APPENDIX VI.—*The* NON-MARINE MOLLUSCA *of* CLACTON-ON-SEA.

By ALFRED SANTER KENNARD, F.G.S., and BERNARD BARHAM WOODWARD, F.L.S., F.G.S.

An account of the non-marine mollusca of Clacton based on the known collections was published by us in 1897,[1] when we were able to record sixty-one species; but of these fifteen were unconfirmed records. Since then Dr. Frank Corner has kindly sent us a small series principally obtained from the estuarine bed, while the extensive collection of the late Dr. Henry Woodward has passed into our keeping. From this additional material we were able to raise the total number of known species to sixty-seven.

We are greatly indebted to Mr. S. Hazzledine Warren for placing at our disposal the results of his systematic exploration of these beds. The number of known species is now eighty-two, the longest list from any English Pleistocene deposit. One species, *Vertigo pusilla* Müller, although recorded by S. V. Wood,[2] we have omitted, since there are no examples extant. In the following table we have indicated in the first column the results of previous work, while the remainder show the frequency of each species in the various layers recognized by Mr. Warren.

TABLE OF DISTRIBUTION OF THE NON-MARINE MOLLUSCA.

[R=rare; C=common.]	Former Collections.	*l*	*q*	*r*	*w*	Nut-Bed.	*x*	*y*	*y**	*z*
Limax maximus Linn.	...	R	...	...	...	...	...	...	...	R
L. arborum Bouch.-Chant.	...	...	...	...	R	...	R	R		
Vitrea crystallina (Müller)	R	...	...	...	...	...	...	R	...	R
Helicella cellaria (Müller)	...	...	...	...	...	...	...	R		
H. nitidula (Draparnaud)	...	...	...	R	...	...	...	R		
H. radiatula (Alder)	R	R	R	R	...	...	R	R	...	R
Zonitoides nitidus (Müller)	R	...	...	R	R	...	C	R		
Z. excavatus (Alder)	R	...	R	R	...	...	...	R		
Petasina fulva (Müller)	R									
Arion sp.	R									
Punctum pygmæum (Draparnaud)	...	...	R	...	...	...	R	...	...	C
Goniodiscus rotundatus (Müller)	R	...	...	R	...	...	...	R		
G. ruderatus (Studer)	R	...	R	R	...	...	R	R	...	R
Jacosta itala (Linn.)	...	...	...	R	...	...	...	R		
J. crayfordensis (Kenn. & B. B. Woodw.)	R	R	R	C	...	...	...	R	R	R
Fruticicola hispida (Linn.)	C	R	C	C	R	...	C	C	R	C
Acanthinula aculeata (Müller)	R	...	...	...	...	...	...	R	...	R
Vallonia pulchella (Müller)	C	...	C	...	C	...	C	C	...	C
V. excentrica Sterki	C	R	R	R	C	...	R	C	R	R
V. costata (Müller)	C	...	C	R	C	...	C	C	...	C
Chilotrema lapicida (Linn.)	R	...	...	R						
Arianta arbustorum (Linn.)	R	...	R	...	...	...	...	...	...	R

[1] 'Essex Naturalist' vol. x, pp. 97–100.

[2] 'Monogr. Crag Moll.' vol. ii, Pal. Soc, 1856, pp. 307–10.

[R = rare; C = common.]	Former Collections.	*l*	*q*	*r*	*w*	Nut-Bed.	*x*	*y*	*y**	*z*
Helix nemoralis Linn.	C	R	R	R	...	...	R	R	...	R
H. hortensis Müller	R									
Ena montana (Draparnaud)	R	...	...	R						
Cochlicopa lubrica (Müller)	R	...	R	R	R	...	R	R	...	C
Azeca goodalli (Férussac)	R	...	...	R	...	...	...	R	..	R
Pupilla muscorum (Linn.)	R	...	R	R	C	...	R	...	...	C
Vertigo antivertigo (Draparnaud)	R	...	...	...	...	...	...	R	...	R
V. pygmæa (Draparnaud)	R	...	...	...	...	...	...	R		
V. moulinsiana (Dupuy)	R									
Columella edentula (Draparnaud)	R									
Truncatellina cylindrica (Férussac)	...	...	...	...	R	...	...	...	...	R
Clausilia rugosa Draparnaud	R	R	...	...	R					
C. ventricosa Draparnaud	R	...	...	R	...	...	R	R	...	R
Succinea pfeifferi Rossmässler	C	...	R	R	C	...	R	R	...	R
Carychium minimum Müller	R	...	R	...	R	...	R	R	...	C
Ancylus lacustris (Linn.)	R	R								
Ancylastrum fluviatilis (Müller)	C	R	C	R	C	...	R	C	R	
Limnæa auricularia (Linn.)	R	R	...	R	...	R	R	R	R	
L. pereger (Müller)	C	R	C	C	C	R	C	C	R	C
L. palustris (Müller)	R									
L. truncatula (Müller)	C	...	...	R	C	...	C	R	...	C
L. stagnalis (Linn.)	R	...	...	...	...	...	R			
Planorbis albus (Müller)	C	R	C	C	C	R	C	C	...	C
P. lævis Alder	R	...	...	R	...	...	...	R		
P. crista (Linn.)	R	R	C	R	C	...	C	C	...	C
P. carinatus (Müller)	C	R	...	R	C	...	R	C	R	
P. planorbis (Linn.)	R	...	R							
P. vortex (Linn.)	...	...	...	...	...	...	...	...	...	R
P. leucostoma Millet	R	...	R	R						
P. contortus (Linn.)	R	...	R	R	...	...	R	...	...	R
P. complanatus (Linn.)	R	...	..	...	R	...	R	R	...	R
Segmentina nitida (Müller)	R	...	...	...	...	...	R			
Physa fontinalis (Linn.)	...	...	...	R	...	...	...	..	...	R
Aplexa hypnorum (Linn.)	...	...	...	...	...	...	...	R		
Belgrandia marginata (Michaud)	C	C	R	R						
Paladhilia radigueli (Bourguignat)	C	R								
P. deani (Kendall)	R									
Pseudamnicola confusa (Frauenfeld)	R									
Bithynia tentaculata (Linn.)	C	C	C	C	C	C	C	C	R	C
B. leachi (Sheppard)	...	...	...	...	R	...	R	C	...	R
Vivipara diluviana (Kunth)	R									
Valvata piscinalis (Müller)	C	C	C	C	C	R	C	C	...	C
V. antiqua Sowerby	...	C								
V. cristata Müller	R	R	R	R	R	...	R	C	...	C
Unio tumidus Retzius	...	R								
U. littoralis Lamarck	C	R	C	C	C	C	C	C		
Anodonta anatina (Linn.)	R	...	...	...	...	...	...	R		
Corbicula fluminalis (Müller)	R									
Sphærium corneum (Linn.)	C	C	C	C	C	R	C	C	...	R
Pisidium amnicum (Müller)	C	C	C	C	C	R	C	C	R	C
P. astartoides Sandberger	C	C	R	C	R	...	R	R	...	R
P. cinereum Alder	C	...	C	...	...	...	C	C	R	C
P. nitidum Jenyns	C	R	R	R	...	...	C	R	R	C
P. personatum Malm	R									
P. pusillulum B. B. Woodw.	C	...	C	C	R	...	C	R	R	R
P. milium Held	R	...	R	R	...	...	R	R		
P. subtruncatum Malm	C	...	C	R	C	...	C	C	...	C
P. henslowanum (Sheppard)	C	C	C	C	C	R	C	C	C	C
P. supinum A. Schmidt	R	R	...	R						
P. obtusalastrum B. B. Woodw.	...	...	...	...	...	...	R			
Totals 82	68	28	36	44	30	9	41	49	13	41

From the estuarine bed three species were obtained, namely :—

Paladilhia radigueli (Bourguignat) common,
Vivipara diluviana (Kunth) rare,
Corbicula fluminalis (Müller) rare,

as well as two marine species, namely :—

Scrobicularia plana (Da Costa).
Cardium edule Linn.

Thus sixteen new records are added to the list, while eight known species were not represented in Mr. Warren's collection.

Notes on the Species.

Limax.—Hitherto no species of *Limax* has been recorded from Clacton. Why this genus should be so rare in this deposit is puzzling, for, as a rule, it is quite common in Pleistocene beds.

Zonitoides excavatus (Alder).

An extremely rare form in the Pleistocene, Dog Holes, Warton (Lancashire), is the only other record. It is unknown living in Essex, though it is known from the early Holocene of Copford and Chignal St. James.

Fruticicola hispida (Linn.).

This species is represented by the large flat form, so common at Woodston (Huntingdonshire), to the total exclusion of the high-spired *liberta* (Westerlund). It is, however, possible that the *Helix conoidea* Sowerby [1] may be *liberta*, although we have seen nothing from Clacton that in any way resembles Sowerby's species. In the collection of Dr. Henry Woodward were several examples of a high-spired *hispida* labelled 'Clacton', which came from the same source as the shells described by G. B. Sowerby: namely, John Brown, of Stanway.

The locality ascribed to Dr. Woodward's examples is certainly incorrect, for they are manifestly from Grays. Is it possible that a similar mistake was made in the specimens described by G. B. Sowerby?

In the early days of Geology the importance of recording the exact locality of specimens was too often not recognized, while the rivalry of collectors was frequently the cause of wrong localities being attached to specimens.

Ena montana (Draparnaud).

The southernmost record for this species in the Pleistocene; Woodston, Orton Waterville, and the Cambridge gravels being the only other localities.

[1] Ann. Nat. Hist. vol. vii (1841) p. 429.

Clausilia ventricosa Draparnaud.

Originally recorded from the Pleistocene of Woodston,[1] it has since been recognized from Orton Waterville and Apethorpe. Probably the early records of *Clausilia biplicata* (Montagu) from Grays also really refer to this species.

Limnæa auricularia (Linn.).

The small inflated form so characteristic of the Pleistocene deposits alone occurred. This is quite unknown living in England, although we have seen examples from Germany as var. *monnardi* Hartmann.

Limnæa truncatula (Müller).

As in all Pleistocene beds, the examples of this species are small; the large form so common in the Holocene and living is quite unknown in the Pleistocene.

Paladilhia radiguelli (Bourguignat).

This species occurred only, and that but rarely, in Bed *l*, though it was common in the Estuarine Bed. From this one might infer that it was a brackish-water form, yet it occurred commonly in the freshwater deposit of Grays, and rarely at Swanscomb, Crayford, and Ilford. The closely-allied form, *P. deani* Kendall, hitherto only known from Woodston and Orton Waterville also occurred, but its exact horizon is unknown.

Pseudamnicola confusa (Frauenfeld).

Hitherto unrecorded from Clacton, it is a rare species in the Pleistocene: Stutton, West Wittering, and Stone being the only other localities.

Bithynia tentaculata (Linn.).

The most abundant species in these beds, but none of the examples attain the size of recent and Holocene examples.

Viviparа diluviana (Kunth).

Clacton and Swanscomb are the only English localities for this interesting species, which is said to be still living in the South of Russia. This is the *Paludina clactonensis* S. V. Wood.[2] Though it was found by Mr. Warren only in the Estuarine Bed, we have seen examples which from their condition probably came from Bed *l*. Judging from the preservation of all the examples, there is a strong probability that they are derivatives from a yet older bed.

[1] Journ. of Conch. vol. xiv (1913) pp. 83 & 89.

[2] 'Monograph of the Crag Mollusca' 2nd Suppl. p. 69 & pl. i, figs. 4 *a* & 4 *b*.

VALVATA ANTIQUA Sowerby.

This species occurred, not uncommonly, only in Bed *l*, and, if we judge from their condition, the specimens found are certainly derivatives. This is an early Pleistocene form known only from Grays, Kelvedon, Hoxne, and Swanscomb. It has hitherto never occurred with *Valvata piscinalis* (Müller), and in this case the two species are assuredly not contemporary.

UNIO LITTORALIS Lamarck.

This form attains its maximum of size in these beds, one pair in the British Museum (Natural History) measuring $69 \times 47 \times 28$ mm. Crayford examples come next in size, while the shells from Barnwell, Swanscomb, and Peterborough are much smaller. This is merely the result of environment, for the species prefers mud to gravel.

CORBICULA FLUMINALIS (Müller).

Decidedly rare at Clacton, and apparently occurring only in the Estuarine Bed. There again the condition of the specimens leads one to infer that they are derivatives.

ANODONTA ANATINA (Linn.).

A rare Pleistocene fossil, the only other locality for it being Grays.

Conclusions.

Though we have always borne in mind the probability that a river-deposit might contain derivatives, and thus lead to confusion, this is the first instance in which we can say definitely that this is exactly what has occurred. Besides the three species that we have already claimed as derivatives (*Valvata antiqua*, *Vivipara diluviana*, and *Corbicula fluminalis*) there are examples of *Limnæa peregra* and *Bithynia tentaculata* which we would place in the same category; but, since there are abundant contemporary examples of these two species, no confusion is likely to arise. In all probability, these derived specimens have been washed out of an early Pleistocene deposit of the same age as Swanscomb: that is, High Terrace of the Thames. As further evidence in support of our view, we may mention that Bed *y* yielded rolled examples of two marine species, *Purpura lapillus* (Linn.) and *Nucula* sp., as well as three indeterminable examples which are probably of Eocene age.

These beds are clearly of one age, and no great interval of time separates the highest from the lowest. In our opinion they belong to the same Pleistocene stage as the Woodston, Orton Waterville, Barnwell Abbey, Grantchester, Ilford (Uphall), West Wittering, and Stutton deposits. In several of these there can be read the same physical history.

The gradual elevation of the land which had been proceeding, doubtless intermittently, since early Pleistocene times received a temporary check, and a slight reverse movement set in, thus enabling the sea to regain for a short interval part of its old domain.

The Woodston, Orton Waterville, West Wittering, Clacton, and probably the Ilford deposits, all show freshwater beds succeeded by estuarine. Possibly the remaining localities were too far inland to show marine influence.

The Clacton deposit is thus later than the older brick-earths of Grays, and older than the Crayford deposits, and may well be termed Mid-Pleistocene.

As to the climate, this must have been very similar to that of the present day, though possibly rather more genial.

Discussion on the two foregoing Papers.

Prof. W. J. Sollas complimented the Author on the importance of his discoveries, and remarked that Essex, as represented by Mr. Reid Moir and the Author, was doing much to remove the reproach which might at one time have been made against British geologists of being rather behindhand in these matters.

The beautiful Chellean implement, with its dagger-like blade, evidently marked a different horizon from that of the overlying gravels which yielded a 'cold' fauna. The discovery of greatest importance would appear to be the presence of alleged Mesvinian implements beneath a late Acheulean horizon. These implements are good examples of the Mousterian industry, and recall the 'warm' Mousterian implements of Commont, which similarly occur in an anomalous position.

Since the 'Mesvinian' of M. Rutot was originally regarded as pre-Chellean, it might be better to restrict the use of that term to Belgium, although there also the horizon, as shown by Commont, seemed to be Acheulean. The technique of the Essex implements is, however, markedly superior to that of the Mesvinian, and they might be described as Mousterian implements on a possibly Mesvinian horizon.

The replacement of the Acheulean by Mesvinian in Belgium and the re-appearance of the Acheulean in Essex after a stage of the Mousterian industry, would seem to indicate the contemporaneous existence of two races (possibly *Eoanthropus* and *Homo neandertalensis*) which, perhaps under the influence of climatic changes, encroached on each other's hunting-grounds.

Mr. W. Whitaker said that the geological survey of the Clacton district was carried out, under his supervision, about half a century ago. Personally, he mapped only the less interesting tract east of Clacton; while the more interesting beds west of Clacton were carefully noted by Mr. W. H. Dalton, who mapped that part. The work having been done so long ago, it was clearly time that the district should be again examined, and fresh sections

noticed, and he hoped that the Author would continue his work there. Coast-sections were liable to change, and needed constant observation.

He was glad to note Mrs. Reid's remarks as to the relations of the Clacton deposit with the Forest-Bed of the Norfolk coast. On stratigraphical grounds he held that the latter was the older, and it was satisfactory that in this case stratigraphy and palæobotany were in agreement.

Mr. W. JOHNSON suggested that, in view of the general character of the fauna and flora of the Lea-Valley deposits, boreal would be a better term than Arctic, and that the latter term might be reserved as an equivalent for Glacial. Where did the Author place the dividing-line between the Pleistocene and the Holocene? Was the presence of the Mammoth deemed sufficient to class a deposit as Pleistocene? He thought that the Admiralty section at Spring Gardens might be considered as marking the commencement of a cold period, which lasted throughout the time when the buried channel was eroded, and during the infilling of the greater portion of that channel, the Ponders End deposit coming near the close. After the Ponders End deposit came further slight subsidences, indicated perhaps by the Hackney-Wick section. With respect to the Mesvinian implements, they seemed to represent types which are found in several periods, and, unless associated as a group, they would require further investigation before the date assigned could be accepted.

Dr. R. L. SHERLOCK mentioned that recently he had mapped a considerable area of clay at Cheshunt, in the Lea Valley. The clay, which appeared to be within the flood-plain terrace, was in part blue and in part black, the latter burning white as if the blackness were caused by organic matter. Unfortunately, only a very poor section had been seen, as the outcrop was built over, and evidence was obtainable solely from well-records.

The clay, which has not yielded fossils, is usually from 2 to 3 feet thick, although in one case there was over 14 feet of it. He asked the Author whether this clay was likely to be the Arctic Bed of Ponders End.

Mr. G. W. LAMPLUGH asked whether the Author had found any evidence bearing on the relationship of the Clacton and Ponders-End deposits to the products of the great glaciation which were recognizable a little farther north.

Prof. P. G. H. BOSWELL said that, according to the plant-remains, the Clacton deposits were to be correlated rather with those of Selsey than with the Cromer Forest-Bed, whereas the mammalian remains seemed to recall the Cromer Forest-Bed. It was indubitable that the Cromer Forest-Bed was earlier than the first great till of the East of England.

The AUTHOR thanked the Fellows for their favourable reception of his paper. He was glad that Prof. Sollas agreed with the Mousterian affinities of the flint-industry, which however, as a whole, was much more primitive than a true Mousterian industry,

such as that of the Stoke Newington 'floor'. But it exactly filled the place of a precursor of that industry.

In reply to Mr. Johnson, he agreed that the climate of the Arctic Bed was not an extreme Arctic one. It was always difficult to draw sharp boundaries, but he thought that all British deposits yielding contemporary Elephant and Rhinoceros should be classed as Pleistocene. He was a little puzzled by the Admiralty section; and would like to re-examine it in the light of the comparative evidence now available.

He thought it extremely probable that the clay in the flood-plain gravel referred to by Dr. Sherlock represented the same Arctic Bed; but it would, of course, need examination.

In reply to Mr. Lamplugh's question, he had not found any direct evidence of the relation of the Clacton bed to the Glacial deposits; but the higher-terrace gravels with Chellean implements contained erratics probably derived from the Boulder Clay, while the Clacton bed occupied a tributary channel which was trenched through the plain of that higher terrace.

With reference to the question raised by Prof. Boswell, the mammalia of the Clacton bed were very different from those of the Forest-Bed; in the Author's opinion, *Elephas meridionalis*, *Rhinoceros etruscus*, and their associates, which characterize the Forest-Bed, were definitely pre-Chellean.