

APPENDIX III.—*The MOLLUSCA.* By ALFRED SANTER KENNARD,
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[PLATE XVII.]

THE material on which the following notes are based was derived from two sources—(1) a large series sent by Mr. S. Hazzledine Warren, and (2) a number of examples collected by Messrs. A. S. Kennard & F. N. Haward, the result of washing several hundred-weight of the clay, the water in the pit being very convenient for that operation. Mr. Warren's collection consisted of four series marked 'Upper Bed,' 'Middle Bed,' 'Lower Bed,' and 'General.' We have considered it advisable to enumerate these separately, but we have incorporated our own series with the last.

LIST OF MOLLUSCA FROM THE ARCTIC BED.

Genera and Species. * = scarce; ** = abundant; *** = very abundant. ¹	Ponder's End.			Angel Road.	
	General Collection.	Special Site.			
		Upper Bed.	Middle Bed.		Lowest Bed.
<i>Arion</i> sp.	*				
<i>Limax arborum</i> Bouch.-Chant.	**				
<i>Agriolimax levis</i> (Müll.)	*				
<i>Sphyradium columella</i> (G. v. Mts.)...	**	..	*	*	
<i>Vertigo parcedentata</i> (A. Braun) ...	*	..	*	*	
<i>Jamnia muscorum</i> (Linn.)	***	***	..	***	
<i>Limnæa pereger</i> (Müll.)	*	*	
<i>Limnæa palustris</i> (Müll.)	*	*	
<i>Limnæa truncatula</i> (Müll.)	**	*	
<i>Limnæa stagnalis</i> Linn.	*	..	*	
<i>Limnæa</i> sp.	*	..	*	
<i>Planorbis crista</i> (Linn.)	*	*	
<i>Planorbis arcticus</i> Beck	*	*	
<i>Planorbis spirorbis</i> (Linn.)	*	*	
<i>Planorbis leucostoma</i> Millet	*	*	
<i>Succinea oblonga</i> Drap.	***	..	***	***	
<i>Succinea schumacheri</i> And.	*	***	
<i>Succinea</i> cf. <i>grænlantica</i> Beck	*	*	
<i>Succinea elegans</i> Risso	*	
<i>Valvata piscinalis</i> (Müll.)	*	*	
<i>Spherium corneum</i> (Linn.)	*	*	..	*	
<i>Pisidium supinum</i> A. Schm.	*	
<i>Pisidium obtusale</i> Pfr.	*	*	
<i>Pisidium nitidum</i> Jenyns	*	*	
<i>Pisidium pusillum</i> (Gmel.) Jenyns ...	*	*	
<i>Pisidium henslowanum</i> (Shepp.)	*	
<i>Pisidium subtruncatum</i> Malm	*	
<i>Pisidium casertanum</i> (Poli)	*	

It will be noted that the general list contains all the species from the three beds, with the exception of *Limnæa stagnalis*.

¹ These details are of most value in the 'general collection' enumerated in the first column, as they are there based on more extensive material than in the case of some of the other beds.

Notes on the Species.

ARION sp.

There are several granules representing the internal shell of this genus, but it is quite impossible to ascribe them to a given species. The northern limit of *Arion* is the isotherm of 8° C., but on the Alps its vertical limit is the isotherm of 3° to 4° C. It may here be observed that the isotherms quoted in this note are those for July.

LIMAX ARBORUM Bouch.-Chant.

This species is common, but all the examples are dwarfed. Its northern limit is Iceland, lat. 66° 30' N., with an isotherm of 8° C.; while in both Norway and Sweden its limit is the isotherm of 8° to 10° C. In the Alps its vertical range is the isotherm of 10° C.

AGRIOLIMAX LÆVIS (Müll.).

There are only four examples of the internal shell of this species. Its northern limit in Europe is the isotherm of 14° C.; but, if *A. hyperborea* West is only a variety of *lævis*, as has been suggested, it ranges in Asia as far as the isotherm of 10° to 12° C.

SPHYRADIUM COLUMELLA (G. v. Mts.). (Pl. XVII, figs. 5 a & 5 b.)

Abundant. This is an extremely interesting species, and one over which there has been considerable confusion.

It is the custom in this country to consider it as a variety of *Sph. edentulum* (Drap.), and as not uncommon in a living state; but the shells to which the name *columella* is applied by British authorities are very different from the true *columella*, and are in fact an elongated form of *edentulum*.

The species *columella* (*vera*) does not occur in a living state in these islands. It is a high Alpine and Arctic species inhabiting Norway, Sweden, Finland, and the Alps. Its northern limit is the isotherm of 8° to 10° C., while its vertical limit in the Alps is the isotherm of 6° to 8° C. In these islands it is only known from the Pleistocene of Barnwell (Cambridgeshire) and Copford (Essex). It is a common fossil in the German loess.

It is interesting to note that a similar disposition occurs in the Nearctic region. There, as in Europe, *Sph. edentulum* (Drap.) is a widely distributed species, but an elongated form, *Sph. alticola* Ing., occurs living at a height of 8000 to 9000 feet in Colorado; and it also occurs as a fossil in the Mississippi 'loess.' Whether the species *alticola* is identical with *columella* we cannot say, for we have been unable to see an authentic specimen of *Sph. alticola*.

VERTIGO PARCEDENTATA (A. Braun). (Pl. XVII, figs. 6 a & 6 b.)

Seven examples of this species were detected. They belong to the variety *genesii*, Gred., which is the edentulous form of *parcedentata*. This is a rare form in a living state, being only known

from one locality in Tyrol, one in Sweden, and two in Germany, its northern limit being the isotherm of 12° C. In a fossil state the variety *genesisi* is known from the Pleistocene of Mosbach, from several localities in the 'löss' of Germany, from two Holocene deposits in Germany and one in Sweden. In these islands it is only known from the Holocene of Elie (Fifeshire) and from a deposit of uncertain age at Stamford (Lincolnshire). This last, where the species was common, is probably of late Pleistocene age.¹

JAMINIA MUSCORUM (Linn.).

This is the most abundant form in the deposit and a Holarctic species, the limit of which in Iceland is the isotherm of 8° C.; in Norway, Sweden, and Finland the isotherm of 8° to 10° C.; and in Siberia the isotherm of 12° C.; while in the Alps its vertical limit is the isotherm of 6° to 7° C. There is great variation in the examples of this species, but a certain number may well be referred to the var. *lundstræmi* West, now living in Iceland and Sweden. This variety also occurs in the Pleistocene of Crayford, Swalecliff, and Ightham (Kent); Fordingbridge and Fisherton (Wiltshire); West Wittering (Sussex); Barnwell (Cambridgeshire); and Stamford (Lincolnshire). It is also a common form in the löss of Germany.

LIMNÆA PEREGER (Müll.).

A single dwarfed example is referred to this polymorphic species. Identical shells are in our collection from the Pleistocene of Crayford (Kent), the Holocene of Hale Moss (Westmorland), Silverdale (Lancashire), and Perranporth (Cornwall). In Iceland its limit is the isotherm of 8° C.; in Norway, Sweden, and Finland 8° to 10° C.; and in Siberia 10° to 12° C.; while in the Alps its vertical limit is 4° to 5° C.

LIMNÆA PALUSTRIS (Müll.). (Pl. XVII, figs. 3 a & 3 b.)

This species is represented by three dwarfed examples. It is a Holarctic form, the limit of which in Norway is the isotherm of 14° C.; in Sweden 10° to 12° C.; in Finland 8° to 10° ; while in the Alps its vertical limit is 13° to 14° C.

These shells may be looked upon as a dwarf form of the variety *turracula* Held., and identical shells are in our collection from the Pleistocene of Chelmsford (Essex), St. James's Square, Westminster (Middlesex), and Barnwell (Cambridgeshire), Benkendorf, Regensburg, Stuttgart, and Osterrode in Germany, all of which are late Pleistocene in age.

LIMNÆA TRUNCATULA (Müll.). (Pl. XVII, figs. 4 a & 4 b.)

Not uncommon, about twenty examples having been obtained; all of them are small.

¹ See Proc. Malac. Soc. vol. vii (1906) pp. 119-20.

This is a Holarctic species, the limit of which in Iceland is the isotherm of 8° C. ; in Norway, Sweden, and Finland 8° to 10° C. ; in Siberia 10° to 12° C. ; while in the Alps its vertical limit is 5° C. Judging from the description, these shells belong to the variety *lapponica* West, now living in Lapland.

Identical shells are in our collection from the Pleistocene of Chelmsford (Essex), Swalecliff (Kent), and Stuttgart (Germany) ; while examples from the Pleistocene of Barnwell (Cambridgeshire) and Crayford (Kent) come near to them.

LIMNÆA STAGNALIS (Linn.).

This is only represented by an apical fragment. It is a Holarctic species, the northern limit of which in Norway, Sweden, and Finland is the isotherm of 8° to 10° C., and in Siberia 10° to 12° C. ; while its vertical Alpine limit is 13° C.

PLANORBIS CRISTA (Linn.).

A single dwarfed example only of this species was found.

This is a European form, the northern limit of which in Europe is the isotherm of 12° C. ; while its vertical Alpine limit is that of 14° C.

PLANORBIS ARCTICUS Beck. (Pl. XVII, figs. 8 a & 8 b.)

Rather rare, only six examples being detected.

It is a Holarctic species with a decidedly northern range. In Iceland and Greenland its limit is that of the isotherm of 4° to 5° C., and in Norway 12° C. The examples are quite indistinguishable from specimens in our collection which were brought from West Greenland. *P. arcticus* is not uncommon in the Pleistocene of Crayford (Kent), and it also occurs in lacustrine deposits near Edinburgh, the age of which is still a matter of doubt.

PLANORBIS SPIORBIS (Linn.).

Rather rare, about eight examples having been found.

This European species has a range in Iceland to the isotherm of 10° C. ; in Norway, Sweden, and Finland to 14° C. ; and in Siberia to 12° to 14° C. ; while in the Alps it does not occur above the isotherm of 10° to 11° C.

All the examples from Ponder's End are decidedly dwarfed, and resemble those from the Pleistocene of Chelmsford (Essex).

PLANORBIS LEUCOSTOMA Millet.

Rare, being represented only by three dwarfed examples.

This is a European species, the northern limit of which is the isotherm of 12° C. It is often considered as only a variety of *spirorbis* Linn., yet it is noteworthy that both species occur together in this deposit without any intermediate forms being seen.

SUCCINEA OBLONGA Drap.

Next to *Jamiania muscorum* (Linn.) this is the most abundant species in the deposit. It is a European form, the range of which in Norway and Sweden is the isotherm of 15° to 16° C., and in Siberia 10° to 12° C. The vertical Alpine limit is the isotherm of 9° to 10° C.

This is a characteristic species of the German loess; while it is represented in our collection from the Pleistocene of Swalecliff and Ightham (Kent), Fisherton (Wiltshire), Portland (Dorset), Barrington (Cambridgeshire), and St. James's Square, Westminster (Middlesex).

SUCCINEA SCHUMACHERI And. (Pl. XVII, figs. 2 a & 2 b.)

Rare; two examples only found.

This is a species of which it is quite impossible to give the present range. If it is identical with *S. altaica* von Mts. var. *norvegica* West, as, judging from the description, it appears to be, then it occurs in Iceland with an isotherm of 10° C. It is a characteristic fossil of the German loess, and is represented in our collection from Bischheim (near Strassburg), Regensburg (Bavaria), and Osterrode (Thuringia).

In these islands it is known in a fossil state from the Pleistocene of Barrington (Cambridgeshire), Crayford (Kent), Chelmsford (Essex), and St. James's Square, Westminster (Middlesex). In our opinion it is indistinguishable from recent shells from Hale Moss (Westmorland), Grange (Lancashire), Stoke Inner Pool (Hereford), Old Colwyn (Denbighshire), and the Orkneys. With regard to the shells from Hale Moss, we had the confirmatory support of the late Dr. O. Böttger.

SUCCINEA cf. **GRÆNLANDICA** Beck. (Pl. XVII, figs. 1 a & 1 b.)

There are seven examples of *Succinea* which we are unable definitely to name. The nearest living form is *S. grænlantica* Beck, but these examples are rather smaller than that species.

S. grænlantica ranges as far north as the isotherm of 4° to 6° C.

We have seen no British fossil examples that will compare with them. Even if the Ponder's End shells are only an extreme form of *S. putris* (Linn.), it is noteworthy that this last species ranges to the isotherm of 8° to 10° C., with a vertical range in the Alps to 13° C.

VALVATA PISCINALIS (Müll.). (Pl. XVII, fig. 7.)

This species is represented by eight dwarfed examples.

Judging from the literature, these may be the variety *cyclomphala* West; but, since we have seen no authentic specimens, we are unable to speak definitely on the point. The range of *V. piscinalis* is to the isotherm of 8° to 10° C. in Europe, and 10° to 12° C. in Siberia. The highest vertical range that we can trace is in the Jura, 15° C.

SPHÆRIUM CORNEUM (Linn.).

This common European species is represented only by fragments;

but they are apparently true *corneum* and not *Sph. mœnanum* Kobelt, while they are certainly not *Sph. solidum* Norm. The species ranges in Europe to the isotherm of 8° to 10° C. and in Siberia to that of 10° to 12° C.

PISIDIUM SUPINUM A. Schmidt. Young specimen. (Pl. XVII, figs. 9 a & 9 b.)

PISIDIUM OBTUSALE (Lamk., ? Pfr.) Jenyns.

PISIDIUM NITIDUM Jenyns. (Pl. XVII, figs. 10 a & 10 b.)

and

PISIDIUM PUSILLUM (Gmel.) Jenyns. (Pl. XVII, figs. 11 a & 11 b.)

These species are represented by a few stunted valves, obviously denoting unfavourable conditions. There has been so much confusion among the *Pisidia* that it is difficult, if not impossible, to state anything as to their range; but it would appear that these three species range in Europe as far north as the isotherm of 8° to 10° C.

Conclusion.

The whole assemblage indicates the fauna of a marsh or swamp. There is practically no other British deposit that is actually analogous. The Pleistocene beds at Swalecliff, near Herne Bay, and the Brickearths, near Chelmsford, are probably of the same age; but in both these instances the number of species is very small as compared with that of Ponder's End.

After careful consideration of the matter, we venture to think that the deposit denotes a July isotherm of 8° to 10° C.—that is to say, the temperature of Southern Iceland or Lapland.

The mollusca from Ponder's End can be divided into two groups: one containing *Sphyradium columella*, *Vertigo parcedentata*, *Planorbis arcticus*, and *Jaminia muscorum* var. *lundstrœmi*, which are all boreal species; while those of the other all have a wide distribution. Practically, all of this latter group are dwarfed, and clearly indicate the existence of unfavourable conditions, which may well be supposed to have been due to the prevalence of a low temperature.

It is noteworthy, too, that a number of species which we might reasonably expect to be present are absent, such as *Planorbis corneus* (Linn.), *P. carinatus* (Müll.), *P. umbilicatus* (Müll.), *P. vortex* (Linn.), *Physa fontinalis* (Linn.), *Ancylus fluviatilis* Müll., *Bithynia leachii* (Shepp.), *B. tentaculata* (Linn.), and *Valvata cristata* Müll. These all range as far north as the isotherms of 13° C. or 14° C., and it is not unreasonable to assume that their absence may be accounted for by the fact that the July temperature was probably below 13° C. Taking into consideration the range of the boreal species, a July isotherm of 8° to 10° C. seems most likely to be the correct one for the period.

At the eastern end of the section the overlying Holocene beds can be seen, although the line of demarcation between the two

deposits is not well marked. We were able to obtain a number of mollusca from these upper beds, namely:—

<i>Vitrea radiatula</i> (Alder).	<i>Planorbis albus</i> Müll.
<i>Hygromia hispida</i> (Linn.).	<i>Planorbis umbilicatus</i> Müll.
<i>Hygromia liberta</i> , ¹ West.	<i>Planorbis carinatus</i> Müll.
<i>Helicigona arborum</i> (Linn.).	<i>Valvata piscinalis</i> (Müll.).
<i>Succinea elegans</i> Risso.	<i>Bithynia tentaculata</i> (Linn.).
<i>Limnæa auricularia</i> (Linn.).	<i>Bithynia leachii</i> (Shepp.).
<i>Planorbis contortus</i> (Linn.).	<i>Neritina fluviatilis</i> (Linn.).
<i>Planorbis crista</i> (Linn.).	<i>Unio tumidus</i> Retz.
<i>Planorbis leucostoma</i> Millet.	<i>Pisidium annicum</i> (Müll.).

These are all normal shells, and exhibit none of the dwarfing so noteworthy in the Pleistocene examples. The contrast between the two faunas is very marked, although a number of species are common to both.

In conclusion, we have to thank Mr. E. A. Smith, I.S.O., for his very kind assistance in the determination of some of the examples.

Supplementary Note on a Collection of Mollusca from the Arctic Bed in the Angel Road Ballast-Pit.

Mr. Warren also sent us another series of molluscan remains obtained at Angel Road, and twenty species were represented. These are enumerated in the last column of the table (p. 234).

It will at once be noticed that this fauna is practically the same as that from Ponder's End: for, excluding the *Pisidia*, there is only one species, *Succinea elegans* Riss., that did not occur at the latter locality. This species has a decidedly northern range. Its limit in Sweden is the isotherm 10° to 12° C., and in Finland 8° to 10° C., thus confirming the views which we have already expressed.

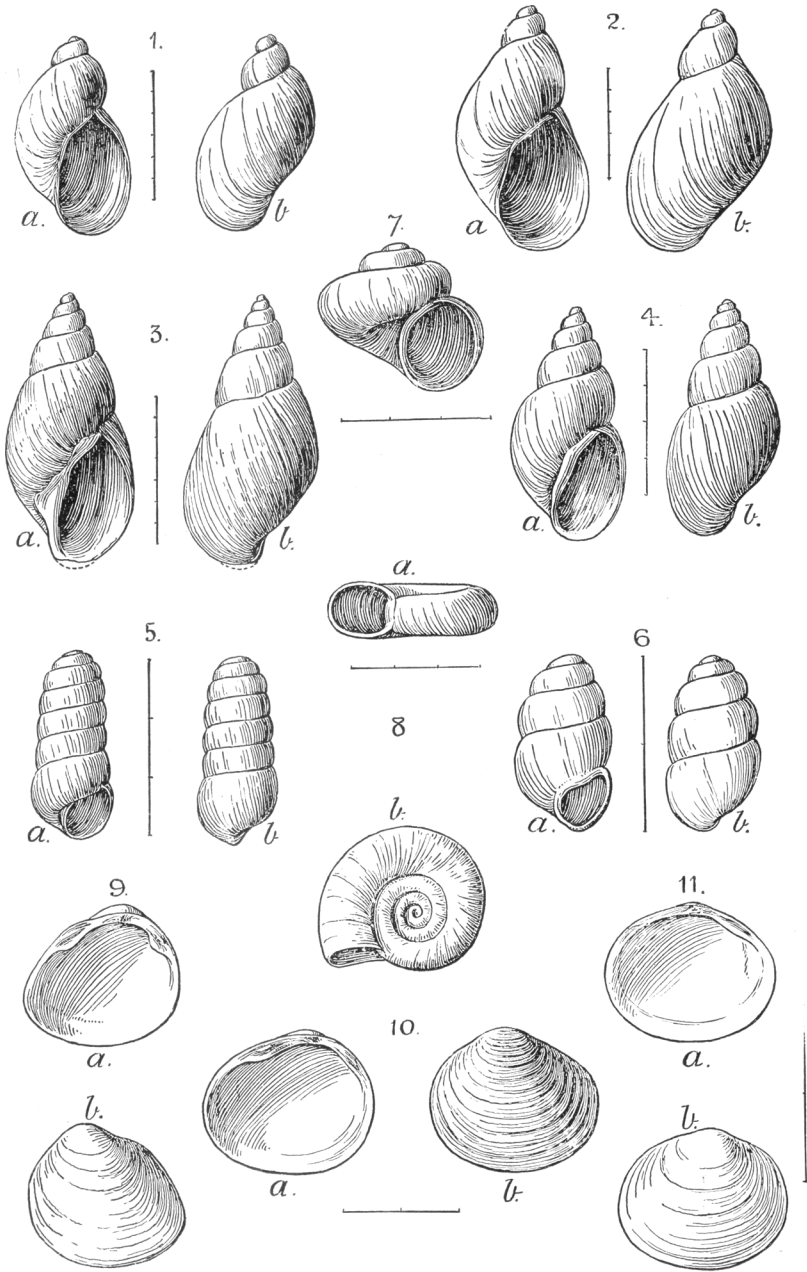
All the *Pisidia* are dwarfed, and the conditions were evidently not favourable. There is the same dwarfing of certain species and the abundance of others as at Ponder's End, and there can be no doubt that they are of the same age and represent similar conditions.

EXPLANATION OF PLATE XVII.

[The dimensions are shown in millimetres.]

- Fig. 1. *Succinea* (cf. *S. grænlandica* Beck). (See p. 238.)
 2. *Succinea schumacheri* Andreæ. (See p. 238.)
 3. *Limnæa palustris* (Müll.) var. (See p. 236.)
 4. *Limnæa truncatula* (Müll.) var. (See p. 236.)
 5. *Sphyradium columella* G. v. Mts. (See p. 235.)
 6. *Vertigo parcedentata* A. Braun. (See p. 235.)
 7. *Valvata piscinalis* (Müll.). (See p. 238.)
 8. *Planorbis arcticus* Beck. (See p. 237.)
 9. *Pisidium supinum* A. Schmidt. Right valve of young specimen.
 10. *P. nitidum* Jenyns. Right valve: dwarfed form. (See p. 239.)
 11. *P. pusillum* (Gmel.) Jenyns. Left valve of young specimen.

¹ = *H. sericea*, Drap. of Continental authors, non Müller



G. M. W. del.

MOLLUSCA FROM THE ARCTIC BED, PONDER'S END.