Arch. Molluskenkunde | **138** | (2) | 113–122 | 30 figures | Frankfurt am Main, 18.12.2009

Anatomical description of *Solen* cf. *exiguus* Dunker from Thailand

(Bivalvia: Solenidae)

Luiz Ricardo L. Simone

Abstract

An anatomical description of the solenid *Solen* cf. *exiguus* Dunker 1862, collected in the Gulf of Thailand, is provided. The anatomical features include high antero-posterior elongation; mantle lobes widely fused with each other; powerful pallial muscles; fused siphons with capacity of autotomy; wide and partially hollow foot; complete separation between gastric style sac and adjacent portion of intestine; all possible common characters of the family. Some so far exclusive attributes include short anterior pallial tentacles; pair of muscular valves at base of siphons; and arrangement of tentacles at siphonal tip. A short discussion on the taxonomy of the *Solen exiguus/leanus* complex is also included.

Key words: Anatomy, morphology, Solenidae, taxonomy, Thailand.

Introduction

The Solenidae have elongated shells, normally with the antero-posterior length several times longer than the dorso-ventral height. The elongated, somewhat rectangular shell is a long known character of the family, raising the common name of "razor shells". They are obligatory collection items and some large species are edible, like the European *Solen marginatus* Pulteney 1799 (Gofas & al. 2001).

Despite of their importance, the anatomy of the solenids is scarcely known and restricted to few species only (Faussek 1897; Bloomer 1905, 1906; Ghosh 1920; Atkins 1937; Owen 1959). From this knowledge, another known character of the solenids is the capacity of autotomy of the siphon (Morton 1984).

During the International Marine Bivalve Workshop of Kungkrabaen Bay, Chanthaburi, samples belonging to the genus *Solen* Linnaeus 1758, family Solenidae, were collected and selected for anatomical study. This study, beyond to be another step in the anatomical knowledge of the family, is part of a larger project of comparative anatomy and phylogeny of bivalves, for which the species is one of the solenid representatives. The data of this paper is used as one of the outgroups in another complementary paper (Simone & Wilkinson 2008), where some additional discussion can be found. The identification on specific level of the small *Solen* from S.E. Asia is problematic, as a number of unclear specific epithets exists. Thanks to R. v. Cosel the studied sample could be identified as belonging to what can be called the " *Solen exiguus/leanus* complex" (v. Cosel personal communication). Until a more complete revision of the taxon, the best way is to denominate the studied material as *Solen* cf. *exiguus* Dunker 1862. More details of the taxonomy are given in the following discussion.

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 ISSN 1869–0963
DOI 10.1127/arch.moll/1869-0963/138/113-122

Material and methods

The available specimens were preserved in 70 % EtOH. They were dissected by standard techniques with the specimen immersed in alcohol. Examination and dissections were done with the aid of a stereomicroscope, and the drawings with the aid of a camera lucida.

The following abbreviations are used in the anatomical descriptions and figures: am: anterior adductor muscle; an: anus; au: auricle; ce: cerebral ganglion; ci: ciliary connection of gill to neighbouring structures; co: cerebro-visceral connective; dd: ducts to digestive diverticula; dg: digestive diverticula/gland; dh: dorsal hood; di: inner demibranch; do: outer demibranch; es: oesophagus; ex: excurrent siphon; fg: gill food groove; fm: posterior foot retractor muscle; fr: anterior foot retractor muscle; ft: foot; ge: gill septum sustaining gill transverse folds; gf: gastric fold; gi: gill ciliary connection to mantle; gp: genital pore; gs: gastric shield; hi: hinge; in: intestine; ki: kidney; li: ligament; mb: mantle border; me: mantle tentacle; mi: inner fold of mantle edge; mm: middle fold of mantle edge; mo: mouth; mp: mantle papilla; mt: mantle; mv: visceral mass; ne: nephropore; om: outer fold of mantle edge; pa: posterior adductor muscle; pc: pericardium; pe: periostracum; pg: pedal ganglia; pl: pallial muscle; pp: palp; sa: gastric sorting area; se: valve in base of incurrent siphon; si: incurrent siphon; sp: valve in base of excurrent siphon; ss: style sac; st: stomach; sy: style; tm: transverse muscles of visceral mass; ty: typhlosole; um: fusion between left and right mantle lobes between siphons; ve: ventricle; vg: visceral ganglia; vm: visceral mass.

Abbreviations of institutions

MZSP	Museu de Zoologia da Universidade de São Paulo, Brazil
MNHN	Muséum National d'Histoire Naturelle, Paris, France
SMF	Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt a. M., Germany.

Systematics

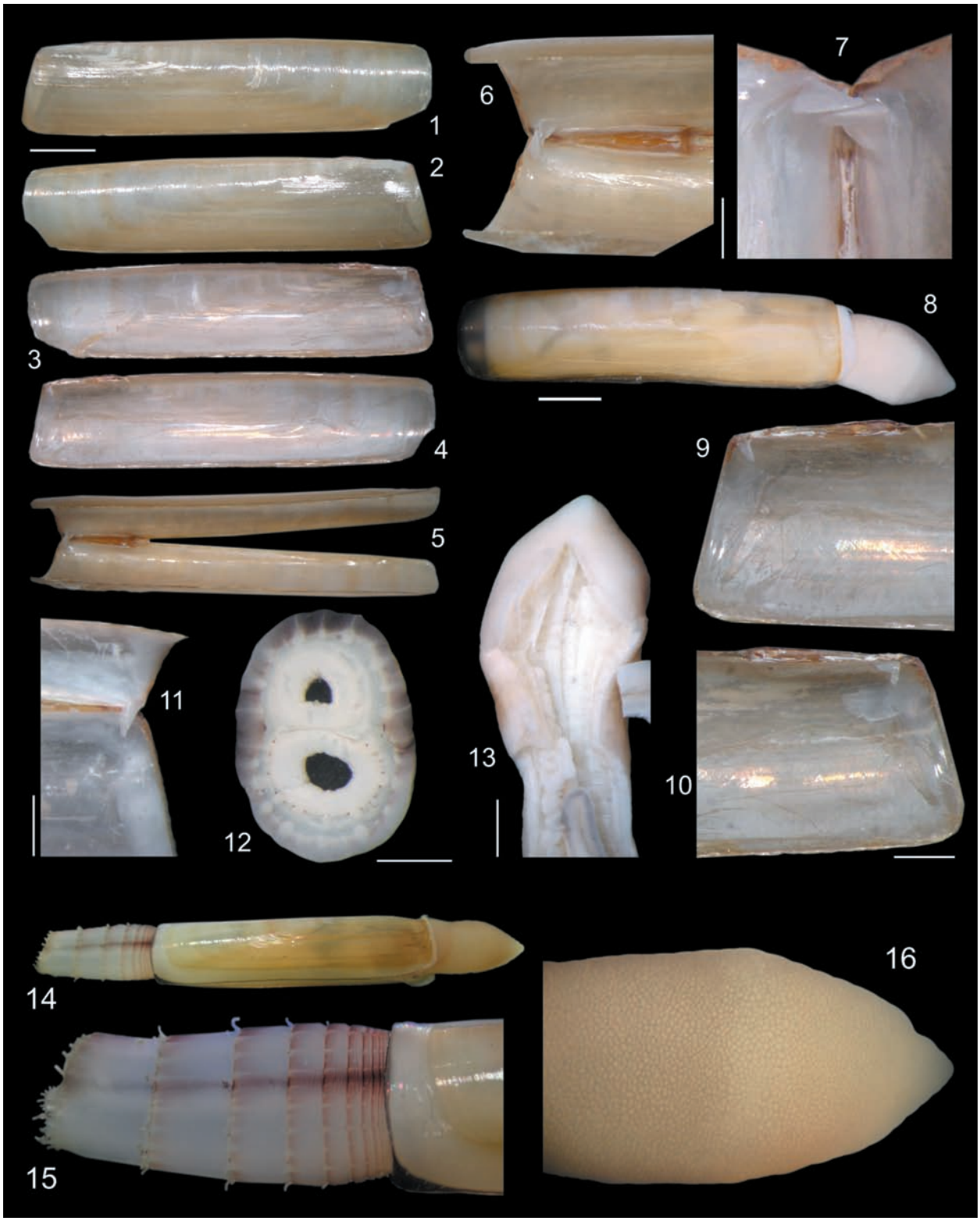
Solen cf. ***exiguus*** DUNKER 1862

Figs 1–30

cf. 1862 *Solen exiguus* DUNKER, Proceedings of the Zoological Society of London, 1861: 419
cf. 1868 *Solen exiguus*, – DUNKER, Novitates conchologicae, 3: 116, pl. 39, fig. 1 ["var."]
cf. 1874 *Solen exiguus*, – SOWERBY in REEVE, Conchologica Iconica, 19, *Solen*: pl. 7, fig. 32
2001 *Solen curtus*, – SWENNEN & al., Molluscs Gulf of Thailand: 83, fig. 119 (non DES MOULINS 1832)
2008 *Solen curtus*, – SIMONE & WILKINSON, The Raffles Bulletin of Zoology, suppl. 18: 152, 182–188 (non DES MOULINS 1832).

Description: Shell (Figs 1–11, 14, 17): Outline somewhat rectangular; anterior end more straight, dislocating weakly anteriorly towards ventral side; posterior end more rounded, cut-edged and fragile. About 4.3 times longer than (dorso-ventral) height. Wall thin, semi-translucent (Fig. 8), fragile. Color mostly beige to pale brown, with paler transverse spots. Umbos not protruding, located at anterior end. Sculpture absent except growth lines and weak undulations. Outer surface smooth, glossy. Periostracum thin, translucent. Hinge (Figs 6, 7, 9–11) with single cardinal tooth per valve, located in extreme anterior end; tooth of right valve more anterior, with posterior surface plane, articulating with tooth of left valve; both hinge teeth of similar shape and enantiomorph; each teeth with wider, discoid, erected region in articulation; broader, thicker base with about twice the length of discoid region. Length of hinge about 1/18 of total shell length. Ligament located just posterior to hinge, making up about 1/5 of shell length; dislocating weakly ventrally and being slightly wider towards posterior end (Figs 6, 5, 17). Inner surface white, glossy (Figs 3, 4). Muscular scars (Figs 3, 4, 9, 10) schematised in Fig. 17; scar of anterior adductor and anterior foot retractor muscles about 5 times longer than height, occupying about 2.5 % of valve surface, located very close to dorsal edge, dislocated posteriorly about 1/22 of shell length; scar of posterior adductor and posterior foot retractor muscles somewhat oval, occupying about 4 % of valve surface, located in same level of anterior scar close to dorsal edge, distance from posterior end equivalent to 1/5 of shell length; scars of pallial muscles thick, forming a special arrangement shown in Fig. 17 (pl), running along middle level between dorsal and ventral edges of each valve, anterior and posterior oblique ventral projections corresponding to angulations of pallial muscles (Fig. 18), ventral to each adductor scars.

Main muscle system (Figs 8, 18, 19, 24): Anterior adductor muscle antero-posteriorly elongated (length about 3 times the height); insertion area elliptical, equivalent to 2.5 % of that of each valve, size about 1/6 of length of valve and ¼ of its height; located close to antero-dorsal corner of each valve, dislocated posteriorly at distance equivalent to about half muscle length. Posterior adductor muscle with about ¾ of anterior muscle size, located in opposed side, close to postero-dorsal corner of valve, dislocated anteriorly in distance equivalent to same muscle length; anterior end of insertion area somewhat pointed. Pair of anterior retractor muscles



Figs 1–16. *Solen* cf. *exiguus* Dunker, shell and anatomical characters (MZSP 55045). 1: left valve, outer view. 2: right valve, outer view; 3: left valve, inner view. 4: right valve, inner view. 5: both valves connected and slightly deflected, ventral view. 6: same, detail of hinge. 7: same, detail of teeth and surroundings. 8: whole specimen, right view. 9: right valve, inner view, detail of posterior region. 10: same for left valve. 11: detail of hinge in a totally deflected valves, ventral view. 12: an autotomous piece of siphon, posterior view. 13: foot, right view, haemocoel sectioned longitudinally, with walls slightly deflected. 14–16: living animal, right view. 14: whole view, siphons and foot extended, shell length about 35 mm. 15: detail of extended siphon and adjacent portion of shell; 16: extended foot showing superficial texture. — Scales: Figs 1–5, 8 = 5 mm; Figs 6, 7, 9–11, Fig. 12 = 1 mm; Fig. 13 = 2 mm.

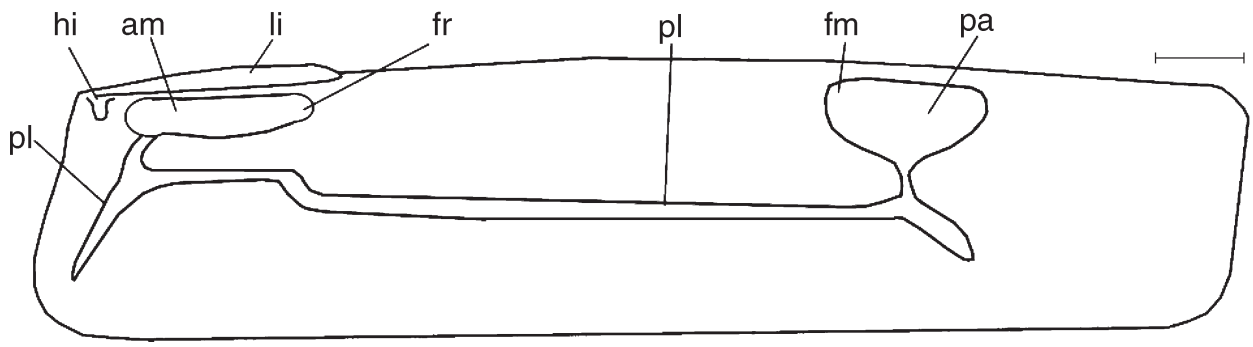


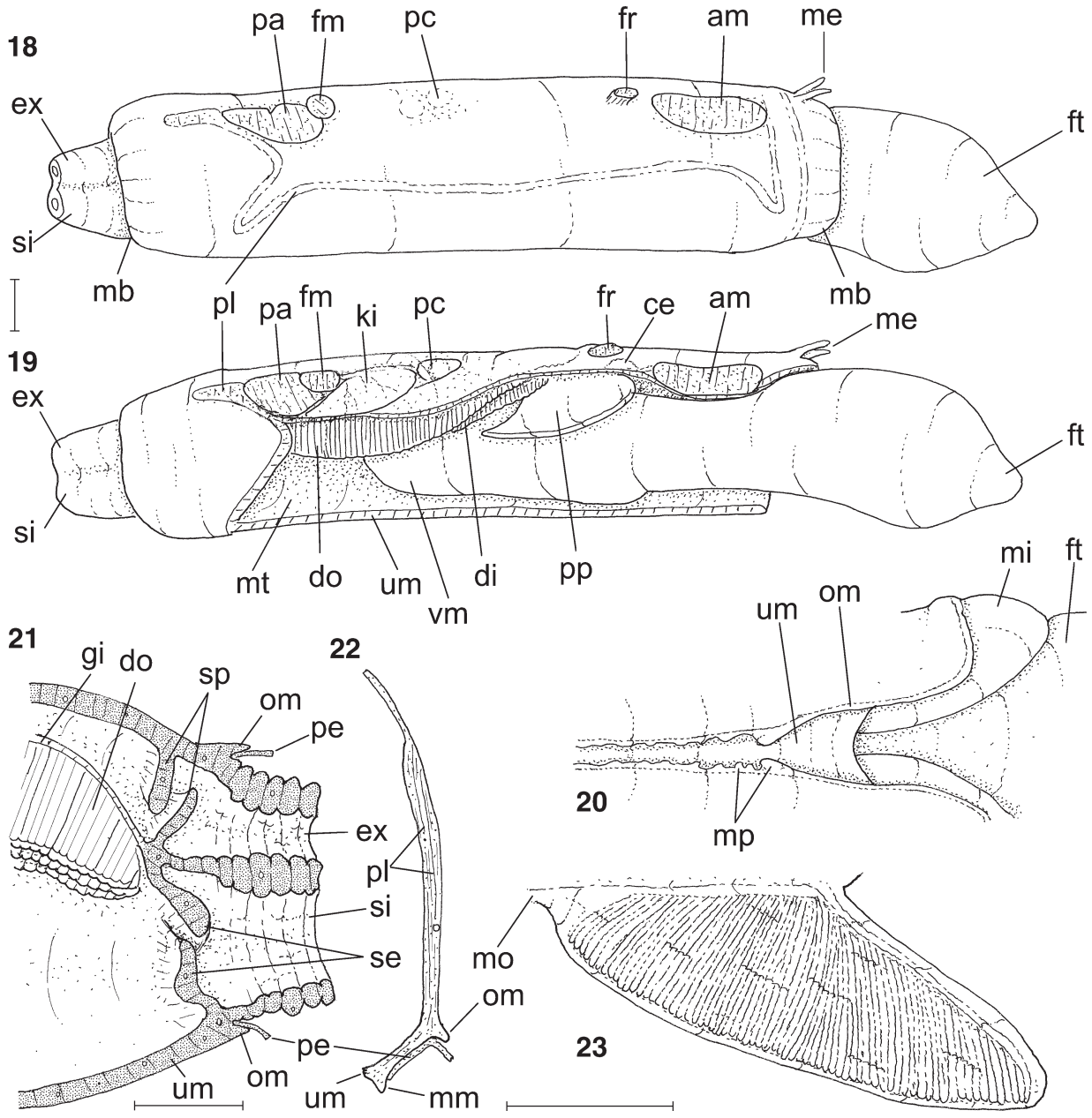
Fig. 17. *Solen* cf. *exiguus* DUNKER, right valve, inner view, semi-schematic representation of muscle scars. — Abbreviations: am: anterior adductor muscle; fm: posterior foot retractor muscle; fr: anterior foot retractor muscle; hi: hinge; li: ligament; pa: posterior adductor muscle; pl: pallial muscle. — Scale = 2 mm.

of foot originating just in posterior region of anterior adductor muscle; insertion area in valves elliptical (in antero-posterior direction) equivalent to 1/12 of that of anterior adductor muscle (Figs 18, 19, 24: fr); running towards ventral and posterior, at distance equivalent to 1/5 of shell length, increasing conspicuously (to about double size) (Fig. 24); splaying in antero-dorsal base of foot. Pair of posterior retractor muscles of foot originating just posterior to posterior adductor muscle in area equivalent to ¼ of that of adductor (Figs 18, 19, 24: fm); running antero-ventrally, splaying along posterior surface of foot base. No clear protractor muscle.

F o o t (Figs 8, 13, 14, 16, 18–20, 24): Size about half of entire animal. Color pale brown; outer surface a mosaic of small nodes (Fig. 16). About 30 % wider distally. Distal end broadly pointed. Inner haemocoel as a hollow chamber reaching almost distal tip (Fig. 13). Greatly turned anteriorly, about perpendicular to dorso-ventral axis.

M a n t l e (Figs 8, 14, 15, 18–22): Mantle lobes mostly as internal moulds of valves (Fig. 18); anterior and posterior edges thick. Both lobes fused along entire ventral edge. Outer folds of mantle edge about as tall as adjacent mantle thickness; mostly simple, except in ventral region preceding pedal aperture (Fig. 20), in which small and broad papillae gradually appear in anterior third part; these papillae gradually becoming taller up to a pair of taller papillae (about as tall as outer fold), located at some distance from anterior end of mantle fusion. Middle folds fused with each other along entire ventral region, being about as thick as adjacent region of mantle; both extremities of fusion marked by abrupt concavity; middle folds absent anteriorly and posteriorly to fusion. Inner folds appearing somewhat suddenly anteriorly and posteriorly to fusion, increasing considerably, being 3–4 times thicker than preceding region of mantle, extending beyond shell edge (Figs 8, 14). Outer folds of mantle edge further surrounding base of siphons in level of shell edge (Figs 18, 21: om) in active animals. Pallial muscles relatively thick, 3–4 times thicker than centro-dorsal region of mantle (Figs 18, 22). Siphons fused with each other, forming an 8-shaped (in section) tube with about half of shell volume (Figs 8, 14, 18, 19); process of autotomy always present, producing a half-sized siphon in fixed specimens, and several 8-shaped free rings (Fig. 12); anatomically each potential free ring marked by strong constriction in outer and inner siphonal surface (Figs 15, 21). Base of siphons marked by a valve in each, dividing supra- and infra-branchial chambers from (incurrent and excurrent) siphonal chambers (Figs 21: se, sp); each valve leaflet occupying slightly more than half of siphonal inner area, with about half of siphonal wall thickness; ventral leaflet of excurrent valve (Fig. 21: sp) and dorsal leaflet of incurrent valve (Fig. 21: se) slightly more posterior than respective pairs, pairs overlapping about 10–20 %. Siphonal tip thick and flat; outer surface with pale brown coloration, with paler longitudinal strips corresponding to each outer edge papilla (Fig. 12); outer edge with about 20 small papillae projected posteriorly, each papilla white, tip rounded, length about 1/3 of adjacent siphonal wall thickness, space between papillae equivalent to double papillae width (Fig. 12), this papillar pattern repeating successively along siphonal rings (Figs 14, 15); thick smooth and white border surrounding both siphonal apertures, occluding about half of each aperture like an incomplete septum; inner edge of these borders simple, smooth; outer edge of these borders possessing about 8 papillae in excurrent and about 15 papillae in incurrent apertures (no papillae between both apertures), characters of papillae somewhat similar to those of outer edge; inner papillae of incurrent siphon with an arrangement mostly with a larger and smaller papillar intercalated, and a pair of dark dots (eyes?), one positioned in each side of their base (Fig. 12, bottom). Pair of mantle tentacles located in dorsal end of anterior pallial aperture (Figs 18, 19: me), close to median line, between inner and middle folds of mantle edge; tip pointed, length about same as adjacent inner fold width.

P a l l i a l c a v i t y (Figs 8, 19, 21, 30): Occupying about 70 % of outer surface of pallial volume, antero-



Figs 18–23. *Solen* cf. *exiguus* Dunker. – Anatomy. 18: whole right view, shell removed. 19: same, right mantle lobe partially removed. 20: detail of anterior region of fusion of both mantle lobes, ventral view. 21: sagittal section in posterior region, left view, main concern to siphons. 22: transverse section in middle portion of a mantle lobe. 23: inner left hemipalp, inner view (outer hemipalp deflected upwards and not shown), anterior region left. — Abbreviations: am: anterior adductor muscle; ce: cerebral ganglion; di: inner demibranch; do: outer demibranch; ex: excurrent siphon; fm: posterior foot retractor muscle; fr: anterior foot retractor muscle; ft: foot; gi: gill ciliary connection to mantle; ki: kidney; mb: mantle border; me: mantle tentacle; mi: inner fold of mantle edge; mm: middle fold of mantle edge; mo: mouth; mp: mantle papilla; mt: mantle; om: outer fold of mantle edge; pa: posterior adductor muscle; pc: pericardium; pe: periostracum; pl: pallial muscle; pp: palp; se: valve in base of incurrent siphon; si: incurrent siphon; sp: valve in base of excurrent siphon; um: fusion between left and right mantle lobes between siphons; vm: visceral mass; Scales = 2 mm.

posteriorly elongated. Palps triangular, located about 30 % of shell length posterior to anterior shell edge (Fig. 19: pp); each hemipalp occupying an area equivalent to 5 % of each shell valve area; both hemipalps similar to each other; distal tip somewhat pointed, strongly turned posteriorly, posterior edge almost straight, ventral edge weakly rounded; inner surface with narrow smooth edge surrounding the free borders of entire palps (Fig. 23), width equivalent to double of each palp's inner transverse folds, being wider in anterior edge of outer hemipalps; a fold parallel to posterior edge flanking dorsal ends of inner transverse folds; inner transverse folds

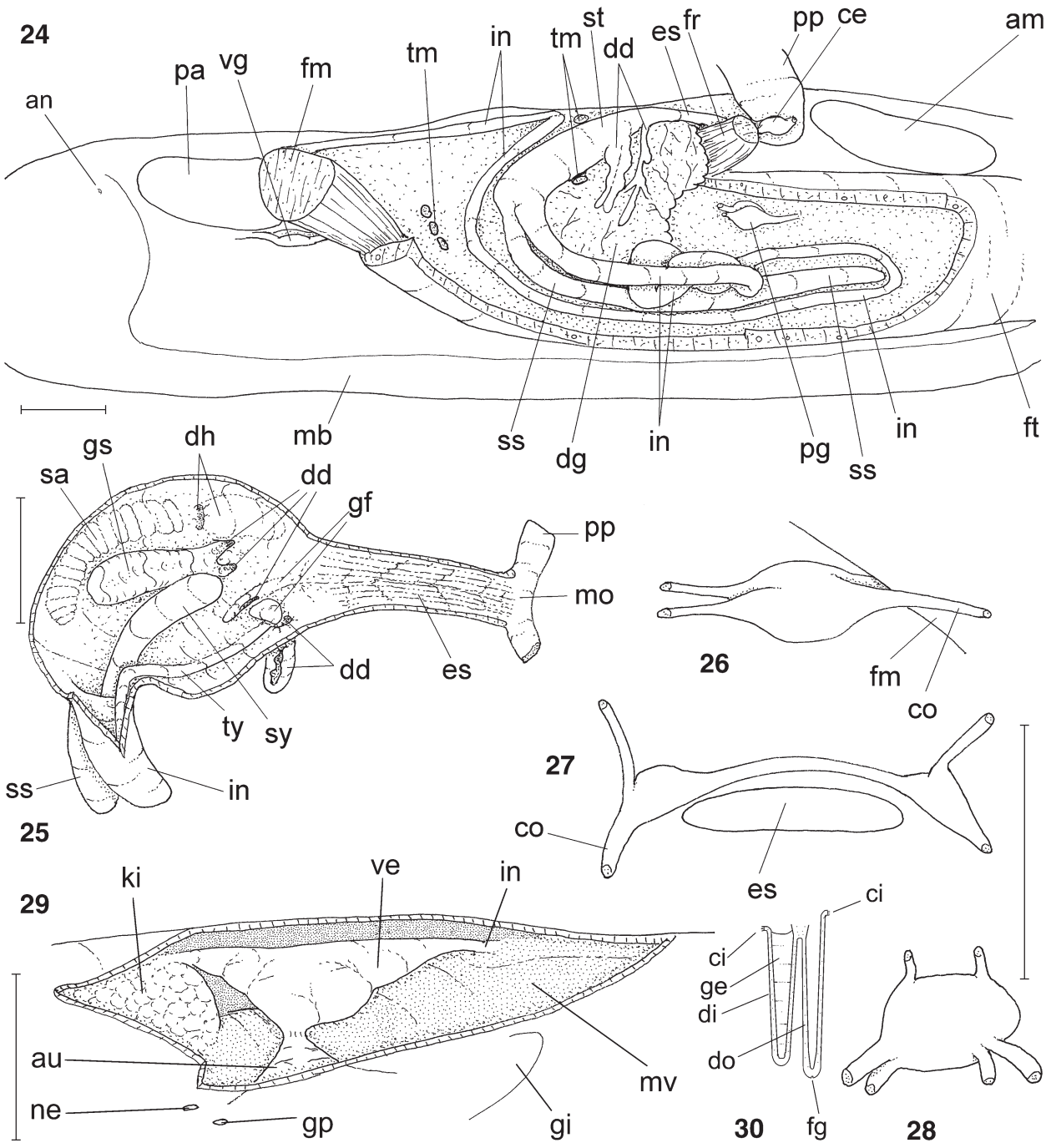
very narrow (about 1/100 of total hemipalp length); ventral end of each fold simple, rounded, abrupt; dorsal end of each fold suddenly fainting, in anterior half ending in smooth furrow between both hemipalps, in posterior half ending in fold parallel to posterior edge. Smooth furrow between both hemipalps with width of about 4–5 times of each transverse fold; another smooth anterior area preceeding mouth, with about 15 % of inner surface of each hemipalp.

Gills (Figs 19, 21; 30) small, each demibranch occupying about 5 % of valve area; triangular, narrow (wider posterior width about 15 % of length). Outer demibranch about 15 % shorter than inner demibranch, both demibranchs with same posterior end, outer demibranch ending posteriorly to that of inner demibranch (Fig. 19: di), between both hemipalps. Gills transversely folded, each fold containing about 14 filaments. Transverse septum-like membrane regularly located in supra-branchial chamber of both demibranchs sustaining transverse folds (Fig. 30: ge), situated somewhat aligned in both demibranchs and in both gills; each membrane smooth, simple, restricted to inner region of each demibranch (Fig. 30). Ventral edges of both demibranchs similar to each other, profile rounded, a very small and shallow food groove present in ventral and middle region of ventral edge of outer demibranch only (Fig. 30: fg). Connection of outer demibranchs with adjacent region of mantle, and connection of inner demibranchs with visceral mass or its pair (about half of their length) by cilia (Fig. 30: ci), not by tissue; connection between both inner demibranchs in their region posterior to visceral mass (about half of their length) by a horizontal membrane, with a tissue connection; this membrane weakly broader anteriorly, with shallow concavity surrounding visceral mass, gradually narrowing towards posterior up to posterior end of gills.

Visceral mass (Figs 18, 19, 24): Antero-posteriorly elongated, mainly concentrated in posterior half of pedal-visceral mass, occupying about 60 % of shell volume. Stomach discoid, dorso-ventrally flattened, located in dorso-anterior region of visceral mass, just posterior to anterior pair of pedal retractor muscles. Digestive diverticula pale brownish-green, located mostly in lateral and ventral region of stomach, filling out about ¼ of inner space, in centro-dorsal region. Gonad white to cream, mostly located in dorso-anterior region, also surrounding lateral regions covering intestinal loops and digestive diverticula, and posterior region ventral to pericardium and kidney. Transverse muscles well-developed in middle portion of posterior region (Fig. 24: tm), normally in number of three. Other two well-developed transverse muscles, one in ventral and another in dorsal region of stomach (Fig. 24). Reno-pericardial structures located in dorsal region just anterior to posterior adductor muscle; occupying about 7 % of valves inner volume. Pedal retractor muscles (described above) occupying considerable (about 15 %) space of visceral inner volume, mainly constituting anterior and posterior walls (Fig. 24: fm, fr).

Circulatory and excretory systems (Fig. 29): Heart occupying about 60 % of reno-pericardial volume, located anterior and dorsal to kidney. Auricles triangular, thin and simple walled, connected directly to middle portion of gills at about 1/3 of gills length; connection of auricles to ventricle simple, centro-lateral. Ventricle with about 40 % of pericardium volume. Kidney totally solid, color greenish beige. Nephropore a very small slit located in ventro-anterior region of each side of suprabranchial chamber, close to border of pericardium.

Digestive system (Figs 24, 25): Palps described above. Mouth simple, with about 1/3 of anterior adductor muscle width, located close to posterior surface of this muscle. Oesophagus brad and dorso-ventrally flattened; length about 15 % of that of shell; inner surface with 8–10 longitudinal, low folds, located close to each other, gradually disappearing in esophageal insertion in stomach. Stomach discoid, dorso-ventrally flat, slightly longer than oesophagus; two pairs of branched latero-ventral projections connected to digestive diverticula (Fig. 24: dd), in anterior third, directed ventrally, anterior and posterior edges flattened and somewhat undulating. Gastric inner surface (Fig. 25) with a dorsal sorting area, containing transverse, slightly widened folds, occupying about ¼ of gastric dorsal area; gastric shield with approximately same size of sorting area, located in left gastric region, elongated antero-posteriorly, with a pair of anterior projections inserted inside both left apertures to digestive diverticula; gastric fold running along right gastric side, forming anteriorly a curve between both ducts to digestive diverticula, posteriorly running in intestine as typhlosole; a small gastric fold is flanking the ventral edge of ventral-right aperture to digestive gland. Style sac totally separated from adjacent portion of intestine; originating at left and slightly posterior than intestinal origin, as ventral-posterior end of stomach (Fig. 25); running initially ventrally and gradually towards anterior, in ventral region of visceral mass (Fig. 24: ss). Width approximately half of gastric dorso-ventral height; length of style sac about half of that of viscero-pedal mass; distal end rounded, located about midway between stomach and distal end of foot; inner surface smooth, iridescent. Intestine with approximately same width as of style sac; initially running parallel and dorsal to style sac; performing special set of loops (Fig. 24: in) in middle level of style sac; after this loops intestine becoming about 70 % slender, running from dorsal to ventral by surrounding anteriorly the end of style sac, after this, running towards posterior, ventrally to style sac; gradually surrounding, towards dorsal, posterior region of stomach up to stomach middle-dorsal region; abruptly turning towards posterior, passing through pericardium and between both origins of posterior pedal muscles (Fig. 24); after this, intestine is crossing dorsal and pos-



Figs 24–30. *Solen* cf. *exiguus* Dunker. – Anatomy. 24: visceral mass, right view, left region of integument, gonad and part of digestive diverticula removed, topology of some adjacent structures also shown. 25: foregut and midgut, slightly right dorsal view, esophagus, stomach and part of intestine opened longitudinally, inner surfaces exposed, palp deflected and only partially shown. 26: visceral ganglia, slightly right dorsal view, topology of visceral mass shown. 27: cerebral ganglia, anterior view, topology of esophagus shown. 28: pedal ganglia, ventral view. 29: pericardium and adjacent region, right view, right pericardial wall mostly removed. 30: gill, transverse section in its middle region. — Abbreviations: am: anterior adductor muscle; an: anus; au: auricle; ce: cerebral ganglion; ci: ciliary connection of gill to neighbouring structures; co: cerebro-visceral connective ;dd: ducts to digestive diverticula; dg: digestive diverticula/gland; dh: dorsal hood; di: inner demibranch; do: outer demibranch; es: esophagus; ex: excurrent siphon; fg: gill food groove; fm: posterior foot retractor muscle; fr: anterior foot retractor muscle; ft: foot; ge: gill septum sustaining gill transversal folds; gf: gastric fold; gi: gill ciliary connection to mantle; gp: genital porus; gs: gastric shield; in: intestine; ki: kidney; mb: mantle border; me: mantle tentacle; mi: inner fold of mantle edge; mm: middle fold of mantle edge; mo: mouth; mp: mantle papilla; mt: mantle; mv: visceral mass; ne: nephropore; om: outer fold of mantle edge; pa: posterior adductor muscle; pc: pericardium; pe: periostracum; pg: pedal ganglia; pl: pallial muscle; pp: palp; sa: gastric sorting area; se: valve in base of incurrent siphon; si: incurrent siphon; sp: valve in base of excurrent siphon; ss: style sac; st: stomach; sy: style; tm: transversal muscles of visceral mass; ty: typhlosole; um: fusion between left and right mantle lobes between siphons; ve: ventricle; vg: visceral ganglia; vm: visceral mass. — Scales = 2 mm.

terior surface of posterior adductor muscle along median line. Anus papilla-like, peduncled with stalk of length of about 1/30 of shell length; tip blunt; orifice small, ventral; located in posterior region of posterior adductor muscle (Fig. 24: an).

Genital system: Gonad described above. No special gonoduct found. Pair of genital apertures located at a distance equivalent to 1/20 of shell length anterior and slightly ventral to nephropore (Fig. 29: gp).

Central nervous system (Figs 24, 26–28): Cerebral ganglia located just at side of mouth and at a distance equivalent to 1/20 of shell length posterior to anterior adductor muscle (Fig. 24: ce); each ganglion oval, with antero-posterior longer axis; diameter of each cerebral ganglion about half of a transverse section of oesophagus; cerebral commissure about 1.5 times longer than each cerebral ganglion (Fig. 27). Visceral ganglia located in anterior region of posterior adductor muscle ventral surface (Fig. 24: vg); each visceral ganglion elliptical, with antero-posterior longer axis; volume of each ganglion approximately 1.5 that of each cerebral ganglia; each visceral ganglion positioned very close to each other and to median line, commissure almost invisible. Cerebro-visceral connectives relatively thick (Figs 26, 27: co), running through gonad, between posterior pedal retractor muscles and integument of their posterior region. Pedal ganglia located in anterior region of pedal base, at same vertical level as of cerebral ganglia (Fig. 24: pg); both pedal ganglia amply connected to each other, being practically fused (Fig. 28); volume of both ganglia equivalent to double of each cerebral ganglion.

Measurements (antero-posterior length, dorso-ventral height and maximal lateral inflation): 32.0 × 7.2 × 5.1 mm (MZSP 55045 #3) 29.0 × 7.2 × 5.0 mm (MZSP 55045 #4).

Distribution: Gulf of Thailand.

Habitat: Intertidal, sandy bottoms.

Material examined: **Thailand**. Chanthaburi (Gulf of Thailand): Kungkrabaen Bay, 12°35.16'N 101°54.40'E – 12°35.31'N 101°54.29'E (sta. KKB-03-04 "middle of bay station"), SIMONE leg., Aug.2005 (MZSP 55045, 8 specimens, MZSP 55046, 1 specimen, SMF 333514/2).

Discussion

As stated in the introduction, a more accurate identification of the studied sample is problematic. Based on a dialogue with the solenid specialist Rudo von COSEL, who is performing a complete revision of the solenids from the S.E. Asia, the following taxonomic discussion can be executed. Initially, the sample was identified as *Solen curtus* DES MOULINS 1832 (see SWENNEN & al. 2001); the name appears in the previous paper which deals with some morphological characters formally presented herein (SIMONE & WILKINSON 2008). However, the presumable syntypes of *S. curtus* in MNHN actually belong to *S. brevis* HANLEY 1842 (= *S. vagina* LINNAEUS 1758). This, associated to the incompleteness of the description, shows that recognition of *S. curtus* is difficult. Anyway, the sample here studied fits in the informal complex of *Solen exiguus/leanus*, which is part of an ongoing study of the small solenids from S.E. Asia (v. COSEL, personal communication); both taxa were described by DUNKER (1862) and most possibly are synonyms. Based on these problems, and until the revision of the solenids from that region has been completed, the best accorded procedure is to denominate the presently studied sample as *S.* cf. *exiguus*.

The main feature that is possible to recognize during the dissection of a solenid is the extreme antero-posterior elongation. This is clear in the present material; though, the elongation is still more developed in other members of the family (e.g. BLOOMER 1905, 1906; YONGE 1952). Most organs and structures are antero-posteriorly very elongated, particularly in the pallial cavity and visceral mass. Conversely, the foot is proportionally large; this feature, associated with the relative large hollow region inside the foot, an exclusive modification, shows that the foot is a significant structure for the animal's mode of life. As the solenids are famous quick diggers, the hollow portion of foot can be indicative of large hydrostatic pressure ruling the digging movements. Besides this, other anatomical adaptations, too, look important for rapid digging, such as the siphonal valves, the increasing of anterior pallial edge (also known as pallial crest, cf. MORTON, 1988), the strong transverse muscles in visceral cavity (Fig. 24: tm) and the enlargement of retractor pedal musculature. Interestingly, and against intuitive conclusions, the animal lacks well-developed protractor pedal muscles.

The siphonal autotomy is notorious in *Solen* cf. *exiguus* (Figs 8, 12), provided by deep successive anatomical constrictions of the siphons (Fig. 21). However, this feature appears to be common amongst the solenids (FAUSSEK 1897; MORTON 1984). On the other hand, the pair of transverse valves at base of siphons (Fig. 21: se, sp) is apparently a novelty particular to *S.* cf. *leanus* . The mantle tentacles (Figs 18, 19: me) have been also found in other solenids (MORTON 1988, as anterior pallial tentacles in *Solen* aff. *exiguus*; COSEL 2002), those of *S.* cf. *exiguus*, however, appear to be the proportionally shortest of the known species in this detail.

The knowledge of soft parts of solenids, as usual in Mollusca, is relatively scanty. Some few ultra structural studies (e.g. Hodson & al. 1987), and some morphological approaches (e.g. Bloomer 1905, 1906; Holme 1951; Morton 1984, 1988), have brought additional characters for differentiation and a better definition of species. For example, *S.* cf. *exiguus* appears to be the single species with valves at the bases of the siphons (Fig. 21: se, sp). Although the separation of the gastric style sac from adjacent intestine (Fig. 24: ss), and well-developed transverse muscles in visceral sac (Fig. 24: tm), appear to be characteristic of the family, details of their arrangement are different and worthy for taxonomical analysis. Another important source of comparative data is the arrangement of papillae at the tip of siphons [compare Fig. 12 with Morton (1984) fig. 2].

Acknowledgements

The International Marine Bivalve Workshop (with contributions on other molluscan groups) in Chantaburi, Thailand, was organized by Kashane Chalermwat (Burapha University), Fred Wells (Western Australian Department of Fisheries), Rüdiger Bieler (Field Museum of Natural History, Chicago), and Paula M. Mikkelsen (American Museum of Natural History), and supported by U.S. National Science Foundation grant PEET DEB-9978119 (to RB and PMM). Field transportation in Thailand and chemicals were provided by the Faculty of Science, Burapha University. I specially thank to Rudo von Cosel, MNHN, for the taxonomical information and a special analysis of the samples, a procedure that was also helped by Philippe Maestrati (MNHN), Ronald Janssen (Senckenberg Forschungsinstitut) and the anonymous referees. This study was partially developed under a governmental support of Fapesp (Fundação de Amparo à Pesquisa do Estado de São Paulo) process 2004/02333-8.

References

Atkins, D. (1937): On the ciliary mechanisms and interrelationships of lamellibranchs. Part IV: cuticular fusion, with special reference to the fourth aperture in certain lamellibranches. — Quarterly Journal of Microscopical Science, **79**: 423–445.

Bloomer, H. H. (1905): On the anatomy of certain species of *Siliqua* and *Ensis*. — Proceedings of the Malacological Society of London, **6** (4): 193–196, pl. 12.

Bloomer, H. H. (1906): On the anatomy of *Ensis macha*, *Solen fonesii*, and *S. viridis*. — Proceedings of the Malacological Society of London, **7** (1): 18–19.

Cosel, R. v. (1989): Three new species of *Solen* (Bivalvia: Solenidae) from the Indian Ocean, with remarks in the Solenidae of Madagascar. — Journal of Conchology, **33** (4): 189–208, pls. 21–25.

— — — (2002): Seven new species of *Solen* (Bivalvia: Solenidae) from the tropical Western Pacific, with remarks on other species (pp. 301–341, pls. 31–38). — In: Falkner, M., Groh, K. & Speight, C.D. [eds.]: Collectanea Malacologica – Festschrift für Gerhard Falkner. — 10 + 547 pp, 48 pls.; Hackenheim (Conchbooks) and München (Friedrich-Held-Gesellschaft).

Des Moulins, M. (1832): Notice sur la répartition des espèces dans les genres *Solen, Solecurte, Sanguinolaire* et *Soletelline* de M. de Blainville. — Actes de la Sociéteé Linnéene de Bordeaux, **5**: 92–115.

Dunker, W. (1862): Solenacea nova collectionis Cumingianae descripta a Guilielmo Dunker. — Proceedings of the Zoological Society of London, **1861**: 418–427.

— — — (1868): Novitates conchologicae. Mollusca marina, **3** (6): 117–120, pls. 37–39; Cassel (Fischer).

Faussek, V. (1897): Die Autotomie der Siphone bei *Solen* und *Solecurtus*. — Travaux des Société Impériale des Naturalistes de St. Petesbourg, **28** (2): 249–270, 1 pl.

Ghosh, E. (1920): Taxonomic studies on the soft parts of the Solenidae. — Records of the Indian Museum, **19** (2): 47–78, pls. 2–3.

Gofas, S., Le Renard, J. & Bouchet, P. (2001): Mollusca. — In: Costello, M. J. [Ed.]: European register of marine species: a check-list of the marine species in Europe and a bibliography of guides to their identification. — Collection Patrimoines Naturels, **50**: 180–213.

Hodgson, A. N., Villiers, C. J. & Bernard, R. T. F. (1987): Comparative spermatology of two morphologically similar species of *Solen* (Mollusca: Bivalvia). — South African Journal of Zoology, **22** (4): 264–268.

Holme, N. A. (1951): The identification of British species of the genus *Ensis* Schumacher (Lamellibranchiata). — Journal of the Marine Biological Association of the United Kingdom, **29** (3): 639–647.

Morton, B. S. (1984): Siphonal autotomy in *Solen corneus* (Bivalvia: Solenoidea) from Hong Kong. — Malacological Review, **17** (1–2): 95–96.

— — — (1988): The anterior pallial tentacles of *Solen* aff. *exiguus* (Bivalvia: Solenacea) from Hong Kong. — Journal of Molluscan Studies, **54** (1): 135–137.

Owen, G. (1959): Observations on the Solenacea with reasons for excluding the family Glaucomyidae. — Philosophical Transactions of the Royal Society of London (B), **242** (687): 59–97.

Simone, L. R. L. & Wilkinson, S. (2008): Comparative morphological study of some Tellinidae from Thailand (Bivalvia: Tellinoidea). — The Raffles Bulletin of Zoology, suppl. **18**: 151–190.

Sowerby, G. B. (1874): Monograph of the genus Solen. — In: Reeve, L. A.: Conchologica Iconica, **19**: 7 pls.; London (Reeve).

SWENNEN, C., MOOLENBEEK, R. G., RUTTANADAKUL, N., HOBBELINK, H., DEKKER H. & HAJISAMAE, S. (2001): The mollusks of the southern Gulf of Thailand. — 211 pp.; Bangkok (The Biodiversity Research and Training Program (BRT))

YONGE, C. M. (1952): Studies on Pacific coast mollusks. IV. Observations on *Siliqua patula* Dixon and on evolution within the Solenidae. — Publications in Zoology of the University of California, **5** (9): 421–438.

Manuscript submitted: 19.06.2008
Revised manuscript accepted:02.07.2009