The intervening Nos. 1, 2, 3, and 4 Seams are thin and of inferior quality and nowhere worked. Though the sequence was examined at both Collieries it is thought advisable to give that from Braisdown where an incline runs for 400 yards to cut the Rock Vein or Badger Seam. The sequence is as follows:—

No. 5 Seam or Middle Vein

(1) Thin shale over the coal passing upwards into very massive grey sandstone. 30 feet.
(2) Coal. No. 4 Seam and shales 1 foot 6 inches with roof of iron banded shales passing into sandstone. Iron banded shale and sandstone with two thin sulphury coals. 80 feet.
(3) Thin sulphury coal with strongly iron banded roof, passing to

light blue shales and alternating sandstones and shales massively bedded; shale and coaly band. 40 feet.

(4) Coal and black shales 9 inches.
Dark shales approx. 6 feet.
Coal and band very sulphury. 7 feet.

(5) Broadly iron banded shales alternating with massive sandstones and passing upwards into hard sandstones or "greys." Massively bedded dark blue shale. 55 feet.

(6) Coal seam 18 inches, No. 3 Seam, with blue shale roof and passing upwards to a further very inferior coal 2 feet thick. 10 feet.

(7) Massive blue shale iron banded by crimson streaks about half an inch wide and regularly distributed. 20 feet.

(8) Coal. No. 2 Seam, in two pieces with sulphury partings 1 foot 6 inches and overlain by blue shale roof. Shale becomes massive and iron banded in broad bands. 45 feet.

(9) Coal Seam. Soft shaly coal with sulphur partings 2 feet 6 inches and roof of massive "clift" or shale strongly iron banded. This "clift" passes upwards into dark shales with thin coals which are overlain by further massively bedded shale, with widely spaced iron bands. 40 feet.

(10) Black shales with thin coaly lenticles soft and friable. 12 feet.

(11) Dark grey sandstones passing upwards into thinly bedded blue shales iron banded and forming the low floor of the Rock Vein. 25 feet.

Thus the sequence from the No. 5 or Middle Vein up to the Rock Vein or Badger consists of approximately 350 feet of strata enumerated above. The sequence at Ludlow's was very similar, the No. 4 Seam lying 28 feet above the No. 5. A flora was obtained from the No. 1 Seam of this colliery and contained:—

Alethopteris serli (Brongt.)
Alethopteris cf. *grandini* (Brongt.)
Neuropteris flexuosa Sternb.
N. rarinervis Bun.
Mixoneura (*Neuropteris*) cf. *ovata* Hoff.
Asterotheca cf. *arborescens* (Schloth.)
A. cf. *miltoni* (Art.)
Ptychocarpus unitus (Brongt.)
Eupecopteris sp.
Calamites sp.
Annularia stellata (Schloth.)

This collection is important, being the highest known flora from the Farrington Group.

At the Lower Writhlington Colliery a further inset level occurs at the horizon of the Rock Vein; the intervening strata between that Seam and the Deep Middle Vein are not exposed. Their thickness is given, however, as about 320 feet. The shaft of the Kilmersdon Colliery was sunk in a fault, and only part of the sequence above the Middle Vein has been proved by exploration branches. The Rock Vein is not, however, worked from this Colliery.

The Rock Vein or Badger Seam

This, the highest Seam occurring in the Farrington Group, is well known and extensively worked in the group of collieries under discussion with the exception of the Kilmersdon Colliery. It forms an important datum line since it provides a notable faunal horizon. Shells from this Seam at the Writhlington Colliery have been described by Dix and Trueman (1929, pp. 499-501). Bolton (1911, p. 322) found shells on the tip of Ludlow's Colliery; these were described by him as coming from the deep, i.e., the Farrington seams, and hence probably from the Rock Vein. Material from the Badger Seam of Braisdown has yielded excellent specimens of *A. pringlei* Dix and Trueman, identical with those from the Writhlington Rock Vein.

This Seam provides a house coal of good quality, its section at Braisdown being:—

Hard mudstone roof cleaving badly.
12 inches coaly blacks known as Badger.
9 inches coal and blacks.
14 inches Bottom coal.

At the Writhlington Collieries the Rock Vein has been followed and worked over an extensive area from its outcrop to the east, westwards to Radstock. The average section of the Seam is:—

Roof thin mudstone.
Badger, black shale and coal streaks.
Dull black shale.
Coal 18 inches.

A massive micaceous sandy shale overlies the thin mudstone and contains only fragmentary plant remains. Following the Seam towards Radstock, the sandstone roof was found to become more prominent, and in many cases the thin fossiliferous shale was absent.

The Seam deteriorates from east to west; whilst, at the disused Foxcote Colliery the coal was relatively thick with a thinner Badger, the opposite is the case near Radstock.

At Ludlow's Colliery the section given is thus :—

Hard sandy shale roof.
Grey hard " clod " 20 inches.
Coal 14 inches.

The roof presented a hard uniform textured micaceous sandy shale devoid of fossils, and no fossiliferous band was present where the Seam was cut in the level branch.

THE FARRINGTON GROUP WORKED TO THE WEST OF THE CLANDOWN FAULT

The seams of this group in the western portion of the basin are worked by the Norton Hill, Old Mills and Marsh Lane Collieries. The two former shafts were sunk directly into the Farrington Group after passing through some part of the Barren Red measures lying above; this was also the case with the now disused Farrington Gurney Colliery. The Marsh Lane Colliery comprises a slant by means of which the lowest seam is worked. No seams are at present worked above the horizon of the Middle Vein or No. 5 Seam. The sequence in the upper portion of the Farrington Group of this area is, therefore, only known from shaft sections and hence the faunal horizon equivalent to the Rock Vein is unknown.

The nomenclature of the worked seams in this area differs from that met with in the collieries previously discussed; the seams here have a characteristic name. It is proposed for clarity to head each seam with its appropriate number and so to facilitate correlation between the two areas.

Nos. 8 and 9 Seams

This horizon is represented by the Jubilee Group of seams of Farrington Gurney, the Brights Vein of Old Mills Collieries, and the Big Vein of Norton Hill Collieries.

McMurtrie (1901, p. 13) gives a section of strata explored (1898) at the disused Farrington Gurney Colliery; a three-coal group of seams, called the Jubilee Group, was proved giving the following section :—

Coal 1 foot 3 inches.
Soft shale and " clift " 6 feet.
Coal 1 foot 9 inches.
" Clift " or shale 5 feet.
Coal stony 2 feet 1 inch.

The lowest coal of this Group is at present worked by the Marsh Lane

Colliery at Farrington Gurney. Sections of the Brights Vein of Old Mills, and Big Vein of Norton Hill, are given below for comparison :—

Old Mills, Brights Vein	*Norton Hill, Big Vein*
Roof hard sandstone with thin shale.	Roof hard sandstone.
Thin coal 6 inches, soft and dirty.	" Clod " of irregular thickness.
Black band 12 to 18 inches.	Top coal 24 inches.
Top coal 24 to 36 inches.	Dark shale 18 inches.
Dark shale often sulphury 4 feet.	Bottom coal 18 inches to 2 feet.
Bottom coal 18 inches.	Pan floor.
Pan floor.	

Thus, passing eastwards from Farrington Gurney through Old Mills to Norton Hill this Seam would appear to improve ; the section of the Kilmersdon Colliery New Seam (p. 273), with which the Nos. 8 and 9 Seams of the eastern area are correlated, would suggest continued improvement eastwards.

It would appear, however, that the Seam splits up going from south to north to give the Ludlow's, Braisdown and Writhlington Nos. 8 and 9 Seams.

A seam was cut below the Big Vein at Norton Hill Colliery but was worthless ; similarly at Old Mills, 30 yards below the Brights Vein, a shaly coal was cut. The workings were stopped by water from massive sandstones termed " Pennant." Lower seams have been proved by a borehole at Farrington Gurney (Moore and Trueman, 1936).

The horizon under discussion presents probably the richest flora from the coalfield, and correlation has been based on the following occurrences :—*Sphenopteris macilenta* L. and H. is abundant on the Ludlow's No. 8 Seam, Old Mills Brights Vein and the 21-inch seam of Marsh Lane Colliery. Specimens have been obtained from the Norton Hill tip in material which strongly resembles the Big Vein roof. This plant has not been recorded from the Kilmersdon New Seam or the Braisdown No. 9. It is interesting to note that this species has not been recorded from other seams in the Farrington Group.

Sphenopteris alata Kidston, which is abundant on Ludlow's No. 8 Seam, occurs on the Norton Hill Big Vein. Further specimens were obtained from No. 9 Seam roof material at Braisdown Colliery tip. Specimens referred to *S.* cf. *pecopteroides* Kidston are present at the Braisdown No. 9, Ludlow's No. 8 and Kilmersdon New Seam, but are are not recorded from Old Mills or Norton Hill at this horizon.

The genus *Neuropteris* is abundant and many species occur, the most interesting being a small pinnuled form referred to *Neuropteris* cf.

rarinervis Bun., but which bears resemblance to *N. nikolausi* Gothan; this plant is recorded from the Brights Vein, Big Vein, and 21-inch Seam of Marsh Lane, and it also occurs in the branch at Writhlington Colliery. It has been found at Norton Hill at a higher horizon on the New Vein, but has not been recorded above that seam. *Mariopteris* sp., a peculiar plant with doubtful affinities, is abundant on the Brights Vein and has been recorded from the Big Vein.

Pecopterids are generally rare, though the occurrence of *Asterotheca cyathea* (Schloth.) is typical of this horizon. It has been recorded from Braisdown No. 9, Kilmersdon New Seam, Norton Hill Big Vein, and Old Mills Brights Vein. The collection obtained from the latter seam is given for the illustration of other species :—

Sphenopteris macilenta L. and H.
S. cf. *neuropteroides* (Boul.)
Mariopteris nervosa (Brongt.)
M. cf. *carnosa* Corsin
M. sp.
Alethopteris serli (Brongt.)
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. cf. *rarinervis* Bun.
N. scheuchzeri Hoff.
N. macrophylla Brongt.
N. cf. *tenuifolia* (Schloth.)
Mixoneura (*Neuropteris*) *ovata* Hoff.
Cyclopteris orbicularis Brongt.
Asterotheca cyathea (Schloth.)
A. miltoni (Art.) *Pec. abbreviata* Brongt.
A. cf. *daubreei* (Zeiller)
Pecopteris dentata (Brongt.)
Ptychocarpus unitus (Brongt.)
Sphenophyllum cf. *majus* Bronn
Lepidodendron lycopodioides Sternb.
Calamites undulatus Sternb.
Annularia sphenophylloides (Zenker)

Both at Old Mills and Norton Hill Collieries, very strong and massive sandstones form the higher roof of the seams above discussed. A level branch driven at the Old Mills No. 1 Colliery has cut 200 feet of strata between the Bottom Seam and the Brights Seam. The sequence consists chiefly of grey-blue massive shales strongly iron banded, with a few thin sandstone bands. Four thin seams of a sulphury nature were encountered, the thickest being only 1 foot where cut in the branch. This latter seam, lying about 25 feet above the Brights Vein,

was explored and found to attain a maximum thickness of 2 feet 8 inches, and was designated the New Seam. In character the coal is soft and sulphury, whilst the roof is bad and consists of a coaly, sulphury shale, which does not yield identifiable plants. The higher roof consists of strongly iron banded shale with a tendency to the development of ironstone nodules. This seam traced in the workings is seen to be lenticular in shape, passing in the same " heading " from 2 feet 6 inches to 1 foot; northwards it swells to 2 feet 8 inches and divides into two coals with a shale parting. A thin coal (6 inches) occurs in a similar position with regard to the Brights Vein at the Old Mills No. 2 Colliery.

At the Norton Hill No. 2 Colliery a similar branch has proved a thickness of 180 feet from the New Vein to the Big Vein, passing through a sequence almost entirely in strongly iron banded shale with occasional thin sandstones. Four thin and unworked coals occur in the lower part of this sequence. The lowest of these, some 15 feet above the Big Vein, has a roof in which ironstone nodules are developed; its sandy floor passes down to form the hard roof of the Big Vein.

No. 7 Seam

The New Vein of Norton Hill and the Bottom Vein of Old Mills are to be correlated with the above Seam. The roofs of these Seams are very hard and formed of massive blue shale, though at Norton Hill a softer " clod " rests on the coal. The sections of these Seams at the two Collieries are thus :—

New Vein, Norton Hill	*Bottom Vein, Old Mills*
Roof shale with " Clod."	Roof of shale and sandstone.
Coal 15 inches.	Top coal 6 to 7 inches.
Binching 4 inches.	Binching 1 to 2 inches.
Coal 10 inches.	Coal 24 inches.

Collections were made from both Seams, that from Norton Hill colliery including :—

Sphenopteris neuropteroides (Boul.)
Mariopteris cf. *carnosa* Corsin
M. cf. *daviesi* Kidston
Alethopteris serli (Brongt.)
Neuropteris macrophylla Brongt.
N. cf. *rarinervis* Bun.
N. scheuchzeri Hoff.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Asterotheca cf. *cyathea* (Schloth.)
A. cf. *oreopteridia* (Schloth.)
Sphenophyllum emarginatum Brongt.
Sigillaria nortonensis Crookall

Calamites carinatus Sternb.
Annularia stellata (Schloth.)
A. sphenophylloides (Zenker)
Cordaites sp.
Lepidodendron aculeatum Sternb.

A collection from Old Mills Bottom Vein does not show the rich Mariopterid flora, but *Sphenopteris neuropteroides* (Boul.) is abundant and *Asterotheca daubreei* (Zeiller) is present. *Calamites carinatus* Sternb. is present at Old Mills, and the general assemblage of the flora is similar.

The Seam itself, its roof and flora, bear strong resemblances to the No. 7 Seam of the eastern area. This horizon may be that of the Church Close Seam of the disused Farrington Gurney Colliery. McMurtrie (1901, p. 13) gave a thickness of 204 feet of strata to lie between that Seam and the Jubilee Group of coals, a thickness which compares favourably with that of Old Mills Collieries.

No. 6 Seam

At both Collieries the succession is continued by massive blue shale with occasional beds of sandstone to the Slyving Vein. This Seam is not worked at Old Mills Colliery; it consists of two coals of inferior quality 1 foot 6 inches thick. At Norton Hill the Seam has improved but is still a "two coal" seam, the top coal of which is poor in quality. At Norton Hill it lies 98 feet above the New Vein.

Section at Norton Hill Colliery:—

Roof, blue shale.
"Clod" soft, blue in colour averaging 1 foot.
Top coal 10 inches.
Binching 4 to 6 inches.
Bottom coal about 2 feet and of good quality.

The following specimens were obtained:—

Alethopteris serli (Brongt.)
A. serli forma grandini Crookall
A. serli var. *lonchitifolia* P.B.
Neuropteris flexuosa Sternb.
N. flexuosa var. *rotundifolia* Brongt.
N. scheuchzeri Hoff.
Mixoneura (*Neuropteris*) *ovata* Hoff.
Cyclopteris orbicularis Brongt.
Ptychocarpus unitus (Brongt.)
Sphenophyllum cf. *emarginatum* Brongt.
Trigonocarpus nœggerathi (Sternb.)
Cordaites cf. *angulo-striatus* Grand-Eury
Sigillaria tessellata Brongt.

The characteristics of this Seam render it extremely similar to the No. 6 Seam of the Ludlow's and Braisdown Collieries.

The sequence above this Seam consists of blue shale with very pronounced and regular iron bands, and passes upwards to more massively bedded light blue shale lying below the Middle Vein. A thickness of 38 feet of such strata lies between the Slyving and Middle Vein at Norton Hill.

No. 5 or Middle Vein

This Seam shows identical characteristics when compared with the Middle Vein of the eastern area, and is no doubt the same seam. The thick band of "greys" or coarse sandstones noted above this Seam in the eastern area is present in both Collieries. It is interesting to note from the shaft section of the old Farrington Gurney Colliery the presence of this sandstone above the Middle Vein of that colliery.

Sections of the Seam at Norton Hill and Old Mills Collieries are given below:—

Norton Hill	*Old Mills*
Roof hard sandy shale.	Roof hard sandy shale and sandstone.
Blue "clod" very variable thickness.	
Coal 22 inches good quality.	Coal 22 inches good quality.
Hard floor.	Hard floor.

The shale over this Seam has yielded a good flora; the facilities for collecting being greater at Old Mills, the flora from that locality is given:—

Sphenopteris cf. *laurenti* Andræ
S. striata Gothan
Alethopteris seri (Brongt.)
A. serli forma grandini Crookall
A. serli var. *lonchitifolia* P.B.
Neuropteris cf. *flexuosa* Sternb.
N. scheuchzeri Hoff.
Asterotheca cf. *arborescens* (Schloth.)
A. oreopteridia (Schloth.)
A. cf. *miltoni* (Art.)
A. daubreei Zeiller
Ptychocarpus unitus (Brongt.)
Annularia sphenophylloides (Zenker)

The collection from Norton Hill Middle Vein is rather poor, but *Neuropteris macrophylla* Brongt. is a species not recorded from Old Mills. *Dicksonites pluckeneti* (Schloth.) was obtained on the tip from the Middle Vein roof at Norton Hill.

An abundance of *Asterotheca oreopteridia* and *A. daubreei* together with the occurrence of the rather rare Sphenopterids make this collection very similar to the Middle Vein or No. 5 flora previously discussed from the eastern area.

A further seam known as the Top Vein and occurring above the Middle Vein at Norton Hill and Old Mills was formerly worked but is not now accessible. This may represent the No. 4 Seam of the eastern area.

The Farrington Group of seams has been proved at a number of collieries. These include Old Grove Colliery, Timsbury, an account of which was given by J. Prestwich (1871, pp. 59-60), the disused Dunkerton Collieries to the north-east of the basin, Camerton Colliery, where a little coal from the Badger Seam was worked, and Old Welton Colliery, where seams from the No. 1 to the No. 6 were proved, of which the Nos. 3, 5 and 6 Seams were worked.

Though the Greyfield Colliery, 2 miles north of Farrington Gurney, lies outside the confines of the Radstock basin, evidence of possible correlation may prove interesting at this point. Mr. Cottle, manager of the Marsh Lane Colliery, from his experience at Greyfield Colliery, believes that the horizon of the Jubilee Group of seams was represented there by the Bantam Seam and two further coals below it. The New Seam of Greyfield would thus be correlated with the Church Close and Bottom Seam of Farrington Gurney and the Old Mills Collieries respectively. A suggested correlation of the seams in the Farrington Group is given in Fig. 23.

The Barren Red Measures

McMurtrie (1901, p. 11) stated: "These (i.e., the Farrington and Radstock Groups) are separated from each other by 550 to 750 feet of unproductive strata near the middle of which occur certain well-defined beds of red shale from 130 to 250 feet thick, which form a well-marked line of separation between the two groups."

This unproductive ground and the red beds are nowhere visible, and all information is obtained from shaft sections. These measures have been proved by all the collieries in the eastern area of the Radstock basin which have continued their shafts from the Radstock Group into the underlying Farrington Group.

The Norton Hill and Old Mills shafts were commenced probably not far below the coals of the Radstock Group and so present a section of the strata. In order to suggest the nature and thickness of this part of the succession, the Norton Hill, Old Mills, Braisdown and

Old Grove shaft sections will be given, thereby considering variations from the south northwards.

At Norton Hill 700 feet of strata were proved down to the first coal in the Farrington Group. The upper 140 feet consisted of " argillaceous shales " with bands of " coal blacks " and strong grey sandstones. The latter were underlain by 320 feet of red shales divided by two bands of sandstone. More massive shale and sandstone continued the sequence down to the first seam of the Farrington Group.

Less than 1 mile north-west of Norton Hill Colliery occurs that of Old Mills, where 610 feet of strata were cut down to the first seam of the Farrington Group. The upper 150 feet compare lithologically with that at Norton Hill, but 190 feet of red shales occur in one band and are underlain by shales and massive sandstones.

The shaft section of Braisdown Colliery as given by Greenwell and McMurtrie (1864, p. 26) showed 720 feet of strata between the lowest, or 9-inch, seam of the Radstock Group and the first coal proved in the Farrington Group. The red shales here were 160 feet thick.

Old Grove Colliery at Timsbury, some 3 miles to the north of Old Mills Colliery, proved both Radstock and Farrington coals, and is the most northerly shaft proving the ground under discussion. Greenwell and McMurtrie (1864, p. 21) gave a detailed account of the sinking which showed, between the 9-inch seam of the Radstock Group and the first coal of the Farrington Group, a thickness of 530 feet consisting chiefly of sandstone. Red measures here were described as " clift," a term implying a sandy shale ; these were only 120 feet thick.

It is clear that a general thinning of this ground is taking place northwards within the Radstock basin.

THE RADSTOCK GROUP OF SEAMS

This Group of seams, comprising the highest productive strata of the Somerset Coalfield, is only known within the Radstock basin. These coals have been for the most part worked to their outcrops by a series of collieries long ago disused, and the Group lies practically exhausted of profitable coal. Information concerning this Group of seams can only be obtained from the records of old shaft sections of which a large number exist. Two Collieries, those of Braisdown and Camerton, are at present working a small quantity of these coals.

The thickness of the Group has been given by Prestwich (1871) as 1,000 feet, whilst McMurtrie (1901) suggested 500 feet. It would

appear that, from the highest or Great Seam to the lowest 9-inch Seam, a thickness of slightly more than 300 feet would be representative of the collieries within the southern part of the basin. Northwards this decreases to 250 feet at Old Grove Colliery.

Though eight seams are recorded, only six of these have been recognised throughout the area worked. The seams in descending order are :—

Withy Mills Vein.
Great Vein.
Top Little Vein.
Middle Vein.
Slyving Vein.
Under Little Vein.
Bull Vein.
9-inch Seam.

CHARACTER OF THE SEAMS

9-inch Seam

This thin coal has only been worked in the Radstock district, where it has attained a thickness of 1 foot 4 inches ; its presence is noted in most of the available sections.

Bull Vein

In the neighbourhood of Radstock this Seam has proved to be the most important, being 2 feet 6 inches thick. It deteriorates rapidly on being followed northwards until at Camerton and Timsbury it is found to be unworkable, being represented by 8 or 9 inches of poor coal.

Under Little Vein

This Seam was found to be very constant with an average thickness of 1 foot 6 inches.

Slyving Vein

The finest quality gas coal was provided by this Seam, which provides further evidence of seam splitting. Correlation by means of shaft sections provides considerable difficulty. The Seam would appear to average 2 feet in thickness at the southern end of the basin, but this decreases when followed northwards.

Middle Vein

At the Writhlington Collieries and others in the southern part of the basin this Seam proved to be 2 feet 4 inches thick, but when traced northwards was found to deteriorate and become thinner until at

Camerton it was represented by only 1 foot 4 inches of coal. West of Camerton this Seam is reported to have split. Evidence of this fact is shown by the shaft sections of the Paulton Engine and Old Grove Collieries.

Top Little Vein

The coal from this Seam was of excellent quality and though only 1 foot 6 inches thick it was found to be constant over very wide areas.

Great Vein

This coal has an average thickness of 2 feet 3 inches and has been found on the northern side of the basin to split into two coals.

The Withy Mills

This Vein occurs a considerable distance above the Great Vein, and is only known at the old Withy Mills Colliery, and at Clandown Colliery where it was brought in by the Clandown fault. The coal is reputed to have been of inferior quality and only 12 inches thick.

It would appear from this brief summary of the Radstock Group of coals that there is a great tendency to seam splitting and the thinning of coals northwards.

Seams of this group have been examined at the Braisdown and Camerton Collieries where a part of the sequence is available in each colliery. The workings of these collieries approach so closely as to warrant the existing correlation of the seams between them; hence, by an examination of the sequence from the Bull Vein to the Slyving Vein at Braisdown, and from the Slyving Vein to the Great Vein at Camerton, some idea of the complete sequence may be ascertained.

THE SEQUENCE OF THE RADSTOCK GROUP OF THE CAMERTON AND BRAISDOWN COLLIERIES

Near the shaft of the Camerton Colliery occurred very coarse grey sandstones with dark fine-grained well-laminated shales, above which lay a thin coal regarded as the 9-inch Seam. Similar shale continued to the Bull Vein coal some 1 foot thick, with a massive barren roof resting on the coal. At Braisdown the Bull Vein has the following section:—

"Clod" 6 inches blue and irregularly iron banded.
Binching—soft, 3 inches.
Top coal 11 inches, soft bright coal.
Binching—soft, varying from ½ inch to 2 inches.

Bottom coal 13 inches, bright coal.
Blacks very hard.

A strong and massive blue shale roof was strongly iron banded. Similar iron banding in more thinly-bedded shale was observed at Camerton up to the Under Little Vein. Above the latter Seam a light blue mudstone, iron-banded in extremely regular bands 1 inch wide and a similar distance apart, passed into light blue shales underlying the Slyving Vein. This Seam shows a similar section at both collieries :—

Camerton	*Braisdown*
Roof, hard massive sandstone.	Roof shale.
Coal 18 inches.	Coal 18 inches bright and good quality.
Binching—soft and of variable thickness.	Binching 9 inches hard and black.

At Braisdown, in most places where the Slyving Vein was seen, some 6 inches to 1 foot of very dark blue shale was found over the coal; this yielded abundant plant remains. The more massive shales above this Seam were strongly iron banded and contained small ironstone nodules. These beds ultimately passed into a hard, very coarse sandstone, which, when traced laterally, was often found to rest directly on the coal. The Slyving Vein at Camerton is characterised by the presence of this coarse sandstone resting on the coal, its thickness being 15 feet. Regular iron banded shale overlies the sandstone and continues upwards to the Middle Vein. Similar iron banded shale overlies the Middle Vein and continues the sequence to the Top Little Vein which at Camerton shows the following section :—

Roof shale.
Coal 18 inches.
Black band and shale 12 inches.
Bottom coal 8 to 9 inches.

Further hard micaceous shales, irregularly iron banded, and strong sandstones continue the succession up to the Great Vein, which at Camerton consists of :—

Roof—blue shale resting on the coal.
Coal dull 18 inches.
Binching soft 2 inches.

The shales overlying this Seam, which subsequently pass into massive sandstones, have yielded a rich flora. A section of strata occurring above the Great Vein at Clandown Colliery was given by Buckland and Conybeare (1824, p. 278) as follows :—

Clift and shales	420 feet 0 inches.
Withy Mills Seam	10 inches.

Clift and greys	240 feet 0 inches.
Ore Seam sulphury	6 inches.
Greys and clift	90 feet 0 inches.
Shales and Great Seam	12 feet 0 inches.
Broken clives	42 feet 0 inches.
Plastic clay	5 inches.
Great Vein greys	24 feet 0 inches.
Great Vein coal	2 feet 0 inches.

This approximately 830 feet added to the 300 feet previously suggested would imply a known thickness from the 9-inch Seam upwards of about 1,130 feet for the Radstock Group within the southern part of the basin.

It is thought that, since seam splitting is a common occurrence, and moreover, since supposed deterioration of coals within a short distance is often quoted, the exact correlations within the limits suggested by the shaft sections (Fig. 23) should be questioned. Particularly is this the case to the north of the Radstock basin where the Bull Vein and Middle Vein are often omitted; it will be noted that at the most northerly colliery where these seams were worked, namely Fry's Bottom, new names and extra seams were introduced into the section. There is, however, strong reason for believing these coals to have been worked there, since they were worked at Greyfield Colliery above the Farrington coals and proved in a number of old workings as far north as Fry's Bottom. The highest seams in the Pensford shaft are suggested to belong to this Group.

The flora of the Radstock Group is well known, being described and figured by Kidston (1888). Unfortunately, in any previous collections made from this Group little account has been taken of the horizon at which the specimens occurred, and it may be that valuable knowledge has thus been lost. Specimens obtained from the roofs of the seams at the Camerton and Braisdown Collieries are given in tabular form below :—

	C.G. T.V.	C.T. L.V.	C.M. V.	C.U. L.V.	B.S.	B.U. L.V.	B.N. S.
Sphenopteris pecopteroides Kidston						3x	
S. cf. *pecopteroides* Kidston					2x		
S. neuropteroides (Boul.)			x				
S. cf. *neuropteroides* (Boul.)		x		x			
S. sp.					x		
Alloiopteris radstockensis Kidston	x						
Mariopteris plumosa Kidston	x						
M. sp.	x						
Alethopteris grandini (Brongt.)		x			x	4x	
A. cf. *grandini* (Brongt.)						x	3x

	C.G. T.V.	C.T. L.V.	C.M. V.	C.U. L.V.	B.S.	B.U. L.V.	B.N. S.
A. serli forma *grandini* Crookall							x
A. serli (Brongt.)	x						8x
A. cf. *magna* Grand-Eury							x
A. sp.		2x				x	
Neuropteris scheuchzeri Hoff.		5x			x		5x
N. macrophylla Brongt.							3x
N. flexuosa Sternb.	2x		x				x
N. cf. *flexuosa* Sternb.					x	x	x
N. sp. (cf. *N. blissi* Lesq.)							x
N. cf. *cordata* Brongt.							2x
N. cf. *fimbriata* Lesq.	2x						
Mixoneura (*Odontopteris*) sp.	x				x		x
M. (*Neuropteris*) *ovata* Hoff.	5x					x	2x
Callipteridium sp.	2x	x					x
Asterotheca (*Pecopteris*) *lamurensis* (Heer) ..	x	3x			4x	x	
A. cf. *lamurensis* (Heer)		2x		x	x		
A. candolleana (Brongt.)					x		
A. cf. *candolleana* (Brongt.)					2x		
A. daubreei (Zeiller)		6x		x	x		
A. cf. *daubreei* (Zeiller)		3x		3x	2x	2x	
A. arborescens (Schloth.)	3x						
A. hemitelioides (Brongt.)				x			
A. cf. *hemitelioides* (Brongt.)	x				x		
A. crenulata (Brongt.)					x	x	3x
A. cyathea (Schloth.)	3x	x			2x		
A. cf. *cyathea* (Schloth.)	3x				x		
A. oreopteridia (Schloth.)					3x		x
A. cf. *oreopteridia* (Schloth.)					4x		
A. cf. *miltoni* (Art.)		x					
A. sp.		x					x
Acitheca polymorpha (Brongt.)					5x	2x	
A. cf. *polymorpha* (Brongt.)		2x			3x	2x	
Pecopteris dentata (Brongt.)	x			2x	x		
Pecopteris sp.	4x	3x		x	x		3x
Eupecopteris bucklandi (Brongt.)		x					
E. cf. *bucklandi* (Brongt.)	x					x	
E. cf. *fletti* Kidston	x						
Cf. *E. camertonensis* Kidston		x		x			
Ptychocarpus unitus (Brongt.)	8x	x			2x	2x	
Sphenophyllum oblongifolium G. and K. ..				x			
S. cf. *oblongifolium* G. and K.	5x				x		
S. emarginatum Brongt.	4x	x		x	3x	x	
Lepidodendron lycopodioides Sternb. ..		x				x	
Lepidodendron sp.	x	x			x		
Lepidophyllum cf. *acuminatum* Lesq. ..	x						
L. sp.	x	x			x	x	x
Calamites carinatus Sternb.					x		
C. sp.					x	x	
Annularia stellata (Schloth.)		4x		2x	3x	x	x
A. sphenophylloides (Zenker)	x	10x					
Asterophyllites equisetiformis (Schloth.) ..				x			
Cordaites sp.	x						
Trigonocarpus noeggerathi (Sternb.) ..						x	

KEY :

Camerton Great Vein—C.G.T.V.
Camerton Top Little Vein—C.T.L.V.
Camerton Middle Vein—C.M.V.
Camerton Under Little Vein—C.U.L.V.
Braisdown Slyving Vein—B.S.
Braisdown Under Little Vein—B.U.L.V.
Braisdown Bull Vein—B.N.S.

The abundance of Pecopterids at this horizon is well known, and several species, of which *Asterotheca lamurensis* (Heer), *Callipteridium* sp. and *Asterotheca hemitelioides* (Brongt.) would appear to be the most important, suggest that this group lies within the floral zone of I. Bertrand and Corsin (1931, p. 216) considered these beds to lie at the very top of the Westphalian or perhaps the base of the Stephanian.

Fauna of the Radstock Group

Previous records of the fauna of this Group are confined to the occurrence of *Anthracosia* and *Limulus* (Morris, 1868, p. 357).

It is interesting to note that no fauna band with shells in profusion, such as occurs in the Farrington Group, has yet been discovered. Lamellibranchs are, however, present in this Group, but are always found as more or less isolated individuals associated with the flora. This mode of occurrence has not been noticed in the Farrington Group.

At Camerton Colliery the following shells were obtained: Under Little Vein, *Anthracomya prolifera* forme *juvensis* Waterlot; Middle Vein, *Anthracomya prolifera* cf. forme *valida* Waterlot; tip and probably Great Vein, *A.* cf. *palatina* Schmidt.

At the Lower Conygre Colliery, where only the Radstock Group of coals were worked, *Anthracomya prolifera* Waterlot was obtained from the tip. These forms are characteristic of the Lower Stephanian of France.

THE STRUCTURE OF THE RADSTOCK BASIN

Attention was paid to the structural features of the basin by Greenwell and McMurtrie (1864), whilst Anstie (1873) gave much valuable data. Important work was produced by McMurtrie in a series of papers on the methods of working adopted and the chief faults affecting the basin. The "overlap" faults led McMurtrie (1890, pp. 49-66) to compare this area of the coalfield with the Coal Measures of Belgium and the north of France, whilst in 1901 (Pl. XII, Fig. 1) he produced a sub-Mesozoic map of the Somerset and Gloucestershire Coalfield, and illustrated this by horizontal sections (see also Crookall, 1929, pp. 88-89, Figs. 1 and 2). Welch (1933) also gave a very able account of the tectonics of the Radstock coal basin.

The extent of the basin shown by the map (Plate 32) has been proved by a series of collieries. The eastern border is well known; the Radstock Group of coals have there been worked to their sub-

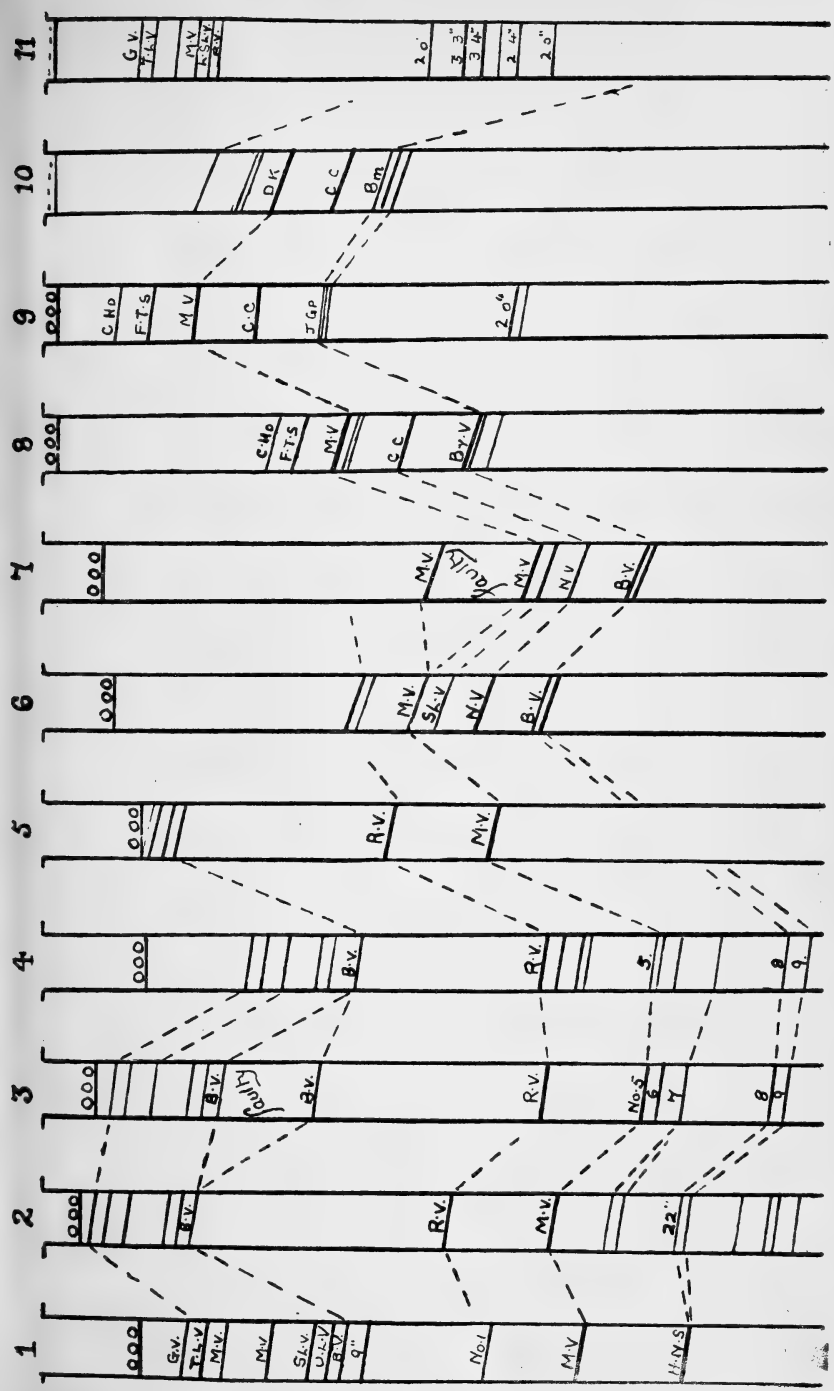

1
2
3
4
5
6
7
8
9
10
11
G.V.
T.L.V.
M.V.
M.V.
S.L.V.
U.L.V.
B.V.
9"
No.1
M.V.
H.N.S.
B.V.
B.V.
B.V.
R.V.
R.V.
M.V.
22"
No.5
6
7
8
9
5
9
R.V.
M.V.
M.V.
S.L.V.
M.V.
B.V.
M.V.
N.V.
B.V.
C.Ho
F.T.S.
M.V.
C.C.
B.Y.V.
C.Ho
F.T.S.
M.V.
C.C.
J.G.P.
2.0"
D.K.
C.C.
Bm.
G.V.
T.L.V.
M.V.
S.L.V.
B.V.
2.0'
3.3"
3.4"
2.4"
2.0"

Fig. 23

Mesozoic outcrop, as has the Rock Vein of the Farrington Group. The south-eastern border, worked by the Writhlington Collieries, is particularly well known.

The Clandown fault divides the basin into two convenient portions, the eastern portion containing the synclinal axis, which runs from a point north-east of Clandown Colliery to between the Ludlow's and Tyning Collieries and thus takes a general south-south-east direction. The Braisdown Colliery in this area shows westerly dips, whilst north of this at Camerton the strata dip entirely to the south.

The western portion of the basin is fairly well known; its western border turns sharply to a north-south strike, and dips east at a low angle, whilst passing eastwards through the Old Mills and Norton Hill Collieries the dips are predominantly north-east; no southerly dips are known in this portion of the basin. It is at once evident that this western portion of the basin has suffered the more acute disturbance; its southern edge is that at present being worked, and its limits are less well known.

The Radstock basin may be considered to terminate in a northerly direction at the line of the Temple Cloud fault, which runs north of east from the latter place to the north side of the Camerton Colliery workings. This fault has been proved to attain a throw of 420 feet near Withy Mills. The Farmborough fault, which has for so long provided an effective barrier to workings to the north, runs more or less east-west, and probably meets the Temple Cloud fault in the neighbourhood of Tunley. These two faults provide a wedge-shaped area of Coal Measures wider to the west. Prominent north-east dips in the Farrington and Radstock Groups of coals were proved by the Greyfield Colliery, and a precise limit to these Groups can here be shown.

Eastwards, within this faulted block, Radstock coals have been worked with very varying dips, due to a series of smaller north-south and east-west faults.

The strike at Greyfield Colliery swings to a more northerly direction, as proved by Burchell's Colliery near Clutton, and the measures are cut by east-west faults. It would appear that north of the Temple Cloud fault a further basin exists.

Faults of the Basin

The faults of the Radstock basin fall naturally into two main groups, those trending north-south and those trending east-west.

Of the north-south trending faults, the Clandown fault appears

to be the best known example. It runs north-north-west from Kilmersdon Colliery through Radstock to Clandown Colliery and is reputed to die out northwards. A downthrow west of 600 feet has previously been given as the magnitude of the fault, though it is doubtful if it exceeds 400 feet according to evidence from sections drawn. At the Kilmersdon Colliery this fault has been well proved and has a low hade westwards (Fig. 24). Its effect at this Colliery is that of a downthrow west, since the outcrop of the Radstock Group of seams dipping north-east is thrown southwards on its western side. Whether this fault is a continuation of the Luckington fault (Moore and Trueman, 1938) it is difficult to say. However, since the Clandown fault must certainly lie below the major thrust postulated (Moore and Trueman, 1938), and the Luckington fault is known to occur above this thrust, it is uncertain whether they are one and the same fault.

A fault occurring east of Norton Hill Colliery, and previously proved at Old Welton Colliery, is suggested as joining the Stoke Lane and Coal Barton faults of the south crop.

A further north-south fault bounds the workings to the west of Norton Hill Colliery and in its northward course cuts off the eastern end of the Old Mills workings, and runs towards an 80 fathoms fault proved in the workings of the disused Withy Mills Colliery to the north. Though the line of this fault is unknown, it is suggested to be a continuation of the Oakhill fault. A considerable displacement of strata northwards on its western side may point to its being a tear fault heaving west.

The thrust faults of the Central Mendips exhibit a tendency to swing northwards, which may partly account for the sudden turn to north-south strikes along the western border of the basin at Farrington Gurney. The north-south strikes, however, are a feature of the western border of the coalfield and are considered to mark the western border of a main north-south syncline.

Those faults in the Radstock basin which trend in an east-west direction include both normal and overthrust faults. Normal east-west faults are rare, but a series of such, downthrowing south, occurs south of Camerton Colliery where values of 30, 42, and 48 fathoms are given as their magnitudes. The Temple Cloud and Farmborough faults are reputed to be normal faults, and evidence obtained from a stream section north of the Farmborough fault seems to indicate a considerable downthrow to the south which, near Fry's Bottom at least, may be something near 1,000 feet. It may be noted, however, that when the

positions of the Upper Coal Series north and south of these faults are considered, a westward displacement of the northern area seems likely, and the faults (or the Farmborough fault alone) may be tear faults; they show evidence of normal movement certainly in post-Triassic times, but the variety of throw along the Farmborough fault may be due to horizontal movement across the fold.

Overthrust faults are extremely common in the central and eastern portions of the Radstock basin; they vary in size from an overlap of a few feet to one of hundreds of feet. The Radstock "slide" fault of McMurtrie (1901, p. 27, Pl. XIV) has been proved by a number of collieries. Many suggestions to explain the increased overlap on the lower seams have been put forward, including the inference that such a fault had commenced before the deposition of the upper seams. The change in the amount of overlap, however, can only be ascribed to the change in inclination of the fault plane, which is shown to increase from the Bull Vein to the Great Vein, hence decreasing the amount of overlap. The amount of downthrow from a seam above the lap to the corresponding seam below the lap thus varies from 105 to 216 feet.

This fault has been proved in the Writhlington Collieries, where it has been traced on the Rock Vein and Deep Middle Vein of the Farrington Group. North of Huish Colliery it shows a downthrow north of 210 feet on the Rock Vein, but when followed eastwards for approximately two miles it is found to die out, and where last seen has a downthrow north of only a few feet. Its course on the Deep Middle Vein has not been so extensively proved, but south of Huish shaft a value of 270 feet downthrow north is given. Two further "overlap" faults proved at the Lower Writhlington Colliery on the Rock Vein and Deep Middle Vein show values of 137 and 102 feet downthrow north on their western end; traced eastwards these likewise die out.

On the other hand, faults which near Huish Colliery show a small amount of overlap, increase in size eastwards and become larger and apparently normal faults. Some of these may downthrow to the north and others to the south.

The largest overlap fault in the district which has not been previously described is that proved at the Norton Hill No. 2 Colliery; it affects seams of the Farrington Group at this colliery and is considered to be the same fault as that encountered by the Old Welton and Clandown Collieries in workings on the Radstock Group of seams. The downthrow north on the Farrington seams is 375 feet, and the fault has a low hade. The crop of the seams on the upper side of the lap runs east-west, the

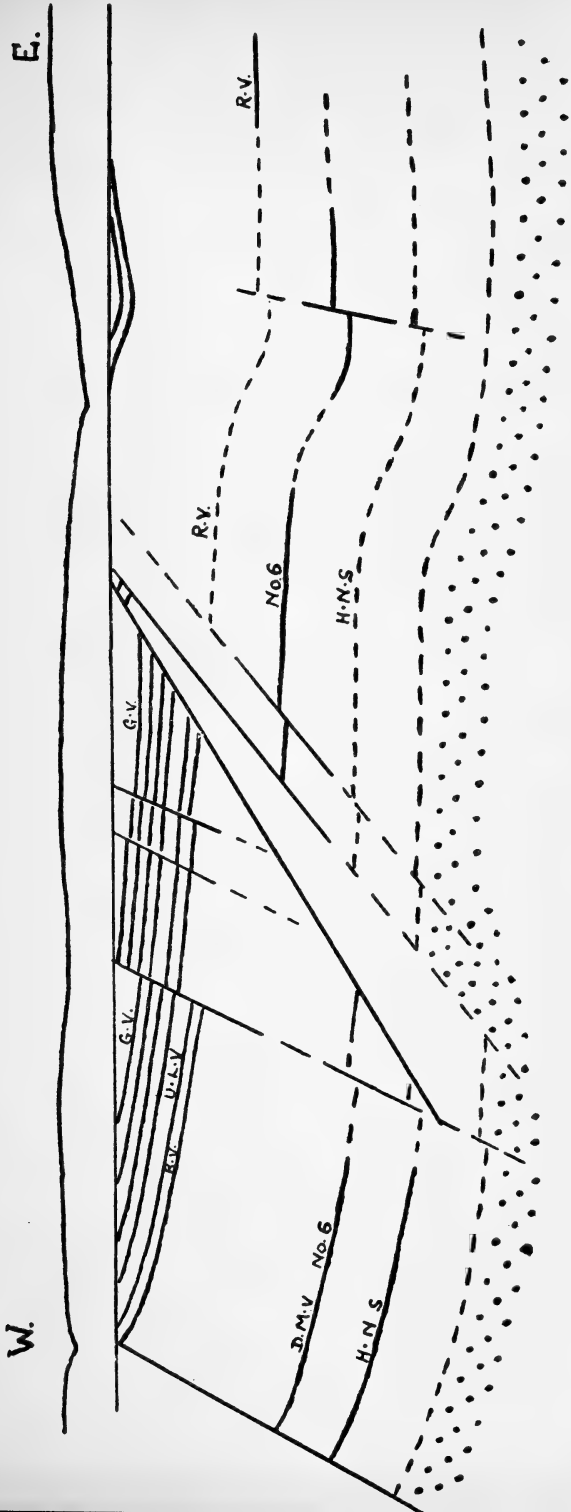


FIG. 24

dip of these measures being generally northwards. On the underside of the lap, the crop of the seams against the fault plane runs north-west, the measures having a north-easterly dip. The effect produced is apparently one of movement in an anticlockwise direction.

This overlap fault may terminate against the north-south fault, but no evidence is obtainable to the west although overlap faults are singularly absent in the Old Mills and Farrington Gurney Collieries. This overlap fault at Norton Hill may be a continuation of the Radstock overlap fault; it will be noticed that this fault in Radstock is known to increase in magnitude westwards, which would agree with the data concerning the fault proved at Norton Hill.

Welch (1933) gave a very useful account of the tectonic features of this basin and noted the axis of the Coal Measures basin to lie north-north-west and south-south-east, meeting the east-west direction of the Mendip folds.

It is probable that the first stage in the tectonic history of this district was due to pressure from the east with the resultant formation of a syncline running roughly north and south. It is possible that the Beacon Hill pericline had originally an arcuate limb conforming somewhat to the southern border of the Coal Measures syncline. The northward drive of the Mendips does not appear to have seriously affected the configuration of the nose of the Radstock basin, since low dips are observed in the Farrington and Radstock Groups of seams at the Writhlington Collieries. The syncline was held by powerful pressure from the east, and though foreshortening on the application of the south to north pressure was inevitable, this took the form of overthrusting on a large scale. It will be remembered that the overthrust faults die out eastwards, which may be explained by the fact that south to north pressure was considerably less dominant near the eastern border. Further west, south to north pressure being dominant, expressed itself in overthrust faults.

The north-south faulted block lying west of the Clandown-Luckington line has apparently received the most severe effects of northerly directed pressure. The nature of these north-south faults is very doubtful; they may have been caused by tension in the syncline resulting from the application of the south to north pressures though they appear to have a pronounced westerly hade. (Fig. 24.)

That portion of the basin lying west of the Oakhill-Norton Hill fault, released from the restraining influence of the eastern border, appears to have been driven northwards and moulded by the Central

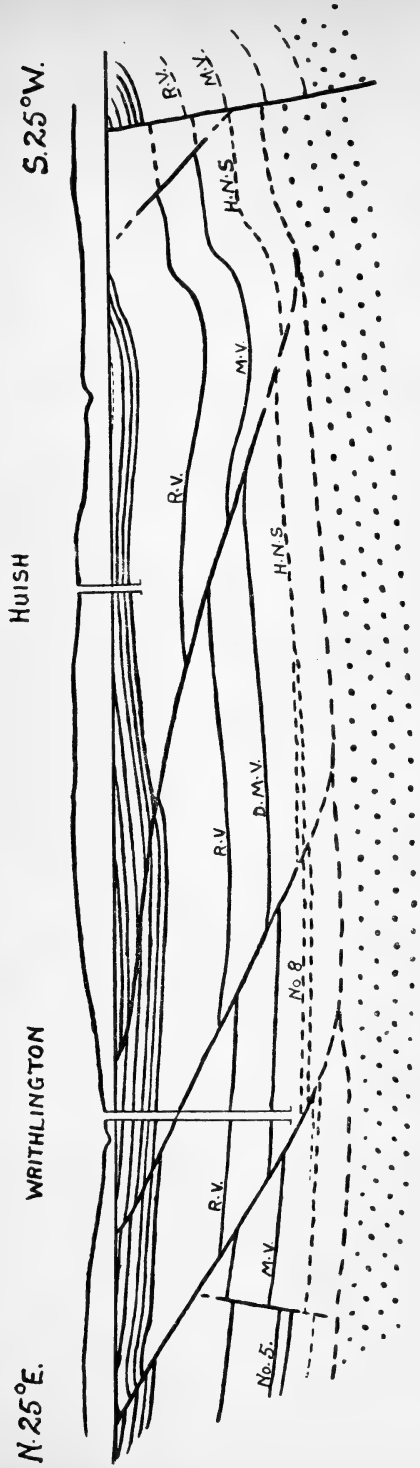

N.25°E.
WRITHLINGTON
HUISH
S.25°W.
R.V.
M.V.
H.N.S.
R.V.
M.V.
H.N.S.
R.V
D.M.V.
No.8
R.V.
M.V.
No.5.

FIG. 25

Mendips. This would explain the absence of thrust faults in this corner of the basin.

The northern boundary of the basin appears to be a faulted anticlinal fold in the neighbourhood of Temple Cloud; this may have resulted from the growth of Broadfield Down. The final disturbances affecting the configuration of the western boundary of the basin may have emanated from the Central Mendips, as a succession of powerful north-south faults cutting through any previous east-west structures, and so accounting for the position and southerly dips of the Bishop Sutton workings.

Description of Plate and Figures

Plate 32.—Possible sub-Mesozoic outcrops of Radstock Basin; worked outcrops are shown by a continuous line, approximate outcrops are dotted. Faults where proved are shown by a continuous line. Pennant Sandstone shown dotted, and Barren Red Shales by oblique shading. Arrows indicate direction of dip.

Fig. 23.—Suggested correlation chiefly of seams in Farrington Group. Collieries numbered as follows :—1. Kilmersdon; 2. Lower Writhlington; 3. Ludlow's; 4. Braisdown; 5. Foxcote; 6. Norton Hill No. 1; 7. Norton Hill No. 2; 8. Old Mills; 9. Farrington Gurney; 10. Greyfield; 11. Old Grove.
Scale 1 inch—600 feet.

Fig. 24.—Section across the Clandown fault from the workings of Kilmersdon Colliery. Extending from Waterside Farm on the west towards Terry Hill on the east.

Fig. 25.—Section across the workings of Writhlington and Huish Collieries showing "overlap" faults in seams of Radstock and Farrington Groups.
Scale 3 inches—1 mile.

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Speedwell Pit

By L. G. G. Warne, M.Sc., Ph.D.

THE Kingswood area of the Bristol and Somerset Coalfield is generally taken to comprise an area of about 20 square miles, extending from Bristol in the west to Siston, Warmley and Bitton in the East, and from Mangotsfield and Stapleton in the north to Hanham and Conham in the south. This area lies wholly within the area of the old Kingswood Forest or Chase and its boundaries agree closely with those of Kingswood as shown in a map of 1610, by which time the original Kingswood Forest had become much reduced in area and, in fact, the Kingswood Coalfield agrees fairly well with the area of the Kingswood Forest at that time.

Coal appears to have been mined in the district for over 700 years, and in the year 1223 we find references to charges for digging sea-coal in Kingswood, whilst in 1371 the King granted permission to the then Lord of Bitton to remove sea-coal from the Kingswood Chase. Probably in these early days coal was not mined extensively, but in later years the industry developed rapidly, and in a survey of the Forest in 1615 it is reported that " The coale mines also devoure the principal hollies in all parts of the forest for the supportation of these pittes." About 1665 various abortive attempts were made to use coal for the smelting of iron in the district, and the total number of coal pits in the area had increased to seventy-two by 1670. From this time onwards numerous pits were sunk, the pits being drained by the ingenious method of driving " levels " into the side of the hill, upwards of ten miles of these levels being in existence by 1790, and by this time over one hundred coal pits were in existence. The extent to which the coal mining industry developed here can be judged from the report that in the eighteenth century Whitefield preached in the open air at Kingswood to congregations of over ten thousand colliers.

Coal pits continued to be sunk, and between 1850 and 1860 the Kingswood Coal Company sank shafts at Speedwell known as Speedwell Pit and Deep Pit for the purpose of working at a lower level the seams which had been proved at the Easton and Pennywell Collieries. These were the last pits of any size to be sunk although, during this century, outcrops of coal have been worked during coal strikes at Soundwell and at Prospect Avenue, Kingswood.

No pits are now worked in the district, Deep Pit being closed about 1926 and Speedwell Pit in 1936.

The Coal Measures of the Bristol and Somerset Coalfield are divided into the upper division which includes the Radstock Series and the Farrington Series, and the lower division which is separated from the upper division by an extensive development of Pennant Grit. The lower division comprises the New Rock Series and the Vobster Series. At Speedwell, seams belonging to the New Rock Series were worked, and during the sinking of the shaft the following Seams are said to have been cut :—

Doxall Seam.
Upper Toad Seam.
Hole Seam.
Lower Five Coals Seam.
Thurfer Seam.
Great Seam.
Gillers Inn Seam.
Lower Toad Seam.

Within the last ten years a further Seam—the Two Foot Seam—has been proved. Of these Seams, the only ones worked were Five Coals, Great Vein, Gillers Inn, and Two Foot.

Although coal has been mined extensively in the district for such a long period, fossil records for the area are few, doubtless due to the fact that only a small number of pits have been worked in recent times. The only extensive published records are those of Crookall, and Moore and Trueman, and in each case a list of fossils is given for Speedwell Pit. There are a few earlier scanty records which, however, include no species not listed by Crookall or Moore and Trueman. Crookall's list includes twenty-one species from Speedwell, and as these were collected previous to the proving of the Two Foot Seam, they probably represent material from the Five Coals, Gillers Inn and Great Vein Seams. Moore and Trueman give a list of 19 species from Speedwell Pit, and Dr. Moore informs me that they collected from fresh material on the tip, and so the material comes from either the Five Coals or Two Foot Seams, as they were the only ones being worked at the time.

I have collected material from the tip at Speedwell Pit for a number of years. The collecting was all done previous to the proving of the Two Foot Seam and so represents material from the Five Coals, Great Vein and Gillers Inn Seams. The list of fossils collected is given below :

List of Fossil Plants from Speedwell Pit, Bristol

**Lepidophloios laricinus* Sternb.
* ,, *acerosus* L. and H.

**Lepidodendron lycopodioides* Kidston.
* ,, *rimosum* Sternb.
,, *obovatum* Sternb.
,, *simile* Kidston.
,, *ophiurus* Brongt.
,, *aculeatum* Sternb.
* ,, *lanceolatum* Lesqx.
**Sigillaria tessellata* Brongt.
* ,, *mammillaris* Brongt.
* ,, *scutellata* Brongt.
* ,, *boblayi* Brongt.
**Bothrodendron minutifolium* Boulay
**Lepidostrobus morissianus* Lesqx.
Stigmaria ficoides Sternb.
Calamites undulatus Sternb.
,, *carinatus* Sternb.
* ,, *cisti* Brongt.
Annularia radiata Brongt.
* ,, *galioides* L. and H.
**Sphenophyllum saxifragæfolium* Sternb.
,, *cuneifolium* Sternb.
,, *myriophyllum* Crepin
**Paleostachys* sp. Weiss
Mariopteris nervosa Brongt.
**Sphenopteris dilatata* L. and H.
,, sp. Brongt.
Neuropteris obliqua Brongt.
* ,, *tenuifolia* Schloth.
,, *heterophylla* Brongt.
,, *pseudogigantea* Potonié
Diplotmena cf. *furcatum* Brongt.
**Samaropsis* sp. Goeppert

Of this list, the eighteen species marked * represent new records for Speedwell Pit, although a number of these have been recorded from Deep Pit.

Three of the recorded species, namely :—

Lepidophloios acerosus L. and H.
Sigillaria boblayi Brongt. and
Annularia galioides L. and H.

are new for the Bristol and Somerset Coalfield.

I have made no attempts to indicate the relative abundance of the various species. The tip at Speedwell Pit is allowed to burn and the material turns a nice red colour and is removed for making paths, etc. The removal of the burnt material results in fresh exposures being frequently made. In the burnt material, however, whilst it is relatively easy to distinguish pith casts of *Calamites* and impressions of the bark

of Lycopods, small fragments of foliage are difficult to distinguish. Because of this the preponderance of Lycopods in the list of fossils given may not represent a real preponderance in the coal seams concerned.

I have to thank Dr. Crookall, whose help has ensured the accuracy of the identification of the fossils, Dr. Moore, for helpful advice, and the East Bristol Collieries Ltd., for information as to the seams worked at Speedwell Pit.

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Studies on the Biology of the Bristol Channel

I

GENERAL INTRODUCTION

By C. M. Yonge, D.Sc.

THERE is no region around the shores of Great Britain of greater intrinsic interest than the Bristol Channel and the estuary of the River Severn. The exceptional range of the tides and the long distances over which estuarine conditions prevail, both the result of the gradual narrowing of the Channel and estuary, combine to produce unusual hydrographic conditions which have a profound effect on the animal life. Animals living in the upper regions of the Channel and the lower region of the estuary (taking the mouth of the River Avon as the boundary between these) suffer daily the effects of wide ranges in salinity, of the backward and forward movements of the greatest tides found in Europe, and of the exposure to the abnormally heavy concentrations of silt brought down by the rivers and kept long in suspension by the violent water movements caused by the tides.

Despite the obvious interest of this region, practically no work has been done upon it. One explanation of this is certainly the difficulty —and unpleasantness—of working on shores covered by thick deposits of soft mud. There exist a number of papers dealing with the local fish fauna, largely incorporated in accounts of the unique "fixed engines"—shrimp "Kypes" and salmon "Putchers"—and various types of stake nets in which the great range of the tides is exploited for catching fish and shrimps. The most recent paper on this subject is by Mr. L. H. Matthews, now a member of the staff of the Department of Zoology, University of Bristol, and it contains an adequate bibliography (Matthews, 1934). The same author has also published a short note on the shore fauna at Portishead (Matthews, 1923), but this appears to represent the extent of existing knowledge on the invertebrates.

It is clearly one of the functions of the Department of Zoology in the University to remedy this state of affairs. This provides the reason for the publication of the series of papers of which this statement forms the first. Mr. R. D. Purchon, at that time an Honours student in this Department, carried out during the session 1936-37 comparative surveys of the fauna and flora on the shore and in the dock at Portishead,

relating differences in these, as far as was possible, to environmental factors. His completed account forms the second paper in this series. At the present time Mr. A. J. Lloyd is studying the nature and abundance throughout the year of the animals caught in the kypes and putchers at Berkeley and at Hallen, and is paying especial attention to the biology of the common shrimp, *Crangon vulgaris*, about which surprisingly little is known. This work will be published in due course.

It is hoped, later, to extend this faunistic work to shores further down the Channel, and, if possible, to dredging in mid-stream, and to supplement it with investigations into the significant environmental factors, notably salinity, tidal movements, silt content (involving the penetration of light) and temperature. The object aimed at is a full description of the fauna of the estuarine regions of the Channel and of the environment, linking the two with studies on the biology of the animals, including the morphological and physical adaptions which permit existence in regions exposed to this wide range of environmental variation.

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II

AN ECOLOGICAL STUDY OF THE BEACH AND THE DOCK AT PORTISHEAD

By R. Denison Purchon, B.Sc.

CONTENTS

1.—INTRODUCTION

DURING 1936-37 an ecological comparison was made between the Royal Beach and the dock at Portishead.

Matthews (1923) has published an introductory account of the beach and the dock, in which mention was made of a number of species which were found in the dock but not elsewhere in the vicinity.

The object of the investigation was to obtain, as far as possible, a full fauna list, and also an indication of the range of the chemical and physical factors of the two environments.

It was considered that alkaline reserve, silicate and phosphate contents were unlikely to show any significant variations, so no analyses of these were undertaken.

The author wishes to express his gratitude to Professor C. M. Yonge, Dr. R. Bracher, Dr. E. Ashby, Mr. H. A. Hyde, Mr. L. F. Cowley, Mr. F. Hannell, and also various fellow students, for their assistance in this work. Acknowledgments are also due to the Colston Research Society of the University of Bristol for financial aid towards the publication of this paper.

2.—TOPOGRAPHY

Portishead is situated on the south-west coast of the estuary of the Severn, a short distance west of the Bristol Avon.

(*a*) THE BEACH. (See Map, Fig. 26.)

The area of beach examined extends from Battery Point on the west to Portishead pier on the east. The beach faces roughly north and is composed of a great variety of substrate, including seaweed-covered rocks of steep or gentle inclination, shingle, sand and mud.

By means of a series of five sections obtained by the use of a simple water level, and transects which crossed all types of substrate, adequate information was obtained regarding the fauna and flora of the beach. The transects are represented by a series of broken lines numbered 1-5 on the map.

Traverse 1

140 feet in length. Direction 13° E. of N. On Battery Point. It passes through lichen-covered steep rocky surfaces, next through an area of very steep rocks covered largely with *Ascophyllum nodosum*, and finally over a flat expanse of sandy mud and boulders to L.T.M. of spring tides.

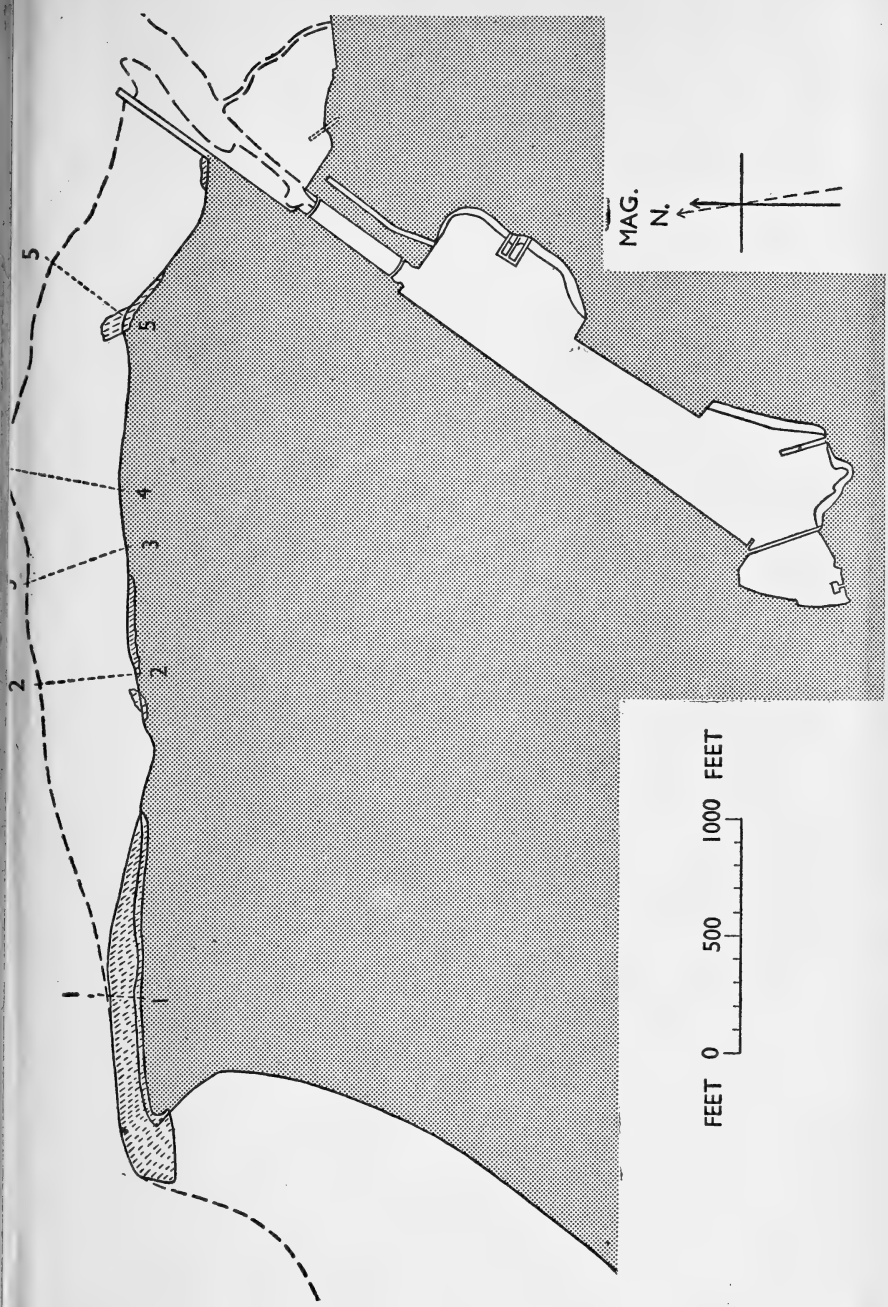

FIG. 26.—MAP OF THE ROYAL BEACH AND THE DOCK AT PORTISHEAD

The positions of the traverses taken on the beach are represented by the broken lines numbered 1–5. The steep rocky surfaces on the beach are represented by heavy shading. High water mark of ordinary tides is represented by a continuous line, and low water mark of ordinary tides by a broken line.

Traverse 2

Some distance east of traverse 1, 417 ft. in length. Direction 6° E. of N. This passes first through a zone of shingle, then a flat expanse of seaweed-covered boulders lying in mud, then a broad belt of deep mud, and finally through a wide belt of steep, clean sand to L.T.M. of spring tides.

Traverse 3

Still further to the east, just on the west side of the culvert. 458 ft. in length. Direction 2° W. of N.

This traverse passes first through a very wide area of boulders lying on mud, then through a wide belt of flat rocks covered with *Ascophyllum nodosum*, through occasional fairly large pockets of mud, and finally through a small area of muddy sand terminating in a dead colony of *Sabellaria alveolata* at L.T.M. of spring tides.

Traverse 4

A little distance to the east. 452 ft. in length. Direction 22° E. of N.

Passes in the main through similar areas to those covered by traverse 3. At its seaward extremity it passes through a zone of small pebbles and occasional boulders lying on a thin muddy substrate.

Traverse 5

Near the Pier. 353 ft. in length. Direction 49° E. of N. This passes first through a region of steep, jagged, lichen-covered rocks, next through a broad flat zone of rocks covered with *Ascophyllum nodosum*, through a pocket of mud, and finally over an expanse of flat rocks devoid of algæ.

(*b*) The Dock. (See Map.)

The dock entrance is at the N.E. end and lies on the east side of Portishead Pier. Along the N.W. side of the dock there are stone walls and deep water. It is here that coal vessels unload their cargo. Dredging in this region proved unprofitable.

On all other sides of the dock the bottom is slowly shelving, and when the water level is low it is possible to examine the fauna by digging and sieving. There are wooden piers, jetties and wharves on the S.E. side, and these have yielded interesting results by scraping surface forms into a metal basket specially made for the purpose.

The dock differs from the beach in possessing water which is much

less heavily laden with silt. There is also less variation in water level in the dock; at the N.E. end of the dock there is an inlet through which sea water is occasionally pumped into the dock.

A certain amount of water will seep into the dock from the surrounding soil, thus lowering its salinity, but as there is no stream, or other source of drainage into the dock, there is no reason why there should be any more dilution by fresh water than occurs on the beach.

The highest level reached in the dock is about 39 ft., and the lowest about 28 ft., but the daily variation probably does not ever exceed 2 or 3 ft.

3.—THE FAUNA OF THE ROYAL BEACH

An extensive study of the beach was carried out in the last half of August and the first half of September, 1936, by means of the series of five traverses which crossed all the various associations found on the beach.

Zonation of the Shore

The shore between tide marks can be divided into three main zones disposed horizontally, one above the other, the most important feature of this zonation being the facilities afforded to the population for gaining protection against the violence of the sea.

Zone 1

Stretches from a point slightly above H.T.M. of neap tides to above H.T.M. of spring tides. At points where the substrate is steep, and exposure great, the splash zone is proportionately greater, and this results in the lower limit of this zone being raised; e.g., at Battery Point, where on traverse 1 the lower limit is nearly 3 ft. higher than the average.

Consideration of the nature of the substrate leads to a division of this zone into three associations.

(*a*) *The steep bare rock association.*—Rock pools are common, crevices in the rocks forming the only protection against exposure and the sea's action.

The dominant plant is the lichen *Physcia parietina.* No algæ are present. The crevice fauna consists of the dominant *Littorina rudis,* frequent small specimens of *Ligia oceanica* which scamper everywhere over the rocks, occasional *Petrobius maritimus*, *Porcellio scaber* and rare *Gamasellus inermis.*

(*b*) *The Shingle association.*—As the substrate is of far greater mobility, life is more precarious, and the population is scanty. There are no dominant species but occasional colonies of *Ligia oceanica* and *Gammarus marinus* can be found below stones, whilst more rarely, specimens of *Geophilus longicornis* and small Oligochæts may be observed.

On shingle banks there is typically a well-defined association in the débris at the H.T. mark. This association is dominated by *Talitrus saltator* and dipterous larvæ, pupæ and adults, e.g., *Cœlopa frigida.* Dead and dying samples of other communities are frequently found in the litter, e.g., *Sertularia operculata.*

(*c*) *Loose Boulders on a muddy substrate.*—Protection is greater here owing to the greater size of the stones and the possibility of burrowing into the substrate.

The dominant species is *Lipura maritima.* Oligochæts and Nemertea can be found below boulders, while the mud is densely colonised whenever possible by *Nephthys hombergi.*

ZONE 2. *The algal zone, on steep or flat rock surfaces*

This extends from Zone 1, where the substrate permits, to a level which, on an average, approximates closely to that of L.W. neap tides. Either owing to the low illumination in these muddy waters or to some chemical factor, there is no *Laminaria* zone on the shore, and thus the algæ never extend below L.T.M. of neap tides.

The presence of the algæ affords great protection against dessication and mechanical violence of the sea ; it also provides a source of food to some species. The zone is of great vertical range, about 24 ft. It may be divided into a smaller upper zone (*a*) in which the algæ are not so large, and a larger zone (*b*).

(*a*) *Pelvetia—Fucus spiralis sub-zone.*—*Pelvetia canaliculata* has a slightly higher range than *Fucus spiralis*, the two ranges overlapping somewhat. *Littorina rudis* extends into this zone, its lower limit being slightly higher than that of this zone.

(*b*) *Ascophyllum nodosum sub-zone.*—Other algæ of importance are *Fucus serratus* and *Fucus vesiculosus.* Small green algæ such as *Ulva lactuca, Enteromorpha* sp. and *Cladophora rupestris* are found in most cases on clean rocks below the canopy of Phæophyceæ.

The dominant animals are *Littorina littoralis* and *Gammarus marinus.* *Carcinus mænas,* especially small specimens, is very abundant.

This sub-zone is replaced in some areas by wide stretches of mud which appears to support almost no life. This is typical of the mud belt through which traverse 2 passes, in which the only living animals

found were one or two *Corophium volutator* and a few spat of *Macoma balthica*.

Smaller pockets of mud are frequently found in dips in the rocks in the midst of the sub-zone, and here *Nereis diversicolor* is dominant. The tubes of *Pygospio elegans* are abundant, and *Hydrobia ulvæ* is occasionally found.

ZONE 3

An area generally extending from about L.T.M. of neap tides to below L.T.M. of spring tides. It may be divided into four well-defined associations, all of which are typified by the absence of any algæ.

(*a*) *Sand.*—This is of great mobility, movement occurring by water currents when submerged and by the prevalent S.W. winds when exposed. The only living animal found in the whole of the wide belt of sand extending from Battery Point to the culverts was one specimen of *Nephthys hombergi*.

(*b*) *Flat rocks.*—The dominant species is frequently *Sertularia argentea*, which here never exceeds three inches in length. Where *S. argentea* is absent, small shells of *Balanus improvisus* may often be found in great abundance. In rock pools there may be a very dense population of *Tubularia indivisa*. *Tealia felina* and *Patella vulgata* occur on overhanging surfaces.

(*c*) *Pebbles and boulders on a thin mud substrate.*—Specimens of *Balanus improvisus* are again abundant on all freely exposed surfaces. *Tubularia indivisa*, *Tealia felina*, *Bowerbankia imbricata*, *Lepidonotus squamatus* and *Lepidochiton cinereus* are commonly found on overhanging surfaces. *Jæra marina* and *Onchidoris muricata* are less frequently found. On overturning the stones, a distinct sub-association is to be found, which is dominated by *Amphitrite johnstoni*. *Nereis virens* and *Terebella lapidaria* are frequently found. *Pandalus annulicornis* and *Crangon vulgaris* are often stranded on the pebbles. Two specimens of *Eupagurus bernhardus* were collected here. Near L.T.M. of spring tides *Nymphon gracile* is abundant in the tiny pools between the stones.

4.—THE FAUNA OF THE DOCK

A series of weekly expeditions to the dock was begun in October, 1936, and continued as regularly as possible until Easter of the following year. During these months observations were made on the fauna by the use of tow-nets, the dredge, by scraping the bottoms of ships, and

the sides of wharves, and by raising buoys, floating timber, mooring ropes, and chains.

(*A*) Planktonic Community

Adult *Aurelia aurita* were very abundant in August and early September. Tow-net hauls yielded a number of small Copepoda, a few Foraminifera, and one or two specimens of *Eurydice pulchra.*

(*B*) Encrusting Community

Upon all surfaces standing clear of the muddy bottom.

(i) *Serpulid* association

Mercierella enigmatica was dominant, growing in great profusion on the sides of an old metal ship which has since been demolished. *Lepralia pallasiana* was abundant, growing on the surface of the serpulid tubes. In all probability the two species were present on the ship before it entered the dock, for they are not found attached to any other similar substrate in the dock in such great profusion, and apart from two species of *Membranipora,* no species related to either are found in the vicinity. Occasional specimens of *Lepidonotus squamatus* were found.

(ii) *Mytilus edulis* association.

Large colonies of *M. edulis* are uncovered on the stone walls and on the wooden wharves when the water level in the dock falls below about thirty feet. *Balanus improvisus, Botryllus schlosseri* and *Molgula citrina* are frequently found attached to *M. edulis.*

(iii) *Corophium* association.

This is typical of almost all floating objects. There is a luxuriant growth of Chlorophyceæ and Rhodophyceæ amongst which *Corophium insidiosum* is dominant. *C. acherusicum* is frequent, and so also are *Idotea baltica* and *I. viridis. Gammarellus homari* and *Gammarus locusta* are occasional inhabitants of this association.

(iv) *Gonothyræa loveni* association.

Chiefly on old ropes, deeper than the algæ. *Pygospio elegans* is to be found attached to *G. loveni.*

(v) *Limnoria lignorum* association.

Though this is a burrowing and not an encrusting association, it has been included in the Encrusting Community in that it is dependent upon wooden structures projecting above the bottom.

Limnoria lignorum is the dominant form. No specimens of *Chelura*

or *Teredo* have been discovered inside the dock. *Palæmonetes varians* and *Praunus flexuosus* have been obtained relatively frequently when scraping this association.

(*C*) Benthic Community

This is divided into two associations of different horizontal distribution, which overlap each other slightly.

(i) *Mya arenaria* association.

This is found all round the south and south-east sides of the dock where the bottom shelves gradually. It is uncovered when the water level in the dock falls below about 29 ft.

Mya arenaria is dominant, the substrate is clay, and as many as 10 specimens of *Mya* may be exposed with one turn of the fork. *Lutraria lutraria* is frequent, but large specimens were never encountered. *Macoma balthica* was only occasionally collected in this zone. Empty shells of *Cardium edule* are common. *Nereis diversicolor* was frequently dug up in the association and *Littorina rudis* is very abundant in some areas, especially beneath the footbridge where it is found in great quantities among empty *Mya* shells.

(ii) *Cardium edule* association.

This is found typically in deeper water, the substrate is very soft and is not heavily laden with oil, as are many parts of the *Mya* association. The dominant species is *Cardium edule* var. *rusticum*. *Macoma balthica* is frequent although never exceeding one twentieth of the numbers of *C. edule* in the dredge hauls. It is particularly frequent in the small bay on the east side of the dock, near the footbridge, and between this and the pier.

Occasional small specimens of *Tealia felina* were found attached to empty shells of *C. edule*. *Nereis diversicolor* was frequently collected in the dredge. One specimen of *Carcinus mænas*, two of *Hydrobia ulvæ* and a number of spat of *Lutraria lutraria* were also found in the association.

5.—CHEMICAL AND PHYSICAL FACTORS

(*A*) Chemical

There is no drainage of fresh water into the dock, all dock water coming from the sea, especially large influxes occurring at times of spring tides. A close approximation between the chemical characteristics of the dock and the outside water would therefore be expected.

It was considered necessary to determine only oxygen tension, salinity and *p*H.

A large number of samples were taken at irregular intervals from the water's edge, whatever the state of the tide; all analyses were carried out at Bristol. Only the extreme readings are here recorded (see Tables 1–5). It was found that with the exception of the turbidity (see Table 5), the differences between the dock and sea water were negligible compared with the full range of variation for each environment.

(1) *Oxygen tension*

Analyses were made with Winkler's method, using Alsterberg's correction method for the presence of reducing bodies. No difficulty was found in the use of this correction method in the case of dock water, but in the case of sea water, owing to some chemical effect of the silt in suspension, the bromine always entered into the final titration of thiosulphate against iodine, rendering the end point difficult to observe, and generally raising the reading slightly.

As shown in Table 1, representing extreme conditions, there is no indication of any significant difference between the oxygen tensions of the two waters.

TABLE 1.—VARIATION IN OXYGEN CONTENT.

	Dock water.	*Sea water.*
7.11.36 ..	68·6% saturation.	70·1% saturation.
19. 3.37 ..	93·3% ,,	97·2% ,,

(2) *Salinity*

This was estimated by titration against standardised silver nitrate. Great variation in salinity was found during the year, but here again there was no significant difference between the salinities of the two waters. All the animals found in this region of the Bristol Channel must be tolerant of wide ranges in salinity.

TABLE 2.—VARIATION IN SALINITY.

	Dock water.	*Sea water.*
4.2.37	14·59°/₀₀	17·00°/₀₀
23.4.37	26·11°/₀₀	33·52°/₀₀

(3) *p*H.

Estimations of *p*H were made by the use of Palitzsch's buffers at intervals of ·05. No significant difference was detected between dock water and sea water.

TABLE 3.—VARIATION IN *p*H.

			Dock water.	*Sea water.*
22.1.37	..	..	7·94	7·97
30.3.37	..	..	8·05	7·94

(*B*) PHYSICAL

(1) *Temperature*

The temperatures of dock and sea water were in close agreement throughout the year.

TABLE 4.—VARIATION IN TEMPERATURE.

			Dock water.	*Sea water.*
2.9.36	..	..	20·3° C.	19·4° C.
8.3.37	..	..	4·6° C.	4·8° C.

(2) *Wave and Current Action*

Mechanical shock may be partially responsible for the failure of certain species to colonise the beach. Mobility of the substrate is probably of no importance, for *Mya arenaria* and other species of Lamellibranchia are frequently found in soft intertidal muds.

(3) *Turbidity of the water.*

There is considerable difference between dock and sea water in this respect; the former is very clean while the latter may hold as much as 3 grams per litre of suspended matter. It is probably the clean nature of the dock water which enables the various Lamellibranchia, Tunicata, and *Aurelia aurita* to live in such profusion in the dock.

TABLE 5.—VARIATION IN TURBIDITY.

			Dock water.	*Sea water.*
17.10.36	..	..	0·13 g.p.l.	1·48 g.p.l.
8.3.37	..	..	0·78 g.p.l.	5·70 g.p.l.

6.—LABORATORY EXPERIMENTS ON SPECIES OF LAMELLIBRANCHIA

It was shown in the preceding section that there is no evidence that oxygen tension, salinity, *p*H, and temperature play any part in the limitation of a number of species to the dock.

A series of experiments was carried out in the laboratory to investigate the effect of turbidity upon the various species of Lamellibranchia found in Portishead dock.

Three aquarium tanks were filled with dock water, and roughly equal numbers of five species of Lamellibranchia, recorded in Table 6,

were placed in each. The water in tank A was untreated, the water in tanks B and C was rendered turbid by adding what were deemed suitable quantities of dried and powdered mud to the former, and precipitated chalk to the latter. The water in the three tanks was agitated efficiently by stirrers driven by an electric motor, and also by a plunger system driven by water dripping from a constant level reservoir. These stirring mechanisms maintained the mud and chalk in suspension, and also maintained a high oxygen concentration. It was found that animals kept in tank A lived throughout the experiment, whereas those in tanks B and C all died after a short time.

TABLE 6.

Species.	Date of addition to the aquarium.	No.	Tank A. Average life in days.	No.	Tank B. Average life in days.	No.	Tank C. Average life in days.
Cardium edule	Feb. 26	3	∝	2	10	3	8
Macoma balthica	,,	2	∝	2	7	2	25
Mytilus edulis	,,	4	∝	4	13	4	25
Mya arenaria	Mar. 8	3	∝	2	11	2	15
Lutraria lutraria	,,	2	∝	3	9	3	14

At the end of the experiment the waters of the aquaria were analysed (see Table 7). A rise in oxygen content was found in tanks B and C which was considered to be due to the steadily decreasing demands on it. There was also a slight rise in *p*H, but this was not considered to have played any part in the death of the Lamellibranchia. It was found impossible to maintain the quantity of silt in suspension at any definite amount expressed in grams per litre, owing to the high rate at which the Lamellibranchia immobilised the suspended matter with mucus. Excess over normal amounts was therefore used in each case, and the amount remaining in suspension at the end of the experiment was estimated.

TABLE 7.—ANALYSIS OF AQUARIUM WATER ON COMPLETION OF EXPERIMENT.

	Tank A.	*Tank B.*	*Tank C.*
Oxygen tension expressed in % saturation	78·4	98·7	99·4
Salinity	31·07°/₀₀	31·07°/₀₀	31·26°/₀₀
Temperature	16·8° C.	16·1° C.	16·1° C.
*p*H	7·8	8·1	8·1
Turbidity	0·44 g.p.l.	1·20 g.p.l.	1·52 g.p.l.

The experiment was repeated four times, and it was found on each occasion that the Lamellibranchia in tank A lived whilst those in tanks B and C died.

7.—DISCUSSION

The object of the ecological survey was to ascertain the difference between the faunas of Royal Beach and Portishead dock, and, if possible, to determine which chemical or physical factors are responsible for these differences.

The differences between the two faunas may be classified as follows :—

1. Animals present on Royal Beach, and absent in the dock.

Dynamina pumila.
Obelia dichotoma.
Sertularia argentea.
Tubularia indivisa.
Amphitrite johnstoni.
Eteone flava.
Eunoe nodosa.
Nephthys hombergi.
Nereis virens.
Sabellaria alveolata.
Terebella lapidaria.
Corophium volutator.
Gammarus marinus.
Hyale nillsoni.
Orchestia gamarella.
Talitrus saltator.
Jæra marina
Geophilus longicornis.
Nymphon gracile.
Bowerbankia imbricata.
Membranipora hexagonia.
,, *monostachys.*
Ligia oceanica.
Porcellio scaber.
Sphæroma serratum.
Crangon vulgaris.
Eupagurus bernhardus.
Pandalus annulicornis.
Collembola sp.
Lipura maritima.
Petrobius maritimus.
Staphylinid.
Gerris sp.
Bibionid.
Dipterous fly.
Gamasellus inermis.
Rhyncholopus tardus.
,, *norvegicus.*
Littorina littoralis.
Patella vulgata.
Onchidoris muricata.
Lepidochiton cinereus.
Clupea sprattus.
Gadus merlangus.

2. Animals collected in the dock, but not on the beach.

(*a*) In which there is insufficient evidence for stating that they do not occur on the beach.

Palæmonetes varians.
Praunus flexuosus.
Gasterosteus aculeatus.

(*b*) Those which have not successfully colonised the beach.

(1) Of which casual specimens were collected on the beach.

Macoma balthica - -	3 spat on the beach.
Mytilus edulis - -	1 spat on the beach.
Limnoria lignorum -	On driftwood on the beach.

Balanus improvisus - Small specimens cover the stones near L.T.M. on the beach.

(2) Of which no specimens were collected on the beach.

Gonothyræa loveni.
Aurelia aurita.
Corophium acherusicum.
,, *insidiosum.*
Lepralia pallasiana.
Mercierella enigmatica.
Cardium edule.
Lutraria lutraria.
Mya arenaria.
Botryllus schlosseri.
Molgula citrina.

The only factors of any apparent significance in which difference between the two localities were detected, are :—

(1) *Wave action*

May play a subsidiary part in the exclusion of delicate species from the beach. No work has been done on this subject.

(2) *Turbidity*

The experiments carried out in the laboratory upon five species of Lamellibranchia suggest that these ciliary feeding species are unable to live in water of high turbidity. It is probable that the same holds good for other ciliary feeders, such as *Aurelia aurita* (which feeds partially by means of cilia, especially in the ephyræ (Gemmill, 1921 ; Orton, 1922)) and the two species of Ascidia. Thus the high turbidity of the sea water limits these species to the dock.

Macoma balthica is probably a species especially adapted for life in muddy water. Kellogg (1915) has shown that in *M. secta* the gut frequently contains large amounts of bottom material. The shells of *M. balthica* together with those of *Tellina tenuis* were found in abundance on many beaches in the vicinity of Portishead, indicating that it tolerates the muddy water of the Severn in some places, although it does not colonise the mud on Portishead beach. In the laboratory experiments it was shown that *Macoma balthica* could not tolerate turbidity of a similar degree to that occurring on Portishead beach ; probably the turbidity of the water is less on the beaches higher up the estuary, e.g., at Berkeley and Severn Beach, which are less subject to wave action owing to greater protection from the wind than at Portishead, and therefore the turbidity would be lower in these localities.

The limitation of certain species to the dock cannot be ascribed to the turbidity, and upon these no experiments have been undertaken. The serpulid, *Mercierella enigmatica*, was probably introduced into the dock upon the ship. In all probability *Lepralia pallasiana*, which was chiefly found on the tubes of the serpulid, was introduced in a similar way. The presence of the two species of *Corophium* in the dock is possibly associated with the presence of certain algæ on floating objects in the dock which are absent on the beach. *Corophium volutator* is tolerant of the turbidity of the sea water, and it is unlikely that the other two species of *Corophium* would be intolerant of it.

It is more difficult to account for the limitation of *Limnoria lignorum* to the dock. Infection of new wood is, however, by way of the adult, and this would be less likely to occur in the rough waters of the Bristol Channel than in the calm water of the dock, which may explain why the woodwork on the beach has not been infected with *L. lignorum*.

Balanus improvisus was found to have colonised the beach on some recent occasion, small specimens being found there in 1936. In the dock, however, a small number of large specimens in a healthy condition were found on *Mytilus edulis*. It is not possible to draw any conclusions at present on the conditions which must have existed to enable this species to have colonised the beach only recently, unless, of course, young individuals are tolerant of conditions which are unfavourable to the larger ones. It is possible, however, that some of these species are unable to live under conditions of high turbidity.

Certain groups of animals and species are notable by their absence from both beach and dock. These are probably excluded by the low salinity or by the great variations in this. Thus Echinodermata and Porifera are entirely absent and so are *Nucella* (*Purpura*) *lapillus*, *Buccinum undatum* and *Cancer pagurus*, which are present on beaches further down the estuary, for instance at Brean Down. *Actinia equina* was abundant at Portishead in 1923 (Matthews), but is now apparently absent. *Petrobius maritimus*, which is abundant on Steepholm, is very rare on Portishead beach, which is the limit of its range up the Bristol Channel.

8.—SUMMARY

1. An ecological survey of the Royal Beach and the Dock at Portishead was carried out during the latter part of 1936 and early 1937, and a full list of species made.
2. Sea water at Portishead is much more heavily laden with silt

than is the dock water; the only other detected difference between the conditions in the two areas was the wave action on Royal Beach.

3. A number of Lamellibranchia present only in the dock were placed in sea water of high turbidity under laboratory conditions, and it was found that they were unable to withstand these conditions.
4. It was concluded that these Lamellibranchia and other ciliary feeders are prevented from colonising the beach by the high turbidity of the sea water; in addition, wave action may be responsible for the absence of other species from the beach.
5. Other species present only in the dock are:—*Aurelia aurita, Corophium acherusicum, C. insidiosum, Lepralia pallasiana, Mercierella enigmatica, Limnoria lignorum* and *Balanus improvisus.* (Only small specimens of the latter were found on the beach.)
6. Echinodermata, Porifera and such usually common species as *Nucella lapillus, Buccinum undatum* and *Cancer pagurus* are absent from both the beach and the dock, due, it is considered, to the low salinity or to the great variations in this.

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10.—FAUNA LIST

The nomenclature adopted is, wherever possible, that of the *Plymouth Marine Fauna* (2nd edition). Species not included in this were named in accordance with the nomenclature given in the various works cited in the list of references.

PHYLUM CŒLENTERATA.

(a) *Hydrozoa.*

Abietinaria abietina. Dead unattached specimens on Royal Beach.

Dynamæna pumila. A few specimens on Battery Point, attached to stones.

Hydrallmania falcata. One dead unattached specimen stranded on Royal Beach.

Obelia dichotoma. Small specimens on rock fragments just above L.T.M. of neap tides.

Gonothyræa loveni. Quite common on mooring ropes in the dock, some distance below the surface.

Sertularia operculata. A large dead mass of this in the detritus at H.T.M. on Royal Beach.

Tubularia indivisa. Large colonies in rock pools, and on the sides of boulders in zone 3 on the Royal Beach. More frequent between the culverts and the Pier than on Battery Point.

(b) *Scyphozoa.*

Aurelia aurita. Adult specimens abundant in the dock during August and early September.

(c) *Anthozoa.*

Actinia equina. Common on Royal Beach in 1923 ; only one specimen, about 3 mm. in diameter, in 1936-7.

Tealia felina. Common on Royal Beach in zone 3. Also found on empty cockle shells in the dock.

PHYLUM NEMERTINI.

Lineus spp. Occasionally found on Royal Beach, below stones.

PHYLUM ANNELIDA.

(a) *Polychæta.*

Amphitrite johnstoni. Common under stones below L.T.M. of neap tides at the seaward end of traverse 4.

Eunoë nodosa. A few specimens among colonies of *Tubularia indivisa* on Royal Beach.

Eteone flava. One specimen in a tube of *Terebella lapidaria* on Royal Beach.

Lepidonotus squamatus. On the under surfaces of stones in zone 3 on Royal Beach.

Mercierella enigmatica. Growing profusely on the sides of an old metal ship in the dock. Probably introduced on the ship as it was not found in such profusion elsewhere in the dock.

Nephthys hombergi. Common on Royal Beach in mud.

Nereis diversicolor. Common on Royal Beach, and in the dock, in mud.

Nereis virens. Common below stones in zone 3 on Royal Beach.

Pygospio elegans. On the surface of mud on Royal Beach in *Sabellaria* tubes, and in the dock on *Obelia flabellata.*

Sabellaria alveolata. Tubes common near L.T.M. of spring tides on Royal Beach. No animals found.

Terebella lapidaria. In tubes made of small stones, near L.T.M. of spring tides on traverse 4.

(*b*) *Oligochæta.*

Two unidentified specimens found on Royal Beach, one under stones at H.T. mark, and one in mud near H.T.M. of neap tides.

PHYLUM ARTHROPODA.

CLASS CRUSTACEA.

(a) *Cirripedia.*

Balanus improvisus. Small specimens abundant in zone 3 on Royal Beach. Large specimens obtained in the dock.

(b) *Isopoda.*

Eurydice pulchra. Collected on Royal Beach swimming at the water's edge, also in the dock.

Idotea baltica. Both on Royal Beach and in the dock.

Idotea viridis. Common on Royal Beach and in the dock.

Jæra marina. Occasional specimens below stones on Battery Point, near L.T.M. One large colony on the under surface of a boulder near H.T.M. of traverse 2.

Ligia oceanica. Common among shingle, and on bare rock surfaces, on Royal Beach. Only small specimens on the bare rocks, these often possessing a temporary roseate colour.

Porcellio scaber. Common above H.T.M. of spring tides in crevices in the rocks on the Royal Beach.

Sphæroma serratum. Common under stones below about Mean Sea Level on Royal Beach.

(c) *Amphipoda.*

Corophium acherusicum. Common on weeds in the dock.

Corophium insidiosum. Common on weeds in the dock.

Corophium volutator. Occasionally in burrows in mud on Royal Beach and in the inlet to the dock.

Gammarellus homari. Both in the dock and on Royal Beach.

Gammarus marinus. Common on Royal Beach.

Hyale nilssoni. On Royal Beach in empty tubes of *Sabellaria.*

Orchestia gammarella. Common on Royal Beach.

Talitrus saltator. Common on Royal Beach above H.T.M. of neap tides and especially in H.T.M. detritus.

(d) *Mysidacea.*

Praunus flexuosus. Obtained when scraping wooden structure in the dock.

(e) *Decapoda.*

Carcinus mænas. Common on all regions of Royal Beach, one specimen dredged in the dock.

Crangon vulgaris. Occasionally stranded on Royal Beach.

Eupagurus bernhardus. Two specimens in zone 3 on Royal Beach.

Palæmonetes varians. A number obtained in the dock when scraping wooden structures.

Pandalus annulicornis. Occasionally stranded on Royal Beach.

CLASS INSECTA.

(a) *Apterygota.*

Collembola sp. Green in colour, in a crack in the mud on Royal Beach; only one colony found.

Lipura maritima. Abundant on Royal Beach, above H.T.M. of neap tides on stones or mud.

Petrobius maritimus. A few small specimens in crevices in the rocks above H.T.M. of spring tides on Royal Beach.

(*b*) *Pterygota.*

Bibionid pupa. One specimen from mud on Royal Beach.

Cheironomid pupæ. Many specimens from mud on Royal Beach.

Cheironomid larvæ. Many specimens among weeds in the dock.

Dipterous larvæ and adults (*Cœlopa frigida* ?) in H.T.M. detritus on Royal Beach.

Gerris sp. One specimen was found in a pool near H.T.M. of spring tides.

Staphylinid larvæ and adults in H.T.M. detritus, and on mud on Royal Beach.

CLASS ARACHNIDA.

(a) *Acarina.*

Gamasellus inermis. Occasional near and above H.T.M. on Royal Beach.

Rhyncholopus norvegicus. Occasional on mud and stones on Royal Beach.

Rhyncholopus tardus. Occasional under stones on Royal Beach.

(b) *Pycnogonida.*

Nymphon gracile. Exposed in abundance in zone 3 on Royal Beach during low spring tides.

CLASS CHILOPODA.

Geophilus longicornis. Occasionally found in gravel under large stones, near H.T.M. on Royal Beach.

PHYLUM BRYOZOA.

Bowerbankia imbricata. Abundant on overhanging ledges near L.T.M. on Royal Beach.

Lepralia pallasiana. Encrusting the serpulid tubes on old iron ship in the dock.

Membranipora hexagonia. Small colonies on algæ and occasionally on stones on Royal Beach.

Membranipora monostachys. Abundant on Battery Pt., also between the culverts and the Pier, on stones in zone 3.

PHYLUM MOLLUSCA.

(a) *Placophora.*

Lepidochiton cinereus. Abundant below about Mean Sea level on Royal Beach.

(b) *Gastropoda.*

Hydrobia ulvæ. Occasional specimens in mud on Royal Beach and in the dock.

Littorina littoralis. Abundant on *Ascophyllum nodosum* on Royal Beach.

Littorina rudis. Abundant among stones and on rocks on Royal Beach, also in the dock in the *Mya arenaria* association.

Patella vulgata. Frequent on Royal Beach below about Mean Sea Level.

(c) *Lamellibranchia.*

Cardium edule var. *rusticum.* Dominant species in the soft mud in the dock, always submerged.

Lutraria lutraria. Occasional small specimens both in the *Cardium* and the *Mya* associations in the dock.

Macoma balthica. Abundant in the *Cardium* association in the dock, also in the inlet to the dock. Three spat were found at the surface of the mud on Royal Beach.

Mya arenaria. Abundant on the south and south-east sides of the dock.

Mytilus edulis. Abundant on the dock walls and wharves, one small specimen at L.T.M. on Royal Beach.

PHYLUM CHORDATA.

(a) *Tunicata.*

Botryllus schlosseri. Abundant on any submerged objects in the dock.

Molgula citrina. Frequent on submerged objects in the dock.

(b) *Pisces.*

Anguilla vulgaris. Abundant beneath stones on Royal Beach and also in the dock.

Clupea sprattus. One specimen stranded alive on Royal Beach.

Gadus merlangus. One specimen stranded, dead, on Royal Beach.

Gasterosteus aculeatus. One specimen in the dock.

Bird-Life on Barrow Gurney Reservoirs

By H. Tetley, B.Sc., F.Z.S.

CONTENTS

I.—INTRODUCTORY

OBSERVATIONS on the bird-life at these reservoirs have been carried out over a number of years beginning with 1923, and latterly much more fully owing to the greater number of observers. There are only a few notes available prior to the date mentioned, and these are taken from the Rev. F. L. Blathwayt's account of Birds in the *Victoria County History of Somerset*, published in 1902. Many notes are included in the Annual Reports of the Ornithological Section of the Somerset Archæological and Natural History Society, and a useful summary was given by Mr. A. C. Leach in the *Proceedings of the Bristol Naturalists' Society*, 4th series, Vol. VII, pp. 463-9, 1933 (1934). Since then, however, there have been no less than eleven additions to the list of species, as well as one or two quite unusual seasons, and it seems worth while not only to comment on all these, but to review all the knowledge up to the present, so as to try to give a complete picture as far as present information goes.

Sixty-three species have now been recorded from the reservoirs, as given in the following account, and of these only seven (Mallard, Tufted Duck, Great Crested Grebe, Little Grebe, Herring Gull, Coot and, on the old reservoir, Moorhen) can be called " Residents " and then only if the term is used to imply that some of these birds are present in every month of the year, for there is no adequate cover for nesting birds, and only Mallard, Great Crested Grebe, Coot and Moorhen have been recorded as breeding, and then irregularly and not always successfully.

The population is unstable and always changing, and this may be recorded by the variation in the number of species seen in each month of the year as follows :—January, 20 ; February, 25 ; March, 26 ; April, 23 ; May, 14 ; June, 7 ; July, 14 ; August, 24 ; September, 41 ; October, 28 ; November, 24 ; and December, 22. If one excludes the

seven residents mentioned, these figures would show the following results: 13, 18, 19, 16, 7, 0, 7, 17, 34, 21, 17, 15, which indicates what a great preponderance there is in September, a subject that will be noticed later.

The reservoirs are numbered, in the order of construction, 1, 2 and 3, and this incidentally expresses their size if No. 3 is regarded as the largest. They are all different, and it may be due to these differences that so many species have been attracted to these waters. No. 3 is by itself on the north side of the main road and has a large expanse of water, unsheltered in any way; even in the driest season there is very little mud, as the whole reservoir has been artificially constructed with blocks of stone right out to the middle. It is not, therefore, an attractive place for waders, though one or two interesting ones have been seen, at a time, however, when the other reservoirs were in an ideal condition for such visitors. On the other hand, it is suitable for birds which demand plenty of space, and it is on this reservoir only that the following species have been recorded, viz.:—Pintail, Goosander, Red-breasted Merganser, Smew, Great Northern Diver and Red-throated Diver.

No. 2 usually holds a good population of birds. The eastern border is often shallow and then provides excellent feeding-ground for Mallard and especially for Wigeon and Teal, many of which may be seen on the water or resting on the banks. It was here that 1,000 Teal were counted on December 15th, 1935. It is also suitable for waders if the water is sufficiently low, as there is a fair amount of mud about.

No. 1 is essentially a wader's reservoir for, under suitable conditions, there is a large expanse of mud which is very attractive to these birds. If the water is low and mud exposed in September, which unfortunately (from the ornithological standpoint) is not always the case, one may reasonably expect to see some interesting waders. The large number of 41 species seen at the reservoirs in September is mainly due to waders; 16 have been recorded in this month and of these 7 (Ruff, Sanderling, Knot, Curlew-Sandpiper, Little Stint, Spotted Redshank, Black-tailed Godwit) in September only, while 3 more (Ringed Plover, American Pectoral Sandpiper, Greenshank) only in September and early October. Some of the most interesting of these, e.g., American Pectoral Sandpiper, Knot, Black-tailed Godwit, have been recorded from No. 1 only, while another two (Spotted Redshank and Little Stint) have occurred on the adjoining No. 2. Lapwing occur in huge flocks at No. 1 or No. 2 in the late Summer and Autumn. When flooded, No. 1 does not usually

hold many birds; there are some Tufted Ducks, Grebes and Coots, often some Pochard, and Goldeneye and the drake Scaup have been seen there, but on many occasions very few birds are present. It is the lowest and most sheltered of the three reservoirs, the bottom of it being considerably below the level of No. 2 and also of the main road.

The condition of the reservoirs is important, and had No. 1 always been full during the Autumn migration some valuable records might have been lost. But even allowing for this, September is undoubtedly the best month in which to see a variety of birds. During that time the great Autumn migration is in progress, and old and young of birds that have bred farther north are passing through. It is undoubtedly a more leisurely and wide-spread movement than the Spring migration, and the figures at Barrow tell their own tale; only 23 species are recorded for April and 14 for May against 41 for September. Of the waders recorded for the latter month only three (Lapwing, Dunlin and Curlew) have occurred in the Spring, and there is only one record of Terns in Spring, when 4 Black Terns were seen in May, 1936.

Seasons naturally vary, and certain years may be noteworthy for special events. On the Autumn migration of 1923, 8 Ringed Plover, 4 Ruff and 8 Curlew-Sandpipers were seen; in 1933, when the reservoirs were abnormally dry, a Spotted Redshank, 6 Greenshanks, and 2 or more Black-tailed Godwits; in 1935 a Ruff, Knot and American Pectoral Sandpiper with, curiously enough, a complete absence of Greenshank; several of these are the only records for the reservoirs. The Winter of 1935-36 will always be remembered for the sudden and enormous increase in the number of duck; from very much smaller numbers Mallard went up to 300, Teal to 1,000, Wigeon to 250, Shoveler to 65-70, Pochard to 1,200. On one day (28th December, 1935) there were well over 2,000 duck on the reservoirs, apart from other birds not counted, and this represents so far the maximum population on any one occasion.

The list of birds recorded month by month together with the systematic list will serve to give an idea of the fluctuations of bird-life on the reservoirs. Numbers are given only in the case of birds which may occur in large flocks and for which there are plenty of figures available. Further details of these and particulars of the others are given in the systematic portion.

A few details may be given on the old reservoir which lies on the south side of the road opposite No. 1 and is separated from No. 3 by

another road. This has, at the south end, a small pool of water with plenty of mud, a grove of willow trees, a swampy, reedy part going up to the road, and above it on either side much drier ground. Moorhens are always present here and Teal very often, while a few Mallard, Wigeon and Shoveler have also been recorded. The swampy parts favour some waders, and, at suitable times of year, Snipe, Jack Snipe and Green Sandpipers have been seen there. In the descriptions that follow, the remarks only apply to the main reservoirs and not to the old one unless this is specially stated. Observations are included up to the end of 1937.

II.—THE RESERVOIRS MONTH BY MONTH

January

Mallard	to 200
Teal	to 70
Wigeon	to 200
Shoveler	to 25
Pochard	to 509
Tufted Duck	to 82
Scaup	
Goldeneye	to 7
Smew	to 7
Great Crested Grebe	to 13
Slavonian Grebe	
Black-necked Grebe	
Little Grebe	1 or 2
Great Northern Diver	
Lapwing	
Dunlin	
Common Snipe	
Black-headed Gull	
Common Gull	
Herring Gull	
Great Black-backed Gull	
Coot	to 200

February

Sheld-duck	
Mallard	to 100
Teal	to 50
Wigeon	to 140
Pintail	
Shoveler	to 27
Pochard	to 295
Tufted Duck	to 60
Scaup	
Goldeneye	to 4
Goosander	
Smew	
Great Crested Grebe	to 6
Slavonian Grebe	
Red-necked Grebe	
Black-necked Grebe	
Little Grebe	as January
Oystercatcher	
Lapwing	
Green Sandpiper	
Curlew	
Common Snipe	
Jack Snipe	
Gulls	as January
Lesser Black-backed Gull	to 1
Coot	to 34

March

Mallard	to 70
Teal	to 30–40
Wigeon	to 93
Pintail	
Shoveler	to 12
Pochard	to 243
Tufted Duck	to 47
Scaup	
Goldeneye	to 6
Goosander	
Great Crested Grebe	to 12
Slavonian Grebe	
Black-necked Grebe	
Little Grebe	as January
Lapwing	

Green Sandpiper	
Curlew	
Common Snipe	
Jack Snipe	
Black-headed Gull	
Common Gull	
Herring Gull	
Lesser Black-backed Gull	to 45
Iceland Gull	
Coot	to 20

April

Mallard	to 18
Teal	to 20
Wigeon	to 4
Shoveler	
Pochard	to 1
Tufted Duck	to 31
Scaup	
Goldeneye	to 9
Common Scoter	
Red-breasted Merganser	
Great Crested Grebe	to 20
Slavonian Grebe	
Black-necked Grebe	
Little Grebe	as January
Lapwing	
Dunlin	
Common Sandpiper	
Curlew	
Gulls	as March
Lesser Black-backed Gull	to 34
Coot	to 12

May

Mallard	to 14 : breeding
Teal	
Pochard	to 3
Tufted Duck	to 30–40
Scaup	
Goldeneye	to 2
Great Crested Grebe	to 40
Black-necked Grebe	
Little Grebe	as January
Dunlin	
Common Sandpiper	
Black Tern	
Herring Gull	
Lesser Black-backed Gull	to 70
Coot	to 2

June

Sheld-duck	
Mallard	to 11 : breeding
Teal	
Tufted Duck	
Goldeneye	
Great Crested Grebe	to 41
Little Grebe	
Herring Gull	
Coot	

July

Heron	
Mallard	to 48
Pochard	to 15
Tufted Duck	to 67
Great Crested Grebe	to 44
Black-necked Grebe	
Little Grebe	to 15
Lapwing	to 600–700
Common Sandpiper	
Gulls	as March
Lesser Black-backed Gull	to 60
Coot	to 70

August

Heron	
Mallard	to 45
Gadwall	
Pochard	to 52
Tufted Duck	to 160
Scaup	
Great Crested Grebe	to 54
Black-necked Grebe	
Little Grebe	to 15
Lapwing	
Turnstone	
Common Sandpiper	
Green Sandpiper	
Redshank	
Greenshank	
Curlew	
Common Snipe	
Gulls	as March
British Lesser Black-backed Gull	to 80
Scandinavian Lesser Black-backed Gull	
Kittiwake	
Coot	to 117

September

Heron	
Mallard	to 47
Gadwall	
Teal	to 105
Wigeon	to 36
Pintail	
Shoveler	
Pochard	to 260
Tufted Duck	to 55
Goldeneye	
Common Scoter	
Cormorant	
Great Crested Grebe	to 54
Slavonian Grebe	
Black-necked Grebe	
Little Grebe	to 30
Ringed Plover	
Golden Plover	
Lapwing	to 1,000
Ruff	
Sanderling	
Knot	
Dunlin	
Curlew-Sandpiper	
Little Stint	
American Pectoral Sandpiper	
Common Sandpiper	
Green Sandpiper	
Spotted Redshank	
Greenshank	
Grey Phalarope (?)	
Black-tailed Godwit	
Curlew	
Common Snipe	
Black Tern	
Common (? Arctic) Tern	
Gulls	as January
Lesser Black-backed Gull	to 40
Coot	to 330

October

Heron	
Mallard	to 150
Gadwall	
Teal	to 300
Wigeon	to 29
Shoveler	
Pochard	to 340
Tufted Duck	to 68
Scaup	
Goldeneye	
Cormorant	
Great Crested Grebe	to 26
Black-necked Grebe	
Little Grebe	to 27
Ringed Plover	
Lapwing	
Dunlin	
American Pectoral Sandpiper	
Common Sandpiper	
Green Sandpiper	
Greenshank	
Grey Phalarope	
Curlew	
Common Snipe	
Gulls	as March
Lesser Black-backed Gull	to 6
Coot	to 170

November

Heron	
Mallard	to 150
Teal	to 140
Wigeon	to 30–50
Pochard	to 300
Ferruginous Duck	
Tufted Duck	to 220
Scaup	
Goldeneye	
Eider	
Great Crested Grebe	to 20
Black-necked Grebe	to 8
Little Grebe	
Golden Plover	
Lapwing	
Green Sandpiper	
Redshank	
Curlew	
Common Snipe	
Gulls	as January
Lesser Black-backed Gull	to 2
Coot	to 87

December

Mallard	to 300
Gadwall	
Teal	to 1,000
Wigeon	to 250
Shoveler	to 65–70

Pochard	to 1,200	Black-necked Grebe	
Tufted Duck	to 130	Little Grebe	1 or 2
Scaup		Great Northern Diver	
Goldeneye		Red-throated Diver	
Common Scoter		Curlew	
Goosander		Gulls	as January
Smew		Iceland Gull	
Great Crested Grebe	to 12	Coot	to 30

III.—SYSTEMATIC LIST

1. British Dipper - - - - *Cinclus cinclus gularis* (Lath.)
2. Kingfisher - - - - - *Alcedo atthis ispida* Linn.
3. Heron - - - - - *Ardea c. cinerea* Linn.
4. Sheld-duck - - - - *Tadorna tadorna* (Linn.)
5. Mallard - - - - - *Anas p. platyrhyncha* Linn.
6. Gadwall - - - - - *Anas strepera* Linn.
7. Teal - - - - - - *Anas c. crecca* Linn.
8. Wigeon - - - - - *Anas penelope* Linn.
9. Pintail - - - - - *Anas acuta acuta* Linn.
10. Shoveler - - - - - *Spatula clypeata* (Linn.)
11. Pochard - - - - - *Nyroca f. ferina* (Linn.)
12. Ferruginous Duck - - - *Nyroca n. nyroca* (Güld.)
13. Tufted Duck - - - - *Nyroca fuligula* (Linn.)
14. Scaup - - - - - *Nyroca m. marila* (Linn.)
15. Goldeneye - - - - - *Bucephala c. clangula* (Linn.)
16. Eider - - - - - - *Somateria m. mollissima* (Linn.)
17. Common Scoter - - - *Oidemia n. nigra* (Linn.)
18. Goosander - - - - - *Mergus merganser merganser* Linn.
19. Red-breasted Merganser - - *Mergus serrator* Linn.
20. Smew - - - - - - *Mergus albellus* Linn.
21. Cormorant - - - - *Phalacrocorax c. carbo* (Linn.)
22. Great Crested Grebe - - *Podiceps c. cristatus* (Linn.)
23. Slavonian Grebe - - - *Podiceps auritus* (Linn.)
24. Red-necked Grebe - - - *Podiceps g. griseigena* (Bodd.)
25. Black-necked Grebe - - *Podiceps n. nigricollis* Brehm.
26. Little Grebe - - - - *Podiceps r. ruficollis* (Pall.)
27. Great Northern Diver - - *Colymbus i. immer* Brünn.
28. Red-throated Diver - - *Colymbus stellatus* Pont.
29. Oystercatcher - - - - *Hæmatopus ostralegus occidentalis* Neum.
30. Ringed Plover - - - *Charadrius h. hiaticula* Linn.
31. Golden Plover - - - - *Pluvialis apricarius* (Linn.)
32. Lapwing - - - - - *Vanellus vanellus* (Linn.)
33. Turnstone - - - - - *Arenaria i. interpres* (Linn.)
34. Ruff - - - - - - *Philomachus pugnax* (Linn.)
35. Sanderling - - - - - *Crocethia alba* (Pall.)
36. Knot - - - - - - *Calidris canutus canutus* (Linn.)
37. Dunlin - - - - - *Erolia alpina* (Linn.)

38. Curlew-Sandpiper - - -	*Erolia testacea* (Pall.)
39. Little Stint - - - -	*Erolia minuta* (Leisl.)
40. American Pectoral Sandpiper	*Erolia melanotos* (Vieill.)
41. Common Sandpiper - -	*Tringa hypoleucos* Linn.
42. Green Sandpiper - - -	*Tringa ochropus* Linn.
43. Redshank - - - - -	*Tringa totanus* (Linn.)
44. Spotted Redshank - - -	*Tringa erythropus* (Pall.)
45. Greenshank - - - -	*Tringa nebularia* (Günn.)
46. Grey Phalarope - - -	*Phalaropus fulicarius* (Linn.)
47. Black-tailed Godwit - -	*Limosa l. limosa* (Linn.)
48. Curlew - - - - -	*Numenius a. arquata* (Linn.)
49. Common Snipe - - -	*Capella g. gallinago* (Linn.)
50. Jack Snipe - - - -	*Lymnocryptes minimus* (Brünn.)
51. Black Tern - - - -	*Chlidonias n. niger* (Linn.)
52. Common (? Arctic) Tern -	*Sterna h. hirundo* Linn. (? *macrura* Naum.)
53. Black-headed Gull - - -	*Larus r. ridibundus* Linn.
54. Common Gull - - - -	*Larus c. canus* Linn.
55. Herring Gull - - - -	*Larus a. argentatus* Pont.
56. Scandinavian Lesser Black-backed Gull - - -	*Larus f. fuscus* Linn.
57. British Lesser Black-backed Gull - - - - -	*Larus fuscus grællsii* Brehm.
58. Great Black-backed Gull -	*Larus marinus* Linn.
59. Iceland Gull - - - -	*Larus leucopterus* Vieill.
60. Kittiwake - - - - -	*Rissa t. tridactyla* (Linn.)
61. Water Rail - - - -	*Rallus a. aquaticus* Linn.
62. Moorhen - - - - -	*Gallinula ch. chloropus* (Linn.)
63. Coot - - - - - -	*Fulica a. atra* Linn.

Note.—In the case of the Golden Plover (31), Dunlin (37) and Redshank (43) binomials only are used as it is impossible to say to which sub-species the birds belonged. It is presumed that the Oystercatcher (29) and Common Snipe (49) belonged to the sub-species given.

NOTES

1. Dipper. One was seen in 1921.
2. Kingfisher. A Kingfisher is seen occasionally, particularly where the water comes in at the head of No. 1 reservoir.
3. Heron. Herons are recorded from July to November, the extreme dates being 17th July (1935) and 20th November (1932). The largest number is 5 on 17th July, 1935, and 8th August, 1937, the former representing 4 immatures and 1 adult, and the latter 5 adults.
4. Sheld-duck. The only records are of one seen on 2nd February, 1936, and of one flying round on 1st June, 1937.

5. Mallard. During the last three years (1934-1936) there has been a considerable increase of Mallard visiting the reservoirs; up to that time 48 was the largest number recorded, but since then these have increased up to 100, 150, and 300, the last being in the "record" month of December, 1935, when such a great number of duck visited the reservoirs, over 200 in all occurring on the 28th of that month. No definite breeding was recorded until 1934, when 3 broods were seen on 29th May. The largest numbers for each month are as follows: January, 200; February, 100; March, 70; April, 18; May, 14; June, 11; July, 48; August, 80; September, 47; October, 150; November, 150; December, 300. For each season they are: 1933-34, 70; 1934-35, 200; 1935-36, 300; 1936-37, 85.

6. Gadwall. A drake was seen from 22nd August to 10th October, and again in December, all 1937.

7. Teal. The Teal now seems well-established as a regular visitor to the reservoirs, often up to as many as 60 and occasionally very many more, the largest recorded being the remarkable number of 1,000 on 15th December, 1935, and the next the 400 on the 28th of that month. From September to the beginning of April are the months when they are present, though odd birds have been seen on single occasions in May and June, but none so far in July and August. The largest numbers recorded for each month are as follows: January, 70; February, 50; March, 30-40; April, 20; September, 105; October, 300; November, 140; December, 1,000, these last four all occurring in 1935; and for each season: 1931-32, 30-40; 1932-33, 70; 1933-34, 61; 1934-35, 50; 1935-36, 1,000; 1936-37, 62.

8. Wigeon. Up to the years 1923-26, Wigeon had only been recorded in small numbers, but in the Winter of 1927-28 a flock up to 50 visited the reservoirs, and this number has been kept up in all subsequent Winters and culminated in the record number of 250 on 28th December, 1935. They appear in September, the earliest being one on 8th September, 1926, and remain mainly until the third week in March, though there is one record of 4 on 7th April, 1936. There are no records from May to August inclusive. The largest numbers recorded for each month are as follows: January, 200; February, 140; March, 93; April, 4; September, 36; October, 29; November, 30-50; December, 250. For the various seasons it has been:

1925-6, few; 1927-28, 50; 1928-29, 50; 1929-30, 93; 1930-31, 37; 1931-32, 50; 1932-33, 100; 1933-34, 50; 1934-35, 140; 1935-36, 250.

9. PINTAIL. The only records are of a pair on 25th March, 1928, and also 25th February, 1934, and of 3 (immature or female) on 19th and 26th September, 1937.

10. SHOVELER. The Shoveler seems to be an occasional visitor, though further observations may show it to be more regular than present records suggest. With the notable exception of 1935-36 there have never been any large numbers, the greatest being 8 recorded on three occasions, once in January and twice in March. Details of 1935-36 are as follows: 29th September, 1; 15th December, 65-70; 28th December, 65; 13th January, 25; 2nd February, 27; 16th February, 12; 1st March, 12; 8th March, 8. They are present from September to April, the range being 8th September to 23rd April; so far there is no record for November.

11. POCHARD. Pochard, though recorded in every month of the year except June are, considering the large numbers in which they occur, quite the most erratic duck visiting the reservoirs. It seems evident, from a number of observations, that they move about in a large flock, and that though they may be very numerous one day, they may be completely absent the next. Some observations made in 1931 may be given to support this: 20th September, 52; 27th September, 260; 3rd October, 340; 11th October, 289; 24th October, none; 30th October, 2; 10th November, over 300; 22nd November, 17. It is to be presumed that they move between Barrow and Blagdon, but so far there is no direct observation to support this. Another point of particular interest is that in any large flock there is almost always a large preponderance of males, in some cases as much as 9 to 1 female. The largest number recorded is 1,200 on 28th December, 1935, and for each month it is as follows: January, 509; February, 295; March, 243; April, 1; May, 3; July, 15; August, 52; September, 260; October, 340; November, 300; December, 1,200. It will thus be seen that the large flocks are present from September to March; they are largely gone by the third week in March and begin to come in again at the end of July.

12. Ferruginous Duck. A probable male of this species was seen on 26th November, 1923.

13. Tufted Duck. Tufted Ducks are almost always present on the reservoirs and often in some numbers. They have actually been recorded in every month of the year, though so far there is only one record, and that of a single bird, for June. The largest numbers per month are as follows: January, 82; February, 60; March, 47; April, 31; May, 30-40; June, 1; July, 67; August, 160; September, 55; October, 68; November, 220; December, 130. More observations are needed, particularly for the Summer months; there are only four for May, one given above and the other three each of 2 birds, and one for June. From present details it seems that the Tufted Duck begins to arrive in numbers in early July, 46 being seen on 12th July, 1934, and as many as 67 occurring on 31st July, 1937. This would suggest a marked movement of birds immediately the breeding season is over, a movement which is continued to the middle of August, when as many as 160 were counted on 15th August, 1936. From September to the end of March the numbers vary from about 12 to 80, though on two occasions the latter figure was exceeded, 220 being recorded on 4th November, 1935, and 130 in December, 1927. In April the numbers drop, and still more so in May and June. The duck does not nest on the reservoirs and, in view of the lack of suitable cover, is not likely to do so.

14. Scaup. Up to the autumn of 1931 there were only two records of Scaup, that of one on 5th January, 1926, and of 4 (the highest number up to the present) on 19th January of the same year. The first of these was a female, and a female was again recorded from October to December, 1931. Omitting the 4 mentioned above, for which the sexes have not been given, all others have been adult males, and only on two occasions (20th November and 24th November, 1932), when two were present, has there been more than one. Assuming it to be the same bird, it has been reported as follows: 1932-33, 13th October, 1932, to 13th April, 1933; 1933-34, 9th December, 1933, to 10th May, 1934; 1934-35, 16th January to 23rd April, 1935; 1935-36, 15th December, 1935, to 28th April, 1936; 1936-37, 15th August, 1936, and 14th February, 1937.

15. Goldeneye. With the exception of 1928-29 and 1929-30,

Goldeneye have been recorded in every season from 1923-24 onwards. They are never in large numbers, 9 on 3rd April, 1926, being the largest so far. They have occurred in every month except July and August, the highest for each being as follows: January, 7; February, 4; March, 6; April, 9; May, 2; June, 1; September to December, 4 each. The dates range from 8th September (1926) to 21st June (1933). Adult drakes are present most years, but never more than one at a time, the others being the brown-headed female or young birds.

16. Eider. A female was shot about the beginning of November, 1888. This is the only record.

17. Common Scoter. Scoters have occurred on both the Spring and Autumn migrations, on the former in April and on the latter in September. With the exception of 3 (2 males, 1 female) seen on 5th April, 1930, and of two males on different reservoirs on 11th April, 1937, all have been solitary, adult males occurring three times to female once. An isolated occurrence is of a female on 12th December, 1937.

18. Goosander. The red-headed (female or young) birds have been seen as follows: 1 on 5th December, 1927; 2 on 9th February, 1928; and 3 on 13th March, 1928. The adult male has not been recorded so far.

19. Red-breasted Merganser. The only record is of a female seen on 10th April, 1936.

20. Smew. Smew occur irregularly in the Winter months of December, January and February. There are only four records, of solitary birds, except in the case of a party of 7 seen on 8th January, 1928.

21. Cormorant. The Cormorant has been recorded on four occasions, once in April, twice in September and once in October, in each case a single bird only.

22. Great Crested Grebe. The Great Crested Grebe is usually present at all times of the year, though the numbers may vary considerably. Out of 96 observations, there are only three (1 in January and 2 in February) in which their complete absence has been noted. The highest number recorded has been 54 on two occasions both in 1936, one on 9th August, and the other on 12th September, but in May, June, and July numbers of 40 or over have occurred, the highest for these three months being 40 on 10th May, 1934, 41 on 13th June, 1936, and 44 on

17th July, 1935. It seems rather remarkable that such large numbers should be present during these Summer months. The bird only breeds very exceptionally at Barrow, and even then often unsuccessfully and only one or two pairs at the most, and only 17 pairs bred in the whole of Somerset in 1931, according to the British Birds' Census, of which 12 were at Blagdon and none at Barrow. Those for May and June would appear to be non-breeders, but the July birds may be on passage, a movement which is very marked in August and September when the highest numbers have been present. These drop considerably in October and November, and still more so in December. In January and February there are very few, the Grebes having no doubt moved to the sea. During March and April they are returning. The approximate average of birds present per month is as follows: January, 3·9; February, 3·6; March, 8·6; April, 11·9; May, 26·3; June, 19; July, 32; August, 42·7; September, 24·8; October, 15·7; November, 11·6; December, 6·5.

23. Slavonian Grebe. Odd birds have been seen at irregular intervals, the records being as follows: 1 on 30th March and 2nd April, 1924; 2 from 17th to 25th February, 1934; 1 on 28th September, 1935; and 1 on 7th and 10th April, 1936. There are also old records of one in January, 1885, and one in 1890.

24. Red-necked Grebe. One on 21st February, 1937, is the only record.

25. Black-necked Grebe. Black-necked Grebes were first definitely seen in September and October, 1924. They were not recorded again until 1930, but since then they have been seen every year, and in every month except June. Usually there are not more than 1 or 2 present, but the largest number recorded is 8, which were seen on 4th November, 1935. Between April and August they are, however, scarce and have only been seen, out of about 60 occasions, twice in April and August and once each in May and July.

26. Little Grebe. More observations are required to fill in details of the distribution of the Little Grebe, but present information would show that from January to May, probably also June and most of July, only one or two are present. At the end of the last month numbers may swell considerably, and evidently

some passage movement goes on between then and October. The highest recorded for July is 15 on 31st July, 1937; for August, 15 on 30th August, 1936; for September, 20 on 27th September, 1936; and for October, 27 on 3rd October, 1936, the last-named being also the highest figure for any month. There is a decrease in November and still more so in December, when only one or two are present. So far there is no record or suggestion of any Spring passage at all comparable with that of the Autumn.

27. Great Northern Diver. One was seen on 20th December, 1928, and there is an old record of a young one on 20th January, 1881.

28. Red-throated Diver. One was reported in December, 1927.

29. Oyster-catcher. One was seen on 14th February, 1929.

30. Ringed Plover. A party of 8 were present in September, 1923, and 1 on 8th October, 1926.

31. Golden Plover. The Golden Plover is a very scarce visitor in the Autumn or early Winter. From 1 to 6 were seen in September, 1923, 1 on 20th November, 1932, and 3 were flying over on 26th September, 1937.

32. Lapwing. Large flocks of Lapwing visit the reservoirs in late Summer and Autumn. These may vary in number from 100 to more than 1,000, the latter figure being counted on 27th September, 1931, and being so far the record. They come in about the end of July, between 600 and 700 being there on 31st July (1937) and continue into the third week in November, though in one year (1936) great numbers were present on 16th January. There are no records for December, only two for January, and one each for March and April, though, with the exception of that quoted above for 1936, no more than 50 have been seen, so the numbers are far fewer than those of the Autumn. Twelve were seen on 7th April (1935), the latest date recorded for the Spring; there are no records for May or June, and two for July of 2 on 17th July, 1935, and 600-700 on 31st July, 1937.

33. Turnstone. The only record is of one on 22nd August, 1937.

34. Ruff. There are four records, all for September, 4 birds being seen in 1923, and 1 in 1934, 1935 and 1937.

35. Sanderling. Three were seen on 17th and 18th September, 1930.

36. Knot. An immature bird, seen on the mud of No. 1 reservoir

on 28th September, 1935, is the only record. It was extremely tame and was amongst a large flock of Lapwing, and in company with a Ruff and an American Pectoral Sandpiper, an unusual trio.

37. Dunlin. Dunlins have been seen on eight occasions, of which four have been in September, one in October, January, April and May. Usually they have been single birds, but on the Autumn migration 6 were present on 8th September, 1926, and 8 on 19th October, 1933.

38. Curlew-Sandpiper. A party of from 8 to 10 were present in September, 1923.

39. Little Stint. The only record is of two, a juvenile and an adult in winter plumage, seen on the flooded edge of No. 2 reservoir on 26th September, 1936. Both were very tame and were watched at close range.

40. American Pectoral Sandpiper. One was present on the mud of No. 1 reservoir from 28th September to 3rd October, 1935. It is the only record for Barrow, and also for Somerset.

41. Common Sandpiper. With the exception of Lapwing, the Common Sandpiper is the most regular wader seen at Barrow. It occurs both on the Spring and Autumn migrations, more usually on the latter, but this movement may start as early as July when (in 1934) the quite unusual number of 20 to 25 were present on the 12th. The latest date is of 4 seen on 9th October, 1936, and there are usually 6 or so present during the Autumn.

42. Green Sandpiper. Single Green Sandpipers have occurred on a number of occasions from August to November and from February to April, but 2 were seen on 5th October, 1927. The extremes of these two periods are as follows: 8th August (1935) to 20th November (1932) and 17th February (1934) to 26th April (1934).

43. Redshank. There are only two records, a single bird being seen on 7th November, 1927, and 22nd August, 1937. As it is very common on the coast it is rather remarkable that it has not occurred more often.

44. Spotted Redshank. An immature bird was present on 17th September, 1933.

45. Greenshank. Greenshanks have only been seen on the Autumn migration, between 17th August (1932) and 8th October (1926).

In the main, there are only 1 or 2, but in 1933 there were an unusual number, as many as 6 being recorded on 26th September. As a contrast, none were seen in 1935, although conditions were much the same as in 1933.

46. Grey Phalarope. One, an uncertain record though of a species of Phalarope, on 25th September, 1932, is the only occurrence on the main reservoirs. Another, certainly this species, was seen on the old reservoir about the middle or end of October, 1934.

47. Black-tailed Godwit. One or two were present in September, 1933, between the 17th and the 30th.

48. Curlew. The fields surrounding the reservoirs seem to be an attraction as great as, or even greater than, the reservoirs themselves to the Curlews, and from them have come the records of the largest numbers, 30-40 being seen in November, 1931. The largest party on the actual reservoirs was 13 on 9th November, 1930. Curlews have occurred between 2nd August (1932) and 10th December (1927) and also between 25th February (1929) and 30th April (1928). They have varied in number from single birds to parties of 6, 7, 8 or 13, or from 24 to 40 in the surrounding fields or flying over the reservoirs.

49. Common Snipe. The actual records so far show that the Common Snipe has been recorded from January to March and again from August to November. Usually they are single birds, but 18 were seen on 3rd March, 1930, this being by far the largest number so far recorded.

50. Jack Snipe. Including the old reservoir, there are three records for Jack Snipe, one in February and two in March. The details are 5 on 3rd March, 1930, 1 on 2nd February, and 2 on 1st March, both 1936.

51. Black Tern. Black Terns have been observed on the Autumn migration in 1926, 1933, 1935, and 1936, in numbers varying from 1 to 3. The extremes are 8th September (1936) and 1st October (1933). There is only one Spring record, that of 4 seen on 5th May, 1936.

52. Common or Arctic Tern. There are 3 records, all for September, 2 on 8th September, 1926, 1 on 16th September, 1930, and 2 on 21st September, 1935. Of these, those in 1926 were probably Common Terns, and one of those in 1935 was probably an Arctic, but it is very difficult to distinguish between the two species

in the Autumn. Both in 1930 and 1935 there had been stormy weather shortly before the birds were seen.

53. Black-headed Gull. With the exception of May and June, for which at present there are no records, these Gulls have been seen in every month of the year, and they are usually present in some numbers. As might be expected, they are more numerous outside the breeding season, the largest number recorded being about 700 on 1st September, 1937.

54. Common Gull. The Common Gull is an irregular visitor to the reservoirs. It has occurred on various dates between 12th July (1934) and 14th April (1924), and, with one exception, only in small numbers not reaching double figures. The exception is, however, noteworthy, as the quite unusual number of 54 was seen on April 14th, 1924.

55. Herring Gull. Herring Gulls are almost universally present, though actually there are no records for May and June. But this is doubtless due to lack of observers or lack of notes, or a combination of both. The highest number recorded is about 100 in July and January.

56. Scandinavian Lesser Black-backed Gull. The only definite record is of an adult on 22nd August, 1937, though on several occasions dark birds have been noted but could not be completely identified as of this race.

57. British Lesser Black-backed Gull. This Gull is a migrant which occurs on the reservoirs between February and November. The records for the first month consist of single birds in 1932, 1934 and 1935. There are two phases of migration, a Spring one between 18th March and 27th May, when numbers varying from 20 to 70 may be seen, and an Autumn one from 17th July to 24th September in numbers from 11 to 80, the great majority of these birds being adults. The highest number recorded is the last-mentioned 80 on 11th August, 1937. So far there do not seem to be any records for June, probably from lack of observation, as birds occur on the Avon in that month. This marked migration is of some interest as, although large numbers nest on Steep Holm, five miles off Weston-super-Mare, the bird is very scarce on the coast, though it is common on the Avon. It has only rarely been observed in the Stoke Gifford neighbourhood, north of Bristol, and never in any numbers,

so it seems as if it may migrate overland between western and eastern England, or carry out its migration by night.

58. Great Black-backed Gull. Up to 2nd August, 1932, when one immature was seen, there do not seem to be any records for the reservoirs. Since then, however, they have been observed every year except 1935, and in all months except March to June inclusive and October. The largest number recorded is 4 seen on 20th December, 1936.

59. Iceland Gull. One, probably a second-year bird, was seen on 2nd March, 1931, and the bird, which stayed for two years in the Bristol district, visited the reservoirs on 24th December, 1933, 23rd March, 1934, and doubtless at other times.

60. Kittiwake. The only record is of a very tame juvenile seen on 9th August, 1936.

61. Water Rail. One was seen on 1st November, 1928, and several on 3rd March, 1930.

62. Moorhen. The only records are from the old reservoir where the bird is commonly seen.

63. Coot. Coots are one of the most universal birds present on the reservoirs, though many more notes are necessary before one can get an accurate picture of their movements. Present information suggests that, although there is actually no record so far for June, they occur in every month of the year, though much less plentifully from April to June. From the middle of July until the beginning of November they are present in numbers varying from 30 to 330; the last figure, and also the highest so far, being on 13th September, 1935. There is evidently a considerable movement going on during these months, and from December and January to early July the numbers are considerably less, an exception being on 29th January, 1933, when about 200 occurred. It will thus be seen that, as with some other birds, the autumnal migration is far more marked than that of the Spring.

The Heath Association on Blackdown, Mendip, Somerset

By G. H. Heath, B.Sc., L. C. Luckwill, Ph.D., and O. J. Pullen, B.Sc.
With a Preface by Rose Bracher, Ph.D.

CONTENTS

I.—PREFACE

WORK on the Heath Association on Blackdown was started in the Botanical Department of the University of Bristol in 1925, and since that date the area has been under constant observation.

The bulk of the work has been carried out by advanced students of the Department, while I have been responsible for making the initial observations and for maintaining the continuity of the work as it changed hands during the twelve years' survey.

R. Bracher.

1937.

II.—SITUATION AND GENERAL TOPOGRAPHY

Blackdown forms a part of the Mendip range of hills which run from east to west across northern Somerset, about 15 miles south of Bristol. It is the highest hill of the range, its summit lying at 1,068 ft. above sea level.

The northern slopes of the hill, from 500 to 1,000 ft., are rather steep, having an average gradient of 1 in 6. On the south side the land slopes away more gradually, the average gradient being about 1 in 20. Above 1,000 ft. the hill flattens out into an almost level expanse, about $1\frac{1}{4}$ miles long and from $\frac{1}{3}$ to $\frac{1}{6}$ of a mile in width, and the present account deals chiefly with the conditions prevailing on this flat-topped summit.

III.—GEOLOGY

The anticlinal fold which forms the Mendip range is composed of massive beds of Carboniferous Limestone overlying a core of Old Red Sandstone. In several places, as the result of pre-Triassic erosion, the Carboniferous Limestone has been removed from the arch of the fold, thus exposing the underlying Sandstone. This is the case on Blackdown, where the upper parts of the hill are formed of Old Red Sandstone and the lower slopes are of Carboniferous Limestone. Small areas of Dolomitic Conglomerate deposited in Triassic times also occur on the lower slopes of the hill.

IV.—GENERAL CLIMATE

1. *Temperature.*—The air temperatures on Blackdown differ from those of neighbouring but lower lying areas chiefly in their greater range. The Winter temperatures are very low, and during January, February and March, severe frosts of several days' or even weeks' duration are frequent. The Summer temperatures on the other hand, because of the great insolation of the area, are comparatively high, and temperatures of 80° F. are frequently exceeded during the months from May to August. The diurnal temperature range also is high in Summer, but falls to very low values (1° to 2° F.) on dull Winter days.

2. *Rainfall.*—The rainfall on Blackdown is much above the average for the district, especially in the Autumn months. The mean annual rainfall over the years from 1923 to 1934 inclusive was 46·6 inches, the figures ranging from 31·12 inches in 1933 to 58·42 inches in the exceptionally wet year 1927 (Table 1B). The figures for the distribution of rainfall throughout the year indicate that the Autumn months are the wettest and the Spring months the driest. Summer and Winter rainfall occupy intermediate positions (Table 1A). The records were taken at Charterhouse, 619 ft. above sea level and about 2 miles from the summit of Blackdown, and were supplied by the Bristol Waterworks Company, to whom we here tender our thanks.

TABLE 1A.—MEAN MONTHLY RAINFALL

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
4·20	3·17	2·10	2·93	3·32	2·59	4·16	5·39	4·19	5·43	4·63	4·25

TABLE 1B.—TOTAL ANNUAL RAINFALL

1923.	1924.	1925.	1926.	1927.	1928.	1929.	1930.	1931.	1932.	1933.	1934.
45·14	55·96	47·18	46·68	58·42	47·74	47·02	48·91	43·49	47·14	31·12	38·68

3. *Evaporation.*—It is usually assumed that evaporation over heaths and similar exposed places is very high, but certain observations taken during the Winter, 1928–1929 seemed to indicate that this may not always be so. The problem was more fully investigated during the months from September, 1934, to May, 1935, the instruments employed for measuring the evaporation being a rain-proof atmometer of the Livingstone and Thone (3) type, and a wet and dry bulb recording hygrometer. A Livingstone atmometer on a potometer mounting was also employed for measuring the evaporation over short periods under varying conditions. Owing to the difficulty of keeping the instruments working during the very cold weather the records are necessarily incomplete, but so far as they go they indicate that the evaporating power of the atmosphere is very low from about the end of October until the beginning of March (See Table 2). This phenomenon seems to be caused chiefly by the low temperatures and the large amount of rainfall.

TABLE 2.—EVAPORATION DATA. SUMMIT OF BLACKDOWN

Period.	Mean air[1] temp. °F.	Total rainfall ins.	Total evaporation from atmometer ccs.	Mean sat$^{n.}$[1] deficit mm. Hg.
Sept. 12—Sept. 25 ..	59·9	1·85	148	—
Sept. 25—Oct. 9 ..	67·5	2·80	93	—
Oct. 9—Oct. 23 ..	54·3	0·78	95	—
Oct. 23—Nov. 6 ..	48·5	1·32	60	—
Nov. 6—Nov. 20 ..	46·4	1·58	10	—
Nov. 20—Dec. 4 ..	51·4	2·94	18	—
Jan. 29—Feb. 12 ..	39·7	1·01	—	1·06
Feb. 12—Feb. 26 ..	42·5	2·44	—	0·55
Feb. 26—Mar. 12 ..	37·8	1·04	—	0·55
Mar. 12—Mar. 26 ..	42·9	1·53	181	1·11
Mar. 26—Apr. 9 ..	39·3	2·64	—	1·18
Apr. 9—Apr. 23 ..	43·1	2·57	—	0·96
Apr. 23—May 7 ..	—	—	—	1·47

[1] Observations taken at two hourly intervals from 2 a.m. to 12 midnight.

4. *Winds.*—The prevailing winds are from the W. and S.W., and often reach a considerable force on the exposed summit of Blackdown. Observations show that evaporation depends more on the direction of the wind than on its velocity, always being greater when the wind is from the N. or E. than when it is from the S. or W.

V.—PEAT FORMATION

The principal factors concerned in the formation of peat on the summit of Blackdown appear to have been :—

1. The level nature of the summit plateau.
2. The nature of the underlying rock which is non-calcareous and comparatively impervious.
3. The high rainfall of the district.

The first two of these factors are responsible for the very poor drainage conditions which exist on the summit, and combined with the third factor they have resulted in a soil which is continually water-logged and very poorly aerated. Furthermore, owing to the absence of mineral bases the soil reaction is strongly acid. As a result of the combined action of all these factors the rate of decomposition of organic matter by bacterial action has been greatly retarded and the plant remains have gradually become compacted into a close fibrous peat. It is of interest to note that on the flanks of the hill, even where the sub-soil is still non-calcareous, but where the drainage conditions are much better, no true peat is formed.

VI.—VEGETATION

The vegetation of Blackdown belongs to the Upland Heath Association developed on thin peat. It appears to be the climax vegetation in this situation, further development being limited by edaphic conditions, i.e., an edaphic climax association.

Three principal consociations are represented, viz., Callunetum vulgaris, Molinietum cœruleæ and Pteridetum aquilinæ, the local distribution of which is controlled by edaphic factors. The dominant plant over the greater part of the summit is the Ling (*Calluna vulgaris*). The Purple Moor Grass (*Molinia cœrulea*) is locally dominant on the damper parts of the heath and covers quite a large area on the south side of the hill (see Fig. 27). The flanks of the hill are occupied by a consociation of Bracken (Pteridetum), which extends to an altitude of about 950 ft., above which it ceases to grow and is replaced by the

Callunetum of the summit plateau. This change in the vegetation corresponds closely to the change in slope which occurs at about this altitude, and the consequent change in edaphic conditions to which reference has already been made.

On the slopes of Blackdown there rise several springs, around the sources of which considerable areas of *Sphagnum* bog are developed, and a similar bog occurs on the summit plateau. There also occur on the summit of Blackdown several small ponds, fed by surface drainage water, which are partially or completely full throughout the Winter months but often dry up for considerable periods during the Summer. In such regions as these there occur specialised communities of bog and water plants which differ considerably in floristic composition from the surrounding vegetation.

The principal vegetational features of these various communities will now be considered in more detail.

1. Callunetum

Pure Callunetum, containing only a small percentage of other species, occurs on those areas of the summit which have remained undisturbed for ten years or more. Owing to the prevalence of heath fires, however, most of the area is at present occupied by consocies in which *Erica Tetralix*, and often *Molinia cærulea* as well, are co-dominant with *Calluna*. These consocies are transitional communities in the succession from the bare peat surface, which is left after firing, to the climax vegetation (see page 360), and their limits, which are often extremely irregular, are easily observable because of the difference in height of the vegetation on either side of the fire line.

All these communities exhibit a two-layered structure, for beneath the larger ericaceous shrubs and heath grasses there is a lower stratum of vegetation composed of various smaller phanerogams and cryptogams. The so-called " bare " areas of peat between the heather bushes are particularly favourable for colonisation by such plants, and during the early stages of re-colonisation after a fire, when there is little shading, a large variety of species is to be found. *Potentilla erecta* is particularly characteristic of such situations as are also species of the lichens *Lecidea* and *Cladonia*. The peat surface in such bare areas is usually covered with a thin layer of gelatinous algæ, but in hollows, where water lies in pools during wet weather, they may be colonised to the exclusion of all other species by the reddish alga *Zygnema ericetorum*. *Campylopus flexuosus* is a common moss which is typically confined

to cracks in the peat, although in regions where there is heavy rabbit attack it may spread over the surface of the peat as well.

In older communities where the shade cast by the upper stratum is much greater, the vegetation in the lower stratum contains fewer species and individuals. Dwarf specimens of *Vaccinium Myrtillus*, the liverwort *Calypogeia fissa*, and etiolated specimens of *Bryum* and *Ditrichum* are practically the only plants to be found beneath the shade of *Calluna* which exceeds the age of ten years.

2. Molinietum

The Molinietum, unlike the Callunetum, is a closed consociation, and even in the early stages of recolonisation, the "bare" areas which are such a characteristic feature of the latter are entirely absent. As a consequence of this, the consociation is less rich in species, especially in cryptogams. Its boundary also is somewhat indefinite, and where it adjoins the Callunetum of the summit plateau there is a wide transitional zone in which *Molinia* and *Calluna* are co-dominant. Like the Callunetum it exhibits a two-layered structure although the stratification is here less well marked. *Nardus stricta* is abundant and, in drier situations, may locally attain the rank of co-dominant. *Juncus spp.* and *Eriophorum angustifolium* are plentiful, and the latter is a conspicuous feature of the landscape when it is in fruit. In the lower stratum, *Polygala serpyllacea* and dwarf specimens of *Vaccinium* are of frequent occurrence, as are also several of the larger mosses such as *Polytrichum commune* and *Aulacomnium palustre*, and in damper situations species of *Sphagnum*. Lichens are entirely absent.

3. Pteridetum

The flora of this consociation is made up partly of typical heath species and partly of species which, although they are not intolerant of an acid soil, are not usually considered as true heath plants, e.g., *Viola canina* and *Digitalis purpurea*. The vegetation here exhibits a three-layered structure. Beneath the fronds of *Pteridium* there is a fairly close turf composed of various species of heath grasses, such as *Agrostis canina*, *Deschampsia flexuosa* and *Festuca ovina*; *Vaccinium Myrtillus* also is very abundant and in places co-dominant with *Pteridium*. As in the case of the Callunetum, the lowermost stratum of vegetation is composed of various small phanerogams and cryptogams, but owing to the close growth of the plants in the middle stratum the conditions for growth are less favourable than in the

corresponding horizon of the Callunetum, and fewer species are to be found. *Polytrichum juniperinum* and *Ditrichum flexicaule* are both common mosses in this stratum, and in situations where *Vaccinium* is abundant the liverworts *Cephalozia bicuspidata* and *Sphenolobus exsectiformis* are characteristic.

4. Ponds and Bogs

The dominant species of *Sphagnum* in the bogs are *S. cymbifolium* and *S. acutifolium*, and cushions of other large mosses (e.g., *Polytrichum commune* and *Aulacomnium palustre*) are of frequent occurrence. The bog flora is moderately rich in species but many of these are local in their distribution and are known only from one particular station, e.g., *Narthecium ossifragum*, *Drosera rotundifolia*.

The vegetation of the ponds consists chiefly of various species of grasses, rushes and sedges, and often there is a distinct zonation of vegetation around the edge of the pond. In addition to the permanent vegetation, various casual species make their appearance from time to time on the dried-up beds of the ponds in Summer. During the Summer of 1934, for example, the following were observed :—*Polygonum Hydropiper*, *Plantago lanceolata*, *Cerastium vulgatum*, *Polygala serpyllacea*, *Trifolium pratense*.

The Heath Association on Blackdown is represented by the following species, the relative frequencies of which in the different consociations are shown in the list. The frequency symbols employed are the usual ones, viz.: d = dominant; a = abundant; f = frequent; o = occasional; r = rare; vr = very rare; l = local.

	Callunetum.	Molinietum.	Pteridetum.	Ponds and Bogs.
Ranunculus hederaceus L. ..	—	—	—	vr
Ranunculus Flammula L. ..	—	—	—	vr
Viola palustris L.	—	—	—	r
Viola canina L.	—	—	f	—
Polygala serpyllacea Weihe. ..	o	o	f	—
Hypericum pulchrum L. ..	—	—	o	—
Oxalis Acetosella L.	—	—	vr	—
Ulex europæus L.	r	r	o	—
Ulex Gallii Planch.	f	o	o	—
Lotus uliginosus Schkuhr. ..	—	—	—	r
Lathyrus pratensis L.	—	—	vr	—
Potentilla erecta Hampe. ..	f	o	f	—

	Callunetum.	Molinietum.	Pteridetum.	Ponds and Bogs.
Cratægus Oxyacantha L. ..	vr	—	vr	—
Chrysosplenium oppositifolium L.	—	—	—	vr
Drosera rotundifolia L.	—	—	—	lf
Epilobium angustifolium L. ..	—	—	f	—
Sambucus nigra L.	—	—	r	—
Galium saxatile L.	o	vr	f	r
Scabiosa Succisa L.	—	vr	—	—
Vaccinium Myrtillus L. ..	va	f	va	—
Calluna vulgaris Hull.	d	o	o	r
Erica Tetralix L.	va	o	—	—
Erica cinerea L.	lf	—	o	—
Anagallis tenella Murr.	—	—	—	vr
Veronica officinalis L.	—	—	o	—
Pedicularis sylvatica L. ..	o	r	—	r
Digitalis purpurea L.	—	—	o	—
Rumex Acetosella L.	—	—	a	—
Urtica dioica L.	—	—	vr	—
Orchis elodes Gris.	—	vr	—	—
Scilla non-scripta Hff. and Link.	—	—	o	—
Narthecium ossifragum Huds. ..	—	r	—	la
Juncus effusus L.	r	o	—	f
Juncus articulatus L.	r	o	—	f
Juncus squarrosus L.	o	f	—	o
Juncus bufonius L.	—	—	—	r
Luzula campestris L.	—	—	r	—
Luzula multiflora DC.	o	o	r	—
Scirpus cæspitosus L.	lf	r	—	f
Eriophorum vaginatum L. ..	—	r	—	vr
Eriophorum angustifolium Roth.	—	f	—	f
Carex echinata Murr.	—	f	—	—
Carex Goodenowii Gay. ..	r	—	r	o
Carex panicea L.	r	o	—	o
Carex binervis Sm.	—	—	o	o
Carex flava L.	—	—	—	r
Anthoxanthum odoratum L. ..	—	—	f	—
Agrostis canina L.	—	—	f	—
Agrostis tenuis Sibth.	—	—	f	o
Aira caryophyllea L.	—	—	o	—
Deschampsia cæspitosa Beauv.	—	o	—	o
Deschampsia flexuosa Trin. ..	f	—	a	—
Sieglingia decumbens Bernh. ..	o	—	—	—
Molinia cærulea Mœnch. ..	a	d	—	f
Glyceria fluitans Br.	—	—	—	vr
Festuca ovina L.	—	—	f	—
Nardus stricta L.	f	a	o	f
Pteridium aquilinum L. ..	—	—	d	—
Blechnum Spicant With. ..	—	—	vr	—

	Callunetum.	Molinietum.	Pteridetum.	Ponds and Bogs.
Polytrichum commune L. ..	r	a	—	f
Polytrichum juniperinum Willd.	o	—	f	—
Hypnum fluitans L.	—	—	—	o
Hypnum cupressiforme L. ..	o	o	—	—
Do. var. *ericetorum* Sch. ..	r	r	—	—
Hypnum Schreberi Willd. ..	r	f	—	—
Campylopus flexuosus Brid. ..	f	—	o	—
Hylocomium squarrosum B. & S.	r	o	—	r
Aulacomnium palustre Schwæg.	—	o	—	f
Ditrichum flexicaule Hampl. ..	o	—	f	—
Bryum alpinum Huds.	—	—	o	—
Bryum capillare L.	r	—	o	—
Bryum pallens Swartz.	r	—	o	—
Dicranum scoparium L. ..	o	o	—	—
Rhacomitrium lanuginosum Brid.	lf	—	—	—
Funaria hygrometrica Hedw. ..	—	—	o	—
Webera nutans Hedw.	o	—	—	—
Dicranoweisia cirrata Lindb. ..	o	—	—	—
Sphagnum cymbifolium Ehrh. ..	—	o	—	va
Sphagnum acutifolium Ehrh. ..	—	o	—	va
Gymnocolea inflata Huds. ..	o	—	—	—
Lophocolea cuspidata Limpr. ..	o	—	—	—
Lophozia inflata Howe ..	o	o	—	—
Sphenolobus exsectiformis Steph.	r	—	o	—
Cephalozia bicuspidata L. ..	r	—	o	—
Cladonia sylvatica Hffm. ..	o	—	—	—
Cladonia coccifera Willd. ..	f	—	r	—
Cladonia pyxidata Fr.	f	—	r	—
Cladonia uncialis Hffm. ..	o	—	—	—
Cladonia furcata Hffm. ..	o	—	—	—
Lecidea granulosa Schrad. ..	a	—	—	—
Lecidea uliginosa Schrad. ..	o	—	—	—
Parmelia physodes L.	lf	—	—	—
Zygnema ericetorum, Hansg. ..	f	—	—	r
Zygogonium ericetorum Kutz. ..	o	—	—	—
Hormidium flaccidum Kutz. ..	f	—	—	—
Mesotænium violascens De Bary	o	—	—	—
Glœocystis vesiculosa Næg. ..	f	—	—	—
Chlorococcum humicolum Næg.	f	—	—	—
Glœocapsa Ralfsii Harv. ..	o	—	—	—
Trochischia aspera Reinsch. ..	o	—	—	—

VII.—FACTORS INFLUENCING THE DISTRIBUTION OF VEGETATION

The general physiographic and climatic features of Blackdown have already been described. Although these factors exert little or no direct effect on the vegetation, they are indirectly of fundamental importance. Not only are they the primary cause of peat formation and hence of the presence of the Heath Association on Blackdown, but the physiographic features, through their effect on the local edaphic conditions, largely control the distribution of the plant communities within the Association.

1. Climatic Factors

Of the various climatic factors, the only one which shows any appreciable variation, and hence exerts any influence on the distribution of vegetation over the area, is the light intensity. The floristic composition and density of the vegetation in the lower strata of the various communities depend chiefly on the amount of shade cast by the upper strata. The paucity of the ground flora beneath tall *Calluna*, for example, is attributable to the low light intensity (Table 3). In consocies dominated by *Calluna* and *Erica Tetralix*, where the edaphic conditions are similar but the light intensity at ground level is much higher, the ground vegetation is far more prolific.

Table 3.—Light intensities at ground level expressed as a fraction of the light intensity in the open as measured with a photographic exposure meter at various times throughout the year.

Callunetum (18 ins. high)	= 1/20—1/60
Calluna-Erica (12 ins. high)	= 1/5 —1/8
Pteridetum (summer)	= about 1/3
Pteridetum (winter)	= 1/3 —1/80
Molinietum (winter)	= 1/10—1/60

2. Edaphic Factors

(*a*) *Soil profiles.*—Three soil layers can be distinguished. The surface peat, which is black and fibrous, varies from 1 in. in depth in the Pteridetum to 6 ins. in the Callunetum. The less fibrous sub-peat varies from 2 ins. in the Pteridetum to about 9 ins. in the Callunetum; it is composed of moderately small particles which become smaller with increasing depth (70 per cent. exceed 1 mm. at 4 ins.; 50 per cent. exceed 0·5 mm. at 6 ins.). The sandy loam beneath the sub-peat is composed of much smaller particles (70 per cent. are below 0·04 mm.), and also contains numerous stones of varying size. This stony layer is usually about 5 ins. in depth.

(*b*) *Soil temperatures.*—Owing to its dark colour, the surface peat of the Callunetum, where it is exposed, often attains temperatures considerably in excess of the air temperatures during the Summer months. Under these conditions, the cryptogams colonising the surface of the peat shrivel and appear dead, but on the return of cooler conditions most of them revive again. They appear to be equally resistant to the low soil temperatures of Winter and can remain frozen in ice for many weeks without losing their vitality.

(*c*) *Water content, humus content and acidity.*—The water content of the soil is largely determined by the humus content, and this in turn is controlled by the type of vegetation which is growing in the area. The coefficient of humidity (Crump (1)), which is the ratio $\frac{\text{water content}}{\text{humus content}}$, gives an estimate of the amount of soil water available for the plant, i.e., soil water which is not held by the humus colloids.

TABLE 4.—MEAN VALUES OF WATER AND HUMUS CONTENT, COEFFICIENT OF HUMIDITY, AND ACIDITY OF BLACKDOWN SOILS. READINGS TAKEN ONCE A MONTH FROM NOVEMBER TO FEBRUARY, 1928. EXPRESSED AS PER CENT. OF OVEN DRY WEIGHT.

Depth of sample	1½ ins.	6 ins.	9 ins.
Water Content :—			
Callunetum	298·5	79·6	30·2
Call.-Ericetum.	229·9	72·9	29·6
Molinietum	446·4	185·3	137·3
Pteridetum	147·2	48·6	25·5
Humus Content :—			
Callunetum	68·7	19·9	5·3
Call.-Ericetum.	66·3	20·6	6·2
Molinietum	74·4	42·6	29·5
Pteridetum	32·6	10·2	5·0
Coefficient of Humidity :—			
Callunetum	4·6	4·4	5·6
Call.-Ericetum	3·5	3·8	4·8
Molinietum	6·1	5·1	3·3
Pteridetum	4·6	5·0	5·5
p^H :—			
Callunetum	4·2	4·6	5·3
Call.-Ericetum	3·9	4·7	5·3
Molinietum	3·9	4·1	4·6
Pteridetum	4·6	5·4	6·3

It can be seen from Table 4 that the Callunetum and Calluna-Erica soils are very similar although, as the coefficients of humidity show, the latter tend to be somewhat drier than the former. The more open nature of the vegetation, allowing of more rapid evaporation from the soil surface, is probably responsible for this difference. The soils of the Pteridetum contain approximately the same percentage of available water as those of the Callunetum, but in the surface peat of the Molinietum the percentage is higher. This is probably due to the fact that the Molinietum is developed in depressed areas where it receives surface drainage water from the surrounding heath.

The soil acidity as expressed by the p^H value also shows a close correlation with the humus content. In all soils the humus content and the acidity are at a maximum in the surface peat, and both fall with increasing depth. The highest humus contents and acidities are found in the Molinietum, and the lowest in the Pteridetum, whilst the soils of the Callunetum occupy an intermediate position.

(*d*) *Soil aeration.*—In Table 5 are summarised the results of investigations of soil aeration carried out between January and April, 1929.

TABLE 5.—AIR CONTENTS AS PERCENTAGE BY VOLUME OF BLACKDOWN SOILS. JAN.–APRIL, 1929.

Type of Vegetation	2 ins.	6 ins.	9 ins.
Callunetum	10—20	2—8	—
Pteridetum	—	17—30	—
Molinietum	4	7—11	1—4
Vaccinium society	12—50	10—20	—
Path across Callunetum ..	5—9	4	—

The values for any given type of soil show considerable variation, but in general the peats are found to have a higher air-content than the more compact sub-peats. In the Molinietum the high water content of the surface peat is no doubt responsible for the low aeration values, and in the paths, where the surface peat has about one-half the air content of that of the surrounding heath, the same factor, combined with the constant trampling to which the paths are subjected, is probably responsible. The highest aeration values were found in soils where *Pteridium* or *Vaccinium* were dominant.

3. BIOTIC FACTORS

Under the heading of biotic factors we class those features of the habitat which are due, either directly or indirectly, to other living organisms, whether plants or animals.

The effects of plants on other plants are usually indirect, the immediate effects being due to changes in the edaphic or climatic factors of the habitat. Some of these have already been described (see page 357). Animals may exert a more direct effect on the vegetation. In places, for example, the Callunetum of the summit plateau, especially where it adjoins the Pteridetum, shows signs of rabbit attack. The *Calluna* bushes in such regions are nibbled into the cushion-like form described by Farrow (2), whereas *Erica Tetralix*, *Erica cinerea*, *Vaccinium* and *Pteridium* seem immune from attack. Where the attack is heavy, the *Calluna* is eventually killed and is succeeded by *Vaccinium*, the increased soil aeration which results from the burrowing activities of rabbits, favouring colonisation by this plant. *Vaccinium* is eventually followed by *Pteridium*. This process can be seen in progress in many places on the northern slopes of the hill where there is often a zone of almost pure Vaccinietum separating the Pteridetum from the Callunetum.

The heath is probably less subject to human interference nowadays than it was in Roman times when the area was worked for lead. The various paths which cross the area, however, bear a specialised vegetation which is the direct result of human interference. The less frequented paths are usually colonised by *Molinia*, but this plant seems unable to withstand much trampling, and on the main paths it is replaced by *Nardus stricta* which is able to survive under these conditions.

4. Heath Fires and Recolonisation

Heath fires are of very frequent occurrence on the summit of Blackdown and have an important effect on the vegetation. Owing to the high water content of the soil, the peat itself is not usually burnt, and the edaphic conditions are therefore not interfered with to any great extent. The principal effects of such fires are :—

(i) Total destruction of the sub-aerial parts of the vegetation. Plants with underground storage organs, e.g., *Calluna*, *Erica*, *Molinia*, *Vaccinium*, survive these fires and regenerate from their underground parts within a few weeks. Others, having no storage organs, e.g., *Polygala serpyllacea*, *Galium saxatile*, and nearly all cryptogams, are killed.

(ii) The creation of bare areas of peat which may be colonised by seedlings of various heath plants and also by various smaller cryptogams.

The vegetation which first establishes itself on a burnt area is therefore not the same as that which was present before burning, and there follows a process of recolonisation which is considered below.

The destruction by fire of the overground portions of the vegetation results in the exposure of large areas of bare peat suitable for colonisation, and to this fact can be attributed the rapid increase of certain species, notably *Molinia cærulea* and *Erica Tetralix*, as a result of firing. Many other species also make their appearance. On the bare areas of peat between the regenerating stools of Calluna and Erica plants of *Potentilla erecta* become established, and the moss *Funaria hygrometrica* together with various algæ (chiefly *Hormidium flaccidum* and *Chlorococcum humicolum*) is also abundant in the first year after the fire. This change, however, is only a temporary one, for as the *Calluna* bushes increase in size, the shade which they cast becomes deeper and more extensive, and their rivals are gradually exterminated. *Potentilla erecta* seems to be particularly susceptible to shading and is one of the first plants to disappear, whilst *Molinia cærulea* and *Erica Tetralix* become greatly reduced in frequency by the fifth year. After about six or seven years the process of recolonisation is complete and Calluna has regained its dominance. This process is illustrated graphically in Fig. 28, in which are shown typical quadrats from similar areas in the Callunetum, 1, 3, 4, and 6 years after burning. Each quadrat represents the vegetation on an area 5 ft. square.

VIII.—SUMMARY

1. Geologically Blackdown is an uplift of Carboniferous Limestone which has become so far denuded as to expose the underlying Old Red Sandstone 'core.'
2. The chief features of the climate are the extremes of temperature which are experienced and the high rainfall. The evaporating power of the atmosphere was found to be very low during the Winter months.
3. The vegetation of the summit plateau belongs to the Upland Heath Association and is developed on thin peat. Three consociations are developed, viz., Callunetum, Molinietum and Pteridetum, the vegetation of each of which is described.
4. The distribution of the various plant communities within the area is determined largely by edaphic conditions although, for the smaller phanerogams and cryptogams, light intensity is a factor of importance.

5. The effect of heath fires on the vegetation, and the course of re-colonisation after burning are briefly described.

We wish to acknowledge our indebtedness to Dr. R. Bracher, at whose suggestion the work was carried out, for her constant help and advice; also to Prof. M. Skene for his criticism of the manuscript and advice, to the late Sir Vernon Wills, the former owner of Blackdown, for permission to carry out the survey, and to the Sir Edward and Lady Fry Memorial Fund for a grant in aid of publication.

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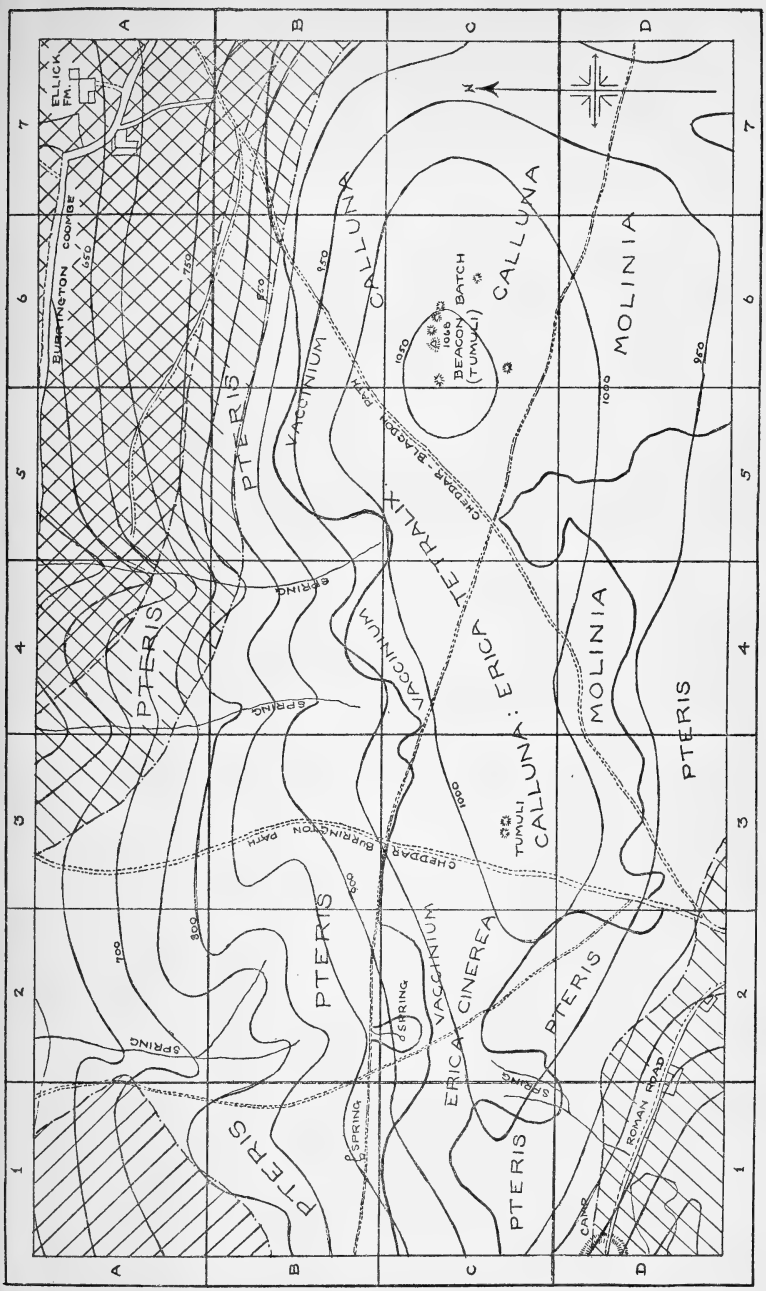

FIG. 27.—MAP OF BLACKDOWN ON MENDIP SHOWING THE CHIEF TOPOGRAPHICAL, GEOLOGICAL AND VEGETATIONAL FEATURES. The heavy line represents the upper limit of the Pteridetum. Based on the Ordnance and Geological Survey Maps of the district.

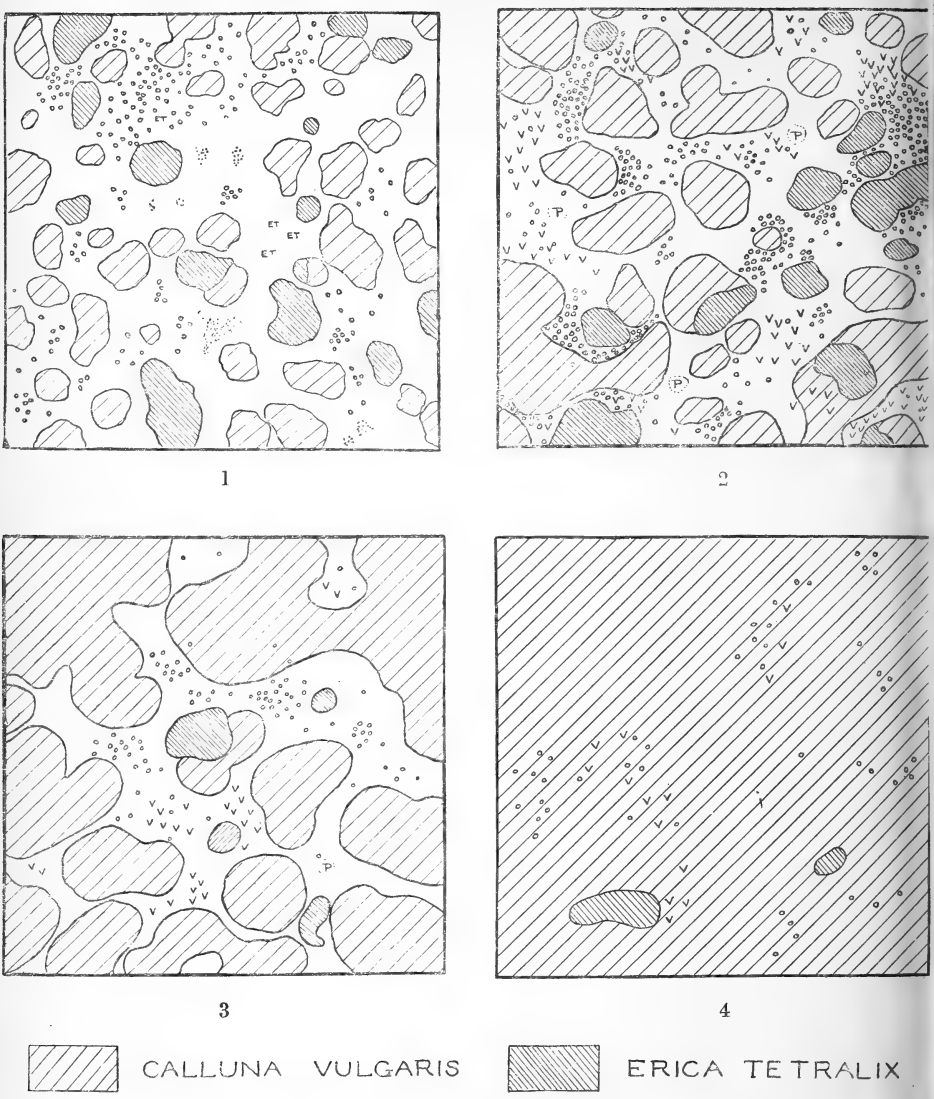

FIG. 28.—TYPICAL QUADRATS TAKEN IN CONSOCIES OF VARIOUS AGES SHOWING STAGES IN RE-COLONISATION AFTER BURNING. EACH QUADRAT IS 5 FT. SQUARE.

Age of the vegetation: 1 = 1 year; 2 = 3 years; 3 = 4 years; 4 = 6 years.

Symbols used: V = *Vaccinium Myrtillus*; O = *Molinia*; E.T. = seedlings of *Erica Tetralix*; P = *Potentilla erecta*.

Notes on Melville Island Flowers

By H. S. Thompson, A.L.S.

IN *Proc. B.N.S.*, Vol. VII, Part 2, 1872, two and a half pages were devoted to a lecture with the above title by the late A. E. Hudd, F.S.A., when a young man. It was read before the Botanical Section, Dec. 19th, 1872.

When clearing and trying to rearrange the miscellaneous and, alas, dirty contents of the cupboard principally containing the H. O. Stephens herbarium, I came across the little collection of about 45 Arctic plants from Melville Island, the largest of the islands of the Arctic Archipelago, formerly known as N. Georgia and later called the Parry Islands. These were collected by Lieut. John Bushnan, R.N., one of Parry's officers, in 1820, 1822, and 1823.

There are 45 small sheets, 8¼ in. x 6 in., with the plants mounted thereon. Most of them were named, but not located. A. E. Hudd had attempted to name several. But as some of the names were obviously wrong, I eventually sent several of these to Kew, where they were examined and neatly named by Mr. A. A. Bullock.

It is desirable that the correct names should now be published, as far as possible. The little collection comprises no Monocotyledons (no Sedges or Grasses even). *Parrya arctica* R. Br. has been confirmed at Kew. *Cardamine* sp. is *C. pratensis* L. ? var. *angustifolia ; Arenaria rubella* Wahl. = *A. verna* L. *Saxifraga Hirculus* (?) is certainly correct ; *Dryas integrifolia* Br. is *D. octopetala* L. as named originally but erased ; *Oxytropis arctica* R. Br. is confirmed at Kew, and though it appears in Hudd's list, the actual plant on a duplicate sheet was unnamed[1] and had a (?). *Cineraria congesta* Br. = *C. palustris ; Erigeron uniflorum* L. (*sic.*) is confirmed as *E. uniflora* L. *Pyrethrum alpinum* is *Matricaria Hookeri ; Onosma micrantha* (?) Kew says is the totally different *Trientalis arctica* Fisch. A "(?) *Senecio*" is the Crucifer *Lesquerella arctica* (R. Br.) S. Wats. *fide* Kew. Mr. Bullock says the "*Chrysanthemum* (*Pyrethrum*) *grandiflorum* Hook." is better placed under *Matricaria inodora* var. *nana* (Hook.) Torr. et Gray.

A. E. Hudd remarked in his paper that "nearly one-third of the species (the fourteen marked *) are included in our (British) lists."

With the collection is the rather longer MS. of A. E. Hudd as originally

[1] There are about 200 species of this genus.

read. This is endorsed by the late Miss Roper: "Notes on some flowers from Melville Island, read to the Botanical Section, B.N. Soc." There are also 12 pp. of MS. notes by Mr. Hudd on the plants, some of which in regard to geographical distribution are very useful. Also a large scale MS. map showing the position of the Parry Islands.

Many copies of Part 2 of Vol. VII, *Proc.*, 1872, are still in stock and can be purchased for 1s. each. It contains, *inter alia*, an interesting paper on "Twenty Years' Rainfall at Clifton," by G. F. Burder, M.D.

Reviews

THE SCENERY OF ENGLAND AND WALES

By A. E. Trueman, D.Sc., F.G.S., Professor of Geology in the University of Glasgow. London: Victor Gollancz, Ltd., 1938. 7s. 6d. net.

This very delightful and informative book should be of considerable interest to many members of the Society. In the first place, it is written by a fellow member well known to many in the Society, and it includes, of course, a chapter on the more immediate local scenery. But the book is of great general interest quite apart from its local associations. England and Wales are divided for the author's purpose into regions, the scenic features of each are described, and the geological background of these features is simply and interestingly explained. The additional interest thus given to the observer must add enormously to his appreciation of the scenery, and probably in many cases his attention is drawn for the first time to many features which he may have overlooked or just taken for granted without enquiry as to geological background; even the experienced observer may well have failed to notice some of the scenic features to which Professor Trueman draws attention. Geological expressions, such as the building stones of the regions, are not overlooked by the author, and, in fact, his very human approach to his subject is one which not only the geologist but the geographer and, indeed, all who love scenery and wish to understand it, will appreciate. The pages are profusely illustrated with the author's own charming sketches, and useful diagrams also appear.

H. W. T.

THE MICROSCOPE

Vol. 1, No. 1. August, 1937. 28 pp. 1s. monthly.

The appearance of a British magazine devoted to microscopy and photomicrography will be welcomed by the adherents to this science and recreation. Contributions cover a wide range of interests, both technical and biological; articles on the recording of colour in photomicrographs and a simple method of stereoscopic photomicrography, techniques for mounting filamentous algæ and diatoms for microscopic use, and descriptive articles on marine diatoms, *Vorticella* and the common house fly appear in this issue. The reviews and microscopical club notices have additional interest for the keen microscopist. The format is attractive and four pages of excellent plates illustrate the articles.

A. H. C.

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A.	Crofton, Miss K.	11 Holmes Grove, Henleaze, Bristol, 6	*O.*
	Crosland, J. H.	130 Stackpool Road, Bristol, 3	*Bi.*
†	Daniels, F. L., F.G.S.	Stringer's Court, Rodborough, Stroud, Glos.	
A.	Daniels, Miss G. (resigned 1938)	4 Weston Crescent, Horfield, Bristol, 7	*Bi.*
	Davies, T. H.	Down House, Stoke Bishop, Bristol, 9	
*	Davis, H. H., M.B.O.U.	Little Stoke, Patchway, near Bristol	*O.*
	Davis, Mrs.	Little Stoke, Patchway, near Bristol	*B.O.*

A.	Davis, Miss M. C.	71 Arley Hill, Bristol, 6	*F.*
A.	Davis, Mervyn J. L.	8 Osborne Road, Clifton, Bristol, 8	*E.*
	Daws, Miss H.	109 Forest Road, Fishponds, Bristol	*F.*
	Derham, R. J., M.B., Ch.B.	Bristol General Hospital, 1	*O.*
A.	Desbrow, Norman (resigned 1938)	Glanville House, 49 Bridgwater Road, Bristol, 3	*Bi.*
J.	Dixon, Miss M. D.....	11 Pembroke Road, Clifton, Bristol, 8	*O.*
A.	Dobbin, G. M.	12 Eaton Crescent, Clifton, Bristol, 8	*G.*
	Druitt, C. F.	"Springfield," The Avenue, Clevedon, Som.	*O.*
	Duddridge, Miss E., B.Sc.	59 Kellaway Avenue, Bristol, 6	*Bi.F.O.*
A.	Dunnicliff, H.	10 Effingham Road, St. Andrew's, Bristol, 6	*O.*
J.	Dunn, Miss A. J.	"Cambri," Elm Park, Filton Bristol	*B.F.*
	Dunscombe, Miss A.....	5 Westmoreland Road, Durdham Park, Bristol, 6	
	Durrant, U. J.	The Glebe, Long Ashton, nr. Bristol	*O.*
*	Edmonds, H. O.	33 Wellington Park, Clifton, Bristol, 8	*F.*
	Edwards, C. (resigned 1938)	50 Elton Road, Bishopston, Bristol, 7	*E.*
	Edwards, T. G.	40 Holmes Grove, Henleaze, Bristol	*Bi.*
A.	Elkins, Miss A. K. (resigned 1938)	Speedwell Senior School, Bristol, 5	*Bi.*
	Evans, I. W.	46 Horfield Road, St. Michael's, Bristol, 2	*B.F.*
	Evens, F. W., A.C.A.	Stretton, 77 Manor Road, Fishponds, Bristol	*B.F.*
	Eyres, Miss G., B.Sc. ...	35 Deanery Road, Warmley, nr. Bristol	*Bi.B.*
	Fear, A. C. K., B.Sc., F.R.H.S.	Lodway Road, Pill, nr. Bristol	*B.G.*
	Fitzjames, R. H.	17 St. Martin's Road, Knowle, Bristol, 4	*G.*
	Fitzjohn, Miss A., M.Sc....	1 Audley Park Road, Bath	*Bi.B.F.*
*	Flemming, A. L., M.B., Ch.B.	48 Pembroke Road, Clifton, Bristol, 8	*O.*
	Ford, Roger	Hartfield, Cotham Park, Bristol, 6	*F.O.*
	Fox, Mrs. A.	Brislington House, near Bristol	
	Fraser, Mrs. H. G.....	Foye House, Leigh Woods, Bristol	*O.*
A.	Fry, T. R.	59 Air Balloon Hill, St. George, Bristol, 5	*G.*
J.	Fursdon, G. H. J.	Wills Hall, Stoke Bishop, Bristol, 9	*O.*
	Gardner, D. A.	30 Gloucester Road North, Horfield, Bristol, 7	*B.F.G.*
	Gibbs, Miss M. A., M.Sc. ..	27 Eastbourne, Claremont Road, Bath	*Bi.*
	Glass, Arthur	19 Berkeley Square, Clifton, Bristol, 8	*Bi.*
	Glasspool, F. F., M.Sc., F.C.S.	6 Southfield Road, Cotham, Bristol, 6	*B.*

	Goodall, Rev. Canon R. W. (deceased 1938)	19 Elmdale Road, Tyndall's Park, Bristol, 8	*G.*
A.	Gorham, Major A.	Avonside, Limpley Stoke, Bath, Som.	*G.*
	Gorvett, Harold, Ph.D.	"Onaway," Station Road, West Town, Som.	*B.*
A.	Gowan, Miss J. E.	26 Woodstock Road, Redland, Bristol, 6	*B.F.*
A.	Green, Mrs. M. B., L.L.A.	Dyrham, nr. Chippenham, Wilts	*O.*
A.	Green, T. L., B.Sc.	The University, Bristol, 8	
A.	Green, Mrs. T. L.	The University, Bristol, 8	
A.	Greenland, F. J.	20 King's Avenue, Bristol, 7	*Bi.*
A.	Grignon, Miss A. E.	41 Filton Avenue, Horfield, Bristol, 7	*B.F.G.*
A.	Habgood, Miss M. E. (1939)	9 Burlington Road, Redland, Bristol, 6	*F.*
A.	Hall, Miss J. H.	373 Fishponds Road, Upper Eastville, Bristol, 5	*Bi.*
A.	Hallam, A. D., D.Phil., B.A., B.Sc., F.G.S.	16 Cheddon Road, Taunton	*G.*
	Hamilton, R. G., B.A.	1 Elgin Park, Bristol, 6	*O.*
A.	Hardy, Miss B., B.Sc.	5 Clare Road, Cotham Bristol, 6	*Bi.*
A.	Harker, Miss J. M., B.Sc. ..	27 Beaconsfield Road, Clifton, Bristol, 8	*Bi.*
	Hayman, Mrs. E. S.	3 Chatford House, Clifton Down, Bristol, 8	*B.E.F.G.O.*
	Hayward, Miss E.	31 Manor Road, Bishopston, Bristol, 7	*O.*
+	Heslop, I. R. P., M.A., F.R.E.S.	34 Henleaze Gardens, Westbury-on-Trym, Bristol	
	Hiley, Miss M. D.	9 Vyvyan Terrace, Clifton, Bristol, 8	*F.*
	Hiley, Miss W. F.	9 Vyvyan Terrace, Clifton, Bristol, 8	*F.*
A.	Hill, Miss L. M., B.A.	15 Clare Avenue, Bishopston, Bristol, 7	*Bi.*
	Hillyer, Miss E. M.	13 Caledonia Place, Clifton, Bristol, 8	*O.*
A.	Hodder, Mrs. N. F.	11 Beaufort Road, Clifton, Bristol, 8	*F.*
	Hodgson, C. J.	5 Cotham Terrace, Cotham, Bristol, 6	
A.	How, John C.	17 Wellington Park, Clifton, Bristol, 8	*B.*
	Howells, G. T. (1939) ...	43 Wellington Walk, Henleaze, Bristol, 6	
	Hudson, F. G.	The Elms, Stinchcombe, Dursley, Glos.	*G.*
	Hudson, Mrs. (1939)	The Elms, Stinchcombe, Dursley, Glos.	*G.*
	Humphries, Lady	Eastfield Lodge, Westbury-on-Trym, Bristol	*O.*
A.	Hunt, Miss L. A.	7 Alpha Road, Southville, Bristol, 3	*F.O.*
A.	Hutchinson, Miss M. I. ..	57 Oakfield Road, Clifton, Bristol, 8	*F.*
J.	Iles, J. F.	26 Leonard Road, Redfield, Bristol, 5	*B.*
	Ivens, H. P.	18 Alexandra Road, Clifton, Bristol, 8	*F.*
	Jeffcoat, Rev. R., M.A. ..	5 Berkeley Square, Clifton, Bristol, 8	*B.E.F.G.O*

	Jenkin, Miss P. M., M.A. ..	The University, Bristol, 8	
	Jenkins, F. G., M.B., Ch.B.	51 Redcliff Hill, Bristol, 1	
*	Kearns, H. G. H., Ph.D., B.Sc., F.R.E.S.	The Research Station, Long Ashton, Bristol	
*	Kellaway, G. A., B.Sc. ..	Geological Survey and Museum, South Kensington, London, S.W.7.	*G.*
*	Kendall, O. D., M.A.	3 Old Sneed Road, Stoke Bishop, Bristol, 9	
A.	King, B.	Mayfield, Uplands Road, Saltford, Bristol	*B.O.*
A.	King, Mrs. B.	Mayfield, Uplands Road, Saltford, Bristol	*O.*
A.	Kromler, A. A.	45 Summerleaze, Fishponds, Bristol	*E.*
A.	Lamb, Miss W. H.	Harcombe Hill, Winterbourne Down, nr. Bristol	*B.F.*
*	Leach, A. C., M.A.	11 Percival Road, Clifton, Bristol, 8	*O.*
	Leach, Mrs. A. C.	11 Percival Road, Clifton, Bristol, 8	*O.*
A.	Lewis, Mrs.	12 Broadway Avenue, Westbury-on-Trym, Bristol	*F.O.*
	Lewis, H. M.	"Arnwood," Lansdowne Road, Bath	*O.*
A.	London, Miss G. M.	26 Woodcroft Avenue, Whitehall, Bristol, 5	*B.Bi.*
A.	Lucas, H. J., F.S.L., F.I.S.A.	14 Walcot Parade, Bath	*G.*
*A.**	Luckwill, L. C., B.Sc.	36 Lower Redland Road, Bristol, 6	*B.*
	Macdonald, D.	Hill View, Berrow Road, Burnham-on-Sea	*O.*
	Macpherson, Miss B. B. ..	35 Richmond Terrace, Clifton, Bristol, 8	*F.*
	Mappin, S. W.	100 Pembroke Road, Clifton, Bristol, 8	*G.*
	Marsden, A., M.Sc., F.I.C.	161 Bishop Road, Bishopston, Bristol, 7	*G.*
	Marsden, Mrs.	161 Bishop Road, Bishopston, Bristol, 7	*F.G.*
*	Matthews, L. H., M.A.	27 Hanbury Road, Clifton, Bristol, 8	*O.*
	Maunder, G. S., B.Sc.	83 Coronation Road, Bristol, 3	*B.F.G.*
	Maxwell, H. W.	10A Downfield Road, Clifton, Bristol, 8	*F.O.*
	Maxwell, Mrs.	10A Downfield Road, Clifton, Bristol, 8	*F.*
	McErvel, Miss N.	Westonbirt School, near Tetbury, Glos.	*O.*
*	McMurtrie, G. E. J.	Eastfield House, Westbury-on-Trym, Bristol	*F.G.*
	McMurtrie, Mrs.	Eastfield House, Westbury-on-Trym, Bristol	*F.*
	Mead, Miss C. E., B.A.	16 Quadrant West, Hillfields Park, Bristol	*F.G.*
A.	Merryweather, Miss M. D.	11 St. John's Road, Clifton, Bristol, 8	*F.*
	Milton, Mrs. I. C.	10 Randall Road, Bristol, 8	*F.O.*
	Mogford, C. J.	13 Park Grove, Westbury Park, Bristol, 6	*Bi.F.G.*

*A.**	Mogg, G.	483 Fishponds Road, Bristol, 5	*F.O.*
A.	Morrison, Miss A. M. C.	8 Richmond Hill, Clifton, Bristol, 8	*F.*
	Morrison, Miss E. J. D., M.A.	6 Greenway Road, Redland, Bristol, 6	*F.*
A.	Muschamp, D.	32 Davis Street, Avonmouth, Bristol	*Bi.*
A.	Neal, H. W.	70 Trymside, Sea Mills, Bristol, 9	*O.*
A.	Nettle, Miss E. C.	3 Beaufort Road, Kingswood, Bristol	*Bi.F.*
A.	Newman, Miss E.	49 Henleaze Road, Westbury-on-Trym, Bristol	*Bi.*
	Norgrove, J. W.	22 Alma Road, Clifton, Bristol, 8	*E.*
A.	Patch, Miss E. M., B.Sc.	71 Canford Lane, Bristol, 9	*Bi.*
A.	Paterson, Miss K. M. Noel (resigned 1938)	Windyridge, 17 Greendale Road, Redland, Bristol, 6	*O.*
*	Peach, A. H.	5 Hanbury Road, Clifton, Bristol, 8	*E.*
*	Pearman, J. V., F.R.E.S.	56 Clifton Park Road, Clifton, Bristol, 8	*E.*
A.	Pedler, H. H.	21 Clift Road, Ashton Gate, Bristol, 3	*G.*
A.	Perryman, F.	21 St. Albans Road, Westbury Park, Bristol, 6	*Bi.*
A.	Potter, Miss E. A.	Westonbirt School, near Tetbury, Glos.	*Bi.O.*
	Powell, J. J., M.D.	18 Elgin Park, Redland, Bristol, 6	*G.*
A.	Pratt, Miss D. L.	1 Hughenden Road, Clifton, Bristol, 8	*B.F.*
	Priscott, Miss L. (1939)	16 Victoria Square, Clifton, Bristol, 8	*G.*
*	Purchon, R. Denison, B.Sc.	11 Cotham Gardens, Redland, Bristol, 6	*O.*
A.	Race, Miss E. M.	16 Upper Belgrave Road, Clifton, Bristol, 8	*F.*
*	Rafter, J., M.A.	228 Shirehampton Road, Westbury-on-Trym, Bristol	
	Reed, F. N.	18 Stackpool Road, Southville, Bristol, 3	*B.F.G.*
	Reed, W. N.	18 Stackpool Road, Southville, Bristol, 3	*F.G.*
	Rendell, Miss G.	19 Westfield Park, Bristol, 6	*Bi.*
*	Reynolds, Prof. S. H., M.A., Sc.D., F.G.S.	13 All Saints' Road, Clifton, Bristol, 8	*G.O.*
	Richards, G.	Pensylva, Cecil Road, Weston-super-Mare	*F.G.*
A.	Riddle, Miss H. E.	20 Banwell Road, Ashton Gate, Bristol, 3	*Bi.F.*
	Ross, F. Stenhouse	25 Tugela Road, Uplands Estate, Bristol, 3	*G.*
	Ross, James, F.L.A.	Central Library, Bristol, 1	
	Rutter, Miss E. M.	32 Henleaze Gardens, Bristol, 9	*B.*
	St. John, Miss E., M.A.	19 Down Cote View, Bristol, 9	*Bi.*
A.	Salmond, P. W.	22 Tyndall's Park Road, Clifton, Bristol, 8	*F.G.*
	Salter, Miss Joan E. R., B.A.	47 Well Lane, Horsell, Woking	*B.*

A.	Sampson, Miss A. M.	Bristol Road, Congresbury, nr. Bristol	*Bi.*
	Sanders, Miss L. M. (resigned 1938)	Redroofs, 6 Downs Cote Park, Westbury-on-Trym, Bristol	*F.G.*
*	Sandwith, Mrs.	26 Canynge Square, Clifton, Bristol, 8	*B.E.*
A.	Saunders, Miss C. E.....	25 Robertson Road, Eastville, Bristol, 5	*Bi.*
	Savory, J. H.	Windyridge, Abbots Leigh, near Bristol	*O.*
A.	Scase, R. P.	Wills Hall, Stoke Bishop, Bristol, 9	*O.*
	Scougall, A., B.Sc..... (resigned 1939)	109 Howard Road, Westbury Park, Bristol, 6	*G.O.*
	Selley, A.	116 Coronation Road, Bristol, 3	*G.*
	Shaw, Miss T.	12c Kingsdown Parade, Bristol, 6	*B.F.G.*
	Shearer, Miss O. M. (1939)	15 Abbotsford Road, Redland, Bristol, 6	*F.O.*
A.	Shield, Miss M., B.Sc.	Brackenhurst, 6 Southmead Road, Filton, Bristol	*Bi.*
	Shilstone, H. C.	124 Victoria Avenue, Redfield, Bristol, 5	*F.G.*
A.	Simmons, Miss L., L.R.A.M.	47 Grosvenor Road, St. Paul's, Bristol, 2	*F.O.*
*	Skene, Prof. Macgregor, D.Sc., F.L.S.	The University, Bristol, 8	*B.F.*
	Skene, Mrs. (1939)	36 Lawrence Grove, Westbury-on-Trym, Bristol	
A.	Smith, Miss M. de Lattre ..	The School House, High Ham, Taunton, Som.	*G.*
	Smith, D. Munro, M.R.C.S., L.R.C.P.	Norfolk House, Overnhill Road, Downend, near Bristol	*B.O.*
J.	Smith, P. G. Munro	Norfolk House, Overnhill Road, Downend near Bristol	*B.O.*
*	Smith, Stanley, M.A., D.Sc., F.G.S.	The University, Bristol, 8	*G.*
A.	Stanhope, Rev. A. J.	"Jesmond," 182 Bishop Road, Bristol, 7	*F.G.*
	Statton, A. G.	2 Auburn Road, Redland, Bristol, 6	
A.	Strudwick, Miss F. E., M.A.	26 Woodstock Road, Redland, Bristol, 6	*B.F.*
	Sully, H. T. (deceased 1939)	Elmside, Julian Road, Stoke Bishop, Bristol, 9	
	Tarring, E. (resigned 1938)	Mimosa, 196 Bishop Road, Bristol, 7	*B.F.*
	Taunton, W. C.	70 Halsbury Road, Westbury Park, Bristol, 6	*E.O.*
	Taylor, Miss M., D.Sc.....	The University, Bristol, 8	*O.*
A.	Taylor, R. J.	12 Claremont Avenue, Bishopston, Bristol, 7	*F.*
	Taylor, W. R., M.A.	5 Pembroke Vale, Clifton, Bristol, 8	*O.*
*	Tetley, H., B.Sc., F.Z.S. ..	4 The Avenue, Sneyd Park, Bristol, 9	*E.O.*
	Tetley, Mrs.	4 The Avenue, Sneyd Park, Bristol, 9	*O.*
A.	Thomas, Richard	131 Cumberland Road, Redcliff, Bristol, 1	*G.*
*	Thompson, H. S., A.L.S...	22 West Mall, Clifton, Bristol, 8	*B.F.G.*
A.	Tombleson, F. B. (deceased 1938)	Shirley, Briercliffe Road, Westbury-on-Trym, Bristol	*G.*

J.	Trenerry, G. G.	Windover, 54 Kellaway Avenue, Bristol, 6	*O.*
*	Trueman, Prof. A. E., D.Sc. F.G.S.	The University, Glasgow.	*G.*
	Trueman, Mrs. A. E.	c/o The University, Glasgow	*G.*
	Tucker, B. W., M.A., M.B.O.U.	9 Marston Ferry Road, Oxford	*O.*
	Turner, H. W., M.A., F.G.S.	The University, Bristol, 8	*G.*
	Turner, Mrs. H. W.	Mortimer House, Clifton, Bristol, 8	
*	Tutcher, J. W., M.Sc.	57 Berkeley Road, Bishopston, Bristol, 7	*F.G.*
	Veal, Mrs. G. C. (resigned 1939)	Lower Hazel House, Rudgeway, near Bristol	*O.*
A.	Verhey, Miss D. E., B.Sc. ..	Stanmore House, Royal Crescent, Weston-super-Mare	*B.*
*	Wallis, F. S., D.Sc., Ph.D. F.G.S.	The Museum and Art Gallery, Bristol, 8	*F.G.*
A.	Walsh, Miss C. L. B.....	8 Alma Vale, Clifton, Bristol, 8	*F.*
	Walton, C. L., Ph.D., M.Sc.	The Research Station, Long Ashton, nr. Bristol	*O.*
	Walton, Mrs. C. L., ...	34 Northumberland Road, Redland, Bristol, 6	*O.*
	Wareham, Miss F.....	252 Charlton Road, Kingswood, Bristol	*O.*
	Webb, H. M., B.Sc.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*G.O.*
	Webb, Mrs. H. M.	Redgarth, Church Road, Stoke Bishop, Bristol, 9	*O.*
	Webb, H. Vicars	58 Belmont Road, St. Andrew's, Bristol, 6	*F.O.*
A.	Weetman, Miss M. J. (resigned 1938)	60 Ashley Road, Bristol, 6	*Bi.F.*
*	Welch, F. B. A., B.Sc., Ph.D., F.G.S.	H.M. Geological Survey, S. Kensington, S.W.7	*G.*
A.	Wheeler, Miss K. E.	Hillside, Watchet, Som.	*F.*
	Whittard, Prof. W. F., D.Sc., Ph.D., F.G.S.	The University, Bristol, 8	*G.*
+	Wills, W. Melville	Bracken Hill, Leigh Woods, Bristol	
A.	Woolls, Miss F. R.	14 Russell Grove, Westbury Park, Bristol, 6	*Bi.B.*
A.	Yeates, G. K. ..... (resigned 1938)	Sherborne School, Sherborne, Dorset	*O.*
*	Yonge, Prof. C. M., D.Sc. ..	The University, Bristol, 8	
A.	Zealand, Mrs. H. W. (resigned 1939)	Brecon Lodge, Westbury-on-Trym, Bristol	*F.*

* * * *

Honorary Members

R. M. Prideaux, F.R.E.S., Brasted Chart, near Sevenoaks, Kent.
Prof. H. S. Hele Shaw, M.I.C.E., LL.D., F.R.S., 64 Victoria Street, Westminster, S.W.1.
Sir Ernest Cook, D.Sc., 40 Alma Road, Clifton, Bristol, 8.
H. Womersley, F.R.E.S., A.L.S., 36 Wattle Street, Fullerton Estate, Adelaide, S. Australia.

REPORT OF COUNCIL

TO DECEMBER 31st

1938

YOUR Council reports that during the year the Society has lost 3 members by death, and 36 members by resignation, whilst 36 new members were elected. The number of members now stands at 239.

Council regrets to record the deaths of Mr. B. A. Baker, Mr. F. B. Tombleson and Canon the Rev. R. W. Goodall, M.A.

At the Annual General Meeting in January the following new appointments were made : President, Professor M. Skene ; Vice-President, Mr. H. Tetley ; Members of Council, Prof. W. F. Whittard, Messrs. I. Evans and L. H. Matthews. At this meeting Mr. G. E. J. McMurtrie, the retiring President, presented to the Society the Epidiascope purchased as a Memorial to the late Miss Ida Roper.

The Society was represented at the Centenary Celebrations of the Linnean Society of London by the President.

During the year a communication was received from the Association for the Study of Systematics in Relation to General Biology, asking for co-operation in its work. A report on this work was presented to Council by Professor C. M. Yonge. Particulars have been sent to the sections concerned and it is hoped that these sections and their members may be able to undertake some of the investigations suggested in the coming year. Council believes that work of this nature would offer new opportunities to members of the Society.

Your Council has been in communication with various local bodies interested in the sign-posting of field paths in the neighbourhood. It has not been found possible to take any definite action, but a Committee has been appointed to watch the situation.

The 11th Annual Dinner was held in the Royal Hotel on February 3rd, and was attended by 54 members and guests. After dinner those present were entertained by Mr. Prideaux.

The Summer Field Meeting was as usual arranged by the Field Section and was successfully held on June 18th, when Mr. H. F. Barke led the party through Ebbor Gorge and over Dulcote Hill.

F. STENHOUSE ROSS, *Hon. Secretary.*

The Hon. Treasurer in Account with the Bristol Naturalists' Society

Dr. RECEIPTS AND PAYMENTS FOR THE YEAR ENDING 31st DECEMBER, 1938 *Cr.*

1937 £	s.	d.		£	s.	d.	£	s.	d.
			To Members' Subscriptions :—						
	10	0	Ordinary : Arrears from 1936 ..		5	0			
6	17	6	,, ,, 1937 ..	2	5	0			
50	10	0	,, 1938	51	10	0			
5	5	0	,, 1938 (new)	4	10	0			
3	15	0	,, in advance, 1939 ..	1	5	0			
			,, ,, 1939 (new)	1	0	0			
1	2	6	Associate : Arrears from 1937 ..		10	0			
16	15	0	,, 1938	16	0	0			
	17	6	,, in advance						
			,, 1938 (new)		10	0			
	2	6	Junior : Arrears from 1936 ..		2	6			
	7	6	,, ,, 1937 ..		2	6			
	2	6	,, 1938		7	6			
							78	7	6
86	5	0							
28	3	0	,, Subscriptions to Sections received by Hon. Treasurer	..		..	26	11	0
114	8	0					104	18	6
10	0	0	,, Grants received towards *Proceedings*	..		..	22	0	0
4	19	3	,, Sale of Publications	..		..	6	17	6
13	15	0	,, ,, Dinner Tickets	..		..	13	10	0
12	0	6	,, ,, Tickets for Field Meeting	..		..	12	0	6
1	12	0	,, Interest on Deposit	..		..	1	7	2
143	0	5	,, Balance from last Account ..	..		..	104	17	8
299	15	2					£265	11	4

1937 £	s.	d.		£	s.	d.	£	s.	d.
			By Subscriptions :—						
1	1	0	Ray Society	1	1	0			
2	10	0	Zoological Record	2	10	0			
	18	0	S.W. Naturalists' Union, 1938 ..		18	0			
			British Empire Naturalists' Assn. 1938 and 1939		10	0			
							4	19	0
70	3	4	,, Cost of *Proceedings*, 1937	..		..	71	16	4
10	3	0	,, Reprints of various papers ..	..		..	14	9	2
12	0	7	,, Printing, Postage, Stationery, etc.	..		..	18	7	9
6	3	2	,, Lecture Expenses	..		..	11	2	2
1	11	0	,, Rent and Fire Insurance	..		..	1	11	0
12	19	0	,, Dinner Expenses	..		..	13	8	0
1	6	8	,, Librarian's Expenses	..		..	8	1	5
12	11	9	,, Field Meeting : Expenses ..	..		..	12	0	6
28	7	6	,, Subscriptions to Sections paid over by Hon. Treasurer	..		..	26	11	0
35	2	6	,, Memorial Fund to late Miss I. M. Roper. Purchase of Journal of Botany" (6 volumes) and incidental expenses	..		..	8	10	6
			,, Cash at Bank :—						
92	14	8	General Fund	70	14	6			
8	3	0	Ida M. Roper Memorial Fund ..						
							70	14	6
4	0	0	,, Cash in hands of Hon. Secretary ..	..		..	4	0	0
299	15	2					£265	11	4

F. W. EVENS, *Hon. Treasurer.*
7th January, 1939.

Audited and found correct.

ERNEST H. COOK,
CHAS. BARTLETT, F.C.A. } Auditors.

Bristol, 16th January, 1939.

LIBRARIAN'S REPORT

FOR THE YEAR 1938

IN the Librarian's Report for 1937 it was suggested that a rack for the display of new books would be a useful addition to the Library. A rack of the type suggested has now been acquired, and all recent additions can now be seen at a glance. Arrangements for borrowing have been somewhat simplified by the introduction of a Borrowers' Book, and a beginning has been made on the work of cataloguing the Library although it will be some time before this work is completed. A list of books for binding is being prepared for consideration by the Library and Publications Committee.

Arrangements have been made during the year for exchange of the Society's *Proceedings* with the following:

1. Annual Report of the Devon Bird-watching and Preservation Society.
2. Mitteilungen aus dem Zoologischen Museum zu Berlin.
3. Publications of the Societas pro Fauna et Flora Fennica.
4. The American Midland Naturalist.

The Society is indebted to the British Museum (Natural History), Mr. H. S. Thompson, Mr. I. R. P. Heslop and Mr. H. J. J. F. Gibbons for the presentation of books. A number of geological books were also received from the estate of Mr. B. A. Baker, F.G.S. Witherby's *British Birds* is being purchased for the Library as published; Volumes I and II are already in the Library. Six volumes of the *Journal of Botany* were purchased out of the balance of the Roper Memorial Fund, and current numbers of this periodical are now subscribed for by the Botanical Section, and presented to the Library. Journals have been received, as in previous years, from the Geological, Entomological and Ornithological Sections.

The number of books borrowed from the Library during the year was 189.

H. GORVETT, *Hon. Librarian.*

REPORT OF BIOLOGY TEACHERS' SECTION

1938

THIS has been the first complete year for this Section, and it would seem that its formation has been fully justified. It has a membership of thirty-two, most of whom are very keen. During the year nine meetings have been held and attendance at these, especially the later ones, has been very encouraging.

In February, Mr. L. W. Gilbert, of the Local Inspectorate, opened a discussion on "The Content of the Biology Syllabus in Elementary Schools," a subject which is naturally of great importance to all teachers. Experiences were recounted and discussed and many useful suggestions were brought forward.

At the March meeting, Dr. R. Bracher gave a most helpful talk on "Ecology in the Schools." Her numerous exhibits gave practical demonstration of the possibilities of dealing with this subject within the confines of the classroom.

The Open Meeting of the Section was held in April when Professor R. Hewer, lecturer of the Imperial College, London, and co-director of biological film production for Gaumont British Instructional Films, gave a very enlightening programme of biological films, and also spoke on the actual making of the films.

During the summer, meetings took the form of excursions such as might suitably be taken with a class of children. To follow up her talk on Ecology, Dr. Bracher conducted the first of these to Blaise Castle Woods where members were instructed in field methods of estimating numbers of plants and ecological factors with a view to using these methods in schools.

In June, Miss Bowen conducted a party to Nailsea where she demonstrated various methods of collecting pond material, both plant and animal.

Professor Skene took the lead in the third of the out-door meetings which involved a study of the flora of the Downs and Gully.

As the Section had completed its first year of existence, a General Meeting was held in October though it is hoped in future to hold this in January, and thus fall into line with other Sections of the Society. The President and Secretary were re-elected, and Dr. Bracher, Miss M. Shield, Miss G. Cornish and Miss J. Harker were elected to the committee to serve with Miss A. Fitzjohn and Mr. T. L. Green who were re-elected. Miss Bowen then addressed the meeting as President, taking as her subject "Films in the School." She spoke of the advantages and disadvantages of the use of the film, and said that the chief difficulty seemed to be in finding the right films to fit in with the syllabus of work. She showed how this could be overcome by giving a demonstration of films which she had made herself to fit in with the work she was doing with her classes. At the end of the meeting she suggested that, if any members were keen enough, a sub-group might be formed for the purpose of making biological films.

At the next meeting, which was an Open one, Dr. G. K. Sutherland spoke on "Natural History Methods in the Elementary School." He urged the necessity of first-hand observation in the keeping of aquaria and vivaria and also spoke at some length on school gardens.

At the final meeting of the year, Mr. C. C. Perkins of Clifton Zoological Gardens, gave practical hints on the keeping of aquaria. He gave very clear and definite instructions on the best means of keeping healthy aquaria, and the questions asked at the end showed how widely interested members are in this subject.

E. DUDDRIDGE, *Hon. Secretary.*

REPORT OF BOTANICAL SECTION

1938

AT the Annual Meeting in January it was decided that, as the *Journal of Botany* had been brought up to date with the balance of the Roper Memorial Fund, the Section would subscribe to this publication and present the volumes to the Library of the Society. In order to do this the sectional subscription has been increased by sixpence.

The epidiascope, which is the memorial to Miss Roper, was used for the first time in February to illustrate a lecture by Mrs. Sandwith on the South African Flora. Photographs of the vegetation and district around the Cape and in Southern and Northern Rhodesia were shown, together with a number of flowers and fruits which Mrs. Sandwith brought back in 1931.

Members of the Section expressed a willingness to co-operate with the "Association for the Study of Systematics in relation to General Biology" in the district designated as the Bristol Coalfield. When fuller details had been obtained from the Association, the Section agreed to give special attention to the ecological distribution of *Silene Cucubalus* and *Silene maritima* and the geographical distribution of the rayed varieties of *Centaurea nigra*. The following names were submitted as recorders: Mrs. Sandwith for Higher Plants, Dr. Campbell for Fungi, and Miss Fitzjohn for Algae.

In July, the Section again paid a visit to the University Gardens under the leadership of Prof. Skene. Many interesting specimens were observed in the Natural Order Beds, the Cactus House and the new pond.

The Open Meeting in October was well attended by members of the Section and fifteen visitors from other Sections. Prof. Skene gave a paper on the Vegetation of Steep Holm. He dealt first with the records of visits of early botanists and then referred to his own visit during which he found six plants not formerly included in the list of plants growing on the island. In the discussion which followed, Mrs. Sandwith showed sheets with specimens of the Steep Holm Leek, *Allium ampeloprasum*, and one grown from a bulbil.

At the December meeting, Dr. Yemm gave a lecture on the Yorkshire Peat Moors, dealing particularly with the peat deposits on limestone at Wensleydale. These peat moors are comparatively recent, having Anglo-Saxon place names and covering a Roman Road.

Specimens and exhibits of botanical interest have been shown at each monthly meeting.

F. F. GLASSPOOL, *Hon. Secretary.*

REPORT OF ENTOMOLOGICAL SECTION

1938

12th Jan. 74th Annual Meeting. Mr. C. Bartlett, having acted as President and Hon. Secretary for the last four years, asked to be excused further office, as he had held the position of Hon. Secretary for 33 years and that of President for 13 years. Mr. J. W. Norgrove was elected President, and Mr. C. Edwards, Hon. Secretary.

Mr. Bartlett exhibited, for Dr. E. Barton White of Braunton, a live full-grown larva and an imago of the Cockchafer *Melolontha vulgaris.*

2nd Feb. Special Meeting to report the resignation of Mr. C. Edwards as Hon. Secretary through removal from Bristol; the office was not filled as no member would undertake the duties.

8th Feb. Open General Meeting held at the University.

Mr. H. Tetley read notes upon the Termites and exhibited pieces of wood destroyed by their ravages. The various forms were described as king, queen, soldiers and workers; their underground galleries, huge colonies and ant hills, fungus gardens, and parasitic polyzoa which assisted the digestion of food, were also described.

Mr. W. R. Taylor read extracts from the works of Fabre including sections relating to assembling in moths, Pine Processionary Moth, Hairy Hunting Wasps and Scarab Beetle.

Mr. Norgrove exhibited specimens of *Bombyx quercus* and *Psilura monacha,* and described his experiences in assembling with these species of moths.

Mr. Bartlett read a paper upon the British Humble Bees and their hymenopterous parasitic genus *Psithyrus* and dipterous parasite *Volucella bombylans,* illustrated by a cabinet drawer of the species.

12th April. Mr. Bartlett again agreed to accept and was elected to the office of Hon. Secretary.

It was unanimously resolved to request the Society to provide their own room to house the library and to be available for sectional meetings at all reasonable times as in past years.

Notes and exhibits were provided by Messrs. Audcent, Bartlett, Davis, Kromler and Peach.

11th Oct. Exhibition by members of the season's captures.

13th Dec. Mr. M. Davis read a paper upon the British Hairstreak butterflies, illustrated by examples of the five species. Mr. P. Davis exhibited some Lepidoptera taken by Mr. L. H. T. Ashburner from the Rupunani district of British Guiana, which included two new and undescribed species of moths, *Phaloc* n.s. and *Stenele* n.s., both of which are mimetic.

The year closed with sixteen members.

CHAS. BARTLETT, *Hon. Secretary.*

REPORT OF FIELD SECTION

1938

AT the Annual Meeting held in January all the officers were re-elected, as was the Committee with Mr. H. O. Edmonds in lieu of Mr. H. C. Bishop who had resigned. Instead of the more orthodox Presidential Address a discussion took place regarding the value of the scenic heritage with especial reference to the West of England. Dr. F. S. Wallis introduced the subject and emphasised the importance of safeguarding this inheritance, enumerating the four chief factors which determined scenery. He also mentioned some of the powers given to local authorities by recent Acts of Parliament for the purpose of controlling amenities. Many members took part in an interesting discussion.

Following the policy of recent years, an area was selected for the summer session, all meetings being confined within this chosen district. The prominent Carboniferous Limestone inliers which rise up steeply from the moors to the south of Mendip formed an excellent district, and your Section is grateful to those who so generously led meetings or contributed to the descriptive notes.

Mr. G. H. Beacham was the general leader in May when Nyland Hill and Draycott were visited. Owing to the drought, vegetation was poor, but members were interested in the Draycott stone.

In June the President and Secretary of your Section (Mr. H. F. Barke and Miss M. D. Hiley) were responsible for the arrangements at the Annual Field Meeting of the Society at Ebbor Gorge and Dulcote Hill. Members descended the well-known gorge, and after tea the church at Wookey was visited under the guidance of the Rev. H. Lawrence Walker, M.A.

Dulcote Hill with its prominent crags of limestone provided much of interest for all members, botanists being especially fortunate in observing many characteristic plants.

Mr. H. O. Edmonds was the general leader in July when the neighbourhood of Croscombe and Ham Woods was visited. On this occasion there were morning and afternoon parties which met at Maesbury Camp. Professor Macgregor Skene was able at several places to demonstrate the relationship of the trees with the solid rocks shown by the sharp contrast between the ash woods on the limestone and the oak copses on the Old Red Sandstone.

At Lodge Hill in September, Mrs. E. Hayman and Mr. Ivor Evans were leaders. Once again the predominant calcareous nature of the vegetation was demonstrated. The Rev. R. Jeffcoat fully described the small Rodney Stoke church, drawing particular attention to the Rodney effigies.

Finally, in October, Mr. G. E. J. McMurtrie led the party from Dinder Church through the village to Dinder Wood. A walk over the top of Lyatt Hill enabled members to epitomise in a short distance all the various features

that had been examined during the summer. A visit to Tor Hill quarry near Wells was instructive on account of the iron-staining and Triassic dykes.

The special Ornithological meetings were again arranged by Mr. Vicars Webb who conducted five parties in April, May and early June, to Filton and Stapleton, Blagdon Lake, Hanham Woods, Leigh Woods and Abbot's Pool, and Saltford.

At Saltford on 15th June, a pair of red-backed Shrikes were seen at their nesting site, and on the river banks four Waterhens' nests, all occupied. At the weir the leader gave a short talk on a young Cuckoo found there dead in a Pied Wagtail's nest.

Mr. Ivor Evans kindly arranged and conducted six parties for Botanical study, and visited Crew's Hole and Brislington, Bitton, Grantham Rocks and Wick, Pensford, Hunstrete Woods and Woollard, Brockley Combe and Broadfield Down, Shirehampton and Hallen Marsh and the Wickwar district. The last named, in August, was a whole day meeting when Mr. F. W. Evens acted as co-leader.

The membership of the Section at the end of the year stands at 79.

M. DORIS HILEY, *Hon. Secretary.*

REPORT OF GEOLOGICAL SECTION

1938

THE Annual Meeting was held on January 27th, 1938, at 7.15 p.m. Professor W. F. Whittard was elected President, and Dr. F. S. Wallis was re-elected Vice-President. The Secretary, Treasurer and Committee were re-elected, with Mr. H. S. Barker to fill the vacancy on committee caused by the departure of Mr. G. Kellaway for London. Mr. H. S. Cole then delivered his lecture, "Some Historic Aspects of Geology."

February 24th. Professor W. F. Whittard gave a lecture on "Glaciers, Icebergs, and Pack Ice" which was illustrated with many fine lantern slides.

March 17th. Professor W. T. Gordon gave a most interesting lecture entitled "The Scientific Basis of the Lapidary's Art."

Our Summer season was opened with an excursion to Limpley Stoke and Bradford-on-Avon, led by Dr. S. Smith; a party of 25 attended. We were met at Limpley Stoke by Major Gorham who directed the party to an exposure in the Upper Lias where members collected some fine specimens, especially ammonites.

The next field meeting was held on July 13th and was led by Dr. F. S. Wallis and Mr. H. M. Webb. The party visited the bore hole at Alma Road, Clifton, where Dr. Wallis explained the local geological structure in relation to the present exposures. Mr. Webb compared this boring with the main bores that were to be made in the Carboniferous Limestone for the new sewage system for the City of Bristol. The party then visited a well-known quarry at King's Weston Down, where the Carboniferous Limestone is intensely folded and faulted.

The last Summer meeting was by charabanc to the eastern Mendips. The object of this excursion was to examine the exposures of the Silurian rocks, which include lavas and tuffs. The party stopped at Beacon Hill where Prof. S. H. Reynolds first explained the relationship between the Old Red Sandstone and the Silurian rocks and then pointed out the topographical features which can be seen from this viewpoint. A visit was then made to the quarries in the Silurian volcanic rocks.

The Winter session opened on October 20th with an interesting and instructive lecture by Mr. F. C. Hudson, illustrated with some very fine lantern slides, on the "Scenery and Geology of the Southern Malverns."

On November 17th, Dr. T. Wallace gave an instructive lecture on "Soils and Soil Survey" illustrated by soil maps and sections.

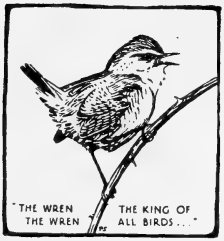
We regret to record the deaths of the Rev. Canon Goodall and Mr. B. A. Baker, also the resignations of Mr. H. S. Cole, Mr. H. S. Barker, Mr. W. E. Madkins and Miss L. M. Saunders.

We welcome four new members, viz., Mr. F. S. Clements, Miss L. Priscott, Mr. F. B. Welch, Mr. A. Scougall.

F. STENHOUSE ROSS, *Hon. Secretary.*

REPORT OF ORNITHOLOGICAL SECTION

1938



OWING largely to an increased membership, now totalling 72, and the continued enthusiasm among members themselves, this Section has enjoyed another most successful year. To this must be added the kindness and generosity of several leading ornithologists who have so willingly come long distances to lecture.

Six ordinary meetings have been held, with an average attendance of 30. At the Open Meeting in *November* there was an attendance of 95, the largest yet recorded at an Open Sectional Meeting. On this occasion the President of the Section gave his very popular lecture, "Lundy and its Bird-life."

The *January* meeting was devoted to two short accounts—"Bird-life in Iceland" by Prof. S. H. Reynolds, and "Some Birds observed in Spitzbergen" by Mr. H. M. Webb, both containing much of interest. More was learnt of bird-life in northern latitudes when in *February* Mr. B. W. Tucker came from Oxford and lectured on "A Bird Trip to Lapland." A fine series of slides was shown illustrating, among others, such interesting species as Mealy Redpoll, Lapland Bunting, Red-spotted Bluethroat, Three-toed Woodpecker, Rough-legged Buzzard and Temminck's Stint. In *March* much valuable information was given by the Rev. F. L. Blathwayt when he spoke on "Field Characters and Call Notes of British Waders."

At the *September* meeting Mr. H. Tetley gave an excellent illustrated account of "Bird-life in the Outer Hebrides," the outcome of a recent stay in that area. In *October* members were fortunate to hear the Rev. F. C. R. Jourdain who journeyed from Bournemouth and lectured, with slides, on "A Bird Trip to Palestine." Lastly, in *December*, Mr. W. B. Alexander gave a most instructive lantern talk on "Bird Observatories."

By kind invitation of the Society of East Anglians in Bristol, members were privileged to attend a meeting at the Royal Hotel on March 16th when Mr. Jim Vincent gave a lantern lecture on "Broadland Birds." A few members were fortunate in being able to accept an invitation from the Bristol University Zoological Society to a meeting on November 22nd, when Mr. G. H. J. Fursdon gave an illustrated account of "Bird-life on Skokholm."

The recent renewed effort to save the Kite in mid-Wales has received support from the Section, a sum of one guinea having been contributed to the Kite Preservation Fund. It has further been decided that support shall be given to the British Trust for Ornithology, and an immediate application for corporate membership is being made. It is much to be hoped that members will endeavour, whenever possible, to assist the Trust in its various activities.

The emblem shown at the beginning of this report has been adopted by the Section. This life-like picture of the Wren (first published in Lord Kennet's *A Bird in the Bush*) is from an original drawing by Mr. Peter Scott, who has kindly given his permission for it to be used for this purpose. The origin of the underlying inscription is fully quoted in Swainson's *Provincial Names and Folk Lore of British Birds*, pp. 36-37.

As in the past, members are greatly indebted to the Bristol Waterworks Company for permits, so readily granted, to visit their reservoirs at Barrow Gurney and Blagdon. This privilege has now been extended to include the newly constructed reservoir at Cheddar.

H. H. DAVIS, *Hon. Secretary.*

Account of the Annual and General Meetings

1938

THE 75TH ANNUAL MEETING of the Society was held at the University of Bristol on January 20th. The President-elect, Professor Macgregor Skene, was in the chair. Forty-two members were present. The Annual Reports were presented and accepted. The old Officers were re-elected with the exception of the retiring President and Vice-President whose offices were filled by Professor Macgregor Skene, President, and Mr. H. Tetley, Vice-President. New members of Council elected were: Mr. Ivor Evans, Mr. L. H. Matthews and Professor W. F. Whittard.

The motion of Dr. F. S. Wallis in reference to rule 4 was seconded by Mr. McMurtrie and carried without dissent.

The Epidiascope in memory of Miss Roper was formally presented to the Society. The President-elect received it in their name.

Mr. McMurtrie gave as his final address a review of his term of office, which has been reported in the 1937 *Proceedings*.

Mr. Turner moved a vote of thanks to the retiring President for his unstinted services; this was seconded by Mr. Evens, and carried with acclamation.

The 593RD GENERAL MEETING was the 11th Annual Dinner held in the Royal Hotel, College Green, on February 3rd. Professor Macgregor Skene was in the chair. In his address of welcome to the guests, he stressed the value of the *Proceedings*, containing facts collected by local naturalists, which were helpful to the specialists.

The 594TH GENERAL MEETING was held on March 3rd, in the University. Professor Skene was in the chair. Dr. Kitching gave his lecture, "Diving in the Sub-Littoral Regions," which was extremely interesting and original and an extensive survey of this subject.

The 595TH GENERAL MEETING was held on Saturday, June 18th, at Ebbor Gorge and Dulcote Hill. The Botanists had a good field day and the Geologists were able thoroughly to inspect the large quarry at Dulcote Hill.

The 596TH GENERAL MEETING was held in the University on October 6th. Professor Skene was in the chair. Coffee was served before the meeting. This was the Annual Exhibition Night, and the following were the exhibits:—

BOTANICAL.

Exhibits by Mrs. Sandwith, Mr. F. W. Evens, Miss Fitzjohn, Mrs. Bell and the Botanical Department of the University.

The University exhibit, the most popular of the exhibits, included squirting cucumber, and water hyacinth with inflated leaf stalks which caused it to float.

Mrs. Sandwith showed Umbelliferae in fruit.

Mrs. Bell showed Tamarind, Cardamon and Betel nut, from India.

GEOLOGICAL

Fine exhibit of metamorphic rocks from Cornwall by the Department of Geology of the University.

Mr. F. Stenhouse Ross—Ammonites from the Jurassic in Horn Park and Yeovil district, Dorset. Fine specimen of the Ammonite *Strenoceras niortense.*

Mr. H. G. Bell—Flexible sandstone from Rajputana, India.

ORNITHOLOGICAL

Mr. J. H. Savory—A fine series of Bird photographs.

Mr. H. H. Davis—A series of colour reproductions illustrating British Birds of Prey from drawings of the late Archibald Thorburn.

We trust the Biology Teachers' Section will be represented next year.

The 597TH GENERAL MEETING was held in the Museum Lecture Theatre on November 3rd, Professor Macgregor Skene in the chair. The film entitled "Moorland," featuring the Geology, Botany and Ornithology of Dartmoor, was shown. Comments were made by Professor W. F. Whittard, Professor Skene and Mr. H. Tetley. This was the Open Meeting.

The 598TH GENERAL MEETING was held in the Botanical Department of the University on December 1st. Professor Macgregor Skene was in the chair. Nominations for Officers and Council for 1939 were received. Professor W. F. Whittard gave a lecture, "A Visit to East Greenland," giving a general survey of the work that was carried out on the expedition, illustrated with some wonderful slides of glaciers and ice packs.

F. STENHOUSE ROSS, *Hon. Secretary.*

Bristol Botany in 1938

By Cecil I. Sandwith

(*Read in title, 2nd March,* 1939)

A MILD winter without the usual quota of frost and snow heralded an unusually early spring. To those hoping for a good season in the field, any gain was offset by the ensuing long season of drought. It was noticeable in this district that the sedges did not grow and flower with their normal vigour, and botanically the year was disappointing. One noticed that, in late autumn, plants that had no chance to grow in the earlier months were struggling on with little hope of fulfilling their vocation, and many *Rumices* were still in an early stage of flowering and immature fruit. Life had begun too late for them. An observer in Perth writes : " No fruit to speak of and except roses all flowers were unsatisfactory, being tall and untidy, a prey to every wind, so that they were over as soon as they flowered. I never saw a mountain-ash berry." Gales and drought had a disastrous effect on things generally. The high winds of early autumn did exceptional damage. In a West Country orchard four miles from the Channel, leaves on the fruit-trees were turned black in a night, a rather general idea being that this was caused by salt in the air driven from a distance at very high pressure. That these climatic conditions were not confined to this district or the West Country only is confirmed by observations made by the Statistical Department, Rothamsted Experimental Station, on the persistent spring and summer drought and the high temperature of early spring and late autumn, this combination of meteorological factors having an adverse effect on growing crops. The total rainfall recorded for the first eight months was 9·05 in., compared with the average of 17·89 in., the figures for temperature being January (+ 3·2 deg. F.), February (+ 1·0 deg. F.), March (+ 6·5 deg. F.), all warmer than the average, while April (— 1·3 deg. F.), and May (— 1·8 deg. F.) were below the average. Those who may not have considered this from a botanical point of view must have been concerned with the shortage, quality and high price of green vegetables during the autumn, the Broccoli particularly being a complete failure. It has been necessary to note this unusual season for the cause and effect on the flora generally which those studying in the field must have observed.

Through the kindness of Mr. H. Locke, Long Ashton Research Station, I am able to add the variations of temperature and rainfall in our own district, which are interesting for comparison. He remarks that the lack of sunshine was notable, a deficiency of 108·9 hours from the normal; March with 23·0 and April with 57·9 hours were the only months above the normal, April values being the highest since 1921.

1938

	Mean Temperature.		*Rainfall.*	
		Deviation.	*Total.*	*Deviation.*
February	44·1° F.	+ 3·4° F.	1·11 inches	— 1·78 inches
March	47·7	+ 4·2	0·46 ,,	— 2·02 ,,
April	46·3	— 0·6	0·25 ,,	— 2·25 ,,
May	52·3	— 0·5	2·19 ,,	— 0·22 ,,
June	58·1	— 0·4	1·29 ,,	— 0·82 ,,
July	59·5	— 2·8	3·94 ,,	+ 0·71 ,,
August	61·1	+ 0·2	3·36 ,,	+ 0·07 ,,
September	56·9	— 0·1	2·28 ,,	— 1·11 ,,

Hypericum hircinum L. In an old lane on Stoke Hill descending from Durdham Down, G., *Ivor Evans.*

Oxalis stricta L. Garden weed at Weston, Bath, S., *T. H. Green.* This species occurred plentifully in October, 1919, in a field of stubble by Failand House, S., *C.* and *N. Sandwith.*

Trifolium incarnatum L. Near Stoke Gifford, G., 1938, *Miss A. Dunn.*

Astragalus glycyphyllos L. Roadside between Chelwood and Hunstrete, S., *Miss Fitzjohn.*

Vicia sylvatica L. For a hundred yards near the Hawkesbury Monument towards Wotton-under-edge, G., *Ivor Evans* and *F. W. Evens.*

Epilobium montanum L. × *parviflorum* Schreb. Waste ground near the University, Bristol, G., 1938, *Mrs. Bell.* This interesting hybrid has not been recorded before for the W. Glos. side of the district.

Caucalis nodosa Scop. var. *pedunculata* (Rouy et Foucaud) Druce. Uphill, S., *J. P. M. Brenan.*

C. daucoides L. var *muricata* (Bisch.) G. et G. Several plants occurred among the typical form at Avonmouth Docks, G., last June,

C. and *N. Sandwith.* For a paper on this variety, which was first recorded for Britain from a railway siding between Shirehampton and Avonmouth in July, 1922, see the *Report of the Botanical Society and Exchange Club of the British Isles* for 1924.

Sambucus nigra L. var. *viridis* Ait. With pale yellowish-green, transparent berries. In an old lane on Stoke Hill, G., *Ivor Evans.* For the record of a similar bush from near Portishead, S., see "Bristol Botany in 1918," in *Proc. Bristol Nat. Soc.* 1920, p. 89.

Achillea Ptarmica L. A large patch of a very handsome "flore pleno" form in a rough pasture on Nailsea Moor, S., *N. Sandwith.*

Senecio squalidus L. A form with the heads rayless or with very reduced rays, unmatched in the National Herbaria, was found last June at Avonmouth Docks, G., *C.* and *N. Sandwith.*

Symphytum tuberosum L. Completely naturalised in one spot in the enclosed portion of Leigh Woods, S., May, 1932, *C.* and *N. Sandwith.*

Mentha gentilis L. Peat moor near Burtle, S., *A. L. Still* and *C. Sandwith.*

Ceratophyllum submersum L. Near Kingston Seymour, S., 1928, *H. J. Gibbons.*

Populus canescens Sm. × *tremula* L. (*P. hybrida* M. Bieb.). A tree bearing female catkins with crimson stigmas on the Manor Farm, Corston, S., *C. Sandwith.*

× *P. regenerata* Henry. Trees of this hybrid, which bears female catkins and is believed to have originated on several occasions as a backcross between × *P. serotina* Hartig and *P. nigra* L., have been noticed for some years near the G.W.R. west of Keynsham, S., *C. Sandwith.* An important paper on the Black Poplars and their hybrids cultivated in Britain was published as a separate memoir last year by G. S. Cansdale and members of the staff of the Imperial Forestry Institute, Oxford (price 3s. 6d., printed at the University Press, Oxford, 1938).

Carex Hudsonii Ar. Benn. Attention should be drawn to the remarkably early flowering of this species, which may be compared with that of the unrelated *C. humilis* and *C. digitata,* and contrasted with the later development of the allied *C. Goodenowii* and *C. gracilis.* In the abnormally precocious spring of 1938, stamens of *C. Hudsonii* were fully expanded in the Tickenham locality in the last days of February.

C. extensa Good. Shore of the Channel at Kingston Seymour, S., Sept., 1933, *C.* and *N. Sandwith.*

Pholiurus incurvus (L.) Schinz et Thellung. New to the district and to N. Somerset. At the base of dunes on the seaward side of the golf-course at Berrow, S., June, 1938, *R. Melville*; and on dry mud between Brean Down and Uphill Ferry, S., June, 1938, *J. P. M. Brenan.* For a full account of this species see C. E. Hubbard in *Proc. Linn. Soc.*, 1936, pp. 111-113. It differs from our common *P. filiformis* (Roth) Schinz et Thell. (*Lepturus filiformis* Trin.) in the spreading or ascending habit, the short culms with curved rigid spikes, and above all by the very short anthers (0·5–1 mm., not 2–3 mm.); and it prefers drier situations.

Bromus commutatus Schrad. Uphill, S., *J. P. M. Brenan.*

Lycopodium Selago L. Still existing very sparingly on Rowberrow Warren, S., in March, 1938, *C.* and *N. Sandwith.*

Aliens. The following were first records for Britain: *Carthamus oxyacantha* M. Bieb., found at Avonmouth Docks, G., by *C. Sandwith*; *Rumex stenophyllus* Ledeb., found at Avonmouth Docks, G., by *J. E. Lousley* (det. K. H. Rechinger); *Aegilops ligustica* (Sav.) Cass., found on the N. Somerset side of Bristol by *Ivor Evans.*

The following are additions to the adventive flora of Bristol (coll. C. I. and N. Y. Sandwith unless otherwise mentioned):—*Isatis tinctoria* L., *Euclidium syriacum* (L.) R. Br. and *Tordylium aegyptiacum* (L.) Lam., all at Avonmouth Docks, G.; *Atropa Belladonna* L., at Ashley Hill, G., *R. L. Smith* and *C. Sandwith*; *Chenopodium Botrys* L., at Wapping Wharf, Bristol Harbour, G.; *Phalaris paradoxa* L. var. *praemorsa* Coss. et Dur., at Avonmouth Docks, G.; and *Lagurus ovatus* L., on the N. Somerset side of Bristol, *Ivor Evans.*

The following species, which occur rarely in the district as colonists, were found last year as casuals in Avonmouth Docks, G.:—*Caucalis arvensis* Huds., *Valerianella rimosa* Bast. and *Galeopsis versicolor* Curt. The two last are additions to the Bristol adventive list. *Galeopsis versicolor* persists in its locality on the Somerset peat moor between Ashcott Station and Glastonbury. *Plantago aristata* Michx., a rare Bristol alien, was found at Avonmouth last year by *T. H. Green.*

Bristol material of the genus *Beckmannia* has recently been examined by Mr. C. E. Hubbard of Kew and has been assigned to two distinct

species, viz. *B. eruciformis* Host (spikelets 2-flowered) and *B. syzigachne* (Steud.) Fernald (spikelets 1-flowered). Of the Bristol gatherings mentioned in the "Adventive Flora," all should be assigned to *B. syzigachne* with the exception of the Avonmouth (1930) collection, which is *B. eruciformis*.

A form of *Carthamus lanatus* L., with pure white instead of yellow flowers, was found by C. Sandwith on the N. Somerset side of Bristol in 1937. This matches *Sintenis* 1957, from the Transcaspian region, in the Kew Herbarium, but appears to have no varietal name.

Found by *Miss White* near Bath, S. :—*Adonis annua* L. and *Salvia glutinosa* L. The latter species, discovered near Claverton, is new to the district.

"Flowers along a Deserted Roman Road" by Mr. H. O. Edmonds, March, 1938, in the *North Western Naturalist*, is a delightful account of the author's exploration of the Fosse and the old Roman road from Sarum which crosses Mendip at Charterhouse and leads to an ancient port at the foot of Brean Down. His observations on the wild flowers are those of a true lover of Nature.

Ornithological Notes, Bristol District, 1938

By H. H. Davis, M.B.O.U.

(*Read in title, 2nd March,* 1939)

IN recording the more important observations for 1938, special reference must be made to the recently constructed reservoir at Cheddar, which, by kind permission of the Bristol Waterworks Co., ornithologists have been able to visit frequently during the year. Lying at the foot of the Mendips, and within sight of the famous Cheddar Gorge, this huge reservoir contains an area of some 230 acres, is 2¼ miles in circumference, and has a holding capacity of 1,250 million gallons. As was to be expected, it is proving a great attraction to water birds, while it has already been visited by such interesting passerines as Snow Bunting and Black Redstart. Fully detailed accounts have been published in *British Birds* (Mag.) of the remarkable spring passage of Black Terns and Little Gulls, and the visit of a Black-winged Stilt in September.

Ducks have been well represented at Barrow Gurney and Blagdon, although no unusually large numbers have been reported. Special mention may be made of Smew at Barrow in January and December, and the visits, for the sixth successive year, of an adult male Scaup. At Blagdon, Wigeon were present in full force, both early and late in the year. On December 11th there were not less than 500 Teal at Cheddar among an even larger gathering of Mallard, Wigeon, Shoveler and Pochard. Other duck identified on this new reservoir are a pair of Garganey in May, Tufted Duck and Goldeneye on various occasions, a Common Scoter in October, and Pintail and Smew in December.

During the first week of May, Sanderlings and a Bar-tailed Godwit, waders rarely met with inland, were seen at Cheddar; while the visit of a Ruff to Blagdon, and Greenshanks to the R. Axe provide the first spring record of either species for the district. The autumn passage brought Little Stints and Black-tailed Godwits to Blagdon and a Ruff to Cheddar, while Greenshanks occurred at both places. The prolonged stay at Cheddar of Green Sandpipers and Black-tailed Godwits as well as such coastal species as Ringed Plover and Dunlin can only be attributed to the low water level while repair work was in progress. Whether

this reservoir, with its wholly concrete sides, will normally be an attraction to waders remains to be seen.

From early September onwards, a number of quite unusual visitors were identified. An Osprey, the first record for the district for over twenty years, was seen at Blagdon, while, as a result of strong westerly gales, a Gannet and a Fork-tailed Petrel visited the Severn. A Fulmar was picked up at Cheddar after further rough weather, and a Great Northern Diver came to Barrow Gurney where it remained for a fortnight. Finally, a Glaucous Gull was twice seen in the Severn estuary.

A unique record for the district, and indeed for the British Isles, was the recovery in February of a ringed Continental Great Tit at Cotham Park, Bristol.

The following specific notes are, in most instances, the result of observations by members of the B.N.S. Ornithological Section. A more complete list of records for the Somerset side of the district will be included in the 1938 *Report on Somerset Birds.*

Raven (*Corvus c. corax*). A pair bred in the Avon Gorge for the third successive year. At least three young were reared.

Starling (*Sturnus v. vulgaris*). The roosting of large numbers in thorn bushes on Chipping Sodbury Common has not, apparently, been previously known to Bristol ornithologists. This roost undoubtedly draws birds from a wide area and, according to local information, is one of long standing. It was visited by the writer on four occasions during the year. Enormous numbers, perhaps as many as 100,000, were coming in on April 14th, when the overhead evolutions were most spectacular. Although very much reduced in size by May 18th, the roost was evidently in use during the breeding season. Numbers had greatly increased by August 20th, while by December 29th the total had again reached huge proportions.

Hawfinch (*Coccothraustes c. coccothraustes*). Nested as usual in Leigh Woods. Young were successfully reared from five out of seven nests found in May.

Siskin (*Carduelis spinus*). A small party was frequently seen at Saltford from January 25th to February 6th.

Lesser Redpoll (*Carduelis f. cabaret*). Up to thirteen in number were often met with at Long Ashton from February 13th to April 14th.

A party of ten were seen at Little Stoke on March 11th. Twenty-eight were counted in Leigh Woods on November 25th.

Corn Bunting (*Emberiza calandra*). One, a male in song, seen between Old Sodbury and Lyegrove on June 26th provides the first breeding season record for this part of the Cotswolds. A few pairs, however, nest annually at Marshfield.

Cirl Bunting (*Emberiza c. cirlus*). Observed occasionally between Weston-super-Mare and Hutton Hill in the spring. A pair was seen near Filton Aerodrome on April 2nd, and two males at Cheddar on September 25th.

Snow Bunting (*Plectrophenax n. nivalis*). Close views were obtained of a single bird, probably an adult female, at Cheddar reservoir on November 17th.

Wood-Lark (*Lullula a. arborea*). A few pairs were met with on the Mendips between Cheddar and Wells on April 3rd.

Continental Great Tit (*Parus m. major*). A ringed Great Tit recovered on February 4th at Cotham Park and sent to the Bristol Museum proved to be of the continental race. The bird was ringed as a nestling near Bautzen, Saxony, about 700 miles east of Bristol, on May 20th, 1937. This is the first recovery in the British Islands of a ringed Great Tit from the Continent (cf. *British Birds*, Vol. XXXI, p. 352).

Pied Flycatcher (*Muscicapa h. hypoleuca*). Two visited Little Stoke during the spring passage—a male seen on April 30th remained until May 1st, while a female stayed for a short while on May 4th.

Fieldfare (*Turdus pilaris*). As late as May 2nd a flock of fifteen was seen on Kenn Moor, Nailsea.

Black Redstart (*Phœnicurus o. gibraltariensis*). No less than three were met with in December—one at Sea Wall Farm, Severn Beach, on the 9th, another at Cheddar reservoir on the 11th, and a third near Sand Point on the 27th. All apparently immature birds.

Wryneck (*Jynx t. torquilla*). One was seen, and heard, at Blagdon on April 20th. As the species is not now known to breed in the district, this was probably a passage bird.

Short-eared Owl (*Asio f. flammeus*). The occurrence of a single bird near Severn Beach on December 27th was perhaps due to severe weather a few days previously.

PEREGRINE FALCON (*Falco p. peregrinus*). The Avon Gorge eyrie, last used in 1934, was still unoccupied. Single birds (falcon and tiercel), however, were seen on various dates in the Gorge and near Avonmouth. Seen also at Aust in January and April. One was observed at Blagdon reservoir on September 8th and again on the 16th.

HOBBY (*Falco s. subbuteo*). Seen over Blagdon reservoir on May 18th (one or perhaps two), and on September 10th (two). This suggests that a pair may have bred near by. On the north side of Bristol good views were obtained of a single bird at Little Stoke on July 26th, and again on the 27th.

COMMON BUZZARD (*Buteo b. buteo*). A Buzzard winged by a gamekeeper at Walton-in-Gordano on August 27th was kept in an outhouse until September 17th. It was then sufficiently recovered to be taken to the Quantocks and liberated. One was seen at Blagdon on December 4th.

OSPREY (*Pandion h. haliœtus*). Fine views were obtained of an Osprey, in flight, over Blagdon reservoir on September 8th. It was being persistently mobbed by Rooks and eventually flew in the direction of the Channel. The only previous record for Blagdon is that of a bird seen in September, 1914, also being mobbed by Rooks.

COMMON HERON (*Ardea c. cinerea*). Thirty-three occupied nests were counted at the Brockley Combe Heronry on April 24th, and twenty-eight at the Banwell Heronry on May 4th. There was thus a total of sixty-one breeding pairs as compared with forty-eight in 1937.

WHITE-FRONTED GOOSE (*Anser albifrons*). About fifty Grey Geese, most probably this species, were seen on the Severn bank between Avonmouth and Severn Beach on December 24th, while on the 28th a similar number were observed over Leigh Woods flying toward the Channel.

GARGANEY (*Anas querquedula*). Two, male and female, were disturbed from marshy ground adjoining Cheddar reservoir on May 6th. They alighted on the reservoir but were not seen subsequently.

PINTAIL (*Anas a. acuta*). A pair was seen off Severn Beach on May 1st. Observed at the North Somerset reservoirs as follows—three at Blagdon on January 4th, one at Barrow Gurney on November 17th and 27th, four at Cheddar on December 15th and six on the 20th.

Common Pochard (*Nyroca f. ferina*). Ten, nine males and a female, were swimming off the Severn bank on the north side of Avonmouth on December 30th. More partial to inland waters, Pochard are rarely seen in the Severn estuary.

Scaup (*Nyroca m. marila*). Once again an adult male visited Barrow reservoirs where it was frequently seen from early February to early May. It reappeared in mid-September and was still present at the end of the year. A female was identified off Severn Beach on April 25th, and again on May 1st.

Common Scoter (*Oidemia n. nigra*). A single bird was seen at Portishead Dock in September. One was present at Cheddar reservoir from October 7th to the 14th when it was picked up dead, and another was picked up at Barrow Gurney on November 3rd. All were adult males.

Smew (*Mergus albellus*). On January 3rd two were identified at Barrow reservoirs, where also two were seen on December 29th. Two were observed at Cheddar reservoir on December 11th and one on the 20th. All were "redheads."

Gannet (*Sula bassana*). An adult over the Severn bank near Severn Beach on October 5th had probably been brought in by the strong westerly gales of the 3rd and 4th.

Storm Petrel (*Hydrobates pelagicus*). Part of a dead bird was found along the Severn bank on the north side of Avonmouth on October 16th.

Leach's Fork-tailed Petrel (*Oceanodroma l. leucorrhoa*). A Petrel seen over the Severn at Aust Cliff on October 7th was confidently identified as this species. It was watched at close quarters and was quite certainly too large for a Storm Petrel. There had been violent westerly gales a few days previously.

Fulmar (*Fulmarus g. glacialis*). A female, undoubtedly blown in by rough weather, was picked up dead at Cheddar reservoir on November 24th (or 25th), and is now in the Bristol Museum Collection.

Blacked-Necked Grebe (*Podiceps n. nigricollis*). One, in breeding plumage, was seen at Blagdon reservoir on March 18th, and was still present on April 3rd. Two, also in breeding plumage, were frequenting Cheddar reservoir on May 4th.

Great Northern Diver (*Colymbus immer*). A single bird visited No. 1 reservoir, Barrow Gurney, late in November. It was first seen on the 24th and remained until December 8th, or later.

Red-throated Diver (*Colymbus stellatus*). An oiled bird was frequenting the harbour at Mardyke, Bristol from January 30th to February 9th. It was then caught and sent to the Clifton Zoological Gardens where it died.

Golden Plover (*Charadrius apricarius*). As in previous years, considerable numbers were frequenting Marksbury Plain during the winter months. They were seen on various dates from early February to the end of April, and a few were still there in the first ten days of May. The birds were again present from October onwards, as many as 300 being counted on December 1st. About forty seen overhead at Stoke Gifford on December 20th were flying very fast from N.E. to S.W. in bitterly cold weather.

Grey Plover (*Squatarola squatarola*). A few were seen in Woodspring Bay on March 13th, and again on April 8th. Single birds were identified on the Avonmouth—Severn Beach mud-flats on October 28th and December 11th.

Ruff (*Philomachus pugnax*). One, a Reeve, was observed at Blagdon reservoir on May 5th. One was seen at Cheddar reservoir on September 7th.

Sanderling (*Crocethia alba*). A single bird was seen at Cheddar reservoir on May 4th. Another was identified at the same place on the 6th.

Knot (*Calidris c. canutus*). A few were frequenting the Avonmouth —Severn Beach mud-flats during the last week of December.

Little Stint (*Calidris minuta*). Single birds were seen at Blagdon reservoir on September 5th and on October 6th and 9th.

Purple Sandpiper (*Calidris m. maritima*). Frequently observed, up to ten in number, along the Avonmouth—Severn Beach mud-flats from late January to late April. Two were seen at the same place on November 16th, and two on December 28th.

Green Sandpiper (*Tringa ochropus*). One was frequently seen at Dyrham from March 19th to the 26th, and two were disturbed at a small pond near Stoke Gifford on April 16th—the first spring-passage records for the Gloucestershire side of the district. Three were seen overhead at Little Stoke on August 16th, and one near Severn Beach on the 17th. Two, or more, were frequenting Cheddar reservoir on August 18th and as many as five on the 24th. Observed also at Barrow Gurney and Blagdon in September.

Greenshank (*Tringa nebularia*). One was seen along the R. Axe on May 4th and two on the 7th. Up to three in number were frequenting Blagdon reservoir during the first three weeks of September, while at Cheddar a single bird was identified on the 3rd.

Black-winged Stilt (*Himantopus h. himantopus*). A single specimen of this rare visitor was watched at close range on the west side of Cheddar reservoir on September 4th. This is the first recorded occurrence for the Bristol district, and only the third for the county of Somerset (cf. *British Birds*, Vol. XXXII, p. 156).

Bar-tailed Godwit (*Limosa l. lapponica*). Four (two in red plumage) were seen on the Avonmouth—Severn Beach mud-flats on May 1st and three on the 2nd. A single bird was watched at close quarters at Cheddar reservoir on May 4th.

Black-tailed Godwit (*Limosa l. limosa*). Frequently seen at Cheddar reservoir from August 17th to the 24th—the largest number being ten on the 18th. Two were observed at Blagdon on September 5th, and six on the 10th.

Whimbrel (*Numenius ph. phœopus*). A party of five were seen, and heard, at Cheddar reservoir on May 5th.

Jack Snipe (*Lymnocryptes minimus*). Three were put up at Blagdon reservoir on October 30th, and one near Avonmouth on December 29th.

Black Tern (*Chlidonias n. niger*). An extraordinary passage of Black Terns was witnessed at the Cheddar and Blagdon reservoirs in the spring. At Cheddar three were seen on May 4th, and as many as twenty-one on the 6th. All had departed by the 8th. There were eight at Blagdon on May 5th, and two on the coast at Woodspring Bay on the 6th. No such numbers have hitherto been recorded in spring (cf. *British Birds*, Vol. XXXII, p. 52). Up to six in number were observed at Blagdon in the first ten days of October, while three were seen at Cheddar as late as October 15th.

Common Tern (*Sterna h. hirundo*). No less than twenty were seen at Blagdon reservoir on June 2nd. So unusual a date suggests that these birds had deserted their breeding quarters. A few, up to six in number, were observed at Cheddar from late June to mid-August.

Little Gull (*Larus minutus*). Excellent views were obtained of five, in fully adult plumage, at Cheddar reservoir on May 4th. At least twelve (adults and immatures) were seen two days later, while four (an adult and three immatures) were observed on the 7th. These

birds, the first to be recorded for Somerset in spring, were apparently forming part of a joint movement with the Black Terns mentioned above (cf. *British Birds*, Vol. XXXII, p. 52). One, an immature bird, was identified at Blagdon reservoir on October 8th.

Glaucous Gull (*Larus hyperboreus*). Following a week of severe weather, an immature bird visited the Severn estuary late in December. It was watched at close quarters between Avonmouth and Severn Beach on the 27th and again on the 30th. When seen alongside a Great Black-backed Gull, it was correspondingly large with an equally massive bill. This, and the greyish-white plumage with an entire absence of black on the primaries, placed its identity beyond doubt. The only previous record of this species on the Severn is that of an adult shot in 1840 and figured in Yarrell's *British Birds*.

Kittiwake (*Rissa t. tridactyla*). One was found dead between Avonmouth and Severn Beach on February 20th, and another on November 25th. Two were picked up in the same place on December 28th.

Land-rail (*Crex crex*). One was killed at Lulsgate Bottom on September 3rd by striking the windscreen of a passing car. One, evidently a passage bird, was disturbed from a late grass crop near Patchway Common on October 30th.

Water-Rail (*Rallus a. aquaticus*). A female, now in the Bristol Museum Collection, was picked up dead at Westbury Park on October 26th.

Erosion Levels in the Bristol District, and their relation to the Development of the Scenery

By A. E. Trueman, D.Sc., F.R.S.E., F.G.S.

(*Read before the Geological Section, Feb.* 16, 1939)

THE hills of the Bristol district are mostly flat-topped, and a view across any considerable piece of country usually shows that many hills rise to a common level. Even sky-lines are therefore frequent, and this is as true on the high tracts of the Mendips and Cotswolds as it is in the areas of lower elevation to the north of Bristol, for example around Yate. The origin and extent of these various plateaux have not received much attention, and for several years the writer made observations upon them in the course of field work devoted mainly to other studies: these observations are admittedly incomplete but it may be useful to summarise the evidence obtained and to indicate lines along which further work may usefully be done. In view of the great development of interest in the study of land-forms in recent years, it may be hoped that some members of the Bristol Naturalists' Society will make more detailed investigations along these lines.

It is well known that the rocks of the Bristol area include older rocks, of Palaeozoic age, often folded and steeply dipping, and also newer rocks, of Mesozoic age, which are usually nearly horizontal. The latter rocks rest unconformably on the former, the plane of unconformity in some cases being remarkably smooth and even, as in the limestone quarries at Chipping Sodbury and at Vobster; the plane of unconformity in each of these cases is a plane of marine denudation, and it is apparent that the removal of the softer Mesozoic rocks from such a surface would yield a smooth platform cut cleanly across the older strata. Such a tract would then look very much like the level surfaces on the Mendips summit or on Durdham Down, and the opinion has been expressed that these plateaux in areas of older rocks represent Mesozoic erosion planes.

It may briefly be mentioned that similar conditions also occur in South Wales, notably in the Vale of Glamorgan, and that Sir Aubrey Strahan (1907) believed the plateau features to be the result of Mesozoic erosion and to represent old wave-worn surfaces from which a Jurassic cover had recently been stripped by denudation. Further work in

South Wales, however, showed this view to be untenable, for the plateau surfaces are developed *on the newer rocks* as well as on the older (North, 1929; Goskar & Trueman, 1934). Much more recent periods of erosion must therefore be held responsible for the planing down of these surfaces (although, of course, the inclusion of areas planed down at an earlier date is not impossible or, indeed, unlikely in some instances). Plateaux of similar character in Cornwall have been shown to date from the Pliocene, and it is generally assumed that the South Wales and other coastal plateaux of more or less corresponding altitude date from the same period.

The following discussion will probably be read more easily if it is made clear at once that in the writer's opinion the Bristol plateaux pass across the outcrops of both older and newer rocks, and that they have similarly resulted from erosion (either marine or sub-aerial) in late Tertiary times. Each platform represents a time when the sea stood at about that particular level in relation to the land, and either sea-level has fallen or the land has risen subsequently. It may be noticed that Mr. A. A. Miller has reached similar conclusions concerning the plateaux across the Severn, which are obviously similar to some (at least) of those in the Bristol area (Miller, 1935).

The study of the plateaux in the Bristol area is facilitated by the absence of glacial deposits or of other superficial deposits which conceal the pre-glacial surfaces, and the only subsequent modification is the lowering of parts of the surfaces by later denudation. The cutting of valleys into the plateaux has usually left flat-topped hills, but in some cases the dissection of the low plateaux has proceeded so far that the original form is more obscure, and especially in outlying portions it may be doubtful whether any part of the original surface remains. In general, least modification is to be found in those areas where plateaux have been cut in Carboniferous Limestone, for the predominance of underground drainage leaves the surface comparatively free from change.

On the other hand, most rapid denudation and modification of the plateau form has occurred in areas of clay (such as the Lias and Keuper Marl). Since these areas are built up of alternating groups of more resistant and less resistant strata which are nearly horizontal, there is a possibility that the harder bands will form cappings to flat-topped hills merely as a result of post-Pliocene denudation (see O. T. Jones, in discussion of Hollingworth, 1938, p. 82); it appears, however, that in the Bristol area there are wide areas of plateau surface formed

by the softer rocks, and that the harder bands often form their most conspicuous features when they coincide in height with one of the main erosion surfaces, as Dr. A. J. Bull has also shown to be the case in the South Downs (1936, p. 112).

The chief purpose of this paper is to draw attention to the evidence in favour of a post-Mesozoic origin of many platforms in the Bristol area, and to suggest a late Tertiary age for these features. It must be noted, however, that some geologists consider that even Pliocene erosion surfaces are likely to have been so greatly modified by post-Pliocene denudation that it is doubtful whether they can be widely recognised at the present time. With this possible criticism the writer does not propose to deal in detail here; attention may be drawn to the fact that extensive dissection of the upraised surfaces has certainly occurred, but that it does not prevent the recognition of the original platforms. In the writer's opinion, no other hypothesis satisfactorily explains the distribution of the observed features.

METHODS OF INVESTIGATION

The great interest which has been taken in erosion surfaces in the past few years has led to the development of several methods of study.[1] Some of these are based partly or wholly on map work, but while they afford most important data for various purposes and form an essential check on other observations, it must be emphasised that the investigation of plateau surfaces requires special field work. Level areas may thus be mapped, and their boundaries, where marked by steeper slopes, may be recorded accurately: the exact heights of particular points, not indicated on available maps, must be determined. The application of such field methods to the south-east of England by a group of workers has led to far-reaching results.

Some of the methods of map study have been employed to supplement the field work carried out in this area. One method involves the measurement of the areas between adjoining contour lines and the drawing of a hypsographic curve (showing the proportions of the area above given heights) or a clinographic curve (devised by J. Hanson-Lowe to show the actual average slopes). This method is laborious, and although it has certain merits, it may not give very

[1] These are summarised in an excellent recent text-book by Wooldridge and Morgan (1937); reference may also be made to Baulig (1935).

sure indication of distinct plateau remnants which occupy only small areas.

Another method of map study is the construction of "projected profiles," developed in America by Barrell and applied to several British areas (Goskar and Trueman, 1936, Fig. 1; Hollingworth, 1937, Pl. VIII). Such a projected profile represents the form of the ground as seen in a block of country viewed perpendicularly from the various points in a vertical plane passing through a selected base-line. It is better than a view of the sky-line, for it shows the actual heights of the hills represented, regardless of their distance from the base-line, and not their apparent heights (Figs. 31 and 32). The drawing of a projected profile is not easy and leaves something to the personal choice of the worker. For a correct impression of an area it is desirable to draw more than one projected profile showing the country from different base-lines.

Superposed profiles illustrate the platforms in a somewhat different way. These consist of a number of profile sections drawn accurately along parallel lines at small intervals, and traced on a single sheet (Figs. 29 and 33). They have the disadvantage, as compared with projected profiles, that they may not intersect the crests of all ridges, and so may give a false impression of levels by cutting along the sides of valleys, whereas a projected profile necessarily represents a projection of the hill crest; much of the information in a series of superposed profiles is thus irrelevant, but provided a sufficient number of sections are drawn, and that conclusions are checked by drawing a second set at an angle to the first, there is much to be learned from them. Moreover, they have the advantage that, if the lines are drawn rigidly at chosen intervals, the result is independent of any views held by the investigator.

Superposed profiles may be made still more illuminating in some cases by varying the nature of the line on each section according to the rock outcropping there (Figs. 35 and 37; also Goskar and Trueman, 1934, Figs. 3 and 4); such superposed geological profiles show at a glance how far the erosion platforms are related to geological structure and how far they cut across different outcrops. Naturally, such information can be ascertained by a direct study of the maps, but it is useful to construct such sections along lines chosen at random as a check on conclusions reached in other ways and as a means of quickly demonstrating the facts.

Dr. S. E. Hollingworth (1938) has lately developed another method of

analysis of relief, which had formerly been used with some success in France; this method, the construction of altimetric frequency curves, depends on "spot-heights" on hill summits. For a given area, all such spot-heights are tabulated and a curve showing the relative frequency of heights in various intervals of altitude is constructed. The presence of maxima in the curves indicates levels at which there are numerous hill tops of similar altitude, and it is found that there are platforms or remnants of platforms at those particular levels. Dr. Hollingworth has applied this method to various areas in western Britain, from Scotland to Cornwall, but it has not been used in the Bristol area and the writer has not found opportunity to do so.

Apart from actual hill summits, remnants of high level platforms are most likely to have survived on the ridges between valleys (which are known as the "interfluves"), for in the valleys themselves they have been destroyed, unless they survive as shoulders or terraces high on the valley sides (Fig. 30). Profile sections drawn along interfluves may thus show steps or ledges representing the remnants of erosion surfaces; the information is most reliable where the interfluves are broad, for where they are narrow or ridge-like the crest is likely to have suffered more denudation. Sections along interfluves must be drawn with great care, for they can rarely be drawn along straight lines, and the choice of direction in some cases leaves a good deal to the selection of the student. When facets or levels have been located on a series of interfluves it is sometimes useful to insert a series of generalised contours marking their slope and boundaries and ignoring the valleys which separate them (see for example, Miller, 1937, plate facing p. 150; Wooldridge and Morgan, 1938, Fig. 159).

In dealing with these phenomena, the gradients of the rivers and streams may themselves be studied with advantage; one of the earliest investigations bearing on these problems was the study by Professor O. T. Jones of the drainage of the Upper Towy (1924). While it is familiar that the thalweg or gradient curve of a river is concave, the gradient being steepest near the source and flattening towards the mouth, detailed levelling along the course of a number of rivers has shown that several curves are represented. The upper part of each course may be marked by a curve which, if continued towards the mouth, would leave the river some hundreds of feet above sea level; below this part of its course, however, its gradient steepens again, and the succeeding curve is again concave, though it also may be interrupted by a steeper gradient after a certain distance (Fig. 36).

It is probable that the rivers formerly flowed into a sea standing some hundreds of feet higher than the present sea-level (in the case of the Towy, about 600 feet higher), and that their courses were then graded to that sea-level; uplift of the land (or lowering of sea-level) in several stages led to the rivers cutting down their valleys and grading them successively to the new base-levels. This has been familiar in the rejuvenation of river valleys, but what has not been so generally recognised is that, when relative uplift occurs, only the lower part of the river is affected, and the down-cutting process must travel slowly inland to the source. It may be put crudely by suggesting that the upper parts of many of our rivers are as yet unaware that uplift has been taking place at intervals since the late Tertiary.

The marks of these changes in gradient are very pronounced in some rivers, and the name knick-point has been suggested for the place where two gradient curves meet (Wooldridge and Kirkaldy, 1936). Such " steps " in a river profile have generally been attributed to the presence of more resistant bands of rock, as in the case of many waterfalls, but such irregularities in a stream bed tend to disappear with maturity, while knick-points may be recognised (as in the case of the Towy studied by Professor O. T. Jones) in river courses where no noticeable change in the character of the rocks occurs. Very striking knick-points are recognisable in some Bristol rivers, notably in the Frome. Unfortunately, the sources of most of the streams in the Bristol district are too low for the gradients to show any traces of the earlier stages of these uplifts.

GENERAL DISTRIBUTION OF EROSION SURFACES

While the existence of distinct platforms at several levels in the Bristol area can be established beyond doubt, the actual limits of some of them are not certain, and the correlation of those recognised in different areas requires further study. Briefly, it may be emphasised that a platform (perhaps more than one level is involved) at from 200 feet to just over 300 feet is the most widespread in the area. It may extend downwards to levels below 200 feet, but other levels near 100 feet are probably distinct: upwards it seems in some areas almost to merge into a higher surface at 400-450 feet, but as there seems to be a steeper slope between this and the 300 foot platform in some parts, it is proposed at this stage to treat them as distinct. A further platform at about 550-600 feet is also recognisable, and

this appears to be distinct from the lower surfaces and from a very well-marked higher level (in the Mendips) at 750-850 feet.

In thus summarising these platforms it must be noticed that some variation in level occurs in each one.[1] This is not surprising, for they were not horizontal at the time of their formation; a wave-cut platform has a gentle seaward slope, while a peneplain of sub-aerial origin not only has a seaward inclination but has also other minor irregularities. A wave-cut platform may be expected to end inland against cliffs, and some would regard the presence of a cliffed inner edge as the best evidence (apart from marine deposits) of the marine origin of a plateau. It may be pointed out, however, that a wide plain of marine erosion is characteristic of a mature coast line, and it is by no means certain that many cliffs would persist if this were fully established. A surer evidence of marine origin would perhaps be found in the uniform height of the inner margin of the platform, but here again caution is necessary, for during the long period of still-stand needed to carve a wave-cut platform, a high degree of peneplanation of the area above sea level might be expected, and a merging of the two surfaces at many points would not be unlikely.

Some uncertainty in the identification of the platforms at this early stage of investigation is not surprising, for not all are present at each locality. The absence of one or more platforms from a particular hill slope need occasion no confusion, however, for if, as the writer suggests, the higher platforms are the older, it is to be expected that a more extensive growth of a lower platform might destroy a higher one in any area. The presence of a platform at the lower level under a steeply cut hill, showing no trace of the next higher platform, may indeed be used to prove the distinctness of those two erosion surfaces. The absence of the erosion levels at some places along the southern border of the Mendips, owing to more recent denudation, illustrates this fact very suitably.

(*a*) The Area around Dundry Hill

Seen from Bristol (for example from the Suspension Bridge), Dundry rises steeply out of the nearly level platform which extends continuously from Knowle to Bishopsworth. The even top of this surface is very striking; it extends from about 200 feet to more than 250 feet,

[1] In writing of these platforms in the following pages they are spoken of as the "300 foot platform," etc., for brevity, but the fact that they cover a range some times of 100 feet must be understood in all cases.

at which level the scarp of Dundry rises more steeply. This level can be traced without difficulty westwards towards Barrow Gurney, where it makes extensive flat tracts near the Barrow reservoirs ; south of Long Ashton it is represented again in several hills of 250 feet. Its widest extent is found, however, to the east, at Bristol airport and Whitchurch.

This 200-300 foot platform is very deeply dissected by several streams, notably by the Malago, the narrow valley of which is no more than a deep trench in the comparatively flat surface. The Malago valley, like many valleys cut into the Knowle platform and its presumed equivalents, is immature and indicates fairly recent rejuvenation. The lower levels at about 200 feet are very distinctive in some parts and may indicate a platform below the 250-300 foot areas ; no attempt is made to separate them at this stage, however.

In the Knowle area the 200-300 foot platform is mostly underlain by Lias, and it may perhaps be suggested that its presence is due to the occurrence of the Lias limestones. Even in this area, the platform is not confined to this formation, however, and elsewhere, what must undoubtedly be the same platform cuts across other rocks ; south of Stanton Drew it is cut in Keuper Marl. It may therefore be suggested that the preservation of so wide an area of the 200-300 foot platform in this area has been helped by the presence at about this level of the Lias limestones, but the platform itself is in the main due to other factors.

The 400-450 foot platform is not so clearly developed on the north of the Dundry ridge, but it is recognisable at some points, especially on the interfluves ; although these latter are narrow and possibly incomplete they usually show one or more ledges (Fig. 30) and the levels are conspicuously developed at about 250 feet and above 400 feet. The 400-450 foot surface (rising in places to 500 feet) is more extensive on the south of the hill, forming a somewhat deeply dissected shoulder, seen in Chew Hill and other summits above Chew Magna and near Norton Malreward. Although this platform is here formed by Lias limestones it may also be traced southwards on to the outcrop of the Keuper, where it is, as would be expected, less continuous.

There is no definite evidence on Dundry of any higher platforms, although the summit of the hill (just over 750 feet) may link it with a higher platform elsewhere ; in other words, Dundry Hill may have

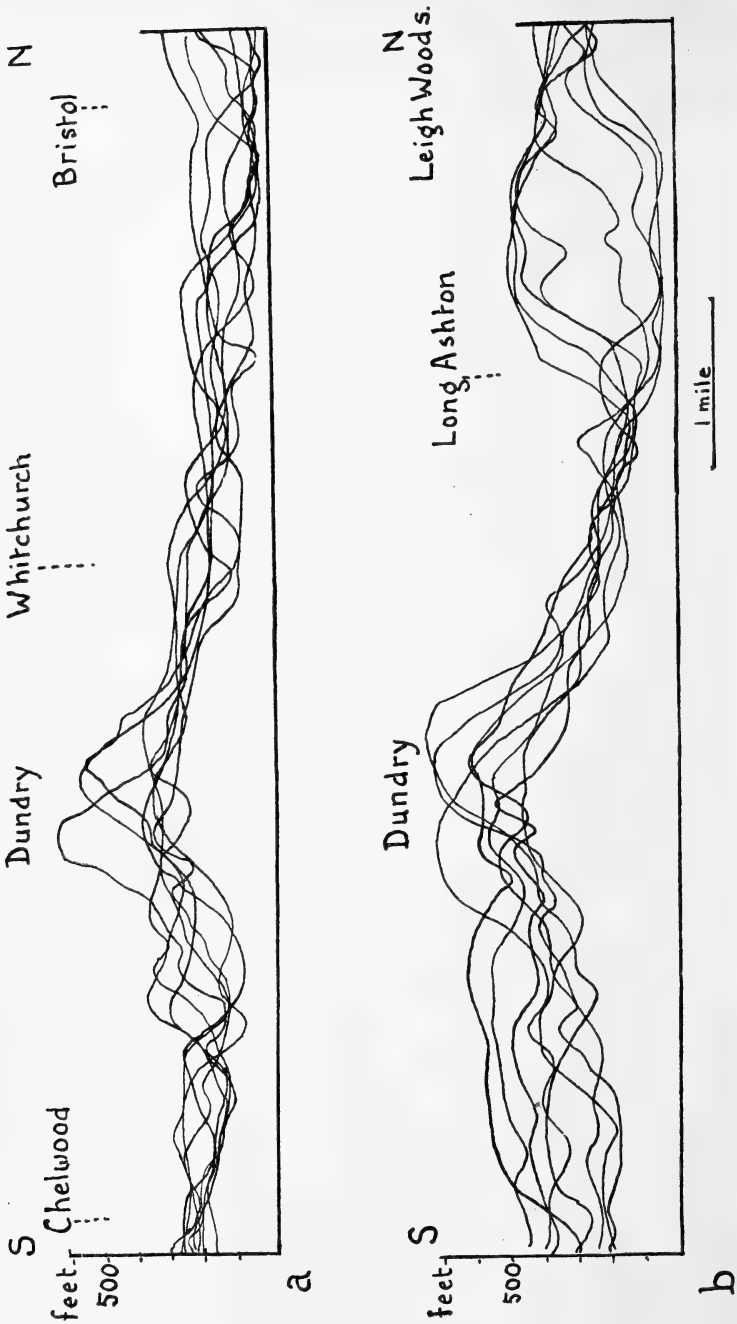

S
N
Chelwood
Dundry
Whitchurch
Bristol
feet
500
a
S
N
Dundry
Long Ashton
Leigh Woods.
1 mile
feet
500
b

FIG. 29

survived because there the Inferior Oolite is at such a height that it was involved in a plateau surface, the greater part of which in the Dundry area was formed by less resistant strata and has been destroyed.

(*b*) The Avon Valley and its Neighbourhood

The 200-300 foot platform extends over wide areas in the Bristol district. It includes Durdham Down, in which it rises to just over 300 feet, and extends northwards through Horfield and Filton, and to the level tract between Over and Patchway. Lias limestones and the Carboniferous Limestone have been largely concerned with the preservation of this surface.

On the other side of the Avon valley the Downs level is traceable in Leigh Woods, but then the ridge stretching into Clevedon rises to higher levels and the relations are not very clear: the 200-300 feet platform extends north-westwards, however, in the hills south of Pill.

Eastward from Bristol the same platform is well marked on both banks of the Avon. From Whitchurch it extends over a wide tract (chiefly of Lower Lias) to Queen Charlton. Here and there hills of somewhat greater height rise fairly conspicuously from this level, but the general uniformity of the tracts between the valleys is particularly striking. North of the Avon the platform is still more interesting, for here it cuts a variety of rocks. From Staple Hill to Hanham it is chiefly Coal Measures which are affected, and the surface extends across both Pennant Sandstone and the predominantly clay series beneath (the Lower Coal Series); it is remarkable that some of the highest ground in the area, near Kingswood, is actually on the outcrop of this latter series, although sandstone bands within it contribute towards the persistence of the surface. Here, too, the streams tributary to the Avon are deeply incised in narrow immature valleys, such as that cutting the Pennant Sandstone at Fishponds and that in the Lower Coal Series just north of Speedwell.

Eastwards from Oldland and Warmley a wide expanse of a flat-topped feature extends on both sides of the River Boyd. This includes the hill between Bitton and Bridge Yate, and a tract around Wick which tapers southwards to Upton Cheyney, where, though deeply dissected, a very definite platform is evident. Lower Lias is again the rock chiefly involved in this surface, but the feature also continues across the Carboniferous at Wick (Fig. 32). This feature is well seen from several viewpoints east of Warmley on the main road to Wick. The levels

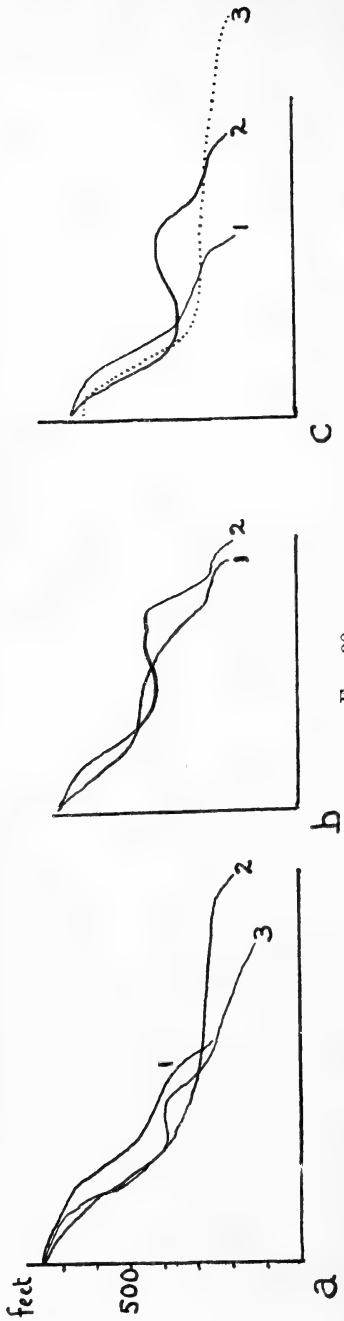

feet
500
a
1
2
3
b
1
2
c
1
2
3

Fig. 30

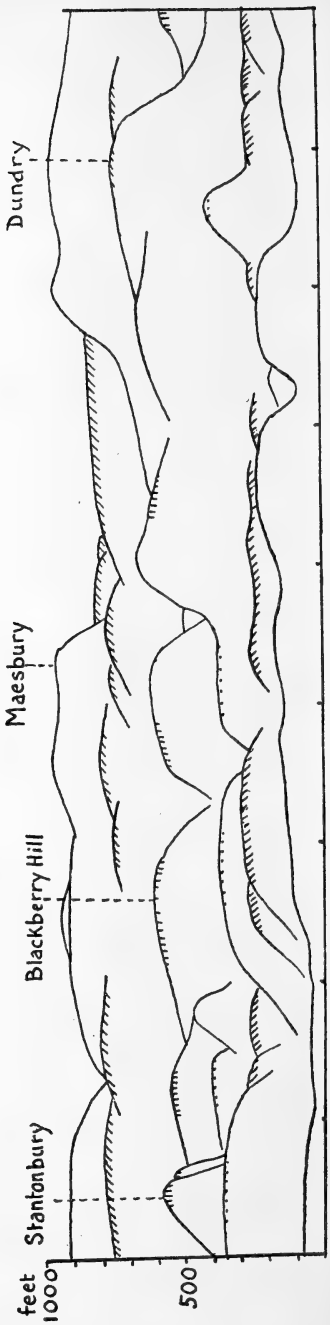

feet
1000
500
Stantonbury
Blackberry Hill
Maesbury
Dundry

Fig. 31

extend somewhat indefinitely northwards and it is not yet certain whether they merge with the higher tract (about 400 feet) around Pucklechurch.

The 300-foot platform is not traceable very distinctly nearer Bath, though it is represented at Corston and probably also in the flats at Kelston Park and Newton St. Loe.

Under the steep Cotswold scarp nearer Bath little trace of a 400-foot platform has been preserved (if it were ever present) but there may be evidences of it near North Stoke and elsewhere north of the river, and near English Combe on the south. It is tempting also to suggest that the oolite-capped Lansdown Hill is an area of the 750-foot plateau (Fig. 32).

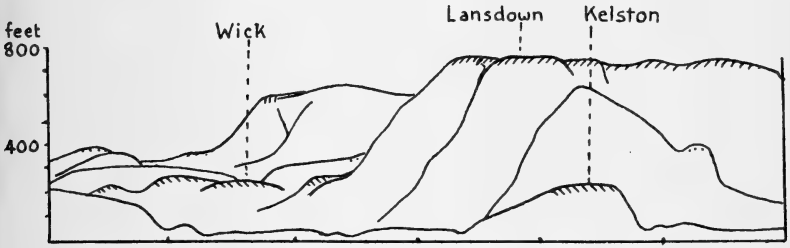


Fig. 32

Above the Bath gorge, however, both the 200-300 foot and the 400 foot platforms again appear to be distinguishable, the former especially well developed to the south of Bradford-on-Avon in the valley of the Frome, the latter forming a shoulder on the Cotswold dip slope (Fig. 33).

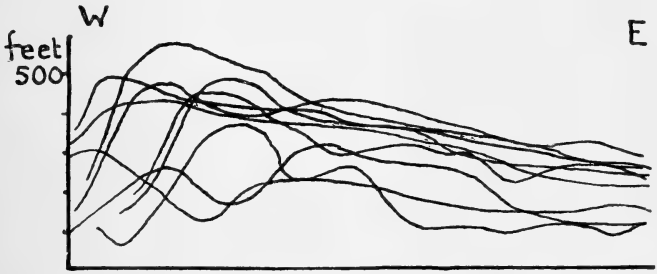


Fig. 33

Southwards from Keynsham a 200-300 foot platform is well represented in the Chew Valley, as has been noted above. Through Compton Dando, Publow and Chew Stoke it can be traced to the Mendip borders at Compton Martin. It forms a distinct feature and is succeeded by higher platforms.

(c) The Yate Area and the Frome Valley (Glos.)

No part of the Bristol district illustrates these erosion platforms more remarkably than the area flanking the River Frome, and although there are many problems awaiting solution there is little doubt that smooth surfaces have been cut in this area through a variety of rocks. Indeed, the most impressive feature in the area is the absence of any noticeable change in level as the almost flat surface cuts across near Yate from the Pennant Sandstone to the shales of the Lower Coal Series and the Millstone Grit. At first sight it appears that this plain may have formed the base of the Keuper (and may thus be of pre-Tertiary origin) but diggings for celestine in this area often show a little Trias, and one near Stanshawe's Court, Yate, in 1935, showed a thickness of at least 12 feet of littoral Keuper banked against a cliff of quartzite, a thin layer of Tea-Green Marl beneath the erosion surface passing unbroken across the junction. There appears to be no doubt therefore that this Yate platform is of Tertiary age.

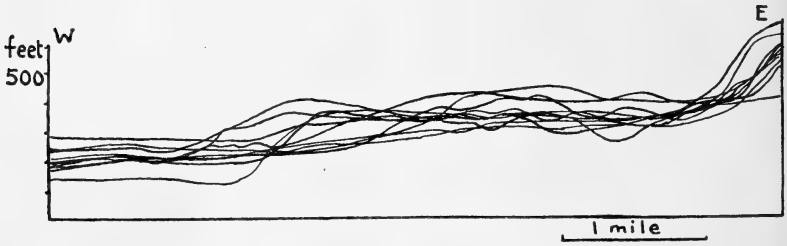


Fig. 34

At Yate this 200-300 foot platform stretches both north and south of the main road, extending southwards through Westerleigh Common to the hills on either side of Westerleigh itself, and northwards to Rangeworthy (and less continuously to Tytherington and Wickwar). For a mile at a time the platform is scarcely broken by any elevation, but at some points where the River Frome is entrenched in a gorge its tributaries have caused some dissection of the surface. Thus near Nibley, on the Bristol road from Yate, tributaries following the strike of shale groups have begun to etch out the sandstone bands as flat-topped ridges. A similar feature is seen again near Frampton Cotterell, where a sandstone ridge traversed by " Park Lane " rises to the level of the Yate platform.

The continuation of this platform westwards across the valley of the Frome is illustrated in the superposed geological profiles in Fig. 35 ; it

will be noticed that all divisions of the Coal Measures and also Keuper and Lias form parts of this surface in different places. The surface is generally lower near the river, and possibly other platforms may be distinguishable there, but in general the Yate platform is traceable across to that already mentioned near Patchway and thence northwards along the Gloucester road. It is well seen from Milbury Heath in the hill south-east of Rockhampton. The higher parts of Tortworth also reach the same level but the platform has here been more deeply dissected by the Little Avon and its tributaries. Beyond this to the north, the 300-foot platform is less widely recognised, for both Palæozoic and Mesozoic rocks have been worn down to much lower levels: this difference has perhaps resulted from the slower lowering of the basin of the Bristol Avon, which must have been controlled everywhere by the rate of cutting down of the limestone in the gorge at Clifton.

To the east of the Yate platform another level tract stretches almost to the foot of the Cotswold edge; this rises commonly to about 400 feet and extends from Chipping Sodbury southwards to join the platform already noticed at Pucklechurch. Now this platform is cut almost wholly in Lower Lias, and the more or less definite step by which it rises from the Yate platform (near the Parkfield Colliery, in Westerleigh Hill, and at Chipping Sodbury) partly coincides with the boundary of the Lias outcrop. Above Chipping Sodbury this 400-foot platform is drained by the Frome, which meanders as an apparently mature stream. It does not appear that the platform results from the maturity of the drainage, however, although its lack of dissection may well be due to the retarded recession of the knick-point owing to the Carboniferous Limestone outcrop at Chipping Sodbury (a suggestion comparable with that made above in regard to the Avon basin); the occurrence of wide platforms at this level in other areas seems to suggest a similar origin.

In this area a beginning has been made in the levelling of the river gradients, and Figure 36 shows the results of the levelling of the Frome. It will be noticed that after falling fairly rapidly from its source in Dodington Park, the river follows a very low gradient until it reaches Frome Bridge where there is a slight steepening; a much more important knick-point is found just below the Wickwar road in Chipping Sodbury, although through Yate the river appears to have cut down very little into the Yate platform. Another knick-point (one of the most impressive in the district) is easily seen on the Iron Acton road about a mile south-west of Iron Acton, near Cogmill, where the river,

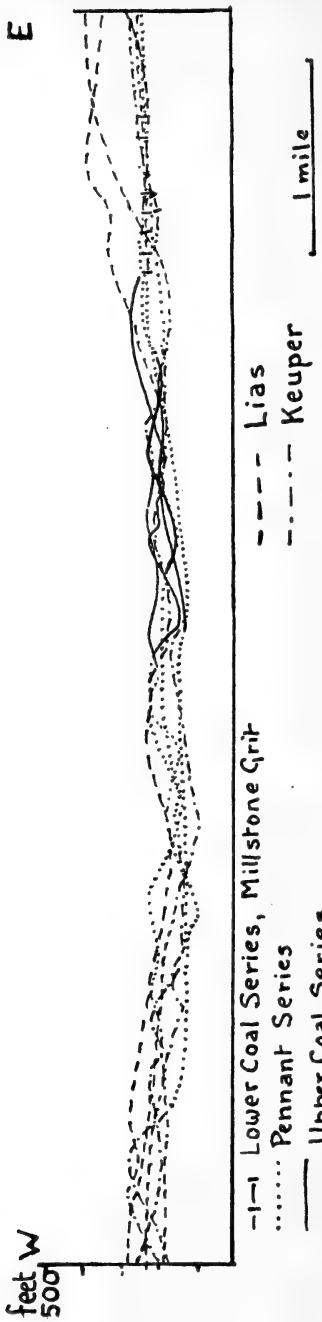

E
W
feet
500
1 mile
Lias
Keuper
Lower Coal Series, Millstone Grit
Pennant Series
Upper Coal Series

FIG. 35

after flowing in a very shallow valley little below the level of the Yate platform, begins rapidly to cut down into the Pennant Sandstone (Fig. 36), and by Frampton Cotterell and Winterbourne, succeeds in entrenching itself in a gorge. The interpretation of all these facts, and their relation to the platforms under discussion, requires further observations; it appears, however, that the upper part of the Frome is graded to a sea-level 200-300 feet above the present. Observations are required on other rivers, however, including the Upper Avon and others which rise in the higher hills.

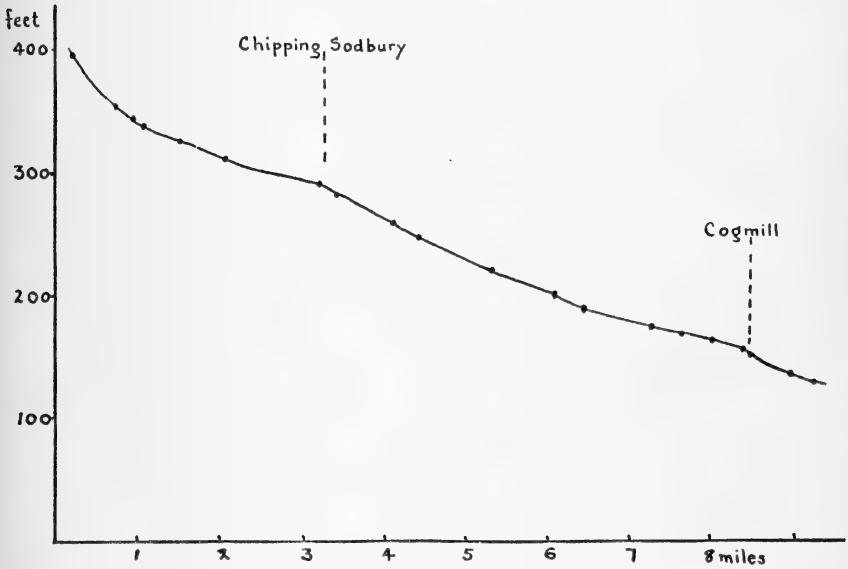


FIG. 36

(*d*) THE COTSWOLD EDGE

Only a few preliminary observations have been made along the Cotswold edge near Wotton-under-Edge and Dursley. As already noticed, the 200-300 foot level is not conspicuous in much of this area, although it survives in the area west of Nibley. The most interesting feature is the strength in this area of the 400-450 foot level, which exists in the platform above Nibley Church and a mile or so farther north. It is noteworthy, however, that these levels coincide with the outcrop of the marlstone of the Middle Lias, and it is uncertain how far the wide expanse of its outcrop at those places is due to the coincidence of its

level with an erosion platform, and how far the ledge is due simply to the presence of the harder strata. The occurrence of flat tracts on marlstone at somewhat different altitudes down to 300 feet appears to support the latter view, but the absence of pronounced platforms on the marlstone at other places appears to support the first-mentioned explanation. The relations of these platforms require further study, however ; it must be remembered that immediately under the Cotswold edge conditions must have been affected by the erosion and recession of the scarp, and it is quite uncertain what amount of recession may have occurred since late Tertiary times. It may be hoped that further examination of the rivers and terraces of this area will throw light on this problem.

(*e*) Broadfield Down and the Clevedon Area

The generally flat top of Broadfield Down, cut across Carboniferous Limestone and (littoral) Lias limestones of similar character, reaches over wide areas to 550-600 feet (Fig. 29b). Around its margins traces of lower platforms may be detected, but along the north-west the deep dissection of the Nailsea Basin has apparently led to the disappearance of most of these levels. The 200-300 foot platform survives in the outlier at Cadbury House, between Yatton and Congresbury, and in small ledges to the east of that and in Cleeve Hill. The 400-450 foot platform occurs more extensively around Butcombe but it is also traceable at the top of Goblin Combe. This platform is not at once separated from the higher level, however, and more examination is needed before they can be properly distinguished. What does seem clear from a rapid study of Broadfield Down is the distinctness of the 200-300 foot platform from those at higher levels, for a definite inner margin appears to be recognisable.

The Clevedon-Clifton ridge, as already noted, presents more difficulty. This is partly to be expected, no doubt, owing to the ridge-like nature, for little of a plateau surface remains except in the east, and denudation has been active both to the north and south of it. Its height varies from 200-300 feet at the western end to over 500 feet just above Wraxall. The best view of the ridge is that from Broadfield Down, for instance above Backwell. The rise in slope seems on the whole to be very gradual, with little evidence of a "stepped" profile. Along the south side there appear to be slight remnants of the lower platform, but the wearing down of the Nailsea basin to levels of 100 feet and less has destroyed practically all this platform (if it were ever present).

(*f*) THE MENDIPS

The writer has already emphasised the extent of the high plateau on Mendip at about 800 feet (1938, p. 282); its limits may be placed at approximately 750-850 feet. At various places along the north border lower platforms are plainly represented, and although along a considerable part of the southern edge the Mendips fall sharply to the marsh level, there are traces, especially in the " islands " in that tract, of other platforms. It will be unnecessary to treat these in detail, and a brief summary only will be given here.

There is a wide level at about 550-600 feet on the north of the Mendips. It is splendidly seen on the Wells road near Ston Easton; it stretches to Chewton Mendip and southwards towards the Mendips, where its inner edge is somewhat uncertain but not much over 600 feet (Fig. 37). This platform is cut mainly in the Lower Lias but it passes on to other formations, Keuper, Coal Measures and Carboniferous Limestone. Probably this platform is represented above Burrington Combe and further east, where the Nettlebridge valley has been cut down into high ground near this level, while hills near Bishop Sutton may belong to the same platform (as does much of Broadfield Down). South of the Mendips it is less conspicuous, but it seems to be traceable in flats above Wells, as at West Horrington, which, while mainly on Lias, also cut Carboniferous Limestone.

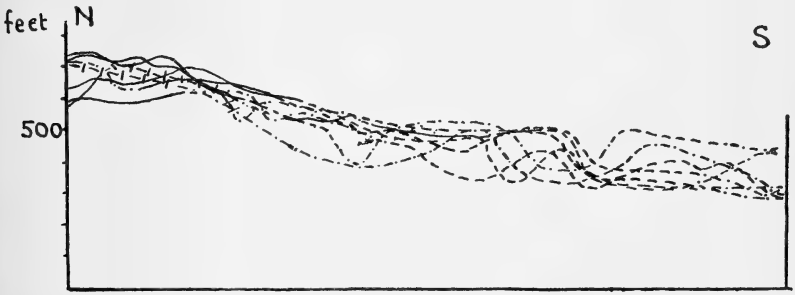


FIG. 37

A 400-450 foot platform is present near Farrington Gurney and Radstock, and may be seen in smaller areas further west. It is also probably represented south-east of Wells and around Nunney where a platform cuts indifferently across Mesozoic and Carboniferous rocks.

The 200-300 foot platform is more prominent: around Compton Martin and West Harptree it has already been pointed out. From

those points it is not traceable further to the east along the north border of the Mendips but westwards it is seen in small areas above Banwell and at other places to Weston-super-Mare. It forms part of the summit of Brean Down and extends to the flat top of Steep Holm. Worlebury Hill is too ridge-like to preserve any definite platform, but viewed from the south it appears to show traces of a step from a level crest.

This platform is also seen as a ledge at intervals along the south of the Mendips, becoming more distinct near Wells, and in some of the "islands" such as Nyland Hill. Whether the flat terrace on the north of Brent Knoll, and the level tops around Weare and Wedmore belong to this or lower terraces needs further examination. Certainly, lower levels are present near Uphill, where a definite platform occurs at 100 feet (e.g., under Uphill Church and at Bleadon); this is obviously a marine platform backed by old cliffs.

In the Mendip area the 200-300 foot and possible 400-450 foot platforms appear to be distinct; certainly traces of successive levels can be made out. But there is much variety of level, and the number of possible ledges at intermediate altitudes makes caution necessary in interpreting this area.

(*g*) The Quantock Hills

Little more than a casual examination of the areas south of the Mendips has been made, but there appear to be similar platforms at many places. On the west of the Quantocks a level at 500-600 feet seems fairly distinct, while a lower platform at about 400 feet is also present. Thence to the coast are wide areas not far from 200-300 feet.

GENERAL DISCUSSION OF THE PLATFORMS

It appears to the writer to be beyond dispute that the surface features of the Bristol district include platforms at several levels which are due to the elevation of plains of marine or sub-aerial denudation. By analogy with other areas, it may be suggested that some at least of these erosion platforms were cut in late Tertiary (probably Pliocene) times. While some of them may never have been perfectly smooth, and all have undergone subsequent modification by later denudation, the general agreement of hill-top levels suggests that the elevation of these platforms has controlled the broader topographic features over much of the Bristol area. In detail the relief is closely related to the geological structure and to the distribution of hard and soft rocks,

but in so far as the relief is not in close harmony with these factors, the existence of earlier denudation levels probably affords the best explanation. It may, however, be pointed out that the distribution of these levels, on the areas most easily planed down, was originally controlled to some extent by the distribution of the outcrops of the harder and softer rocks. For example, comparatively few areas of the Carboniferous Limestone were planed down to the level of the lower platforms, and those areas stand out from amongst the country formed by Mesozoic rocks much as they stood out during the deposition of the Keuper Marl; that the Bristol area is in part a disinterred "fossil landscape" must not be lost sight of in considering the alterations brought about by late Tertiary erosion.

Some consideration has been given to the question of whether any of the level tracts observed owe their existence to pre-Tertiary erosion. This is a difficult problem and at present it can only be stated that there appears to be no adequate evidence of any extensive area which owes its flatness to erosion before the deposition of the Mesozoic rocks. The plane of unconformity on which the Mesozoic rocks rest was of marked irregularity, as already noted: that part which was buried in Keuper times was in many places particularly uneven, but the portions which were cut by the Rhaetic and Lias seas were much smoother. Especially in the Mendip area the movement of the Palæozoic floor in Jurassic times allowed repeated planing of the same tract, and no doubt smooth planes were cut in the Carboniferous Limestone (as at Vobster and Vallis Vale). It is possible that some parts of the higher platforms represented in the limestone area of the Mendips were cut in Jurassic time, but it is unlikely that as a whole the platforms are of such great antiquity: it is difficult to estimate the extent of post-Jurassic movements in the Bristol district (see O. T. Jones, 1930) but it is certain that there has been considerable post-Jurassic folding and faulting (in this connection, see Reynolds, 1937) and it is unlikely that large areas of any pre-Jurassic marine platforms have escaped modification.

The platforms discussed appear to fall into several groups, of which the most widespread is that at about 200-300 feet. It is believed that this platform represents a separate (and very considerable) time of still-stand and that higher levels, ranging up to about 450 feet, represent a different period of erosion. In places these two surfaces appear to be distinct (as near Yate) but elsewhere there are possibly intermediate levels.

Above these main platforms others are less widely shown, but a level at 550-600 feet is fairly widespread, especially on the north of the Mendips and in Broadfield Down, and one at 750-800 feet is commonly found on the Mendips and possibly in the Cotswolds (though here the influence of nearly horizontal bedding makes the identification of platforms more difficult).

Below the 200-300 foot platforms are other levels, near 50 and 100 feet above sea-level, traceable in some river valleys, at Clevedon, in the Nailsea area and elsewhere. They are presumably connected with the river terraces at corresponding levels, and the lower one with the 50 foot raised beach. They are later than the platforms described above.

No conclusions have been reached as to the origin of the platforms. The coastal plateaux in South Wales at similar heights are believed to be of marine origin, on account of their remarkable smoothness, while Mr. Miller (1935, p. 176) has also suggested that the coastal platforms near Chepstow are of marine origin. The smoothness of parts of the platforms in the Bristol area, especially where they cut across the Carboniferous Limestone (as in Durdham Down) and have suffered less from subsequent modification than in the Mesozoic areas, suggests marine rather than sub-aerial erosion. A similar conclusion is indicated by those areas where a well-developed platform at this height occurs on the borders of higher tracts (as in Broadfield Down and the Mendips); this is almost certainly the case also as regards the 100-foot platform at Uphill and Clevedon, but this probably relates to a later stage.

A sub-aerial origin is not excluded, however, especially for some of the more inland portions of this 300 foot surface and for the 400-450 foot platform in those parts which seem closely linked with existing valleys, such as that of the Chew. The possible relation of these platforms (as peneplanes or hemiplains) to a wave-cut platform at a slightly lower level must not be overlooked in considering alternative explanations, but the writer proposes to put forward no more definite hypothesis at this stage.

The 550-600 foot platform is regarded as marking an earlier and separate stage of erosion: at some points, as in South Wales (for instance in Garth Wood near Cardiff) the inner edge of this platform is quite distinct, and a marine origin is not excluded. This is perhaps contrary to the views of Mr. A. A. Miller, who regards the 600 foot platform in Pembrokeshire as due " mainly to sub-aerial erosion, having been peneplaned by a system of rivers graded to a 400 foot sea-level "

(1937, p. 159); the writer finds it difficult to accept Miller's explanation, however, for he considers that a peneplane graded to a 400-foot sea-level would in any event tend practically to merge into a wave-cut platform related to the same sea-level.[1]

RELATION OF PLATFORMS TO THE DEVELOPMENT OF THE RIVER SYSTEM

If the suggested platforms do represent erosion surfaces cut at various stages when sea-level was higher in relation to the land than at present, their history throws some light on various problems of river development in the area.

In the first place, if the platforms (especially the 300 foot platform) were wave-cut, the uplift which raised the wave-cut platform led to rivers developing as an initial drainage on the old sea floor; while these rivers represented seaward continuations of pre-existing rivers they must have wandered across a nearly level surface towards the new coast line. For example, if the 300 foot platform were cut by the sea, it follows that at that stage the mouth of the Avon was not far below Bath, and it is highly doubtful if the Avon gorge had been initiated before that time. Flowing westwards across this newly upraised tract, joined by the Chew which followed a narrow tract about the same level and by the Frome which meandered on a very wide flat, the Avon flowed just east of the high ground of the Clevedon-Clifton ridge; presumably it was unable to take a course through Long Ashton (although that area may have been part of the general plain) because of a continuation of higher ground near Flax Bourton, between Broadfield Down and the Clevedon ridge, which must have been cut down subsequently.[2] The river must rapidly have cut down its valley north of the present position of the Clifton Gorge, but this may have formed a knick-point for some time following the uplift, and sub-aerial erosion may have continued the levelling of the basin above that position; at any rate the down-cutting of the valleys was probably checked owing to the slowness of vertical erosion on the limestone tract.

[1] A more detailed discussion of the relation of the 600 foot platform in South Wales to a lower marine level has been published since the above was written (George, 1938, pp. 26-28). Prof. George's views are substantially in agreement with those expressed here.

[2] It must be remembered that possibly no part of the Bristol area at that time was lower than the 300 foot platform (though it was not then 300 feet above sea level).

If this extension of the Avon across a newly raised wave-cut platform correctly interprets the course of events, it will be noticed that some modification of the usual account of the superimposed drainage of the area is necessary; the lower Avon and its tributaries were developed on an erosion platform and not on a cover of newer rocks.

In any event, it follows that the cutting of the Avon Gorge itself was not begun until after the uplifting of this 300 foot platform; for some time the Avon must have flowed in a shallow valley represented in the shoulders seen in parts of the gorge, and the deepening of the gorge only took place as the platform was further raised in the stages marked by the river terraces. If the 300 foot platform was cut, as is suggested, in Pliocene time, then the cutting of the gorge (and of the Pennant Sandstone gorge higher up the Avon) has been achieved since that time. This suggestion may usefully be examined in relation to the view, held by some geologists, that the Avon may represent a reversed river, the remains of drainage which formerly passed from Wales across the Bristol area to south or east, before the development of the Bristol Channel. It is certain, however, that the Bristol Channel had come into being before the cutting of the platforms; therefore, any rivers flowing from Wales had disappeared by that time, and no Welsh water ever flowed through the Avon gorge. This must have been cut entirely by the Avon itself (that is, by a river flowing north-westwards).

There are other interesting features in the river system of the area which need investigation in the light of the suggestions put forward here. For example, the course of the drainage from Frome (Somerset) north-eastwards to the Avon at Freshford rather than westwards, may imply the existence of higher land in the area of the present Somerset fens at the time of the 300 foot platform. The course of the Wellow Brook from Radstock is also interesting.

The progressive uplifting of the area (and possibly the accompanying lowering of the fenland area) must also be considered in relation to the cutting of the Mendip gorges, which must have been deepened in stages as their base-level fell, partly owing to the elevation and perhaps partly also to the subsequent removal of impervious Mesozoic sediments on the hill flanks which may have held up the level of the water-table in the Carboniferous Limestone. High-level valleys on the Mendips (e.g., above Cheddar) may be related to these early stages. It may be suggested that a study of cavern levels in the Mendips will possibly throw some light on the progressive deepening of the gorges and on the lowering of the water-table.

CORRELATION WITH OTHER AREAS

It will be sufficient briefly to record the fact that there appears to be close agreement between the heights of the platforms provisionally delimited here and those recognised by workers in various other parts of Britain. Whether it is possible on the grounds of mere height above sea-level to correlate erosion platforms in different areas is perhaps debatable, but the remarkably close agreement in levels is so striking that we are almost forced to the conclusion that the changes in sea-level affected much of Britain to almost the same extent.

In the Wye Valley region, Mr. Miller (1935) recorded platforms at 250 feet (the Liveoaks stage) and about 400 feet, with higher levels possibly of sub-aerial origin. In South Wales, platforms at about 200 feet, 400 feet and 600 feet have been noticed (Goskar and Trueman, 1934, p. 474); Dr. F. J. North also mentioned a 300-330 foot level (1929). Miller recognised substantially the same levels, although he suggested a gradual withdrawal of the sea from the 400 foot to the 200 foot stage (1937, p. 159). Professor O. T. Jones' work on the Upper Towy led him to believe that sea level had formerly stood at about 400 feet and 580 feet above its present level. In the London area and much of the south-east of England erosion platforms at about 200 and 400 feet have been discussed in pioneer work by Dr. S. W. Wooldridge (1928) while Mr. J. F. N. Green has lately summarised the evidence of a number of workers (including especially that of Barrow and Dewey) in Devon and Cornwall; here, besides a 1,000 foot level, there is the Bodmin Moor Terrace (750-800 feet) which Green believes to be of marine origin, a terrace near 600 feet, also probably marine, and a wide platform at about 400 feet which he separates into a higher wave-cut surface up to 385 feet and a lower reaching up to 310 feet. Dr. S. E. Hollingworth, by other means, has established for many places in western Britain the existence of levels at 1,000-1,070 feet, 730-800 feet, 550-570 feet (less well marked), 430 feet, and 320 feet (less well marked); some of them had been recognised earlier by Greenly and others in North Wales.

The occurrence in so many of these records of features at 750-800 feet, 550-600 feet, and 400 feet, with a lower terrace not so certainly marked off from the last-named, is, to say the least, very remarkable, and is in close agreement with what the writer believes can be seen in the Bristol area.

It may be mentioned here that in his recent account of the terraces of the Severn, Professor L. J. Wills (1938) mentioned a high terrace

(the Woolridge terrace) at about 200 feet; he quoted evidence of the occurrence of this terrace in the Bristol area, and regarded it as of Pleistocene age. The general coincidence of this terrace with the wide platform recognised at about the same level raises the question of the age of the latter; it is, of course, conceivable that sea-level remained for a very long time at approximately that height (as the wide extent of the platform would suggest). The Woolridge terrace may represent only the lowest part of what is here referred to as the 250-300 foot platform, which may well be composite.

CONCLUSION

The writer has called attention to the extensive development of level tracts in the Bristol area which he suggests are erosion platforms comparable with those already noticed in other areas. It is probable that these represent stages of erosion during late Tertiary (probably Pliocene) times when sea-level was much higher in relation to the land[1]; in that case the story of these platforms throws light on a stage in geological history which has been quite unknown in the area, the "lost interval" between Cretaceous and Pleistocene. Some rather speculative considerations of other scenic features which must have been affected by these events are also introduced, in the hope that these will stimulate further interest in these problems among members of the Society.

In conclusion, the writer wishes to thank Professor W. W. Jervis and Mr. O. D. Kendall for loan of levelling instruments used in the course of the work, and his son (E. R. Trueman) for assistance in the field.

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[1] A series of falls in sea-level may have occurred, rather than risings of the land.

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Legend of Figures

Fig. 29.—Superposed profiles along north-south lines south of Bristol, at ½ mile intervals.
(*a*) South-east of Bristol; (*b*) South-west of Bristol.

Fig. 30.—Profiles drawn along spurs of Dundry Hill.
(*a*) From Dundry summit :—1. towards Winford; 2. to Barrow Gurney; 3. to Bishopsworth.
(*b*) From middle Dundry :—1. to the south-south-west; 2. to Chew Magna.
(*c*) From Maesknoll :—1. to the south; 2. towards Publow; 3. from north-west of Maesknoll to north.

Fig. 31.—Projected profile of an area, from a base line between Bitton on the east and Long Ashton on the west, looking to the south. The marks on the base line are 1 mile apart.

Fig. 32.—Projected profile of an area, from a base line extending eastwards from near Oldland, along the Avon valley, to a point near Bath, looking north-east. The marks on the base line are 1 mile apart.

FIG. 33.—Superposed profiles along east-west lines near Bradford-on-Avon, at $\frac{1}{2}$ mile intervals, showing the ledge on the Cotswold dip slope. Horizontal scale, 1 inch to a mile.

FIG. 34.—Superposed profiles along east-west lines between Chipping Sodbury and Pucklechurch, at $\frac{1}{2}$ mile intervals, showing 200-300, and 400-foot platforms. Horizontal scale, 1 inch to a mile.

FIG. 35.—Superposed geological profiles along east-west lines across the Frome valley near Yate, at 1 mile intervals.

FIG. 36.—Gradient curve of River Frome above Winterbourne.

FIG. 37.—Superposed geological profiles along north-south lines on the northern border of the Mendips, through Ston Easton, at $\frac{1}{2}$ mile intervals.
Lines used as in Fig. 35, except that a continuous line shows the outcrops of the Carboniferous Limestone. Horizontal scale, one inch to $1\frac{1}{4}$ miles.

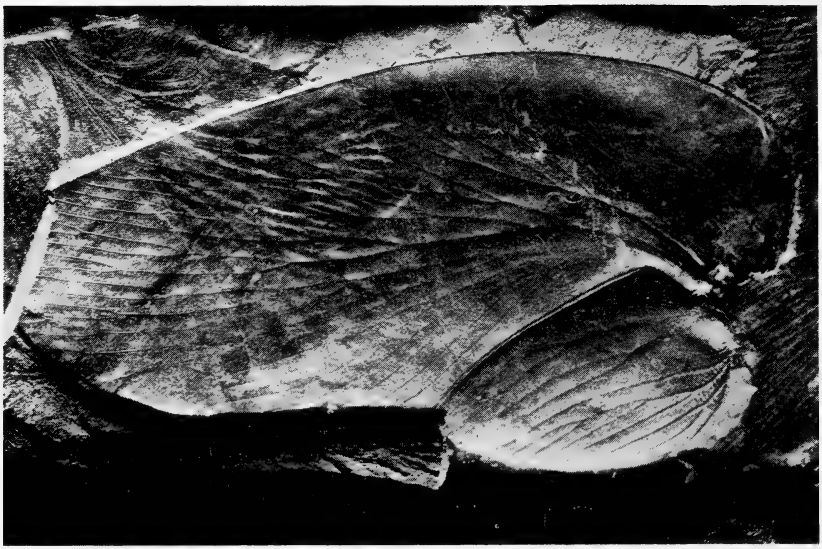


Fig. 1

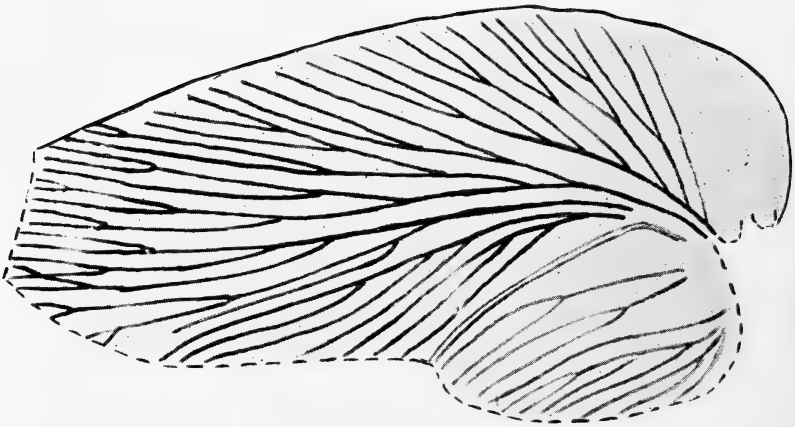


Fig. 2

Soomylacris celtica Bolton

To face p. 429] [*Photo: Miss P. M. James*

The Fossil Insects of the Bristol Coalfield

By F. S. Wallis, D.Sc., F.G.S.

(*Read in title 2nd March*, 1939)

CONTENTS

I.—INTRODUCTION

In view of the fact that Bristol has been an important centre for geological collecting and interpretation for over a century it is surprising that only five examples of insects have been found in the local Coal Measures. As some explanation of this fact, we may remember, on the one hand, the difficulty of finding the remains of dead insects in recent forest litter and on the other hand that all the above five specimens are the result of incidental rather than purposeful collecting. They have been discovered chiefly by research workers on the palæobotany of the seams, who were sufficiently discerning to realise that certain markings were of animal rather than plant origin. The pencil-like markings of both fossil wings and leaves are often superficially similar in outline; the best distinguishing feature between them is that the symmetrical markings on a leaf are quite distinct from the asymmetrical veins on the wing of a fossil insect.

As nearly 30 of these fossil insects have been collected from the Coal Measures of South Wales, it is fair to make the assumption that a more intensive search in the local coal shales would result in an important addition to the known fauna. Until far more specimens are available our knowledge of the insect life of these early and consequently interesting times must be incomplete.

II.—NOTES ON SPECIMENS

The late Dr. H. Bolton indicated the insects known up to 1931 (*Proc. B.N.S.*, 4th Series, Vol. VII, 1931 (1932) 259-60), but in view

of the desirability of describing a recently discovered wing, it also seemed advisable to summarise our knowledge to date.

In this part of the paper it will be convenient to deal with the specimens in the chronological order of their discovery.

1. The first wing fragment was brought to the notice of the late Dr. H. Bolton by Dr. E. A. Newell Arber. It was found at Tyning Batch, Radstock, a waste tip which at that time was receiving material from at least five collieries. The exact horizon of the fossil is thus indeterminable. The specimen is now in the Sedgwick Museum, Cambridge.

The fragment consists of the proximal portion of the wing of a giant dragon-fly and probably formed about one-third of the whole. It was originally described as *Meganeura radstockensis* Bolton, but has more recently been transferred by Handlirsch to his new genus *Boltonites*. The specimen is important, for it still stands as the only representative of dragon-flies in the English Coal Measures, although they are well known at Commentry in France.

2. For a few years previous to 1911 Dr. Bolton was working on the faunal horizons in the Bristol Coalfield. In this research he was fortunate enough to discover two small wing-fragments with their counterparts, partly superimposed on each other, in the shales at South Liberty Colliery. The horizon is in the Lower Coal Series and was cited as 637 feet below the Bedminster Great Vein and 137 feet above the Ashton Great Vein.

The fragments were identified as *Genentomum* (?) *subacutum* Bolton and belong to the order Protorthoptera in which the resemblance in venation and structure to locustid wings is remarkably close. The Protorthoptera are probably the early ancestors of the Orthoptera, an order of living insects which includes earwigs, cockroaches, and crickets. The fragments are now in the collections of the Bristol Museum and Art Gallery.

3. In 1930, when Dr. R. Crookall was investigating the plant remains of the Coal Measure series at Coalpit Heath, he had the good fortune to discover the hind-wing of a blattoid insect. The wing was found complete with its negative in the shales over the High Vein seam and belongs to the Farrington Group. It was fully described by Dr. H. Bolton and presented by him to the Bristol Museum and Art Gallery in 1931. The wing was obviously blattoid in character and was stated to belong to the tribe Hemimylacridia, a series of forms intermediate between the families Archimylacridæ and Mylacridæ. It was thus the

first blattoid remain to be found in the Bristol Coalfield and was important in that it was a hind-wing and not an example of the more usually-preserved fore-wing.

4. All the above remains are, however, fragmentary and it was not until 1934 that Dr. R. Crookall discovered a complete wing with counter impression in the shales over the High Middle Vein at Camerton Colliery near Radstock. The specimen was presented to the Museum of the Geological Survey. The wing is blattoid in character and thus is an early ancestor of the present-day cockroaches. It was described as *Archæotiphe regularis* by Dr. H. Bolton in the last paper which he wrote.

5. Still another blattoid wing in an even more perfect state of preservation was found by Dr. L. R. Moore in 1935. At this time Dr. Moore was working on the faunal and floral content of the Coal Measures and the discovery of such a wing is evidence of his discernment in collecting. The specimen was submitted to Dr. Bolton and identified by him as *Soomylacris celtica*. It was given to the Bristol Museum and Art Gallery in 1938 and is here described and figured. This species was first described and figured by Dr. H. Bolton (*Q.J.G.S.*, Vol. XC (1934) 293-5), from the Upper Coal Series (Pretoria Seam) at Cily bebyll, near Swansea, South Wales—a distinctly higher horizon than the one in which it was found at Bromley Colliery.

Material

A detached, incomplete, right fore-wing lying ventral surface uppermost on greyish coal measure shale crowded with leaves of *Annularia* and *Neuropteris*, *Calamites* and other vegetative débris. Bristol Museum and Art Gallery collections, Reg. No. Cb 2692. Collected and given by Dr. L. R. Moore, 1938. The discovery of the specimen was reported by Professor A. E. Trueman and Dr. L. R. Moore in *Q.J.G.S.*, Vol. XCIII (1937) 236.

Horizon and Locality

Upper Coal Series, Tenuis (or top of Phillipsi) zone, roof shales of No. 6 seam. Bromley Colliery, near Pensford, Somerset.

Description

The wing is ovate, about twice as long as wide and narrows towards a blunt apex. The length of the wing is 2.35 cms. and the width across the anal area is 1.3 cms. The base is rounded inwards towards the point of wing attachment and the humeral angle is large. The outer

margin is strongly convex whilst the inner margin is apparently almost straight. Being an under surface the veins appear as slight ridges. The surface of the wing is wrinkled and irregular. Faint indications of cross nervures between the veins may be discerned especially on the inner part of the anal area. The interpretation of the wing is complicated by the superposition of a *Neuropteris* pinnule.

The anterior or costal margin is strongly marked. Two nodulose elevations occur at base of costal area near the point of attachment of the wing. The subcostal area is triangular. The subcosta has six branches and ends in a long fork. The first and sixth branches are simple, the second, fourth and fifth fork once and the third forks twice and ends in three twigs.

The radius branches twice and ends in three twigs. The radial sector arises low down near the base of the wing, covers a much larger area than the radius and is much branched, ending on the present margin of the wing in fourteen twigs.

As in all members of the genus *Soomylacris* the median divides into two main branches and covers a small area. The outer of these branches reaches the apical area as six twigs whilst the inner branch ends as four twigs on the posterior border and has one branch which does not reach the margin.

The cubital area is small and gives off four inner branches; the first of these forks twice whilst the other three are simple.

The anal furrow is deeply marked and the anal area is convex. The first anal vein probably forks twice into four branches, one of which has a marginal twig; the second is simple; the third divides into four branches; the fourth only forks once whilst the fifth is simple.

Relationships

The total number of insect remains found in the Coal Measures is so relatively small, even in this age of intensive collecting, that seldom can two specimens be referred to the same trivial name.

In this case, however, the wing is remarkably near the holotype. The relative proportions of the areas in the two specimens are almost identical. The chief differences lie in the fewer number of veins in the anal and cubital areas of the specimen here described as compared with the holotype.

III.—TABULATED LIST OF SPECIMENS

The above notes have been re-drafted in tabulated form and the species arranged in systematic order. In this way the relationships of the forms are more clearly seen.

No.	Name	Locality	Horizon	Original and principal subsequent references	Location and Description of Specimen
2	Order Protorthoptera. Family Œdischiidæ. *Genentomum* (?) *subacutum* Bolton.	South Liberty Colliery, Bristol.	Lower Coal Series, ? Ovalis zone. 637 feet below the Bedminster Great Vein and 137 feet above the Ashton Great Vein.	1. *Q.J.G.S.*, Vol. LXVII (1911) 334, Pl. XXVII, figs. 18, 19. 2. Fossil Insects of the British Coal Measures. *Pal. Soc. Mono.* (1921-22) 84, Pl. V, figs. 4*a* and 4*b*.	Bristol Museum and Art Gallery collections, Reg. No. C 972. Holotype. Two wing fragments with counterpart.
4	Order Blattoidea. Family Archimylacridæ. *Archæotiphe regularis* Bolton.	Camerton Colliery, near Radstock, Somerset.	Upper Coal Series. Radstock Group. Stephanian, Hig h Middle Vein.	*Q.J.G.S.*, Vol. XC (1934) 287-8, Pl. IX, fig. 7, and text fig. 7.	Geological Survey collections, Reg. Nos. 51232 and 51233. Plaster cast in Bristol Museum and Art Gallery collections, Reg. No. Cb 2693. Holotype. Left fore-wing and counterpart.
3	Tribe Hemimylacridia gen. and sp. indet.	Coalpit Heath Colliery, near Bristol.	Upper Coal Series. Farrington Group, Tenuis zone, shales over High Vein Seam.	*Proc. B.N.S.*, 4th. Series, Vol. VII, Pt. IV, 1931 (1932) 259-60.	Bristol Museum and Art Gallery collections. Reg. No. Cb 2098. Described and figured specimen. Hind-wing with counterpart.
5	Family Mylacridæ. *Soomylacris celtica* Bolton.	Bromley Colliery, near Pensford, Somerset.	Upper Coal Series, Tenuis (or top of Phillipsi) zone, roof shales of No. 6 seam.	Figured and described in this paper.	Bristol Museum and Art Gallery collections. Reg. No. Cb 2692. Described and figured specimen. Right fore-wing.
1	Order Protodonata. *Boltonites radstockensis* (Bolton).	Tyning Batch, Radstock, Somerset.	Upper Coal Series, Farrington Group (? Tenuis zone). Exact horizon not known.	1. *Q.J.G.S.*, Vol. LXX (1914) 119-127. Pls. XVIII and XIX, as *Meganeura radstockensis*. 2. Handirsch, A. *Revision der Palæozoischen Insekten* (1919) 571. 3. Fossil insects of the British Coal Measures. *Pal. Soc. Mono.*, (1921-22) 140-144. Pl. X, fig. 1, text fig. 44.	Sedgwick Museum, Cambridge. Plaster cast in Bristol Museum and Art Gallery collections. Reg. No. Cb 2752. Holotype. Fragment of wing.

PLATE 33

FIG. 1.—*Soomylacris celtica* Bolton. A right fore-wing. Upper Coal Series, Tenuis (or top of Phillipsi) zone, roof shales of No. 6 seam. Bromley Colliery, near Pensford, Somerset. Bristol Museum and Art Gallery collections. Reg. No. Cb 2692. × 4.

FIG. 2.—*Soomylacris celtica* Bolton. Showing venation. × 4.

In conclusion, I am indebted to Professor A. E. Trueman and Dr. L. R. Moore for details concerning geological horizons of the specimens and to Miss P. M. James for the excellent photograph.

Acknowledgements are also due to the Colston Research Society, University of Bristol, for financial assistance in the publication of this paper.

A List of Lepidoptera from Leigh Woods

By A. H. Peach

(*Read in title, 2nd March,* 1939)

THE following is a list of Butterflies and Moths that I have personally taken or observed in Leigh Woods during the years from 1925-1938. Every month from February to December inclusive has yielded some species. I have not visited the Woods in January, and very rarely in August. The times of my visits have been variously from 11 a.m. to 2.30 a.m. (Summer Time).

The earliest date for a capture—viz., The Spring Usher (*Hybernia leucophaearia*)—is 2nd February. There are certainly other species in the Woods which I have not been fortunate enough to observe, apart from the micro-Lepidoptera which I have not included.

RHOPALOCERA

Pieris Brassicae.
,, *rapae.*
,, *napi.*
Euchloe cardamines.
Gonepteryx rhamni.
Polygonia C-album.
Vanessa urticae.
,, *io.*
Pyrameis atalanta.
Argynnis paphia.
Parage egeria.
,, *megaera.*
Aphantopus hyperanthus.
Coenonympha pamphilus.
Zephyrus quercus.
Thecla w-album.
Cyaniris argiolus.
Ochlodes venata.

HETEROCERA

Chaerocamha elpenor.
Stauropus fagi.
Drymonia chaonia.
Pheosia dictaeoides.
Notodonta trepida.
Lophopteryx camelina.
Pterostoma palpina.
Phalera bucephala.
Habrosyne derasa.
Thyatira batis.
Asphalia diluta.
Polyploca flavicornis.
,, *ridens.*
Dasychira pudibunda.
Porthesia similis.
Lymantria monacha.
Poeciliocampa populi.
Cosmotriche potatoria.
Drepana falcataria.
,, *harpagula.*
(The only locality known in the British Isles for this species.)
,, *binaria.*
,, *cultraria.*
,, *lacertinaria.*
Cilix glaucata.
Spilosoma menthastri.
,, *lubricipeda.*
Hipocrita jacobœa.
Demas coryli.
Acronycta megacephala.
,, *psi.*
,, *rumicis.*
Craniophora ligustri.
Agrotis segetem.
,, *puta.*

Agrotis exclamationis.
,, *ypsilon.*
,, *saucia.*
Noctua c-nigrum.
,, *triangulum.*
,, *brunnea.*
,, *primulae.*
,, *rubi.*
,, *xanthographa.*
,, *plecta.*
Triphaeua comes.
,, *pronuba.*
Aplecta nebulosa.
Barathra brassicae.
Mamestra oleracea.
,, *thalassina.*
Charaeas graminis.
Apamea gemina.
,, *secalis.*
Xylophasia rurea.
,, *lithoxylea.*
,, *monoglypha.*
,, *hepatica.*
Miselia oxyacanthae.
Euplexia lucipara.
Phlogophora meticulosa.
Leucania pallens.
,, *impura.*
,, *conigera.*
Grammesia trigrammica.
Caradrina morpheus.
,, *taraxaci.*
Amphipyra pyramidea.
Taeniocampa gothica.
,, *pulverulenta.*
,, *stabilis.*
,, *incerta.*
,, *munda.*
Calymnia trapezina.
Amathes macilenta.
,, *circellaris.*
,, *helvola.*
Cirrhia citrago.
Xanthia lutea.
Orrhodia vaccinii.
,, *ligula.*
Eupsilia satellitia.
Graptolitha ornithopus.
Rivula sericealis.
Scoliopteryx libatrix.
Plusia moneta.
,, *chrysitis.*
,, *gamma.*
Zanclognatha grisealis.
Hypena proboscidalis.
Brephos parthenias.
Geometra papilionaria.
,, *vernaria.*
Euchloris pustulata.
Iodis lactearia.
Hemithea strigata.
Acidalia aversata.
,, *bisetata.*
,, *dimidiata.*
,, *remutaria.*
Ephyra annulata.
Anaitis plagiata.
Lobophora polycommata.
,, *carpinata.*
,, *viretata.*
Chœimatobia brumata.
,, *boreata.*
Triphosa dubitata.
Scotosia rhamnata.
Eustroma silaceata.
Cidaria pyraliata.
,, *fulvata.*
,, *corylata.*
,, *truncata.*
Lampropteryx suffumata.
Coremia unidentaria.
,, *ferrugata.*
,, *designata.*
Amoebe viridaria.
Oporabia dilutata.
Xanthorhoe montanata.
,, *fluctuata.*
,, *rivata.*
,, *sociata.*
Eulype hastata.
Mesolenca ocellata.
Melanthia procellata.
Perizonia flavofasciata.
Camptogramma bilineata.
Hydriomena furcata.
Anticlea badiata.
,, *rubidata.*
,, *nigrofasciaria.*
Asthena candidata.
,, *luteata.*

Asthena blomeri.
Eupithecia vulgata.
,, *lariciata.*
,, *castigata.*
,, *subfulvata.*
,, *haworthiata.*
,, *abbreviata.*
Chloroclystis coronata.
,, *rectangulata.*
Phibalapteryx vitalbata.
,, *tersata.*
Abraxas sylvata.
,, *grossulariata.*
Loniaspilis marginata.
Ligdia adustata.
Bapta temerata.
Cabera pusaria.
,, *exanthemata.*
Metrocampa margaritaria.
Ennomos alniaria.
Selenia bilunaria.
,, *tetralunaria.*
Hygrochroa syringaria.
Gonodontis bidentata.
Himera pennaria.
Crocalis elinguaria.
Ourapteryx sambucaria.
Eurymene dolabraria.
Opisthograptis luteolata.
Epione advena.
Venilia maculata.
Hybernia leucophaearia.
,, *aurantiaria.*
,, *marginaria.*
,, *defoliaria.*
Anisopteryx aescularia.
Phigalia pedaria.
Pachys betularia.
Boarmia gemmaria.
,, *repandata.*
Tephrosia bistortata.
,, *crepuscularia.*
,, *luridata.*
,, *punctularia.*
Thamnonoma wauaria.
Lozogramma petraria.
Hepialus lupulina.
,, *hecta.*

A Survey of Steep Holm

(*Read in title, 2nd March,* 1939)

CONTENTS

I

INTRODUCTION AND HISTORICAL NOTES

By L. Harrison Matthews, M.A.

STEEP HOLM is a limestone island lying in the Severn estuary between Somerset and Glamorgan, two and a quarter miles from its twin island of Flat Holm. The topographical features are not described here as they are treated in some detail in a later section.

Like all islands, Steep Holm exercises a peculiar fascination for many people, and several visits have been paid to it by persons with interests more serious than those of the casual tripper. In 1938 Mr. H. E. Matthews and the writer organised a small expedition, which spent three days and two nights on the island in July, to carry out the survey of which the present report is the result. Permission for the visit and much help in the arrangements were given by the courtesy of the lessee, Mr. Harry Cox of Brean Down, and assistance in the cost of publication of this survey has been given by the Colston Research

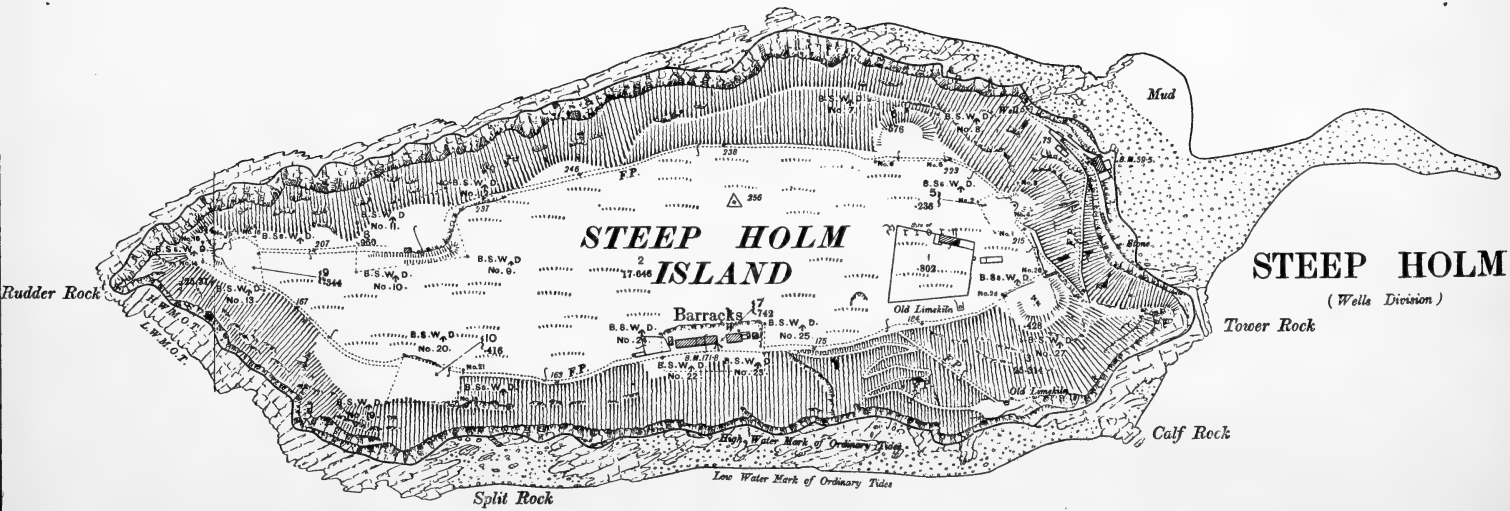
Society of the University of Bristol. The survey was made in an endeavour to amplify the results obtained on the previous visits of naturalists and to investigate the ecological relationships of the fauna and flora.

History

The history of the human occupation of the island is obscure until quite recent times, and in compiling this summary the writer has made full use of the authorities cited in a later section.

A Priory dedicated to St. Michael once stood on the island. A charter from the muniment room of Berkeley Castle shows that it was in existence and adding to its original endowments at the close of the twelfth century in the time of Richard I, but nothing is known of its founder or the date of its founding. Bates Harbin shows that it was probably founded between 1100 and 1166 by one of the de Ewyas family, who owned lands in Somerset and Herefordshire. In the late thirteenth century the community consisted of a minimum of two Austin canons, of whom the elder was the Prior. One William, who is mentioned in a document of 1236, is the only Prior whose name has been preserved. A representative of the de Ewyas family, Robert de Tregoz, who was killed at the battle of Evesham in 1265, was the patron in 1260, when he transferred the Priory with all its belongings to Studleigh Priory in Warwickshire. By the terms of his gift it is evident that he intended to retain a religious community on the island but his intention appears never to have been fulfilled. No reference later than 1260 is known regarding the community. John Smyth, writing at the end of the sixteenth century, stated that Maurice, the third Lord Berkeley, rebuilt the Priory at the beginning of the fourteenth century, but Bates Harbin shows that this, too, was probably an intention that was never fulfilled.

The legend that the monk Gildas (A.D. 516-572) took refuge in the island and there composed his *Liber querulus de Excidio Britanniae* appears to rest solely upon the statement of Leland who, writing a thousand years after the time of Gildas, quotes a fragment of an unknown author to the effect that Gildas and Cadocus retired to two islands, Cadocus to one near the Welsh coast and Gildas to one near the English. The names of the islands are not given, but are supplied by Leland as Ronnet and Echin (Steep and Flat Holm). Gildas, of course, may have been upon the island, but the evidence is of the flimsiest.



Scale : 10 inches to 1 mile

Reproduced from "The Ordnance Survey Map" with the sanction of the Controller of H.M. Stationery Office

FIG. 38

In 918 the Danes took refuge on either Steep or Flat Holm after their defeat at Watchet, and used the island as their headquarters for raids on the mainland, until they were forced to go to South Wales for want of food, many of them having died of hunger. The ambiguity is due to some of the copies of the Saxon Chronicle reading Steep and others Flat Holm, but the latter is usually accepted as being correct.

The story that Githa, the mother of King Harold, sojourned on Steep Holm in 1067 before leaving by sea for St. Omer, appears to be incorrect and due to a mistranslation of the Saxon Chronicle, which states that "Bradanreolice" (Broad, i.e., Flat Holm) was the island where she stayed. The Saxon name for Steep Holm was "Steopanreolice."

There appears to be no more written history of the island until the eighteenth century. It is said to have been the rendezvous of smugglers and pirates, but the many stories concerning them that were in circulation up to about fifty years ago are now lost. The ownership passed through various hands, but the statement that in the early part of the nineteenth century it lay with the Corporation of Bristol is incorrect. Since 1373, when Edward III granted a charter making Bristol a county, the island has formed the western point of the boundary of the county of Bristol, and the boundary stone, a modern successor of older stones, stands at the foot of the cliff near the landing beach.

J. W. White shows that the botanist Turner, when Dean of Wells, must have visited the island in the sixteenth century, and Lobelius soon after him. A century later James Newton was there botanising on behalf of Ray, and in July, 1773, the Rev. J. Lightfoot and Sir Joseph Banks visited the island in search of plants. Collinson records that in 1776 a "tenement" was built for the convenience of storm-bound fishermen, from which it would appear that the island was not then permanently inhabited. Thomas Clark's account of his visit seems to imply that there were only some fishermen living there in 1831. Further, the census returns of the county show no population on the island for each decade from 1801 to 1861 inclusive, but in each decade from 1871 to 1901 inclusive a return varying from five to nine inhabitants is given. Knight says that in 1902 the only persons on the island were a few gunners in charge of the forts. Certain it is that for a very long period a successful fishery was carried on there. A spit of shingle runs out into the tide-way from the east end of the island, and on it was a long row of stakes from which bag-shaped nets were hung. The ebbing tide swept the fish into the nets which were emptied by the fishermen at low water. William Withering, the editor

of the seventh edition of his father's *British Plants*, paid a visit in June, 1826, and refers to the "little enclosure with ruinous walls and few remaining vestiges," evidently the old Priory garden, now obliterated by the Garden battery. He says that no inhabitant had dwelt upon the island within the memory of man "save the solitary fisherman who makes the crazy hut his cheerless abode, and that only through the dreary season of winter."

In 1832 Col. Tynte of Haswell, Bridgwater, purchased the island and built a house near the landing place. Later he leased the island, and the house was turned into an inn. The innkeeper claimed that the island was in no parish and so no license was necessary. About 1884 this claim was challenged, and the Court of Queen's Bench decided that there was no ground for the claim for exemption. According to Knight, Steep Holm was locally regarded as a sanctuary, and about 1840 a Weston innkeeper, to avoid being arrested for debt, lived there for seven years, only going home occasionally on Sundays. The island is still extra-parochial, and was never included in the parish of Brean, as stated by Knight. About three years ago it was attached to the west ward of Weston-super-Mare, but for Parliamentary purposes only.

During the war scare of the 1860's the island was fortified by the War Office. In 1867 six batteries and a barracks for about fifty men were built, the armament being ten 7-inch muzzle loading rifled guns. The batteries are protected by earth banks and have underground ammunition stores attached to them. The barracks are most substantially built and are supplied with water from a 49,000 gallon reservoir which is filled by the rain. After its earliest years the garrison appears never to have consisted of more than a few men. In 1899 the War Office decided to replace the guns with modern breech loaders. As they were in doubt whether the guns should be in barbets or behind shields, a dummy 9.2 in. gun, protected by a Harveyed shield of nickel steel thirty feet long and three inches thick, was mounted at the Rudder Rock battery. The second class cruiser *Arrogant* fired some hundreds of rounds from her 6-inch, 4.7-inch and smaller guns at ranges of 1,800 to 2,000 yards, and the shield was greatly damaged and the cement wall demolished. The remains of the shield and wall still lie there. The modern armament appears never to have been mounted, and in 1903 the island was abandoned by the War Office. The guns, weighing just on seven tons apiece, were dismantled and sold as scrap to a Cardiff firm which, however, found the task of removing them too great, so that they lie there to this day. One of them has been cut

in half with an oxy-acetylene burner, and attempts have been made to cut others, but the intensely hard inner lining of the bore evidently defeated the efforts at cutting them into manageable pieces for removal down the cliff.

The batteries were named the Garden, Split Rock, Rudder Rock, Summit, Laboratory, and Tombstone batteries; the origin of the first and last names will appear below, that of three others is topographical, but why the Laboratory battery was so named remains a puzzle.

Prior to the early 1880's the island was farmed and the inn kept by a family (Harris) which then migrated to Flat Holm where some of its representatives still live. A son of the tenants (Davies) who succeeded them has given Mr. Harry Cox the following reminiscences of the two or three years which he spent there as a boy. Garden produce and vegetables of all kinds were raised, oats and barley were grown, and the whole of the island, not otherwise cropped, was mown for hay. Live stock was kept, including young cattle, pigs, goats, a donkey and poultry. The inn, which contained some thirteen or fourteen rooms, did not have many visitors beyond day trippers who came in boats from Weston or occasionally by tug-boat from Cardiff. The permanent employees of the informant's family were a maid for the house, and two farm labourers. Stores were brought to the island once or twice a week both for the garrison, which consisted of six to eight men, and for the inn, by the yacht *Spray*, owned by a Mr. Perry of Weston. Good water was obtained from the near-by well, filled from a spring, which gave an ample supply for all purposes.

The tenants owned a pilot cutter, which was kept moored off the island, and several flat-bottomed Weston-built boats. During the fishing season in the winter six or eight fishermen were employed. The nets on the bar caught fish of all sorts, but principally sprats and whiting. Lines with hooks were also set for conger, skate and cod which were caught in large quantities. Catches varied, being sometimes as much as three tons a tide, and were usually taken to market at Cardiff in the pilot cutter.

The guns of the batteries were fired periodically "to keep them in order," and officers used to come regularly from Bristol to inspect the fortifications, staying for about a week at a time.

Other tenants came to the island when this family left, and at some time between their arrival and 1900 the inn was abandoned, for it had become ruinous by 1902. These tenants must have occupied the house on the summit, for the barracks were still used by the garrison

until 1903; in fact, the summit house may have been built by them. Very few visits appear to have been paid to the island during the first decade of the present century because the tenant farmer discouraged the landing of strangers.

About 1910 a change of tenancy again took place and the island was inhabited until the middle 1920's, farming and fishing being carried on. The building inhabited during this period was the barracks, all the others being by then ruinous. The last remnant of this tenant's live stock, an old brown goat, was still alive in 1933, but it has since disappeared. For a few years prior to 1931, when the present lessee took the island, it was uninhabited, and the old spirit of the Danes was once more abroad, for at least one piratical raid was made, during which the buildings were broken into and looted of their contents. There is a story of the raiders dumping the *Encyclopedia Britannica* into the sea, volume by volume, in order to lighten their craft as they were being overhauled by a pursuing boat from Weston. Another raid, resulting in prosecutions and fines, was afterwards frustrated by Mr. Cox himself.

The island is now kept under strict supervision as a bird sanctuary.

The only ships known ever to have been wrecked on, or near, Steep Holm are the West Indiaman *Rebecca*, wrecked in 1810, and the Spanish barque *Anita*, which was lost with all hands in 1901.

Literature

Steep Holm is mentioned in many books, and the most important references are here noted. The origin of the story about Gildas in Leland's *Collectanea* has already been mentioned, as has the mistranslation of the Saxon Chronicle which led to the erroneous story of Githa. Dugdale's *Baronage*, published in 1675, contains the first reference to the Priory, and the information was probably taken from John Smyth's sixteenth century manuscript *Lives of the Berkeley Family*. Collinson's *History and Antiquities of the County of Somerset*, 1791, devotes a section to the island, and this is repeated almost verbatim in Rutter's *Delineations of the north western Division of the County of Somerset*, 1829.

The botanists seem to have been the most energetic explorers of the island, and to the earlier visits already mentioned must be added a considerable number to which reference is made in the section of this symposium dealing with the flora.

In 1883 John Storrie took a large party from Cardiff for a day's outing to Steep Holm. The results of the trip were published in the

Transactions of the Cardiff Naturalists' Society for that year, with a list of the plants, shells, insects and fossils found, and an illustration showing the peony growing in its natural habitat, and of the tombstone, described below. The party went by the paddle-steamer *Nelson* and picnicked on the summit of the island. The inn was then still inhabited, as reference is made to it and to the landlady.

In 1902 F. A. Knight published his well-known *Sea Board of Mendip,* which contains a useful and interesting account of both Steep and Flat Holm.

In May, 1914, seven members of the Bristol Naturalists' Society paid a day's visit to the island, and the result of their researches was published in the *Proceedings* of the Society for that year, with lists of plants, mollusca, land crustacea, arachnids, myriapods and insects.

In 1916 the Rev. Prebendary E. A. Bates Harbin published in the *Proceedings of the Somerset Natural History and Archaeological Society* an account of the Priory of St. Michael, and printed for the first time five charters from the muniment room at Berkeley Castle, together with two other thirteenth century references, one of which concerns two lay brothers who, in 1243, were found guilty of larceny by the jury of Winterstoke hundred.

The first two volumes of the *Victoria County History of Somerset,* all that have yet been published, do little more than barely mention the island.

A note on the geology of Steep Holm by Dr. Stanley Smith and G. D. Willan appears in the *Geological Magazine* for 1937, and the latest account of the island is an illustrated article, by Mr. Harry Cox, in *Country Life* for January, 1939.

The Ruins

In 1938, and on a previous visit in 1935, some attention was paid to the ruins of the Priory, and part of the foundations was excavated. Knight tells us that, " before the construction of the batteries in 1867, the walling of the priory was still standing to a height of about seven feet, faced with dressed stone of the island. At the base was a plinth of sandstone three feet broad. Most of this is now buried, but part, from which the facing has been removed, is visible near the roofless ruins near the top of the path. During the construction of the Garden battery, built on the alleged site of the prior's garden, the foundations of the priory were in great part laid bare. One chamber was in such good repair that it was used as living quarters by the foreman. In clearing out the earth to lay a wooden floor the whole space was found

to be packed with skeletons laid close together side by side only a few inches below the surface. Near by, many bones of deer, brass rings of primitive workmanship, a coin with the figure of an archer, as well as many old pieces of money said to show no legible inscription or device, were found. There was a tradition that a former tenant of the island dug up a pot of coins, but of them there is no trace now known." Mr. Harry Cox has found that the bones were taken to a show-cave on the mainland and exhibited there, but all further trace of them appears to be lost.

The wall of which Knight speaks as still visible is the southern wall of a building, and is 16 yards in length. At its east end the foundations of another wall, running at right angles towards the north for 14 yards can be traced. Parallel with the latter and four yards to the west is the foundation of another wall running north for about 12 yards from the south wall. At the west end of the south wall further foundations run north for about 5 yards. The foundations thus form three sides of each of two adjoining rectangular enclosures, but the walls on the north side which should close them are not visible. The south wall rises to a height of about three feet above the outside ground level, but the others are visible only on the surface. The interior of the building is filled with earth and stones nearly to the top of the south wall. Our party cleared a portion of the interior by digging trenches parallel to the south, east, and first west walls.

The south and east walls are 2 ft. 6 ins. to 3 ft. wide (the outside facing being removed), and show traces of plastering on the inner surface down to about 6 ins. above the bedrock, which we reached at a depth of about 4 ft. 6 ins. below the level of the top of the wall. The first west wall appears to be of later date and is of lighter construction. It is 2 ft. to 2 ft. 6 ins. wide, and 18 ins. below the top we came to the footings which projected for about 6 ins. on each side, and extended down a further 18 ins. This wall is not founded upon the rock as are the others. On the inside of the foot of the east wall, 8 yards from the south wall, was a recent hearth of loosely laid bricks surrounded by much ash. It is tempting to surmise that this building is the one referred to by Knight in which the burials were found, and this hearth was used when the building was occupied by the foreman during the construction of the Garden battery. Certainly the east wall must have been standing to some considerable height in recent times, for such a hearth would be made only within a building of some sort.

The infilling of the building consisted of a superficial layer of earth 1 foot thick, above a mass of earth and stones 2 ft. 6 ins. to 3 ft. 6 ins.

thick, lying on the rock. In the underlying layers of earth and stones, especially in their upper parts, a number of objects were found. Their nature and distribution show that the infilling is not of ancient origin, and it appears to be rubbish moved from elsewhere. Nearly all the stones are of small size, and do not appear to be derived from any building; the surrounding walls have been removed and have not just collapsed inwards. The objects found included bones and pottery fragments: the latter have been examined and identified as far as possible by Mr. H. W. Maxwell, who assisted in the work of excavation. The bones are those of domestic animals including sheep, young oxen, pig and horse, the latter represented by a single tooth. The pottery is very mixed, the oldest fragment being part of the foot of a neolithic bowl. Many pieces of coarse unglazed earthenware, which might be assigned to any date during the last thousand years, were found. With them were associated fragments of buff-coloured mediæval ware with greenish glaze, sixteenth and seventeenth century reeded ware, and shards of modern china. Several pieces of dressed freestone were also found, some with dowel holes; these had evidently formed part of the window of an ecclesiastical building, presumably the Priory.

To the north of the Priory ruin, between it and the Tombstone battery, is an area of ground covered with loose stones forming a low mound. They evidently do not lie there naturally and may represent the disintegrated ruins of a building, but we had no time to investigate them.

Built into the wall of the sidearm store of the Tombstone battery is a piece of a thirteenth century stone coffin lid or memorial slab of hard blue lias. The edge is moulded and the centre bears part of an incised fleury cross. An inscription on it records that it was excavated near by in 1867, during the construction of the batteries.

Just west of the Priory and slightly to the north stands the roofless ruin of a cottage. It is 11 yards in length from east to west, and 5 yards in width. There is a doorway in the south wall and a chimney at each end. Traces of a transverse wall dividing it into two rooms remain. At the west end a corbelled alcove surrounds the chimney, and within it is a corbelled recess in the wall. The upper part of the west wall shows traces of a loft or upper room. There are windows in the north, south and east walls. A small stone annexe has been built as a lean-to outside the west wall. We removed the bushes and elder trees growing within the ruin, and cleared out much of the fallen masonry covering the floor, but found no objects giving any clue as to its former

inhabitants. It would appear, however, that this is the cottage built in 1776, and occupied by fishermen when Thomas Clark visited it and described it so graphically in 1831.

Further to the west again is a large enclosure bounded by a stone wall, with the ruins of another building at its northern edge. This building is of more modern origin than the hut, and has evidently been inhabited in fairly recent times, for, although it is roofless, some of the grates and a small kitchen stove are still in place, as are the wooden door and window jambs. Roofing felt, too, still covers the collapsed roof of a small shed. At one side of the house there is a cemented tank, which is still watertight and is filled with rain water. The enclosure was evidently cultivated as a garden, and lines of stones still show the boundaries of the garden beds. This is not, however, the old garden of the Priory, which is said now to be covered by the Garden battery. Both the enclosure and the building appear to have been made since the fortifications were constructed in 1867.

In the area bounded by the east wall of the garden, the first cottage, and the Priory, the ground has been much disturbed and is covered by several mounds of earth and loose stones. The writer has heard stories from some of the Weston fishermen to the effect that a former resident on the island had said that a large number of skeletons lay buried near the surface under the east wall of the garden. The fishermen understood this statement to refer to the existing wall of the enclosure. In 1935 and 1938 the writer searched carefully on both sides of the wall, and made trial diggings, but with no success. The ground is very stony and most unpromising, and soil which appears to be undisturbed lies very close to the surface. It may be that this story is a garbled version of that told by Knight about the skeletons. It may really refer to the east wall of the Priory, where the modern hearth was found in 1938, pointing to the possibility of its being the building mentioned by Knight as the one where the skeletons were found when the wooden floor was laid in 1867.

The only further building on the summit, other than the batteries and the barracks, is a lime kiln just south of the garden. This was used during the building of the fortifications, and near-by is a small quarry from which the stone was dug. On the steep slope of the island above the Calf Rock—the ancient landing place from which a path leads to the summit—stands another lime kiln. On this slope, too, a platform was constructed which was used as a base for a derrick for landing stores and equipment when the fortifications were built. A recess beside the path above accommodated the winch.

The ruin of the inn at the foot of the cliff is now merely an empty shell, only the four walls still standing. A short way up the cliff path behind it is the ruin of a small cottage. This is built against the cliff, which forms the back wall of it. Judging from its style and state of preservation, it must be contemporary with the inn, though its position seems to be much more suitable for a fisherman's shelter than that of the much older ruined cottage on the summit. It is the least dilapidated of the ruins, for it still has a roof, and was used until recent years as a store house for fishing gear. Fishing was last carried on in the winter of 1931-32, and a number of the old fishing stakes still stand on the bar.

A little to the west of the inn and cottage is the well, a shallow basin filled by a spring in the rock above. Knight says that it goes almost or quite dry during long droughts, though the inhabitants in the early 1880's found that it gave an ample supply for all purposes. Before the construction of the barracks all the water, apart from rain water, used at the fisherman's cottage on the summit must have been carried up from this well. In recent years, though it has never dried, it has gone very low in hot summers.

On the beach below the inn can be traced the remains of an artificial harbour, which dried out at low tide. It lies in a natural angle of the rocks which formed two sides of it, and quay walls had been built out on the east and north sides, the entrance being at the north-east corner. The walls are now entirely demolished, but the line of the foundations can still be traced, and the stump of a wooden pile which stood at one side of the entrance, evidently as a fender, is still in position. The foundations are made of large blocks of stone from the beach. This boat harbour, which would have accommodated small ships up to about 30 or 40 tons, judging by the width of the entrance, is apparently contemporary with the inn, and must have been demolished by the sea not long after its construction, for no reference to its existence has been found in any document beyond the projected " pier for fishing boats " mentioned by Thomas Clark in 1831.

Caves

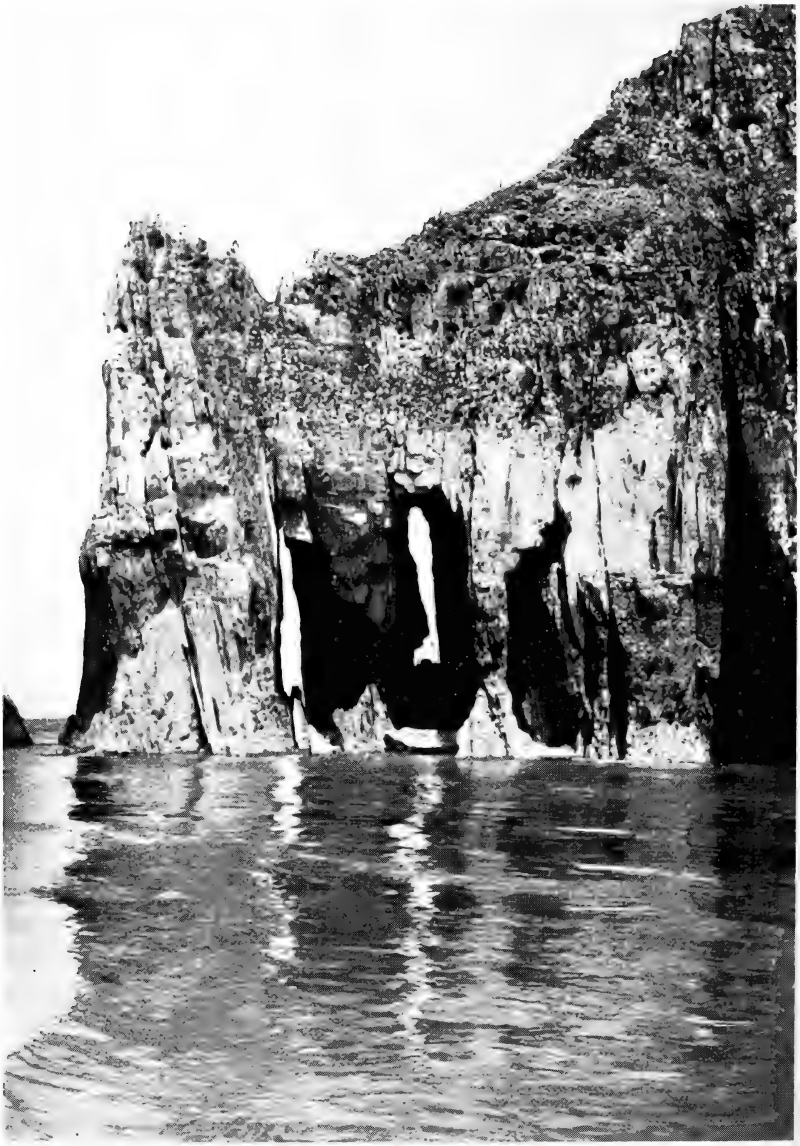
Knight states that " on the north side there is a cave running deep into the island. It is difficult of access, and although above high water mark, it is only to be reached at low tide. It was visited about 1880 by two men from Weston, who brought away a number of stalactites of great size and beauty. They also saw bats in great numbers clinging to the roof. The explorers crawled through a narrow passage into a

much more spacious chamber beyond. From the roof of this hung many fine stalactites and the floor was covered with a sheet of water."

In 1935, with some members of the Wessex Cave Club, we found, after some search, a cave that appeared to answer this description. The mouth is about forty feet above the cliff foot, and with considerable difficulty we got into it, after trying unsuccessfully to approach it by rope from above, a manœuvre that was defeated by the overhanging nature of the cliff. The interior of the cave, however, does not agree with Knight's description. It is not of any large size, and consists of an inner and an outer chamber. The outer chamber is about twelve feet in height, and from one corner of it a steep ramp leads to the inner chamber, which curves round in a semi-circular shape so that its furthest end communicates again with the outer chamber. The levels are such that this connection forms a chute or chimney opening into the roof of the outer chamber. There are no large stalactites, or signs of there having been any. The floor of the inner chamber is covered with a sheet of stalagmite under which lies a mass of red cave-earth. With the erosion of the cliff the cave has been diminished in size so that the stalagmite floor and underlying earth appear in section. Embedded in the exposed earth were fragments of sub-fossil bones, one of which has been identified as that of Red or Rein Deer. On many parts of the walls of the inner chamber there was a curious soft efflorescence of stalactitic material. In the chute connecting the roof of the outer with the floor of the inner chamber was a mass of small stones cemented together with stalagmite, presenting the appearance of a petrified cascade. The cave is evidently an old swallet, filled in with cave-earth before the separation of the island from the mainland.

Although the approach to this cave agrees with Knight's description, it appears that his account of the interior refers to another. There is on the island another large cave, which was called "the church" by a former tenant. This cave could be approached from the land by some precarious scrambling, but its site has not yet been re-discovered.

There is a third small cave at the foot of the cliff not far from the landing beach. Its mouth is entirely submerged at high water, and a large pool fills the entrance at low tide, necessitating a wade up to the waist in order to enter it. Within the narrow mouth it opens out to a chamber of some size, and a beach of fine shingle lies at the far end. It contains nothing of particular interest.



Rudder Rock, the Western Extremity of Steep Holm

To face p. 451] [*Photo : H.C.*

II

PHYSIOGRAPHY AND GEOLOGY

By Stanley Smith, M.A., D.Sc., F.G.S.

STEEP HOLM, one of several islands which rise out of the Bristol Channel, lies five miles due west of Weston-super-Mare, Somerset, and about the same distance S.S.E. of the nearest point on the Glamorganshire coast. It is, however, only three and a half miles W. 15° N. of Brean Down, the promontory on the south side of the bay in which Weston is situated. The island is elliptical in outline, with its longest axis orientated east and west, in which direction it is 950 yards long. The shorter axis (north and south) is only 350 yards.

Both at its eastern and western ends the island is drawn out into points, Rudder Rock and Tower Rock. At low tide it is surrounded by a platform of rock and beach approximately 120 feet wide, and at the eastern end a spit of sand and shingle stretches outwards for a distance of 330 yards. Platform and spit are entirely covered by the sea at high tide.

From the surrounding platform the island rises as vertical cliffs to a height of fifty feet or more, and then slopes steeply up, at angles approximating 30°, to the fairly level surface of the summit. The sloping sides are broken in places by ledges of vertical rock.

The surface rises from its south-western edge, where it is only a little more than 160 feet above the sea, towards its north-eastern edge, reaching its highest point (256 feet O.D.) in about two thirds of the distance. North and east of the summit the ground falls away to a height of about 230 feet.

The island is formed entirely of limestone, of Lower Carboniferous age, and consists of beds which represent only the middle part of the massive limestone of the Avon Gorge, and belong chiefly, if not entirely, to the *Syringothyris* Zone. The strata are folded into an anticline, the axis of which runs E.N.E.–W.S.W., and the southern limb of this is thrust over the northern. The rocks are mainly of light colour and are in part oolitic. Steep Holm and its neighbouring island Flat Holm are formed from continuations of the Mendip folds.

III

BOTANY

By Macgregor Skene, D.Sc., F.L.S.

MORE attention has been paid to the botany of Steep Holm than to other branches of its natural history. The following visits of botanists have been recorded:—

(1) W. Turner, a probable visit before 1562 (Turner, 1568).
(2) M. de l'Obel, in 1581 (de l'Obel, 1605).
(3) A note of botanical interest in *The Account Book of the Manor of Norton Beauchamp* of about 1625 (White, 1912).
(4) J. Newton, about 1688 (Ray, 1724).
(5) J. Banks and J. Lightfoot, in 1773 (Riddelsdell, 1905).
(6) F. P. Wright, about 1803 (Turner and Dillwyn, 1805).
(7) W. Withering *fil.*, in 1826 (Withering, 1830).
(8) T. Butler, about 1845 (Cardew and Baker, 1912).
(9) T. Clark, in 1830 (Dilks, 1939).
(10) Cardiff Naturalists' Society, in 1877 (Storrie, 1878).
(11) Cardiff Naturalists' Society in 1883 (Storrie, 1883).
(12) T. B. Flower, in 1887 (Murray, 1891).
(13) R. P. Murray and others, in 1891 (Murray, 1891).
(14) C. G. Druce, in 1909 (Druce, 1910).
(15) Bristol Naturalists' Society, in 1915 (Roper, 1915).
(16) Cardiff Naturalists' Society, in 1923 (McLean and Hyde, 1924).
(17) Party of Bristol Naturalists, in 1938 (this paper).

Of these visits it may be noted that the first record of *Smyrnium Olusatrum* comes from (1); the doubtful record of *Suaeda fruticosa* from (2); the first records of *Allium Ampeloprasum* from (3); of *Paeonia mascula* from (6) and of *Plantago coronopus*, var. *Sabrinae* from (8). Most of the plants growing on the island were recorded on the visits numbered 10 to 13, and a few additions were made on the later visits.

The following is a complete list of the plants so far discovered; the number after each refers to the list given above and indicates the original discovery. The plant list is in the order of the *London Catalogue* Ed. 11.

Clematis Vitalba, 11
Anemone nemorosa, 11
Ranunculus acris, 11
Ranunculus repens, 11
Ranunculus bulbosus, 13
,, *Ficaria*, 11
Paeonia mascula, 6
Laurus nobilis, 17

Papaver dubium, 13
Fumaria capreolata, 13
,, *officinalis*, 11
Cheiranthus Cheiri, 11
Barbarea vulgaris, 11
Cardamine hirsuta, 11
Erophila verna, 13
Cochlearia officinalis, 11
,, *danica*, 4
Sisymbrium Thalianum, 11
,, *officinale*, 11
Brassica oleracea, 11
,, *Rutabaga*, 13
,, *Rapa, a. sativa*, 11
,, *arvensis*, 11
Diplotaxis tenuifolia, 14
,, *muralis*, 13
Capsella Bursa-pastoris, 13
Coronopus procumbens, 13
Lepidium campestre, 11
Cakile maritima, 11
Raphanus maritimus, 11
Reseda Luteola, 16
Viola sylvestris, 11
,, *Riviniana*, 14
Polygala vulgaris, 13
Silene Cucubalus, 13
,, *maritima*, 11
Lychnis alba, 13
,, *dioica*, 11
Cerastium tetrandrum, 11
,, *pumilum*, 13
,, *semidecandrum*, 13
,, *viscosum*, 11
,, *vulgatum*, 13
Stellaria nemorum, 11
,, *media*, 11
Arenaria serpyllifolia, 11
Sagina apetala, 13
,, *procumbens*, 11
Spergula vulgaris, 11
Hypericum pulchrum, 11
,, *montanum*, 13
Lavatera arborea, 5
Malva sylvestris, 11
Linum catharticum, 13
Geranium molle, 13
,, *dissectum*, 11
Geranium Robertianum, 11
,, ,, *b. maritimum*, 16
Erodium cicutarium, 11
,, *maritimum*, 5
Oxalis Acetosella, 11
Acer Pseudoplatanus, 11
Genista anglica, 11
Ononis repens, 11
Medicago lupulina, 13
Trifolium pratense, 13
,, *repens*, 11
,, *procumbens*, 13
,, *dubium*, 13
Anthyllis Vulneraria, 13
Lotus corniculatus, 11
,, *uliginosus*, 10
Vicia hirsuta, 11
,, *tetrasperma*, 11
,, *sepium*, 14
,, *sativa*, 11
,, *angustifolia*, 14
,, *lathyroides*, 11
Lathyrus pratensis, 11
Prunus spinosa, 17
Rubus rusticanus, 13
,, *pyramidalis*, 15
Rosa canina, r. dumalis, 13
,, *rubiginosa*, 16
Crataegus Oxyacantha, 13
Saxifraga tridactylites, 14
Ribes Grossularia, 16
Cotyledon Umbilicus-Veneris, 11
Sedum Telephium, 11
,, *acre*, 10
Sanicula europaea, 11
Conium maculatum, 5
Smyrnium Olusatrum, 1
Carum Petroselinum, 13
Pimpinella Saxifraga, 13
Anthriscus sylvestris, 16
Foeniculum vulgare, 11
Crithmum maritimum, 5
Aethusa Cynapium, 10
Peucedanum sativum, 13
Heracleum Sphondyllium, 13
Coriandrum sativum, 12
Caucalis Anthriscus, 11
Hedera Helix, 11
Sambucus nigra, 11
Symphoricarpus racemosus, 14
Rubia peregrina, 13
Galium Cruciata, 11

Galium verum, 11
,, *Mollugo*, 13
,, *saxatile*, 17
,, *Aparine*, 11
Sherardia arvensis, 13
Kentranthus ruber, 11
Dipsacus sylvestris, 13
,, *fullonum*, 14
Bellis perennis, 11
Filago germanica, 11
,, *minima*, 10
Inula squarosa, 11
,, *crithmoides*, 5
Chrysanthemum segetum, 11
,, *Leucanthemum*, 11
Tussilago Farfara, 11
Senecio vulgaris, 11
,, *viscosus*, 11
,, *Jacobaea*, 13
Carlina vulgaris, 11
Arctium majus, 10
,, *minus*, 14
Carduus nutans, 10
,, *crispus*, var. *acanthoides*, 11
Cnicus lanceolatus, 13
,, *acaulis*, 11
,, *arvensis*, 11
Centaurea nigra, 11
,, *Scabiosa*, 11
Picris echioides, 13
Crepis capillaris, 17
Hieracium Pilosella, 13
,, *murorum*, 11
Hypochaeris radicata, 13
Leontodon hispidum, 13
,, *autumnale*, 13
Taraxacum officinale, 13
,, *laevigatum*, 13
Sonchus oleraceum, 13
Campanula latifolia, 11
,, *rotundifolia*, 11
Limonium vulgare, 5
,, *binervosum*, 11
Armeria maritima, 11
Primula vulgaris, 11
,, *veris*, 11
Anagallis arvensis, 14
,, *foemina*, 11
Ligustrum vulgare, 3
Syringa vulgaris, 14
Blackstonia perfoliata, 10
Erythraea Centaurium, 14
Cynoglossum officinale, 10
Lycopsis arvensis, 14
Myosotis palustris, 14
,, *arvensis*, 13
,, *collina*, 13
,, *versicolor*, 14
Echium vulgare, 14
Hyoscyamus niger, 13
Verbascum Thapsus, 10
Anthirrhinum majus, 13
Scrophularia nodosa, 13
Digitalis purpurea, 13
Veronica agrestis, 16
,, *persica*, 13
,, *arvensis*, 13
,, *serpyllifolia*, 11
,, *Chamaedrys*, 13
Euphrasia officinalis, 11
Bartsia Odontites, 11
Verbena officinalis, 11
Thymus Serpyllum, 11
Calamintha ascendens, 13
Prunella vulgaris, 17
Nepeta hederacea, 11
Marrubium vulgare, 11
Lamium amplexicaule, 13
,, *maculatum*, 11
Ballota nigra, 11
Teucrium Chamaedrys, 10
,, *Scorodonia*, 13
Plantago Coronopus f. Sabrinae, 8
,, *maritima*, 11
,, *lanceolata*, 11
,, *media*, 11
Chenopodium album, 11
,, *rubrum*, 11
Beta maritima, 11
Atriplex patula var. *angustifolia*, 11
,, *glabriuscula*, 13
Suaeda fruticosa, 2
,, *maritima*, 11
Salsola Kali, 11
Polygonum aviculare, 11
Rumex crispus, 13
,, *Acetosa*, 11
,, *Acetosella*, 11
Euphorbia Lathyris, 5
Mercurialis perennis, 11

Urtica dioica, 13
,, *urens*, 11
Parietaria ramiflora, 11
Orchis mascula, 11
Ophrys apifera, 10
Iris foetidissima, 10
Allium Ampeloprasum, 3
Scilla non-scripta, 11
Arum maculatum, 11
Carex diversicolor, 14
Anthoxanthum odoratum, 11
Agrostis canina, 11
,, *alba*, 11
Aira caryophyllea, 11
Trisetum flavescens, 11
Avena pubescens, 13
,, *pratensis*, 11
,, ,, *c. longifolia*, 16
Arrenatherum elatius, 11
Dactylis glomerata, 11
,, ,, *b. congesta*, 16
Briza media, 13
Poa annua, 11
,, *pratensis*, 11
,, ,, *b. subcoerulea*, 13
Festuca rigida, 10
,, *rottboellioides*, 16
,, *ovina*, 13
,, ,, var, *duriuscula*, 11
,, *rubra*, 11
,, *fallax*, 16
,, *pratensis*, 11
,, *pratensis* × *Lolium perenne*, 16
Bromus erectus, 11
,, *sterilis*, 13
,, *hordeaceus*, 11
Lolium perenne, 11
Hordeum nodosum, 11
,, *murinum*, 11
Asplenium Adiantum-nigrum, 11
,, *marinum*, 5
,, *Trichomanes*, 11
,, *Ruta-muraria*, 13
Ceterach officinarum, 16
Phyllitis Scolopendrium, 11
Polypodium vulgare, 13

Mosses

Barbula convoluta
Tortula intermedia
Bryum Donianum
Camptothecium sericeum
,, *lutescens*
Eurhynchium circinatum
,, *tenellum*
Hypnum cupressiforme v. tectorum
,, *cuspidatum*
,, *Schreberi*

Liverworts

Madotheca platyphylla
Metzgeria furcata
Frullania tamarisci

Lichens

Physcia tenella
,, *pulverulenta*
Xanthoria parietina
Placodium callopismum
,, ,, var. *plicatum*
Callopisma citrinum
,, *pyraceum*
,, *ochraceum*
,, *calvum*
,, *ferrugineum* var. *festivum*
Lecanora galactina
Lecania prosechiza
,, *erysibe*
Bacidia muscorum
Bilimbia mesoidea
Placynthium nigrum
Verrucaria integra
,, *rupestris*
Cladonia pyxidata
,, ,, var. *pocillum*
,, *rangiformis*, *f. foliosa*
,, *furcata* var. *pinnata*

Fungi

Puccinia Smyrnii

All the records of mosses, liverworts and lichens are due to McLean and Hyde, the plants having been determined by W. Watson. The rust was first recorded by Storrie (1877).

On the present visit 85 species of plants were collected and of these 5 had not been previously noted. Even although each of the later visits has added a few plants to the list, it may be taken that the flora is now very fully known. The total number of species and varieties of flowering plants and ferns is 254, or just about one quarter of the number known from Somerset. For a small area this is a considerable flora. It includes a number of rare and interesting plants; but even more interesting is the general nature of the vegetation.

The steep slopes and ravines on the southern side of the island are clothed with a dense thicket of privet and bramble. In the ravines the bushes may be as much as 8 ft. high; towards the edge of the plateau they are stunted and, on the rounded upper slopes, are only about 1 ft. high. There is no sign of rabbit nibbling, and the stunting seems to be due to wind action. Occasional bushes of elder are quite bare and brown on the windward side in July, except for a few sprouting buds; on the leeward side they are in full leaf. On the slopes about the landing stage and path, the privet and elder are mingled with a good deal of sycamore, maple, sloe, and lilac which must have been originally planted. The privet-bramble society is a characteristic, though not very rich, limestone scrub.

The most interesting feature of the vegetation is, however, the "meadow" of *Smyrnium Olusatrum* on the plateau. On the southern side, on the shoulder of the slope, the thicket of privet thins out to isolated patches among which grow abundant alexanders, wood sage and ground ivy. This mixed vegetation is succeeded on the plateau by a pure growth of alexanders, covering many acres at a density of 1 to 10 plants per square yard. Between the alexanders plants there are sometimes patches of ground ivy and wood sage, but, over great areas, the ground is quite bare. In July the foliage has completely died away, except for a few ground leaves of non-flowering shoots, and, from above the barracks, a stretch of plateau some 400 to 500 yards long by 100 yards across may be seen, bearing nothing but the tall, dead stems crowned by fruiting heads of the alexanders.

Passing over to the northern slope of the island, ragwort first mixes with the alexanders and then replaces it completely; after the alexanders has disappeared, thistles come in and the ground becomes covered with a close turf of fescues, yellow stonecrop, ground ivy and wood sage. This occupies the gentle slopes on the northern side; towards the cliffs the grass becomes coarser with meadow grass, false-oat, yellow oat and cocksfoot. This rough pasture runs to the top of the steep cliffs and down into the gullies. Towards the north-west the

alexanders comes right across the island to the edge of the cliffs and down the gullies. On the southern side, where alexanders grows amongst privet and bramble, another interesting plant is present in abundance; this is the stinking iris which sometimes occupies bare patches and sometimes thrusts its leaves, much bitten by rabbits, through the low thickets.

The most interesting feature of the vegetation is the dominance of alexanders which, seen from above the barracks, is most impressive. The status of this plant is a matter of opinion. Its chief area of distribution is the coasts of the Mediterranean and it also occurs on the Atlantic coasts of the continent. It is quite possible that it is a native in the West of England. But it was formerly grown as a pot herb and there is little doubt that in many of its present British stations it is an escape. In view of the early occupation of Steep Holm it may seem likely that alexanders was introduced to the island by man. Yet as a rule, in this country, the plant favours rather damp places, especially where refuse has accumulated; a typical example is to be seen at the foot of Bridge Valley Road, Clifton. On Steep Holm the habitat is strikingly like that of the plant in its Mediterranean stations.

If we attempt to trace its history we find that it was the first plant recorded for the island, by Turner. In the *Account Book of the Manor of Norton Beauchamp* it is stated that nothing grows on the Holm save privet, elder and a "kind of wilde garlicke." It is remarkable that alexanders was not noted, especially as the author goes on to say of the rabbits of the island that they "be so fedd with garlicke, privet and elder (grasse lackeinge) that they doe savor of the garlicke and privet in eating." At present the top of the island is covered with either grass or alexanders. The definite statement as to lack of grass and the failure to note so obvious a plant as alexanders may indicate that at this time the whole top of the island was under scrub.

This hypothesis is supported by the report of Banks and Lightfoot in 1773 that alexanders and privet are the "praedominant plants upon the Top of the Island, which totally cover it." Evidently at that time privet occupied the plateau, while now it reaches only the edges. This may represent a time when alexanders was extending and invading the scrub. Whether the island was inhabited at this time is not known.

The accounts of the next two visits, those of the younger Withering in 1826 and of Clark in 1830, agree. There was now an inn on the island but apparently no cultivation. Natural conditions on the top may have been little interfered with. Withering says: "the herbage more general consists of the gigantic *Smyrnium Olusatrum, Lavatera*

arborea, Hyoscyamus niger and a brush-wood of *Ligustrum vulgare*"; and Clark: "This (alexanders) was most plentiful, I think all over the island; I distinctly recollect it at both ends—the most abundant, at least the one which occupies the largest space, is the common privet which closely covers whole acres." Although both statements lack precision as regards the distribution of these plants the impression one gains is that privet occupied the top of the island along with alexanders.

The garrisoning of the island in 1867 must have meant considerable disturbance; apparently between that date and 1880 it was first occupied by a farmer, and cultivation of the plateau continued till about twenty years ago. During this period oats, barley, hay and garden produce were grown. I was told by the warden that a heavy crop of hay was taken in good years. Murray in 1891 speaks of alexanders as being a prominent feature of the vegetation, and of privet as being in plenty on rocks and cliffs. This agrees with the exact recent description given by McLean and Hyde whose account of the flora and vegetation is very full. They say that, since the visit of Banks when alexanders covered the top of the island, culture has done away with it on the plateau; and they describe the plant as occurring in a Smyrnium-Iris association along with bramble and privet. This agrees with what we found on the upper slopes of the southern side of the island and restricts the alexanders in 1925 to a small part of its present area. The visit must have taken place within a year or two after the abandonment of cultivation, when the island was still in a state showing the maximum effects of human interference. Now, thirteen years later, alexanders has occupied nearly half the plateau.

Although our data are not always precise we may surmise that in the 17th century Steep Holm was largely covered by limestone scrub of bramble and privet with some alexanders. In the 18th century alexanders had become a striking feature, and in the early years of the 19th century it was dominant along with the privet. Military and agricultural occupation cleared the top of the island of both, and alexanders became confined to the upper slopes of the cliffs. With the removal of human influence, alexanders has occupied the arable land and replaced the grass over a very large part of the plateau in less than 20 years. At present it forms, with a few other plants, a society which is certainly unique in this country.

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IV

THOMAS CLARK'S ACCOUNT OF A VISIT TO STEEP HOLM IN 1831

By T. Bruce Dilks, B.A., F.R.Hist.S.

THOMAS CLARK was of Quaker parentage and was born in 1793 at Street, Somerset. When he and his brother John were of an age to enter on a business career their parents migrated to Bridgwater in order to give the youths a better opportunity than they could look for in their birthplace.

John was a genius and could turn his mind to anything except making his livelihood. His chief invention—that which has conferred most benefit to mankind—was the air-cushion. Thomas was of a different type. He was able to keep himself and others, and at the same time to pursue researches in natural science during his leisure. Chiefly he was a botanist and he formed a herbarium which has, I believe, found a resting place in the museum at Cardiff. His correspondence with the leading botanists of his time witnesses to the esteem in which he was held. One of his most interesting discoveries in geology was that of the head of Plesiosaurus in the Lias at Street. He died in 1864.

This account of his visit to Steep Holm is an extract from his diary, and is here published for the first time.

1831.

8th mo. 16th. . . . To Weston-super-Mare arriving there about 11. By 12 or soon after, we had engaged a boat, 27 feet long with two masts and sails, and two men to take us to the Steep Holm. We had also a small boat in tow, in which we landed. The air was exceedingly still, and the sea exceedingly smooth; much smoother than I had supposed the sea ever to be. Except an almost imperceptible swell, it was as smooth as our river (the Parret) in a still evening just at the hour of a high tide. The men were therefore obliged to row the greater part of the way, though we were assisted by the tide, and a quarter of an hour before we reached the island a smart shower of rain came on, and with it a brisk air, but these soon passed off. It was three o'clock or past before we landed. We left at six, and, the calm continuing, we did not get back to Weston till past eight. Altogether we were five hours and a half on the water, though the boatmen told us that the distance

from Weston to the island, or back, is sometimes sailed over in a half an hour, and even twenty minutes. If we had had a wind we should have visited the Flat Holm also. One of the boatmen told us that the Steep Holm has been lately purchased for £7,000 or £700, he could not tell which. The latter sum is the more probable one. The proprietor is about to construct a pier for fishing boats, which will probably be a profitable speculation, for £500 worth of sprats are said to have been caught round the island last season. Several men were employed in cutting a winding road from the little pebbly beach, our landing place, at the eastern end of the island, to the top; in part through the solid rock; and in one place they had dug through a bed of shells of the common limpet, mixed only with a little loose earth. It was a query how they came there, and at what remote time. Perhaps, numerous as they are, they are only the accumulated heap thrown from time to time from some cottage or hut, of whose inhabitants this shell fish formed it may be the principal food; and though we did not observe any vestige of a building very near, the well of good spring water, the only well on the island, is almost close by. Gildas, the historian, appears from Rutter's Delineations of the N. Western Division of the County of Somerset, to have led a hermit kind of life here, and it may be that his dinners contributed to this accumulation of shells. Githa, the mother of Harold, the last of the Saxon Kings, who also took refuge here, was, I hope, supplied with more queenly food. The old house on the top of the island, and near the eastern end, has been in part repaired for the accommodation of the workmen. Here we dined off the sandwiches and tarts with which we were provided, in a room which reminded us of the romance descriptions of a cave of banditti. It contained three or four small beds, and the pots, frying-pans, and other cooking apparatus of the whole inhabitants of the island. We however were as little disposed to be dissatisfied with our dining-room as with our dinner, and I know not whether we the more enjoyed this repast or our far more elegant tea-supper when we got back to our hotel at Weston. I have had for many years the wish to visit this island, principally on account of the rare plants which I know grow there—the piony, the great round-headed garlic, and the caper spurge. We found all three and I have them now planted in my garden. The garlic I saw and knew from the boat before we landed, growing abundantly on a high ridge at the eastern end of the island, though I know not that I ever saw it before. The piony and the spurge grow on the flat top. The shrubby saltwork and the tree mallow, as I have since learnt, are also inhabitants of the island. The latter Dr. Gapper

tells me he once found there. He also informs me that a plant of which I have brought home the seeds and roots only, the foliage being nearly decayed, is the common Alexanders. This was very plentiful, I think all over the island; I distinctly recollect it at both ends. I was much interested with a plant growing on a rocky declivity at the Western end, but could not get to it without greater labour and risk than I was disposed to encounter. It appeared to be composed of upright stems a foot or more high, clothed with bright green leaves and covered on the top with golden flowers. Dr. Gapper supposed it to be the samphire-leaved flea-bane. Besides these there are many other plants of less interest. The most abundant, at least the one which occupies the largest space, is the common privet which closely covers whole acres. It probably forms, as Dr. Gapper remarks, the principal food of the numerous rabbits on the island, for though they do not, I believe, usually eat this plant, I do not know what else they can have to live on, at least in the winter. The other plants that I recollect to be in great abundance are ragwort and wood sage. Young plants of henbane I observed on the top of the island, near the caper spurge, and a single bush of elder under a rock not far from the well. Ivy grows about the rocks in some places; also the common polypody, wall-rue spleenwort, wall pellitory; samphire plentifully. The bright coral berries of the cuckoo-pint were on some spots very conspicuous and ornamental, the plant growing not singly or by twos or threes, as on hedgebanks, but in groups of a dozen or more. The only butterfly which I recollect to have seen is a large white one, I suppose the large cabbage butterfly. The two very common snails, *Helix aspersa* and *nemoralis*, were very plentiful and fine. A smaller snail, *Helix virgata*, I believe, was also very plentiful, and I found a few empty shells of *Turbo elegans*. *H. aspersa* I have before observed to be commonly of a large size near the sea. Is this from the influence of the sea air, or because that on the sea border it is left to attain its full growth and not destroyed at all ages, as in gardens? At the south eastern corner of the island near the house there is a space of perhaps 50 yards square which we supposed was once a garden and brother William was strongly of the opinion that piony and other rare plants were once cultivated in it and since its desertion have run wild where they would, an opinion which on the whole I think likely to be correct. This place is surrounded by a ridge of stones which I took for the dilapidated wall, but Robert Anstice, though he is of the opinion that the plants are not indigenous, says it may have been a rude fortification. At the Western end I observed an oval space, also surrounded with a ridge of stone, but still ruder and less

conspicuous. The island is far more picturesque than I had supposed it to be. Instead of being the clumpy rock which it appears from the main land, its shores are indented with little bays and varied with projecting and detached rocks, and the sides are traversed by fissures and little ravines. These were richly and profusely ornamented with the golden flowers of the ragwort and in some places the rocks were ornamented almost as richly and profusely with samphire, its lively green leaves being scarcely less bright than the flowers.

V

VERTEBRATA

By H. Tetley, B.Sc., F.Z.S.

(*a*) Mammals

WITH the exception of Rabbits (*Oryctolagus cuniculus*) and an occasional Bat, there appears to be a complete absence of mammals from Steep Holm. It is certainly difficult to prove a negative but Mr. L. H. Matthews and the writer paid a visit in June, 1935, and spent two nights there, and though about thirty " nipper " traps were set each night in suitable places, and the weather was very fine, nothing was caught nor was the bait touched. Food has also inadvertently been left in the barracks during the winter but, though readily accessible to mice, it has not been touched. It looks therefore as if the smaller mammals (Shrews, Voles, Mice) are completely absent, which is all the more remarkable as there has been fairly constant traffic to the island for many years, and one might have expected such animals to be introduced accidentally, for the island is only five miles from Weston-super-Mare and considerably less from Brean Down. If one compares Steep Holm with St. Kilda which lies out in the North Atlantic about forty miles west of the Outer Hebrides, one finds that, although the latter is so isolated, it possesses a Field-Mouse (*Apodemus hirtensis*) and a House-Mouse (*Mus muralis*) which have been so long established as to form new species. It is therefore very surprising to find such a complete absence on Steep Holm, and no adequate reason can be assigned for it.

The Rabbits occur in good numbers in spite of living in the midst of a colony of gulls which must take toll of their numbers. Once or twice a small Bat, probably a Pipistrelle (*Pipistrellus pipistrellus*), has been seen round the barracks, and a dead Mole (*Talpa europaea*) was picked up in July, 1938. But the latter had no doubt been carried across, or picked out of the tide, by a gull.

(*b*) Birds

The ornithology of Steep Holm has changed considerably in the last 70 years, largely through the influence of man. There is, unfortunately, no record of bird-life on the island at the time when the Priory was built, but in 1829, Rutter (Lewis, p. 222) said that vast numbers of

sea-birds resorted to the ledges and crevices of the rocks and that their eggs were sometimes collected for profit, being sent to sugar refineries in Bristol. Eggs have not been collected for human consumption since 1922. He does not seem to give the species, but in 1858, J. Hayward (Lewis, *loc. cit.*) referred to great numbers of Guillemots, Razorbills and Puffins, so it may be assumed that Rutter's birds were the same. Soon after the last date, however, i.e., in 1867, batteries and barracks were constructed, and this occupation had the effect of driving away the Puffins very soon, though Lewis thinks that the other two may have survived until later; no doubt their breeding-ledges would be more inaccessible. These birds have never returned, though odd examples of both Razorbill and Puffin have been seen in recent years close to or on the island, and this might be a sign of a possible recolonisation. At the same period there were doubtless gulls breeding there but, as their eggs were taken for food both during the occupation of the barracks and afterwards when there were permanent residents, their numbers were kept down. In June, 1901, the Rev. F. L. Blathwayt visited the island and found 12 pairs of Herring Gulls and 11 pairs of Lesser Black-backed Gulls breeding, but no Great Black-backed Gulls, an observation which throws some doubt on Knight's statement—probably founded on hearsay—that in 1902 there were about fifty pairs of Herring Gulls, a few Lesser Black-backed Gulls and a small number of Kittiwakes. Later, the island was left uninhabited as it remains at the present day except for sporadic visits in the summer, and it has recently been protected. This has resulted in a vast increase of Herring and Lesser Black-backed Gulls to altogether unreasonable numbers in view of the damage these birds do to other bird-life. The Great Black-backed Gull has also returned and has increased to eight pairs or so. Another feature of the breeding-birds is the colony of Cormorants that has recently become established at the north end of the island. This fact was not definitely proved until 1934 (when 10 nests were seen) though it had been previously suspected. At present there are about 16 to 18 pairs. Sheld-duck also nest in some numbers but, apart from these sea-birds, the chief interest lies in the presence of a pair of Ravens and of Peregrine Falcons, both of which breed on the cliffs and may have done so for many years. There are very few passerines nesting there and those only in small numbers. The only real shelter is afforded by the bushes and trees above the landing-place at the east end as, although there are many bushes down the slopes of the southern side, they are fully exposed to the prevalent south or south-west winds. Occasional visitors (i.e., those which have never

been known to breed) number about 25, but it cannot be supposed that this total is in any way complete, for there are no records at all from autumn to spring inclusive, and even in the summer the records are only occasional. So no doubt a number of other small passerines may come to the island, and other birds as well. There is, however, one considerable lack on the island, and that is the absence of any surface-water which would attract any birds passing over. Water for the building is drawn from a well, so there is no occasion for any other supply.

Steep Holm, then, is an island with a very limited bird-population, the chief feature of which is the large number of sea-birds breeding there. At the present time the dominant species are the Herring and Lesser Black-backed Gulls which occur in about equal numbers of several hundred pairs, and a few pairs of Great Black-backed Gulls. The first two occupy a large part of the top and sides and must make it nearly or quite impossible for any other ground-building species to survive ; the nests of the third are scattered round the lower slopes. The Cormorants all breed on the steep face of the north side, and it is to be presumed that this will also have been the nesting site of the Guillemots and Razorbills in times past. Puffins would have more scope as there is a good deal of land which either has been excavated by rabbits or which could be excavated to form suitable nesting-holes. It would certainly seem as if all these four fish-eating birds would have to travel some distance for food in view of the great opacity of the water in the immediate neighbourhood of the island. And now that Cormorants have such a firm hold here it may be difficult for the Guillemots and Razorbills to reinstate themselves.

The paper by Lewis quoted below gives a useful account of the birds of Steep Holm, and the reader is referred to it for further information. One or two additions have been made since then, and in the following list the birds are classified in four categories. These are as follows :—

(*a*) Breeding (14).

Raven, Starling, Meadow-Pipit, Rock-Pipit, Song-Thrush, Blackbird, Wren, Peregrine Falcon, Cormorant, Sheld-duck, Mallard, British Lesser Black-backed Gull, Herring Gull, Great Black-backed Gull.

(*b*) Have bred, but doubtfully now. Occasional visitors (6).

Linnet, Robin, Wheatear, Hedge-Sparrow, Kestrel, Oystercatcher. (Knight's record of Hobby in 1849 is obviously incorrect.)

(*c*) Have bred, but do not now. Occasional visitors (7).

Carrion-Crow, Skylark, Spotted Flycatcher, Whitethroat, Razorbill, Common Guillemot, Puffin.

(*d*) Occasional visitors (25).

Jackdaw, Rook, House-Sparrow, Greenfinch, Goldfinch, Chaffinch, Tree-Pipit, Pied Wagtail, Great Tit, Coal Tit, Pied Flycatcher, Blackcap, Willow Warbler, Chiff-Chaff, Redstart, Whinchat, Cuckoo, Little Owl, Shag, Wood Pigeon, Turtle Dove, Redshank, Dotterel, Whimbrel, Lapwing, Manx Shearwater.

This makes a total of some 52 species recorded from the island but, as stated above, the list of occasional visitors would no doubt be largely increased if more frequent visits could be paid.

(*c*) Reptiles and Amphibia

The earliest record dealing with the Reptiles is that of Mr. John Storrie of Cardiff who found a sloughed skin of an Adder (see *Proc. Cardiff Naturalists' Society*, 1877). But it is possible that Storrie's record really refers to the Slow Worm, for Leighton (1901) quotes a letter, written by Storrie shortly before his death, as follows. "The Slow Worm—*Anguis fragilis*—is always called an adder here [in the Vale of Glamorgan], and is fairly common. Before the Government took possession of the island of Steep Holm in the Bristol Channel, there was a very handsome cream-coloured variety to be found there, while on the Flat Holm there was only the ordinary chocolate-coloured one, like that found in the country elsewhere." On no other occasion has any Snake been found either alive or dead. Slow Worms occur and were found by the party of Bristol Naturalists in 1914, as also in 1935 and 1938. No Lizards have been discovered.

There are no Amphibia, as might be expected from the entire absence of any surface-water in which they might breed.

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VI

LAND INVERTEBRATES, EXCLUDING INSECTS

By J. E. Hamilton, M.Sc.

My collection includes land invertebrates, excluding insects, and is made up of Mollusca, 7 species; Araneida, 14 species, and 5 juveniles which can only be allotted to genera; Acarina, 3 species; Opiliones, 1 species; Myriapoda, 3 species; and Isopoda, 6 species.

F. G. Pearsey (1915) published lists of terrestrial invertebrates, and in them occur five of the seven molluscs, one spider, two myriapods and two isopods identical, or presumably so, with my species. The present additions to the Steep Holm list are therefore 29 in number (the juvenile *Meta* and *Lycosid* might be the same as the identified species).

An endeavour was made to connect the specimens with their habitats. The whole island was very dry indeed, but could be divided into two major parts; (1) The plateau which had very short vegetation and was exposed to the sun and wind; it was accounted "*dry*" and the specimens labelled as such. (2) The winding path is on the most overgrown part of the cliffs and runs through thickets of mixed bushes, etc., which provide a good deal of cover, and presumably, but not obviously, the ground here must be damper than the plateau: specimens labelled "*path*." The stones in both these areas provided additional cover for some species. The old *magazines* of the batteries were themselves all dry but moisture could be found at the entrances of some or about the cement works outside them. The *excavations* were those being made by members of the party in the ruins on the plateau.

In the following list, therefore, the animals have been marked as from the "dry" ground, the "path," and, in a few cases, a special note indicates a different environment.

"Dry" and "path" have one snail, one spider, two mites, probably the opilionid, and one isopod in common.

"Dry" has a snail and nine spiders which were not found elsewhere, and the "path" had five snails and four spiders not found elsewhere.

The conspicuous *Meta menardi* and its large cocoons occurred only in the magazines.

Thrombicula autumnale was not seen but is very abundant. I have ventured to include it on the evidence of 250 to 300 personal bites.

Name	Nature of habitat			Pearcey's name, if in his list
	Dry	Path	Other, if any	
MOLLUSCA				
Pomatias elegans Müller ..	—	x	—	*Cyclostoma elegans* Müller
Lauria cylindracea da Costa	—	x	—	*Pupa cylindracea* da Costa
Vallonia costata Müller ..	x	—	—	—
Helicella caperata Montagu	x	x	Excavations	—
Trichia hispida L.	—	x	—	*Helix hispida* L.
Cepaea nemoralis L. ..	—	x	—	*Helix nemoralis* L.
Oxychilus alliarius Müller ..	—	x	—	—
ARACHNIDA				
Araneida				
Dysdera erythrina Walck. ..	x	x	—	*Dysdera erythrina* Walck.
Segestria renoculata L. ..	—	x	—	—
Drassodes(*?lapidorus* Walck).	x	—	Excavations	—
Episinus truncatus Latr. ..	—	x	—	—
Stemonyphantes lineatus L.	x	—	—	—
Leptiphantes flavipes Bl. ..	—	x	—	—
Meta sp. juv.	—	x	—	—
Meta menardi Latr. ..	—	—	Magazines	—
Araneus sp. juv.	x	—	—	—
Xysticus cristatus Clerck. ..	x	—	—	—
Phrurolithus festivus C.L.K.	x	—	—	—
? Micaria sp. juv. ..	x	—	—	—
Tegenaria derhami Scop. ..	—	—	Magazines	—
Lycosa tarsalis Thor. ..	x	—	—	—
Lycosid sp. juv.	x	—	—	—
Heliophanus cupreus Walck.	x	—	—	—
Euophrys frontalis Walck. ..	x	—	—	—
Neon reticulatus Bl. ..	—	x	—	—
Salticus scenicus Clerck. ..	x	—	—	—
Acarina				
Anistys baccarum L. ..	x	—	—	—
Thrombicula autumnale Shaw	x	x	—	—
Eugamasus sp.	—	—	—	—
Opiliones				
? sp. immatures	x	x	—	—
MYRIAPODA				
Diplopoda				
Julid	x	—	—	?= *Julus niger*
Chilopoda				
Lithobiid	—	—	Excavations	?= *Lithobius forficatus*
Geophilid	—	—	do.	—
CRUSTACEA				
Isopoda				
Trichoniscus pusillus Brandt.	—	x	—	—
Oniscus asellus L.	x	—	Dampish	*Oniscus asellus* L.
Philoscia muscorum Scop. ..	x	x	—	—
Platyarthrus hoffmanseggii Brandt.	—	x	—	—
Metaponorthus sp., or *Porcellio* sp.	—	x	—	?= *Porcellio scabra* Latr.
Armadillidium vulgare Latr.	x	—	Dampish	—
Oligochaeta				
Allobophora terrestris Lav. ..	—	—	Excavations	—

My sincere thanks are due to Dr. A. R. Jackson of Chester, Dr. H. Gorvett of the University of Bristol, Mr. G. L. Crawford and Mr. R. J. Whittick of the British Museum (Natural History), and to Dr. L. V. Cernosvitov, for the identifications which have made it possible to publish this list.

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VII

ENTOMOLOGY

By G. W. Parnell, B.Sc., M.S.B.E.

THE number of species of insects found on the island was surprisingly small. The present fauna differs considerably from that listed by Griffiths and Bartlett in 1914. There has been a considerable increase in the number of carnivorous and carrion-feeding species and a decrease in herbivorous species. In my opinion this change has been brought about by the increase in the number of gulls present on the island. These birds affect the insect fauna in two ways. On the one hand they destroy a large amount of vegetation which would otherwise support a considerable insect population, and on the other, their dead bodies supply the carrion-feeding species with a constant, if small, amount of food throughout the summer. This source of food is supplemented by the bodies of rabbits of which quite a number were found.

This change in the type of fauna is particularly noticeable in the Coleoptera—burying beetles, staphylinids and carabids, the majority of which are new to the island inasmuch as they were not found in 1914, were in abundance. Two species of the genus *Hister* were found, of which the larger *H. unicolor* was very common. A single specimen of a smaller species was taken in the body of a rabbit, the striae of the elytra of which were so damaged that it was impossible to say definitely to which species it belonged. I am of the opinion that it was *H. bissexstriatus*.

Two cockchafer larvae of the common species *Melolontha melolontha* were found in the soil on the top of the island.

The number of Diptera taken was very small. In this respect the fauna has not changed.

Large numbers of the common earwig *Forficula auricularia* were taken and I was surprised to find a female specimen of the rather rare *F. lesnei*.

Colonies of ants were found all over the island. In all, six species were found of which *Formica fusca* and *Acanthomyops brunneus* were the most common. Two colonies of *F. sanguinea* were uncovered living at the expense of *F. fusca* in so far as large numbers of workers of the latter species were found in their nests.

The presence of so many ants is undoubtedly due to the absence of the bird and insect predators which normally feed on the males and females during the nuptial flight. An exceptionally large number of colonies are thus started each year.

Despite the presence of a number of adult Lepidoptera I searched in vain for larvae and pupae. It is therefore reasonable to assume that the majority of the adults captured had flown over from the mainland.

COLEOPTERA.

**Nebria brevicollis*
**Nebria gyllenhali* v. *balbii*
Harpalus aeneus (*Harpalinus aeneus*)
Amara communis
Melanotus rufipes
Staphylinus olens Mull. (*Ocypus olens* Brit. Cat.)
Staphylinus globulifer Geof. (*Ocypus morio* Gr.)
Brachylacon murinus L. (*Lacon murinus* Lap.)
Meligethes obscurus
Syncalypta striatopunctata Steff. (*Syncalypta hirsuta* Shp.)
Orthochaetes segiter
Otiorrhynchus sulcatus (*Otiorhyncus sulcatus*)
Aleochara curtula Goez. (*Aleochara fuscipes* Gr.)
**Necrophorus vestigator*
**Necrophorus humator*
**Adonia variegata*
**Melolontha melolontha* L. (*vulgaris* F.)
**Hister unicolor*
**Hister bissexstriatus ?*
**Carabus violaceus*

ORTHOPTERA.

**Ectobius panzeri*

DERMAPTERA.

Forficula auricularia
**Forficula lesnei*

HEMIPTERA.

**Aphis sambuci*

HYMENOPTERA.

Formica fusca
**Formica sanguinea*
**Acanthomyops* (*Lasius*) *brunneus*
Acanthomyops (*Lasius*) *niger*
Acanthomyops (*Lasius*) *alienus*
Myrmica scabrinodis
**Pimpla rufata*
**Cladius pectinicornis*

LEPIDOPTERA.

**Pyrameis atalanta*
**Epinephele ianira* (*jurtina*)
Pieris brassicae
Pieris rapae
Pyrameis cardui

Plusia gamma
Euclidia mi.
Zygœna filipendulæ
Camptogramma bilineata
**Coremia* (*Ochyria*) *ferrugata*
**Triphaena* (*Agrotis*) *pronuba*
**Agrotis ravida* (*obscura*)
**Hama oblonga* (*abjecta*)
**Nonagria geminipuncta*
**Eurois occulta*

DIPTERA.

Nematobia cylindrica
**Musca domestica*
**Calliphora vomitoria*
**Lucilia caesar*
***Lonchoptera** sp.

THYSANURA.

Machilis maritima

* Species not previously recorded from the island.

REFERENCE

Griffiths, G. C. and C. Bartlett. 1915. *Proc. Bristol Naturalists' Soc.*, 4th Series, IV, Pt. 2.

VIII

THE SHORE FAUNA OF STEEP HOLM (being STUDIES ON THE BIOLOGY OF THE BRISTOL CHANNEL, III)

By C. M. Yonge, D.Sc., and A. J. Lloyd, B.Sc.

1.—INTRODUCTION

THE party, organized by Mr. H. E. Matthews, to whose initiative the authors are greatly indebted, visited Steep Holm from Saturday, July 23rd, to Monday, July 25th, 1938. The island lies in the main channel some five miles off Weston-super-Mare, and its shores are thus fully exposed to the exceptionally turbid waters of the upper reaches of the Bristol Channel. The opportunity was taken, during the two low tides in the day time, of examining the fauna on the shore. The nature of the shore fauna of the mainland at Portishead has already been described by Purchon (1938) together with that of the dock at Portishead where suspended silt is largely absent. It was felt that comparative data from Steep Holm would be of value. Unfortunately, neap tides prevailed during the period spent on the island and the mud bank which extends north of the shingle beach on the eastern point of the island was not exposed.

The exposed shores consisted of (1) the shingle beach at the landing place on the eastern extremity of the island, (2) the north shore which consists of a rocky platform with many boulders and occasional areas of shingle and (3) the south shore which is similar to the north shore but has a broader platform and less shingle. No shore was exposed at the western end of the island. Except on the shingle beach and in local areas where there is a constant scouring by the tides, a film of mud covered these shores.

The shingle beach was found to be devoid of life. There is a considerable growth of algae on the other shores, especially on the south of the island. Near high water mark, *Pelvetia caniculata* occurs on suitable areas. On the platform and boulders lower down, *Fucus vesiculosus* and *F. serratus* are abundant, in the order named, especially on the south shore where they form a thick carpet in certain areas. Of the Chlorophyceae, *Enteromorpha intestinalis* occurs wherever fresh water comes down from the cliffs, small colonies of *Ulva lactuca*

are not uncommon in pools except where there are great quantities of mud, while *Cladophora rupestris* was found in similar areas but not so frequently and not descending so low on the shore. No Rhodophyceae were found on the shores exposed at these tides.

2.—FAUNA LIST

Coelenterata

No Hydrozoa were found, the brown algae on which they usually occur being devoid of any attached or encrusting animals.

Actinia equina. This is the only common actinian, the great majority of specimens being exposed. It is local in distribution, being commonest on the south shore and especially in the base of gulleys in the cliffs where the constant movement of water prevents deposition of mud. The majority of individuals are of the common red variety, the remainder being dark green. Specimens were also abundant on the tops of smooth boulders in the *Fucus* zone. These were protected from mud by the over-arching fronds of the algae. In this locality *all* specimens are dark green.

Tealia felina. Two specimens were found on the south shore in a narrow rocky gulley near low tide mark. They were covered with mud. It probably occurs in abundance in the region between low tide mark of neap and spring tides, Purchon (1938) having found it in abundance in zone 3 on the beach at Portishead.

Sagartia troglodytes var. *ornata.* Three specimens of this small and characteristically marked variety (see Stephenson, 1935) were found high on the south shore in cracks in the rock in the base of shallow pools. The pools were perfectly clean and so high on the shore that, except at spring tides, they are probably filled only with spray.

Nemertini

One unidentified specimen was found in mud under a stone on the north shore adjacent to the shingle beech.

Annelida

The only species found was *Polydora ciliata* which occurs in abundance burrowing in the rock in pools high on the shore. It is not affected by mud.

Crustacea

Representatives of this Class were few and sparsely distributed.

Balanus balanoides. This was found on the face of the rocks about high tide mark but in numbers only in two localities. One of these

was on the inner face of a high rock on the north shore, the other on the sides of a deep crevice in the cliff on the south shore (where *Actinia equina* was found in abundance). Both regions were therefore protected from full exposure to the muddy water. Apart from these two areas only occasional scattered specimens were found.

Gammarus sp. A few specimens were found under rocks, amongst stones and mud, on the north side of the shingle spit. We are informed by Mrs. E. W. Sexton and Mr. G. M. Spooner, of Plymouth, that these individuals belong to a hitherto undescribed species, apparently characteristic of somewhat brackish waters.

Ligia oceanica. As usual this is abundant in cracks in the rocks at and above high tide mark.

Idothea viridis. A few specimens were found on *Cladophora* in rock pools near high tide mark on the south shore.

Carcinus maenas. A few small individuals were found under stones; one was carrying eggs.

Insecta

The only species found was *Lipura* (*Anurida*) *maritima* but this was restricted to a few very sheltered pools near high tide mark on the south shore.

Mollusca

Representatives of this phylum formed the bulk of the population but there were no Lamellibranchia.

Lepidochitona cinereus. This was the only species of the Loricata (Placophora) found; it was not uncommon in rock pools in muddy water especially on the north shore.

Patella vulgata. This is the most conspicuous member of the fauna. It occurs in great numbers everywhere on the surface of rocks and in pools near high tide mark. In view of the controversy as to the habits of this species (see Graham, 1932) it is interesting to note that the majority of animals exposed on the rock were moving about and feeding. The position of their "homes" was conspicuously indicated by clean light coloured patches in the otherwise mud-covered surface. Only where the rock was dry were the animals motionless and occupying their "homes."

Patella athletica. A few individuals of this species were found.

Littorina rudis. Common on stones near high tide mark.

Littorina littoralis (= *obtusata*). This was the only animal found on the fronds of *Fucus*, where it is common. Egg masses belonging to this species were found on *Fucus*.

Littorina littorea. This occurs more sparsely near to low tide mark. It is probably common between this level and that of low water spring tides.

Buccinum undatum. Although only empty shells of this species were found, it is included because Mr. L. H. Matthews informs us that it occurs in the mud exposed at low water spring tides.

3.—DISCUSSION

The shore fauna of Steep Holm is remarkable for paucity of species although the fauna list would certainly have been somewhat greater had it been possible to examine the mud near low water spring tide level. Here, judging from the findings of Purchon (1938) at Portishead, Annelids such as *Nereis virens, N. diversicolor* and *Amphitrite johnstoni,* Crustaceae such as *Corophium volutator* and Gastropoda such as *Hydrobia ulvae,* probably occur.

Purchon (1938) drew attention to the two factors which limit the fauna at Royal Beach, Portishead, namely low salinity (minimum figures 17‰) and high turbidity (maximum figures 5·7 grams per litre). In the Dock at Portishead where only the former factor is operative (maximum turbidity recorded being 0·78 grams per litre), the fauna included many ciliary feeders, such as Lamellibranchs and Ascidians, which are unable to exist in the turbid water outside.

Clearly the same factors operate at Steep Holm. The salinity was not determined but may be assumed to fall almost as low as that at Portishead. This will explain the absence of Echinoderms and possibly Porifera, although the latter might equally be affected by the high turbidity. Of the Crustaceae found, *Idothea viridis* has frequently been recorded in brackish waters (see Howes, 1939), *Carcinus maenas* is a typical estuarine species while the *Gammarus* sp. is also apparently associated with low salinity. *Polydora ciliata* frequently extends into brackish waters (Howes, 1939).

The high turbidity is certainly responsible for the complete absence of ciliary feeding animals. The absence of encrusting animals from the fronds of *Fucus* may be ascribed primarily to this factor, ciliary feeders such as compound Ascidians and Polyzoa will be unable to function, while Hydroids, of which *Gonothyraea loveni* occurs in abundance in the Dock at Portishead (Purchon, 1938), and in similar salinities elsewhere (Howes, 1939), would be smothered. This distribution of *Balanus balanoides* provides an interesting demonstration of the effect of turbidity. It is abundant in two regions, indicating

that it is not affected by the low salinity, but these are regions of sheltered water where the mud will tend to settle. Of the Coelenterates only *Tealia felina* is clearly fully tolerant of mud, as already recorded by Matthews (1923) and Purchon (1937), *Actinia equina*, although common, being confined to protected regions below *Fucus* or in the base of gulleys.

The dominant Phylum is certainly the Mollusca. *Lepidochitona cinereus*, *Patella vulgata* and the three species of *Littorina* are all abundant. They are apparently unaffected by either low salinity or high turbidity. The fact that *Patella* feeds when the tide is out will account for its indifference to the second factor. These Mollusca are all herbivorous and feed either on the encrusting vegetation on the rocks or, in the case of *Littorina littoralis* and *L. littorea*, on the *Fucus*. The absence of *Nucella* (*Purpura*) *lapillus* which, as shown by Matthews (1923), is plentiful between tide-marks at the end of Brean Down, the nearest point on the mainland to Steep Holm, is probably associated with the absence of suitable food, i.e., *Mytilus edulis* or *Balanus* spp. (Moore, 1936).

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An Ecological Survey of Dundry Down with Special Reference to the Open Down Association

By Gertrude M. Boley

(*Read in title, 2nd March,* 1939)

I.—INTRODUCTION

THE object of this paper is to provide an ecological survey of Dundry Down. Systematic botanists have recorded the flora of the surrounding district but, so far as the author can discover, little botanical research has been done on the Down itself. The present observations were made from May to September, 1936, and during the flowering period of 1937. Life-forms of most of the plants were collected and added to the Ecological Herbarium of the Botanical Department, Bristol University, where they may be viewed.

(*A*) Geography

The area is situated on the western summit of Dundry Hill, North Somerset, a bleak upland rising to 760 feet and extending east and west for nearly four miles. It is five miles south of the City of Bristol, and from its lofty position commands extensive views of the surrounding country. To the north are the Cotswolds, in Gloucestershire, to the west, the Severn, bounded by the Welsh coast, and to the south the lovely Chew Valley extends along the foot of North Mendips.

(*B*) Geology

Dundry Hill is mainly a formation of massive limestone of the Jurassic period. It is capped by Inferior Oolite resting upon Upper Lias, and Dundry Down is situated on the extreme north-west corner of the limestone cap. The characteristic feature of this area of 57 acres is the "old workings" of limestone quarries dating back to the middle ages, or perhaps much earlier, when the Dundry quarries in Somerset had a reputation comparable to Doulting or Ham Hill of the present day. Valuable freestone beds were found on the western side of the Hill, and on the Down the "workings" in several places are left sharp and clear. Apparently the stone was excavated only to a depth of 30 ft. for the sides are still in situ and bear on their surface every indication of weathering.

(*C*) History

The limestone quarries are mentioned early in history. In the fourteenth century we discover stone-traders engaged upon "the fine grained oolite of Dundry Hill" with Bristol as an important centre for their trade. Outstanding examples of the value and local importance of this trade may be seen in Bristol Cathedral, St. Mary, Redcliffe and St. Michael's, Dundry, which are all built of Dundry freestone.

It is doubtful whether quarrying dates from Roman times but, from the local name "Cold Harbour" and from the few fragments of pottery found above the cave in a disused quarry in 1925, a Roman occupation may be assumed.

II.—THE PLANT ASSOCIATIONS OF DUNDRY DOWN

The vegetation of Dundry Down may be divided into three types of plant association: (*see map, Fig.* 39)

(*A*) *Open Down.*—The grassland association considered in this paper.

(*B*) *Wooded Quarry.*—An old working 187 ft. by 50 ft. by 20 ft., thickly wooded and supporting several strata of vegetation.

(*C*) *Hazel Copse.*—A small region, west of the Down, dominated by Hazel.

With the exception of the Hazel Copse the whole area is enclosed by limestone walls.

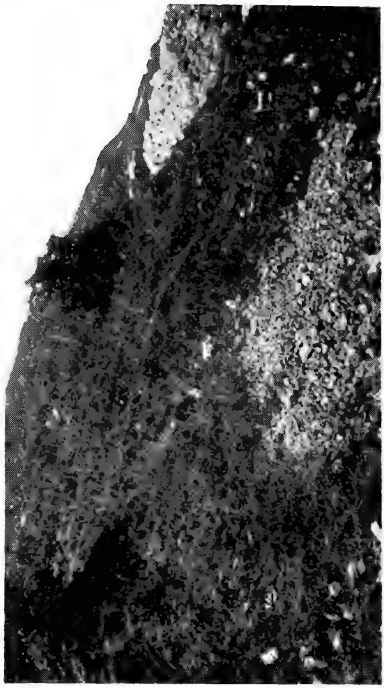
III.—OPEN DOWN ASSOCIATION

(*A*) Floristics

Trees and Shrubs. From the name Dundry (Dundrey), Collinson suggests that possibly the site once formed part of an ancient hill of oaks, but if this is so, none but the barest evidence remains, one old oak, and this in the wooded quarry.

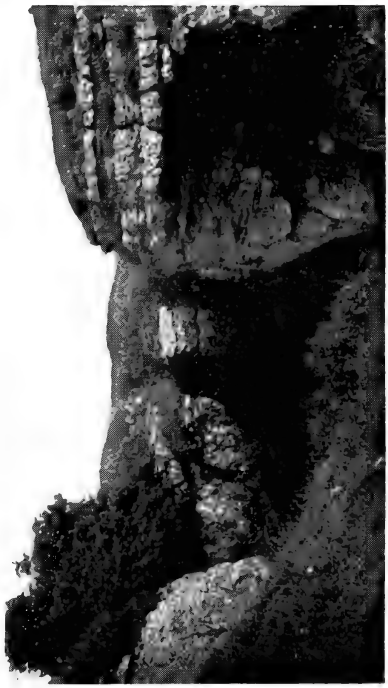
The ash (*Fraxinus excelsior*), characteristic of the older limestones, is the one tree species distributed on the open Down. The ash, and the frequent patches of scrub dominated by hawthorn, suggest an earlier Ash-Hawthorn Association. The recurrence of ash, which follows the belt of elevations (*Plate* 35), and its persistence amongst scrub and débris seem to strengthen this view. The shrubs occurring frequently on the open Down are: *Crataegus Oxyacantha* (hawthorn), *Rubus fruticosus* (blackberry), *Rosa canina* (dog-rose), *Rosa arvensis* (field rose), *Hedera Helix* (ivy), *Sambucus nigra* (elder), *Clematis Vitalba* (traveller's joy), *Corylus Avellana* (hazel), *Prunus spinosa* (blackthorn),

II. Grassland with Elevations



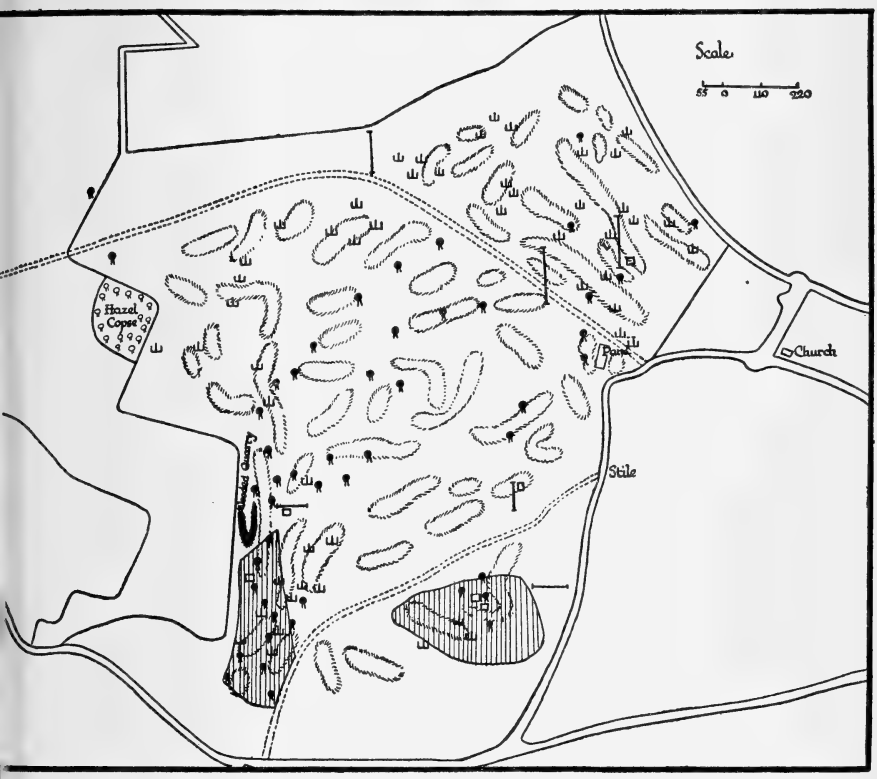
IV. Turfy Slope with Debris from Quarry

I. General View of Open Down



III. Quarry

DUNDRY DOWN



1 Pasture Land
2 Quarries
3 Elevations
Position of Transects
" " Quadrats
" " Rooting System

FIG. 39

Acer campestre (field maple), *Lonicera Periclymenum* (honeysuckle), *Ilex Aquifolium* (holly), *Cornus sanguinea* (dogwood), *Ligustrum vulgare* (privet).

Herbaceous Flora. The plant association of the open Down falls naturally into three societies (*Fig.* 39):

(*a*) *Grassland*
(*b*) *Disused Quarries*
(*c*) *Local Elevations*

and the herbaceous flora is considered in relation to these. Chart quadrats taken from (*a*), (*b*) and (*c*) are given in *Figs.* 40 *and* 41. Numerical tables of plant frequencies occurring in transects taken from (*a*) and (*c*) are given in *Tables* 1 *and* 3. The position of each transect and square is marked on the *Map* (*Fig.* 39) and their distinguishing features are given in *Table* 5.

(*a*) *Grassland*

Holcus lanatus dominates the grassland which encircles the regions of the local elevation and the quarries. It also colonizes many of the hollows. Though but a narrow margin south of the quarries, the surrounding grassland extends north-west and south-east. (*Fig.* 39 *and Plate* 35, *photographs* 1 *and* 2.) The almost flat surface is broken occasionally by small mounds 2 ft. to 4 ft. high. These slight elevations are covered with a close turfy vegetation dominated by *Poterium Sanguisorba.*

In the south-east, *Carduus arvensis* is abundant, and *Poterium Sanguisorba* less frequent, but the latter occurs again abundantly on the margin of grassland to the south-west, where it is found in close association with *Festuca ovina* (*Fig.* 40*a*). A list of the plants with their frequencies is given in *Table* 1.

TABLE 1

List of Plants in Grassland.	Numerical Frequencies Compiled from Three Transects.
Holcus lanatus—Yorkshire Fog	78
Poterium Sanguisorba—Salad Burnet	28
Plantago lanceolata—Ribwort Plantain	26
Achillea Millefolium—Yarrow	23
Lotus corniculatus—Bird's-foot Trefoil	21
Trifolium pratense—Red Clover	19
,, *repens*—White Clover	17

List of Plants in Grassland.	Numerical Frequencies Compiled from Three Transects.
Carduus arvensis—Field Thistle	17
Medicago lupulina—Black Medick	16
Dactylis glomerata—Cock's-foot	15
Koeleria gracilis—Koeleria	15
Lolium perenne—Rye-grass	14
Hieracium Pilosella—Mouse-ear Hawkweed	12
Poa trivialis—Rough Meadow-grass	12
Thymus Serpyllum—Thyme	12
Agrostis tenuis—Bent-grass	9
Poa pratensis—Smooth Meadow-grass	8
Galium verum—Ladies' Bedstraw	8
Ranunculus arvensis—Field Buttercup	7
Galium Aparine—Goosegrass	6
Euphrasia officinalis—Eyebright	6
Festuca ovina—Sheep's Fescue	6
Hypochaeris radicata—Cat's-ear	5
Agrostis alba—Bent-grass	5
Prunella vulgaris—Selfheal	5
Carduus lanceolatus—Spear Thistle	4
„ *acaulis*—Ground Thistle	4
Arrhenatherum elatius—False Oat	3
Cerastium viscosum—Mouse-ear Chickweed	3
Leontodon autumnale—Hawkbit	3
Bellis perennis—Daisy	3
Anthoxanthum odoratum—Sweet Vernal-grass	2
Trifolium procumbens—Hop Trefoil	2
Rumex Acetosa—Sorrel	2
Taraxacum officinale—Dandelion	2
Potentilla Anserina—Silver-weed	1
Briza media—Quaking-grass	1
Conopodium denudatum—Pignut	1

(*b*) *Disused Quarries*

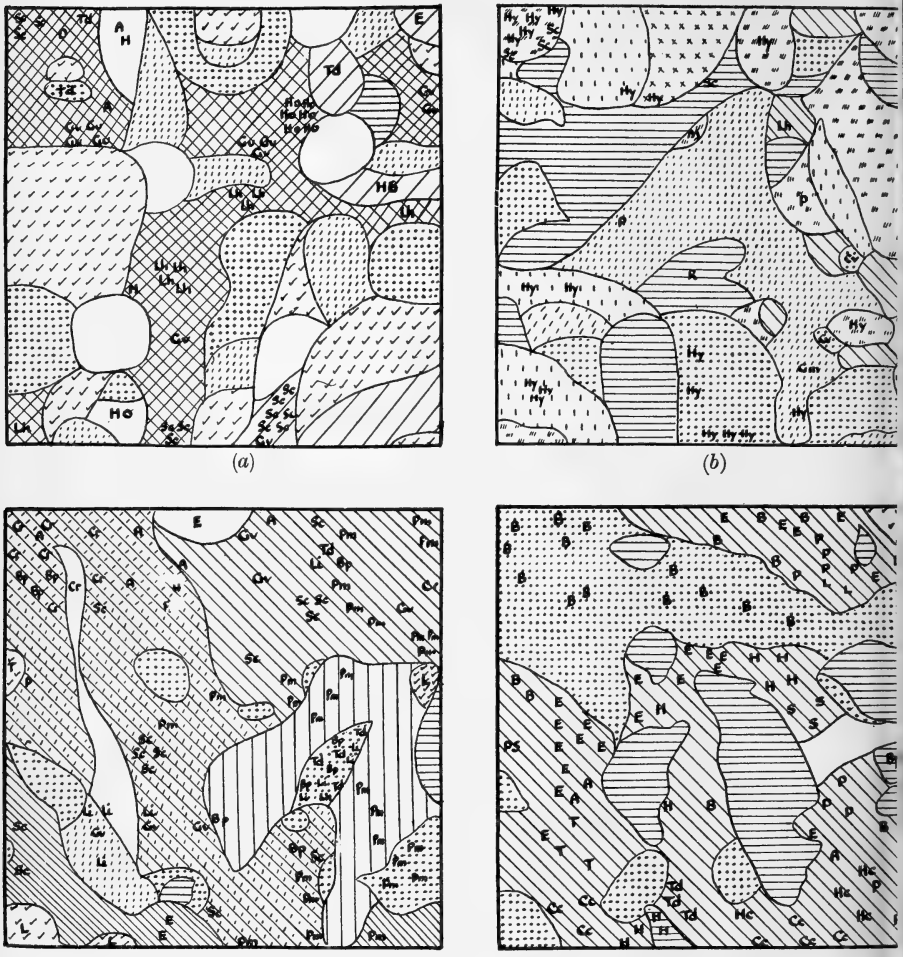
Evidence of human influence may be seen in the region of the disused quarries. Excavations 20 feet deep, exposed rock and débris, turfy elevations 50 feet long separated by grassy hollows, rocky walls and open caves all bear witness to man's activities. (*Plate* 35.)

Ecologically the region may be divided into two areas, east and west. In the eastern area there are few trees or shrubs but in the west the ground flora is shaded by densely wooded vegetation. (*Fig.* 39.) In both areas *Poterium Sanguisorba* dominates the slopes and summits of the elevations, while *Holcus lanatus* invades the hollows. (*Fig.* 41.)

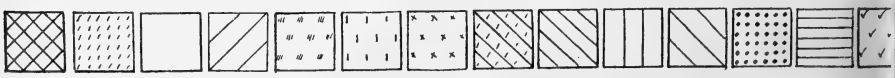
The abundance of Poterium on the limestone is shown in *Fig.* 40*b*, where the plant frequently abuts on the bare rock. On the quadrat may also be seen *Hypericum perforatum* which, at the time of the survey, was confined to this one station only. A list of plants occurring in the two quarry areas, east and west, is given in *Table* 2.

FIG. 40

QUADRATS FROM: (*a*) GRASSLAND; (*b*) DISUSED QUARRIES; (*c*) AND (*d*) LOCAL ELEVATIO



Sc, *Scabiosa Columbaria*; Gv, *Galium verum*; Lh, *Leontodon hispidum*; D, *Dactylis glomera*
Hy, *Hypericum perforatum*; Cv, *Cerastium viscosum*; R, *Rubus fruticosus*; Gm, *Geranium mo*
M, *Myosotis collina*; Pm, *Plantago media*; Cr, *Campanula rotundifolia*; Li, *Linum catharticu*
E, *Euphrasia officinalis*; B, *Briza media*; P, *Plantago lanceolata*; H, *Hieracium Pilosella*;
Koeleria gracilis; Ho, *Holcus lanatus*; T, *Trifolium pratense*; S, *Scabiosa arvensis*; Td, *Trifol*
dubium; A, *Achillea Millefolium*; L, *Lotus corniculatus*; Ps, *Poterium Sanguisorba*; Bp, *B*
perennis.



(1) *Poa trivialis* and *Briza media*
(2) *Poterium Sanguisorba*
(3) *Festuca ovina*
(4) *Holcus lanatus*
(5) Shallow soil
(6) *Hieracium Pilosella*
(8) *Poa pratensis* and *Poterium Sanguisorba*
(9) *Briza-Koeleria*
(10) *Carduus acaulis*
(11) *Poa pratensis*
(12) *Thymus serpyllum*
(13) Bare Limestone

TABLE 2

List of Plants in Quarry Area.	East.	West.
Poterium Sanguisorba—Salad Burnet	Dom.	Dom.
Festuca ovina—Sheep's Fescue	A.	A.
Thymus Serpyllum—Thyme	A.	F.
Lotus corniculatus—Bird's-foot Trefoil	A.	F.
Briza media—Quaking-grass	A.	F.
Holcus lanatus—Yorkshire Fog	A.	F.
Linum catharticum—Purging Flax	A.	F.
Scabiosa Columbaria—Lesser Scabious	A.	A.
Bellis perennis—Daisy	F.	F.
Ranunculus repens—Creeping Buttercup	F.	F.
,, *bulbous*—Bulbous Buttercup	F.	F.
Achillea Millefolium—Yarrow	F.	F.
Leontodon hispidum—Hawkbit	F.	F.
,, *autumnale*—Autumnal Hawkbit	F.	O.
Arrhenatherum elatius—False Oat	F.	A.
Euphrasia officinalis—Eyebright	F.	O.
Carex diversicolor—Common Sedge	F.	O.
Koeleria gracilis—Koeleria	F.	F.
Poa pratensis—Smooth Meadow-grass	F.	F.
Cerastium vulgatum—Mouse-ear Chickweed	F.	O.
,, *viscosum*—Mouse-ear Chickweed	F.	O.
Anthoxanthum odoratum—Sweet Vernal-grass	O.	—
Lolium perenne—Rye-grass	O.	A.
Medicago lupulina—Black Medick	O.	F.
Trifolium pratense—Red Clover	O.	A.
,, *repens*—White Clover	O.	F.
,, *procumbens*—Hop Trefoil	O.	O.
Galium verum—Ladies' Bedstraw	O.	F.
,, *Mollugo*—Hedge Bedstraw	O.	F.
,, *Aparine*—Goosegrass	O.	F.
Urtica dioica—Stinging Nettle	O.	F.
Geranium Robertianium—Herb Robert	O.	F.
,, *lucidum*—Shining Crane's-bill	O.	F.
,, *molle*—Dove's-foot Crane's-bill	O.	O.
,, *pusillum*—Small-flowered Crane's-bill	O.	O.
Senecio Jacobaea—Ragwort	O.	O.
Hypochaeris radicata—Cat's-ear	O.	O.
Dactyllis glomerata—Cock's-foot	O.	F.
Prunella vulgaris—Selfheal	O.	F.
Conopodium denudatum—Pignut	O.	O.
Fragaria vesca—Wild Strawberry	O.	F.
Rumex Acetosa—Sheep's sorrel	O.	O.
Lactuca muralis—Wall Lettuce	O.	O.
Veronica Chamaedrys—Germander Speedwell	R.	O.
Hypericum perforatum—St. John's-wort	—	R.
Bromus erectus—Upright Brome-grass	—	F.
Avena flavescens—Yellow Oat-grass	—	F.

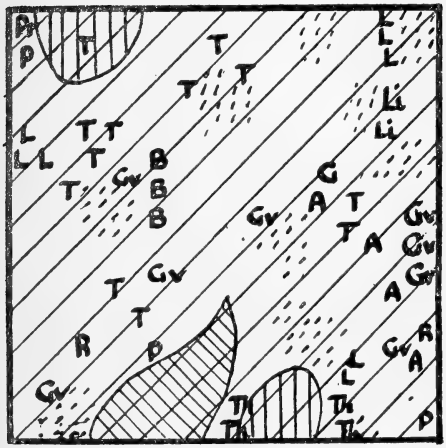
Dom.—Dominant; A.—Abundant; F.—Frequent; O.—Occasional; R.—Rare; — Absent.

(c) *Local Elevations*

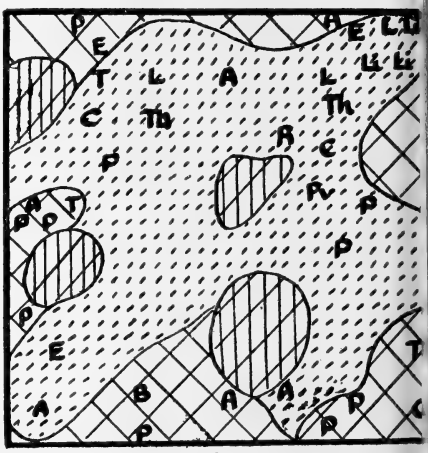
To the region of the disused quarries must be added the local elevations, mounds of débris, which are so characteristic a feature of the open Down. From the general appearance of these, it can be assumed that the quarry men worked in a somewhat primitive fashion, since

FIG. 41

QUADRATS FROM DISUSED QUARRIES: (*a*) HOLLOWS; (*b*) SLOPES



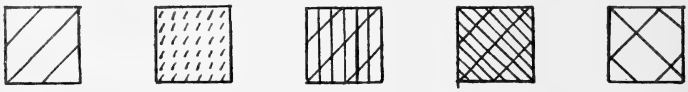
(*a*)



(*b*)

T, *Trifolium pratense*; Gv, *Galium verum*; L, *Lotus corniculatus*; Th, *Thymus serpyllum*; A, *Ach Millefolium*; P, *Plantago lanceolata*; B, *Briza media*; Li, *Linum catharticum*; Pr, *Prunella vulga* Pv, *Primula veris*; C, *Carduus acaulis*; E, *Euphrasia officinalis*.

1 2 3 4 5



(1) *Holcus lanatus* (2) *Poterium Sanguisorba* (3) *Holcus-Koeleria*
(4) *Holcus-Arrhenatherum* (5) *Festuca-Poa*

there does not seem to be any ordered sequence in their work. An excavation was made and a quantity of material removed—the softer beds and layers being thrown away only so far as was necessary to obtain the desired strata.

These débris accumulations occur all over the Down, sometimes bare but generally covered with a shallow soil with a close turfy vegetation (*Plate* 35). *Poterium Sanguisorba* is very abundant but there are many subordinate species which have acquired a local dominance and occur in masses of social vegetative growth. This is shown in *Fig.* 40*c* where Poa and Poterium are co-dominant, and in *Fig.* 40*d* where *Poa pratensis* and *Thymus Serpyllum* dominate, and lesser plant societies occur within the association.

The numerical frequencies of plants taken from transects in this region (*Fig.* 39) are given in *Table* 3.

TABLE 3

List of Plants of Local Elevations.	Numerical Frequencies Compiled from Three Transects.
Thymus Serpyllum—Thyme	64
Lotus corniculatus—Bird's-foot Trefoil	51
Poterium Sanguisorba—Salad Burnet	44
Hieracium Pilosella—Mouse-ear Hawkweed	41
Plantago lanceolata—Ribwort Plantain	28
Trifolium repens—White Clover	28
,, *pratense*—Red Clover	24
Achillea Millefolium—Yarrow	22
Medicago lupulina—Black Medick	19
Carduus acaulis—Ground Thistle	13
Bellis perennis—Daisy	10
Euphrasia officinalis—Eyebright	10
Briza media—Quaking-grass	8
Leontodon hispidum—Hairy Hawkbit	8
Carduus arvensis—Creeping Field Thistle	8
Agrostis alba—Bent-grass	8
Arenaria serpyllifolia—Thyme-leaved Sandwort	8
Lolium perenne—Rye-grass	7
Holcus lanatus—Yorkshire Fog	6
Galium Mollugo—Hedge Bedstraw	6
Prunella vulgaris—Selfheal	5
Galium verum—Ladies' Bedstraw	4
Poa pratensis—Smooth Meadow-grass	4
Polygala vulgaris—Milkwort	3
Plantago media—Hoary Plantain	3
Linum Catharticum—Purging Flax	3
Carex flacca—Glaucus Sedge	2
Koeleria gracilis—Koeleria	2
Ranunculus bulbosus—Bulbous Buttercup	1
Cerastium vulgatum—Mouse-ear Chickweed	1
Poa trivialis—Rough Meadow-grass	1
Campanula rotundifolia—Hairbell	1
Scabiosa arvensis—Field Scabious	1
Avena flavescens—Yellow Oat-grass	1
Ranunculus repens—Creeping Buttercup	1
Veronica officinalis—Common Speedwell	1

A grassland association, with *Holcus lanatus* dominant, invades many of the hollows between the elevations, and a comparison has been made of plant species occurring on the elevations and in the hollows. This is given in *Table* 4.

TABLE 4

COMPARATIVE LIST OF PLANTS FROM ELEVATIONS AND HOLLOWS

	Frequencies in: Elevations.	Hollows.
Poterium Sanguisorba—Salad Burnet	Dom.	O.
Festuca ovina—Sheep's Fescue	V.A.	O.
Lotus corniculatus—Bird's-foot Trefoil	V.A.	O.
Thymus Serpyllum—Thyme	V.A.	O.
Carduus acaulis—Ground Thistle	V.A.	—
Arrhenatherum elatius—False Oat-grass	V.A.	F.
Lolium perenne—Rye-grass	V.A.	F.
Plantago media—Hoary Plantain	A.	F.
Koeleria gracilis—Koeleria	A.	A.
Briza media—Quaking-grass	A.	F.
Hieracium Pilosella—Mouse-ear Hawkweed	A.	—
Euphrasia officinalis—Eyebright	A.	—
Poa pratensis—Smooth Meadow-grass	A.	A.
Linum catharticum—Purging Flax	A.	—
Scabiosa arvensis—Field Scabious	A.	F.
,, *Columbaria*—Small Scabious	F.	O.
Leontodon hispidum—Hawkbit	F.	O.
Galium verum—Ladies' Bedstraw	F.	O.
Poa trivialis—Rough Meadow-grass	F.	F.
Trifolium pratense—Red Clover	F.	F.
,, *repens*—White Clover	F.	F.
Bellis perennis—Daisy	F.	F.
Campanula rotundifolia—Hairbell	F.	O.
Holcus lanatus—Yorkshire Fog	F.	Dom.
Medicago lupulina—Black Medick	F.	—
Achillea Millefolium—Yarrow	F.	F.
Leontodon hispidum—Lesser Hawkbit	F.	—
Hypochaeris radicata—Cat's-ear	F.	F.
Carlina vulgaris—Carline Thistle	F.	R.
Geranium pusillum—Small-flowered Geranium	F.	—
Ranunculus repens—Creeping Buttercup	O.	F.
,, *bulbosus*—Bulbous Buttercup	O.	F.
Prunella vulgaris—Selfheal	O.	F.
Geranium molle—Dove's-foot Crane's-bill	O.	F.
Cerastium vulgatum—Mouse-ear Chickweed	O.	R.
,, *viscosum*—Mouse-ear Chickweed	O.	—
Geranium Robertianum—Herb Robert	O.	F.
Carex diversicolor—Common Sedge	O.	—
Dactylis glomerata—Cock's-foot	O.	F.
Bromus erectus—Upright Brome-grass	—	F.
Agrostis tenuis—Bent-grass	O.	F.
Carduus arvensis—Field Thistle	O.	F.
,, *lanceolata*—Spear Thistle	—	O.
Polygala vulgaris—Milkwort	O.	—
Agrostis alba—Bent-grass	—	O.
Anthoxanthum odoratum—Sweet Vernal-grass	—	O.
Phleum pratensis—Cat's-tail	—	O.

Dom.—Dominant; V.A.—Very Abundant; A.—Abundant; F.—Frequent; O.—Occasional; R.—Rare; — Absent.

In *Table* 5 are shown the distinguishing features of the transects and quadrats in the three regions (*a*), (*b*) and (*c*).

TABLE 5

DISTINGUISHING FEATURES IN TRANSECTS AND QUADRATS IN REGIONS (*a*), (*b*) AND (*c*)

Regions.	Geographical Position.	Total Number of Species in Transects.	Dominant Plant.	Frequency % in Transects.
(*a*) Grassland	S.W.	164	*Achillea Millefolium*	10%
	S.W.	*	*Poa pratensis*, and *Briza media* co-dom.	—
	S.E.	103	*Holcus lanatus*	33%
	N.W.	159	*Holcus lanatus*	25%
(*b*) Disused Quarries	S.W.	*	*Holcus lanatus*	—
	S.W.	*	*Poterium Sanguisorba*	—
	S.W.	*	*Poterium Sanguisorba*	—
(*c*) Local Elevations	N.	136	*Poterium Sanguisorba*	16%
	N.E.	179	*Thymus Serpyllum*	21%
	N.E.	*	*Poterium Sanguisorba* and *Poa pratensis*	—
	S.	138	*Thymus Serpyllum*	11%
	S.	*	*Poa pratensis* and *Thymus Serpyllum*	—

* Denotes quadrats.

From this general description of the vegetation and the statistical evidence derived from quadrats and transects, it can be seen that the Open Down Association may be divided into the three natural regions, grassland, quarries and elevations. It now remains to give an account of the ecological factors obtaining in the district, with a view to finding an explanation for the above divisions.

(*B*) ECOLOGICAL FACTORS OF OPEN DOWN ASSOCIATION

(*a*) *Climatic Factors*

The climate of Dundry Down is mild in summer but very bleak and cold in winter when N.E. winds prevail. The average temperature for the summer months, May to September, 1936, was 60°, with a high rainfall and prevailing S.E. or S.W. winds. Temperature records and measurements of light intensities taken from the open Down and also from the region of the quarries will be found in *Table* 6.

Records of the evaporating power of the air, an indication of the relative exposure in the open and in the shelter of the hollows, taken

by the Livingston Atmometer on Oct. 12th, 1936, showed that evaporating power in the hollows was about 8% of that in the open.

TABLE 6

GENERAL CLIMATIC CONDITIONS FROM MAY TO SEPTEMBER, 1936

Month.	Temperature.		Rainfall.	Prevailing Winds.
	Max.	Min.		
May	77° F.	44° F.	·71″	N.E.
June	83° F.	46° F.	5·38″	S.E. and S.W.
July	74° F.	54° F.	5·91″	S.W.
August	79° F.	55° F.	·48″	W. and S.W.
September ..	76° F.	48° F.	3·45″	S.W. and S.E.

Data obtained from Messrs. Dunscombe, Bristol.

RELATION OF LIGHT INTENSITIES ON OPEN DOWN AND IN QUARRY AREAS, OCTOBER 26TH, 1938 (CLOUDY DAY; SUNNY INTERVALS) 1.30—2.15 P.M.

Open.	Open Down.		Quarry Areas.			
			East.		West.	
	In Hollow.	Beneath Trees and Shrubs.	Open.	In Hollow.	Open.	Beneath Trees and Shrubs.
13	6·4	3·9	11·3	4·9	12	4·2

Based on methods of determining light intensities in *Field Studies in Ecology*, Bracher (1).

(*b*) *Physiographic Factors*

The position of Dundry Down on the western summit of Dundry Hill, and its elevations have been mentioned. The local elevations undulating from the margin of grassland vary considerably in their dimensions from the very small mounds in the grassland to the larger elevations rising over 20 ft., with a surface area of 1,500 sq. ft. The highest of these are to be found in the region of the disused quarries where, in the western area, they rise steeply to nearly 30 feet (*Fig.* 39).

(*c*) *Edaphic Factors*

A mechanical analysis was made of the soils of the three regions. The colour varied from light brown to black, with an intermixture of white particles, especially in the lower layers. The transition from coarse to fine particles is almost imperceptible, and there is no definite sand layer.

In the pasture, the soil consists of 40% sand and coarse clay; 60% fine clay and organic matter.

In the region of the quarries and the local elevations beneath a turfy layer, the soil, 2 in. to 5 in. deep, is composed, for the most part, of 50% clay and 50% chalky grit and fine dark organic matter. This rests upon a bed of calcareous grit, clay and limestone rubble.

TABLE 7

SOIL ANALYSIS AND PLANT DISTRIBUTION

No.	Region.	Dominant Plant.	Soil Depth.	Water Cont.	Organic Cont.	Reaction (*p*H)
GRASSLAND.						
1	S.W.	*Achillea Millefolium*	4·5″	20·94%	14·62%	7·5
2	S.E.	*Holcus lanatus*	4·5″	32·85%	10·25%	6·0
3	N.W.	*Holcus lanatus*	5·0″	18·47%	14·04%	5·5
DISUSED QUARRIES.						
1	S.W.	**Holcus lanatus*	4·5″	14·69%	13·71%	7·5
2	S.W.	**Poterium Sanguisorba*	2·5″	14·69%	16·51%	7·5
3	W.	**Poterium Sanguisorba*	2·0″	13·57%	21·26%	7·5
LOCAL ELEVATIONS						
1	N.	*Poterium Sanguisorba*	3·5″	15·92%	22·91%	7·0
2	N.E.	*Thymus Serpyllum*	4·5″	39·30%	5·18%	7·0
3	S.	*Thymus Serpyllum*	1·5″	15·23%	19·05%	7·0

* Denotes quadrats.

The water content of the soil was higher and the content of organic matter lower in the east than in the west. The soil samples taken from the pasture gave, with one exception, acid reactions but those taken from the other region were definitely basic. These results, together with the relation of the soil analysis to the distribution of plants, are given in *Table* 7.

Rooting Systems, measured in situ in a trench 3 ft. by 12 ins. dug across the summit of an elevation N.E. of the Down, are shown in *Fig.* 42. The depth of soil occupied by different species of plants is shown. *Hieracium Pilosella*, *Carex diversicolor*, *Festuca ovina* and *Ranunculus bulbosus* have their roots close to, or immediately below, the surface of the soil. *Lotus corniculatus*, *Plantago media* and *Poterium Sanguisorba* have penetrated much deeper. The rooting system of *Thymus Serpyllum* penetrates beneath the rubble of the sub-soil.

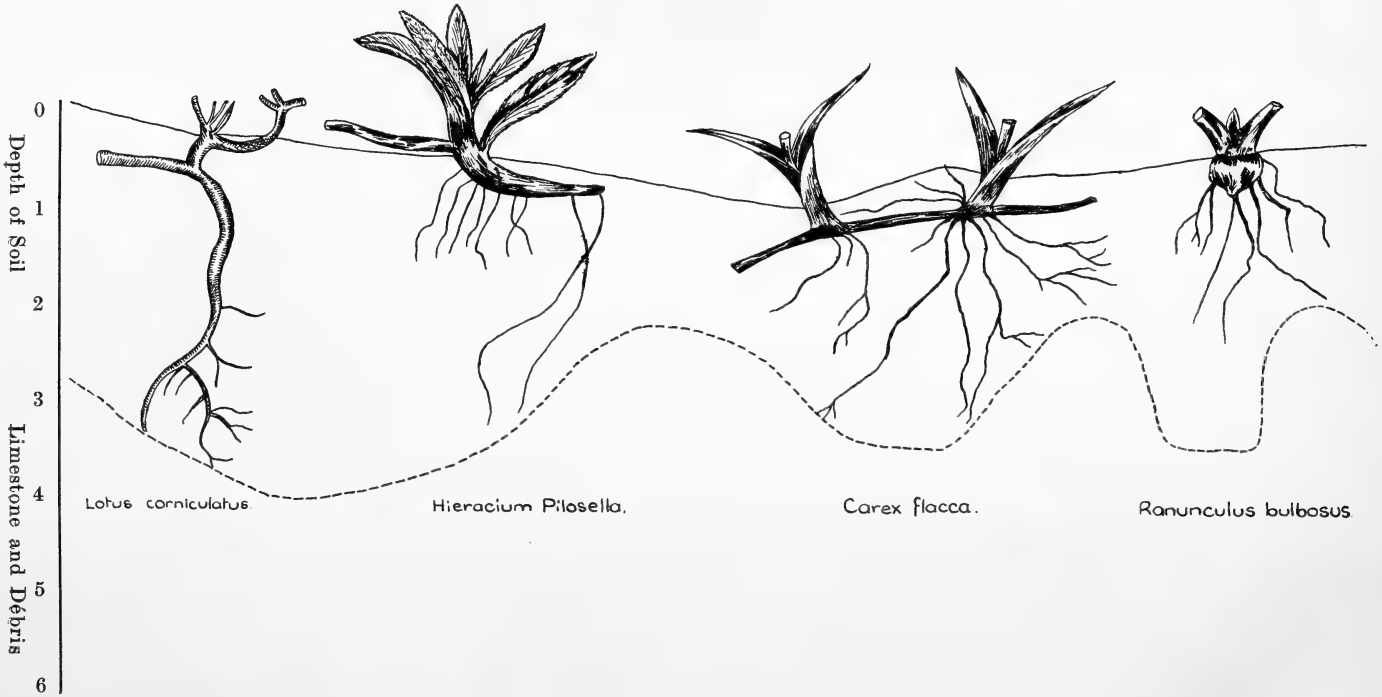


FIG. 42*a*

ROOT SYSTEMS OF PLANTS ON DUNDRY DOWN

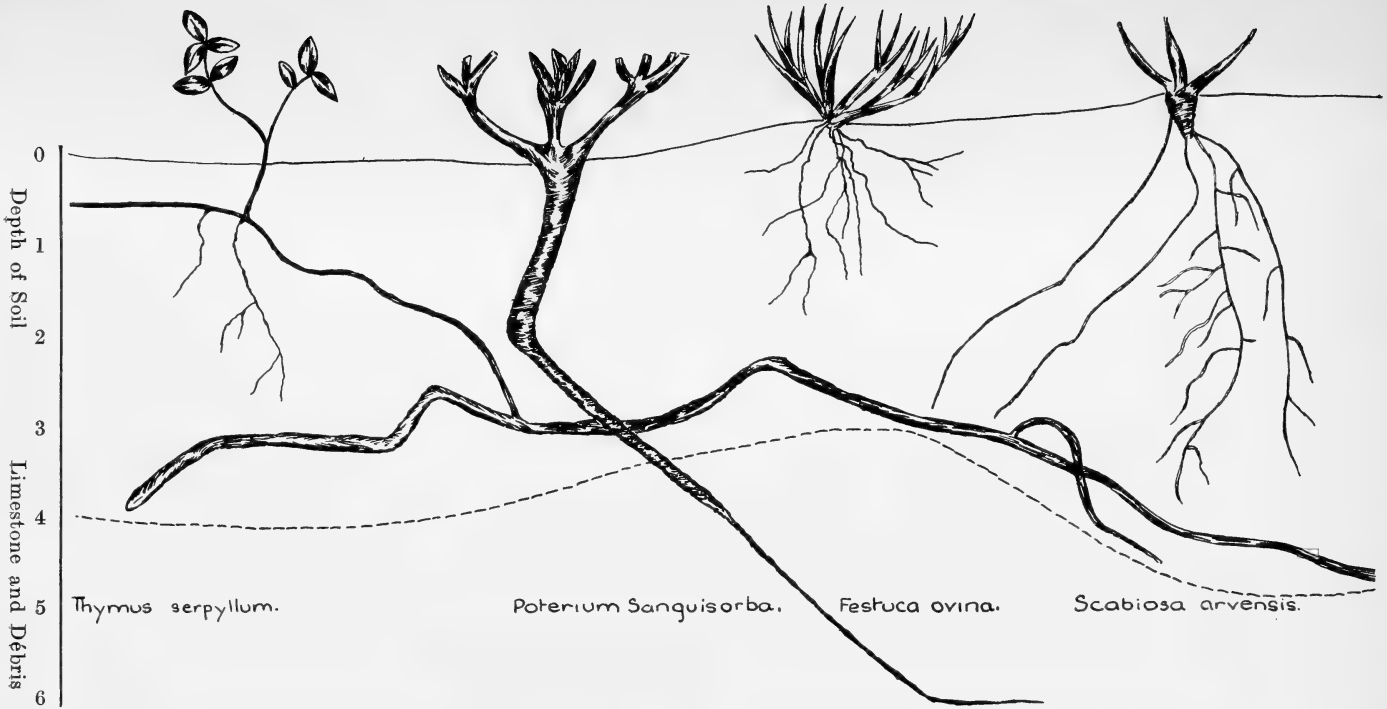


Fig. 42*b*

Root Systems of Plants on Dundry Down

(*d*) *Biotic Factors*

Amongst the biotic factors operating on the open Down, soil bacteria and worms play their part, but moles, rapidly increasing in number, prey upon the earthworms.

In the damp pits and hollows of the limestone débris, the English grass-snake, *Natrix natrix*, has found a home, and may frequently be seen on the slopes during the later months of summer. The fox and the badger have gone to earth amongst the limestone cavities but the rabbit, formerly a pest, is now being largely exterminated by the tenant farmer.

Sheep and cattle feed continually on the pastures which are regarded as amongst the richest "grazing" in North Somerset, but the most influential biotic factor to be considered is man himself who, by his activities in quarrying, changed the character and appearance of the Down.

(*e*) *Conclusion concerning Ecological Factors*

From the brief consideration of the ecological factors which determine the character of Dundry Down, and its individuality in the surrounding district, it may be concluded that the master or controlling factors are biotic.

The differentiation of the open Down into its three natural divisions is due entirely to the activity of man. From primitive pasture land he quarried and removed blocks of limestone, laid bare the rock, and with the superficial soil and rubble raised mounds of débris, thus bringing about three distinctive regions so familiar to-day.

The vegetation of this altered surface has been grazed, probably for hundreds of years, and has been influenced both by the cropping of herbage and by the incidental manurial enrichment.

The underlying rock, brought to the surface in the mounds of grit and rubble, has given rise to a looser soil and one richer in lime, and has favoured the development in such places of a more calcicolous vegetation. The sharp difference between the appearance of the grassland and that of the vegetation of quarries and local elevations is due principally to the character and depth of the soil. Local climatic differences are also effective. In the hollows and in the shade of trees and shrubs the evaporation is much lower than in the open, and a more luxuriant herbaceous flora is seen in consequence.

Species which grow in more than one situation show the effect of these factors in their individual development. Individuals are dwarfed

on the dry shallow soil of the summits and reach their maximum size in deeper soil and in the shade of trees and shrubs. Examples of these effects are preserved in the Ecological Herbarium of the University.

(*C*) Plant Succession in the Open Down Association

In the succession of plant life which has led to the establishment of the communities of the open Down there appear to have been two types of progressive change.

(1) The occurrence of ash, and its persistence in areas of débris avoided by cattle, suggests that the primitive vegetation was ashwood and scrub and that its clearing gave rise to conditions which allowed of the development of calcareous pasture. The actual stages of this progression cannot be traced. It may be assumed that, with the change brought about in such factors as exposure and light intensity, woodland species gave place to those of the grassland. Alteration of the soil by increasing grazing and manuring would favour such a progression.

(2) Of the second type of change—from bare rock and débris surface to grassy turf—there is more direct evidence. In the region of the quarries, colonisation from the initial stages may be seen. Wherever the limestone is exposed, its surface is invariably corroded with lichen or tufted with mosses. Many rocks occur which have their surface layer disintegrated into deep pockets filled with earth deposits and decaying plant remains in which spores of ferns and seeds of species of Gramineae and Compositae have germinated. On some rocks, Thymus and Lotus have rooted, and in their season cover the limestone with purple and gold.

Along the upper levels of the rock face of the quarry walls, the polypody fern occurs abundantly in competition with species of grasses and Compositae.

Over the loose mineral surface of the rubbly mounds, re-colonization has reached a climax vegetation in close turfy pasture. It has been mentioned that in this region—by the activity of man—the original character of the soil had been changed to one of higher calcareous content. This would encourage calcicolous species to come in and remain with those early comers tolerant of limestone. As, in process of time, a habitat was formed for species characteristic of a calcareous pasture land, the vegetation closed in to a matted turf in which competition now is very keen but which is still dominated by *Poterium Sanguisorba*.

Plant succession has, however, reached its ultimate climax on the

open Down in the recurrence of shrub and forest trees which, from their position, seem to have followed the older limestone (*Fig.* 39).

IV.—GENERAL CONCLUSIONS

From this ecological survey of the open Down it may be concluded that in all probability the open vegetation of Dundry Down originated in the clearing of primitive woodland and was used for the grazing of sheep and cattle. Perhaps much later the site was modified by quarrying limestone, and two new types of habitat were formed—the Quarries and the Elevations. The vegetation which now occupies these is the result of a secondary succession, and their differing floras express the different conditions of the habitats. The calcareous soil supports a turf which is not so close as that of the natural grassland. The most striking differences in the vegetation of different parts of the Down are due to the influence of man.

I wish to acknowledge my indebtedness and express my thanks to Dr. R. Bracher for much help and advice in the preparation of this paper. I should also like to thank Miss M. Thomas for preparing the diagram of the rooting systems, Miss James for carrying out the soil analyses, and Mr. E. W. Hopkins for preparing the specimens for the Herbarium. Finally, I am indebted to the Fry Memorial Fund for a grant in aid of publication.

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The Coast of Somerset (II)

By O. D. Kendall, M.A.

(*Read March 2nd,* 1939)

THIS paper is a continuation of one published in the *Proceedings* for 1936, and is chiefly concerned with field work carried out during the years 1937-38. Certain additional evidence is also included and mention is made of some of the work which it is hoped to carry out in the present year (1939).

The Low Lighthouse Marsh (Burnham)

This marsh is now a very noticeable feature of the landscape and has become relatively well established in a very short time. It is not marked on the Ordnance Survey six-inch map of 1904 and its first mention in print appears to be as late as 1922.

I am informed by Mr. Haile (1) (late Engineer to the Somerset Rivers Catchment Board) that about twenty years ago some roots of *Spartina Townsendi* were brought from Poole by a local farmer living in the vicinity of Yatton. These were planted on the foreshore by the sea wall to accumulate the foreshore and thus avoid expensive works on the actual earth and sea defences. Soon afterwards the grass began to appear at Burnham, and it is reasonably assumed that pieces of the plant were carried there from the Yatton district since there is no evidence that anybody deliberately planted the grass at Burnham.

Writing in 1922, Stuart Thompson (2) described the marsh as adjoining the hard Strand, and stretching seawards from about 400 yds. N.W. of Burnham low lighthouse to 600 yds. S.W. of Berrow Church. He made a compass sketch which showed the marsh as being about 500 yds. wide, 1,500 yards long, tapering at both ends and having an approximate area of 100 acres. He further fixed the date of its inception as about 1910. This agrees very well with all other available information.

Writing again in 1930, Thompson (3) noted that the marsh had extended about 100 yards at its north end, but had retreated about 300 yards at the south end. It thus extended for about 1,100 yards along the shore, having a greatest width of rather less than 300 yards, and a very irregular seaward border.

In 1937 a traverse of the marsh was carried out by plane table

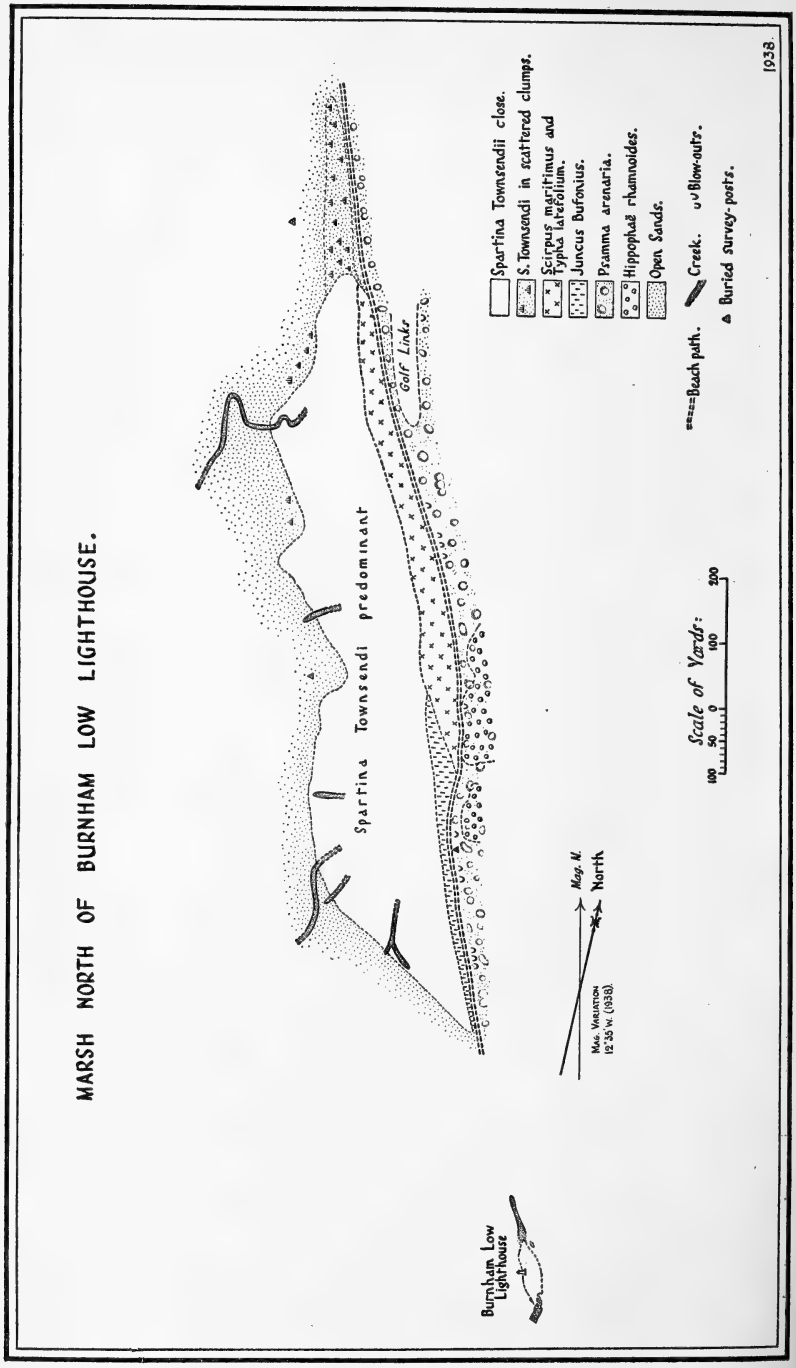

MARSH NORTH OF BURNHAM LOW LIGHTHOUSE.
Spartina Townsendii predominant
Golf Links
Burnham Low Lighthouse
Mag. N.
North
Mag. Variation 12°35' W. (1938).
Scale of Yards:
100 50 0 100 200
Spartina Townsendii close.
S. Townsendi in scattered clumps.
Scirpus maritimus and Typha latefolium.
Juncus Bufonius.
Pramma arenaria.
Hippophaë rhamnoides.
Open Sands.
Beach path.
Creek.
Blow-outs.
Buried survey-posts.
1938.

FIG. 43

and chain and three fixed points were established. At that time the dimensions of the area were a greatest length of 1,280 yards and width of 200 yards. In the following year, August, 1938, the traverse was repeated, and little change was found in these measurements, which were then of the order of 1,250 yards by 240 yards. The marsh had certainly lost ground at its northern extremity and there was evidence there of overwhelmed vegetation. On the other hand the seaward border, though irregular, seemed to be very flourishing and definitely pushing out over the sands. The area of the marsh calculated by planimeter at that time was about forty-four acres.

Over the greater part of its area the vegetation of the marsh is exceedingly dense, a very striking feature of which is the predominance of the grass *Spartina Townsendi*. The marsh is not crossed easily, but is mostly very wet and muddy; on the landward side, even at low tide, standing water on mud separates a great length of the marsh from the dune line, and on the seaward side, several small creeks up to two feet in depth drain outwards into the sand. Innumerable winding streamlets appear to give way more and more to a smaller number of well marked creeks, and perhaps emphasize the fact that the marsh is firmer and higher. Some of these creeks disappear in the course of a year, but the bigger ones retain their general position over a much longer period.

Observations over the last few years tend to support the following conclusions which it is hoped to amplify by an accurate fixing of levels in the present year. Along a considerable portion of its length the marsh is now definitely tied on to the dune line, but to north and south of it there are considerable mud patches, that to the north being a "no man's" land over which the spread of vegetation shows big differences from year to year. To the south, the end of the marsh is more sharply defined and sand is more quickly met with. Further south a depression around the low lighthouse gives rise to more mud and a spread of vegetation south of the light.

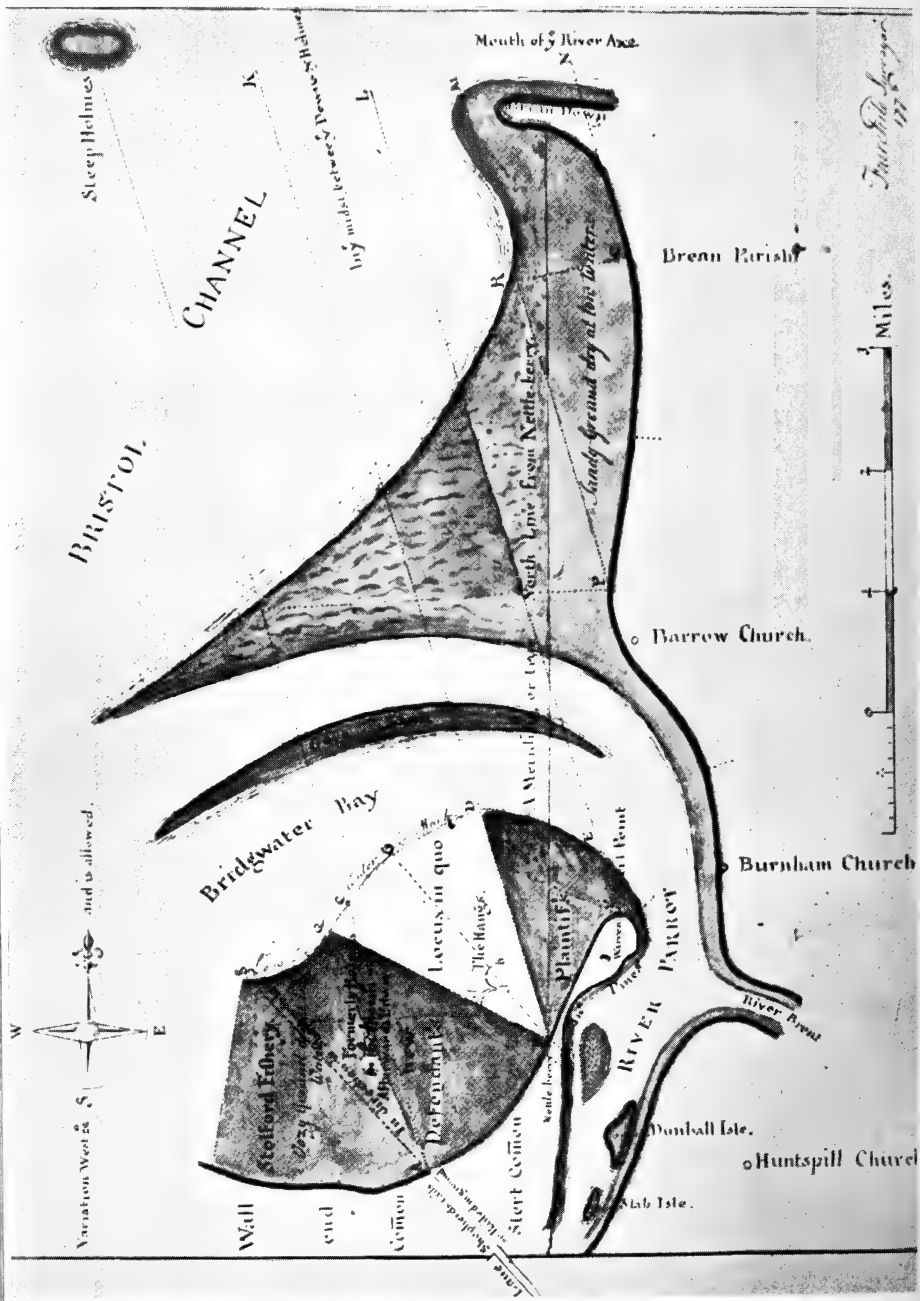
The seaward side is usually bordered by sand, and in many patches, particularly to the north, small sand ridges are a distinctive feature. Some of these have a length of twenty or more yards and usually run in a W.N.W.-E.S.E. direction. They are flat-topped and only about a foot higher than the surface of the surrounding marsh or sand. Such accumulations are probably wind-blown, and it is perhaps at this point that the windiness of the area and the prevalence of sand drifting should be emphasized. There is no doubt whatever that here wind action is very important, apart from any wave action.

In his 1922 paper, Stuart Thompson showed a stream tributary to the Parret and bordering the marsh along the greater part of its seaward border. He suggested this as a possible cause of the development of the vegetation, " by diminishing the force of scour over the flat between it and the sand dunes." In his second paper, the same writer mentioned that the channel was then silting up at its northern end and that this had " enabled the old forces of the waves to carry off some of the vegetation."

In 1937 this channel had entirely disappeared and the marsh was bordered there by a broad expanse of sand which seemed little changed in 1938. Out to sea, however, at a distance of about half a mile, a big gully was seen which was apparently tributary to the Parret. It was impossible to reach this on account of the soft mud, but a subsidiary channel running from an approximately north easterly direction was examined. It is impossible to say whether this was a new formation or not, and there is no survey detail regarding it available. First impressions suggest that the expanse of sand to seaward of the marsh is higher than the marsh itself, and that there is another relatively high patch of sand to the north-west. Some of the channels out of the marsh have been cut off by this higher sand and the drainage thus considerably affected.

To the north-west of the marsh it seems therefore that, between the high sand and the main channel, a depression of some extent has been enclosed. The main drainage of this basin appears to be by the gully just mentioned and leading to the main channel. Possibly the gully was cut by the water of this depression seeking an outlet back to sea. This water is a constant danger to the marsh, the north end of which seems to suffer erosion from high tides, as witness the loss in recent years at this extremity. If the increase in sand on the seaward side of the marsh goes on, then the activities of the drainage to the north may be stopped and the cover of vegetation again extended. On the other hand, the depression may be pushed in a southerly direction, in which case the marsh will probably lose further ground in the north. It is hoped that levelling may be carried out this year, without which it is not easy to say anything useful on the relative heights in this rather difficult area.

The gully is a very definite feature, cut in the soft mud, and gradually attains a depth of at least ten feet and a width up to twenty feet. It is obviously subject to severe erosion owing to its rapid fall towards the main channel, and the quick changes after a tide are very marked.


Mouth of ye River Axe.
Steep Holmes
CHANNEL
BRISTOL
Brean Parish
Barrow Church.
Bridgwater Bay
Burnham Church
RIVER PARRET
Dunball Isle.
Huntspill Church
Stab Isle.
Stolford Fishery
Miles.
Variation West 24°
and is allowed.

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Berrow Church Marsh

This is a smaller marsh lying 700 feet north of Berrow Church and immediately bordering the trackway at the bottom of the dune line. It is approximately 1,500 feet long and tapers to north and south from a maximum width of 250 feet. No significant change in its size has occurred at any rate since 1936. It was resurveyed in 1938 by chain and compass. It is cut up into four sections by narrow gaps almost perpendicular to the dunes. The marsh itself is comparatively dry and is flanked on its seaward side by a new dune line in which individual dunes rise to a height of four or five feet. Here again there are extensive patches of *Spartina Townsendi*.

As a matter of fact, a new dune line seems to have become established in this area and to the north since 1904, as it is not shown on the Ordnance Survey six-inch map published in that year.

A Plan of Stert Fisheries

Further evidence of Stert Island is afforded by a Plan of Stert Fisheries dated 1776, a copy of which has recently been given to me by Mr. Kelting (4), Engineer to the Somerset Rivers Catchment Board. This shows very clearly that at that date Stert Island did not exist and, further, that the neck of land, which must have been breached when the island was formed, was less than a hundred yards wide. This evidence corroborates previous suggestions.

The plan shows many other interesting points. The Warren is marked near Stert Point, and three islands are shown in the River Parret. Two of these are named Slab Isle and Dunball Isle. The third is without a name but its position suggests that it was Fenning Island (Jennings) which now forms a part of the mainland and is flanked by the shingle ridge of Stert Point.

A further interesting detail is the position of the Gore sand which is shown as long and narrow, almost perpendicular to the coast and separating two channels of the Parret. This fits in very well with a statement by Locke (5) in 1789. In a letter of that date he gave some interesting details concerning this area. Apparently Dunball Island was already connected to the mainland, and the Gore sand had extended so that the easterly channel was " almost filled with sand and slub." He further remarks " Our fishermen inform me that, with the assistance of their slime carts, they can go near ten miles straight west into St. George's Channel at dead low water, when the tide is run out the lowest possible."

Mud Balls

Some mention was made in the 1936 paper of mud balls which were seen particularly on Stert Island but also on the foreshore north of Burnham. These have been further observed, and in 1938 they were seen in considerable numbers to the west and north of the lighthouse marsh. Many of these, however, were made up of a black interior, possibly of old marsh soil, with a mud and sand coating up to a quarter of an inch in thickness. The exposure from which the black soil had been eroded was not seen. They tend to occur particularly along the junctions between sand and clay, and a tentative suggestion previously put forward for their development seems to be corroborated by further observations. It does not appear that a nucleus pebble is necessary for their initiation. Pieces of clay are eroded from exposures on the shore. These are possibly sun-dried in many cases, following the cracking of dried clay and mud. Later they are rolled along by the tides and collect mud, sand, tiny pebbles and other débris. On one occasion they were actually seen being rolled along by a rising tide on the western shore of Stert Island. Many are oval in shape, but the spherical form is often seen, and some are very irregular. It is probable that the balls disappear quickly and are often covered by deposition from the tide following their development. Should they be initiated on a falling tide succession they will possibly have a better chance of survival. It is not usual, however, to see them, other than those which are the result of recent tides.

Dr. Wallis (6) has kindly drawn my attention to a mention of the "mud pellets" in a paper published by him in 1928. He writes of their occurrence on the sandy foreshore at Uphill, Somerset, and other places. "The mud pellets are generally oval shaped (from 1-6 cms. in length) or may be spherical. The coast at Uphill is sandy with mud flats exposed at low tide. The incoming tide picks up small quantities of this mud, rolls it into lenticles or spheres and finally deposits it on the sand area."

Stert Island

Erosion on the island has continued on both the east and west sides, but particularly the latter. On that side the more westerly of the two drainage lines is now wiped out for the greater part of its length. The greatest change, however, is at the south end of the island where the shingle spread has been largely changed, and a small patch of vegetation has disappeared. In this area shingle has been pushed south and east and now encloses a pool which is about a hundred

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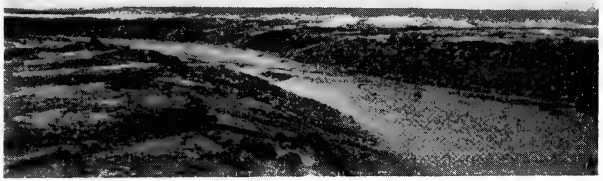
I

Low Lighthouse Marsh, Burnham, Looking Towards Dune Line. In Foreground Creek Running Out to Sea



II

Same Standpoint as No. I, but Looking Out to Sea, and Along the Gully Leading to the Parret

III

Half a Mile Seaward of Marsh, Looking in Direction of Berrow Church. Gully Here Six Feet Deep and Over Twelve Feet Wide

IV

Landward End of Gully, in Direction of Berrow Church. Note Evidence of Rapid Changes

yards long at low water. The southern extremity itself is more blunted, and here also the spread of shingle is rather more extensive than in 1936.

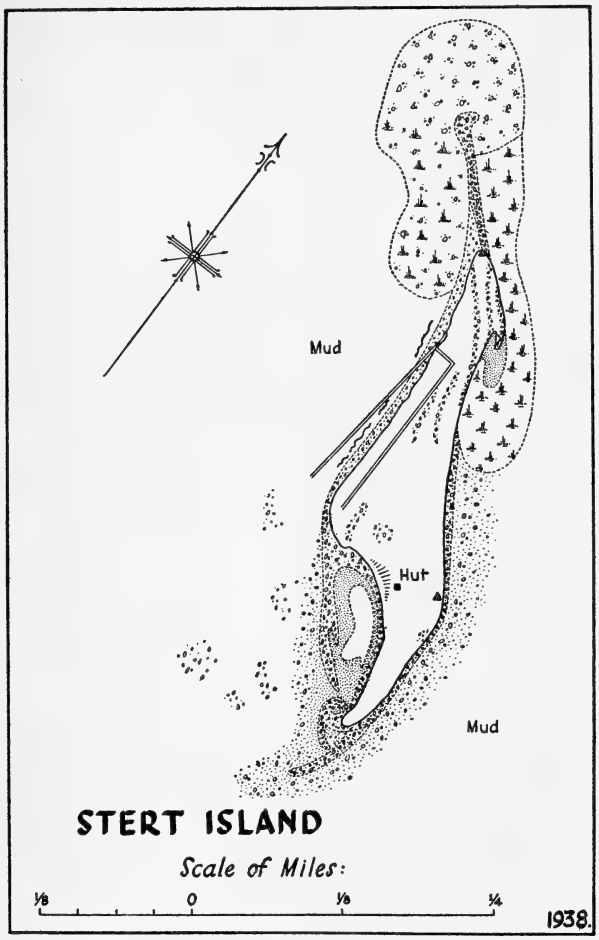


Fig. 44

Stert Point

Recent changes in the point are not spectacular, but nevertheless serious erosion continues on the bank of the River Parret, and on the seaward side the shingle continues to be pushed forward over the land. The actual point continues to swing round, and a new spread of sand seems to point the way for further encroachment. In 1937 a detailed survey of a piece of the bank of the river was made. This was one

hundred feet in length, in which every small variation was plotted. It was evident that erosion was rapid in this part, but we were surprised and disappointed to find in 1938 that our fixed points had been carried away, even though they were twelve feet back from the edge of the marsh in 1937.

A further survey of a like nature was carried out in August, 1938, over a length of the river bank, 466 feet in length, and this time we took the precaution to fix our measuring points well back from the bank.

Wind Statistics. Burnham and Bridgwater

In general the prevailing winds in the Bristol Channel are westerly, and in many cases greatly outnumber those from all easterly directions. A preliminary study of a short series of weather observations for Burnham, however, does not appear to agree with this general statement. Statistics for the five years 1932-36 were examined. This, of course, is a very short period, but in each of these years both the strongest and the most frequent winds were from the north-west, and blew up to force seven. These winds, however, appear to be most frequent during the months of May, June, July and August, when gales are comparatively rare. This area is a relatively bad one for gales but general evidence shows that they are most frequent from the westward during the months from October to March, and often last three or four days.

In the same way a series for Bridgwater for one year only, 1934, gives similar results, i.e., the north-west wind is a stronger and more frequent wind than that from the south-west. On one occasion the wind attained force eight, and on several occasions it stayed in the northerly sector swinging between north-west and north-east for periods up to fourteen days.

Such differences as these must not be overstressed from short series of observations. They do, however, emphasize the need for care in general assumptions, and efforts will be made to examine more complete records. Burnham, of course, is renowned for the force and frequency of its breezes off the sea.

The tidal stream follows the general direction of the prevailing winds, which are westerly. In the wider area of the Bristol Channel, the dominant waves follow the same direction, travelling almost due east. But although the run of the longshore current is parallel to the shore, it should be remembered that there are currents running into all bays. Further, the turn of the tidal stream offshore is seldom at the same time

I
Mud Balls Being Rolled Along by the Tide Off the West Coast of Stert Island

II
Stert Island, South-West Corner. New Pool Left at Low Water, a Change Since 1936

III
The Only Dune Formation on Stert Island. South End of Island

[*To face p.* 504

as that of high and low water on the shore. For instance, in the gap-way (7) between Stert Point and Stert Island the flood-tide makes from about half-tide up to one hour before high water, when it returns seawards and runs rapidly until the gap-way dries, i.e., at about half-ebb tide. Other things being equal, this fact may have a definite bearing on the amount and movement of material carried in suspension. The Somerset Rivers Catchment Board propose to close this gap and so cause the whole of the water of the ebb tide to return by the main channel of the Parret. This, it is suggested, would not only deepen the channel but would also tend to improve the entrance to the river. The Huntspill bank would also be protected from the severe erosion which it suffers at present when westerly gales generate heavy seas through the gap.

In the evolution of the shape of the shoreline, two main forces are at work; there is the longshore drift of material by the prevalent waves and also the dominant waves which pile up the material on the coast. In recent years the latter have been neglected, but their great power, especially if their direction should coincide with that of the greatest fetch of open water, has been recently demonstrated by Lewis (8). In the case of Bridgwater Bay such a coincidence does exist and it is probable that the curve of part of the shoreline is changing so as to face these dominant breakers.

In this connection the change in the direction of the coastline near Berrow is significant; the low lighthouse marsh described is forming to the south between this point and the lighthouse. Similarly, to the north of the change of direction, a new dune line and the smaller marsh are forming as already stated. Further, the higher patch of sand already mentioned is roughly in line with the swing of the coast. It is hoped that this matter will be investigated further this year (1939).

I cannot close this report without thanking the Colston Research Society who have continued to make grants in aid of the work, and also my students who have given invaluable help in the making of the surveys.

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