

THE POST-PLIOCENE NON-MARINE MOLLUSCA OF IRELAND.

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I.—INTRODUCTION.

IT is to be regretted that the geological history of our present fauna has not yet received the attention it deserves. Numerous theories have been propounded dealing with geographical distribution, theoretical land connections and hypothetical climatic conditions, yet it must be admitted that the evidence on which such theories should be based is but scanty. One reason for this comparative neglect undoubtedly is that until quite lately a line has always been drawn between Zoology and Palæontology, and even now the boundary exists officially. Hence it comes about that in all museums fossils are placed in one department and recent specimens in another. The remains from our more recent deposits have thus been not old enough for the palæontologist and too old for the zoologist, or if noticed at all were dismissed as sub-fossil. Most archæological investigators are also neglectful in these matters, and the phrases one usually sees are "bones of domestic animals" or "shells of living species." This lack of accuracy could be pardoned if these despised bones and shells had been preserved, but in nearly all cases they have been thrown away, and thus most important evidence has been destroyed. Perhaps another reason for this neglect is that the more recent deposits have never appealed to the æsthetic taste of the collector, a circumstance which is not an unmixed evil.

Viewed from either a geological or zoological standpoint, the fauna of Ireland is of extreme interest, and could its correct history be ascertained a great advance in our knowledge would be made.

It is the privilege of the student of any particular branch of

Zoology or Botany to consider its study of paramount importance, and he is apt to think that theories which account for his difficulties are equally applicable to other groups, a misconception which becomes only too obvious on reference to the apertaining literature. Thus since all the Lusitanian plants living in the British Isles have small seeds it has been suggested that they have been introduced by "birds driven by exceptional gales." This is not unreasonable, yet recent investigations show that plants introduced in this manner are not likely to obtain a permanent foothold.* Moreover, W. H. Griffin notes:—

In 1905 I planted in wild places in West Kent seeds of sixty species, mostly aliens, but a few of them from Northern and Western counties. In no instance was a flowering plant produced.†

He adds that Mr. Reuter had a similar experience in Middlesex. Thus it is possible, though extremely improbable, that the Lusitanian flora has been accidentally introduced overseas into Ireland, yet it is obvious that this theory will not account for the associated fauna.

Comparisons are always invidious, still it has always appeared to us that there are few groups of animals which are of more importance to the naturalist in the study of geographical distribution, or to the geologist, than the non-marine mollusca. They cannot fly, and their ova are not usually carried by the wind, and the hypothetical tree-trunk, with its miscellaneous cargo of snails and slugs, has not yet materialised.

These animals are as a rule extremely slow in extending their range except by the aid of human agency; they are very susceptible to slight changes in environment, and are the most abundant fossils in the more recent deposits. Hence any conclusions based on a study of their past history and present distribution must merit consideration. Although the remains of mollusca are abundant their correct identification is not always an easy matter. Too often they are fragmentary or decorticated, rendering their determination extremely difficult, and to err is easy under such circumstances.

Furthermore, there are many difficulties arising from the chaotic state of the nomenclature—due to several causes. In the early days of Palæontology the comparison between living and fossil mollusca was by no means so carefully made as now, and early identifications must always be treated with great caution. To repeat them without comment or without any attempt to check them only adds to the confusion, especially of continental workers.

There are to-day in Europe three distinct "schools" in matters malacological, each "school" with its own system of nomenclature. First there is what may well be called the "Jeffreysian school," which is practically confined to these

* C. B. Moffatt, "Bees and Flowers," *Irish Nat.*, vol. xxii, 1913, pp. 65-74.

† *South East Nat.*, 1912, p. 26.

islands, where till recently its influence has been paramount. For this school the species are limited to those known to the author of "British Conchology," with the addition of numerous so-called varieties.

Under this scheme colour forms and trifling differences in shape, size and texture are placed in the same category as sub-species and geographical races, whilst, until quite lately, sinistral, scalariform and decollate specimens were also classed as varieties and dignified with names, the describer's name being appended. As an instance of the total disregard of the principles of binominal nomenclature we may cite the following:—*

It is possible to have such a combination as the following: *H. nemoralis*, *m. scalariforme* + *m. sinistrorsum* + *v. major* + *compressa* + *libellula* + *roseolabiata* + *roseonata*.*

More recently J. W. Taylor has stated that

to fully express the peculiarities of any single shell it would be necessary to use two or more varietal names, and this act would not be a reversion to the old polynominal system of general descriptive nomenclature, but would on the contrary constitute a strictly precise and accurate terminology.†

It is, of course, obvious that to express fully the peculiarities of any single shell a detailed description must be given. Taylor has misunderstood the principles of the Linnean system; the name of the shell is one thing, its accurate description is another and totally different matter. Certain it is that Taylor's views have no support outside Britain.

Jeffreys, though the author of a very readable book, was notoriously careless, and was too prone to differ from the conclusions of contemporary workers on insufficient grounds. It has been a too-prevalent idea in this country to consider that the "British Conchology" summarised within its covers all the requisite knowledge of British shells. The pioneers in British Malacology—Alder, Brown, Bean, Forbes, Gilbertson, Gray, Hanley, Montagu, Pickering and Thompson—had far saner and more scientific views on the subject than their successors with their meaningless lists of "varieties" and "monstrosities" and their total disregard of all continental work.

With respect to the "French school," it must always be remembered that their conception of a species has differed from that usually adopted. Their view has been clearly stated by Commt. E. Caziot.‡ The species of an English writer is too often the "group" of a follower of the "new school." This last was founded by Bourguignat and continued by Ancey, Drouet, Locard, Mabille and other writers, and under their auspices innumerable species have been described, with the inevitable result that chaos has ensued, necessitating rectification and re-rectification in the nomenclature. Hence it becomes exceedingly

* L. E. Adams, *Collectors' Manual*, 2nd edit., 1896, p. 62.

† Monograph, vol. iii, p. 288.

‡ Moll. Corse, 1902, pp. 149-154.

difficult to follow so much of the modern French work. Able a malacologist as Bourguignat undoubtedly was, this fundamental difference in the conception of what constitutes a species mars much of his work and is to be deplored. International Congresses of Zoology may be held *ad infinitum*, but so long as there are these fundamental divergences of opinion it is hopeless to expect any uniformity in nomenclature. Fortunately in the last few years a decided change of view has taken place in France, and good work has been accomplished in reducing the numerous redundant species to their proper synonymy, and science owes a great debt to such writers as Coutagne, Grainger, Dollfus and Germain in their endeavour to refound malacology in France on a scientific basis.

Lastly, there is the school which may well be termed the "modern school," founded mainly by Hyatt and Grabau, and to which we incline. To us a species is

a number of related individuals having a similar genetic history and possessing a tendency to evolve along strictly analogous lines.*

Particular stages in the development of a series may well be termed subspecies, and are worthy of a name, remembering at the same time that but little has been accomplished towards a correct knowledge of the range of variation.

Most mollusca are subject to normal, or as it has been termed, non-significant variation. Thus in a fairly large collection of *Pyramidula rotundata* a perfect series can be graded from the shells which are nearly flat to those in which the spire is distinctly raised, and there is no scientific utility in giving varietal names to the two extremes. A similar range of variation exists in the coloration, and here again it is waste of energy to name the extremes or the intermediates. Whether the colour mutations, where the distinctive coloration is inherited, such as the var. *exalbida* of *Helix aspersa*, should be named is another matter, but such are of no use to the palæontologist. The occurrence of sinistral examples in a normally dextral species, or the converse, is also a case of non-significant variation. The same remark applies to scalariform individuals. These abnormalities are of interest only from a pathological standpoint, whilst decollate shells arising from extraneous causes are of more interest to the chemist than to the systematist.

Other phases of variation arise from environment. Here the characters are not inherited, but remain constant so long as the environment is unchanged, a resumption of normal conditions causing reversion to the type. H. Hannibal has proposed the term "syntonic" for these,† though some of the species which he considers syntonic are distinctly true species. Syntonic forms are far more abundant amongst aquatic than amongst terrestrial species.

* H. Hannibal, *Proc. Malac. Soc.*, Lond., vol. x, 1912, p. 118.

† *Proc. Malac. Soc.*, Lond., vol. x, 1912, pp. 114-5.

In this paper, beyond accepting such changes in nomenclature as proved inevitable, the names employed are those mostly used in these islands of late years. The task of seeking out the correct synonymy according to the latest of the variable rules produced by succeeding Zoological Congresses and their diverse interpreters is reserved for a later occasion. We have for some few years been examining all available material concerning the past history of the Irish non-marine mollusca.

Unlike the condition of affairs in England, where the literature is extensive and goes back to the early fathers of Geology, practically nothing has been done in Ireland, and the only references are a few scattered notices, nearly all of no great interest, and too often quite untrustworthy. This has materially lightened our labours and rendered our work less difficult. Even so our task could not have been attempted without the aid of numerous friends, and in this respect we have been fortunate. The answers to our appeals for assistance have been numerous. Material has been sent with a lavish hand, whilst information has always been freely given. To our numerous friends and helpers, sometimes quite unknown to us personally, we take this opportunity of acknowledging their kindly aid, and we would especially mention A. Bell, R. Bell, the late Dr. O. Boettger, Dr. C. Boettger, the Rev. E. W. Bowell, Miss Brittain, the late Rev. R. A. Bullen, Commt. E. Cazier, Dr. F. Corner, Prof. Grenville A. J. Cole, the late Dr. G. W. Chaster, E. Collier, Miss M. Delap, W. K. Fayle, D. Geyer, W. Gray, J. W. Groves, G. K. Gude, J. Wilfrid Jackson, Dr. A. C. Johansen, Fleet-Surgeon K. H. Jones, B. R. Lucas, Major R. G. Macnamara, A. McHenry, Miss Parkinson, R. Lloyd Praeger, the late J. H. Ponsonby-Fane, T. Plunkett, R. A. Russell, Dr. R. F. Scharff, H. J. Seymour, the late E. A. Smith, R. Standen, the late Major H. Trevelyan, the late R. J. Ussher, the late Colonel Underwood, and Dr. E. W. Wüst. R. A. Phillips placed at our disposal large series of recent mollusca from the South and West of Ireland, besides sending samples from various deposits. To A. W. Stelfox we are indebted for the recent distribution of the species in Ireland, as well as for large series of living shells and material from and notes on several deposits. On the shoulders of R. Welch has fallen the greater part of the burden of collecting or forwarding material. No trouble has been too great and no journey has been too long; his extensive knowledge has always been at our disposal, and we have no hesitation in saying that it is owing to his enthusiasm and energy this paper has been possible. Judging, however, from what, with all this assistance, we have been able to accomplish, there is obviously still a vast field in Ireland for future workers. We have been able only just to touch the fringe of the subject, and when more workers appear many more important discoveries

will be made, new light will be thrown on problems at present obscure, whilst not impossibly some of our most cherished conclusions will be modified.

II.—DESCRIPTIONS OF SECTIONS.

As compared with those of England, the post-Pliocene deposits of Ireland are not so varied, and show greater similarity to those of Scotland and Wales. The deposits from which molluscan remains have been obtained may well be divided into seven groups: Crannoges, Kitchen-middens, Raised beaches, River deposits, Caves, Old land surfaces, and Chara marls.

A. CRANNOGES.

These are artificial islands occurring in many of the Irish lochs. Many have been explored by archæologists, and it has been shown that, though constructed in the Early Iron Age, they were inhabited to a much later period, in some cases the sixteenth century. We have examined molluscan remains from two crannoges, Clanreen and Drumcliffe, both in Co. Clare.

(1) *Clanreen Crannoge.*

Collected by Miss Parkinson and forwarded by R. Welch. Sixteen species were determined, viz.:—

<i>Polita hibernica</i> , com.	<i>Limnæa stagnalis</i> , com.
<i>Zonitoides nitidus</i> , 3 ex.	<i>Limnæa truncatula</i> , 1 ex.
<i>Helicella itala</i> , 3 ex.	<i>Planorbis albus</i> , 3 ex.
<i>Helix nemoralis</i> , com.	<i>Planorbis umbilicatus</i> , 2 ex.
<i>Helix aspersa</i> , 1 ex.	<i>Planorbis leucostoma</i> , 2 ex.
<i>Succinea putris</i> , 1 ex.	<i>Planorbis contortus</i> , 3 ex.
<i>Limnæa pereger</i> , com.	<i>Valvata cristata</i> , 10 ex.
<i>Limnæa palustris</i> , com.	<i>Sphærium corneum</i> , 3 val.

These have been presented by Miss Parkinson to the Dublin Museum.

(2) *Drumcliffe Crannoge.*

Collected by Miss Parkinson and forwarded by R. Welch. Eight species were determined, viz.:—

<i>Polita hibernica</i> , com.	<i>Helix nemoralis</i> , com.
<i>Polita alliaria</i> , 1 ex.	<i>Limnæa pereger</i> , 1 ex.
<i>Pyramidula rotundata</i> , 2 ex.	<i>Limnæa palustris</i> , 1 ex.
<i>Helix aspersa</i> , 5 ex.	<i>Planorbis leucostoma</i> , 2 ex.

The specimens of *Polita hibernica* are the largest we have seen, one shell measuring 15 mm. in diameter.

With these shells the smaller land species, such as *Polita hibernica*, *Pyramidula rotundata*, etc., probably lived there during the period of human occupation; *Helix aspersa* and *H. nemoralis* may have been used as food or bait, whilst the freshwater forms would owe their presence to accident. Judging, however, from the large number of *Limnaea stagnalis* which was found in the Clanreen Crannoge, many of which were broken, it is by no means improbable that this species was also used for food or bait. It must, however, not be forgotten that this form is a favourite diet of the otter, and one of us (A. S. K.) has repeatedly seen heaps of these shells, broken and perfect, on the banks of the river Deben, in Suffolk, the relics of the meals of the otter. It can readily be imagined that when the crannoge was deserted otters would resort to it and leave behind them similar heaps of shells.

The age of the shells from the crannoges is comparatively modern.

B. KITCHEN MIDDENS.

Kitchen middens in Ireland are notoriously of all ages, ranging from neolithic to modern times. We have noted molluscan remains from five middens, viz.: Mahee Island, Rosapenna, Inishcoole, Achill Island, and Iniskea.

(1) *Mahee, Co. Down.*

This island is situated on the western side of Strangford Lough. The deposit is 8 ft. to 10 ft. above high-water mark. The sample was collected by R. Bell and forwarded by R. Welch. The shells are nearly all marine forms, the most abundant species being *Ostrea edulis* and *Littorina littorea*, whilst *Chlamys varius*, *Patella vulgata*, *Cardium edule* and *Mytilus edulis* also occur.

Four species of non-marine mollusca were collected:—

<i>Polita alliaria</i> , 1 ex.	<i>Pyramidula rotundata</i> , 1 ex.
<i>Vitrea crystallina</i> , 2 ex.	<i>Helix aspersa</i> , 1 ex.

(2) *Rosapenna, West Donegal.*

In 1894 an account of the kitchen middens was given by W. H. Patterson,* whilst in 1902 additional details were given by R. Welch.† The middens occur under blown sand, and they have been claimed to be of neolithic age. Objects of the tenth century, A.D., occur on top of the middens, but never in them. It is quite possible that in so remote a part as the old kingdom of Fanad that the neolithic

* *Irish Nat.*, vol. iii, pp. 49-51.

† *Proc. Roy. Soc. Antiq., Ireland*, vol. xxxii, pp. 225-231.

culture stage lasted much longer than it did in those regions more accessible.

The material was collected and forwarded by R. Welch.

Eleven species were determined, viz. :—

<i>Polita alliaria</i> , 5 ex.	<i>Cochlicopa lubrica</i> , 1 ex.
<i>Pyramidula rotundata</i> , 1 ex.	<i>Lauria cylindracea</i> , 1 ex.
<i>Helicella itala</i> , 3 ex.	<i>Pupilla muscorum</i> , 3 ex.
<i>Vallonia pulchella</i> , 3 ex.	<i>Clausilia bidentata</i> , 3 ex.
<i>Vallonia excentrica</i> , 6 ex.	<i>Carychium minimum</i> , 3 ex.
<i>Helix nemoralis</i> , 10 ex.	

Besides the uncertainty as to the age of the middens, there is the possibility that some of these shells have been derived from the layer beneath the middens (see page 131).

(3) *Inishcoole, Bunbeg, West Donegal.*

Collected and forwarded by R. Welch from a midden.

The non-marine species determined were :—

Polita nitidula, 1 example.
Helix nemoralis, 4 examples.

The marine species determined were :—

Patella vulgata. *Littorina obtusata*.
Purpura lapillus. *Ostrea edulis*.
Littorina littorea.

Teeth and fragmentary bones of a young individual of *Homo sapiens* were also sent, as well as two fragments of iron slag. The examples of *Purpura lapillus* were broken in the usual manner, presumably for dye. This midden is not of any great antiquity.

(4) *Achill Island, West Mayo.*

In 1891 J. G. Milne published an account of the non-marine mollusca of Achill Island,* and he notes that he obtained several species from the middens at Keel, but these are not enumerated.

(5) *Iniskea, West Mayo.*

R. Ll. Praeger sent a series from the kitchen middens at Iniskea North, off the Mullet Coast.

The non-marine species were :—

Polita nitidula, 5 examples.
Helix aspersa, 1 example.
Helix nemoralis, common.

* *Journ. of Conch.*, vol. vi, pp. 412-421.

The marine species were :—

<i>Patella vulgata.</i>	<i>Littorina obtusata.</i>
<i>Purpura lapillus.</i>	<i>Calliostoma zizyphinus.</i>
<i>Littorina littorea.</i>	

A canine tooth of seal was also sent. The examples of *Purpura lapillus* were broken in the usual manner. The band formulæ of *Helix nemoralis* are :—

1 2 3 4 5	17 examples.	0 0 0 0 0	2 examples.
0 0 3 0 0	4 examples.	0 0 3 4 5	1 example.

Many of this species are eroded by blown sand, and some are rather heavy in weight. There is great variation in size, the largest being 23×18 mm., and the smallest 16.5×15 mm.

The ages of these middens are so uncertain and the species obtained are too few for any definite conclusions to be drawn.

C. RAISED BEACHES.

Under this head we include the deposits at Cloughan Point, Portrush, Howth Head, Sandymount, and the Estuarine Clays of N.E. Ireland.

(1) Cloughan Point, Co. Antrim.

At Cloughan Point, between Kílroo and Whitehead, Belfast Lough, is a well-preserved section of a raised beach. The section is exposed in a low cliff, and is as follows :—

- 1 surface soil, 6 in.
- 2 small pebbles, chalk and flint flakes, 10 in.
- 3 raised beach, 18 feet exposed.

In the raised beach, at a point 2 ft. below the upper surface of the beach, R. Welch discovered a small pocket of Land shells. Six species were represented, viz. :—

<i>Polita hibernica</i> , com.	<i>Helix nemoralis</i> , 2 ex.
<i>Pyramidula rotundata</i> , com.	<i>Cochlicopa lubrica</i> , 1 ex.
<i>Hygromia hispida</i> , com.	<i>Clausilia bidentata</i> , 3 ex.

The age of these shells is uncertain. It is difficult to accept the view that they are of the same age as the raised beach, yet it is equally difficult to account for their introduction into the deposit at a later period. The condition of the hillside is not, and has not been for many years, favourable to *Polita hibernica*, which is the most abundant form, about 70 per cent. of the shells being of that species.

(2) *Portrush, Co. Antrim.*

The raised beach at Portrush was first noted by James Smith, of Jordanhill, but the first record of non-marine mollusca was given in 1842, by Capt. J. E. Portlock,* who listed nine species, viz. :—

Helix trochilus [= *Euconulus fulvus*].
Helix crystallina [= *Vitrea crystallina*].
Helix nemoralis.
Helix paludosa [= *Vallonia* sp.].
Clausilia rugosa [= *Clausilia bidentata*].
Clausilia biplicata.
Carychium minimum.
Pupa vertigo [= *Vertigo* sp.].
Pupa pygmæa [= *Vertigo pygmæa*].

In 1890 A. Bell recorded the same number of species,† but there are differences in the species: *Helix nemoralis* is omitted, *Zua* [= *Cochlicopa*] *lubrica* is added, whilst *Pupa vertigo* is transformed into *Pupa venetzii* [= *Vertigo angustior*].

S. A. Stewart, in 1897, recorded five species,‡ viz. :—

Polita radiatula. *Vertigo* sp.
Polita alliaria. *Balea perversa*.
Vallonia pulchella.

The deposit is commonly stated to be a thing of the past, but a good section is still exposed, and after washing a large sample sent by R. Welch we obtained ten species, viz. :—

Polita radiatula, 1 example.
Vallonia pulchella, common.
Vallonia costata, 7 examples.
Vallonia excentrica, 1 example.
Cochlicopa lubrica, 1 example.
Clausilia bidentata, 4 apical fragments.
Vertigo pygmæa, 2 examples.
Vertigo angustior, 5 examples.
Succinea pfeifferi, 1 example.
Carychium minimum, 5 examples.

There are thus five records unconfirmed :—

Vitrea crystallina. *Balea perversa*.
Polita alliaria. *Clausilia biplicata*.
Helix nemoralis.

* Report Geol. Londonderry, p. 162.

† "Fourth and final Report upon the Marine Gravels of Wexford." *Brit. Assoc. Rep.* for 1890, p. 3.

‡ *Irish Nat.*, vol. vi, pp 287-290.

Of these *Clausilia biplicata* must be rejected, since it is improbable it should occur in an Irish Holocene deposit. It is also possible that the record of *Balea perversa* may be a misidentification of an apical fragment of *Clausilia bidentata*, but we have allowed it to stand.

(3) *Howth Head, Co. Dublin.*

At Howth Head there was a calcrete of angular fragments of quartzite and rounded pebbles, with bones of mammals and fish and land shells, the whole firmly cemented together, and to the cliff. The deposit was well above high-water mark, 10 ft. in one place. R. Ll. Praeger, who first discovered it, is of opinion that the angular fragments and the land shells had fallen from the slopes above the cliffs and mixed with the beach material in hollows, and concluded that the deposit was of raised beach age, an opinion which has received the support of G. W. Lamplugh.

The material was sent by R. Welch.

Six species were determined, viz. :—

Pyramidula rotundata, 1 ex. *Helix aspersa*, 2 fragments.

Hygromia hispidula, 1 ex. *Helix nemoralis*, 2 ex.

Vallonia excentrica, 1 ex. *Clausilia bidentata*, 1 ex.

The only perfect example of *Helix nemoralis* measured 25 mm. in breadth. Since these examples were collected the deposit has been destroyed by marine action.

(4) *Sandymount, Co. Dublin.*

The existence of a raised beach here was first noted by R. Welch in a small temporary excavation made to obtain gravel for concrete. The section was :—

1 Surface soil, 6-8 in.

2 Yellowish shelly sand full of marine shells, 6-8 in.

3 Stratified raised beach gravel and sand, 6 ft.

Paludestrina ulva (Penn.) was extremely common in bed 2, and with them at the base of the layer, and in undoubted undisturbed sand, an example of *Succinea pfeifferi* was obtained.

(5) *The Estuarine deposits of the North-East.*

The occurrence of non-marine mollusca in the Estuarine clays has been noted by S. A. Stewart,* by A. Bell,† and by Canon

* "List of the fossils of the Estuarine Clays," 8th Ann. Rep. Belf. Nat. Field Club 1871, Appendix.

† "Fourth and Final Report of the Committee upon the Marine Gravels of Wexford," Brit. Assoc. Rep. for 1890.

Grainger,* whilst a full account was given in 1892 by R. Ll. Praeger.†

The species recorded are nine in number :—

Vitrea crystallina, Belfast.

Polita nitidula, Belfast, Larne, Magheramorne.

Polita radiatula, Larne.

Pyramidula rotundata, Belfast, Larne.

Vallonia pulchella, Larne.

Helix nemoralis, Belfast.

Paludestrina ventrosa, The Bann, Eglinton, Downpatrick, Holywood.

Bithynia tentaculata, The Bann.

Limnaea palustris, Larne.

These shells are of great importance, because their age can be fixed from a stratigraphical standpoint. We have, however, failed to trace any of these specimens. It should be noted that the records for *Vallonia pulchella* and *Paludestrina ventrosa* are for the aggregate species.

These raised beach deposits are certainly of early Holocene age,‡ and are unconnected with the recently-discovered pre-glacial raised beaches of the south. The single example of *Helix nemoralis* from Howth is much larger than recent shells from the neighbourhood, indicating a warmer climate. This confirms Mr. Praeger's view that many of the raised beaches are of the same age as the *Thracia convexa* clays near Belfast, which clearly indicate more genial conditions.

D. RIVER DEPOSITS.

(1) Templeogue, Co. Dublin.

At Templeogue the River Dodder has excavated its valley through a series of Pleistocene clays and gravels, leaving three distinct terraces as evidences of its former base levels, and it is probable that these are connected with the changes in level that have occurred in Ireland in Holocene times. The middle terrace is 22 ft. above the stream, and on it is an alluvial bed, from which R. Welch obtained nine species, viz. :—

Polita hibernica, 1 ex.

Hygromia hispida, 4 ex.

Polita nitidula, 1 ex.

Helix aspersa, 4 fragments.

Polita radiatula, 1 ex.

Succinea putris, 2 ex.

Helicella virgata, 1 ex.

Succinea pfeifferi, 1 ex.

Cochlicella barbara, 2 ex.

The absence of all true fluviatile shells should be remarked.

* *Nat. Hist. Review*, vol. vi, 1859, pp. 135-151.

† *Proc. Roy. Irish Acad.*, Series iii, vol. iv, 1892, pp. 212-289.

‡ cf. G. Coffey and R. Ll. Praeger, *Proc. Roy. Irish Acad.*, vol. xxv, 1905, pp. 143-200; and R. Ll. Praeger, *Proc. Roy. Irish Acad.*, Series iii, vol. ii, 1892, pp. 212-289.

(2) *Falcarragh, West Donegal.*

A. W. Stelfox discovered an important deposit at the mouth of the Ray River, Falcarragh. The section is :—

- 1 Modern blown sand.
- 2 Blown sand with shells, 3 ft.
- 3 Sands with black bands representing flood deposits, 2½ ft.
- 4 River gravel, 2 ft.

Mr. Stelfox states :—

This deposit covers perhaps a square mile of alluvial flats. I was only there a few minutes, and had only one bag, into which I had to put all the material. The freshwater shells and many of the land forms came from the black bands in bed 3. *Helix nemoralis* was also present in bed 4.

The species obtained from beds 2 and 3 were :—

<i>Vitrina pellucida.</i>	<i>Pupilla muscorum.</i>
<i>Punctum pygmaeum.</i>	<i>Vertigo pygmaea.</i>
<i>Pyramidula rotundata.</i>	<i>Carychium minimum.</i>
<i>Helicella itala.</i>	<i>Succinea pfeifferi.</i>
<i>Cochlicella barbara.</i>	<i>Limnaea pereger.</i>
<i>Hygromia hispida.</i>	<i>Limnaea palustris.</i>
<i>Vallonia costata.</i>	<i>Planorbis albus.</i>
<i>Vallonia excentrica.</i>	<i>Valvata piscinalis.</i>
<i>Helix nemoralis.</i>	<i>Pisidium sp.</i>
<i>Cochlicopa lubrica.</i>	

Mr. Stelfox notes that

Planorbis albus and *Valvata piscinalis* have hitherto not been found so far west, but they may exist in the same area.

(3) *Ballinasloe, S.E. Galway.*

R. A. Phillips has described a section and enumerated a number of species from this locality.* The material was obtained from a lenticular patch, about 2 in. thick and several feet in length, at a depth of 2 ft. from the surface, exposed in the bank of the River Suck. From material sent and the published list thirty-five species can be cited :—

<i>Polita radiatula</i> , 1 ex.	<i>Limnaea stagnalis</i> , 1 ex.
<i>Zonitoides nitidus</i> , 1 ex.	<i>Limnaea truncatula</i> , 1 ex.
<i>Hygromia hispida</i> , 1 ex.	* <i>Amphipeplea glutinosa</i> , 1 ex.
<i>Vallonia excentrica</i> , 2 ex.	<i>Planorbis umbilicatus</i> , 2 ex.
* <i>Helix nemoralis</i> , 1 ex.	<i>Planorbis carinatus</i> , 2 ex.
<i>Succinea pfeifferi</i> , 5 ex.	<i>Planorbis leucostoma</i> , 2 ex.
<i>Carychium minimum</i> , 3 ex.	<i>Planorbis contortus</i> , com.
<i>Limnaea pereger</i> , com.	<i>Planorbis vortex</i> , com.
<i>Limnaea palustris</i> , 3 ex.	<i>Planorbis albus</i> , 10 ex.

* *Irish Nat.*, vol. xxiv, 1915, p. 140.

<i>Planorbis crista</i> , 9 ex.	<i>Pisidium casertanum</i> , 10 valves.
* <i>Physa fontinalis</i> , 4 ex.	<i>Pisidium nitidum</i> , com.
<i>Aplecta hypnorum</i> , 1 ex.	<i>Pisidium pusillum</i> , com.
<i>Bithynia tentaculata</i> , com.	<i>Pisidium milium</i> , 1 valve.
<i>Theodoxus fluviatilis</i> , com.	<i>Pisidium subtruncatum</i> , 9 valves.
<i>Valvata piscinalis</i> , com.	<i>Pisidium henslowianum</i> , 1 valve.
<i>Valvata cristata</i> , com.	<i>Pisidium lilljeborgii</i> , 2 valves.
<i>Sphærium corneum</i> , com.	<i>Pisidium obtusale</i> , 1 valve.
<i>Pisidium amnicum</i> , 6 valves.	

This is a true river deposit, but is probably of no great age. A sample of recent drift taken from the edge of the same river was practically identical.

(4) *Limerick Alluvium, Co. Limerick.*

Sample sent by H. J. Seymour, who states :—

The exact locality is some 400 yards N.W. of Barrington's Quay, near Hawthorne House, Limerick. The area is part of an extensive flat, at one time forming slob land between tides, and is now reclaimed by an embankment, and salt or brackish water no longer reaches the area. The section is some 4 to 6 feet thick, and contains many branches and trunks of trees. The deposit is quite recent, but in a portion of this flat, at a somewhat greater depth, remains of *Cervus giganteus* have been obtained. The level is at or slightly above average high-tide level.

The material resembled some of the alluvial deposits of the Thames, and the contained fossils were either land or fresh-water organisms. Hence it is probable that the deposit is of some antiquity, and was laid down when different conditions prevailed.

Twenty-two species were determined, viz. :—

<i>Polita radiatula</i> , 1 ex.	<i>Limnæa truncatula</i> , com.
<i>Zonitoides nitidus</i> , 2 ex.	<i>Planorbis umbilicatus</i> , 2 ex.
<i>Arion</i> sp., 1 granule.	<i>Planorbis leucostoma</i> , 2 ex.
<i>Pyramidula rotundata</i> , com.	<i>Planorbis contortus</i> , 2 ex.
<i>Hygromia hispida</i> , 2 ex.	<i>Paludetrina jenkinsi</i> , 1 ex.
<i>Helix nemoralis</i> , 2 ex.	<i>Bithynia tentaculata</i> , com.
<i>Cochlicopa lubrica</i> , 3 ex.	<i>Valvata piscinalis</i> , 6 ex.
<i>Clausilia bidentata</i> , 1 ex.	<i>Valvata cristata</i> , 1 ex.
<i>Succinea pfeifferi</i> , com.	<i>Theodoxus fluviatilis</i> , com.
<i>Limnæa pereger</i> , com.	<i>Pisidium amnicum</i> , 1 valve.
<i>Limnæa palustris</i> , com.	<i>Pisidium casertanum</i> , 2 valves.

It is remarkable that we have only been able to enumerate molluscan remains from four river deposits. This is in marked contrast with the condition of things in England. Nevertheless, the reasons we have already given may account for the apparent difference. Both Limerick and Falcarragh are of importance, and we hope that further investigation will add to our knowledge.

* Found by Mr. Phillips, but not present in the sample sent.

E. CAVES.

(1) *Otters' Cave, Islandmagee, Co. Antrim.*

During the construction of a new cliff-path at the Gobbin's Cliff by the B. & N.C. Railway Company, in 1902, a number of hitherto inaccessible caves were opened, the principal one being the Otters' Cave. This had two entrances, one covered by a boulder beach, the other completely hidden by a large slip which occurred about 40 years previously. The upper part of the cave was not filled in, whilst the floor consisted of boulders calcreted together. At a little distance in the cave, under 5 ft. to 6 ft. of boulders, were some land and marine shells, with masses of bones, mostly broken, perhaps a kitchen midden. Possibly the non-marine shells are a modern introduction since they were not calcreted to the boulders as the marine shells were.

Five species were determined, viz. :—

Polita alliaria, 9 ex. *Clausilia bidentata*, 6 ex.
Pyramidula rotundata, 1 ex. *Limnaea truncatula*, 1 ex.
Cochlicopa lubrica, 1 ex.

Dr. R. F. Scharff* has given a short account of the bones found and recorded two of these species.

(2) *Edenvale and Newhall Caves, Co. Clare.*

Dr. R. F. Scharff† has described the molluscan remains from these caves. From the upper layer of the Alice and Gwendoline Caves six species were noted :—

Vitrea cellaria [= *Polita hibernica*?], common.
Pyramidula rotundata, rare.
Hygromia rufescens [= *striolata*], rare.
Helix aspersa, rare.
Helix nemoralis, common.
Clausilia bidentata, rare.

The upper layer of the Catacombs yielded four species :—

Vitrea cellaria [= *Polita hibernica*?], common.
Helix nemoralis, common.
Cochlicopa lubrica, rare.
Clausilia bidentata, rare.

The upper layer of the Newhall caves yielded eleven species :—

Vitrea cellaria [= *Polita hibernica*?], common.
Vitrea crystallina, rare. *Helix hortensis*?, rare.
Pyramidula rotundata, rare. *Lauria cylindracea*, rare.
Hygromia hispida, rare. *Clausilia bidentata*, rare.
Helix aspersa, common. *Carychium minimum*, rare.
Helix nemoralis, common. *Acicula lineata*, rare.

* *Irish Nat.*, vol. vii, 1903, pp. 55-6.

† *Trans. Roy. Irish Acad.*, vol. xxxiii, sect. B, pp. 22-24.

From the lower layer of the Alice and Gwendoline Caves five species were noted :—

Vitrea cellaria [= *Polita hibernica*?], common.

Pyramidula rotundata, rare.

Helix aspersa, rare.

Helix nemoralis, rare.

Bithynia tentaculata, 1 example.

In the lower layer of the Catacombs three species occurred :—

Limax maximus.

Vitrea cellaria [= *Polita hibernica*?], common.

Helix nemoralis, common.

These shells are preserved in the Dublin Museum, and we regret that we have not seen them.

(3) Rainwash Catacomb Caves, Edenvale, Co. Clare.

R. Welch detected a rainwash at the mouth of the Dogs' Cave and the Bats' Cave, from which he obtained a series of mollusca and some vertebrate remains. The bones have been determined by M. A. C. Hinton as

Hare (*Lepus variabilis*).

Common mouse (*Mus musculus*).

Wood mouse (*Mus sylvaticus*).

Frog (*Rana temporaria*).

Eel (*Anguilla anguilla*).

The species of mollusca were :—

Limax maximus, 1 ex.

Vitrea crystallina, 2 ex.

Polita hibernica, com.

Polita alliaria, 1 ex.

Polita radiatula, 7 ex.

Arion sp., 1 granule.

Pyramidula rotundata, com.

Vallonia excentrica, 1 ex

Hygromia hispida, 6 ex.

Helicella itala, 7 ex.

Helix nemoralis, com.

Cochlicopa lubrica, 4 ex.

Lauria cylindracea, 4 ex.

Clausilia bidentata, 10 ex.

Acicula lineata, 1 ex.

Nothing can be stated as to the age of this deposit.

(4) Kesh Caves, Co. Sligo.

An account of the mollusca obtained from these caves was given by us in 1903.*

From the upper layer of the Plunkett Cave came :—

Vitrea crystallina.

Polita hibernica.

Polita radiatula.

Euconulus fulvus.

Pyramidula rotundata.

Helix nemoralis.

The second stratum yielded *Polita hibernica* only.

* *Trans. Roy. Irish Acad.*, vol. xxxii, Sect. B, pp. 181-2.

The second layer of the Coffey Cave, containing remains of the Arctic Lemming, yielded:—

<i>Polita hibernica.</i>	<i>Pyramidula rotundata.</i>
<i>Helix nemoralis.</i>	<i>Clausilia bidentata.</i>

(5) *Ballinamintra Cave, Co. Waterford.*

The remains obtained from this cave were described in 1881 (*Trans. Roy. Dub. Soc.*, ser. ii, vol. i, pp. 177-266).

In the third stratum, at a depth of 6 ft., associated with Bear, Reindeer, etc., an immature example of *Helix aspersa* was obtained.

The mollusca obtained from the Irish caves are not satisfactory owing to disturbance. The shells from the lower layers at Kesh and the single example from Ballinamintra are Pleistocene, and thus five species can be classed as of that age.

The shells from the Co. Clare caves are unreliable, though probably some are Pleistocene.

F. OLD LAND SURFACES.

(1) *Giant's Causeway, Co. Antrim.*

Discovered by A. W. Stelfox during the excursion of the Belfast Naturalists' Field Club to the Antrim Coast in May, 1913.

On the east side of the River Bush and close to the tramway bridge is a gravel pit with a varying thickness of blown sand resting on a river gravel. Neolithic flint flakes occur at the base of the sands, and some years ago two human skeletons were found in the pit. In the blown sands, at a depth of about 6 ft., occurred what was obviously a "fossil shell pocket," and this yielded twenty-four species, viz.:—

<i>Vitrea crystallina</i> , 6 ex.	<i>Helix nemoralis</i> , com.
<i>Polita alliaria</i> , com.	<i>Cochlicopa lubrica</i> , abundant.
<i>Polita nitidula</i> , 1 ex.	<i>Lauria cylindracea</i> , 4 ex.
<i>Polita radiatula</i> , com.	<i>Pupilla muscorum</i> , com.
<i>Euconulus fulvus</i> , com.	<i>Vertigo pygmaea</i> , com.
<i>Punctum pygmaeum</i> , 6 ex.	<i>Vertigo substriata</i> , com.
<i>Pyramidula rotundata</i> , 1 ex.	<i>Vertigo angustior</i> , com.
<i>Hygromia hispida</i> , abundant.	<i>Vertigo pusilla</i> , 1 ex.
<i>Cochlicella barbara</i> , abundant.	<i>Columella edentula</i> , 3 ex.
<i>Vallonia pulchella</i> , abundant.	<i>Clausilia bidentata</i> , abundant.
<i>Vallonia excentrica</i> , abundant.	<i>Succinea Pfeifferi</i> , 2 ex.
<i>Acanthinula aculeata</i> , 1 ex.	<i>Carychium minimum</i> , 4 ex.

It was evident from the condition of the shells that they were not all of the same age. *Helix nemoralis* was only represented by young examples and broken fragments, but this is true of all shell pockets, and arises from wind action. *Cochlicopa lubrica* varied greatly in size, but the small sand dune form was the more

prevalent. The abundance of *Vertigo substriata* is noteworthy. The occurrence of *Succinea pfeifferi* is easily accounted for by the close proximity of the river and wind action.

(2) *Whitepark Bay, Co. Antrim.*

Material collected and forwarded by R. Welch. The old land surface is covered by about 15 ft. of blown sand, the shells being washed out by a small stream.

Sixteen species were identified :—

<i>Agriolimnaea agrestis</i> , 4 ex.	<i>Vallonia pulchella</i> , com.
<i>Vitrea crystallina</i> , 2 ex.	<i>Vallonia excentrica</i> , com.
<i>Polita alliaria</i> , 6 ex.	<i>Hygromia hispida</i> , com.
<i>Polita nitidula</i> , 1 ex.	<i>Helix aspersa</i> , com.
<i>Polita radiatula</i> , 1 ex.	<i>Helix nemoralis</i> , com.
<i>Pyramidula rotundata</i> , 2 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Helicella itala</i> , com.	<i>Pupilla muscorum</i> , 1 ex.
<i>Cochlicella barbara</i> , com.	<i>Clausilia bidentata</i> , 1 ex.

No examples of *Vertigo* occurred, though this genus is abundantly represented in the surface pockets. The most numerous are the Xerophiles *Helicella itala* and *Cochlicella barbara*. The largest example of the latter was 21 mm. in height. The former was very variable in height, ranging from 6.5 to 10 mm. The band formulæ of *Helix nemoralis* were :—

1 2 3 4 5	0 0 3 0 0	0 0 3 4 5
(1 2 3 4 5)	0 0 0 0 0	

A few small marine shells also occurred.

(3) *Doonbeg and Lahinch, Co. Clare.*

Miss Brittain sent us, through R. Welch, a series of fossil *Helix nemoralis* and *Helicella itala*, obtained from the sandhills, clearly indicating the presence of buried land surfaces. From the earth contained within these shells five other species were obtained, viz. :—

<i>Hygromia hispida</i> , 3 examples.
<i>Vallonia pulchella</i> , 1 example.
<i>Vallonia excentrica</i> , 1 example.
<i>Cochlicopa lubrica</i> , 1 example.
<i>Clausilia bidentata</i> , 2 examples.

The examples of *Helix nemoralis* are among the largest we have seen from Ireland, specimens in the Dublin Museum, measuring 27 mm. in breadth, whilst many attain 24 or 25 mm. The shells are heavy, though often sand-eroded. Band formulæ:—

1 2 3 4 5	1 2 3 (4 5)	0 0 (3 4 5)
(1 2 3 4 5)	1 0 3 4 5	1 0 3 0 5
(1 2 3) (4 5)	1 0 3 (4 5)	0 0 3 0 0
(1 2) 3 (4 5)	0 0 3 4 5	0 0 0 0 0
(1 2 3) 4 5		

(4) *Bundoran, East Donegal.*

R. Welch informs us that the buried land surface, containing many land shells, occurs in the Finner dunes near the mouth of the River Erne. About the centre of the dune area, *i.e.*, just S.W. of the \triangle 167' mark on the 1 ft. or 6 ft. maps, there is a deep valley in the old dunes, where the deposit is well exposed and the sand is being blown to the eastward. East of this valley the dunes are mostly growing and are sparsely covered with marram grass. In places this arrests the small shells which blow over the ridge or through the dune cols, forming at times numerous shell pockets. Many of the shells pass in high winds right into the river, where numbers are naturally floated, and along the eastern margin of the dunes by the river's margin for half to three-quarters of a mile they form a thick and in places wide tidal fringe, and in dry weather millions of *Pupilla*, *Vertigo*, *Vallonia* and *Cochlicopa* may be sifted out. The valley from which the material comes is over a quarter-mile long now, and may have been much longer formerly: it is eroded through the kitchen middens to the base of the sand deposits. In the modern surface pockets the contained shells have been weathered out of shell zones of all ages, with the exception of a few recent *Cochlicella barbara* and young *Helix nemoralis*. The great feature of the Bundoran deposit is the abundance of *Hygromia hispida*. In the oldest zone there are no Xerophiles, whilst *Cochlicella barbara* exists in myriads in the later zones and modern pockets. There is a total absence also of marine shells and foraminifera in the oldest zone. Twenty-one species were determined, viz. :—

<i>Limax maximus</i> , 1 ex.	<i>Helix nemoralis</i> , com.
<i>Vitrea crystallina</i> , 10 ex.	<i>Pupilla muscorum</i> , abundant.
<i>Polita alliaria</i> , com.	<i>Lauria cylindracea</i> , 1 ex.
<i>Polita radiatula</i> , com.	<i>Cochlicopa lubrica</i> , abundant.
<i>Euconulus fulvus</i> , 1 ex.	<i>Vertigo pygmæa</i> , com.
<i>Arion</i> sp., 2 granules.	<i>Vertigo substriata</i> , 6 ex.
<i>Punctum pygmæum</i> , 4 ex.	<i>Vertigo angustior</i> , com.
<i>Hygromia hispida</i> , abundant.	<i>Vertigo pusilla</i> , 1 ex.
<i>Acanthinula aculeata</i> , com.	<i>Clausilia bidentata</i> , abundant.
<i>Vallonia pulchella</i> , abundant.	<i>Carychium minimum</i> , 2 ex.
<i>Vallonia excentrica</i> , abundant.	

All these were obtained from the lowest layer.

Band formulæ of *Helix nemoralis* :—

o o o o o (1 2 3) (4 5)

(5) *Pollan Bay, East Donegal.*

A buried land surface was discovered amongst the sandhills at Pollan Bay, Ballyliffen, Innishowen, by R. Welch.

The section is :—

1. Calcreted sands.
2. Soft blown sand.
3. Sand with sand shells and human relics.

These last included flint flakes, hammer stones, and the shells of edible marine mollusca. Bed three is from 3 ft. to 6 ft. from the surface. The dunes are situate on the extensive flat (raised beach) that now connects Doagh Isle with the mainland.

Ten species were identified :—

<i>Polita alliaria</i> , com.	<i>Vallonia excentrica</i> , 1 ex.
<i>Polita nitidula</i> , com.	<i>Helix nemoralis</i> , com.
<i>Polita pura</i> , com.	<i>Cochlicopa lubrica</i> , com.
<i>Pyramidula rotundata</i> , 4 ex.	<i>Lauria cylindracea</i> , 3 ex.
<i>Hygromia hispida</i> , 3 ex.	<i>Clausilia bidentata</i> , com.

Band formulæ of *Helix nemoralis* :—

(1 2) 3 4 5
 1 2 3 4 5
 (1 2 3 4 5).

They are decidedly heavier than recent examples.

(6) *Carrickfin, Bunbeg, West Donegal.*

Under the midden layer exposed in Carrickfin dunes, A. W. Stelfox noted a layer about 3 ins. thick, containing numerous shells, the species being :—

<i>Vallonia pulchella</i> .	<i>Pupilla muscorum</i> .
<i>Helix nemoralis</i> .	<i>Clausilia bidentata</i> .
<i>Cochlicopa lubrica</i> .	

The examples of *Helix nemoralis* are small but heavy, and are all white-lipped. Band formulæ :—

0 0 3 4 5 1 2 3 (4 5)
 1 2 3 4 5 (1 2) 3 4 5.

The largest measured 20 × 18 mm., and the smallest 17.5 × 15 mm.

Many of the shells found in the shell pockets at Mullaghderg and Carrickfin are certainly fossils derived from old land surfaces, as noted by Mr. Stelfox (*Irish Nat.*, vol. xv, 1906, p. 67), but in the absence of sections their original source cannot be traced.

(7) *Horn Head, West Donegal.*

Discovered by the late Dr. G. W. Chaster and C. E. Wright (*Irish Nat.*, vol. xviii, 1909, p. 86), described by R. Welch (*Irish Nat.*, vol. xviii, 1909, pp. 113-5). The deposit was exposed in an

old dune, which was being eroded by the wind, and there were several layers of shells from $\frac{1}{2}$ in. to 3 ins. in thickness. It is clearly not a true land surface, but resembles the upper zones at Bundoran. From material sent by R. Welch twenty-two species were determined, viz. :—

<i>Vitrina pellucida</i> , 2 ex.	<i>Helix nemoralis</i> , com.
<i>Vitrea crystallina</i> , com.	<i>Cochlicopa lubrica</i> , com.
<i>Euconulus fulvus</i> , 1 ex.	<i>Vertigo pygmaea</i> , com.
<i>Punctum pygmaeum</i> , com.	<i>Vertigo angustior</i> , com.
<i>Helicella itala</i> , com.	<i>Vertigo pusilla</i> , 1 ex.
<i>Cochlicella barbara</i> , com.	<i>Lauria cylindracea</i> , 1 ex.
<i>Hygromia hispida</i> , com.	<i>Lauria anglica</i> , 1 ex.
<i>Acanthinula aculeata</i> , 4 ex.	<i>Pupilla muscorum</i> , com.
<i>Vallonia pulchella</i> , com.	<i>Clausilia bidentata</i> , 5 ex.
<i>Vallonia excentrica</i> , com.	<i>Carychium minimum</i> , com.
<i>Vallonia costata</i> , 2 ex.	<i>Limnaea truncatula</i> , 1 ex.

Mr. Welch has recorded *Vertigo substriata*, which was absent from our material. The examples of *Helix nemoralis* are rather heavy, and often sand-eroded. Recent examples from the same locality are much less heavy. There is but little variation in size, the largest being 23.5 mm. \times 18 mm., and the smallest 19 mm. \times 15 mm. Many are white-lipped.

Band formulæ of *Helix nemoralis* :—

I 2 3 4 5	I (2 3) 4 5	(1 2) 3 (4 5)
(1 2 3 4 5)	I 2 + 3 4 5	I 2 3 (4 5)
(1 2) 3 4 5	(1 2 3) (4 5)	o o o o o.

(8) *Inishmeane, West Donegal.*

Collected from a rainwash in the sand dunes in 1908, and described in 1909 by A. W. Stelfox (*Irish Nat.*, 1909, p. 88).

The species determined were :—

Polita pura, 3 examples.
Euconulus fulvus, 1 example.
Helicella itala, common.
Cochlicella barbara, common.
Acanthinula aculeata, 3 examples.
Vallonia pulchella, common.
Cochlicopa lubrica, 10 examples.
Vertigo pusilla, 1 example.
Vertigo angustior, 4 examples.
Clausilia bidentata, 1 example.
Carychium minimum, common.

This deposit represents a sand-dune fauna, with an admixture of species derived from an older deposit.

(9) *Narin, West Donegal.*

Collected by Prof. Grenville A. J. Cole and forwarded by R. Welch. Prof. Cole informed us that the deposit is only exposed in a few places in the dunes, and that a generalised section would be :—

1. Recent blown sand.
2. More earthy layer, with many land shells and a few marine.
3. Bed containing abundant marine shells.
4. Blown sand.
5. Neolithic layer, with fire-reddened stones, flint flakes, teeth (some human), and bones.

The material sent was obtained from No. 2, and yielded twenty-one species, viz. :—

<i>Limax maximus</i> , 6 ex.	<i>Vallonia pulchella</i> , com.
<i>Vitrina pellucida</i> , 2 ex.	<i>Vallonia excentrica</i> , com.
<i>Vitrea crystallina</i> , 1 ex.	<i>Helix nemoralis</i> , fragments.
<i>Polita radiatula</i> , 1 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Polita nitidula</i> , com.	<i>Pupilla muscorum</i> , 2 ex.
<i>Arion</i> sp., com.	<i>Vertigo pygmæa</i> , 1 ex.
<i>Punctum pygmæum</i> , 2 ex.	<i>Vertigo substriata</i> , 1 ex.
<i>Pyramidula rotundata</i> , 4 ex.	<i>Vertigo angustior</i> , 10 ex.
<i>Helicella itala</i> , com.	<i>Clausilia bidentata</i> , com.
<i>Cochlicella barbara</i> , com.	<i>Carychium minimum</i> , 2 ex.
<i>Acanthinula lamellata</i> , 2 ex.	

In 1907 R. Welch forwarded material collected by himself from a section near the shore. The section was :—

1. Blown sand, with a few land shells, 4 ft.
2. Midden layer, with marine shells, charcoal, &c., 10 ins. to 2 ft.
3. Grey earth full of land shells, 10 to 14 ins.

The material came from bed 3 and yielded twenty-one species, viz. :—

<i>Vitrina pellucida</i> , 1 ex.	<i>Hygromia hispida</i> , com.
<i>Vitrea crystallina</i> , 2 ex.	<i>Vallonia pulchella</i> , com.
<i>Polita nitidula</i> , 2 ex.	<i>Vallonia excentrica</i> , com.
<i>Polita alliaria</i> , 4 ex.	<i>Helix nemoralis</i> , com.
<i>Polita radiatula</i> , 2 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Polita pura</i> , 2 ex.	<i>Pupilla muscorum</i> , com.
<i>Euconulus fulvus</i> , 1 ex.	<i>Vertigo pusilla</i> , 1 ex.
<i>Punctum pygmæum</i> , 6 ex.	<i>Vertigo angustior</i> , 3 ex.
<i>Pyramidula rotundata</i> , com.	<i>Clausilia bidentata</i> , com.
<i>Helicella itala</i> , com.	<i>Carychium minimum</i> , com.
<i>Cochlicella barbara</i> , com.	

There is great similarity between these two lists, although one was obtained from above the middens, and the second from

beneath it. It is clear, however, that in both cases there is an admixture of shells of various ages, and the oldest land surface has not yet been seen. The most interesting shell is *Acanthinula lamellata*, this being the only Irish deposit in which it has been found. The examples of *Helix nemoralis* are small. The band formulæ are :—

1 2 3 4 5	(1 2 3) (4 5)	0 0 0 4 5
(1 2) 3 4 5	1 0 3 4 5	0 0 0 0 0

(10) *Rosapenna*, West Donegal.

In 1902 R. Welch described this section.* It was as follows :—

1. Blown yellow sand.
2. Midden layer, 8 to 18 ins.
3. A greyish sandy bed, with land shells and a few marine,
15 ins.

The lower part was obscured by talus.

The species determined from bed 3 comprised :—

<i>Polita alliaria</i> , 4 ex.	<i>Helix nemoralis</i> , 2 ex.
<i>Vitrea crystallina</i> , 1 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Arion</i> sp., 2 granules.	<i>Pupilla muscorum</i> , com.
<i>Helicella itala</i> , 6 ex.	<i>Lauria cylindracea</i> , 2 ex.
<i>Cochlicella barbara</i> , 6 ex.	<i>Vertigo pygmæa</i> , 1 ex.
<i>Vallonia pulchella</i> , com.	<i>Clausilia bidentata</i> , com.
<i>Vallonia excentrica</i> , com.	

In 1905 R. Welch forwarded material from a depth of 6 ft. below the midden layer. This yielded twenty-three species, viz. :—

<i>Vitrina pellucida</i> , 6 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Vitrea crystallina</i> , com.	<i>Pupilla muscorum</i> , com.
<i>Polita alliaria</i> , com.	<i>Lauria cylindracea</i> , com.
<i>Polita radiatula</i> , com.	<i>Vertigo pygmæa</i> , 10 ex.
<i>Euconulus fulvus</i> , 5 ex.	<i>Vertigo substriata</i> , 4 ex.
<i>Arion</i> sp., com.	<i>Vertigo pusilla</i> , 8 ex.
<i>Limax arborum</i> , 2 ex.	<i>Vertigo angustior</i> , 10 ex.
<i>Punctum pygmæum</i> , 4 ex.	<i>Columella edentula</i> , 2 ex.
<i>Hygromia hispida</i> , com.	<i>Clausilia bidentata</i> , abund.
<i>Acanthinula aculeata</i> , com.	<i>Carychium minimum</i> , com.
<i>Vallonia pulchella</i> , com.	<i>Acicula lineata</i> , com.
<i>Vallonia excentrica</i> , com.	

The most abundant species was *Clausilia bidentata*, and the fossil examples eroded from the deposit by the wind were to be found in all the hollows.

Since 1905 the dunes have been carefully examined by R. Welch, and he informs us that the oldest deposits are at the

* *Proc. Roy. Soc. Antiq., Ireland*, vol. xxxii, pp. 225-231.

base of the older dunes, *i.e.*, the inner fringe of dunes, which he thinks commenced to form before the raised beach was elevated, for there is a long elevated platform several hundred feet wide in places between the older, inner dunes and the outer ones which fringe the strand. From material sent by him twenty-five species were determined, viz. :—

<i>Agriolimax agrestis</i> , 1 ex.	<i>Helix nemoralis</i> , rare.
<i>Agriolimax lævis</i> , com.	<i>Cochlicopa lubrica</i> , abund.
<i>Vitrea crystallina</i> , com.	<i>Pupilla muscorum</i> , abund.
<i>Polita hibernica</i> , 2 ex.	<i>Lauria cylindracea</i> , 6 sampls.
<i>Polita alliaria</i> , com.	<i>Vertigo pygmæa</i> , com.
<i>Polita radiatula</i> , com.	<i>Vertigo substriata</i> , com.
<i>Arion</i> sp., abundant.	<i>Vertigo angustior</i> , com.
<i>Punctum pygmæum</i> , com.	<i>Vertigo pusilla</i> , 8 ex.
<i>Hygromia hispida</i> , 7 ex.	<i>Columella edentula</i> , 5 ex.
<i>Acanthinula aculeata</i> , com.	<i>Clausilia bidentata</i> , abund.
<i>Vallonia pulchella</i> , abund.	<i>Carychium minimum</i> , abund.
<i>Vallonia costata</i> , com.	<i>Acicula lineata</i> , com.
<i>Vallonia excentrica</i> , com.	

There are differences between the two last lists, and the importance of collecting from more than one spot is emphasized.

The prevalence of *Agriolimax lævis* is noteworthy, since this species is more abundant in this deposit than in any other we have examined, but perhaps the careful system of sieving adopted by Mr. Welch may account for this.

(11) *Tranarossan, West Donegal.*

There are here some fragmentary remains of an old surface soil, containing numerous land and a few marine shells. The deposit is much wind-eroded, and is distinctly higher than the flat wind-swept plain which extends around the patches. The material was collected and sent by R. Welch. Twenty-one species were determined, viz. :—

<i>Agriolimax agrestis</i> , 3 ex.	<i>Helix nemoralis</i> , 5 ex.
<i>Vitrea pellucida</i> , 2 ex.	<i>Helix aspersa</i> , 3 fragments.
<i>Vitrea crystallina</i> , 10 ex.	<i>Cochlicopa lubrica</i> , com.
<i>Polita radiatula</i> , 4 ex.	<i>Pupilla muscorum</i> , 10 ex.
<i>Arion</i> sp., com.	<i>Vertigo pygmæa</i> , 2 ex.
<i>Punctum pygmæum</i> , 10 ex.	<i>Vertigo substriata</i> , 3 ex.
<i>Hygromia hispida</i> , 2 ex.	<i>Vertigo pusilla</i> , 1 ex.
<i>Helicella itata</i> , com.	<i>Vertigo angustior</i> , com.
<i>Cochlicella barbara</i> , com.	<i>Clausilia bidentata</i> , 1 ex.
<i>Vallonia pulchella</i> , com.	<i>Carychium minimum</i> , com.
<i>Vallonia excentrica</i> , com.	

We have here a mingling of a sand dune with a woodland fauna.

(12) *Millisle, Co. Down.*

On the south of Millisle is a small natural section on the sea-shore as follows :—

1. Soil, 12 to 15 ins.
2. Blown sand, with various old land surfaces, 2 to 4 ft.

At the base of No. 1, A. W. Stelfox obtained examples of *Helix aspersa*. Marine shells are common in bed 1, and Mr. Stelfox suggests that they have been brought into the field with seaweed for manure. A similar explanation was given by the Rev. R. A. Bullen in describing sections at Porto Pi and Alcudia in Mallorca (*Proc. Malac. Soc., Lond.*, vol. ix, 1910, pp. 118-9).

(13) *Orlock Point, Co. Down.*

Collected and forwarded by R. Welch. The shells were obtained from a layer about 2 ft. thick covered by a foot of soil. Six species were determined :—

Polita nitidula, 1 example.
Hygromia hispida, 7 examples.
Cochlicella barbara, common.
Helix nemoralis, 3 examples.
Cochlicopa lubrica, 3 examples.
Clausilia bidentata, 1 example.

(14) *Balbriggan Bay, Co. Dublin.*

In the Final Report on the Manure Gravels of Wexford (*Brit. Assoc. Report* for 1890), A. Bell records seven species from a deposit at this locality. He states : "Where the cliff is at its lowest, marking an old line of drainage, it is covered by apparently the remnants of an old sand dune full of land shells of few species and an abundance of littoral shells." The species he records are :—

Bulimus acutus [= *Cochlicella barbara*].
Helix ericetorum [= *Helicella itala*].
Helix virgata [= *Helicella virgata*].
Helix concinna } [= *Hygromia hispida*].
Helix hispida }
Helix rufescens [= *Hygromia striolata*].

The original specimens are preserved in the Dublin Museum, and were forwarded for our inspection by Dr. Scharff. Seven species are represented :—

<i>Helicella itala.</i>	<i>Hygromia hispida.</i>
<i>Helicella virgata.</i>	<i>Hygromia striolata.</i>
<i>Helicella caperata.</i>	<i>Helix nemoralis.</i>
<i>Cochlicella barbara.</i>	

The age of these shells is very uncertain, but they are probably quite modern.

(15) *Dogs' Bay, West Galway.*

This well-known deposit at Roundstone was discovered by Thomas Glover, of Manchester, and was first described in 1885 by R. D. Darbishire (*Journ. of Conch.*, vol. iv, 1885, p. 317). He notes the deposit as "an old sward which appeared as a black band about 2 ins. deep in the face of a small section of the sandhills closing the bay to the eastward," and he cited twenty species from this band. In 1895 E. Collier and R. Standen visited the locality and described the deposit (*Journ. of Conch.*, vol. viii, 1896, pp. 179-190). They failed to find the black band, but in several places in the sandhills the old band surface with many perfect shells was exposed. All the previous records were confirmed and five new ones were added.

In 1895 Mr. Welch also visited the locality, whilst in 1906 E. Collier, R. Standen and A. W. Stelfox also collected there, and from the material thus obtained we are able to add seven new records.

The section as exposed in 1906 was:—

1. A layer of clean sand, foraminifera and finely comminuted shells, the layer being pure white in colour, 3 ft.
2. A grey layer of earthy sand and broken marine shells, 1 ft.
3. Blown sand with many examples of *Helix nemoralis*, 2 ft.

Nearly all the species came from bed 2.

The following are now known or recorded:—

<i>Agriolimax laevis</i> , 2 ex.	<i>Hygromia striolata</i> .
<i>Vitrina pellucida</i> , 2 ex.	<i>Acanthinula aculeata</i> , 6 ex.
<i>Vitrea crystallina</i> , 4 ex.	<i>Vallonia pulchella</i> , common.
<i>Polita cellaria</i> .	<i>Vallonia excentrica</i> , common.
<i>Polita alliaria</i> , 1 ex.	<i>Helix aspersa</i> , 12 ex.
<i>Polita nitidula</i> , common.	<i>Helix nemoralis</i> , abundant.
<i>Polita radiatula</i> , 3 ex.	<i>Cochlicopa lubrica</i> , common.
<i>Euconulus fulvus</i> .	<i>Pupilla muscorum</i> .
<i>Arion</i> sp., common.	<i>Lauria cylindracea</i> , 2 ex.
<i>Punctum pygmaeum</i> , 3 ex.	<i>Vertigo pygmaea</i> , 10 ex.
<i>Helicella itala</i> , common.	<i>Vertigo angustior</i> , common.
<i>Helicella caperata</i> .	<i>Vertigo substriata</i> .
<i>Helicella virgata</i> , 1 ex.	<i>Clausilia bidentata</i> , common.
<i>Cochlicella barbara</i> .	<i>Carychium minimum</i> , common.
<i>Hygromia hispida</i> .	<i>Acicula lineata</i> , 8 ex.

The relative frequency is from the specimens in our collection and from those we have seen. The record of *Polita cellaria* is for the aggregate species, and it is impossible to say which of the

segregates is intended. It would also appear that the record of *Hygromia striolata* is open to grave doubt.

Dogs' Bay has long been famous for the extremely heavy and large examples of *Helix nemoralis*. Mr. Stelfox informs us that the heaviest and largest examples occur at the base of the deposit, and that they gradually become lighter and smaller until in bed 2 they are similar to the ordinary form. A similar state of things occurs with *Helix aspersa*. Band formulæ of *Helix nemoralis* :—

1 2 3 4 5	1 0 3 4 5	0 0 3 (4 5)
(1 2 3) (4 5)	1 2 3 4 0	0 2 3 4 0
(1 2 3) 4 5	0 2 3 (4 5)	0 2 3 0 5
(1 2 3 4 5)	0 2 3 4 5	0 0 3 4 0
1 (2 3) 4 5	1 2 0 4 5	0 0 3 0 5
(1 2) 3 (4 5)	0 (2 3) (4 5)	0 0 3 0 0
(1 2 3 4) 5	0 0 (3 4 5)	0 0 0 0 0

The most abundant forms are 0 0 3 0 0 and 0 0 0 0 0. We shall discuss the supposed identity of the Dogs' Bay shells with *Helix tonnensis*, Sandb., later (postea, p. 169). At least two darts have been extracted from the interior of shells of *Helix nemoralis*.

(16) *Inishbofin, West Galway.*

This deposit has been described by A. W. Stelfox (*Proc. Roy. Irish Acad.*, vol. xxxi., 1912, pp. 51-2), who sent specimens for verification.

Five distinct layers were noted.

E.—A recent bed still forming. This yielded :—

<i>Polita nitidula</i> , frequent.	<i>Vallonia costata</i> , frequent.
<i>Helicella itala</i> , common.	<i>Helix nemoralis</i> , rare.
<i>Cochlicella barbara</i> , frequent.	<i>Cochlicopa lubrica</i> , frequent.
<i>Hygromia hispida</i> , rare.	<i>Clausilia bidentata</i> , very rare.
<i>Vallonia pulchella</i> , frequent.	

D.—A local deposit of marine shells, possibly a kitchen midden.

C.—Containing :—

<i>Polita alliaria.</i>	<i>Helix nemoralis.</i>
<i>Polita nitidula.</i>	<i>Cochlicopa lubrica.</i>
<i>Polita pura.</i>	<i>Pupilla muscorum.</i>
<i>Punctum pygmaeum.</i>	<i>Lauria anglica.</i>
<i>Pyramidula rotundata.</i>	<i>Lauria cylindracea.</i>
<i>Hygromia hispida.</i>	<i>Vertigo substriata.</i>
<i>Acanthinula aculeata.</i>	<i>Clausilia bidentata.</i>
<i>Vallonia pulchella.</i>	<i>Carychium minimum.</i>
<i>Vallonia costata.</i>	

B.—In which were found :—

Helicella itala, scattered.
Cochlicopa lubrica, scattered.
Pupilla muscorum, a distinct zone.

A.—Fine blown sand, no shells. Mr. Stelfox states that *Helix aspersa*, though now abundant, is quite absent from the deposit, and that *Vallonia costata* and *Pupilla muscorum* are not known living on the island.

(17) *Killeany Bay, Inishmore, Aran Islands, Clare.*

R. A. Phillips collected and forwarded a series from this locality from a deposit of blown sand. There is a low-lying sandy waste covered with grass, but in places large pits have been excavated by the wind, and it was from one of these pits that the material was obtained. Nine species were determined :—

<i>Helicella itala</i> , common.	<i>Lauria cylindracea</i> , 2 examples.
<i>Cochlicella barbara</i> , common.	<i>Pupilla muscorum</i> , 1 example.
<i>Vallonia excentrica</i> , 8 examples.	<i>Vertigo pygmæa</i> , 9 examples.
<i>Helix nemoralis</i> , common.	<i>Vertigo angustior</i> , 1 example.
<i>Cochlicopa lubrica</i> , common.	

This list shows that we are dealing with a dune deposit of shells of various ages. The marine shells from this deposit have been enumerated by J. R. Le B. Tomlin.*

(18) *Ballin Prior, North Kerry.*

R. Welch forwarded examples of *Helicella virgata* obtained from "low zones exposed in deep hollows in a very old dune."

(19) *Beginish, Valentia, South Kerry.*

Miss M. Delap sent us a series of shells obtained from this island. Nearly all the shells sent were *Helix nemoralis*, but a few *Helicella itala* were also present. The living shells were obtained from under stones close to the water's edge, and the fossil examples from the sand dunes. The fossil examples of *Helix nemoralis* are as a rule large, and range from 18 mm. to 24 mm. in diameter, and many of them are heavy. The living shells are all thin, and are smaller, ranging from 16 mm. to 20.5 mm. in diameter. A few of the fossil shells are white-lipped, but this state is more prevalent amongst the recent examples.

* *Proc. Malac. Soc., Lond.*, vol. xii, 1916, p. 63.

Band formulæ of fossil examples :—

o o o o o	38 examples.	o o 3 (4 5)	1 example.
1 2 3 (4 5)	2 examples.	o o (3 4 5)	1 example.
(1 2 3) (4 5)	3 examples.	1 (2 3) 4 5	1 example.
o o 3 o o	5 examples.	o (2 3) (4 5)	1 example.
1 2 3 4 5	5 examples.	1 2 3 + 4 5	1 example.
(1 2 3 4 5)	3 examples.	(1 2) 3 (4 5)	1 example.
1 o 3 4 5	3 examples.		

Band formulæ of living shells :—

1 2 3 4 5	9 examples.	(1 2 3) 4 5	4 examples
o o o o o	16 examples.	1 o 3 4 5	1 example.
o o 3 o o	17 examples.	(1 2) 3 4 5	1 example.
(1 2 3) (4 5)	4 examples.	(1 2 3 4 5)	1 example.

As may be seen by comparison, there are marked differences in the bandings.

(20) *Dingle Harbour, South Kerry.*

There is a blown sand deposit on the south shore of Dingle Harbour, and although it apparently did not contain any shells, yet, by careful sieving, A. W. Stelfox obtained eight species from it, viz. :—

Vitrea crystallina.
Helicella itala.
Vallonia pulchella.
Cochlicopa lubrica.

Pupilla muscorum.
Lauria cylindracea.
Vertigo pygmæa,
Vertigo angustior.

This is clearly a dune deposit similar to that at Killeany Bay. All the above species now live on the dunes, with the exception of *Vertigo angustior*.

(21) *Ferriter's Cove, Smerwick, South Kerry.*

Collected and forwarded by A. W. Stelfox. The section was :—

1. Blown sands with a few shells, up to 10 ft.
2. Very compact blackish band with shells, 9 ins. to 1 ft.
3. Sand, no shells noticed.
4. Boulder clay.

No. 1 is by no means a modern deposit. Mr. Stelfox did not specially collect from it, but he noticed that the three Xerophiles, *Helicella virgata*, *H. itala* and *Cochlicella barbara* were present.

The old land surface No. 2 appears to have been almost destroyed before the blown sand covered it. Now both are being rapidly eroded by the sea.

Bed 2 yielded twenty-four species, viz. :—

<i>Limax arborum</i> , 2 ex.	<i>Acanthinula aculeata</i> , 2 ex.
<i>Agriolimax agrestis</i> , 1 ex.	<i>Helix nemoralis</i> , 10 ex.
<i>Vitrea crystallina</i> , com.	<i>Cochlicopa lubrica</i> , com.
<i>Polita alliaria</i> , com.	<i>Pupilla muscorum</i> , com.
<i>Polita nitidula</i> , 8 ex.	<i>Lauria cylindracea</i> , com.
<i>Polita pura</i> , com.	<i>Lauria anglica</i> , 2 ex.
<i>Polita radiatula</i> , 3 ex.	<i>Vertigo pygmæa</i> , com.
<i>Euconulus fulvus</i> , com.	<i>Vertigo angustior</i> , com.
<i>Arion</i> sp., 10 granules.	<i>Vertigo substriata</i> , 1 ex.
<i>Punctum pygmæum</i> , 1 ex.	<i>Clausilia bidentata</i> , com.
<i>Pyramidula rotundata</i> , com.	<i>Carychium minimum</i> , abundant.
<i>Vallonia pulchella</i> , com.	<i>Acicula lineata</i> , com.

A few marine shells were also met with.

Band formulæ of *Helix nemoralis* :—

1 0 3 4 5 (1 2) (3 4 5) 0 0 0 0 0.

All these were of the normal texture, but one broken example, much sand-eroded and probably a derivative, was decidedly thick. A sinistral example of *Acicula lineata* was found by Mr. Stelfox.

(22) Ventry Bay, South Kerry.

R. Welch sent us examples of *Helicella caperata*, which he had obtained from a zone exposed on the seaward face of the sand dunes at a depth of about 4 ft. from the surface.

(23) Achill Island, West Mayo.

In 1891 J. G. Milne described the non-marine Mollusca of Achill (*Journ. of Conch.*, vol. vi, 1891, pp. 412-421). He states : "But there are, besides, indications to be found of the nature of the fauna before the reign of peat in a small portion of old surface uncovered in the banks of a stream near Lough Nambrack." No list is given of the shells obtained, but we gather from the text that the following species were collected :—

<i>Vitrina pellucida</i> .	<i>Helix nemoralis</i> .
<i>Vitrea crystallina</i> .	<i>Cochlicopa lubrica</i> .
<i>Polita alliaria</i> .	<i>Clausilia bidentata</i> .
<i>Polita radiatula</i> .	<i>Carychium minimum</i> .
<i>Pyramidula rotundata</i> .	

Mr. Milne states that all these species, except *Clausilia bidentata*, now live on the island, and that the destruction of the forest has resulted in the extinction of this species, whilst a new fauna is replacing the old one. A. W. Stelfox has, however, shown that *C. bidentata* still lives there.*

* *Proc. Roy. Irish Acad.*, vol. **xxi**, 1912, pp. 25-30.

In 1909 Dr. F. Corner forwarded a series of shells collected on the floor of a dried-up lough on Achill.

Eight species were determined :—

<i>Helicella itala</i> , com.	<i>Limnæa pereger</i> , com.
<i>Helix nemoralis</i> , 6 ex.	<i>Limnæa auricularia</i> , 2 ex.
<i>Cochlicopa lubrica</i> , 2 ex.	<i>Limnæa truncatula</i> , 1 ex.
<i>Succinea Pfeifferi</i> , 1 ex.	<i>Bithynia tentaculata</i> , 1 ex.

Band formulæ of *Helix nemoralis* :—

(1 2) 3 (4 5)	(1 2 3) (4 5)	o o o o o
1 2 3 4 5	o (2 3) (4 5)	

The examples of *Limnæa auricularia* are the var. *acuta*, Jeff. *Bithynia tentaculata* has not yet been found living on the island.

(24) *Clare Island, West Mayo.*

R. Welch forwarded a series obtained from under the kitchen middens on Clare Island.

Three species were present :—

<i>Helicella itala</i> , common.	<i>Cochlicopa lubrica</i> , common.
<i>Vallonia pulchella</i> , 1 example.	

All the examples of the last were the small sand dune form. (Cf. *Proc. Roy. Irish Acad.*, vol. xxxi, 1912, p. 50).

(25) *Dooaghtry, West Mayo.*

R. Welch* collected a series of shells from a deposit under one foot of sandy peaty soil in a marsh. Four species were determined :—

<i>Helicella itala</i> , 2 examples.	<i>Limnæa pereger</i> , 4 examples.
<i>Cochlicopa lubrica</i> , 1 example.	<i>Limnæa truncatula</i> , 2 examples.

(26) *Strandhill, Co. Sligo.*

This deposit was discovered by A. W. Stelfox and R. Welch during the Irish Field Clubs' Conference at Sligo in 1904, and reference was made to it in the report (*Irish Nat.*, vol. ix, 1904, pp. 189-190). The exact locality is S.W. of Knocknarea, on the shore of Ballysodare Bay. There is a fairly wide and deep valley in the dunes, from which the sand had been blown further inland. The bases of the old dunes were left on both sides of the valley, as well as a fringe of kitchen middens across the south (shore) end. Small portions of these bottom layers were consolidated into a friable shell sandstone, and contained *Helix nemoralis*, *Cochlicopa lubrica* and *Hygromia hispida*, the last-

* Cf. *Proc. Roy. Irish Acad.*, vol. xxxi, 1912, p. 50.

named being the most prevalent. In one part an earthy layer contained a number of shells, and a series was sent by R. Welch. Seventeen species were determined, viz. :—

<i>Vitrea crystallina</i> , common.	<i>Pupilla muscorum</i> , common.
<i>Polita radiatula</i> , 2 examples.	<i>Lauria cylindracea</i> , 1 example.
<i>Punctum pygmæum</i> , common.	<i>Vertigo pygmæa</i> , common.
<i>Hygromia hispida</i> , common.	<i>Vertigo angustior</i> , common.
<i>Vallonia pulchella</i> , common.	<i>Vertigo substriata</i> , 1 example.
<i>Vallonia excentrica</i> , common.	<i>Clausilia bidentata</i> , 4 examples.
<i>Helix nemoralis</i> , common.	<i>Carychium minimum</i> , common.
<i>Ena obscura</i> , 14 examples.	<i>Acicula lineata</i> , 2 examples.
<i>Cochlicopa lubrica</i> , common.	

Mixed with these were a few small marine shells.

(27) *Ardcavan, Co. Wexford.*

A. W. Stelfox states : "When I was at Wexford, R. A. Phillips pointed out to me a section on the north shore of Wexford Harbour. The coast there consists of low cliffs (20 ft. high) of stiff boulder clay, and at one place about 3 ft. above high water mark there was a distinct band of shells. The species obtained were :—

<i>Polita hibernica.</i>	<i>Succinea pfeifferi.</i>
<i>Polita nitidula.</i>	<i>Pupilla muscorum.</i>
<i>Polita radiatula.</i>	<i>Lauria cylindracea.</i>
<i>Hygromia hispida.</i>	<i>Limnæa truncatula.</i>
<i>Helix nemoralis.</i>	<i>Paludestrina ulvæ.</i>
<i>Cochlicopa lubrica.</i>	<i>Littorina rudis.</i>

The absence of *Paludestrina jenkinsi*, so abundant in the adjacent coastal marshes, is worthy of note. All the species are now living in the vicinity. This is mainly a brackish, marsh fauna, and it would appear that the boulder clay has slipped over and covered up a marsh, and has thus preserved the marsh fauna in addition to that which was living on the cliff." We agree with these views, and there is therefore no need to invoke a warm interglacial period. There is no clue as to the age of these shells, and they may well be quite modern.

In Great Britain buried land surfaces are practically confined to Cornwall and Wales, whilst in Ireland they are widely scattered, and by keener search their number will be greatly augmented, since it is only lately that their importance has been recognised, and the Irish observers, few but fit, are to be congratulated on the work they have accomplished. Under "buried land surfaces" we have included all sand-dune deposits, for though in several cases they are not land surfaces of long duration, yet many

of the contained shells have been derived from some true land surface. We have examined or recorded molluscan remains from twenty-seven localities, yet since in many the evidence is fragmentary, it is only necessary to describe the more important. Of these Dogs' Bay, West Galway, is perhaps the most interesting, as it is certainly the best known. Two distinct fossiliferous zones are present, the bottom layer yielding the heavy forms of *Helix aspersa* and *H. nemoralis*, other species being almost absent; whilst the upper grey layer contains a varied molluscan fauna, with numerous examples of *H. nemoralis* of the normal type. So that here three stages are represented—a first, when the environment was extremely favourable to the well-being of *H. nemoralis*; a second, when conditions were less favourable to that species, and a woodland fauna was able to establish and maintain itself for some considerable time; and, lastly, the present period, probably one of long duration, throughout which no mollusca have lived on the spot. We should perhaps mention that the term "woodland fauna" does not imply the presence of trees, but only indicates an assemblage of forms which require moisture and shade. Such a fauna could flourish in a scrub growth, and still exists on many cliffs in the West of Ireland, where trees are absent and, indeed, have never existed.

During the first stage the sand must have been covered to some extent by grass and other plants, and frosts have been absent. *Helix aspersa*, instead of burrowing to escape the cold of winter, hides in crevices; and since such do not exist in sand, it is clear that frosts which could reach them in their hiding-places under the tufts of grass were unknown. Of great importance is the fact noted by Mr. Stelfox that *H. nemoralis* diminishes in weight and size from the base of the deposit upwards. This shows that the conditions which were so favourable to this species gradually passed away, and that these heavy shells were not overwhelmed by a sudden sandstorm, as suggested. The layer is at least 2 ft. thick, showing clearly that blown sand was accumulating.

The second stage, represented by the grey, earthy layer, was probably a scrub growth with damp ground beneath. It was seemingly not a permanent marsh, for in that case *Succinea pfeifferi* and *Limnaea trunculata* might be expected to occur, and both are absent. The bed is a foot thick, showing that blown sand was still being accumulated, though possibly not so quickly as before.

Lastly, the scrub growth was destroyed and the existing sand-dune conditions established. It may be mentioned that the typical Xerophile *Cochlicella barbara* did not occur in the material sent us, although it is recorded from the deposit. Possibly this species does not belong to the second stage, but rather to the transitional phase between that and the present-day conditions.

The Rosapenna deposit is an important one. It is, as we have already noted, overlain by a kitchen midden, which has been claimed to be Neolithic, and may well belong to that culture stage; but it certainly predates the 9th century A.D., for objects of that date have been found on top of the midden. With this deposit we are able to see that the extinction of the woodland fauna was gradual. The shells obtained from the lowest exposed part of the deposits are all moisture-loving species. The internal granules of *Arion*, sp., and the internal shells of *Agriolimax laevis* are extremely abundant, whilst *Clausilia bidentata* is present in myriads, and the Vertigoes, with *Carychium minimum* and *Acicula lineata*, are common. All these forms need damp and shade, and such conditions must have existed at Rosapenna when these molluscs flourished there.

In the upper part of the bed the gradual change can be traced. The woodland forms become extremely rare, whilst, for the first time, a few samples of the Xerophiles, *Helicella itala* and *Cochlicella barbara*, are met with; at the present day the woodland forms are extinct, and a sand-dune fauna reigns. Thus at Rosapenna two stages can be recognised—a damp period and a succeeding dry period.

At Inishbofin three stages are clearly shown. The lowest bed of fine blown sand yielded no shells, but in the superimposed layer was a sand-dune fauna. Immediately succeeding is a typical woodland fauna, no Xerophiles being present. It is separated by a kitchen midden from a recent bed containing a typical sand dune fauna with a few derivative woodland shells. This deposit is therefore an exact parallel to that at Dogs' Bay. Firstly, sand-dune conditions; secondly, damper conditions; and lastly, sand-dune.

Ferriter's Cove, Smerwick, furnishes similar evidence. Here the bottom zone unfortunately yielded no shells, the middle blackish layer contained a woodland fauna, whilst the top layer yielded a sand-dune fauna. Here the deposits rest on boulder clay, so that there can be no question as to their age. Elsewhere, as at Bundoran and Pollan Bay, the zone yielding a woodland fauna rests on the well-known raised beach platform. Thus in many places round the Irish coast there is a well-defined zone in the sand hills which contains a well-marked fauna very different from that of the existing sand-dune. This zone is grey or blackish in colour, in marked contrast to the ordinary blown sand, this colour arising from the presence of decayed vegetable matter. The contained fauna shows that humid conditions prevailed during the deposition of this zone, the humidity being more pronounced in some localities than in others. On account of this humidity, blown sand did not accumulate so quickly as previously and subsequently.

Beneath this zone there is sometimes blown sand, which at

the typical locality, Dogs' Bay, yielded very large and heavy *Helix nemoralis*, clearly denoting more genial conditions, whilst in other localities this zone rests directly on the Holocene raised beach platform. Above the grey zone is always blown sand, usually containing a typical sand-dune fauna, often with an admixture of woodland shells derived from erosion of the grey zone. That the change from warm conditions to damp was gradual is clearly shown at Dogs' Bay, whilst a similar change from damp to sand-dune conditions is exhibited at Rosapenna. It may therefore be concluded that subsequent to the glacial period in Ireland there was a decidedly warm period. This gradually passed away, and humid conditions ensued, which also slowly ended, and conditions set in which have lasted without any marked change until the present time.

As to the age of the humid period, it is obviously immediately subsequent to the raised beach, and it may be reasonably supposed that the preceeding warm period was contemporaneous with the formation of the beach, a conclusion which is supported by the evidence derived from the deposit at Howth. These results may next be compared with those deduced from other data both in Ireland and elsewhere. R. L. Praeger states that the typical series of the post-glacial marine deposits in the north-east of Ireland is as follows in descending order:—

Raised Beaches	} Contemporaneous.
Upper Estuarine Clay	
Lower Estuarine Clay.	
Submerged Peat.	
Sands and Gravels.	
Boulder-clay	

He notes that:—

the fauna of the estuarine clays and raised beaches is seen to be of a distinctly southern aspect.

This is the period of maximum dominance of the southern shells. Their number is seen to diminish rapidly, while the northern element remains almost the same, so that at the present day the fauna has assumed a slightly northern aspect.*

Thus Mr. Praeger's conclusions as to the climatic conditions during the deposition of the raised beaches agrees with those we have postulated from the land mollusca. It is now generally held that in early Holocene times more genial conditions existed in the north of Europe than is now the case, and this period has been termed the "*Tapes*" period by Scandinavian geologists, because during this period the genus *Tapes* flourished in the northern seas (though it is now extinct there), with many other species of southern mollusca. In Denmark it has been shown that this period coincides with the end of the Fir period and beginning of the Oak, and is early Neolithic, being contemporary with the well-known Danish kitchen middens.

Dr. A. C. Johansen informs us that the *Tapes* period can be

* *Proc. Roy. Irish Acad.*, series III, vol. iv, pp. 47 and 49.

traced in Greenland, Iceland, and Spitzbergen.* Confirmatory evidence has also been noted in England.

The deposits at Newquay, Cornwall, described some years ago by one of us,† are apparently similar to the Irish deposits, but the full sequence is apparently not represented. Both here and at Harlyn Bay a woodland fauna has been extirpated and replaced by Xerophiles. Heavy shells of *Helix nemoralis* are not uncommon in the sections exposed in the sand dunes in South Cornwall, as noted by A. Bell, and he suggests‡ point to "different conditions to those now prevailing." There are a number of other deposits which indicate similar altered conditions. These include Copford, Chignal St. James, Felstead, and Shalford in Essex; Wheatley in Nottinghamshire, Cuxton and Allens Farm, Ightham in Kent; Wilstone in Hertfordshire, Blashenwell in Dorset, and Leckwith in Glamorgan. In all these deposits the mollusca are extremely abundant, some species are now locally extinct, whilst the general facies indicates much damper conditions. Hence these are probably contemporary with the grey zone at Dogs Bay.

Recent excavations at the Neolithic-flint mines (Grimes Graves) at Weeting, Norfolk, have furnished additional evidence. Here the infilling of the pits took place during a damp period, the contemporary fauna denoting humid conditions whilst the contemporary *Helix nemoralis* were normal. But there were many derivative examples of this species present, and these were much larger and often heavy, so that as at Dogs Bay it is clear that a warm period was succeeded by a damp period. (Report on excavations at Grimes Graves, 1915, pp. 220-231).

An important contribution to our knowledge of the climatic conditions of Holocene times is a series of papers by Professor F. J. Lewis.§ These papers embody the results of much patient labour, amongst the peat mosses of Scotland undertaken to ascertain what climatic changes could be shown to have occurred since Glacial times. The researches were carried on over a very large area and though there was slight local variation yet the practical uniformity of results is noteworthy.

The sequence in descending order in the peat masses is as follows:—

- | | |
|-------------------------------|-------------------------|
| 1. <i>Sphagnum</i> (humid). | 6. Lower Forest growth. |
| 2. Upper Forest growth. | 7. Subarctic plants. |
| 3. <i>Sphagnum</i> (humid). | 8. Arctic plants. |
| 4. Subarctic plants (colder). | 9. Moraine (glacial). |
| 5. <i>Sphagnum</i> (humid). | |

* Cf. also, W. C. Brogger: "Om de senglaciale og postglaciale nivaforandringer i Kristianafelt," *Norges Geol. Under.* No. 31, 1900-1, pp. 645-50; and V. Nordmann, "Dostinia i gene ved Kattegat," *Medd. Dansk Geol. Foren.*, 1904, pp. 33-40.

† B. B. Woodward, *Geol. Mag.*, 1908, pp. 10-18 and 80-87.

‡ *Yorkshire Phil. Soc. Report* for 1892, p. 72.

§ *Trans. Roy. Soc., Edinburgh*, vol. xli, 1905, p. 699; vol. xlv, 1906, p. 335; vol. xlvii, 1907, p. 33; and vol. xlviii, 1911, p. 793.

Professor Lewis states :—

The fossils collected from the lower forest show that the conditions at that time were, as far as temperature is concerned, not markedly different from those of the present day. The Shetland areas, however, show that the forest passed far beyond the present tree limit and indicate that entirely different meteorological conditions obtained there at that time.*

We have only one criticism to make which is that "different meteorological conditions" must have had a marked effect on the temperature.

On correlating the Irish deposits with those of the Scotch peat mosses it is evident that the warm period is the equivalent of the "lower forest growth," and that the succeeding "damp" period is matched by the *Sphagnum* growth above the forest.

If these conclusions are correct many important deductions can be made. Thus it follows that the flint implements of "Raised-beach age" are a little earlier than those of Grimes Graves and to speak of them as Palæolithic is misleading, and those implements from the sandhills resting on a raised beach platform cannot be called early Neolithic. Since, however, these matters are outside the province of this paper there is no need to pursue them.

Mr. Welch is of opinion that great changes have taken place in the sandhills during the last two hundred years. Previously they were probably covered with grass, but the destruction of the larger Carnivora, especially foxes, has enabled the rabbits to increase greatly in numbers. These latter by burrowing have destroyed the natural protective covering of the dunes, thus allowing the wind to have full play. There is certainly much to be said in favour of this view.

G. CHARA MARLS.

(1) *Maghaberry, Co. Antrim.*

Described in 1911 by Prof. Swain† who cited three species :—

Limnæa pereger.
Planorbis levis.

Pisidium pusillum.

More recently this deposit has been investigated by A. W. Stelfox. Section ascertained by boring—

1. Red clay or soil, 1½ ft. to 2½ ft.
2. Marl, 1 in. to 7 in.
3. Stiff blue clay, 6 in. to 9 in.
4. Red sandy clay of unknown depth, perhaps top of

* *Loc. cit.*, xlvii, 1911, p. 826.

† *Irish Nat.*, vol. xx, 1911, pp. 96 and 136.

"Malone sands." These are of glacial age and are re-deposited Trias. The species determined were :—

Agriolimax lævis, 1 example.
Limnæa pereger, common.
Limnæa stagnalis, 1 apical fragment.
Limnæa palustris, fragments.
Planorbis lævis, abundant.
Planorbis crista, very rare.
Pisidium milium, 1 valve.
Pisidium nitidum, common.
Pisidium obtusale, common.

The previous record of *P. pusillum* is open to grave doubt.

(2) *Ballyallia Lake, Co. Clare.*

Obtained from the bank of the river Fergus above Ballyallia Lake and close to Drumcliffe Crannoge. The section showed $3\frac{1}{2}$ inches of marl resting on blue clay. A sample of the latter yielded—

Limnæa pereger. *Valvata cristata*.
Valvata piscinalis.

The marl yielded seven species :—

Planorbis lævis, 6 examples. *Valvata piscinalis*, common.
Planorbis crista, 8 examples. *Valvata cristata*, 2 examples.
Planorbis vortex, 1 example. *Pisidium nitidum*, 2 valves.
Bithynia tentaculata, common.

Ballyallia Lake was lowered by drainage about 60 years ago and thus a quantity of marl, previously forming the lake bottom, was exposed. Samples were collected by R. J. Ussher, and sent by R. Welch, contained :—

Limnæa pereger, common. *Valvata piscinalis*, common.
Planorbis crista, common. *Valvata cristata*, common.
Bithynia tentaculata, common. *Pisidium nitidum*, 4 valves.

Some examples of *Planorbis crista* were deformed, a small portion of the last whorl being free.

(3) *Inchiquin Lake, Co. Clare.*

Collected at Inchiquin Lake, N.W. of Corofin, by Major R. G. Macnamara and sent by R. Welch. A chara marl, friable and soft, shells and ostracods fairly common.

Nineteen species were determined :—

Polita radiatula, 1 example. *Vallonia excentrica*, 1 example.
Zonitoides nitidus, 4 examples. *Cochlicopa lubrica*, 1 example.
Carychium minimum, 1 example.

<i>Ancylus fluviatilis</i> , 3 ex.	<i>Valvata piscinalis</i> , com.
<i>Limnæa pereger</i> , com.	<i>Valvata cristata</i> , com.
<i>Limnæa palustris</i> , 1 ex.	<i>Pisidium casertanum</i> , com.
<i>Limnæa truncatula</i> , 2 ex.	<i>Pisidium pusillum</i> , com.
<i>Planorbis contortus</i> , com.	<i>Pisidium milium</i> , com.
<i>Planorbis crista</i> , 5 ex.	<i>Pisidium subtruncatum</i> , 2 valves.
<i>Bithynia tentaculata</i> , 4 ex.	<i>Pisidium liljeborgii</i> , 2 valves.

More recently R. A. Phillips collected and forwarded another sample, and this yielded eleven species :—

<i>Limnæa pereger</i> , common.	<i>Valvata piscinalis</i> , common.
<i>Planorbis crista</i> , common.	<i>Valvata cristata</i> , common.
<i>Planorbis lævis</i> , 3 examples.	<i>Pisidium pusillum</i> , common.
<i>Planorbis contortus</i> , 6 examples.	<i>Pisidium milium</i> , 1 valve.
<i>Planorbis fontanus</i> , 1 example.	<i>Pisidium nitidum</i> , 6 valves.
<i>Bithynia tentaculata</i> , common.	

There is a marked contrast between these lists, which thus emphasizes the importance of collecting several samples of a marl in order to obtain a correct knowledge of its contents.

(4) *Lough Cahirkine, Co. Clare.*

Collected by Dr. G. Fogerty, forwarded by R. A. Phillips. A small stream flows into this lake from the north, and in deepening the stream the marl had been thrown upon the bank. The locality appears to have been the bed of a more extensive lake altered by drainage in modern times. Eleven species were identified :—

<i>Limnæa stagnalis</i> , com.	<i>Valvata piscinalis</i> , com.
<i>Limnæa pereger</i> , com.	<i>Valvata cristata</i> , com.
<i>Amphipeplea glutinosa</i> , com.	<i>Sphærium corneum</i> , com.
<i>Planorbis fontanus</i> , 3 ex.	<i>Pisidium milium</i> , com.
<i>Physa fontinalis</i> , com.	<i>Pisidium pusillum</i> , com.
<i>Bithynia tentaculata</i> , com.	

Of these the most important is *Amphipeplea glutinosa*, a form which is extremely rare as a fossil, and is not common living in Ireland.

(5) *Lough Corofin, Co. Clare.*

Collected by Major R. G. Macnamara, forwarded by W. J. D. Walker. This marl yielded six species :—

<i>Limnæa pereger</i> , com.	<i>Valvata piscinalis</i> , com.
<i>Limnæa palustris</i> , 2 ex.	<i>Valvata cristata</i> , 3 ex.
<i>Bithynia tentaculata</i> , 6 ex.	<i>Pisidium nitidum</i> ?, 3 valves.

(6) *Kells, Co. Clare.*

Obtained from the shore of the small lake near Lough Monana by W. J. D. Walker, and forwarded by R. Welch. It occurred under $1\frac{1}{2}$ ft. of peat.

Mollusca were numerous, nine species being present, viz. :—

<i>Polita radiatula</i> , 1 example.	<i>Pisidium casertanum</i> , common.
<i>Limnæa pereger</i> , common.	<i>Pisidium pusillum</i> , 1 valve.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium milium</i> , 2 valves.
<i>Valvata piscinalis</i> , 7 examples.	<i>Pisidium subtruncatum</i> , 1 valve.
<i>Valvata cristata</i> , 6 examples.	

The examples of *Bithynia tentaculata* were all immature.

(7) *Monana Lough, Co. Clare.*

Obtained from the east shore of this lake by W. J. D. Walker, and forwarded by R. Welch. Molluscan remains abundant.

Seven species were identified :—

<i>Limnæa pereger</i> , common.	<i>Sphærium corneum</i> , 1 valve.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium pusillum</i> , common.
<i>Valvata piscinalis</i> , common.	<i>Pisidium milium</i> , common.
<i>Valvata cristata</i> , common.	

(8) *Rinroe, near Corofin, Co. Clare.*

Obtained from the base of a "cut away" bog in the townland of Rinroe, $3\frac{1}{2}$ miles north-east of Corofin, by W. J. D. Walker, and sent by R. Welch.

Four species were determined :—

<i>Limnæa pereger</i> , common.	<i>Valvata piscinalis</i> , common.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium pusillum</i> , common.

The examples of *Bithynia tentaculata* were immature.

(9) *Ballyfinder, Co. Down.*

Described by R. Welch in 1902.* Ballyfinder or Ballyfinderagh is 3 miles north of Portaferry. The sample collected by R. A. Russell, and forwarded by R. Welch, contained twelve species :—

<i>Limnæa pereger</i> , 6 ex.	<i>Sphærium corneum</i> , 3 valves.
<i>Planorbis crista</i> , 2 ex.	<i>Pisidium pusillum</i> , 2 valves.
<i>Bithynia tentaculata</i> , 4 ex.	<i>Pisidium milium</i> , 4 valves.
<i>Valvata piscinalis</i> , com.	<i>Pisidium subtruncatum</i> , 2 valves.
<i>Valvata cristata</i> , com.	<i>Pisidium pulchellum</i> , 2 valves.
<i>Acicula lineata</i> , 1 ex.	<i>Pisidium obtusale</i> , 3 valves.

Remains of the Great Irish deer have been found in this marl.

* *Irish Nat.*, vol. xi, p. 46.

(10) Killough, Co. Down.

A. W. Stelfox has investigated the marl at the White Bog, the expenses being defrayed by a grant from the Belfast Natural History and Philosophical Society, and he has kindly furnished us with the following particulars. The marl occurs beneath peat and rests on estuarine sands.

Twenty-five species were determined :—

<i>Cochlicopa lubrica</i> , 1 ex.	<i>Bithynia tentaculata</i> , upper marl.
<i>Vertigo pygmæa</i> , 1 ex.	
<i>Succinea pfeifferi</i> , 1 ex.	<i>Sphærium corneum</i> , upper marl.
<i>Succinea oblonga</i> , 1 example (in marl pocket in peat).	<i>Pisidium casertanum</i> , throughout.
<i>Ancylus fluviatilis</i> , 1 ex.	<i>Pisidium nitidum</i> , throughout.
<i>Limnæa auricularia</i> , 1 ex.	<i>Pisidium hibernicum</i> , throughout.
<i>Limnæa pereger</i> , common throughout.	<i>Pisidium pusillum</i> , throughout.
<i>Limnæa truncatula</i> , a few.	<i>Pisidium milium</i> , throughout.
<i>Planorbis carinatus</i> , top of peat only.	<i>Pisidium subtruncatum</i> , throughout.
<i>Planorbis albus</i> , in peat only.	
<i>Planorbis lævis</i> , abundant in "base marl."	<i>Pisidium, liljeborgii</i> , throughout.
<i>Planorbis crista</i> , throughout.	<i>Pisidium obtusale</i> , mainly in base marl where a minute and globular form is present.
<i>Planorbis contortus</i> , in peat only.	
<i>Valvata piscinalis</i> , upper marl.	
<i>Valvata cristata</i> , throughout.	

Mr. Stelfox notes that *Planorbis lævis* is common in the base marl and rare above. This is the first Irish marl to be properly investigated, and when the full details are published it will mark a considerable advance in our knowledge.

(11) Tyrella, Co. Down.

This locality is situate east of the inner Bay of Dundrum, and the sample was collected by W. Gray, and forwarded by R. Welch. Three species were detected :—

<i>Limnæa pereger</i> , com.	<i>Pisidium nitidum</i> , 1 valve.
<i>Valvata piscinalis</i> , 1 ex.	

(12) Dunsoughly, Co. Dublin.

Obtained west of Dunsoughly Castle, about six miles north-west of Dublin by H. J. Seymour, and forwarded by R. Welch. The marl was over 6 ft. thick and was overlain by 2 ft. of peat. Six species were determined :—

<i>Limnæa pereger</i> , com.	<i>Pisidium pusillum</i> , 5 valves.
<i>Valvata piscinalis</i> , 4 ex.	<i>Pisidium milium</i> , 1 valve.
<i>Valvata cristata</i> , com.	<i>Pisidium obtusale</i> , 5 valves.

(13) *Castlecoole near Enniskillen, Co. Fermanagh.*

Castlecoole is one mile south-east of Enniskillen, and a flaky, peaty marl is exposed in a "cut-away" bog, formerly covered by 12 to 16 ft. of peat. The sample was obtained by T. Plunkett, and sent by R. Welch. Six species were determined:—

<i>Limnæa pereger</i> , 3 examples.	<i>Sphærium coneum</i> , 1 valve.
<i>Planorbis cristata</i> , common.	<i>Pisidium milium</i> , 3 valves.
<i>Planorbis vortex</i> , 1 example.	<i>Pisidium obtusale</i> , 1 valve.

(14) *Cross, near Enniskillen, Co. Fermanagh.*

Situate about two miles east of Enniskillen. Collected by T. Plunkett, and sent by R. Welch. About 6 ft. of marl is exposed in what is now a meadow, but it was formerly covered by 12 to 20 ft. of peat.

Only one species, *Limnæa pereger*, was present, but all the examples were crushed.

(15) *Kilnamadoo, Co. Fermanagh.*

Obtained from under 20 ft. of peat at Kilnamadoo (=wood of the dog) bog near Enniskillen, by T. Plunkett, and sent by R. Welch. Ten species were determined:—

<i>Limnæa pereger</i> , com.	<i>Sphærium corneum</i> , 6 valves.
<i>Limnæa truncatula</i> , 1 ex.	<i>Pisidium pusillum</i> , com.
<i>Planorbis lævis</i> , 1 ex.	<i>Pisidium milium</i> , com.
<i>Planorbis cristata</i> , com.	<i>Pisidium subtruncatum</i> , 2 valves.
<i>Valvata piscinalis</i> , 5 ex.	<i>Pisidium obtusale</i> , com.

(16) *Magheragera, Co. Fermanagh.*

Obtained by T. Plunkett, forwarded by R. Welch. The marl is covered by 16 ft. of peat, and is very free from peaty matter. It contains many shells, these being often in "pockets," whilst many of the bivalves had their valves united. Ten species were identified:—

<i>Limnæa pereger</i> , common.	<i>Pisidium casertanum</i> , common.
<i>Planorbis lævis</i> , 1 example.	<i>Pisidium nitidum</i> , common.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium pusillum</i> , common.
<i>Valvata piscinalis</i> , common.	<i>Pisidium milium</i> , common.
<i>Sphærium corneum</i> , 4 valves.	<i>Pisidium obtusale</i> , 3 valves.

(17) *Clonbrock, North-East Galway.*

Described by R. Welch in 1902.* From this and from material sent we can list eleven species :—

<i>Succinea putris.</i>	<i>Valvata piscinalis.</i>
<i>Succinea pfeifferi.</i>	<i>Valvata cristata.</i>
<i>Limnæa stagnalis.</i>	<i>Sphærium corneum.</i>
<i>Limnæa palustris.</i>	<i>Pisidium pusillum.</i>
<i>Physa fontinalis.</i>	<i>Pisidium nitidum.</i>
<i>Bithynia tentaculata.</i>	

(18) *Menlough, North-east Galway.*

This marl is overlain by about 2 ft. of peaty soil, and was exposed by the deepening of a small stream, about 8 ft. of marl being shown. The locality is close to the river Corrib between Menlough and Galway.

Fifteen species were determined :—

<i>Polita radiatula</i> , 1 ex.	<i>Sphærium corneum</i> , com.
<i>Cochlicopa lubrica</i> , 1 ex.	<i>Pisidium casertanum</i> , 5 valves.
<i>Limnæa pereger</i> , com.	<i>Pisidium nitidum</i> , 8 valves.
<i>Limnæa palustris</i> , 2 ex.	<i>Pisidium personatum</i> , 2 valves.
<i>Planorbis umbilicatus</i> , 2 ex.	<i>Pisidium pusillum</i> , com.
<i>Bithynia tentaculata</i> , com.	<i>Pisidium milium</i> , com.
<i>Valvata piscinalis</i> , com.	<i>Pisidium subtruncatum</i> , 1 valve.
<i>Valvata cristata</i> , com.	

(19) *Portumna, South-East Galway.*

Dredged from a depth of about 9 ft. for the foundations of a new bridge and sent by R. A. Phillips. He notes: The marl bed occurs for some miles along the Shannon and, where I have seen it exposed, it is covered by a peaty soil from 1 to 3 ft. in thickness, some of these places may be "cutaway bog."

Twenty-one species were recognised :—

<i>Limnæa auricularia</i> , 1 ex.	<i>Planorbis umbilicatus</i> , 1 ex.
<i>Limnæa pereger</i> , com.	<i>Planorbis vortex</i> , 1 ex.
<i>Limnæa palustris</i> , 4 ex.	<i>Bithynia tentaculata</i> , com.
<i>Limnæa truncatula</i> , 2 ex.	<i>Valvata piscinalis</i> , com.
<i>Limnæa stagnalis</i> , 3 ex.	<i>Valvata cristata</i> , com.
<i>Amphipeplea glutinosa</i> , 8 ex.	<i>Sphærium corneum</i> , 4 valves.
<i>Planorbis carinatus</i> , 10 ex.	<i>Pisidium amnicum</i> , 4 valves.
<i>Planorbis crista</i> , com.	<i>Pisidium pusillum</i> , com.
<i>Planorbis contortus</i> , com.	<i>Pisidium milium</i> , com.
<i>Planorbis levis</i> , 10 ex.	<i>Pisidium obtusale</i> , com.
<i>Planorbis fontanus</i> , 3 ex.	

These species have been recorded by R. A. Phillips.†

* *Irish Nat.*, vol. xi, p. 46.

† *Irish Nat.*, vol. xxiv, 1915, p. 139.

The examples of *Limnæa pereger* are of extreme interest since they belong to the var. *lacustris*, which form, so far as is known, does not now live in the Shannon. The single example of *L. auricularia* is referable to the var. *acuta*.

(20) *Ballybetagh, Co. Kildare.*

Sample given to R. Welch by Mr. Lyburn of the Department of Agriculture. Clearly a chara marl, and it may well have been obtained from the deposit which has yielded so many remains of the great Irish deer* but no details were forthcoming. Eight species were identified :—

<i>Limnæa pereger</i> , common.	<i>Pisidium casertanum</i> , 1 valve.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium nitidum</i> , common.
<i>Valvata piscinalis</i> , common.	<i>Pisidium milium</i> , 1 valve.
<i>Valvata cristata</i> , 1 example.	<i>Pisidium liljeborgii</i> , 1 valve.

(21) *Birr, King's Co.*

Situate in the townland of Castlelon and Dromoyle, Kilcolman parish, Ballybutt Barony. Two layers of marl are exposed in the section, one 6 in. thick near the surface of the bog, whilst 6 to 8 ft. below is another layer 2 ft. thick. Sample of the lower bed, collected by W. K. Fayle, and sent by R. Welch, yielded eight species :—

<i>Euconulus fulvus</i> , 1 example.	<i>Planorbis crista</i> , common.
<i>Vallonia excentrica</i> , 1 example.	<i>Physa fontinalis</i> , 1 example.
<i>Cochlicopa lubrica</i> , 1 example.	<i>Valvata cristata</i> , 9 examples.
<i>Limnæa pereger</i> , 7 examples.	<i>Pisidium pusillum</i> , 2 valves.

Nearly all the examples are immature. The presence of two distinct layers is unusual.

(22) *Eglish, near Birr, King's Co.*

Situated in the townland of Galross, parish of Eglish, north of Birr. The deposit is extensive, the bog area being about 5,000 acres, part of which overlies the marl. The thickness of the marl is unknown. Sample collected by W. K. Fayle, and sent by R. Welch. Seven species were found :—

<i>Limnæa pereger</i> , com.	<i>Pisidium pusillum</i> , 3 valves.
<i>Bithynia tentaculata</i> , 3 ex.	<i>Pisidium milium</i> , 8 valves.
<i>Valvata piscinalis</i> , 1 ex.	<i>Pisidium obtusale</i> , 6 valves.
<i>Valvata cristata</i> , 3 ex.	

(23) *Kilcolman, King's Co.*

Obtained from a "cutaway bog" in this parish, south-east of Birr, by W. K. Fayle, and sent by R. Welch. The deposit is

* *Vide Geol. Mag.*, vol. viii, p. 358.

18 in. thick and about 30 acres in extent, being formerly covered by 7 ft. of peat. Species identified were :—

Limnæa pereger. *Pisidium* sp.
Valvata piscinalis.

(24) *Lusmagh, King's Co.*

Obtained by W. K. Fayle at Stream (Inches), parish of Lusmagh, Barony of Garrycastle and sent by R. Welch.

Nine species were identified :—

Limnæa pereger, com. *Valvata cristata*, com.
Planorbis crista, 2 ex. *Pisidium nitidum*, com.
Planorbis fontanus, 1 ex. *Pisidium milium*, com.
Bithynia tentaculata, 4 ex. *Pisidium obtusale*, com.
Valvata piscinalis, 8 ex.

(25) *Bliach Lough, Co. Limerick.*

Obtained by A. McHenry at Bliach Lough, north of Kildimo (five miles north of Adare), and sent by R. Welch. The marl is from 1 to 4 ft. thick and is overlain by 2 ft. of peat. Five species were identified :—

Limnæa stagnalis, 1 ex. *Valvata piscinalis*, 9 ex.
Limnæa pereger, com. *Pisidium nitidum*, 6 valves.
Bithynia tentaculata, com.

The examples of *Bithynia tentaculata* are large, 11·5 mm. in altitude, whilst the specimen of *Limnæa stagnalis* attains 35 mm. The examples of *L. pereger* are also decidedly larger than the usual marl shells.

(26) *Rathurd, Co. Limerick.*

This deposit is situate $2\frac{1}{2}$ miles south-east of Limerick. Collected by H. J. Seymour and sent by R. Welch. The marl varies from 6 in. to 4 ft. in thickness and is overlain by a foot of peaty soil. There are many square miles of marl under peat near Limerick clearly proving the former existence of more lacustrine conditions. Species identified :—

Limnæa pereger, common. *Pisidium nitidum*, 1 valve.

(27) *Lakelands Lake, Manulla, East Mayo.*

Described by A. W. Stelfox in 1912.* The marl is exposed 200 yds. west (Castlebar side) of Manulla Station. Sample collected by Macartney Filgate and sent by R. Welch. From these two sources we can list twelve species, viz. :—

* *Proc. Roy. Irish Acad.*, vol. xxxi, pp. 52, 53.

<i>Cochlicopa lubrica</i> .	<i>Bithynia tentaculata</i> , common.
<i>Limnæa pereger</i> , common.	<i>Valvata piscinalis</i> , common.
<i>Limnæa truncatula</i> , 1 example.	<i>Valvata cristata</i> , common.
<i>Limnæa palustris</i> .	<i>Pisidium pusillum</i> , 10 valves.
<i>Limnæa stagnalis</i> .	<i>Pisidium milium</i> , 3 valves.
<i>Planorbis crista</i> , 3 examples.	<i>Pisidium obtusale</i> , 4 valves.

Mr. Stelfox notes that the marl is in places 9 ft. thick, and is sometimes covered by 2 ft. of peat.

(28) *Lough Carra, East Mayo.*

About 1847 the level of Lough Carra near Lough Mask was lowered by drainage about 7 ft., and a large area of land was thus reclaimed. On this area are large deposits of marl often from 6 to 10 ft. thick. Sample obtained near Partry, two miles north-west of Ballinrobe, by W. J. D. Walker, and sent by R. Welch. Five species were determined:—

<i>Limnæa pereger</i> , common.	<i>Valvata cristata</i> , 2 examples.
<i>Bithynia tentaculata</i> , common.	<i>Pisidium pusillum</i> , 2 valves.
<i>Valvata piscinalis</i> , common.	

(29) *Lough Mentrim, Co. Meath.*

From Dr. Scharff we received a sample of marl obtained at a depth of 6 ft. at this locality. Twenty-one species were identified, viz:—

<i>Pyramidula rotundata</i> , 1 ex.	<i>Planorbis contortus</i> , com.
<i>Lauria cylindracea</i> , 1 ex.	<i>Planorbis fontanus</i> , com.
<i>Succinea pfeifferi</i> , 3 ex.	<i>Bithynia tentaculata</i> , com.
<i>Acroloxus lacustris</i> , com.	<i>Valvata piscinalis</i> , com.
<i>Limnæa pereger</i> , com.	<i>Valvata cristata</i> , com.
<i>Limnæa stagnalis</i> , 6 ex.	<i>Sphærium corneum</i> , com.
<i>Limnæa palustris</i> , com.	<i>Pisidium pusillum</i> , com.
<i>Planorbis albus</i> , 9 ex.	<i>Pisidium pulchellum</i> , com.
<i>Planorbis umbilicatus</i> , 2 ex.	<i>Pisidium subtruncatum</i> , com.
<i>Planorbis carinatus</i> , 6 ex.	<i>Pisidium obtusale</i> , com.
<i>Planorbis crista</i> , com.	

Specimens of *Anodonta cygnæa* from this marl are in the Dublin Museum. This is by far the richest marl we have seen, and many of the shells are well developed, which probably arises from the fact that it was not a pure chara marl but contained a large amount of peaty matter.

(30) *Cappagh, Co. Waterford.*

Dredged from the lake at Cappagh House by R. J. Ussher and sent by R. Welch. The lake was mainly formed more than

thirty years ago by digging, and then dredging out peat for fuel. The sample came from the upper layer just under the peat and contained few shells, but Mr. Ussher informed us that at a further depth of 6 ft. a pure white marl with many shells is present. Six species were determined :—

<i>Limnæa pereger</i> , common.	<i>Valvata cristata</i> , 6 examples.
<i>Planorbis lævis</i> , 6 examples.	<i>Pisidium casertanum</i> , 7 valves.
<i>Valvata piscinalis</i> , common.	<i>Pisidium milium</i> , 1 valve.

Planorbis lævis still lives in the lake.

We have examined or enumerated mollusca from thirty marl deposits, but there still remains a very large number to be examined. These marls are often termed shell marls, a misleading term since it is chara debris which forms by far the larger part of the matrix. The Characeæ are not the only plants which produce calcareous deposits, for it has been shown that though they are the most important factor yet they are aided by *Myriophyllum*, *Ceratophyllum*, *Potamogeton*, *Nymphæa* and *Nitella*, all of which precipitate lime, and it is recorded as an example of the large amount of lime which a plant can carry that a dried leaf of *Potamogeton lucens*, weight '35 grammes, carried no less than 4'1 grammes of lime, while a specimen of the bottom deposit forming in Furesø, Denmark, from a bed of *P. lucens* and *Elodea* yielded 72'41 per cent. of lime.* Since all the marls we have seen from Ireland are chara marls there is no necessity to enlarge on this aspect of the subject.

With regard to the conditions under which chara marls are formed there is great divergence of opinion. Wesenberg-Lund has investigated the chara marl found beneath the mud and peat forming the bottom of Hingesø in Jutland.

This lake is 4—5 metres in depth, and the marl "is dug out of the lake by machinery and made use of for agricultural purposes." He concludes that "The origin of the characee-lime must be traced to an earlier period in the history of the lake, when the depth was considerably greater and the water colder. The characee-growths of those days have now disappeared and been supplanted by a vegetation consisting of other plants such as *Potamogeton*, *Myriophyllum* a.o., now producing the mud deposits overlying the lime. At the present day several of our lakes are at the stage at which deposits of characee-lime are still in the course of formation. This will especially occur in the larger bays of lakes when the depth is from 3—5 m." "The formation of characee-lime will take place at a somewhat late period in the history of the lake, viz., when the maximal depth does not exceed 10 m., and the lake bottom is a comparatively level plain over which the characee-growths can spread" (*Loc. cit.*, pp. 155-6).

* C. Wesenberg-Lund, "Studier over Sokalk Bonnemalm og Sogytgie i Danske Indsøer," *Medd. Dansk. Geol. Foren.*, No. 7, 1901.

M. A. Magnin states that the *Chara* zone in the Jura Lakes is from 26 to 52 ft,* whilst in Lake St. Clair, Michigan, U.S.A., A. J. Pieters has noted the *Chara* zone as beginning at 23 ft. and extending to the deepest part of the lake.†

Dr. A. C. Johansen, for Denmark, gives 13 to 26 ft. for the *Chara* zone.‡ S. B. J. Skertchley on the other hand, after an examination of the extensive chara marls in the Fenland of England concluded that the marl had accumulated in wide spread shallow meres in which the peat could not accumulate, and he suggested that the summers were warmer and that the meres dried up during the hot weather.§ It is interesting to note that A. W. Stelfox has arrived at similar conclusions from Irish data, independently of the previous work. Dr. R. Munro has published similar views. He considers that the chara marls are of the same age as the older forest growths, and that they indicate a well-marked phase in the climatic changes since Glacial times.||

There are thus two widely divergent theories respecting the origin of chara marl, one postulating a deep water origin, and the other a shallow water during a former warmer period.

It is thus necessary to examine all the ascertained facts. J. W. Groves informs us that "in this country (including Ireland) Charas do not occur at any great depth. The deepest water I know any of them from is Brittas Lough, Westmeath, where Lévigne discovered *Chara denudata* at about 12 ft."

Chara marl is forming to-day at Lough Carra, Co. Mayo, in very shallow water under similar circumstances to those postulated by Skertchley. R. Welch informs us that chara marl is still forming in the Shannon near Castleconnell. "Whenever the river sinks below the level of the tops of *Chara hispida* as it does in exceptionally dry weather, the plants die, bleach a pure white, become excessively brittle and break off with the first rush of water as the river rises." Mr. Welch adds that though he has dredged a good deal in the northern half of Lough Neagh he has failed to trace any chara deposits. Thus all the evidence derived from present conditions is in agreement with Skertchley's views. Similar support is also furnished from the marl deposits. Lenticular patches of chara marl are not uncommon in the Holocene deposits of the Lea Valley, and these are certainly of shallow water origin as also the marl at Newbury, and a deep water origin for the Fenland marls is an impossible solution. In the North of England marl deposits are abundant, but although numerous records of their existence have been made only one

* *Rev. Gen. Bot.*, 1893, p. 241.

† "The plants of Lake St. Clair," *Bull. Michigan Fish Commission*, No. 2, 1894; cf. also, C. A. Davies, "The flora of Michigan lakes," *Rep. Michigan Acad. Science*, No. 1, 1900, pp. 24-34.

‡ *Vidensk Medd. Nat. Foren. Kobenhavn*, 1901, p. 10.

§ "Fenland Past and Present," p. 572.

|| "Prehistoric Scotland," 1899, pp. 25-6.

has been investigated, the well-known deposit at Silverdale, Lancashire.*

This deposit is seemingly without a parallel in these islands, although a similar case exists in Littlefield Lake, Isabella Co., Michigan, U.S.A.† At Silverdale there is no evidence of a deep lake, neither is there at Hale Moss and Burton Moss. The Pleistocene marl at Hitchin‡ also is a shallow water deposit.

In Scotland chara marls, identical with the Irish ones, appear common but with the exception of those in the neighbourhood of Edinburgh, described by J. Bennie and T. Scott,§ practically no attempt at their investigation has been made since the early days of Sir Charles Lyell.|| All the published evidence, however, supports the shallow water theory. A. W. Stelfox assures us that in Ireland in all the marl deposits he has seen the contour of the country is quite opposed to the deep-water theory.

From the above facts it is clear that at some previous period the conditions were favourable for the accumulation of chara marl in the British Isles, and that subsequently the conditions changed, and an accumulation of peat took place. At the present day wherever chara marl is forming it is of shallow water origin, and the evidence clearly shows that this was true in the past. In our opinion at one time there were numerous shallow meres in many parts of these islands. The summers were warmer than at present, and these meres at times became dry, the chara would die, and thus in time a chara marl would form. As an additional proof of this view we would note that the general facies of the mollusca denotes abnormal conditions, and these shells are often in pockets. One can easily understand that when a mere was drying up the mollusca would accumulate in the remaining puddles just as they do in hot summers in the ditches in marshes. The marl deposits in Hingesø Jutland probably accumulated under similar circumstances instead of being a deeper water deposit as suggested by Wesenberg-Lund. As to the age of this marl period, we would suggest that it coincides with the older forest growth and is thus early Holocene. The occurrence of two layers of marl at Birr, Kings Co., separated by peat would suggest that marl conditions also occurred at a later period, and it is possible that this later deposit represents the upper forest growth.

* J. D. Dean and J. W. Jackson, *Journ. of Conch.*, vol. xi, 1905, pp. 147-151; also J. W. Jackson, *Lanc. and Cheshire Nat.*, 1914, pp. 135-140 and 197-201.

† C. A. Davis, *Journ. Geol.*, vol. viii, 1900, pp. 498-503.

‡ *Proc. Geol. Assoc.*, vol. xiv, 1896, p. 416-417.

§ *Proc. Roy. Phys. Soc. Edinburgh*, vol. x, 1889, pp. 126-136.

|| *Trans. Geol. Soc. Lond.*, ser. ii, vol. ii, 1826, p. 79.

III.—NOTES ON SOME OF THE MOLLUSCAN GENERA AND SPECIES.

In the table appended to this paper (opp. p. 190) an attempt has been made to show the relation of the Irish non-marine mollusca to those of Great Britain and some other countries. In the first column is a list of all British and Irish species whether recent or post-Icenian (Norwich Crag). Under Cromerian we have enumerated the species from the upper freshwater bed at West Runton. This appears to be a well marked horizon, and the fauna is fairly well known. The remaining columns are self explanatory. No record from any Holocene deposit of Great Britain that can be shown to be of post-Roman age has been included in the table, and obvious introductions have also been omitted. It is no easy matter to ascertain the exact range of any species in time and space owing to lack of correct information and extensive mis-identification. Nor is it wise to accept all published records, in these matters due discrimination must be used. We have in the main relied on Jordan for the present distribution,* a work which is not sufficiently known in this country. Owing to the magnitude of the undertaking numerous errors were inevitable. Still, it is by far the best work on the subject. We are also greatly indebted to the thesis by our friend Dr. A. C. Johansen.† The recent distribution in Ireland is mainly the work of A. W. Stelfox. For the fossil records we have relied mainly on Sandberger's "Die Land-und Süsswasser Conchlyien der Vorwelt." Amongst other authors consulted with profit may be cited Dr. J. F. Babor, Dr. Andreæ, Dr. C. Boettger, Dr. O. Boettger, J. R. Bourguignat, Dr. Bollinger, Commt. E. Caziot, S. Clessin, Dr. L. Germain, D. Geyer, A. Locard, Dr. Kobelt, Dr. Steusloff, R. Tournouer, J. W. Taylor, Dr. Wittich, Dr. A. Weiss, Dr. C. A. Westerlund and Dr. Wüst.

Some of the British fossil records have been derived from a large amount of unpublished material in our possession.

The system of trinominal nomenclature so much in use in other branches and commonly employed in Malacology in America is at present impracticable, though it probably will come in the future. Such genera as *Polita*, *Hygromia*, *Helicella*, *Succinea* and *Limnæa*, would appear to be eminently suitable for its application.

LIMAX MAXIMUS, LINN.

The examples of the internal shell of this species from Narin, West Donegal, are extremely thick, attaining 3 mm. A similar thickening was also noted in the examples from the Pleistocene of

* "Die Binnenmollusken der nördl. gemäss. Länder v. Europa u. Asien," *Nova Acta K. Leop.-Carol. Akad.*, Bd. xlv, No. 4, 1883.

† "Om den Fossile Kvartære molluskauna i Danmark," Copenhagen, 1904.

Ightham. There is apparently some connection between the thickness of the shell and the geological formation on which the animal lives. On the London clay areas, where lime is almost absent, the shell is very thin, often only a mere membrane, whereas on the chalk districts it is often very thick, though still not quite so developed as these fossil ones. The Narin examples are from a calc-sand area, and the Ightham shells are from a limestone district. Age, too, probably plays an important part in the thickening, and the animals to whom these fossil shells belonged may well have attained extreme old age.

VITRINA, DRAP.

Until lately only one species, *V. pellucida* (Müll), was recognised as living in these islands, and the recent discovery of a second species has caused much discussion as to its specific identity. In 1904 examples of a shell identified as *V. pellucida*, var. *depressiuscula*, from Collon, Co. Louth, were exhibited on behalf of P. H. Gierson at the meeting of the Conchological Society on September 14th,* and this record was copied by J. W. Taylor† in 1906. In 1907 J. W. Taylor‡ recorded it as *V. elongata* Drap., with a full account of the anatomy, a description of the animal and shell, and notes on the distribution. In 1908 E. W. Bowell§ gave an account of the anatomy of this form which he referred to *V. pyrenaica* Fér. figures being given of the anatomy. In the same year it was described, and figured as a new species by J. W. Taylor, under the name of *V. hibernica*. This description appears on the covers of part 15 of the "Monograph," a curious method of describing a species which is extremely difficult to cite, and wrappers are usually destroyed by the binder. This last account throws light on Taylor's paper in the *Irish Naturalist*, since it is clear that when he referred the form to *V. elongata* it was on shell characters only, so that the whole of the anatomical details do not relate to the Irish mollusc at all.

Mr. Bowell contended in his paper that the identification of the Irish species as *V. elongata*, Drap., by Taylor was incorrect, and that it agreed in its anatomy with the well-known *V. pyrenaica*, Fér. Mr. Taylor now admits the first contention but states that *V. pyrenaica*, Fér., is an indeterminate or dubious species, and in support of this view adduces several arguments.

He states that the figures given by Férussac differ from the Irish shell, and that the species was never described by that author. It is true that there are slight differences in the figures, but for this the artist may be to blame. Early figures are not to be relied on for that absolute accuracy which is now demanded, though we cannot say is yet attained. Férussac did describe the

* *Journ. of Conch.*, vol. xi, 1904, p. 125.

† *Monograph*, vol. iii p. 9.

‡ *Irish Nat.*, vol. xvi, pp. 225-231.

§ *Irish Nat.*, vol. xvii, pp. 91-93, pl. 4.

species in his *Hist. Nat. Moll.*, vol. ii, 1851, "Pulmonés sans opercules," p. 196¹⁸. The method of publication of this work will account for Mr. Taylor's oversight, and it is curious that this description has apparently been overlooked by all writers.

Mr. Taylor also states:—

Moquin Tandon describes a *V. pyrenaica* in his work, and enumerates the places in which it is said to be found, but appears to have done so without personal knowledge, as they lack his usual mark of personal verification; and, further, his description does not apply to the animal inhabitant of the Irish shell, while his figure shows a much more globose and less degenerate shell than our *V. hibernica*.*

We would note that Moquin-Tandon gives a very full description with an admirable drawing of the living animal, and furnishes particulars how to keep the snails alive. If he had "no personal knowledge" from whom did he obtain these facts, for they had not hitherto been published. On comparing the French drawing of the animal with that given by Mr. Taylor, they are seen to be identical. Mr. Taylor expressly states "figure," although the French writer gives four (Pl. IV, figs. 10-13). Mr. Bowell informs us that the obvious distortion in the figures of the shell arises from imperfections in the optical apparatus in use at that time, and that he had himself noticed a similar error when using an uncorrected lens. If one refers to the figures given by Moquin-Tandon of the *Psidia* this distortion is very marked.

The use of "!" for personal verification is quite modern. It was originally introduced by botanists to denote a new locality, and the French author who was also a good botanist probably used it in this sense. Mr. Taylor cites no later author, and one might therefore conclude that nothing further had been published since Moquin-Tandon, *V. pyrenaica* is, however, well known to all the later writers. It is recognised by Westerlund, Bourguignat, Kobelt, Locard and Jordan.

In the latest publication on the mollusca of the Pyrenees by P. Fagot, it is noted as being common in both the French and the Spanish districts.† From these facts it is clear that *V. pyrenaica* is a well known species and has been properly described. No attempt has been made to show that the statement that the anatomy of the Irish animals agrees with those from the Pyrenees is inaccurate. Examples from the Pyrenees were sent by Mr. Bowell to Dr. Simroth, who agreed that they were the same species as the Irish examples, the only question being whether the latter were sufficiently distinct to be considered a variety. Under these circumstances one must adopt the specific name *pyrenaica*, Fér. Recently Dr. A. E. Boycott has criticised the explanation of the anatomy of this species as given by Mr. Bowell‡ who has readily admitted the errors, but this does not affect the correct specific name.

* "Monograph," vol. iii, p. 150.

† *Hist. M. lac. Pyrenées Fr. nc et Espagn.*, 1892, p. 33.

‡ *Irish Nat.*, vol. xxiii, 1914, pp. 205-211.

V. pyrenaica has hitherto only been known from the S.W. of France, the Pyrenees, Spain and Portugal, and by its occurrence in Ireland another Lusitanian species is added to the list. Some additional localities for this species besides the original one at Collon, Co. Louth, have been given by A. W. Stelfox.* The Vitrinæ are not a natural group, but represent a stage in the evolution from a shelled mollusk to a naked one, and when the anatomy of the various species is better known the genus will receive drastic treatment, and forms which are scarcely distinguishable if the shell be the test may be found to have no generic relationship.

ZONITIDÆ.

There is considerable divergence of opinion as to the number of indigenous species of this family, and also as to their classification, so the following list must only be considered as tentative :—

<i>Vitrea crystallina</i> (Müll.)	<i>Polita nitidula</i> (Drap.)
<i>Polita cellaria</i> (Müll.)	<i>Polita pura</i> (Ald.)
<i>Polita hibernica</i> (Ken.)	<i>Polita radiatula</i> (Ald.)
<i>Polita sydneyensis</i> (Cox.)	<i>Zonitoides nitidus</i> (Müll.)
<i>Polita draparnaudi</i> (Beck.)	<i>Zonitoides excavatus</i> (Ald.)
<i>Polita rogersi</i> (B. B. Woodw.)	<i>Eucomulus fulvus</i> (Müll.)
<i>Polita alliaria</i> (Müll.)	

In raising *Polita* to generic rank we have the support of Col. Godwin-Austen, G. K. Gude, and others. *P. scharffi* (Ken.)† is clearly identical with the prior *Helix sydneyensis*, Cox,‡ judging from co-types of that species sent by J. H. Ponsonby. It is also the *Zonites navarricus*, Bourg.,§ whilst there are several other named continental forms which may be identical judging from the descriptions.

Major M. Connolly has shown that the species generally known as *lucida*, Drap., should be called *draparnaudi* (Beck).|| The generic name *Crystallus* Lowe has been used for *V. crystallina* (Müll.) the date cited being 1833 (1830). The name does not occur in Lowe's first paper,¶ and Westerlund is correct in citing 1854** as the correct date, so that *Vitrea* (1833) has precedence.

P. Hesse†† has suggested on anatomical grounds that *Polita nitidula*, *P. pura* and *P. radiatula* should be ranged under *Zonitoides*, but we have not ventured to make this drastic

* *Irish Nat.*, vol. xviii, 1909, p. 204.

† *Proc. Malac. Soc. Lond.*, vol. viii, 1908, pp. 50-51.

‡ "Monog. Aust. Land Shells," 1868, p. 9, pl. ix, Fig. 16.

§ *Rev. et Mag. Zool.*, 1870, p. 20, pl. xvi, figs. 10-12.

|| *Ann. S. Afric. Mus.*, vol. xi, 1912, pp. 114-5.

¶ *Trans. Camb. Phil. Soc.*, vol. iv, 1831, p. 47.

** *Proc. Zool. Soc. Lond.*, 1854, p. 178.

†† *N. schrich, Deutsch. Malak. Gesell.*, Heft iii, 1914, pp. 127-139.

change. We are still of opinion that *Polita rogersi* is not a native of Ireland, a view supported by all competent Irish workers. There is a tendency in some forms of Zonitidæ for the rate of increase in the width of the whorls to take place more rapidly than in others (giving the impression of an enlargement of the last whorl), and thus to suggest an approach towards *Vitrina*. This is noticeable in *draparnaudi* as compared with *cellaria*, *hiulca* as compared with *nitidula*, *radiatula* and *petronella*, and in typical *crystallina* and its var. *contracta*, whilst in the subgenus *Retinella* it is strongly marked in *protensa* (Fér.). It would thus appear that the trend of evolution is from a shell with slowly increasing whorls to a *Vitrina*-like shell. One fact has apparently been overlooked in the *Polita cellaria* gens, namely, its subterranean habit. This gens is particularly common in all cavern deposits, and these shells are always very large, clearly indicating a congenial environment.

VITREA CRYSTALLINA (MULL.).

Speaking broadly there appears to be two forms of this species in the British Isles—a large one with an expanded body whorl, *V. crystallina* (Müll.), and a smaller form with a narrow body whorl, *V. contracta* (West). Unfortunately some continental authors, including Sandberger, follow O. Reinhardt,* and call the large form *V. subterranea* (Bourg.), and the smaller one *V. crystallina* (Mull), so that great care has to be exercised in examining continental records. It is possible that the differences between these forms may be due to environment, still the differences would appear to arise through the evolution of the species, and thus the small form may be considered as worthy of a name though only as a variety. In England the var. *contracta* is the older form, all the Pleistocene examples we have seen being referable to it. Typical *V. crystallina* is, however, not uncommon in the Holocene of England. Nearly all the Irish fossil examples are the var. *contracta*, as are also the larger number of the Irish recent shells.

POLITA NITIDULA (DRAP.).

J. W. Taylor states :—

Irish specimens would appear to almost constitute a geographical race, the bulk of the specimens being characterised by a noticeably paler, almost colourless shell.†

but an examination of the Irish examples in our collection does not support this view. Irish examples are smaller than English ones, but there is no difference in the colour. English specimens are sometimes 11 mm. in diameter, and according to O. Goldfuss‡

* O. Reinhardt, *Arch. und Naturg.*, Jahrg. (1874), Bd. i, pp. 189-191.

† *Monograph*, vol. iii, p. 73.

‡ "Binnenmollusken Mittel-Deutschlands," 1900, p. 84.

some German examples are as large. Mr. Taylor cites 8 mm. as the diameter of this species. These very large examples are quite unknown from English Pleistocene deposits, though they occur in the Holocene. The general facies of the Irish shells, both recent and fossil, agrees much closer with that of the English Pleistocene forms than with the English Holocene and recent shells.

ZONITOIDES, LEHMANN.

The two British species referred to this genus, *nitidus* (Müll.) and *excavatus* (Alder), live in Ireland, but only the former is known fossil. The latter species is apparently endemic to the British Isles for the continental records are doubtful. The genus *Zonitoides* was created to include those forms possessing a dart-sac and dart, but E. W. Bowell considers it open to question whether the possession of what may be only a secondary sexual character is of sufficient importance to justify generic separation. The statement by J. W. Taylor* that one of us "has recently included in the British list, and proposed to add to our native fauna" *Z. minusculus* (Binn) is not correct. It was specially marked as an "introduced species" which is its true status.

EUCONULUS FULVUS (MÜLL.).

Dr. W. H. Dall has recently used the specific name *trochiformis* (Mont.) for this species. He says:—

The name *fulva* (Müller), by which it is best known, was based according to Beck, who was custodian of Müller's types, upon *Helix bidentata* (Gmelin), while a shell which Müller supposed to be the young, but did not figure or fully describe, was supposed by some of the early naturalists to be our species.†

Dr. A. C. Johansen, of Copenhagen, where Müller's shells are still preserved, has however informed us that Müller's species included the form universally called *fulvus* as well as *Helix bidentata*, Gmelin. A certain amount of latitude must always be allowed to the fathers of the science. No confusion is likely to arise from the continued use of *fulvus*, and we fail to see any valid reason why Montagu's later name *trochiformis* should be substituted. The question has been previously raised by Westerlund,‡ who also adopted the name *fulvus*.

ENDODONTIDÆ.

Four of our living species have been referred to this family:—*Punctum pygmaeum* (Drap.), *Columella*[=*Sphyradium*] *edentula* (Drap.), *Pyramidula rupestris* (Drap.), and *P. rotundata* (Müll.).

* "Monograph," vol. iii, p. 150.

† "Land and Fresh Water Mollusca of Alaska," p. 41.

‡ *Acta. Soc. Fauna and Flora Fennica*, 1897, p. 17.

Punctum pygmaeum is probably an Endodont and differs markedly from all the other British Helicoids. *Columella edentula* was removed from *Vertigo* when the Endodont character of its radula was noted. Since, however, many if not all the Vertigoes possess the same feature and yet are separated from the Endodonts by equally important features, it would appear that there was no necessity for the change. *Pyramidula rupestris* and *P. rotundata* are probably not congeneric. The ovo-viviparous habit of the former being in marked contrast with the oviparous habit of the latter besides which the radulae differ. We have, however, not ventured to make any alteration in the classification since in the present imperfect state of our knowledge it is inadvisable.*

HELICIDÆ.

The heterogeneous assemblage of recent British landshells which until lately were placed in the genus *Helix* has now been distributed into a number of genera, and although finality has not yet been attained they may be grouped for the present as follows:—

<i>Helicella virgata</i> (Da Cost.)	<i>Acanthinula aculeata</i> (Müll.)
<i>Helicella itala</i> (Linn.)	<i>Acanthinula lamellata</i> (Jeff.)
<i>Helicella caperata</i> (Mont.)	<i>Vallonia pulchella</i> (Müll.)
<i>Helicella gigaxii</i> (Pfr.)	<i>Vallonia excentrica</i> , Sterki.
<i>Cochlicella barbara</i> (Linn.)	<i>Vallonia costata</i> (Müll.)
<i>Theba cantiana</i> (Mont.)	<i>Helicodonta obvoluta</i> (Müll.)
<i>Theba cortusiana</i> (Müll.)	<i>Helicigona lapicida</i> (Linn.)
<i>Hygromia fusca</i> (Mont.)	<i>Arianta arbustorum</i> (Linn.)
<i>Hygromia granulata</i> (Ald.)	<i>Helix aspersa</i> , Müll.
<i>Hygromia revelata</i> (Fér.)	<i>Helix pomatia</i> , Linn.
<i>Hygromia hispida</i> (Linn.)	<i>Helix nemoralis</i> , Linn.
<i>Hygromia liberta</i> (West)	<i>Helix hortensis</i> , Müll.
<i>Hygromia striolata</i> (Pfr.)	<i>Helix pisana</i> , Müll.

A somewhat different grouping has been suggested by E. W. Bowell† based on the radulae, but since this is still incomplete we have not adopted it.

HELICELLA VIRGATA (DA COSTA)

The Irish examples of this species both recent and fossil are identical with those of the west of England. Examples from Bray, Co. Dublin, have been identified as *H. pilula*, Caziot, by that author. There is a marked absence of the large coarsely striate form which occurs in the south-east of England and on the French coast opposite. Judging from its absence from so

* Cf. E. W. Bowell "On the radulae of the British Helicoids," *Proc. Malac. Soc., Lond.*, vol. viii, 1908, pp. 126-7.

† *Proc. Malac. Soc. Lond.*, vol. viii, 1908, pp. 125-7; 1909, pp. 205-212.

many of the Irish deposits *H. virgata* must be considered a species that has greatly extended its range there in quite modern times as it has in England.

The doubt that has been raised whether the *Helix virgata*, Da Costa, is this species has been finally settled by the recent discovery of the original drawings made for Da Costa's work which show that it is the species so long associated with the name and not *Helix pisana*, Müll., and the localities cited by Da Costa also confirm this.

HELICELLA ITALA (LINN.).

The Irish examples of this species are of great interest. As a rule they are decidedly high spired, though there is local variation in this respect. Unicolorous examples are extremely rare, the banding is very pronounced, and altogether the shells have a different facies from the common English form.

Dr. O. Boettger has identified the Irish form as var. *scythrope*, West, a name we have failed to trace, whilst extreme examples from the Aran Islands have been named *H. lampra* by Westerlund. It is in part the var. *instabilis*, Jeff.,* but the citation of *H. instabilis*, Ziegler, is an error. The var. *servierensis*, Germain, from Angers (Maine et Loire) appears to be identical.† The very small form occurring in Mayo and Galway may possibly be *H. enhalia* (Bourg.).

HELICELLA CAPERATA (MONT.).

This is the *H. intersecta* (Poiret) of French authors though according to Mabille‡ it is not *intersecta* (Poiret). As pointed out by Mr. Stelfox there are two forms of this species in Ireland, one large, diam. 10 mm., occurring in the west, and a smaller form, diam. 7 mm., which has in the main an eastern range.§ The Irish fossil examples belong to the small race. Western English examples both recent and fossil are also the small form. This is another species which has greatly extended its range in quite modern times.

HYGROMIA, RISSO, 1826.

Six species living in the British Isles are usually referred to this genus:—*H. fusca* (Mont.), *H. granulata* (Alder), *H. hispida* (Linn.), *H. liberta* (West.) [= *sericea* Drap. non Müll.], *H. revelata* (Fér.) and *H. striolata* (C. Pfr), whilst *H. montivaga* (West.) occurs in the Holocene of Harlyn Bay (Cornwall). Though occasionally recorded *H. fusca* is quite unknown in a fossil state

* *Brit. Conch.*, vol. i, p. 217.

† *Bull. Soc. Sci. Nat. Ouest France*, 1903, p. 121, pl. ii., figs. 3-4.

‡ *Journ. de Conch.*, 1865, p. 8.

§ *Proc. Roy. Irish Acad.*, vol. xxix, 1911, p. 87.

for the obvious reason as pointed out by R. Welch that the shell is so thin and contains so little calcareous matter. We have followed Pilsbry in uniting all these species under *Hygromia*, but it would appear from the anatomical work of E. W. Bowell that *H. fusca* has no proper affinity with the others whilst P. Hesse informs us that *H. fusca*, *H. granulata* and *H. revelata* "must be eliminated from *Fruticicola* Held" [= *Hygromia* Risso].

We await further research before making these changes.

HYGROMIA HISPIDA (LINN.).

Mr. Stelfox has noted that there are three fairly distinct forms now living in Ireland:—

(a) The small contracted form of the drier parts of the central and eastern counties.

(= var. *nebulata* Menke, fide O. Boettger = var. *nana* Jeff).

(b) The large, flat and very often open umbilicated form which prevails in parts of the north-eastern and south-eastern counties.

(= *H. hispida* (Linn.) type = *H. concinna* (Jeff.).

(c) A form usually hairy, thin, high-spined, and therefore with a narrow umbilicus, which appears referable to Clessin's var. *septentrionalis*.*

H. liberta (West.) is apparently quite absent from Ireland. An extreme form of "b" (= var. *sepulcrorum* West.) which attains a max. diam. of 10.5 mm. and is common in the alluvial flats of the Thames and Severn is also absent.

The fossil Irish shells are easily separable into typical *hispida* and var. *septentrionalis*. To the former belong the examples from Whitepark, Cloghan Point, Howth, Doonbeg, Orlock Point, Templeogue and the Catacomb Caves rainwash; whilst to the latter belong the shells from Tranarossan, Strand Hill, Rosapenna, Narin, Horn Head and Pollan Bay. Both forms occurred at Bundoran and the Giant's Causeway.

HYGROMIA STRIOLATA (C. PFR.).

Two forms of this species live in these islands; a large flat form occurring in the east and south-east of England = *striolata*, vera; whilst the other is decidedly smaller, often high spired, living in Ireland and the west and north-west of England = *abludens* (Loc.).

It is with great regret that we have to discard Pennant's name *rufescens*, for over 100 years associated with this species, but the recent discovery of Pennant's type leaves us no alternative, for his *rufescens* is a young *arbustorum*. The late E. A. Smith† has already noted this, and proposed to substitute

* *Proc. Roy. Irish Acad.*, vol. xxix, p. 89.

† *Ann. and Mag. Nat. Hist.*, series viii, vol. xi, 1913, pp. 263-4.

montana (Stud.) C. Pfr. This name, however, appears to us judging from the figure and description to be a synonym for *H. hispida* (Linn.) and therefore we have adopted *striolata* (C. Pfr.), concerning which, there is no doubt, which has priority of description in C. Pfeiffer's work, and which is the name in use on the continent.* Mr. Stelfox has suggested that this species is quite a modern introduction into Ireland†, and its geological record is not opposed to this view. The shells from the Catacomb Caves may be quite modern, for the cave deposits have been greatly disturbed, the Balbriggan deposit is not an old one, and all efforts to trace the Dogs Bay specimens have failed, and probably these last have been misidentified.

ACANTHINULA, BECK.

Two British species are usually referred to this genus:—*A. aculeata* (Müll.) and *A. lamellata* (Jeff.). P. Hesse informs us that *A. aculeata* is not a Helicoid, judging from its anatomy, and should be transferred to the *Pupillidae*. We have not made this drastic change though conchologically there is much to be said in its favour.

VALLONIA, RISSO.

It was for many years a moot point whether *V. pulchella* (Müll.) and *V. costata* (Müll.) were distinct species or not. In 1893 Dr. Sterki put forward the view based on anatomical and conchological grounds, with which we agree, that three species are native in these islands:—*V. pulchella* (Müll.), *V. costata* (Müll.), and *V. excentrica*, Sterki (*Proc. Acad. Nat. Sci. Philad.*, 1893, pp. 234–279). Since then more attention has been given to the genus, but there has been considerable confusion of the species. In Ireland *V. pulchella* was apparently much more abundant formerly than it is to-day, whilst *V. costata* has greatly increased in numbers.

HELIX ASPERSA, MÜLL.

The occurrence of this Lusitanian species in the Pleistocene of Ballinamintra Cave and in the early Holocene of Dogs Bay shows that this species is indigenous to Ireland, though its range has been greatly extended by the accidental agency of man. The Irish fossil examples that we have seen are either young or fragmentary, except the shells from Iniskea and Dogs Bay. These are extremely heavy and would be regarded as var. *solidissima*, Paul. We might also add that they have the shape of var. *conoidea* and the colour of var. *undulata*, though possessing the exact opposite of the other character, viz., tenuity: a good ex-

* *Ann. and Mag. Nat. Hist.*, series viii, vol. xi, 1913, p. 428.

† *Proc. Malac. Soc. Lond.*, vol. x, 1913, pp. 290–1.

ample of the worthlessness of these so-called varietal names. These heavy shells, as in the case of the next species, arise from the presence of foraminiferal sand. The lime has been assimilated by the animal either through its vegetable food or more directly as in *H. nemoralis*, which is known to swallow sand, and has then been eliminated from the system through the shell-forming glands. Mr. Taylor remarks that—

Helix aspersa tends to produce a thicker shell than usual when living near the sea-shore,

although nearly all the localities quoted by him for var. *tenuior* (the thin shelled form) are coastal. The proximity of the sea has no direct bearing on the thickness of the shell. On the east coast of England, where the sands are siliceous, the shells are decidedly thin; whilst in South Devon the shells from the sandstones are not so heavy as those from the limestone areas, and in Kent the shells living on the Gault are much thinner and smaller than those from the neighbouring chalk hills. Interesting figures have been given by O. Goldfuss respecting the weights of *Arianta arbustorum* (Linn.) and *Helix hortensis*, Müll. showing that there is a close connection between the thickness of the test and the amount of lime present in the soil.* Foraminiferal sand would appear to be more easily assimilated by the animals, hence it is that these extremely heavy shells occur near the sea. A further proof that diet is the true factor is afforded by the case of some specimens of *Helix pomatia* which, having been fed on paper containing a large amount of chalk, gradually increased the weight of their shells. Mr. Stelfox informed us that the shells of *Helix nemoralis* from the calcareous sand-dunes at Pollanguil Bay, Horn Head, West Donegal are very heavy, whilst those from walls in the neighbourhood are normal, and confirmed the statement by forwarding examples. Age, too, plays a prominent part in the question of weight, for in a large series of *H. nemoralis* from Huccombe, S. Devon, those shells which, judging from the periostracum were the oldest, were also the heaviest. It would thus appear that the conditions needed to produce heavy shells are :—

1. Absence of frost thus enabling the animals to attain a ripe old age.
2. Abundance of food.
3. Abundance of calcareous matter in the soil on which they live.

HELIX NEMORALIS, LINN.

The Irish fossil examples are of interest from the frequent occurrence of extremely heavy shells due to the causes just described. The Dogs Bay examples are well known, and have been described several times, but this feature also occurs in the

* "Binnenmollusken Mittel-Deutschlands," 1900, pp. 10-11.

examples from Doonbeg, Lahinch, Iniskea, Beginnish, Carrickfin, Achill, Horn Head, Narin, Rosapenna, and Tranarossan. Clessin has identified the Dogs Bay shells as *H. tonnensis*, Sandb., but notes that the examples sent by Dr. Scharff were only 23 mm. in diameter, whilst *H. tonnensis* are 31 mm.* This opinion is quoted without comment by J. W. Taylor,† who, moreover, considers *tonnensis* to be a sub-variety of var. *ponderosa*, Malm. Through the kindness of Dr. E. Wüst we have been able to examine a series of *H. tonnensis* from the Pleistocene of Tonna, the original locality. *H. tonnensis* is a large form 28–32 mm. in diameter, and is not a heavy shell. It has certainly no affinity with the var. *ponderosa*, Malm, and it is equally certain that it is quite distinct from the Dogs Bay shells. As pointed out by Mr. Stelfox, *H. tonnensis* is near to the large *H. nemoralis* from Inishmurray, but the latter are smaller. There is greater similarity between *H. tonnensis* and recent *H. nemoralis* from the Pyrenees.

Irish examples, both recent and fossil, exhibit far more variation than English. We must dissent from the statement made by Mr. Taylor‡ that *H. nemoralis* is gradually dispossessing from the regions they occupy the closely allied yet earlier evolved and therefore comparatively weaker and less dominant species, *Helix austriaca*, *H. sylvatica*, and even *H. hortensis*. It has yet to be shown that competition between these species does exist. So far as the geological evidence goes it would appear that *H. hortensis* is far more abundant now in England than formerly. The principal enemies of these large *Helices* are birds and the smaller mammals, and these would not exercise any discrimination in favour of *H. nemoralis*. This species inhabited N. Ronaldshay, Orkney, within the historic period, but its supposed extinction has not been through the agency of the other molluscan inhabitants. We know so little of the life history of these animals that it is useless to speculate as to the factors that determine their range.

PUPILLIDÆ.

Four British species were formerly placed in the genus *Pupa*:—*muscorum* (Linn.), *cylindracea* (Da Costa), *anglica*, Fér and *secale*, Drap. More recently the name *Pupa* being sunk in synonymy these were placed under Risso's name *Jamnia*. This also proved not to be valid, so the following nomenclature is now adopted:

<i>Pupilla muscorum</i> (Linn.)	<i>Lauria cylindracea</i> (Da Costa)
<i>Lauria anglica</i> (Fér.)	<i>Abida secale</i> (Drap.)

Of these the last-named is absent from Ireland.

* *Ber. Naturf. Ver. Regensburg*, Hft. xi, 1908, p. 13.

† "Monograph," vol. iii, p. 305.

‡ "Monograph," vol. iii, p. 522.

Judging from its abundance in the old deposits and shell pockets, *Pupilla muscorum* has greatly diminished in numbers in some localities.

LAURIA, GRAY.

In this country *Lauria* Gray has been usually considered a subgenus, but it is worthy of generic rank. It was created by Gray as a section of *Pupa umbilicata* (Drap.) [= *cylindracea*, Da C.] and *anglica* Fér. He described it as "Peristome margined, reflexed; the young shell with a transverse series of short triangular plates."* That most competent observer, Alder, was the first to note that the young shells of *cylindracea* and *anglica* possess a peculiar internal structure. This consists in a raised thread-like lamina running spirally round the columella, and another similar lamina in the centre of the upper side of the whorls; whilst at short distances, small flat shelly plates similar to the septa in *Segmentina nitida* (Müll.) occur. These features were also described and figured by Brown† and are noticed by Jeffreys, Adams, and other writers. Bourguignat has also described and figured them, but he does not refer to the prior work of Alder and Brown.‡ These important ancestral characters are quite unexplained, and must have a direct bearing on the origin and affinities of these two species. Whether they also occur in the various species which have been referred to *Lauria* by continental authors we cannot say. *Lauria*, it may be mentioned is viviparous, whereas *Pupilla* is oviparous

VERTIGINIDÆ.

Thirteen species belonging to this family have been recognized in these islands, living and Postpliocene. Of these *Vertigo parcedentata* (Al. Braun) [= *levenensis*, Scott] is known from the Pleistocene of Apethorpe (Northamptonshire), Ponders End and Angel Road (Middlesex) and the Holocene of Elie (Fifeshire). *V. martini*, Sayn§ from the Pleistocene of Port. Neuf (France), is probably identical, but we have indicated it in the table with an expression of doubt. *Columella columella* (G. von Mts.) is only known from the Pleistocene of Barnwell (Cambridgeshire), Ponders End and Angel Road (Middlesex).

Truncatellina minutissima (Hart.) is said to occur in Ireland from a single specimen (since lost) from North Kerry. There is, however, a single example in the Thompson Collection from the north of Ireland, and one of us detected another example in shell pocket material from Portstewart, Co. Derry. This last example is certainly fossil and a derivative from an old land surface.

* Turton's Manual, 2nd ed., 1840, p. 193.

† *Illustr. Land and Fresh Water Conch.*, 1845, p. 42, pl. v., fig. 5.

‡ *Moll. Algiers*, vol. ii, pp. 92-3, pl. vi, figs. 8-11.

§ *Ann. Soc. Linn. Lyon*, Tom. lxiii, 1911, p. 246.

Vertigo lilljeborgii, West., has only recently been shown definitely to belong to our fauna* though Jeffreys† had recognised it thirty years previously. In these islands it is only known from Ireland; still it may yet be found in Great Britain for it lives in Norway, Sweden, Finland and Denmark. Mr. Stelfox's suggestion that the so-called *V. heldi*, Cless., from Ballintoy‡ is only an abnormal *V. pygmaea*, is probably the correct explanation (*Proc. Roy. Irish Acad.*, vol. xxix, 1911, p. 101).

The remaining eight species live in Ireland, but of these *V. antivertigo* (Drap.), *V. moulinsiana* (Dupuy) and *V. alpestris* (Ald.) have not been detected fossil, though there is no reason to consider them recent introductions. The systematic position usually assigned to this group is unsatisfactory. Several of the species are known to possess Endodont characters and it is probable they all do. On shell characters we have recognised three genera, *Vertigo* for the majority of the species, *Columella* for *edentula* (Drap.), and *columella* (G. von Mts.) and *Truncatellina* for *minutissima* (Hart.).

VERTIGO ANGUSTIOR, JEFF.

Judging from its abundance in some deposits and in shell pockets, this species is much less common now than formerly, and Mr. Stelfox§ suggests that this has been caused by the encroaching of the sand-dunes over the coastal marshes which are its usual habitat. This may be true for Ireland, but since a similar extinction has taken place in England in several inland localities, may it not rather be the result of the changes in climate which have certainly occurred in post-glacial times.

CLAUSILIA, DRAP.

Five species of this genus live in the British Isles:—*C. laminata* (Mont.), *C. bispicata* (Mont.), *C. dubia*, Drap., *C. bidentata* (Strom), and *C. rolphii* Gray; whilst three recent European species are known as Pleistocene fossils:—*C. pumila*, Pfr., from Barnwell and Barrington (Cambridgeshire), and Woodston (Huntingdonshire), whilst *C. ventricosa*, Drap., and *C. parvula*, Studer, are only known from Woodston. The discovery of this last-named deposit by Wyman Abbott, and the careful collecting by the Rev. C. E. Y. Kendall and J. Davy Dean,|| have greatly extended our knowledge of the English Pleistocene fauna.

* *Irish Nat.*, vol. xvii, 1908, p. 89, Pl. iii, and p. 205.

† *Ann. and Mag. Nat. Hist.*, Ser. v, vol. ii, 1878, p. 380.

‡ *Irish Nat.*, vol. xii, 1903, p. 110, and *Journ. of Conch.*, vol. x, 1903, p. 307.

§ *Proc. Roy. Irish Acad.*, vol. xxix, 1911, p. 102.

|| *Journ. of Conch.*, vol. xiv, pp. 83-91.

Two species only live in Ireland, *C. laminata* and *C. bidentata*, and only the last named occurs fossil there.

SUCCINEA, DRAP.

According to the published geographical lists this genus has a world-wide distribution, but this is incorrect. It is true that mollusca, having a conchological resemblance to *S. putris* (Linn), do occur in nearly all parts of the globe, but this resemblance arises from convergence. The trend of evolution in the mollusca is from forms possessing a well-developed shell to the naked mollusca, and *Succinea* represents a stage in this development. Even if, as held by one authority, the converse of this evolutionary sequence were true, *Succinea* would still represent a stage. It is far more probable that *S. australis* bears the same relation to the Australian molluscan fauna that *S. putris* does to the European rather than these two species are co-generic. The proof of this, however, must be left to future anatomical work.

In England it is generally held that there are three British species:—*S. putris* (Linn.), *S. elegans*, Risso, and *S. oblonga*, Drap. Irish malacologists have always maintained that *S. elegans* is not a native of Ireland, and that the Irish shells are *S. pfeifferi*, Rossm. A. W. Stelfox sent us a large series of Irish shells, and we are of opinion that the Irish authorities are correct. We also consider that *S. schumacherii*, Andr., may be only an extreme form of *S. pfeifferi*. We have failed to detect *S. oblonga* in the Irish fossil material, though it was found by Mr. Stelfox in the marl at Killough, Co. Down, and has been recorded from the gravels at Killiney Bay by A. Bell.* It is the custom to refer many of the Irish examples of *S. oblonga* to var. *arenaria*, Bouch.-Chant., thus perpetuating an opinion of Jeffreys. He says, "I can scarcely regard the *S. arenaria*, Bouch.-Chant., as even a well-marked variety of this species [*S. oblonga*]; most if not all of the British specimens belong to this form" (*Brit. Conch.*, vol. i, p. 155). Dr. O. Boettger informed us that *S. arenaria* was a species with which very few continental authorities were acquainted, and that it was a rare coastal species quite distinct from *S. oblonga*, and he kindly sent examples from the Isle of Borkum. An examination of the radula of one of these, by Mr. Bowell, supported this view. Conchologically the shells from Dooaghtry, W. Mayo, are indistinguishable from the Borkum shells, and so are the shells from Braunton Burrows, N. Devon. Since all the known localities for *S. arenaria* are similar, it is possible that it is only a syntonic phase of *S. oblonga*, and as such we have considered it.

* Second Report of the Comm. upon the Marine Gravels of Wexford, *Brit. Assoc. Report*. 1888 (1889), p. 7.

LIMNÆA, LAMARCK.

Nine species of this genus are known from the British Isles, and of these seven live in Ireland. Of the absent species, *L. burnetti* Ald. is confined to Loch Skene (Dumfriesshire), whilst *L. glabra* (Müll), though recorded by Jeffreys from Cork and Belfast, does not live in Ireland.* Two species are confined to Ireland, *L. involuta*, Thomp., and *L. prætenuis*, Bow. The former was, until lately, only known from Lake Cromaglaun, N. Kerry, but it has been found by R. A. Phillips† in Barley Lake, W. Cork. The latter species was originally described from Lough Nagarriva, N. Kerry, but has been obtained by Major H. Trevelyan from a number of small lakes in E. Donegal and Fermanagh. *L. involuta* has been considered to be only a variety of *L. pereger* (Müll), but the anatomical work of Mr. Bowell has shown that it has no affinities with that species, but that both *L. involuta* and *L. prætenuis*, despite the very dissimilar shell, are much nearer to *L. glabra*.‡ Under these circumstances it will be necessary to remove these two species from the sub-genus *Radix*, Mont. Dr. Dall§ has proposed the section *Cyclolimnæa* with *L. involuta* as type. This may be used, though Dr. Dall's definition will have to be modified to include *L. prætenuis*. Lionel Adams has stated that in the very young stage of its growth the shell of *L. involuta* is not intorted,|| but Mr. Bowell assures us that in the embryos of this species examined by him the spire was distinctly intorted. It is not to be expected that either *L. prætenuis* or *L. involuta* would occur fossil, but the remaining Irish species do. In no other genus has there been such a wholesale misidentification of species and varieties as in *Limnæa*. No two authors are in agreement as to the limits of the species, or the varietal names, and it is now a difficult task to place this genus on a satisfactory basis. The hope lies apparently in anatomical research, and though it has been suggested that this is unreliable, yet it cannot lead to worse results than the study of the test alone has done.

LIMNÆA AURICULARIA (LINN.).

As noted by A. W. Stelfox the prevalent form in Ireland is var. *acuta* Jeff., and this may yet prove to be a distinct species. It was originally described as—

shell smaller than the typical form, more oblong and showing the last whorl and mouth proportionally narrower,
and the localities cited were

* A. W. Stelfox and J. N. Milne. *Irish Nat.*, vol. xvi., 1907, p. 282.

† *Irish Nat.*, vol. xviii., 1909, p. 205.

‡ E. W. Bowell, *Irish Nat.*, vol. xvii., 1908, pp. 45-9.

§ "Land and Fresh Water Mollusca Alaska," p. 64.

|| *Journ. of Conch.*, vol. ix., 1900, p. 299.

marshes on the sea-coast of Glamorganshire, Church Stretton, Salop, Kent, Co. Tyrone,*

and Jeffreys adds that it is intermediate between *L. pereger* and *L. auricularia*. This form is often referred to the former species, although the spire is always distinctive. In England we have seen it from Kent, Sussex, and Burton Court, Herefordshire. An account of the anatomy of examples from Burton Court has been given by Boycott and Bowell.† The example from the Norwich Crag of Bramerton is near to var. *acuta*, but elsewhere as a fossil in Great Britain it is only known from the lacustrine deposit at Perranzabuloe (Cornwall).‡ These last examples are identical with recent ones from Carnboy Lough, Carrickfin, W. Donegal, sent us by Mr. Stelfox. All the Irish fossil examples are var. *acuta*.

There is a marked contrast between this var. and the large inflated form (= *auricularia vera*) common in England as well as the small inflated form from the Pleistocene of England (= var. *ampla* Hart. fide Dr. O. Boettger). *L. acutalis*, Mort., from Portugal is very near to if not identical with var. *acuta*. We cannot agree with H. Hannibal in considering that *L. auricularia* is a syntonic form of *L. pereger* and is a native of N. America.§ In England the two species live together under the same conditions, each preserving their well-marked characteristics. Is it possible that this author is not acquainted with *auricularia vera*?

LIMNÆA PEREGER (MÜLL.).

No species is perhaps so difficult to study as this, the commonest of our freshwater molluscs. If one relied on literature alone one would infer that it lives all over the world, which is probably incorrect. The problem is this:—Are we dealing with an extremely variable and adaptable species; or are there a number of species with somewhat similar shells? The latter alternative would account for many of the exotic records. The probability of the latter alternative being correct is shown by the fact as already noted that *L. involuta*, which has been claimed as a variety of *L. pereger*, proves from its anatomy to have no affinity with that species. *L. bowelli*, Prest., from Tibet, bears a great conchological resemblance to *L. pereger*, but judging from its anatomy, has also no relation with that form.|| As a rule the fossil examples of *L. pereger* from Ireland are small, but that is probably a question of environment. Nearly all the deposits which have yielded this species are chara marls, and the great similarity observable in examples from these marls,

* *Brit. Conch.*, vol. 1, p. 109.

† *Moll. Hereford*, p. 84.

‡ *Proc. Malac. Soc., Lond.*, vol. viii, 1909, pp. 247-250 and 373.

§ *Proc. Malac. Soc., Lond.*, vol. x, 1912, pp. 140-1.

|| *Records India Mus.*, 1909, pp. 115-6.

whether British or Irish, is noticeable, and it is clear that the environment was not favourable to the species.

Examples from Ballyallia Lake, Lough Carra, Lough Cahirkine, Portumna, and Mentrim may be referred to the so-called var. *lacustris* (Leach). It is interesting to note how fossil examples of this variety resemble *Amphipeplea glutinosa*, so much so that it is extremely difficult to separate them. This variety has been claimed to be a deep-water form, though the deep-water forms of *L. pereger* from the Swiss lakes are very different, and the fact that it occurs in several marl deposits shows clearly that it is not altogether a deep-water form. It may yet prove to be identical with *L. pratensis*, but this question and its relation to *L. burnetti* will only be solved by anatomical investigation. Speaking broadly there is never so much variation in fossil examples of *L. pereger* as in a large series of recent shells. Isolated artificial ponds appear to be very favourable in this species, as with the *Pisidia*, for the production of extreme variation, and it is clear that such localities would never furnish any material for our fossiliferous deposits.

LIMNÆA TRUNCATULA (MÜLL.).

Mr. Stelfox has noted that there are two races of this species in Ireland, a condition which also obtains in Great Britain. The large form has a decided eastern range in both England and Ireland; whilst the small form is the prevalent western form in both, and also occurs in the Atlantic Islands and North Africa. English Pleistocene examples are all the small form, and, as pointed out by Mr. Stelfox (in litt.), are identical with the western Irish form. The large form is known from the English Holocene deposits, whereas in the Irish deposits only the small form is represented. Is it possible that the large race is quite a modern introduction into Ireland?

PLANORBIS, GEOFFROY.

Of the thirteen species indigenous to the British Isles eleven are found living in Ireland, and of these all but two, *P. corneus* and *P. spirorbis*, have been found fossil. There is no reason to consider either of these two a recent introduction, and their absence from deposits must be attributed to the imperfection of the geological record.

PLANORBIS LÆVIS (ALDER)

This is an extremely difficult species to study. If the apparently closely allied species be united with it, a course adapted by some authorities, then it is an Holarctic species and its correct name is *P. parvus*, Say, but we cannot agree with this view. Though *P. lævis* resembles *P. parvus*, yet it can be

separated from it, and until it has been shown that the animals are identical it is better to consider them distinct. Certain it is that a number of species have been described which, conchologically classed, are allied to each other. Is there a widely spread species with local races or even different phases of development, or, are there a number of distinct species with a superficial conchological similarity arising from convergence? Since no anatomical evidence is available a definite answer cannot be given. It may, however, be noted that similar species occur in the Eocene, Oligocene, and Miocene deposits, and there is no reason to consider these early forms are in any way related to *P. lævis*.

This species is often called *P. glaber*, Jeff., but in error, as one of us [A. S. K.] showed in 1908.* *P. glaber* was described in 1833 by Jeffreys.† He states that it was "found with the last [*P. albus*] though much less common. It is a much more depressed shell than the *P. albus*, of a white colour, more polished and transparent, and is destitute of any markings. The upper side is uniformly more even, and the under exceeding concave." Examples of this shell were sent to Alder by Jeffreys, and Alder‡ considered them a variety of *P. albus*, and as distinct from *P. lævis*, Ald., and in this view he had the support of Capt. T. Brown, Dr. J. E. Gray, and W. Thompson. Thus the four most competent authorities of the day were in agreement that *P. glaber*, Jeff., was only a form of *P. albus*, Müll, and this opinion was based on the examination of specimens sent by Jeffreys (not on a single specimen as has been stated). In 1862 Jeffreys§ noted that *P. glaber* differed from *P. albus* in the upper side being rather convex instead of flat, though in his original description he said exactly the opposite, and he adds:—

I am not aware that both species have been found living together, whereas he originally stated that it occurred with *P. albus*. Hence it is clear that *P. glaber*, Jeff., 1833 was distinct from the *P. glaber*, Jeff., 1862, and that the correct name for the species is *P. lævis*, Ald. Dr. Dall has stated that in the Jeffreys collection, now in the U.S. National Museum, are the original types of *P. glaber* as well as those which served as the types for "British Conchology," and they are both identical with *P. lævis*, Ald.|| It must not be forgotten, however, that a considerable time elapsed between 1833 and the acquisition of the collection by the museum, so that it is not improbable that some substitution may have taken place.

* *Proc. Malac. Soc., Lond.*, vol. viii, p. 46.

† *Trans. Linn. S. c., Lond.*, vol. xvi, pp. 387-8.

‡ *Mag. Zool. Bot.*, vol. ii, 1837, pp. 113-4.

§ *Brit. Conch.*, vol. i, p. 86.

|| *Proc. Malac. Soc., Lond.*, vol. viii, 1908, p. 141.

PLANORBIS LEUCOSTOMA, MILLET.

British Conchologists usually refer this form to *P. spirorbis* (Linn), but on the continent it is generally considered a distinct species. There it is often called *P. rotundatus*, Poiret, and though it is possible that this is correct it is by no means certain. We were indebted to Dr. O. Boettger for the following synonymy:—*P. leucostoma*, Millet, 1813 = *spirorbis*, Jeff. (and all British authors), = *rotundatus*, Bourg., = *septemgyratus*, Dupuy, Moquin-Tandon, and Bourguignat, non Rossmässler = *perezi* Dupuy = *calculiformis*, Sand. = *spirorbis* var. *gracilis*, Gredler. It is the custom in England to consider that there is a sinistral form of this and other species of *Planorbis*, that have been dignified by the bestowal of the name *sinistrosum*. Since the genus is sinistral this is a curious case of mis-nomenclature.

PALUDESTRINIDÆ.

Our knowledge of the small freshwater operculates is not satisfactory. Species and genera have been created on the continent on apparently insufficient grounds, for these forms are very variable and very subject to erosion, thus rendering identification difficult. In this country it is usually considered that five species are represented and these are always placed under *Paludestrina*, viz.:—*confusa* (Frau.), *jenkinsi* (Smith), *taylori* (Smith), *ventrosa* (Mont.), and *ulvæ* (Penn.). Since the last-named is almost a marine form we have omitted it from this paper. Of the remainder *P. taylori* is an *Amnicola* and is an introduction into the British Isles. Only British authors use the specific name *confusa* (Frau.). On the continent *similis*, Drap., or *anatina*, Drap., is generally employed, but there would appear to be great uncertainty as to what Draparnaud's species really were. Continental authors generally place this species in *Amnicola*, Gould and Hald., but this genus is restricted to North America and it should be placed in *Pseudamnicola*, Paul., as pointed out to us by Dr. O. Boettger (in litt.) and clearly shown by F. Taylor and J. W. Jackson.* Until a few years ago *P. confusa* was only known in these islands from the Thames Marshes between London and Gravesend, and since no living examples had been found for some time, in spite of repeated search, it was assumed to be extinct. Since then it has been met with in several localities. It is now known in England from Lincolnshire, Suffolk and Sussex, whilst R. A. Phillips has found it in Carlow, Wexford, Kilkenny, Waterford and Limerick, but it has not yet been found fossil in Ireland.

* *Journ. of Conch.*, vol. xi, 1904, p. 9.

PALUDESTRINA JENKINSI (SMITH).

This interesting species has been the cause of considerable discussion and speculation. Originally described by E. A. Smith * from examples taken by A. J. Jenkins at Plumstead (Kent), it has since been observed in many localities in England and Ireland. It was suggested to be a recent introduction, but specimens exist in the Jeffrey's collection under the name *Hydrobia ferrusina*† that were sent to him by Mr. Sowerby some years before the publication of "British Conchology." Moreover we now know that the *Rissoa castanea* figured, but not described, in 1859 by G. B. Sowerby‡ (second of the name) comprised both *P. jenkinsi* and *P. ventrosa*. Further, the *Rissoa ventrosa*, var., figured and described by Forbes and Hanley § from Grays (Essex), where the examples were collected by that keen observer Mr. Pickering, are undoubtedly *P. jenkinsi*. Jeffreys states that the correct locality for these last was two miles below Gravesend, and that both he and Mr. Pickering had in vain searched the exact spot for more examples.¶ So that now there is abundant proof that the species had for many years been misidentified. Outside the British area it has so far only been found near Warnemunde, Mecklenburg, by Dr. U. Steusloff, the examples having been determined by us.¶ Dr. Steusloff considers it a modern introduction there since it is absent from the underlying Holocene beds. As a fossil it has only been found at Barking (Essex), Blythburgh (Suffolk), and Limerick. The two former deposits are certainly within the historic period. Dr. O. Boettger has described a *P. wenzii* from the Lower Miocene (Hydrobienkalke) of Budenheim that is characterized by the presence of small spines,** thus showing that a spinose *Paludestrina* formerly existed in Europe, for it has been stated that the presence of this character in *P. jenkinsi* lent support to the theory that it was an introduction from the West Indies since this feature had hitherto been known only in species from that region and the Antipodes. Dr. Pallary has also described a *Pseudamnicola jolyi* from the Pliocene of the Puits Karoubi à Oran.††

This species is carinated, and, judging from the figure, may well be allied to *Paludestrina jenkinsi*. So far as the geological evidence goes there is confirmation of the view that it is a European and probably a Lusitanian species. Only one example occurred in the Limerick alluvium, and it has been suggested

* *Journ. of Conch.*, vol. vi, 1889, pp. 142-5.

† *Proc. Malac. Soc. Lond.*, vol. iii, 1899, p. 299.

‡ *Illust. Index Brit. Shells*, pl. xiv., fig. 11.

§ *Hist. Brit. Moll.*, vol. iv, p. 266, pl. cxxxiii, fig. 7.

¶ *Ann. and Mag. Nat. Hist.*, 1859.

¶ *Arch. Ver. Freunde Naturg. Mecklenburg*, 1908, pp. 82-93, and *Nachrichts. Deutsch Malak. Gesell.*, 1909, pp. 80-1.

** *Nachrichts. Deutsch Malak. Gesell.*, vol. xi, 1908, p. 155.

†† "Moll. Foss. Terr. de l'Algerie," p. 169., pl. iv, fig. 18.

that it does not belong to the deposit but that its presence arises from the fissuring of the soil during dry weather. Since, however, it is in the same condition as the majority of the other shells, there is no reason, apart from preconceived ideas, why it should be rejected.

PALUDESTRINA VENTROSA (MONT.).

This is undoubtedly an aggregate species. The Miocene, *P. ventrosa* (Mont.), of German authors, is *P. renevieri* (Loc.).* The English Pleistocene shells referred to this species are for the most part *Paladilhia* [= *Lartetia*] *radigueli* (Bourg.). Dr. A. C. Johansen has called our attention to the occurrence, also of *Paludestrina minuta*, Totten, in these islands, where it has been confounded with *P. ventrosa* (Mont.). From A. W. Stelfox we received a series of *Paludestrina* from Ireland, and in our opinion the shells from Strangford Lough, Co. Down, and Killough, Co. Down, may be referred to *P. minuta*, Totten, whilst those from Inishmore, Aran Islands, Clare, and Larne, Co. Antrim, are *P. ventrosa* (Mont.) vera. Since we have not seen any of the fossil shells recorded as *P. ventrosa* we cannot say which of the segregates really occurred.

BITHYNIA, LEACH.

Two species of this genus live in the British Isles:—*B. tentaculata* (Linn.) and *B. leachii* (Shepp.); both occur in Ireland, though it is only lately that the latter species has been definitely recorded.† We have, however, failed to detect *B. leachii* in the Irish fossil material which has passed through our hands. The Irish examples are typical. In this respect they agree with the recent and Holocene English ones and the Pleistocene examples from Swanscomb.

BITHYNIA TENTACULATA (LINN.).

This species is particularly susceptible to the influence of environment, the examples from one locality exhibiting one facies whilst those from another locality have a different facies. Amongst the Irish fossil examples there is but little variation, for nearly all the deposits have been formed under similar conditions.

VALVATA, MÜLLER.

Three species of this genus now live in the British Isles:—*V. piscinalis* (Müll.), *V. cristata*, Müll., and *V. macrostoma*, Steen. The two former occur in Ireland, both living and fossil, whilst

* "Moll. Terr. et Fluv. Tert. de la Suisse," pp. 190-2.

† R. Welch, *Irish Nat.*, vol. xvii (1908), pp. 1-5.

V. macrostoma is only known living from a few localities, though it has probably a more extended range.*

VALVATA PISCINALIS (MÜLL.).

A number of Irish shells, both recent and fossil, have been determined as *V. alpestris*, Blaun., yet this can only be considered a variety for intermediate forms are not uncommon, and Mr. Bowell has failed to trace any difference in the anatomy. Hence it is probably a syntonic form. It was first noticed and figured by Capt. Brown, who noted it as

a permanent variety with the spire more produced, the volutions somewhat scalariform; found at Clonoony.†

It is apparently identical with the var. *acuminata* Jeff., described as having the

spire still more produced and ending in rather a sharp point,

found at Bristol and the North of Ireland.‡ If our view is correct it follows that *alpestris* has priority, for it was described in 1852.§ The var. *alpestris* may be distinguished by the suture, which is more deeply cut, whilst in typical *piscinalis* it is shallow.

This character tends to make *alpestris* appear scalariform, but R. A. Phillips sent us a series from Cork Park, determined by Dr. O. Boettger as var. *alpestris*, in which the shells were very depressed though the suture was deep.

Speaking broadly, the Irish examples, both recent and fossil, differ from the English in being smaller and having the striæ more pronounced.

THEODOXUS, DE MONTFORT.

It is with great regret that we are compelled to substitute *Theodoxus*, De Mont., for the well-known *Neritina*, Lamk. As pointed out by Major M. Connolly,|| the date for *Theodoxus* is 1810, and the type is *T. fluviatilis* (Linn.) [= *lutetianus* De Mont.] whilst *Neritina* only dates from 1822.¶

THEODOXUS FLUVIATILIS (LINN.).

The geological age of this species is very uncertain. It has been recorded from the Miocene of Germany and Switzerland by several authorities, but through the kindness of Dr. C. Boettger and Dr. Drevermann we have been able to examine a series from Wiesbaden, and in our opinion they are not identical with the recent *L. fluviatilis*. Locard** has described the Swiss shells as

* *Proc. Malac. Soc., Lond.*, vol. ix, 1910, p. 123.

† "Illustr. Conch. Gt. Brit.", edit. 2, p. 7, pl. i, figs. 16-17.

‡ "Brit. Conch.", vol. i, p. 73.

§ Blauner, in *Kuster: Conch. Cab.*, p. 68, pl. xiv, figs. 17-18.

¶ "Conch. Syst.", ii, p. 350.

¶ *Ann. S. Afric. Mus.*, vol. xi, 1912, p. 270.

** "Moll. Terr. et Fluv. Tertiär. Suisse," p. 231, pl. x, fig. 24.

pseudo-fluviatilis. If the Swiss shells are identical with the German, then the correct name is *T. gregaria* (Thom.).* *T. fluviatilis* is recorded from the Pleistocene of Mosbach (Germany), but this record is doubted by Dr. Wüst. In France and England it is not known from any deposit older than the Holocene. The records from the Pliocene and Pleistocene of south-eastern Europe are also open to question, the Pliocene age of the beds being more than doubtful, and the allied species *T. prevostiana* (C. Pfr.) being often mistaken for it. *T. fluviatilis* does, however, occur in the Pleistocene of Denmark.

ANODONTA, LAMK.

There has lately been a tendency to revive *Anodontites*, Brug., cited as 1791 instead of *Anodonta*, Lamk., but this arises from an error. *Anodontites* was established in 1792 by J. G. Bruguière,† and the type is *A. crispata* from Guiana. Simpson‡ places this species in *Glabaris*, Gray, 1847. It is thus clear that *Anodontites* cannot be used for the European species, and the well-known *Anodonta* need not yet be consigned to synonymy, though *Glabaris* may have to be. There has been considerable divergence of opinion as to the species of *Anodonta*. In England it was held that there was only one polymorphic species — *A. cygnæa* (Linn.). On the other hand Locard recognised in France two genera, *Pseudanodonta*, Bourg., and *Anodonta*, the former with twenty-eight species and the latter with two hundred and fifty.

In 1910 D. F. Haas published his important paper, "On *Unio*, *Margaritana*, *Pseudanodonta* and their occurrence in the Thames Valley."§ In this it was clearly shown that the *Anodonta* of English authors comprised two genera, *Pseudanodonta* and *Anodonta*: he identified from the Thames, *P. elongata* (Hol.), and was of opinion that the two species of *Anodonta*, recognised in Germany, viz.: *A. piscinalis*, Nils. [= *anatina* Linn.], and *A. cellensis* (Schrot.) [= *cygnæa*, Linn.], also occurred in England. More recently a second species of *Pseudanodonta*, *P. rothamagensis*, Loc., has been identified from the River Teme (Worcestershire) by the same authority.|| So far *Pseudanodonta* has not been detected in Ireland. Judging from their life history both these genera must be considered degenerate, and will well repay further investigation.

Bloomer and Overton¶ have now shown that *Anodonta cygnæa* and *A. anatina* are distinct and well-recognised species.

* *Jahrb. Nassau Ver. Naturh.*, 1845, p. 161, pl. iii, fig. 3.

† *Jour. Hist. Nat.* [Lamark and others] (1792), pp. 131-6, pl. viii, figs. 6-7.

‡ *Proc. U.S. Nat. Mus.*, vol. xxii, p. 919.

§ *Proc. Malac. Soc., Lond.*, vol. ix, p. 106-112.

|| *Journ. of Conch.*, vol. xiii (1912), p. 274.

¶ *Proc. Malac. Soc., Lond.*, xii, 1917, p. 202.

ANODONTA CYGNÆA (LINN.).

This being, as already noted, very often an aggregate, its correct distribution in time and space is an extremely difficult matter, more especially since the fossil examples are too often fragmentary. A. W. Stelfox* has stated that—

Mr. Henri Drouet has identified the large form from the Royal Canal (Ireland) as *A. cygnæa*, but considered the smaller to belong to *A. cellensis* (Schroter).

We have not seen many Irish Anodons, but all that have passed through our hands are *A. cygnæa*, and it would appear that *A. anatina* does not occur in Ireland, an opinion which has the support of the Irish malacologists.

PISIDIUM, C. PFEIFFER.

This genus has recently been the subject of a monograph by one of us† [B. B. W.], in which fifteen species were recognised, viz.:—

amnicum (Müll.).
astartoides, Sandb.
casertanum (Poli).
nitidum, Jenyns.
personatum, Malm.
pusillum, Jenyns.
milium, Held.
pulchellum, Jenyns.

subtruncatum, Malm.
henslowianum (Shepp.).
supinum, A. Schmidt.
steenbuchii (Möll).
lillejborgii, Cless.
hibernicum, West.
obtusale, Jenyns.

Since then R. A. Phillips‡ has added *P. parvulum*, Clessin, as living in Ireland, and it has also been found living in England, thus confirming the suggestion made in the monograph that it might be found living in these islands (*op. cit.*, p. 106). *P. astartoides* is extinct, and only known in these islands from the Pliocene and Pleistocene of England. *P. supinum*, though a common and widely distributed form, both recent and fossil, in England, has not yet been found living in Ireland. Dead shells have lately been found in sand from the River Suir at Fiddown, Co. Waterford, and the River Barrow, New Ross, Co. Wexford, but there is strong suspicion that they may have been imported with ballast. The remaining species are all met with living in Ireland, and all but *P. steenbuchii* fossil there. With all the species of *Pisidium* environment is a dominant factor, so that there is great variation shown, due to the conditions under which the animals live.

In the various records quoted by us in the table we have only

* *Proc. Roy. Irish Acad.*, vol. xxix, p. 123.

† Catalogue of the British Species of *Pisidium* (recent and fossil) in the collections of the British Museum (Natural History), London, 1913.

‡ *Irish Nat.*, 1916, pp. 103-5.

given those which have been authenticated by one of us [B. B. W.], or by Dr. A. C. Johansen, for so much confusion has existed in the past with regard to the various species that no reliance can be placed on the vast majority of the records, and in our opinion the sin, if such it be, of omission is in this case but venial compared with that of perpetuating very possible errors.

IV.—THE ORIGIN OF THE IRISH NON-MARINE MOLLUSCAN FAUNA.

There are at present three theories which have been propounded to account for the origin of the Irish non-marine mollusca :—

1. What may well be termed the "*Edward Forbes theory*," which is that the fauna of Ireland is not a homogeneous one, and is not a depauperated Britannic one, but on the contrary consists of several elements of different origins and of varying periods of introduction. This view is held by nearly all Palæontologists and by most Zoologists, though there are differences of opinion as to the elements and their antiquity of residence. The truth of this theory has been strongly upheld in recent years by Dr. R. F. Scharff.

2. The "*Pan-Germanic theory*," as it may well be termed, recently advocated by J. W. Taylor, that our non-marine molluscan fauna originated in Germany, the earlier evolved and therefore more primitive types being gradually driven farther and farther away from the evolutionary centre.

3. The "*Glacial extermination theory*," held by some botanists and many geologists, that the glacial period destroyed practically the whole of the fauna and flora, and that nearly all the present inhabitants are the descendants of post-glacial migrants.

As Clement Reid says :—*

any survival of our flowering plants, except in the case of a few arctic and alpine species, was quite impossible. . . . We have merely to account for the incoming of an existing flora after an earlier assemblage had been swept away almost as completely and effectually as the celebrated volcanic eruption wiped out the plants of Krakatoa.

If the flora were destroyed by the glacial period, the molluscan fauna must have shared the same fate.

It is worthy of remark that the first theory was propounded after a study of the flora and fauna, and of the Palæontological evidence, the second from an investigation of the recent non-marine molluscan fauna, and the last from botanical palæobotanical and geological evidence. It is perhaps desirable to examine the second theory first. It forms the main thesis of Mr. Taylor's "*Monograph*," and has recently been stated afresh

* *Irish Nat.*, vol. xx, 1911, p. 203.

by the author,* who attempts to show that it is supported by the evidence derived from other groups, in short that the whole of animated nature was "made in Germany."

With this further extension of his hypothesis we are at present not concerned, but many of his supposed facts will obviously not bear investigation.

It is, however, necessary to examine the theory in its original application, and see if it agrees with the known facts. Unfortunately, Mr. Taylor not being a geologist, as a perusal of his monograph clearly shows, geological evidence is not appreciated at its true value by him. This is to be regretted, since the question of the original home of any species must be settled principally from geological data. So far as these are known it would appear that many species are recognised from an earlier horizon in England than in Germany. These include:—*Zonitoides nitidus*, *Euconulus fulvus*, *Hygromia hispida*, *Arianta arbustorum*, *Cochlicopa lubrica*, *Pupilla muscorum*, *Lauria cylindracea*, *Succinea putris*, *S. pfeifferi*, *Ancylus fluviatilis*, *Acroloxus lacustris*, *Vertigo antivertigo*, *Limnæa palustris*, *L. pereger*, *L. auricularia*, *Planorbis corneus*, *P. albus*, *P. crista* and several species of *Pisidium*. All these are known in England from either the Pliocene Crags or the Forest Bed of West Runton, whilst in Germany they first occur in beds of much later date. So that so far as these species are concerned England is much more likely to have been the evolutionary centre. There are in addition a number of living British species which are quite unknown in Germany, either recent or fossil. These include:—*Testacella maugei*, *T. scutulum*, *Milax sowerbyi*, *M. gagates*, *Vittrina pyrenaica*, *Geomalacus maculosus*, *Helicella virgata*, *H. gigaxii*, *Cochlicella barbara*, *Hygromia fusca*, *H. granulata*, *H. revelata*, *Helix pisana*, *Lauria anglica*, *Vertigo liljeborgii*, *Limnæa burnetti*, *L. involuta*, *L. prætenuis*, *Pseudamnicola confusa*, *Sphærium pallidum* and *Pisidium hibernicum*. So it is evident that we have at least twenty-one species which have not come from Germany. *Helix aspersa* is quite a modern introduction into Germany, though in these islands it has been a resident from Pleistocene times. Moreover, there are very many extinct species formerly living in England which are unknown in Germany. These include practically all our extinct Pliocene forms as well as *Limax modioliformis*, *Hygromia montivaga*, *Vallonia tenuilimbata*, *Carychium ovatum*, *Paladilhia radigueli*, *Nematurella runtoniana*, *Vivipara gibba*, *V. glacialis* and *Sphærium bulleni*. Thus the Palæontological evidence is quite opposed to the "Pan-Germanic" theory. It is true that in Oligocene and Miocene times a varied non-marine molluscan fauna existed in Western Germany and Bohemia, containing probable ancestral forms of some of our living species, but they also lived in Switzerland and France, especially in the

* "Dominancy in Nature," Leeds, 1913.

south-west of France, and the probability is that western Europe was their true home.

Furthermore, there is at the present day a number of species which are extending their range in the British Isles:—*Milax sowerbyi*, *M. gagates*, *Helicella virgata*, *H. caperata*, *H. gigaxii*, *Theba cantiana*, *Hygromia striolata*, *Helix aspersa*, and *Paludestrina jenkinsi*. Of these, *Hygromia striolata* is probably a western form, *Helicella caperata* is certainly a western species, *Helix aspersa*, *Theba cantiana*, and *Paludestrina jenkinsi* are recent introductions into Germany, whilst the remainder do not live and never have lived in that country, so that it is clear that the "dominant" species in these islands are not "Teutonic" in origin. If one were asked the name of the most "dominant" species the only possible answer is *Helix aspersa*, which has been introduced by man into so many countries. This species, as already mentioned, is quite a modern introduction into Germany; in England and Ireland it occurs in the Pleistocene, as also in N. Africa and Malta.

In France, in many parts, this species was probably introduced in the Middle Ages, but in the Riviera it occurs in what are probably early Holocene beds. Its true home is probably south-western Europe, the fact that it does not burrow during the winter clearly showing that its place of origin was a country not subject to severe winters. Yet in the face of all this we are asked to believe in the "Pan-Germanic" theory.

The further statement that the earlier evolved and therefore weaker species have been driven away from the evolutionary centre by the later evolved or dominant species is also at variance with the facts. It does not follow that because a species is higher in the evolutionary scale it is therefore stronger in the struggle for existence with a lower one, for there are bird-eating spiders and a monkey-eating eagle, and even Man has to yield to bacteria. Moreover, there are many primitive species which are well adapted to their environment, *Punctum pygmaeum*, *Cochlicopa lubrica*, *Carychium minimum*, *Columella edentula*, *Physa fontinalis*, etc., are common forms, whilst a distinctly higher type, *Vitrina pyrenaica*, has but a limited range. Amongst the mollusca there are "adaptable" and "non-adaptable" species (these terms are preferable since "dominant" is sacred to the worshippers at the shrine of Mendel). The former are extending their range whilst that of the latter is diminishing. The chief cause in these changes is undoubtedly Man. By the draining of lakes and swamps, by the destruction of woodland, and by the bringing of the land more and more under cultivation, the natural habitats of the non-adaptables have been greatly limited. In England great changes were wrought in the Roman period; in Ireland probably at a much later date. In recent years the destruction of the hawks and owls has been prejudicial to the mollusca. The chief

enemies of the mollusca are the smaller mammals and birds; these have greatly increased since their natural enemies have been destroyed, and the mollusca have suffered. The minor climatic changes that have occurred since Pleistocene times constitute also an important factor. At the same time the local waxing and waning of species is sometimes inexplicable. Thus twenty years ago a chalk hill-side in Surrey simply swarmed with *Helicella virgata*, at the present day it is rare there, though the conditions are apparently unchanged, and many similar cases could be cited. It is thus evident that there are factors with which we are quite unacquainted. The question of the well being of a species is by no means so simple a problem as Mr. Taylor appears to imagine. Far more knowledge of their life histories, of their friends and foes, and of the numerous agencies, friendly and hostile, which affect them is required before it will be possible to speak definitely. This, however, is certain, that over the greater part of the British Isles there is no competition between the various species of mollusca, and the statement that certain species have driven out others is totally at variance with ascertained geological evidence.

Next, as regards the "Great Glacial extermination" theory. According to its supporters, during the glacial period the conditions in Ireland were such that practically the whole fauna and flora were destroyed, whilst they postulate a land bridge between Great Britain and Ireland in post-glacial times to account for the re-population of the latter, the undoubted American and Lusitanian elements being accidental introductions. This hypothetical post-glacial land bridge has been discussed by many writers, and the insuperable objection to it is that Ireland is deficient in many widely spread species of animals and plants which might reasonably be expected to occur if this land bridge had existed. This is particularly true of the mammalia and reptilia. Voles occur throughout Great Britain and in nearly all the outlying islands, yet are absent from Ireland. It is true that Lemmings have been found in the Pleistocene deposits of Ireland, but present-day Lemmings are able to swim across arms of the sea. It is clear that there has been an insuperable barrier between Great Britain and Ireland so far as the Voles are concerned since glacial times and earlier. Further, there are no snakes in Ireland, a fact which requires more adequate explanation than is afforded by the legend that St. Patrick banished them. As to the mollusca, there are three Irish species which are unknown in Great Britain, *Geomacalus maculatus*, *Limnaea involuta* and *L. prætenais*, and these cannot have travelled by any land bridge. Tested by each group of animals this supposed land bridge raises far more difficulties than it settles, and hence must be discarded. But the truth of the "Glacial Extermination" theory depends on this land bridge.

Without it the house of cards collapses, for then the Irish fauna did survive the glacial period, and this last cannot have been so severe as postulated. Though a large part of Ireland may have been glaciated, it would appear that there were many areas which escaped the ice and were in fact sanctuaries for the flora and fauna.

Lastly, there remains the "Edward Forbes" theory, which, on a previous occasion, we ventured to support,* and which we still consider furnishes the most satisfactory explanation of the problem. We would divide the Irish non-marine mollusca into three groups:—

1. THE WESTERN GROUP.—This comprises species whose origin was in western Europe. To a section of these the term Lusitanian has been applied, and it would also include the Atlantic group of Dr. Stejneger.

2. THE GERMANIC GROUP.—This includes species whose origin was either in central or south-eastern Europe. Many of the English species of this group are absent from Ireland.

3. A GROUP OF UNCERTAIN ORIGIN.—These species are Holarctic in distribution, and it is possible that some are of Nearctic origin.

1. THE WESTERN GROUP.—This may well be divided into (a) the Lusitanian and (b) what may be termed the Western group proper. To the first belong *Geomalacus maculosus*, Allm., *Vitrina pyrenaica*, Fér., the three species of *Testacella*, *Helix pisana*, Müll., *H. aspersa*, Müll., *Lauria anglica* (Fér.), *L. cylindracea* (Da Costa), and *Cochlicella barbara* (Linn.). Of these *Helix aspersa*, Müll., *Cochlicella barbara* (Linn.), *Lauria anglica* (Fér.), and *L. cylindracea* (Da Costa) are known from the Pleistocene of England, and the last-named from the Pliocene. *Helix pisana*, Müll., is known from the Pleistocene of the Channel Islands, whilst *Testacella maugei*, Fér., is only known from the Holocene of England, though it occurs in the Pleistocene of Grand Canary. The remaining species are unknown fossil in the British Islands. The geological evidence and present distribution of all the Lusitanian species clearly prove that their home is in south-western Europe.

To the Western Group proper we would assign those species which have had their origin in western Europe and have spread eastward. This includes the larger number of our species, beginning with those of *Arion*, *Limax* and *Amalia*, whose present natural distribution is decidedly western, especially so in the case of *Amalia*, whilst the sparse geological evidence concerning these genera is not opposed to this view. Eleven species of the Zonitidæ also belong to this group; *Polita draparnaudi* (Beck) and *Zonitoides excavatus* (Ald.) have a decidedly western range, and, judged by the geological evidence, the former is only

* *Proc. Geol. Assoc. Lond.*, vol. xvii, 1901, pp. 254-7.

indigenous in the south-west of England, though it is probably native in the south of Ireland. *Z. nitidus* (Müll.) is Holarctic in its distribution, but its true home is undoubtedly western Europe. *Pyramidula rupestris* (Drap.) and *P. rotundata* (Müll.) are widely distributed, but their affinities are with the western group. *Helicella itala* (Linn.), *H. virgata* (Da Costa), and *H. caperata* (Mont.) are also western forms. It is important to bear in mind the two races of *H. itala* (Linn.), the one having a western distribution, the other, the central European form, being apparently a more recent immigrant. *Hygromia fusca* (Mont.) and *H. granulata* (Ald.) likewise belong to the western group (the record of the latter species from Moscow, by C. Milachevich, must assuredly be an error), as well as *Acanthinula lamellata* (Jeff.), *Helix nemoralis*, Linn., and *H. horiensis*, Müll. The theory advanced by Bourguignat,* that the two latter species are of Asiatic origin, is not supported by the facts. A perusal of his pamphlet clearly shows that this view was advanced in an attempt to make the malacological evidence agree with certain conclusions based on the mammalia, conclusions which are probably incorrect. *Carychium minimum*, Müll., is probably yet another western species. The species of *Vertigo* are ancient forms, but it would appear that their origin, too, was in western Europe. *Limnæa auricularia* (Linn.) is of interest, for it would appear to comprise two well-marked races, one central European and the other western, the latter being the older form. To the Western Group, furthermore, may be assigned *Pseudamnicola confusa* (Frau.), *Paludetrina ventrosa* (Mont), *P. jenkinsi* (Smith.), and *Acicula lineata* (Drap.). *Limnæa involuta*, Thomp., and *L. prætenuis*, Bow., are certainly western forms, and would probably be included by Dr. Stejneger in his Atlantic group, since similar forms occur in the Faroes and Iceland.

Helicigona lapicida (Linn.), which has only lately been shown to be a native of Ireland, is certainly of western origin. The systematic position usually assigned to this species is probably incorrect, and in our opinion its affinities are with the Madeiran forms. In addition to the species already cited, there is a number of species which probably belong to the Western group, but concerning which the evidence is not complete. These include *Hygromia hispida* (Linn.), *H. striolata* (Pfr.), *Succinea putris* (Linn.), *S. pfeifferi*, Rossm., *Ancylus fluviatilis*, Müll., *Acroloxus lacustris* (Müll.), *Theodoxus fluviatilis* (Linn.), *Planorbis crista* (Linn.), *P. levis*, Ald., *P. umbilicatus*, Mull., *P. leucostoma*, Mill., and *P. fontanus* (Lightf.), to which may be added *Arianta arbustorum* (Linn.), though this last has been held to be Germanic.

It is interesting to note that there are several English species which are undoubtedly western, and yet are unknown in Ireland.

* Note Mal. et Mamm. Caverne Vence (1868), pp. 5, 6.

These include *Theba cantiana* (Mont.), *T. cartusiana* (Müll.), *Helicella gigaxii* (Pfr.), *Hygromia revelata* (Fér.), and *Pomatias elegans* (Müll.). Of these, *Theba cantiana* (Mont.) is probably a post-Roman introduction; *T. cartusiana* (Müll.), *Helicella gigaxii* (Pfr.) and *Hygromia revelata* (Fér.), are all known from English Holocene beds, and *Pomatias elegans* (Müll.) from the Pleistocene. The last-named species is the only one that from its geological history might be expected to occur in Ireland and yet is absent.

2. THE GERMANIC GROUP.—This is composed of a number of species whose origin is in the Germanic region, but whose affinities are mainly with the mollusca of south-eastern Europe. This group is not so well represented in Ireland as in England, and it is interesting how these species gradually thin out and disappear in a westerly direction. *Ena obscura* (Müll.) and *Cecilioides acicula* (Müll.) are probably Germanic, whilst *Clausilia laminata* (Mont.) and *C. bidentata* (Ström) certainly are. Ireland, be it noted, has two living species of *Clausilia*, whilst England has five recent and, in the Pleistocene, three extinct. *Valvata* is another Germanic genus, and Ireland has two recent species, England three recent and four extinct Pleistocene and Pliocene species. It would thus appear that the Germanic species are not so dominant as Mr. Taylor has assumed. *Planorbis corneus* (Linn.) is probably also Germanic whilst *Bithynia tentaculata* (Linn.) and *B. leachii* (Shepp.) certainly are.

3. THE GROUP OF UNCERTAIN ORIGIN.—These species have an Holarctic range and include *Agriolimax leviss* (Müll.), *Columella edentula* (Drap.), *Cochlicopa lubrica* (Müll.), *Limnæa palustris* (Müll.), *L. truncatula* (Müll.), *Aplecta hypnorum* (Linn.) and *Margaritana margaritifera* (Linn.). One other species may be classed with this group, *Paludestrina minuta* (Totten), though it only occurs on both sides of the Atlantic. Some of these may be of American origin. With regard to the route by which these species travelled, it is interesting to note that *Helix hortensis*, Müll., which is certainly of European origin, for it is the only true *Helix* indigenous in North America, occurs in the Faroes, Iceland and Greenland, clearly showing the route by which it passed. Its absence from northern Asia is remarkable, for it has been maintained that the European species with an Holarctic range reached North America by way of Siberia and a former land bridge between that country and Alaska. *Paludestrina minuta* (Totten) has a similar distribution, and so have a number of littoral marine mollusca and a few plants, hence there is strong confirmatory evidence for a former land connection in the region we have indicated.

V.—CONCLUSIONS.

The foregoing remarks may be summarized as follows :—

1. The non-marine molluscan fauna of Ireland is composed mainly of two groups :—the Western (including the Lusitanian) and the Germanic, the former being the older in order of occupation.

2. That with the exception of two or three which may have been accidentally introduced by man, all the species existed in Ireland in pre-Glacial times and survived the Glacial period.

3. That there has been no land connection between Great Britain and Ireland for a considerable period, and certainly not since Glacial times.

4. That the increase or diminution of range of some of the species has arisen from the minor climatic changes which have occurred since Pleistocene times.

5. That in early Holocene times the climate was warmer, and at this period chara marl was largely deposited in shallow meres liable to desiccation in the hot summers, and these marls are contemporary with the raised beaches of the north-east.

6. That this warm period was succeeded by a damp period during which the woodland mollusca were able to flourish in many areas from which they had hitherto been absent.

7. That the molluscan evidence so far as it goes is in agreement with the views as to the minor climatic changes (with the exception of the hypothetical cold period) postulated by Prof. F. J. Lewis.

BRITISH RECENT AND POST-PLIOCENE NON-MARINE MOLLUSCA.	Irish Recent.	Irish Fossil.	Great Britain Recent.	Great Britain Holocene.	Great Britain Pleistocene.	England Cromerian.	France Recent.	France Holocene.	France Pleistocene.	German Recent.	German Holocene.	German Pleistocene.	Denmark Recent.	Denmark Holocene.	Denmark Pleistocene.	Spain and Portugal Recent.	N. Africa Recent.	N. Africa Fossil.	Asia Recent.	Neartic Recent.
<i>Testatella maugei</i> , Fér. ...	×	...	×	×	×	×	×
" <i>haliotidea</i> , Drap. ...	×	...	×	×	×	×	×	×	×
<i>Limax maximus</i> , Linn. ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
" <i>cinereo-niger</i> , Wolf. ...	×	...	×	×	×	×	×	×	×	...	×	...
" <i>tenellus</i> , Müll. ...	×	...	×	×	×	×	×	×	×	...	×	...
" <i>flavus</i> , Linn. ...	×	...	×	×	×	×	×	×	×	...	×	...
" <i>arborum</i> , Bouch.-Chant. ...	×	×	×	×	×	...	×	...	×	×	×	×	×	...	×	...
" <i>modioliformis</i> , Sandb. ...	×	...	×	×	×	×	×	×	×	...	×	...
<i>Agriolimax agrestis</i> (Linn.) ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
" <i>lævis</i> (Müll.) ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
<i>Milax sowerbyi</i> (Fér.) ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
" <i>gagates</i> (Drap.) ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
<i>Vitrina pellucida</i> (Müll.) ...	×	×	×	×	×	?	×	×	×	×	×	×	×	...	×	?
" <i>pyrenaica</i> , Fér. ...	×	×	×	×	×	...	×	×	...	×	×	×	×	...	×	...
<i>Vitrea crystallina</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Polita draparnaudi</i> (Beck) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>cellaria</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
" <i>hibernica</i> (Ken.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
" <i>sydneyensis</i> (Cox) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>rogersi</i> (B. B. Woodw.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>alliaria</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>nitidula</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pura</i> (Ald.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>radiatula</i> (Ald.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Zonitoides nitidus</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>excavatus</i> (Ald.) ...	×	×	×	×	×	...	×	×	×	?	×	×	×	...	×	...
<i>Euconulus fulvus</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Arion ater</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>subfuscus</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	?	...
" <i>intermedius</i> , Norm. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	?	...
" <i>hortensis</i> , Fér. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
" <i>circumscriplus</i> , Johns. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Arion</i> , sp. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Geomalacus maculosus</i> , Allm. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
<i>Punctum pygmaeum</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
<i>Pyramidula rupestris</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
" <i>rotundata</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
" <i>ruderala</i> (Studer) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
<i>Eulota fruticum</i> Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
<i>Helicella virgata</i> (Da Cost.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>itala</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>capitata</i> (Mont. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>crayfordensis</i> , Ken. and B. B. Woodw. ...	×	×	×	×	×	...	×	×	×	?	×	×	×	...	×	...
" <i>gigaxii</i> (Pfr.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>striata</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Theba cantiana</i> (Mont.) ...	×	×	×	×	×	...	×	×	×	?	×	×	×	...	×	...
" <i>cartusiana</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Cochlicella barbara</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Hygromia fusca</i> (Mont.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>granulata</i> (Alder.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>liberta</i> (West.) ...	×	×	×	×	×	?	×	×	×	×	×	×	×	...	×	...
" <i>hispidata</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>striolata</i> (Pfr.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>revelata</i> (Fér.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>montivaga</i> (West.) ...	×	×	×	×	×	?	×	×	×	×	×	×	×	...	×	...
<i>Acanthinula aculeata</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>lamellata</i> (Jeff.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Vallonia pulchella</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>excentrica</i> , Sterk... ..	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
" <i>costata</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	?	×	...
" <i>tenuilimbata</i> (Sandb.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Helicodonta obvoluta</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Helicigona lapicida</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Arianta arbutorum</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Helix aspersa</i> , Müll. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pomatia</i> , Linn. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>memoralis</i> , Linn. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>hortensis</i> , Müll. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pisana</i> , Müll. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Ena moniana</i> (Drap.) ...	?	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>obscura</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Cochlicopa lubrica</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Azeca menkeana</i> (Pfr.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Cæcilioides acicula</i> (Müll.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Pupilla muscorum</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Lauria tyiindracea</i> (Da Cost.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>anglica</i> (Fér.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Abida secale</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Vertigo antivertigo</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>substriata</i> (Jeff.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pygmæa</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>parcedentata</i> (Al. Braun) ...	×	×	×	×	×	...	×	×	×	?	×	×	×	...	×	...
" <i>mouliniana</i> (Dup.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>hiljeborgi</i> , West. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>alpestris</i> (Ald.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pusilla</i> , Müll. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>angustior</i> , Jeff. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Columella edentula</i> (Drap.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>columella</i> (G. von Mts.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	?
<i>Truncatellina minutissima</i> (Hartm.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Balea perversa</i> (Linn.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
<i>Clausilia lominata</i> (Mont.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>biplicata</i> (Mont.) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>parvula</i> , Stud. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>dubia</i> , Drap. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>bidentata</i> (Ström) ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>pumila</i> , Pfr. ...	×	×	×	×	×	...	×	×	×	×	×	×	×	...	×	...
" <i>ventricosa</i> , Drap. ...	×	×	×	×	×	...	×	×	×	×	×	...</						