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ORIGINAL ARTICLES.

I.—THE BRITISH FOSSIL SHREWS.

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(PLATE XXV.)

REMAINS of Shrews have long been known to occur in the Norfolk 'Forest Bed', and have been discovered in several British Pleistocene deposits. Hitherto they have been referred to one or other of the three species at present inhabiting this country, but having had occasion lately to examine nearly all the available material, comprising representative series of specimens from each of the known horizons, I find that it is not until we reach the latest Pleistocene deposits that we meet with remains of species indistinguishable, with the material before us, from the living British forms.

The Shrews are low Placentals specialized in two ways, viz., (1) for an insectivorous diet, and (2) to a smaller degree for a subterranean existence. They have been divided into two groups:¹ *Soricinæ*, in which the teeth are more or less extensively stained with a reddish-brown pigment; *Crocidurinae*, in which the teeth are quite white. All the British species, fossil and recent, so far discovered belong to the first group; and so far as the characters of the fossil forms are known they are all referable to one or other of the two living British genera, *Sorex* and *Neomys*.

Sorex stands on a slightly lower plane than *Neomys* in most respects.² It retains one more premolar above; in the large lower incisor three or four of the denticles primitively present upon the crowns of mammalian incisors persist until an advanced stage of wear has been reached³; and the condyle of the lower jaw and the glenoid articulation of the skull, although differing much from the normal mammalian type, are a little less highly modified. In the small size of most of the species, their external characters, and the form of the skull and humerus, we see the effects of an adaptation to life underground.

¹ Dobson, Proc. Zool. Soc., 1890, p. 49. Winge suggested this classification many years before (*Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 138).

² The best account of the skull of the Shrews and of their relationships is to be found in the following works of Winge: "Om Muldvarpens og Spidsmusenes Cranier og Spidsmusenes systematiske Stilling," *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 115; "Om Græske Pattedyr," *ibid.*, 1881 (1882), p. 12; "Pattedyr," *Danmarks Fauna*, 1908, pp. 14-16, 22-7.

³ Owen, *Anatomy of Vertebrates*, vol. iii, p. 306, 1868.

Neomys has gone a little further, and, in adopting an aquatic habitat, in a different direction, which has to some extent influenced its external characters. A premolar has been lost above; the large lower incisor has been simplified—only one of the primitive denticles, in addition to that forming the point of the tooth, persisting; and the peculiar modification of the mandibular condyle, and the glenoid cup into which it fits, has proceeded further.

The mandible offers good characters for the determination of the fossil species, and of the earlier British forms little more is known. The strange features presented by the articulation of the lower jaw with the skull in the Shrews were first described by Cuvier,¹ and more fully by Winge² and Parker.³ The mandibular condyle bears two facettes, an upper and a lower, widely separated by a non-articular tract of bone, and which correspond with two facettes upon the squamosal. In *Sorex* (Figs. 7a–14a) the middle non-articular region is as broad as, or broader than, the superior facette, and the lower facette is not prolonged lingually. In *Neomys* the non-articular region is much narrowed, so that it appears on the posterior view of the condyle as a slender rod of bone connecting the two facettes, the lower facette having in addition a great lingual prolongation (Figs. 1a–4a). In *Sorex* the *foramen ovale* passes forward between the squamosal and alisphenoid, its mouth, wholly concealed by a process of the squamosal, lying internally to and a little below the lower glenoid facette.⁴ In *Neomys* the lingual extension of the lower glenoid facette prevents the *foramen ovale* from opening so far forwards; it therefore has its mouth behind the glenoid cup, and is completely visible on the lower view of the skull.⁵

SOREX.

Dental formula : $i. \frac{1.2.3}{1} \quad c. \frac{1}{1} \quad p. \frac{4.3.1}{1} \quad m. \frac{1.2.3}{1.2.3} = 32.$ ⁶ Lower incisor with three or four long persistent denticles. Middle non-articular part of condyle not reduced in breadth, lower condylar

¹ Cuvier, *Leçons d'Anatomie Comparée*, 2nd ed., t. ii, p. 323, 1837.

² Winge, *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, pp. 119, 121, etc.

³ Parker, "On the Structure and Development of the Mammalian Skull."—Part III, Insectivora: *Phil. Trans.*, pt. i, pp. 213–15, pl. xxxi, figs. 3, 3a, 10, *cd. p.*, *gl. c.*, 1885.

⁴ Parker, *op. cit.*, p. 217, pl. xxxi, figs. 2, 3.

⁵ Winge, *op. cit.*, p. 134, fig. 6; Parker, *op. cit.*, p. 217.

⁶ Notwithstanding the fact observed by E. Brandt, viz. that the premaxilla holds four teeth, I prefer to follow Winge and regard the last of these teeth as the canine, and not as inc. ⁴—a tooth quite unknown among Placentalia. The premaxilla has grown that it may accommodate the enlarged first incisor, and in so doing it has embraced the vestigial canine. There is nothing more remarkable in this than there is in the fact that the upper incisor of most rodents bursts through the premaxilla behind and attains a seat in the maxilla. The transgression in either case receives a physiological explanation (see Winge, "Jordfundne og Nulevende Pungdyr fra Lagoa Santa," *E Museo Lunds*, ii (11), p. 122, *Anm.* 39, 1893; *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1881, pp. 12, 13, and 1882, p. 65). I also prefer to write the premolar formula in Hensel's way ("Ueber Hipparion Mediterraneum," *Abhand. Königl. Akad. Wiss. Berlin*, 1860, p. 78). From the excessive reduction of the tooth here called p. ³ we may infer that the missing tooth in *Sorex* is p. ².

facette without lingual prolongation, *foramen ovale* not visible on lower view of skull.

The genus occurs in the Forest Bed and later British deposits. With the exception of *S. savini* all the fossil species are small, forms not exceeding *S. araneus* in size.

SOREX SAVINI, n.sp. (Pl. XXV, Figs. 6, 7, and Text-fig. 7a.)

Sorex remifer, Owen, *British Fossil Mammals*, 1846, p. 28, fig. 14, No. 3.

S. vulgaris, Newton, *Vertebrata Forest Bed*, 1882, p. 97, pl. xv, figs. 5-8;

Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382.

"*Sorex*, large species" Newton, op. cit., p. 97, pl. xv, figs. 13, 14.

Crossopus remifer, Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.

[While this paper has been passing through the press the names of the new species (herein fully described for the first time) have been published in Barrett Hamilton's *History of British Mammals*, parts viii and ix, September and November, 1911, pp. 80, 125.]

Material examined.—(1) Two mandibular rami, left and right, the latter the specimen figured by Owen (loc. cit. sup.) from the Upper Freshwater Bed at Ostend (Green Coll., B.M., Nos. 17653 and 15949a); (2) two right rami and two fragmentary maxillæ, figured by Newton (loc. cit. sup., pl. xv, figs. 5-8), in the Museum of Practical Geology; (3) seven rami (five with posterior end) and several maxillæ in the Savin Coll. (B.M. 6154 and 6157); (4) fifty-four rami (thirty-eight with posterior end) and several maxillæ in Mr. Savin's private collection; (5) posterior part of a right ramus in my own collection; in addition numerous limb-bones. Excepting the specimens in the Green Collection the whole of this material was obtained from the Upper Freshwater Bed at West Runton.

Characters.—Size large (the dimensions of the remains of this and other species are given in the tables of measurements at the end). Mandible (Figs. 6, 7, 7a): coronoid process large and stout, its upper border broad and round, its outer surface having posteriorly a well-marked and extensive fossa for insertion of the tendon of the lower part of the temporal muscle and fibres from the separate horizontal muscular band which runs below the temporal; condyle very massive. Teeth stained deeply from summit to external cingulum; the latter well developed. Incisor (seen in seven jaws) as in recent *Sorex*, with four denticles and three notches in moderately worn specimens—the two posterior notches are the deeper ones. Skull: known at present only from maxillary fragments; posterior border of infra-orbital canal above front edge of m. ¹; lachrymal foramen over middle of m. ¹. Two specimens (S.C. B.M. 6157 and S.C. 637.5)¹ show that there were five unicuspid teeth as in recent *Sorex*. Two specimens (S.C. B.M. 6157 and S.C. 637.7) have the three posterior unicuspid teeth in place and one or more are seen in several other fragments. The unicuspid teeth decrease in size regularly from before backwards as in *S. minutus* and *S. alpinus*; p. ² projects beyond cingulum of p. ¹, it is entirely visible externally and, although

¹ 'S.C. B.M.' means 'Savin Collection, British Museum'; 'S.C.' means the more recently formed private collection of Mr. Savin.

shorter antero-posteriorly, a little wider than either p. ⁴ or the canine. Cheek-teeth (p. ¹—m. ³) essentially as in recent *Sorex*; posterior emarginations of first three (p. ¹—m. ²) considerably shallower than in *S. araneus*—a feature well seen in Newton's figures (op. cit., pl. xv, figs. 5, 6).

The larger limb-bones from the Forest Bed are clearly referable to *S. savini*. The humerus (five complete examples before me) differs importantly from that of *S. araneus* in that the ridges for the insertion of the pectoral, deltoid, and *teres major* muscles descend to a much lower point upon the shaft (*vide* Newton's figure, op. cit., pl. xv, fig. 14). Length of humerus, 9.2–10.1 mm.

Remarks.—Science owes much to Mr. Savin's careful collecting from the Forest Bed, and personally I am indebted to him for the extreme liberality with which he has placed his material at my disposal. I have therefore great pleasure in naming this fine Forest Bed species in his honour. *S. savini* is distinguished as the largest British Shrew hitherto discovered, and it is only known from the Upper Freshwater Bed.

SOREX RUNTONENSIS, n.sp. (Pl. XXV, Figs. 8, 9, and Text-fig. 8a.)

Crossopus fodiens, Owen, *Brit. Foss. Mam.*, 1846, p. 28, fig. 14, No. 1; Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.

Sorex pygmaeus, Newton (in part), *Vert. For. Bed*, p. 97, pl. xv, fig. 11, 1882.

Material examined.—Mandibulae: (1) two left rami from Upper Freshwater Bed, Ostend (Green Coll., B.M. 17653a and 15949), the first specimen being that figured by Owen (loc. cit. sup.) and referred by him to *Crossopus fodiens*—the characters of the condyle and incisor clearly show it to be referable to *Sorex* and not *Neomys*; (2) two rami in the Museum of Practical Geology, of which one was figured by Newton (loc. cit. sup.); (3) a left ramus in Savin Coll. (B.M. 6154); (4) thirty-two rami in Mr. Savin's private collection. All the specimens enumerated have either the condyle or else the incisor in place; all come from the Upper Freshwater Bed, and, excepting the two in the Green Collection, from West Runton.

Characters.—Size small, but considerably larger than *S. minutus*. Mandible (Figs. 8, 8a, 9): coronoid process slender and pointed above; condyle very light, its vertical diameter conspicuously less than the antero-posterior length of ascending ramus at level of molars. Incisor when unworn with four denticles and three notches, the two posterior notches persisting until an advanced stage of wear. Teeth stained extensively.

Remarks.—When determining remains of Shrews from the Forest Bed there cannot be any confusion between those appertaining to the species here named *S. runtonensis* and those of the far larger and very different *S. savini*. In size the lower jaw of *S. runtonensis* is intermediate between those of *S. araneus* and *S. minutus*, and it is distinguished from either by the form of the coronoid process, condyle, etc., as will be best appreciated from the figures and measurements. *S. runtonensis* is known only from the Upper Freshwater Bed.

SOREX sp. (Pl. XXV, Fig. 10, and Text-fig. 10a.)

Sorex vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Among the Shrew remains collected by Mr. Kennard and the writer from the Middle Terrace brickearth of Grays Thurrock are a posterior half of a left ramus, several still more fragmentary rami, and some imperfect humeri of a species of *Sorex*. In size this Middle Terrace form is smaller than *S. araneus*, the difference being quite noticeable in the lower jaw and still more marked in the humeri. The posterior end of the jaw (Figs. 10, 10a) offers some differences in the form of the coronoid process and condyle. The fossa for the insertion of the lower part of the temporal muscle, etc., on the outer surface of coronoid process, is absolutely larger than it is in the bigger jaw of *S. araneus*; the superior articular facette is reduced transversely. The teeth have a weak cingulum externally; the staining appears to have been quite weak because little trace of it can be seen in the only moderately worn teeth of the figured specimen, although the colour is well preserved in the teeth of the species of *Neomys* occurring in the same deposit.

I have no doubt that this Middle Terrace Shrew is distinct specifically from any of the other forms described in this paper. I refrain from naming it because the material is so scanty.

SOREX KENNARDI, n.sp. (Pl. XXV, Fig. 11, and Text-fig. 11a.)

Material examined.—Anterior part of a skull and both mandibular rami of one individual from the Third Terrace drift of the Lea Valley at Ponders End, Middlesex.

Characters.—Size distinctly smaller than *S. araneus*, larger than *S. minutus*. Apart from its smaller size there is little to distinguish what is left of the skull from that of *S. araneus*; the mesopterygoid fossa is proportionately broader, and does not narrow behind. The incisors and unicuspid have unfortunately dropped out, but the alveoli show that the latter were five in number, and, apparently, that they decreased in size regularly from before backwards as in *S. alpinus* and *S. minutus*, and not in rough pairs as in *S. araneus*. The cheek-teeth, p. ¹—m. ², have the posterior emargination less deep than in *S. araneus*. The mandible (Figs. 11, 11a) is distinguished by its form and size; condyle agrees better with *S. minutus* and *S. alpinus* in form than with *S. araneus*.

Remarks.—We owe the discovery of the specimen here described to the keen eye of Mr. A. S. Kennard, who obtained it on the occasion of a visit of the Geologists' Association to the very important section at Ponders End.¹ I am unable to refer it to any known species, and have great pleasure in naming this form after my friend, to whom I am indebted in so many ways.

¹ Warren, *Nature*, vol. lxxxv, p. 206, 1910; *Proc. Geol. Assoc.*, vol. xxii, p. 168, 1911.

SOREX ARANEUS, Linn. (Pl. XXV, Fig. 12, and Text-fig. 12a.)

Sorex araneus, Linnæus, *Systema Natura*, x, 53, 1758.

S. vulgaris, Linnæus and most recent authors; Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382 (Kent's Hole and Teesdale Caverns; material not seen by me); Newton, Q.J.G.S., vol. 1, p. 192, pl. xi, fig. 1, 1894 (Ightham Fissures); Jackson, *Lancashire Naturalist*, 1910 (Dog Holes, Warton Crag).

S. araneus, Dorothea Bate, *GEOL. MAG.*, Dec. IV, Vol. VIII, p. 103, 1901 (Wye Cave; material not seen by me).

Material examined.—Fossil: (1) three nearly perfect and more than a score of fragmentary skulls and numerous mandibulæ from the Ightham Fissures (in the collections of Dr. Frank Corner and myself); (2) one perfect and several fragmentary skulls and many mandibulæ from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) six fragmentary skulls and a left ramus from the submerged forest at Leasowe (B.M. M. 7593); (4) a left ramus from the Holocene of Worm's Heath (B.M., presented by Mr. R. H. Chandler). I have studied this material with skulls of twenty-eight recent specimens of *S. araneus* in my own collection, from West Wickham and Ightham in Kent, Wanstead, Essex, and West Runton, Norfolk.

Remarks.—Ightham Fissures: The three nearly perfect skulls of which the dimensions are given in Table I are a trifle smaller than are those of recent *S. araneus*, but among the fragmentary specimens there are many larger ones; forty-one mandibulæ were carefully measured (results summarized in Table II), and give a range of variation similar to that of the recent specimens. I am unable to distinguish these remains from *S. araneus*. Dog Holes: The perfect skull is remarkable for the great breadth of brain-case; the lower jaws (twelve measured) agree with those of *S. araneus*. Two others, with lengths of 8·9 and 9·1 mm., may indicate the presence of *S. kennardi* in this cave, but more material is required. Leasowe and Worm's Heath (Holocene): The remains from these deposits are referable to *S. araneus*, and call for no comment.

S. araneus is not known from any deposit in Britain of greater antiquity than the latest part of the Pleistocene period.

SOREX MINUTUS, Linn. (Pl. XXV, Fig. 14, and Text-fig. 14a.)

Sorex minutus, Linnæus, *Systema Naturæ*, xii, 73, 1766.

S. pygmaeus, Laxmann, *Sibirische Briefe*, lxxii (ed. Schlözer, 1769); Newton, Q.J.G.S., vol. 1, p. 192, pl. xi, fig. 2, 1894 (Ightham Fissures).

Material examined.—Four rami from the Ightham Fissures in the collection of Dr. Frank Corner.

Remarks.—As will be seen from the measurements, these specimens agree in size with the mandibulæ of this species, to which they appear to be referable.

NEOMYS.

Neomys, Kaup, *System der Europäischen Thierwelt*, vol. i, p. 117, 1829.

Crossopus, Wagler, Oken's *Isis* (Jena), 1832, p. 275, and most subsequent authors.

Dental formula: $i. \frac{1 \cdot 2 \cdot 3}{1} c. \frac{1}{1} p. \frac{4 \cdot 1}{1} m. \frac{1 \cdot 2 \cdot 3}{1 \cdot 2 \cdot 3} = 30$. Lower incisor with one persistent denticle. Middle non-articular part of condyle

reduced in breadth; lower condylar facette with extensive lingual prolongation; *foramen ovale* visible on lower view of shell. The genus is represented in the Upper Pliocene Forest Bed and later British deposits by species none of which exceed the living *N. fodiens* in size.

NEOMYS NEWTONI, n.sp. (Pl. XXV, Fig. 1, and Text-fig. 1a.)

Sorex pygmaeus, Newton (in part), *Vert. For. Bed*, 1882, p. 97, pl. xv, fig. 12.

Material examined.—Mandibulæ: (1) left ramus in Museum of Practical Geology figured by Newton (loc. cit. sup.); (2) two right rami in British Museum (Savin Coll., M. 6154); (3) twenty-six rami in Mr. Savin's private collection; (4) two in my own collection. All these specimens were obtained from the Upper Freshwater Bed at West Runton; all of them have the condyle and one has the incisor in place.

Characters.—Size smaller than *Neomys fodiens*. Apart from its small size the mandible (Figs. 1, 1a) differs in form from that of the living Water Shrew; the coronoid process is relatively lower. The condyle viewed from behind is of extreme form, the non-articular part being greatly reduced in breadth; its superior facette reaches proportionately further back than in *N. fodiens*. The humerus figured by Newton (op. cit., pl. xv, fig. 9) is, in all probability, referable to this form.

Remarks.—I have named this species *N. newtoni* in honour of Mr. E. T. Newton, F.R.S., to whom we owe so much of our knowledge of the Forest Bed vertebrata. The species is known only to occur in the Upper Freshwater Bed, and it does not require any close comparison with other forms.

NEOMYS BROWNI, n.sp. (Pl. XXV, Fig. 2, and Text-fig. 2a.)

Sorex? sp. non det., Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 16, 1885.

S. vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Material examined.—Mandibulæ: (1) posterior half of a left ramus from the brickearth of Grays Thurrock (Middle Terrace), in the British Museum (No. 28079, presented by John Brown); (2) part of a right ramus with m. $\frac{1}{1 \text{ and } 2}$ in place, from the same deposit, in the Hinton and Kennard Collection.

Characters.—Mandible a little smaller than that of *N. fodiens*; its coronoid process low and broad; condyle small, its vertical dimension very small for a *Neomys*, and the superior facette very broad (Figs. 2, 2a). Teeth a little smaller than in *N. fodiens*; their outer cusps stained nearly to cingulum; cingulum strongly developed.

Remarks.—This species is named after the late John Brown of Stanway, a careful observer, who discovered and presented the type jaw to the National Collection. *N. browni* is a very distinctive form, recalling *N. newtoni* in the low coronoid process, but differing from all other species in the form of the condyle. It is only known from the Middle Terrace drift of the Thames at Grays.

NEOMYS FODIENS, Schreber.

(Pl. XXV, Figs. 3–5, and Text-figs. 3a, 4a.)

Sorex fodiens, Schreber, *Die Säugethiere*, vol. iii, p. 571, 1777.*Neomys fodiens*, Dorothea Bate, *GEOL. MAG.*, Dec. IV, Vol. VIII, p. 104, 1901 (Wye Cave).

Material examined.—(1) Four mandibular rami (three, including one perfect one, in the Corner Coll., one in Hinton Coll.) from the Ightham Fissures; (2) a left ramus from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) parts of two skulls and a right ramus from the submerged forest of Leasowe (B.M. M. 7593).

Posterior views of condyles of fossil Shrews.

Remarks.—Miss Dorothea Bate has referred “an upper jaw . . . which still retained its full number of teeth”, which she found in the Wye Cave, to this species (*GEOL. MAG.*, Dec. IV, Vol. VIII, p. 104). With this exception all the previous records of *Neomys fodiens* in a fossil state in Britain appear to have been founded on error.

Late Pleistocene: Ightham Fissures and Dog Holes. The mandibulæ (Figs. 3, 3a, 4, 4a) from these deposits have the coronoid process a little lower relatively than in recent jaws of *N. fodiens*, and the condyle appears to be a trifle larger in proportion. They may belong to a distinct form, but with the scanty material before me I should not be justified in separating them from *N. fodiens*.

Holocene: Leasowe. The remains from this deposit agree perfectly with recent *N. fodiens*.

TABLE I. MEASUREMENTS¹ (IN MILLIMETRES) OF SKULLS OF FOSSIL AND RECENT SPECIES OF *Sorex*.

	<i>Sorex araneus</i> .												<i>Sorex kenwardi</i> .	<i>Sorex alpinus</i> , Transylvania. Recent.	<i>Sorex minutus</i> , Clevedon. Recent.		
	PLEISTOCENE.						RECENT.										
	Ightham Fissures, Corner Collection.						Ightham, Kent.									West Runton, Norfolk.	
	(1)	(2)	(3)	Dog Holes, Warton Crag.	(1)	(2)	(3)	(1)	(2)	(3)							
1. Extreme length to front edge of pre-maxillaries	18.7	18	19.1	18.4	19.0	19.4	19.7	19.1	19.3	19.0	—	19.4	15.3				
2. Greatest width of brain-case	8.9	—	—	9.7	9.1	9.8	9.6	9.7	9.7	9.6	—	9.5	7.3				
3. Interorbital breadth	3.7	3.6	3.8	3.5	3.7	3.7	3.8	3.8	3.8	3.5	3.2	4.2	2.8				
4. Malar breadth	5.28	4.95	5.28	5.17	5.28	5.39	5.39	5.39	5.39	5.39	4.62	5.17	4.07				
5. Length of cheek-teeth (i.e. p. 1-m. 3)	4.51	4.4	4.62	4.51	4.62	4.62	4.73	4.51	4.62	4.73	4.18	4.4	3.63				
6. Length of tooth row, excluding inc. 1	6.82	6.6	7.26	6.82	7.26	7.26	7.48	7.26	7.15	7.26	5.94	7.04	5.5				
Reduction 1=100	100	100	100	100	100	100	100	100	100	100	—	100	100				
2 =	47.6	—	—	52.8	47.9	50.6	48.7	50.8	50.3	50.6	—	49	47.7				
3 =	19.8	20	19.9	19.0	19.5	19.1	19.3	19.9	20.7	18.5	—	21.7	18.3				
4 =	28.2	27.5	27.7	28.1	27.8	27.8	27.4	28.2	27.9	28.4	—	26.6	26.6				
5 =	24.1	24.4	24.2	24.6	24.3	23.9	24	23.6	23.9	24.9	—	22.7	23.7				
6 =	36.5	36.7	38	37.1	38.2	37.4	38	38	37.1	38.2	—	36.3	36.0				

¹ The dimensions 4, 5, and 6 of Table I and all those of Table II, with the exception of the length of the lower jaw, were measured with an eyepiece micrometer and 5 inch objective.

TABLE II. MANDIBULÆ OF FOSSIL AND RECENT SPECIES OF
Sorex AND *Neomys*.

	Length, condyle to most anterior point on bone, inner side.	Length of tooth row, excluding incisor $\frac{1}{2}$.	Length of molars (m. 1 to 3).	Height of coronoid process.	Width of coronoid process, condyle to anterior margin.	Height of jaw, inner side, below m. 2.
A. <i>Sorex</i> .						
<i>Sorex savini</i>	11·8	6·05	4·07	5·61	3·74	1·65
	12·0	—	—	5·72	3·85	1·71
<i>S. runtonensis</i> . Fig. 8, Sav. Coll. 731.8 . . .	9·0	4·73	3·41	—	2·64	1·32
„ Fig. 9, Sav. Coll. 636.15 ¹ . . .	8·9	4·73	3·74	3·74	2·64	1·21
<i>S. sp.</i> Middle Terrace, Grays	—	—	—	4·4	2·75	1·32
<i>S. kennardi</i> . Third Terrace, Ponders End . . .	9·0	4·78	3·41	3·85	2·64	1·21
<i>S. araneus</i> . Pleistocene, Ightham Fissures . . .	10·3	5·5	3·85	4·84	3·08	1·54
	9·7	5·06	3·52	4·4	2·75	1·48
„ „ Dog Holes, Warton Crag	10	5·5	3·85	4·4	3·08	1·32
	9·4	5·06	3·57	4·4	2·75	1·32
„ Recent, Ightham	10	5·5	3·85	4·73	3·19	1·48
„ „ West Wickham	10·4	5·5	3·85	4·51	3·08	1·43
	9·7	5·28	3·63	4·51	2·97	1·54
„ „ Wanstead	9·7	5·28	3·63	4·51	2·97	1·32
„ „ West Runton	9·9	5·28	3·74	4·62	3·19	1·32
<i>S. alpinus</i> . Hatzeg, Transylvania	10·1	5·39	3·63	3·74	2·64	1·32
<i>S. minutus</i> . Pleistocene, Ightham Fissures . . .	7·6	4·07	2·97	2·97	1·98	0·77
	7·4	4·18	2·97	3·0	2·09	0·77
„ Recent, Clevedon, Somerset	7·3	4·07	3·13	3·13	2·2	0·99
B. <i>Neomys</i> .						
<i>Neomys newtoni</i> . Upper Freshwater Bed, West Runton	10·4	5·61	3·85	4·07	2·86	1·54
<i>N. browni</i> . Middle Terrace, Grays	—	—	4·29	4·29	2·97	1·54
<i>N. fodiens</i> . Pleistocene, Ightham	10·9	6·16	4·4	4·34	2·86	1·37
„ „ Dog Holes	10·1	—	4·29	4·18	2·75	1·43
„ Recent, West Wickham	11·0	6·16	4·34	4·56	3·08	1·65
„ <i>naias</i> . Recent. Transylvania	11·4	6·38	4·4	4·73	3·19	1·43

The following scheme shows the range in time in Britain of the various Shrews discussed in this paper:—

HORIZON.	SPECIES.
HOLOCENE	<i>Sorex araneus</i> , <i>S. minutus</i> , <i>Neomys fodiens</i> .
PLEISTOCENE	a. Ightham Fissures, <i>Sorex araneus</i> , <i>S. minutus</i> , etc. <i>Neomys fodiens</i> . b. Third Terrace . <i>Sorex kennardi</i> . c. Early Middle Terrace, Grays <i>Sorex sp.</i> , <i>Neomys browni</i> .
LATEST PLIOCENE	Upper Freshwater Bed <i>Sorex savini</i> , <i>S. runtonensis</i> , (Forest Bed Series) <i>Neomys newtoni</i> .

¹ This specimen is remarkable for the unusually large true molars.

M. A. C. Hinton del.

JAWS OF BRITISH FOSSIL SHREWS.

It will thus be seen that so far as our knowledge of the fossil Shrews goes they promise to support, when better known, the classification of the Pleistocene deposits which I put forward in my preliminary account of the Voles and Lemmings. *Sorex araneus* and *Neomys fodiens* do not inhabit Ireland, although *S. minutus* is found there. All three were present in Britain in the closing stages of the Pleistocene period; it may be that *S. minutus* arrived a little earlier than its two larger relatives, or it may have been a little better adapted for so adventurous an enterprise as a late Pleistocene journey to Ireland. In conclusion, I have to thank many friends, and in particular Mr. A. C. Savin and Dr. Frank Corner, for much fossil and recent material.

COMBINED EXPLANATION OF LOWER JAWS, PLATE XXV, AND TEXT-FIGURES OF CONDYLES OF SHREWS.

a = superior, *b* = inferior articular facette of mandible.

FIG.

1. *Neomys newtoni*, Hinton. Inner view of left ramus; 1*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin private collection, No. 631.5.
2. *N. browni*, Hinton. Inner view of left ramus; 2*a*, posterior view of condyle. Pleistocene, Grays Thurrock. B.M. 28079.
3. *N. fodiens* (?), Schr. Inner view of left ramus; 3*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Corner Coll.
4. *N. fodiens* (?), Schr. Inner view of left ramus; 4*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
5. *N. fodiens* (?), Schr. Inner view of left ramus. Pleistocene, Dog Holes, Warton Crag. B.M., Jackson Collection.
6. *Sorex savini*, Hinton. Outer view of left ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.10.
7. *S. savini*, Hinton. Inner view of left ramus; 7*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Hinton Coll.
8. *S. runtonensis*, Hinton. Inner view of left ramus; 8*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.8.
9. *S. runtonensis*, Hinton. Inner view of right ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 636.15.
10. *Sorex* sp. Inner view of left ramus; 10*a*, posterior view of condyle. Pleistocene, Grays Thurrock. Hinton and Kennard Coll.
11. *S. kennardi*, Hinton. Inner view of right ramus; 11*a*, posterior view of condyle. Pleistocene, Ponders End.
12. *S. araneus*, Linn. Inner view of right ramus; 12*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
13. *S. alpinus*, Schinz. Inner view of left ramus; 13*a*, posterior view of condyle. Recent, Hatzeg, Transylvania. B.M., No. 3.11.8.12.
14. *S. minutus*, Linn. Inner view of right ramus; 14*a*, posterior view of condyle. Recent, Clevedon, Somerset. Hinton Coll.

II.—THE UNCONFORMABLE RELATIONSHIP OF THE LOWER TERTIARIES AND UPPER CRETACEOUS OF NEW ZEALAND.

By Professor JAMES PARK, F.G.S.

WITH the question of conformity or unconformity between the Lower Tertiary and Upper Cretaceous, there is associated a problem of great economic importance to New Zealand. The

¹ Hinton, Proc. Geol. Assoc., vol. xxi, p. 497, 1910.