

Mollusca from the Insect Limestone (Bembridge Marls Member: Bouldnor Formation: Solent Group), Palaeogene, Isle of Wight, southern England

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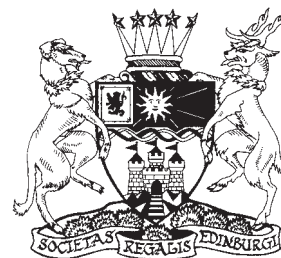
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ABSTRACT: Molluscs from the Insect Limestone of the Bembridge Marls Member are described. The gastropods *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810), *Planorbarius discus* (Edwards 1852), *Gyraulus similis* Férussac, 1814, *Hippeutis headonensis* Jodot, 1942, *Viviparus lentus* (Solander 1766) and *Viviparus angulosus* (J. Sowerby 1817) indicate freshwater alkaline conditions. The cerithioid gastropod *Tarebia acuta* (J. Sowerby 1822) probably represent more brackish conditions. *Polymesoda* (*Pseudocyrena*) *obovata* (J. Sowerby 1817) is the only bivalve present. All were potentially washed into the depocentre. Despite a wide outcrop of the Insect Limestone on the Isle of Wight's northwest and northeast coasts, there are no records of molluscs other than from the Gurnard/Thorness Bay area on the northwest coast of the island.

KEY WORDS: Bivalvia, Gastropoda, Palaeogene

The objective of this paper is to review the molluscs of the Insect Limestone of the Bembridge Marls Member (Bouldnor Formation: Solent Group) and to draw some palaeoenvironmental inferences from those taxa with reference to modern analogues. Many of these fossils have received no systematic treatment for over one hundred years. As their occurrence is limited to just a few specimens from the Insect Limestone, reference has been made to specimens from other horizons in the Solent Group, specifically type material where possible. The Insect Limestone is not a rich source of molluscan fossils; this is despite occurring between shell beds containing a high abundance but a low diversity of mollusc fauna. The adjacent shell beds are dominated by masses of *Tarebia acuta* (J. Sowerby 1822b), *Polymesoda obovata* (J. Sowerby 1817), *Polymesoda convexa* (Brongniart 1810) and less commonly the potamidid *Tympanotonos* (*Eotympanotonos*) *funatus* (Mantell 1820) subspecies 1 of Munt (2005). These taxa are all indicative of brackish water conditions, and the high abundance, combined with low diversity, can be taken to record stressed environmental conditions. Where molluscs occur in the Insect Limestone, the fauna is dominated by the lymnaeid *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810).

Within the Insect Limestone, we can confirm scarce isolated specimens, including *Viviparus lentus* (Solander 1766) and *Viviparus angulosus* (J. Sowerby 1817). *Tarebia acuta* (J. Sowerby 1822b) occurs as scarce isolated specimens; however, there is also a sample at the Natural History Museum (G.24642) which contains *circa* ten specimens in association with the isopod *Eosphaeroma*. This specimen is regarded by Andrew Ross (pers. comm. 2006) as not being from the Insect Limestone lithology. More common are the pulmonate gastropods *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810) and planorbids, including *Planorbarius discus* (Edwards 1852). The corbiculid *Polymesoda* (*Pseudocyrena*) *obovata* (J. Sowerby 1817) is the only bivalve recorded from the Insect Limestone. Records of *Radix pyramidalis minima* (J. Sowerby 1817) (= *Lymnaea minima* J. Sowerby, 1817) in the geological collection of the Isle of Wight Council, refer to juvenile *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810).



Specimens in the same collection assigned to the terrestrial *Palaeoglandina costellata* (J. Sowerby 1822b) have also proved to be *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810), to which it has superficial similarities.

Specimens used in this study are held in two locations. First, within the Palaeontology Department at the Natural History Museum, London; secondly in the Geological Collection of the Isle of Wight Council, care of Dinosaur Isle, Sandown, Isle of Wight. Specimens at the Natural History Museum are from the Hooley Collection, originally found by E. J. A' Court Smith, to whom the publishing of arthropods from the Insect Limestone is first attributed (Jarzembowski 1980). Specimens in the Isle of Wight collection were collected by various people, but include H. F. Poole, J. F. Jackson and A. Yule. The scarcity of gastropod specimens from the Insect Limestone has made it necessary to make reference to, and obtain additional measurements from specimens from other horizons.

Institutional abbreviations. BMDG = British Museum Geology Department. GSM = Geological Survey Museum (British Geological Survey). MIWG = Museum of Isle of Wight Geology, and refers to specimens accessioned prior to 1994. IWCMS = Isle of Wight County Museum Service, and is applied to specimens accessioned after 1994. Specimens at the Natural History Museum, London (NHMUK) are prefixed G and GG.

1. Systematic palaeontology

- Class Bivalvia Linnaeus, 1758
- Subclass Eulamellibranchia Pelseneer, 1889
- Superorder Heterodonta Neumayr, 1883
- Order Veneroida H. & A. Adams, 1856
- Superfamily Corbiculoidea J. E. Gray, 1847
- Family Corbiculidae J. E. Gray, 1847
- Genus *Polymesoda* Rafinesque, 1820
- Subgenus *Pseudocyrena* Bourguignat, 1854

Type species. *Cyrena floridana* Conrad, 1846, by monotypy, Moore (1969) extant from the northern Caribbean.

Diagnosis. Small to medium-sized shells, rounded to trigonal in shape; well developed periostracum; hinge commonly with strong posterior and anterior lateral teeth, usually serrate. Concentric ornament.

Occurrence. Cosmopolitan, Eocene to Recent.

Remarks. Extant corbiculids occur in large numbers often choking water bodies.

Polymesoda (Pseudocyrena) obovata (J. Sowerby 1817)

Plate 1, fig. 1

- 1817 *Cycas obovata* J. Sowerby, vol. 2 p. 140, pl. 192, figs 4, 5–6.
 1822 *Cyrena obovata* (J. Sowerby); de Férussac & Deshayes, pl. 5, figs 2–3.
 1854 *Cyrena obovata* (J. Sowerby); Morris, p. 200.
 1872 *Cyrena (Corbicula) obovata* (J. Sowerby); Sandberger, p. 261 pl. 15 figs 2, a–b.
 1877 *Cyrena obovata* (J. Sowerby); Wood, p. 12, pl. B, figs 3 a–c.
 1891 *Cyrena obovata* (J. Sowerby); Newton, p. 58.
 1901 *Corbicula obovata* (J. Sowerby); Newton, p. 72.
 1966 *Polymesoda (Pseudocyrena) obovata* (J. Sowerby); Glibert & Van de Poel, p. 10.
 1971 *Corbicula obovata* (J. Sowerby); Castell, pl. 11, fig. 1.

Syntypes. NHMUK 43092, Sowerby Collection, Two specimens. However, a third specimen included under the same number excluded from the type series is re-identified herein as *Polymesoda convexa* (Brongniart 1810) from the Woolwich Beds (=Woolwich Formation).

Type locality and horizon. Barton Cliff, 'Barton Clay'.

Referred material. IWCMS.2007.8, from Saltmead, Thorness, Isle of Wight, single right valve.

Diagnosis. Small, equivalved, equilateral, rounded-trigonal in shape. Prominent umbones, height approximately equals length. Posterior margin truncated. Corbiculoid dentition, long serrate laterals.

Distribution. Headon Hill Formation, Bembridge Limestone Formation and Bembridge Marls Member of the Solent Group (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and southwest Hampshire, southern England.

Description. The shell is small and thick, equivalved, equilateral, prosocline, rounded- trigonal in outline shape, inflated. Height, up to 18mm, approximately equals the length. Prominent umbones located towards the anterior of the shell, prosogyrate. The posterior margin, which is truncated/angular to the umbones and ventral margin, is shallowly convex. The ventral margin is shallowly convex, antero-ventral margin convex, antero-dorsal margin concave. The flanks have numerous moderate to strong, regularly spaced growth bands.

The interior of the shell is smooth, the umbonal cavity deep. The pallial line is complete, with a shallow pallial sinus anterior of the posterior abductor muscle. The anterior abductor muscle is large, shallow and oval in shape. The posterior abductor muscle is shallow, large and triangular in shape. The dentition is typically corbiculoid with the formula:

AI AIII 3a 1 3b PI PIII

AII 2a 2b 4b PII

The laterals are serrate, with the anterior laterals approximately half the length of the posterior laterals.

Remarks. This is the most abundant bivalve in the lower part of the Bembridge Marls Member. It occurs as paired, but more frequently disarticulated, valves and rounded fragments. The shells are usually etched. The specimens from the Insect Limestone comprise a single corroded and etched valve and numerous rounded fragments in a single block.

Class Gastropoda Cuvier, 1797

Infraclass Apogastropoda Salvini-Pläwen & Haszprunar, 1987

Superorder Caenogastropoda Cox, 1960

Order Sorbeoconcha Ponder & Lindberg, 1997

Superfamily Cerithioidea Férussac, 1819

Family Thiaridae Troschel, 1857

Genus *Tarebia* H. & A. Adams, 1854

Type species. *Melania granifera* Lamarck, 1822, by subsequent designation by Brot (1874), natural distribution Southeast Asia, southern China.

Diagnosis. Small to medium-sized, turreted, strong axial ribs, which in later growth become dissolved into two or three spiral rows of tubercles, the axial ornament is replaced by strong spiral ribs at the base of the last whorl.

Occurrence. Southeast Asia, introduced into the Caribbean, southern USA and South Africa, extant.

Remarks. Following Brandt (1974) and Glaubrecht (1996) *Tarebia* is treated herein as a genus and not a subgenus of *Melanooides* Olivier, 1804. However, Genner *et al.* (2007), based upon mitochondrial DNA sequences of extant thiarids including *Melanooides* species and *Tarebia granifera*, have concluded that *Tarebia* falls within *Melanooides* and may not be a discrete genus. Moreover, that specimens assigned to *Tarebia* older than Early Pliocene age cannot be unequivocally identified as such, and that *Tarebia* in the Priabonian (and Early Oligocene) requires systematic revision. It is not within the capacity of this work to undertake such a revision. Therefore existing taxonomy is retained herein.

Tarebia acuta (J. Sowerby 1822b)

Plate 1, fig. 3

- 1822b *Potamidus acutus* J. Sowerby, vol. 3, p. 53, pl. 341, fig. 2.
 1856 *Melania muricata* Morris; Forbes, p. 151, pl. iii, fig. 16.
 1856 *Melania muricata* var. *costata* Morris; Forbes, p. 148, pl. ii, fig. 14.
 1889 *Melania (Tarebia) acuta* (J. Sowerby); Vincent, p. cxxix.
 1891 *Melania acuta* (J. Sowerby); Newton, p. 200.
 1909 *Tarebia muricata* S. Wood; Cossmann, p. 134.
 1954 *Melania (Tarebia) acuta* (J. Sowerby); Glibert & Heinzelin, p. 352, pl. v, figs. 16a, b.
 1958 *Tarebia acuta* (J. Sowerby); Castell, pl. 19, figs. 3 & 4.
 1975 *Melanooides (Tarebia) acuta* (J. Sowerby); Castell, pl. 19, fig. 2.

Syntype. BMGD. 43558. Sowerby Collection, Natural History Museum, London.

Type locality and horizon. 'Lower Freshwater Formation' (= Solent Group), Isle of Wight.

Referred material. IWCMS.2007.7 Saltmead, Thorness, Isle of Wight; IWCMS.2003.41 Saltmead, Thorness, Isle of Wight; IWCMS.2007.20 all from Saltmead, Thorness, Isle of Wight; NHMUK G. 24642 Gurnard, Isle of Wight.

Diagnosis. Small, up to 14 mm in height, turreted-conical, whorls shallowly convex. Suture strong, canaliculate. The ornament is cancellate and variable, comprising up to three lines of linked pustules or spines, strong axial costae. Last whorl comprises half of shell height. Aperture is large and oval.

Distribution. Solent Group (excluding Cranmore Member) (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and southwest Hampshire, southern England.

Description. (Table 1) Small in size, up to 14 mm in height; width at the last whorl up to 5.5 mm. Turreted to turreted-conical in shape. Teleoconch of up to seven flat to shallowly convex whorls. The suture is strong, canaliculate. The strength

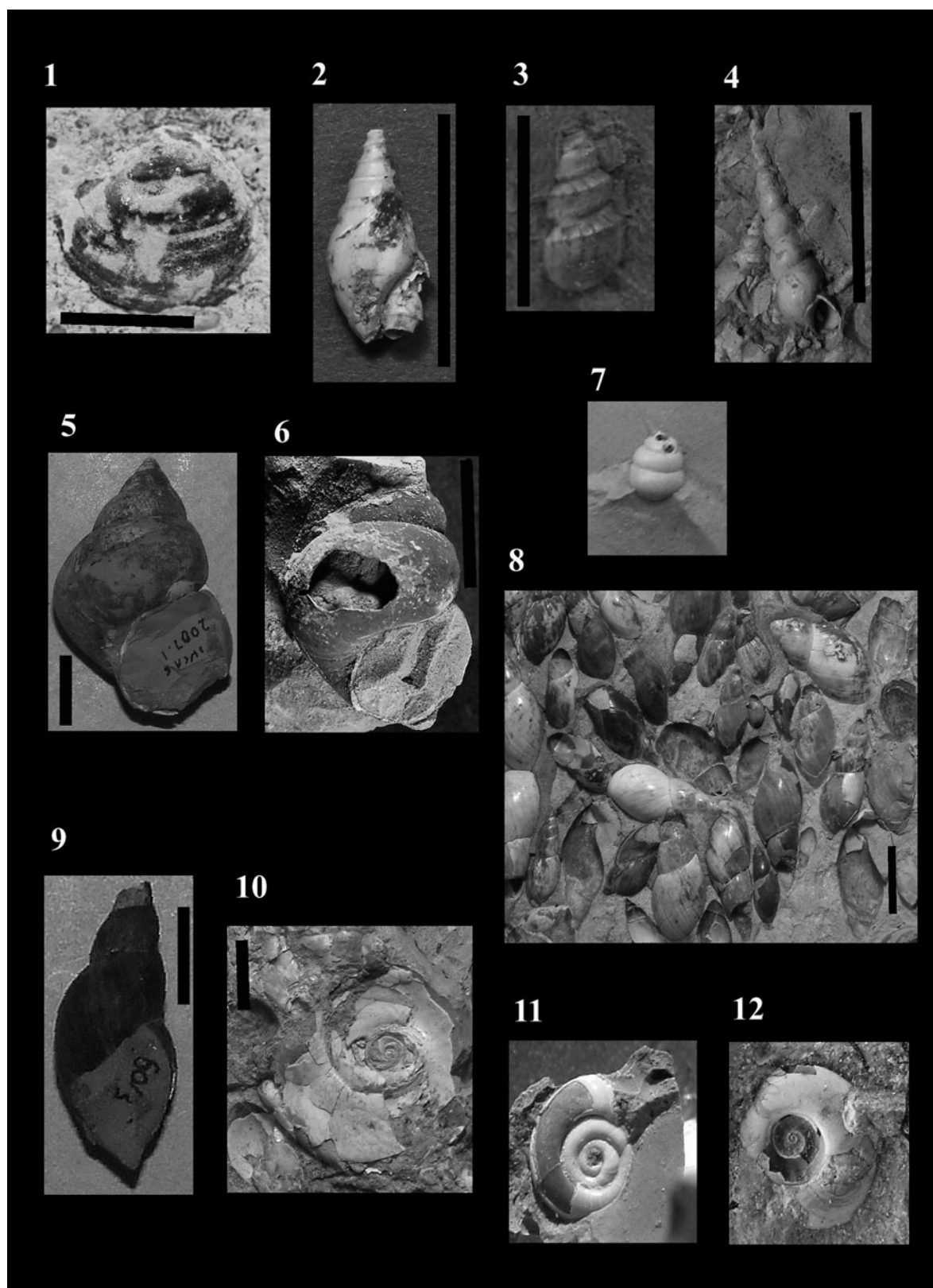


Plate 1 All figures taken with a digital camera (Fuji FinePix S602Z). Scale bars (figs 1–6, 8–10) = 10 mm. All specimens, unless stated otherwise are from the Insect Limestone, Bembridge Marls Member: (1) *Corbicula obovata* (J. Sowerby 1817), IWCMS.2007.8, Saltmead, Thorness, Isle of Wight; (2) *Melanopsis carinata* J. de C. Sowerby, 1826, IWCMS.2005.32, Bembridge Marls Member, Thorness Bay, Isle of Wight; (3) *Tarebia acuta* (J. Sowerby 1822b), IWCMS.2007.7, Bembridge Marls Member, Gurnard, Isle of Wight; (4) *Potamaclis turritis-sima* (Forbes, 1853), GSM 119911, Bembridge Marls Member, Hamstead Cliff, Isle of Wight; (5) *Viviparus angulosus* (J. Sowerby 1817), IWCMS.2007.1, Saltmead, Thorness, Isle of Wight; (6) *Viviparus lentus* (Solander 1766), G.57288, Gurnard, Isle of Wight; (7) ?*Acanthinula* sp. NHMUK GG.2904, Sticelets, Thorness Bay, Isle of Wight. Specimen height 1.5 mm; (8) *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810), MIWG.6016, Thorness Bay, Isle of Wight; (9) *Lymnaea* (*Galba*) *longiscata* (Brongniart 1810), MIWG.4215, Thorness Bay, Isle of Wight; (10) *Planorbarius discus* (Edwards 1852), MIWG.4535, Saltmead Ledge, Thorness Bay, Isle of Wight; (11) *Gyraulus similis* (Férussac 1814), IWCMS.2007.15, Saltmead, Thorness Bay, Isle of Wight. Specimen diameter 4 mm; (12) *Hippeutis headonensis* (Jodot 1942), IWCMS.2007.11, Sticelets, Thorness Bay, Isle of Wight. Specimen diameter 4.5 mm.

Table 1 *Tarebia acuta* biometric data

Sample	Mean apical angle	Mean height (mm)	Max height (mm)	Mean width (mm)	Max width (mm)	Number in sample
BMGD.43558 Syntype	19.5°		4.5	3.0		1
Lower Hamstead Member (Gurnard) ¹	29°	7.6	8.5	3.8	4.5	6
Bembridge Marls Member (Gurnard) ¹	27°	9.1	12.0	4.2	5.0	20
Colwell Bay Member (Colwell Bay) ¹	28°	10.7	14.0	5.1	5.5	16

¹ Specimens from bulk samples.

Table 2 *Melanopsis carinata* biometric data

Sample	Mean apical angle	Mean height (mm)	Max height (mm)	Mean width (mm)	Max width (mm)	Mean sutural angle	Number in sample
Syntype BMGD.43548	34°		17.0		8.0		1
Hamstead Member MIWG.2125	25°	9.6	12.0	4.2	5.5	8.6°	6
Hamstead Member MIWG.6050a	31°	13.2	14.0	5.2	5.5	10°	3

of the suture and rate of whorl expansion gives the shell a stepped profile. The last whorl comprises one half of the total shell height. The protoconch is variable.

The aperture is large and oval. The inductura is smooth and narrow, its leading edge forming a continuous arc from the adapical margin to the base of the aperture. The inner surface of the outer lip is ornamented correspondingly with the main external ornament. The shell is moderately thick. The siphonal canal is very weak, broad and shallow.

The growth lines are very shallowly opisthocyrt, almost orthocline and closely spaced. They vary in strength from faint to very strong and weakly laminar. The ornament is cancellate, which in the early whorls comprises two, becoming three or five in later whorls, lines of linked spiral pustules, tubercles or spines; these are linked by axial costae and varices are formed. Where there are two lines of protruberances they comprise *a* and *d*. When there are three lines, they are *a*, *c* and *d*. Where there are five spiral lines, *d* and *e* are very closely set, with *a*, *c* and *d* being stronger than *b* and *e*. The base of the last whorl carries up to six strong spiral bands.

Remarks. This taxon is highly variable in shape and ornamentation; Morris (1856) recognised two varieties (which, under ICZN rules, are now regarded as subspecies), specimens from the Insect Limestone belong to *T. acuta sensu stricto*.

Family Melanopsidae H. & A. Adams, 1854
Genus *Melanopsis* Férussac, 1807

Synonymy. *Nana* Schumacher, 1817
Melanithes Swainson, 1840
Canthidomus Swainson, 1840
Lyrcaea H. & A. Adams, 1854

Type species. *Buccinum costata* Gray, 1847 (synonym of *Buccinum praemorsus* Linné, 1758 by original designated from southern Spain and North Africa).

Diagnosis. Subulate to turreted, thin shelled, smooth or ornamented with striations, aperture pyriform or oval, callus smooth.

Melanopsis carinata J. de C. Sowerby, 1826
Plate 1, fig. 2

1826 *Melanopsis carinata* Sowerby, J. de C., vol. 6, p. 41, pl. 523, fig. 1.

- 1856 *Melanopsis carinata* Sowerby, J. de C.; Forbes, p. 156, pl. vi, figs 8 & 9.
1873 *Macrospira carinata* (Sowerby, J. de C.); Sandberger, pp. 248, 314; pl. 14, fig. 19; pl. 20, fig. 10.
1891 *Melanopsis carinata* Sowerby, J. de C.; Newton, p. 202.
1889 *Melanopsis carinata* Sowerby, J. de C.; Bristow *et al.*, p. 292, fig. 66.
1929 *Melanopsis carinata carinata* Sowerby, J. de C.; Wenz, p. 2686.
1962 *Melanopsis (Stylospirula) carinata* (Sowerby, J. de C.); Glibert, p. 146.

Syntype. BMGD 43548. Sowerby Collection, Natural History Museum, London. Locality not recorded. The specimen appears to have been removed from its original small block as illustrated by Sowerby (1826, pl. 523 fig. 1).

Referred material. IWCMS.2007.9 Saltmead, Thorness, Isle of Wight.

Diagnosis. Small sized up to 17 mm, fusiform, slender, aperture pyriform; distinctive carina is formed along the suture.

Distribution. Barton Group to Solent Group (excluding Cranmore Member) (Bartonian, Middle Eocene to Rupelian, Early Oligocene) Isle of Wight, southwest Hampshire and southeast Dorset.

Description. (Table 2) Small in size, up to 17mm in height; width at last whorl up to 8mm. Fusiform in shape, with mean apical angle of 29°. Teleoconch of up to eight whorls. The early whorls may be either concave or shallowly convex. The last whorl, which forms two-thirds of the total shell height, appears to be shallowly convex, but in apertural view is subtly concavo-convex in profile. The adapical and abapical edges of the whorls are markedly flared, forming distinctive carinae along the sutures. The whorls are occasionally imbricate; however, the adapical edge of the whorl may rise above the flare. In the early whorls the suture is faint, becoming strong in the last whorl. The suture often shows 'V' and step-like interruptions. The line of the carina/suture may be sinuous. In the last whorl, the concave part of the shell is set above the top of the aperture. The shell is thin.

The aperture is large and pyriform, becoming slit-like adapically; this slit is closed just behind the outer lip. The inductura is smooth and inflated; it is wide and forms a continuous convex arc from the base of the siphonal canal to the top of the aperture. The siphonal canal is short, deep but narrow, curved slightly towards the front of the shell. The inner surface of the outer lip is smooth.

The growth line is opisthocyr, sinuous like a laterally flattened 'S'. The growth line is faint to strong, strong where there is a break in growth indicated, coincident with a step or 'V'-shaped interruption in the suture.

Remarks. This species is most similar to *Melanopsis morrisoni* Wenz, 1928 which is also found within the Solent Group. However, the shell of *M. carinata* is more slender/fusiform and a shoulder is not formed. *Melanopsis carinata* is often very abundant and occurs with freshwater taxa such as *Viviparus lentus*. *Melanopsis carinata* is the most common melanopsisid in the lower part of the Bembridge Marls Member.

Superfamily Rissoidae Gray, 1847
Family Hydrobiidae Troschel, 1857
Subfamily Amnicolinae Tryon, 1863
Genus *Potamaclis* Sandberger, 1873

Type species. *Melania turritissima* Forbes, 1853, by subsequent designation by Clessin (1880), Oligocene (=Solent Group, Late Eocene–Early Oligocene), Hempstead (=Hamstead, Isle of Wight) and Hordwell (=Hordle, Hampshire), southern England.

Diagnosis. Small sized high-spired, turreted shells with convex whorls.

Occurrence. Europe, Eocene-Pliocene.

Potamaclis turritissima (Forbes 1853)
Plate 1, fig. 4

- 1853 *Melania turritissima* Forbes, p. 266.
1856 *Melania turritissima* Forbes; Morris in Forbes, p. 150, pl. 3, fig. 14.
1873 *Potamaclis turritissima* (Forbes); Sandberger, p. 312, pl. 10, figs 5–5c.
1891 *Potamaclis turritissima* (Forbes); Newton, p. 234.
1901 *Potamaclis turritissima* (Forbes); Newton, p. 67.
1921 *Hydrobia* (*Potamaclis*) *turritissima* (Forbes); Cossmann, p. 111, pl. 3, figs 79–80.
1929 *Potamaclis turritissima* (Forbes); Wenz, p. 2630.
1962 *Potamaclis turritissima* (Forbes); Glibert, p. 32.
1975 *Potamaclis turritissima* (Forbes); Castell, pl. 19, fig. 9.

Holotype. GSM 119911, Forbes Collection, British Geological Survey Museum.

Type locality and horizon. 'Bembridge Series' (=Bembridge Marls Member), Hamstead Cliff, Isle of Wight.

Referred material. IWCMS.2007.18, Thorness Bay, Isle of Wight.

Diagnosis. Small, needle-like shell comprising 12 or 13 whorls, slightly asymmetrical convex whorls with strongly adpressed suture.

Distribution. Headon Hill Formation, Bembridge Marls Member and Hamstead Member (Bouldnor Formation) of the Solent Group (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and Hampshire, southern England.

Description. (Table 3) Small, up to 14 mm in height, width of last whorl up to 3 mm. Needle-like turreted in shape, teleoconch typically of 12–13 whorls. The whorls which are slightly asymmetrical are moderately convex. The suture is strong, adpressed. There is a slight overlap of the top of the whorl over the base of the previous whorl. The last whorl comprises approximately one third of the total shell height. The protoconch comprises one and a half whorls, which are smooth and expand rapidly.

The aperture is large, oval to slightly pyriform. The inductura is narrow, smooth and irregular in outline. The peristome is holostomatous. The shell is thick, the inner lip is smooth. The growth line is moderate to strongly opisthocyr, the shell is otherwise smooth.

Table 3 *Potamaclis turritissima* biometric data

Specimen	Height (mm)	Width (mm)
Holotype GSM 119911	12.0	3.0

Remarks. This is a very distinctive taxon that occurs in vast numbers along bedding planes, particularly in the Bembridge Marls Member. Based upon shell shape and co-occurrence with molluscs such as *Unio*, Paul (1989) considered this extinct genus to have lived in fast-flowing freshwater. Specimen IWCMS.2007.18 comprises a current-aligned mass of shells associated with *Melanopsis carinata* J. de C. Sowerby, 1826, a frequent association in the Solent Group (pers. obs.).

Order Architaenioglossa Haller, 1890
Superfamily Ampullarioidea Gray 1824
Family Viviparidae Gray, 1847
Subfamily Viviparinae Gray, 1847
Genus *Viviparus* Montfort, 1810

Synonymy. *Vivipara* J. Sowerby, 1813.
Paludina Lamarck, 1822.

Type species. *Helix vivipara* Linnaeus, 1758, by original designation, distributed across Europe.

Diagnosis. Turbinate in shape, 20–60 mm in height, with concentrically growing horny operculum, sexual dimorphism with female shells larger and more inflated.

Occurrence. Northern Eurasia, Europe, Asia Minor and North America. Jurassic–Recent.

Viviparus angulosus (J. Sowerby 1817)
Plate 1, fig. 5

- 1817 *Phasianella orbicularis* J. Sowerby, vol. 2, p. 167, pl. 175, fig. 1.
1817 *Phasianella angulosa* J. Sowerby, vol. 2, p. 168, pl. 175, fig. 2.
1835 *Paludina angulosa* (J. Sowerby); J. de C. Sowerby, p. 246.
1891 *Viviparus angulosus* (J. Sowerby); Newton, p. 225.
1975 *Viviparus angulosus* (J. Sowerby); Castell, pl. 17, fig. 13.

Syntype. BMGD. 43563. Sowerby Collection, Natural History Museum, London (two specimens).

Type locality and horizon. Shalcombe, Isle of Wight, Bembridge Limestone Formation (Solent Group).

Referred material. IWCMS.2007.1, Saltmead, Isle of Wight.

Diagnosis. Large, up to 45 mm turbinate, high spired, globose shell. Convex whorls with strong rounded carina at the whorl base, visible in internal moulds. Large rounded aperture.

Distribution. Headon Hill Formation, Bembridge Limestone Formation and Bembridge Marls Member (Bouldnor Formation), Solent Group (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and Hampshire, southern England.

Description. (Table 4) Large, up to 45mm in height; width at the last whorl up to 40mm. Turbinate, high-spired, globose shell shape. Teleoconch of up to five convex whorls. The whorls are asymmetrical being shallowly convex on the apertural side, more convex on the opposite. The suture is strong, impressed, on internal moulds the suture is canaliculate. The last whorl comprises almost three-quarters of the total shell height. On internal moulds there is a strong, but rounded carina visible at the base of the whorl. Where the shell is preserved, this is not so obvious. Protoconch imperfectly known but comprises of at least one and a half convex whorls. Start of teleoconch defined by onset of shallower whorl development.

Table 4 *Viviparus angulosus* biometric data

Sample	Height (mm)	Width (mm)	Mean apical angle
BMGD.43563	37 ¹	30 ¹	
Syntypes	35 ¹		
	37 ²	27 ²	64° ²
	42 ³	30 ³	63.5° ³
IWCMS.2007.1	42	24	55°

¹ Syntypes of *Vivipara angulosa*, Bembridge Limestone Formation

² Syntype of *Vivipara orbicularis*, Bembridge Limestone Formation

³ Syntype of *Vivipara orbicularis*, 'Headon Beds'

Table 5 *Viviparus lentus* biometric data

Sample	Mean apical angle	Maximum apical angle	Maximum height (mm)	Maximum width (mm)
NHMUK G.982292 holotype	55°		24.0	24.0
NHMUK G.57288			18.0	15.0
NHMUK G.57289			20.0	16.0
MIWG.6545	58°	68°	28.0	22.0

The aperture is large and round. The inductura is narrow and irregular in extent and surface shape. The peristome is holostomatous. The shell is thin.

The growth lines are moderate to strong, prosocline. Attenuation of growth is marked by strong growth line development. The early whorls carry up to seven evenly spaced fine spiral cords. These eventually (by the third whorl?) become obscured by closely spaced growth lines.

Remarks. This species is found almost exclusively in limestones in the Solent Group and is particularly abundant in the Bembridge Limestone Formation. It is substantially larger than *Viviparus lentus* (Solander 1766), which is found within clastic sediments in the Solent Group. Paul (1989) used the extant *Pomacea* spp. which occupies well weeded pools in the Florida Everglades as an analogue for *V. angulosus*. The extant British species *V. viviparus* and *V. fasciatus* are both found in hard water areas (Macan 1977); the latter is known to occupy stagnant water. *Viviparus angulosus* is known from a single specimen from the Insect Limestone at Thorness. This specimen is extremely useful, as examples from the Bembridge Limestone Formation are usually internal moulds, or the shell is more or less coarsely re-crystallised calcite, which obscures surface details.

Viviparus lentus (Solander 1766)

Plate 1, fig. 6

- 1766 *Helix lenta* Solander, p. 29; pl. iv, fig. 60.
 1813 *Vivipara lenta* (Solander); J. Sowerby, vol. 1, p. 79; pl. 31, fig. 3.
 1891 *Viviparus lentus* (Solander); Newton, p. 225.
 1975 *Viviparus lentus* (Solander); Castell, pl. 17, fig. 14.

Holotype. ? NHMUK G.98292 Brander Collection, Natural History Museum, London.

Type locality and horizon. Headon Hill Formation, Hordle, Hampshire.

Referred material. NHMUK G.57288, NHMUK G.57289, Gurnard Bay, Isle of Wight. MIWG.6545, Totland Bay, Isle of Wight.

Diagnosis. Medium-sized, up to 28 mm high, turbinatoglobose with convex whorls. Suture strong and impressed. Weak spiral

ornament largely obscured by strong prosocline growth lines. Aperture large and round.

Distribution. Solent Group (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and southwest Hampshire, southern England.

Description. (Table 5) Medium-sized, up to 28 mm in height, width at last whorl up to 22 mm. Turbinatoglobose in shape, high-spined with step-like outline. Teleoconch of four moderately convex, shouldered whorls. The suture is strong impressed. The last whorl comprises over two thirds of the total shell height. The protoconch is typically absent.

The aperture is large and round. The inductura is narrow but thick, commonly eroded revealing successive laminae, the leading edge is frequently broken and irregular. However, the inductura is continuous from the base of the aperture to the top of the outer lip. The shell is thick and the inner surface of the shell is smooth. The peristome is holostomatous. The umbilicus, which is mostly obscured, appears to be shallow, with a rounded edge.

The growth lines are fine to strong and densely packed, shallowly prosocline. The shell is ornamented with numerous very fine threads. Otherwise, there are two stronger threads, the upper of which defines the shoulder in the upper one quarter of the whorl and the lower is located along the midline of the whorl, dropping towards the base of the whorl in the last whorl. The shell appears superficially smooth and shiny.

Remarks. Considerably smaller than *V. angulosus*, *Viviparus lentus* is abundant in argillaceous sediments within the Solent Group, and is also present in arenaceous units such as the Seagrove Bay Member. Paul (1989) correlated the occurrence of *V. lentus* with fluvial and lacustrine facies. *Viviparus lentus* is known from two specimens from the Insect Limestone, collected from Gurnard. The shells appear to be a slightly unusual lithology; however not beyond the range of lithologies seen in the Thorness Bay section.

Subclass Euthyneura Spengel, 1881

Order Pulmonata Cuvier, 1817

Suborder Stylommatophora A. Schmidt, 1855

Superfamily Pupilloidea Turton, 1831

Family Valloniidae Morse, 1864

Subfamily Acanthinulinae Steenberg, 1917

Genus *Acanthinula* Beck, 1847

Type species. *Helix aculeata* Müller, 1774, by subsequent designation by Albers & Martens (1860), distributed in northwest and southern Europe.

Diagnosis. Small, conical, with up to four well rounded whorls, aperture round, regularly spaced sharp ribs.

Occurrence. Europe and North America, Eocene to Recent.

Remarks. The extant *Acanthinula aculeata* (Müller 1774) is found in woodland and scrub, occasionally in more open habitats (Kerney & Cameron 1979).

?*Acanthinula* sp.

Plate 1, fig. 7

Material. NHMUK GG. 22904, Sticelets, Thorness Bay, Isle of Wight.

Description. Small, 1.5mm in height and width. Turbinatoglobose shell shape. Teleoconch of four convex whorls. The suture is strong impressed. The protoconch is unknown. Aperture shape unknown. Growth lines fine opisthoclyt. Numerous fine curved ribs.

Remarks. Resembles *Strobilops pseudolabyrinthica* (Sandberger 1873). However, in the specimen from the Insect Limestone, the whorls are slightly more shouldered and convex.

Subordinal Grade Basommatophora Kerferstein, 1864
 Superfamily Lymnaeidea Rafinesque, 1815
 Family Lymnaeidae Rafinesque, 1815
 Subfamily Lymnaeinae Rafinesque, 1815
 Genus *Lymnaea* Lamarck, 1799
 Subgenus *Galba* Schrank, 1803

Synonymy. *Stagnocola* Leach in Jeffreys, 1830
Limnophysa Fitzinger, 1833
Omphiscola Beck, 1838 non Rafinesque, 1819
Leptolimnaea Swainson, 1840

Type species. *Buccinum truncatulum* Müller, 1774, type species by subsequent designated under the plenary powers (ICZN 2001, p. 33), distributed in northwest and southern Europe.

Dignosis. Small to large sized; elongate-oval with convex whorls; aperture narrowly oval; columella straight; umbilicus slit-shaped.

Occurrence. Europe, North America, South America, Asia, Africa. Jurassic–Recent.

Remarks. The type species *Lymnaea (Galba) truncatula* is extant and widespread in Europe and the Middle East. It is found in rivers and small streams and the edges of ditches (Macan 1977).

Lymnaea (Galba) longiscata (Brongniart 1810)

Plate 1, figs. 8–9

1809 *Lymnée effilée* Brard, vol. 14, p. 432, pl. 27, figs 15–16.

1810 *Limneus longiscatus* Brongniart, p. 372, pl. 22, fig. 9.

1822b *Limnaea longiscata* Brongniart; Sowerby, J., vol. 4, p. 57, pl. 343.

1852 *Limnaea longiscata* Brongniart; Edwards, p. 85, pl. xii, figs 3a–3b.

1863 *Limnaea longiscata* Brongniart; Deshayes, vol. 2, p. 722.

1889 *Limnaea longiscata* Brongniart; Cossmann, fasc. 4, p. 329.

1891 *Limnaea longiscata* Brongniart; Newton, p. 278.

1913 *Limnaea longiscata* Brongniart; Cossmann & Pissarro, vol. 2, pl. LVI, fig. 53-1.

1923 *Galba (Galba) longiscata longiscata* (Brongniart); Wenz, vol. 4, pp 1373–1384.

1975 *Galba longiscata* (Brongniart); Castell, p. 84, pl. 27, fig. 7.

1989 *Stagnicola longiscata* (Brongniart); Fischer, p. 348.

Type material. Repository unknown.

Type locality and horizon. Unknown.

Referred material. MIWG.852 and MIWG.4215, Thorness Bay, Isle of Wight; MIWG. 3611, MIWG.6013, MIWG.6016, Gurnard, Isle of Wight; MIWG.4536–MIWG.4538, Saltmead, Isle of Wight; MIWG.4551, Gurnard Point, Isle of Wight; IWCMS.2007.17 Saltmead, Isle of Wight; IWCMS.2007.21, Saltmead, Isle of Wight. NHMUK G.37984–G.37989, NHMUK G.57301–NHMUK G.57304, BMGD.57295–BMGD. 57300, all from Gurnard, Isle of Wight.

Diagnosis. Large, up to 35mm, fusiform with moderately convex whorls, strong, adpressed suture, aperture large and flattened oval shape, thin smooth shell.

Distribution. Solent Group (Priabonian, Late Eocene to Rupelian, Early Oligocene), Isle of Wight and Hampshire, southern England. Bacini Continentali (Eocene–Oligocene) Majorca, Spain. La Calcaire Lacustre de Saint-Ouen (Bartonian), Paris Basin, France.

Description. (Table 6) Large-sized, up to 28 mm in height; width at last whorl up to 12 mm. Fusiform in shape, with an apical angle between 34° and 36° (data based upon specimens from the Insect Limestone). Teleoconch of up to six shallowly convex whorls. The suture is strong adpressed. Sutural angle

Table 6 *Lymnaea (Galba) longiscata* biometric data

Sample	Mean apical angle	Height (mm)	Width (mm)	Sutural slope
MIWG. 3611	34°	22.0	9.0	15°
MIWG.4215	34°	21.0	8.0	16°
MIWG.6013	35°	28.0	12.0	20°
MIWG.6016	36°	23.0	11.0	Not measured

between 15° and 20°. The last whorl, which is sometimes shouldered, comprises two-thirds of the total shell height. Protoconch comprising one and a half shallow, convex whorls.

The aperture is large, flattened oval-shaped. The inductura is smooth and narrow, with an irregular/broken adaxial margin. The shell is thin, the inner surface of which is smooth. The peristome is uninterrupted; however, the abapical margin of the peristome is slightly flattened. The columella has a single, broad flat plication, there is a small umbilical slit, usually obscured by the inductura. The growth lines are faint, prosocyr, the shell is smooth.

Remarks. Wenz (1923) provides an extensive synonymy for this taxon. Both Sowerby (1822b) and Edwards (1852) noted that this shell is highly variable in form. Edwards proposed a variety (subspecies) *distorta* (Edwards 1852, p. 86, pl. 12, figs 3e–h) to accommodate the most extreme variation of the shell with a shorter aperture and higher sutural slope, giving a partly uncoiled, distorted appearance. Due to their morpho-anatomic uniformity, the classification of the Lymnaeidae into subgenera is difficult (Bargues & Mas-Coma 1997). *Lymnaea (Galba) longiscata* shows a range of characters seen in the extant subgenera of *Lymnaea*, namely (*L.*) *Lymnaea*, *Galba* and *Radix*. The subgenus *Stagnicola* was synonymised on the basis of 18S rDNA sequences with *Lymnaea* by Bargues & Mas-Coma (1997). Due to the difficulty in separating the different subgenera, herein *Galba* is retained, as it is the sub-generic name most frequently used to accommodate this widespread taxon.

Specimens collected from the Insect Limestone generally have their shells preserved and are frequently found in groups that appear to have drifted together. Preservation, which is generally excellent, varies from a white-grey colour to black with pyrite growth. This species is particularly abundant in the Bembridge Limestone Formation and throughout the freshwater parts of the Solent Group. Paul (1989) remarked that the numerous forms of *Lymnaea* described by Edwards (1852) are almost certainly shape varieties of the larger species (in the Solent Group); therefore care should be used when identifying lymnaeids from the Solent Group. These nominal taxa require further study before formal synonymisation can be undertaken.

There are some similarities between *Lymnaea (Galba) longiscata* (Brongniart 1810) and *Palaeoglandina costellata* (J. Sowerby 1822b). The latter is ornamented with fine axial ribs, the suture less pronounced, with the preceding whorl over-lapping the previous whorl.

Superfamily Planorboidea Rafinesque, 1815

Family Planorbidae Rafinesque, 1815

Subfamily Planorbinae Rafinesque, 1815

Genus *Planorbarius* Frierie, 1806

Synonymy. *Planorbina* Haldeman, 1842 (part)

Type species. *Helix corneus* Linnaeus, 1758, by original designation, distribution northwest and southern Europe.

Diagnosis. Planispiral, small to large sized, whorls rounded, aperture subcircular-oval.

Occurrence. Late Eocene to Recent, Europe, North Africa and Asia.

Remarks. Historically, planorbid generic assignment has been influenced by geographical distribution (see summary and discussion by McKenna *et al* 1962), with *Planorbarius*, Froriep, 1806 used for some European forms. Based upon the systematic usage of Zilch (1959–60), Paul (1989) used *Australorbis* Pilsbry, 1934 to accommodate the larger planorbids from the Solent Group; however, Paul (1989) noted that *Australorbis* may be a synonym of *Biomphalaria* Preston, 1910. Herein the generic name *Planorbarius* is retained; however, there is clearly a case for review.

Planorbarius discus (Edwards 1852)

Plate 1, fig. 10

- 1852 *Planorbis discus* Edwards, p. 102; pl. xv, figs 7a–b.
 1873 *Planorbis discus* Edwards; Sandberger, p. 285; pl. xvi, fig. 4 p.
 1891 *Planorbis discus* Edwards; Newton, p. 281.
 1923 *Planorbina (Planorbina) discus* (Edwards); Wenz vol. 5, pp. 482–1484.
 1964 *Planorbis (Coretus) cf. discus* (Edwards); Soyer, p. 145.
 1971 *Planorbina discus* (Edwards); Castell, pl. 27, fig. 4.
 1989 *Australorbis discus* (Edwards); Paul, p. 157.
 1995 *Planorbarius cf. discus* (Edwards); Le Renard, p.66608.

Syntypes. NHMUK GG.6933 and NHMUK GG.6934 (ex BMGD.71078), Sconce, Isle of Wight.

Type locality and horizon. Sconce, Isle of Wight, Bembridge Limestone Formation.

Referred material. BMGD.83039 Gurnard Bay, Isle of Wight. MIWG.4535, Saltmead Ledge, Thorness, Isle of Wight.

Diagnosis. Large, up to 37 mm in diameter, planispiral, four whorls, smooth. Adapical side shallowly convex, abapical side concave.

Distribution. Headon Hill Formation, Bembridge Limestone Formation (Solent Group), Bembridge Marls Member and Hamstead Member (Bouldnor Formation, Solent Group), Isle of Wight and Hampshire, southern England.

Description. (Table 7) Large-sized, up to 37 mm in diameter, height up to 10 mm. Planispiral in shape. Teleoconch of up to four convex whorls. The adapical side is shallowly convex, the abapical side concave. The suture is strong, grooved. The whorls expand gradually. Protoconch obscured.

The whorls are the same shape as the aperture, which is a shallow asymmetrical oval, with the abapical edge of the peristome more convex adaxially. The shell is thin and the inner surface smooth. The peristome is holostomatous. The growth lines are moderately pronounced and prosocyrct.

Remarks. This taxon is common in the limestones of the Solent Group and is the largest planorbid present in the Insect Limestone.

Genus *Gyraulus* Charpentier, 1837

Synonymy. *Planaria* Brown, 1827 *non* Müller, 1774.

Trochlea Haldeman, 1841.

Nautilina Stein, 1850 (part).

Gyraulus Moquin-Tandon, 1855.

Gyrulus Gray, 1857.

Type species. *Planorbis hispidus* Draparnaud, 1805, by subsequent designation by Wenz (1923, p. 1540). Distributed over Europe, northern Asia and North Africa.

Table 7 *Planorbarius discus* (Edwards, 1852) biometric data

Specimen	Height (mm)	Width (mm)
NHMUK GG.6934 syntype	9.0	37.0
NHMUK GG.6933 syntype	7.0	27.0
MIWG.4535	Specimen crushed	35.0

Diagnosis. Planispiral, small to large sized, whorls rounded, aperture subcircular-oval.

Occurrence. Jurassic to Recent, Europe, North Africa and Asia.

Gyraulus similis (Férussac, 1814)

Plate 1 fig. 11

- 1809 *Planorbe arrondi* Brard, p. 433, pl. 27, figs 19–20.
 1810 *Planorbis rotundatus* Brongniart, p. 370, pl. 22, figs 4–5 *non* Poiret, 1801.
 1814 *Planorbis similis* Férussac, p. 61.
 1847 *Planorbis platystoma* Wood, p. 118.
 1852 *Planorbis rotundatus* Brongniart; Edwards, p. 100, pl. 15, figs 4a–c.
 1852 *Planorbis platystoma* Wood; Edwards, p. 103, pl. 15, figs 2a–d.
 1873 *Planorbis (Menetus) goniobasis* Sandberger, p. 272, pl. 15, figs 21–21b.
 1891 *Planorbis goniobasis* Sandberger; Newton, p. 282.
 1891 *Planorbis platystoma* Edwards; Newton, p. 283.
 1901 *Planorbis (Menetus) goniobasis* Sandberger; Newton, p. 67.
 1901 *Planorbis platystoma* Edwards; Newton, p. 67.
 1923 *Planorbina (Planorbina) similis* (Férussac); Wenz, p. 1505.
 1962 *Planorbis similis* Férussac; Glibert, p. 85.

Type material. Repository unknown.

Type horizon and locality. Unknown.

Referred material. IWCMS.2007.15, IWCMS.2007.16; both from Saltmead, Thorness Bay, Isle of Wight.

Diagnosis. Large, up to 30 mm, planispiral, convex whorls, aperture oval, adapical surface deeply concave.

Distribution. Headon Hill Formation, Bembridge Limestone Formation (Solent Group), Bembridge Marls Member and Hamstead Member (Bouldnor Formation, Solent Group), Isle of Wight and Hampshire, southern England.

Description. Large-sized, up to 30 mm in diameter, height up to 8 mm. Planispiral in shape. Teleoconch of up to seven convex whorls, the adapical surface of which are flattened. The adapical side is very shallowly convex, the abapical side deeply concave. The suture is strong, grooved. The whorls expand gradually. Protoconch obscured.

The aperture is oval in shape. The shell is thin and the inner surface smooth. The peristome is holostomatous. The growth lines are fine to moderately strong, prosocyrct.

Remarks. Small specimens of this taxon are fairly common in the Insect Limestone.

Genus *Hippeutis* Charpentier, 1837

Synonymy. *Hippeutis* Gray, 1857.

Type species. *Helix complanata* Linnaeus, 1758, by subsequent designation by Clessin (1886).

Diagnosis. Planispiral, small sized, whorls carinated, aperture oblique, subcircular-oval.

Occurrence. Paleocene to Recent, Europe, North Africa and Asia.

Hippeutis headonensis (Jodot 1942)

Plate 1, fig. 12

- 1852 *Planorbis lens sensu* Edwards *non* Brongniart, p. 104, pl. 15, fig 8a–d.
 1891 *Planorbis lens* Brongniart; Newton, p. 282.
 1901 *Planorbis lens* Brongniart; Newton, p. 67.
 1942 *Planorbis (Hippeutis) headonensis*, Jodot, p. 175.

Lectotype. NHMUK G.71081a Edwards Collection, Natural History Museum, London. Edwards (1852) pl. 15, fig 8a. *Paralectotypes*, six specimens NHMUK G.71081 b–g, Edwards Collection, Natural History Museum, London.

Type horizon and locality. Headon Hill Formation, Headon Hill, Isle of Wight.

Referred material. IWCMS.2007.11 Sticelets, Thorness Bay, Isle of Wight; IWCMS.2007.14 Saltmead, Thorness Bay, Isle of Wight.

Diagnosis. Small, planispiral, midline of whorl with sharp carina.

Distribution. Headon Hill Formation, Bembridge Limestone Formation (Solent Group), Bembridge Marls Member and Hamstead Member (Bouldnor Formation, Solent Group), Isle of Wight and Hampshire, southern England.

Description. Small-sized, up to 8 mm in diameter, height up to 1.5 mm. Planispiral in shape. Teleoconch of up to four shallowly convex whorls, of which the abapical surfaces are more convex. Above the midline of the whorls there is a rounded carina, giving the whorl an angular shape. The adapical surface is shallowly convex, the abapical side is less shallowly concave. The suture is strong, grooved. The whorls expand rapidly. Protoconch obscured.

The whorls are the same shape as the aperture which is flattened oval in outline. The shell is thin and the inner surface smooth. The peristome is holostomatous. The growth lines are fine to moderately strong, prosocyrte.

Remarks. Edwards (1852) discussed at length the identity of this shell, concluding that it was identical with *Planorbis lens* Brongniart, 1810. Jodot (1942) observed that the carina in *Planorbis lens* Brongniart, 1810 is sharper, the whorls less convex and the sutures less pronounced than those seen in the English shells; there does however seem to be no difference in the position of the carina in both forms. Edwards makes reference to the illustrations of *P. lens* by Deshayes (1837 vol 2, pl. IX, figs 11–13) which show a much flatter shell than the specimens from the Solent Group, supporting Jodot's conclusion (1942). It is uncommon in the Insect Limestone.

2. Discussion

Only the pulmonate gastropod *Lymnaea (Galba) longiscata* (Brongniart 1810) can be said to be common in the Insect Limestone. It is found both as single specimens and as small groupings of shells showing some indication of current alignment (pers. obs.), sometimes associated with leaves of *Typha*. Extant, large lymnaeids are usually found in bigger water bodies (Macan 1977, Boycott 1934). The extant *Lymnaea stagnalis* (Linnaeus 1758) which is larger than *Lymnaea (Galba) longiscata*, is unable to establish itself in swiftly flowing water, so it is confined to slow-moving rivers, lakes and canals (Ellis 1926), *Lymnaea (Galba) truncatula* (Müller 1774) is common in well-aerated waters, in canals and marshes and on wet mud by rivers, lakes and water meadows (Ellis 1926). Despite some records (see Paul 1989) of lymnaeids found in brackish water, they are essentially occupants of freshwater. Plaziat & Younis (2005) recorded that *Lymnaea* shells commonly float and are stranded on the shores of the Shatt al Arab. Within the Solent

Group, *Lymnaea (Galba) longiscata* can be found in the brackish water setting of the Colwell Bay Member. These could be interpreted as drifted specimens from a nearby freshwater source. *Lymnaea (Galba) longiscata* is abundant in the underlying Bembridge Limestone Formation and in other limestones within the Solent Group; this can be taken to indicate a preference for alkaline, hard waters.

Of the planorbids, the extant *Hippeutis complanatus* (Linnaeus 1758) is found on weeds in ponds, canals, ditches and marshes, and *Planorbarius corneus* (Linnaeus 1758) is found in ponds, canals, marshes and rivers (Ellis 1926). Plaziat & Younis (2005) recorded that *Gyraulus* in the tributaries of the Shatt al Arab typically lives on the submerged portions of rooted plants and is usually associated with the most diverse mollusc assemblages. *Planorbarius discus* (Edwards 1852), like *Lymnaea (Galba) longiscata*, is abundant in the Bembridge Limestone Formation; likewise indicating a preference for hard water. However, it is uncommon in the Insect Limestone, with just a small number of specimens found. They are both as isolated specimens and in groups associated with *Lymnaea (Galba) longiscata*. Paul (1989) notes the association of larger planorbids with well weeded water.

The rare finds of *Tarebia acuta* (J. Sowerby 1822a) are mostly as isolated specimens. It is found in super-abundance in the Solent Group, in particular the Bembridge Marls Member, the rare finds of these shells in the Insect Limestone indicates they were not living in the Insect Limestone environment. *Tarebia granifera* (Lamarck 1822) in Thailand is common in lakes, ponds, rivers, canals and creeks and even enters the tidal zone (Brandt 1974).

Melanopsis spp. are common throughout most of the Solent Group; however, they are rare in limestones (pers. obs.), indicating avoidance of hard water. Colonisation of variable salinity streams by *Melanopsis praemorsa* (Linné 1758) in southeast Spain was studied by Velasco *et al.* (2006), who reported that colonisation only occurred when salinities fell below 3.5‰ with water temperatures between 12.3°C and 33.7°C, typically in runs but absent from pools.

As with the lymnaeids and planorbids, viviparids indicate well weeded hard water. Extant *Viviparus* from Europe live in hard water areas with slight to moderate current and appear to thrive in water where there is a considerable amount of particulate matter in suspension. They are, however, extremely sensitive to any increase in salinity above 3‰ (Fretter & Graham 1962).

There is a single record of a land snail in the Insect Limestone *Acanthinula* sp.; extant forms are found in damp woodland habitats (Kerney & Cameron 1979), indicating the proximity of such to the depocentre or feeder streams.

Daley (1972) recognised four molluscan assemblages in the Bembridge Marls Member, representing a range of salinity and hydrological conditions. The dominance of pulmonate gastropods was used by Daley to indicate a lake margin setting. The gastropods present in the Insect Limestone represent freshwater conditions. However, the abundance of brine shrimps *Brachipodites vectensis* and salt pseudomorphs indicates that more saline influences occurred at times. In other Solent Group limestones where *Lymnaea (Galba) longiscata* occurs, it is in greater abundances than seen in the Insect Limestone. A possible conclusion would be that the gastropods were washed in. *Potamoclis turritissima* (Forbes 1853) indicates that fast flowing water was feeding into the system. Extant lymnaeids occur in both standing and moving waters; this indicates a flow of hard, freshwater into the environment. If we are to accept Paul's (1989) interpretation of the mode of life of *Viviparus angulosus* along with the other analogues, we can build up a picture of well weeded freshwater ponds and water courses.

An alternative interpretation would require layering of the waters, with a salinity gradient, allowing gastropods to occupy lake margins or the upper parts of plants. Significantly, molluscs seem to be restricted to exposures in the Gurnard and Thorness area, principally near Sticelets and Saltmead. This same pattern was noted for the floral remains by Reid & Chandler (1926), possibly indicating proximity to flood prone influxes of fresh-water or indeed the water margin.

3. Acknowledgements

Andrew Ross (NMS) is acknowledged for inviting me to write this review of molluscs from the Insect Limestone. I thank Jon Todd (NHM) for access to collections and, along with Steve Tracey, for conversations about snails. Mike Bishop (Isle of Wight County Museum Service) is thanked for access to collections. Most importantly, Andy Yule of Cowes is thanked for the finds, the enthusiasm and the years of effort he has put into the Insect Limestone and its fossils.

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MS received 9 July 2012. Accepted for publication 31 January 2014.