Fig. 1: (Top left) Living fragment of *Montipora tuberculosa* (Lamarck, 1816), IPUW 3865, with freed *Lithophaga (Leiosolemus) purpurea* Kleemann, 1980, 21.2-7.5-5.9 mm, collected 2007 11 05, Dahab, Red Sea. Note characteristic posterior encrustation. Scale in cm. (Top right) *L. purpurea* from IPUW 3872, M. grisea Bernard, 1897 (see text). (Middle) Several *L. purpurea*, in living *M. corbettensis* Veron & Wallace, 1984 (cf. IPUW 3864, coll. 2007 11 07), from Rick's Reef, Dahab. Scale in mm (Continuation see page 33)
Lithophaga (Leiosolenus) purpurea (Bivalvia: Mytilidae): One species becomes three.

Karl Kleemann, Wien

Abstract

The live coral associated and excavating bivalves, formerly combined under the name Lithophaga (Leiosolenus) purpurea Kleemann, 1980, are a mixture of species. The types and similar looking specimens from acroporid Montipora species belong to L. purpurea in the present sense, specimens from favid Cyphastrea and Echinopora species generally belong to L. paraparurea n. sp., and those from the astrocoeniid Stylocoeniella are members of L. dahabensis n. sp.

Zusammenfassung

Die in lebenden Wirtsorganen bohrenden Muscheln, die bislang unter dem Namen Lithophaga (Leiosolenus) purpurea Kleemann, 1980, zusammengefasst waren, sind ein Artempf.

Introduction

Gohar & Soliman (1963a) noted three mytilid Lithophaga species boring in live coral at Hurgada, northern Red Sea. One of them, their L. lima (non Lam, 1919), was later regarded to represent an undescribed species, L. (Leiosolenus) purpurea Kleemann, 1980. Previously, the author considered Lithophaga specimens associated with Montipora, Cyphastrea and Echinopora as belonging to L. purpurea, later adding Stylocoeniella and Siderastrea as hosts (Kleemann 1992, 1995). Brickner et al. (1993) investigated two L. purpurea populations, one from C. chalcicicum (Forskal, 1775) and the other from M. eurythraea Marenneller, 1907. The latter is neither listed in Cairns et al. (1999) nor in Veron (2000 vol. 1). Evidence from ecological, biochemical and SEM analysis gave Brickner et al. (1993) good arguments for their hypothesis that two distinct species are involved. The present study, based on old and new material, provides more evidence based on morphological differences in posterior shell encrustation. These features, consistent in specimens of each species, become more obvious with increasing shell size. This yields a reliable tool for determination according to the respective encrustation pattern developed (Kleemann 1980, 2004, Kleemann & Hoeksema 2002).

Material and Methods

The material on which the original description of Lithophaga (Leiosolenus) purpurea Kleemann, 1980, is based, was collected by A. & M. Mastaler in 1977 from the reef in front of the Royal Jordanian Marine Research Centre, south of Aqaba. Personally photo documented and sampled material is also from Aqaba as well as a number of Egyptian localities at Hurgada, Safaga, Zabargad Island, and most recently Dahab. The latter locality is mainly restricted to the dive site 'Islands', 28° 28' 38.7" N, 34° 30' 50.5" E to 28° 28' 36.0" N, 34° 30' 46.3" E. Further material for comparison is from a few Great Barrier Reef (GBR), Maldivian and New Caledonian localities. Bivalves inhabiting scleractinian corals were photo-documented in situ using SCUBA. Small colonies or fragments of various host species were collected with hammer and chisel. The fresh corals were either partly dissected with a small chisel or first air-dried and then transported to Vienna for further treatment. Undamaged bivalve specimens were measured with callipers for individual length, height and width to the nearest 0.1 mm. Fresh specimens were preserved in 70% ethanol or, in the case of the recently collected bivalves from Dahab and the Maldives, in pure ethanol, after blotting the shells on tissue paper for draining, to be suitable for DNA analysis. Coral fragments were cleaned either in bleach or hydrogen peroxide ($H_2O_2$).

Museum acronyms: BM(NH) - British Museum of Natural History, IPUW - Institute of Palaeontology University of Vienna.

Taxonomy

Class Bivalvia Linnaeus, 1758
Order Mytiloida J. Férussac, 1822

(Continuation from legend Fig. 1, Page 32) (Bottom left) Three borehole orifices of L. purpurea in M. monasteriata, cf. IPUW 3867. (Bottom middle) Encrusted shell ends of L. laevigata (Quoy & Gaimard, 1835) block the borehole entrance (5.2 mm in length, bivalve -22.7-5.6 mm) in M. modosa (Dana, 1846), IPUW 3868, Lizard Island, GBR, Australia, collected 1991 11 29. (Bottom right) Posterior part of L. laevigata, remaining length ~7 mm, pattern of encrustation divaricate, boring in IPUW 3869, M. monasteriata (Forskal, 1775), from 9 m, transect A3, northern Bay of Safaga, collected 1987 07 15.
Fig. 2: (A) IPHW 20080010001, *Lithophaga* (*Leiosolenus*) *purpurea* n. sp., holotype, 15.0-6.2-5.2 mm, in dorso-lateral view, posterior encrustation smooth, ending in a lip-like structure without distinct spikes. (B) IPHW 20080010002, *L. (L.)* *purpurea* n. sp., 1st paratype, posterior encrustation smooth, ending in a lip-like structure with distinct teeth. (Continuation see Page 36)
Fig. 3 A-C: Bleached *Echinopora lamellosa* (Esper, 1795), IPUW 3870, (A) partly split open, presenting a *L. parapurplea* n.sp. –10 mm in length, posterior encrustation terminating in a few spikes, borehole orifice positioned between corallites. (Continuation see page 36)
Superfamily Mytiloidea Rafinesque, 1815
Family Mytilidae Rafinesque, 1815
Subfamily Lithophaginac H. Adams & A. Adams, 1857
Lithophaga Röding, 1798
Leiosolenus (Carpenter, 1856)

Lithophaga (Leiosolenus) purpurea
Kleemann, 1980 (Fig. 1)

1992 Lithophaga purpurea (pars) Kleemann, Facies, 26: 8, only from Montipora spp.
1993 Lithophaga purpurea (pars) Brickner et al., Marine Ecology Progress Series, 101: 139-145, only from Montipora eymhoevae Marenzeller, 1907, not Cyphastrea chalcidicum (Forskal, 1775).
1995 Lithophaga purpurea (pars) Kleemann, Beiträge zur Paläontologie, 20: 35, tab. 1, only from Montipora spp.

Holotype: BM(NH)197811, 19.7-7.6-6.2 mm (Kleemann 1980: fig. 9-10)
Paratype: BM(NM)197812, 15.4-6.6-5.3 mm (Kleemann 1980: fig. 9-10)
Type locality: Fore reef slope near Aqaba (lat. 29° 26' N, long. 34° 58' E), Jordan, Red Sea (Non Great Barrier Reef, as stated by Brickner et al. 1993: 140).

Diagnosis: Shell purple, up to 35 mm in length (Gohar & Soliman 1963a: tab. 4), posterior higher than anterior end, posterior encrustation in a fine, file-like pattern (Fig. 1), not (or minimally) protruding, shell outline more oval and less slender than in L. paraparapurea n. sp., which has a smooth posterior encrustation (see below).

Description: The original description of L. purpurea (Kleemann 1980: 21), based on the type specimens from Montipora cf. stillosa (Ehrenberg, 1834), is generally upheld. Only the purple colour, being shared with L. paraparapurea n. sp., is no longer regarded as an outstanding species-specific feature.

Remarks: As both holotype and paratype are from Montipora, the synonymy of L. lima, sensu Gohar & Soliman (1963a, b) and Soliman (1969), given in Kleemann (1980: 21) remains valid - with the exception of a few specimens reported from Cyphastrea (Gohar & Soliman 1963a: 93). The latter are now regarded to belong to a distinct species, L. paraparapurea n. sp. (see below). Gohar & Soliman (1963a: 93) already noted L. purpurea boring in Montipora together with L(L). laevigata (Quoy & Gaimard, 1835). Only L. laevigata specimens were found in a colony of M. corbettiensis Veron & Wallace, 1984, from Safaga, northern Red Sea, and in several Montipora species from Lizard Island, GBR, Australia (Fig. 1, bottom middle; see Discussion).

Habitat: Several, probably all, encrusting to massive species of the acroporid Montipora serve as host corals. Previous records include: Montipora, Hurgada, Egypt (Gohar & Soliman 1963a), M. lamuninosa Bernhard, 1897, Hurgada (Soliman 1969: 888); M. cf. stillosa (Ehrenberg, 1834), Aqaba, Jordan (Kleemann 1980: 22, 24, fig. 9-10); M. cf. floweris Wells, 1954 (Kleemann 1990: fig. 5, more likely depicts Astreopora sp. inhabiting L. (L.) simplex Iredale, 1939); M. tuberculosa (Lamark, 1816), NHMW16210, loc. 8, 2 m, Safaga (Kleemann 1990: 86, tab. 1); M. tuberculosa (Kleemann 2001: fig. 5a; 6.5 m, Tubia Al-Bayda 1992 10 01 slide 30).

Material examined: IPUW3863, M. stillosa, at Dabah, Egypt, 2007 11 05 – 4; IPUW3864, M. corbettiensis Veron

(Continuation from legend Fig. 2, page 34) (C) IPUW 200800100004, L. (L.) paraparapurea n. sp. in situ, 3rd paratype, 11.5-5.2-4.3 mm, posterior encrustation smooth, ending in a lip-like structure with few indistinct spikes. (D) L. (L.) laevigata (Quoy & Gaimard, 1835), IPUW 3860, 14.4-6.1-5.2 mm, posterior encrustation pattern divaricate, specimen from the same colony as the types of L. paraparapurea n. sp. (cf. Fig. F). (E) Surface detail of Cyphastrea microphthalma (Lamark, 1816), IPUW3861 (pars), hosting the types of L. paraparapurea n. sp., further specimens as well as one L. laevigata (see Figs. D and F, left of centre). Note borehole orifices and partly visible posterior shell rims. Frame width 27 mm. (F) Same coral as in Fig. D, split open in cross section, depicting boreholes, some still containing L. paraparapurea n. sp., and one L. laevigata, left of centre. Scale in mm. (G) Surface detail of dredged C. microphthalma, MNHN Paris, from 35-45 m, Santal Bay, Lifou, Loyalty Islands, New Caledonia, with various orifices of L. paraparapurea n. sp., some with spiked posterior ends. Scale in mm. (H) Cyphastrea serriata (Forskål, 1775), IPUW 3862, Dabah, surface view with one bigger and one smaller borehole orifice. (I) Colony from H split open, the two L. paraparapurea n. sp. so not yet show a distinct encrustation. Scale in cm.

(Continuation from legend Fig. 3, page 35) (B) more orifices outside calices, particularly those minute ones of recently settled bivalves and an older one, encrusting shell-ends within. (C, photo by C. Bax) a minute L. paraparapurea n. sp., ~0.5 mm, settled on top of an exsult septum denticle on the cornallite wall, encased by self-deposited 'borehole' lining, being round and smooth, while the denticle shows a highly elaborated structure: from Dahab, Red Sea, collected 2007 11 14. (D) IPUW3877 in situ, shingle-shaped colony of L. lamellosa, 18 cm in length, 8 m, Zabargard Island, Red Sea, 1993 11 11 colour slide 22. Note density, location in the coenosmum and different sizes of borehole orifices.
Lithophaga (Leiosolenus) parapurpurea n. sp. (Figs. 2, 3)


1980 Lithophaga (Leiosolenus) purpurea (pars) KLEMMANN, Journal of molluscan Studies, 46: 21-25, only from Cyphestaea (fig. 12) and Echinopora (fig. 13).


1992 Lithophaga purpurea (pars) KLEMMANN, Facies, 26: 8, only from Cyphestaea and Echinopora.

1993 Lithophaga purpurea (pars) BRACKER et al., Marine Ecology Progress Series, 101: 139-145, only from Cyphestaea chalcaicum (Forskal, 1775), not Montipora erythraea Marenzeller, 1907.

1995 Lithophaga purpurea (pars) KLEMMANN, Beiträge zur Paläontologie, 20: 35, tab. 1, only from Cyphestaea and Echinopora.

Etymology: Named after the similarity to L. purpurea, from which it is now separated.

Holotype: IPUM38000100001, 15.0-6.2-5.2 mm (Fig. 2A), host Cyphestaea microphilalma, IPUM3861

Paratype 1: IPUM38000100002, 14.8-6.0-5.3 mm (Fig. 2B)

Paratype 2: IPUM38000100003, 13.5-5.6-5.2 mm

Paratype 3: IPUM38000100004, 11.5-5.2-4.3 mm (Fig. 2C).

All three from the same C. microphilalma, IPUM3861, as the holotype.

Type locality: Makunood, N. Male Atoll, Maldives, 4°31'50,51" N., 73°25'21,54" E. (after Google Earth), collecting date 2007 03 17.

Diagnosis: Shell less than 20 mm in length, purple, posterior encrustation, very thin, smooth and not protruding. Host corals are the favids Cyphestaea and Echinopora.

Description:Shell very thin, fragile, and purple as in L. purpurea, but often less oval and more slenderly elongate in its proportions and smaller in reachable size than L. purpurea. Anterior end nearly hemispherical, slightly lower than posterior end, which is wedge-shaped. Anterior, dorsal,
Fig. 4: (A) Remains of Stylocenella guentheri (Basset-Smith, 1890), in situ, containing Lithophaga (Leiosolemus) dahabensis n. sp., collected from 16 m at Rick’s Reef, the type locality. (B) Fragment of S. guentheri (right part is preserved as IPUW3871), counterpart to centre in Fig. 1, demonstrating dense bivalve population, boring from both sides, the yellowish (upper) light-exposed versus dark brown (lower) shaded surface (see Figs. 5 top and bottom). (C) Specimens of L. dahabensis n. sp. collected from fragments shown above and in Fig. 5, various sizes indicate several generations of bivalves in the same host colony. Scale in cm. (D) Close up of dis-articulated empty shell in C, paratype IPUW200800010005. Note distinct dorsal angle, purplish colour, darkening posteriorly, and pronounced growth steps.
Fig. 5: Fragment of *S. guentheri* which hosted the types and contained numerous further specimens of *L. dahabensis* n. sp., light-exposed surface (top), former shaded surface (bottom). Note borehole orifices blocked by posterior shell ends. Frame size 8x5 cm.
and lateral parts of the shell may be covered by whitish dust to paint-like deposits, a general feature in not too young and small L. (Leiosolenus) specimens. In contrast to this inconsiderable shell cover, a solid, although very thin and smooth encrustation is usually developed at the posterior end in adult L. paraparupurea n. sp., this encrustation does not noticeably protrude above the shell. In horizontal view, these posterior shell rings resemble narrow whitish lips (Fig. 2A, 2C, 2E), comparable with those from L. (L.) kuehneii KLEEMANN, 1977, which are associated with acroporid Isopora species (KLEEMANN 1977). Posterior encrustations of L. paraparupurea n. sp. individuals are occasionally armed with single to several, minute spikes (Fig. 2B, 2G), as opposed to the coarser, blunt-ending and sometimes tightly interlocking ‘teeth’ of the divergating encrustation in L. laevigata (Fig. 2D); see also KLEEMANN 1977: fig. 6, named L. hanleyana (RHEEVE) sensu GOHAR & SOLEMAN 1963a).

Habitat: Host corals for L. paraparupurea n. sp. are members of the families Caryastrea and Echinopora. In the northern Red Sea, as far as C. chalcedicum (FORSKAL, 1775), C. microphthala (LAMARCK, 1816) and C. serailia (FORSKAL, 1775) as well as E. lamellosa (ESPER, 1795) are recognized as hosts to a depth of over 40 m (Fig. 2E, 2G-I, Fig. 3). Colonies of C. microphthala from North Male Atoll, Maldives, and Loyalty Islands, New Caledonia (Fig. 2G), also contained L. paraparupurea n. sp.

Remarks: The types (Fig. 2A-C) are chosen from a Maldivian C. microphthala sample (Fig. 2E-F, IPUW3861), because (1) the gathered bivalve specimens were some of the largest with intact shells being not used for DNA analysis, (2) the coral species is probably the preferred host considering the geographic range of this particular association, and (3) the sample also contained a specimen of L. laevigata, measuring 14.4-6.1-5.2 mm (Fig. 2D, 2F), demonstrating (a) the usability of the posterior encrustation for determination and (b) the occasional co-occurrence of the two bivalve species, as in IPUW3909. VERON (2000b: 246, fig. 1) figured a colony of C. microphthala from the Sinai Peninsula, bearing boreholes of L. paraparupurea n. sp.

Material examined: For types see above. A somewhat eroded colony of C. cf. microphthala, dredged from 35-45 m at Santal Bay, Lifou, Loyalty Islands, New Caledonia, 20° 47.7’ S, 167° 07.0’ E, courtesy of MNHN Paris, was riddled with L. paraparupurea n. sp., most specimens having a “toothed” posterior end (Fig. 2G). Caryastrea spp.: (1) C. microphthala, IPUW3899, 45m, B7, Safaga, 1987; IPUW3909, 8m, C1 Safaga, 1987 07 14; IPUW3916, Zabargad Is., 1993 11 16; IPUW3893, Dahab, 2007 11 04 – 6; IPUW3895, depth 12 m, Dahab, 2007 11 12 – 6, bivalve measurements were 15.1-5.3-4.5 mm, 10.6-3.8-3.6 mm, >10 mm, 9.5-3.6-3.1 mm, 9.3-3.5-3.1 mm, and 8.1 mm; C. cf. microphthala, IPUW3894, from the lagoon south of Dahab, 2007 11 13 – 4, bivalve measurements were 10.6-4.3-3.9 mm and 7.1-3.4-3.1 mm; (2) C. chalcedicum, IPUW3917, SE Zabargad Is., 1993; IPUW3896, Dahab, 2007 11 14 – 6, bivalve measurements were 12.1-4.2-3.5 mm, 11.5-4.3-3.7 mm, ~7.5 mm, and 5.1-2.6-2.1 mm; IPUW3897 depth 17 m, Dahab, 2007 11 14 – 8, bivalve measurements were 12.0-3.9-3.5 mm and 10.4-1.4-3.8 mm; (3) C. serailia, IPUW3862, depth 15 m, Dahab, 2007 11 15 – 1, bivalve measurements were 15.1-4.8-4.1 mm and 6.8-2.9-2.7 mm (Fig. 2H-I); IPUW3898, Safaga, 1986, bivalve measurements were 12.6-4.7-3.4 mm, ~12.4-3.3 mm, and 10.5-4.1-3.8 mm; IPUW3901. From Lizard Is. GBR, 1974, contained only several L. laevigata.

Echinopora lamellosa (Fig. 3A-D): IPUW3910, Safaga, 1984; IPUW3914, Safaga, 1984 10 30 – colour slide 5; IPUW3907, B7, Safaga, 1986 11 15; IPUW3913, 40-47 m, B7, Safaga, 1986 11 15; IPUW3908, Safaga, 1987 02 13; IPUW3904, Safaga, 1992 09 16; IPUW3877, Zabargad Is., 1993 11 11 (Fig. 3D); IPUW3915, 16.5 m, SE Zabargad Is., 1993 11 16; IPUW3911, Zabargad Is., 1993 11 17; IPUW3912, Zabargad Is., 1993; IPUW3870 (Fig. 3A-C), depth 17 m, dive site ‘Islands’, Dahab, 2007 11 14 – 3, bivalve measurements were 13.0-4.7-4.0 mm, 12.7-5.0-3.7 mm, ~12.5 mm, 11.8-3.8-3.6 mm, 11.7-4.8-3.7 mm, 10.9-4.1-3.6 mm, 10.6-3.3-3.1 mm, ~9 mm, and 6.9-2.8-2.5 mm; IPUW3902, Dahab, 2007 11 13 – 10; IPUW3903, Dahab, 2007 11 14 – 9, bivalve measurements were 13.6-5.3-4.4 mm, ~10.5 mm, ~8.5 mm, 8.4-4.4-2.8 mm, 6.5-2.9-2.2 mm, and 6.2-2.9-2.4 mm.

Geographic distribution: In the northern Red Sea, associations with all mentioned host species occur. In C. microphthala, L. paraparupurea n. sp. seems to be distributed further to the Maldives and New Caledonia, but not to the GBR, as two samples, IPUW3905 and IPUW3906, collected at Lizard Is. and the adjoining South Is. in 1974 contained only L. laevigata. WINTER (1985) and BRICKNER et al. (1993) reported C. chalcedicum as host species from near Elat, Israel. The southernmost recorded locality in the northern Red Sea is Zabargad Is. IPUW3892, a colony of this species from Beyrumadivaru, Ari Atoll, Maldives, contained only L. laevigata.

Lithophaga (Leiosolenus) dahabensis n. sp. (Figs. 4-7)

1995 Lithophaga paraparupurea (pars) KLEEMANN, Beiträge zur Paläontologie, 20, tab. 1, only from Stylocoeniella gnutheri (BASSETT-SMITH, 1890)


Etymology: Named after the Egyptian town nearest to the type locality.

Holotype: IPUW200800020001, 16.2-6.9-6.2 mm, host coral Stylocoeniella gnutheri, from 16.5 m depth, collected 2007-11-07 (Fig. 4A-B, Fig. 5, cf. IPUW3871, fragment of the host colony).

40 Club Conchyliaria Information 39 (3/4) October 2008
Fig. 6: IPUW3876, fragment of *S. guentheri*, (top) outer surface with several borehole orifices of *L. (L.) dahabensis* n. sp., scale in cm, (bottom left) underside of fragment, some boreholes with anterior shell ends exposed, scale in cm, (bottom right) x-ray image of fragment, demonstrating the density of boreholes.
Paratype 1: IPUW200800020002, 12.5-6.2-5.6 mm
Paratype 2: IPUW200800020003, 10.6-5.5-4.8 mm, both from the host colony of the holotype (Fig. 4A-B, Fig. 5)
Paratype 3: IPUW200800020004, 13.0-5.8-5.3 mm
Paratype 4: IPUW200800020005, 12.3-5.6-5.0 mm, both from IPUW3876, 26 m, Safaga, 1987 02 19 – slide 36 (Fig. 5).

Type locality: Reef slope at Rick’s Reef, north of Dahab, Sinai Peninsula, northern Red Sea, -28°33’30.50”N, 34°31’31.50”E (data from Google Earth).

Diagnosis: Shell small, relatively high and wide, stout, dorsal angle prominent, posterior part shorter, lacking posterior encrustation, host coral the astrocoeniid S. guntheri.

Description: Shell probably up to 20 mm long, relatively robust, high and wide, oval in general outline but with prominent dorsal angle, anterior part longer than posterior, ligament long in relation to shell length. Dorsal line up to the elevated dorsal angle straight, afterwards slightly curved, sloping rather steeply to the somewhat truncated posterior end, ventral rim slightly convex. In certain individuals, concentric growth lines developed a distinct step-like structure at the posterior extremity. Periostracum brown-purplish antero-ventrally, from the umbo in a more latero-posteriorly darker to almost black, in a pattern similar to the bi-colouration in L. (L.) nasuta (Philippi, 1846). Shells lack any own posterior calcareous encrustation above the diagonal line running from the umbo laterally to the ventral posterior. The posterior surface is commonly camouflaged and covered by a muddy sheet. This probably consists mainly of detritus, accumulated in the dense slime secreted, plus some debris remaining from boring (incomplete dissolution of loosened particles). When dry, the remains of the thin organic sheet-like cover can be wrinkly or even resemble periostracal hairs, but can be wiped off, as long as moist. Then, the postero-dorsal shell is covered only by smooth periostracum, while the antero-ventral part shows a faint, amorphous looking encrustation generally common in Leiosolemus.

Remarks: The specimens from New Caledonia that I named L. lifouensis (Kleemann 2004: 30) may actually be members of L. dahabensis n. sp., but with no information about their habitat, this remains uncertain. Based on the antero-ventral encrustation and the lining of its boreholes, L. dahabensis n. sp. is a member of subgenus Leiosolemus. In alcohol, the dark shell colour may turn to light brown anteriorly and dark brown posteriorly. In shells showing a step-like structure towards the posterior end, this may reflect annual periods of growth and rest, the latter probably during the reproductive season. If that is true, some of the observed larger specimens may be up to 11+ years in age.

Habitat: So far, L. dahabensis n. sp. was recognized only associated with the astrocoeniid S. guntheri. This coral is usually found below 10 m to over 40 m depth, encrusting dead coral and building a surface with mellow to nodular elevations, which may fuse. Colonies were often inhabited by L. dahabensis n. sp. in high numbers, causing intra-specific competition for space and food (Fig. 4A-B, 5, 6).

Material examined: For types see above. Further specimens from the colony holding the holotype, 1st and 2nd paratypes, measured 16.8-6.8-5.9 mm, 16.2-7.0-6.2 mm, 14.6-6.5-5.8 mm, 13.9-6.4-5.9 mm, 12.9-6.2-5.5 mm, 12.3-5.8-4.9 mm, 11.8-5.7-5.0 mm, 11.7-5.1-4.5 mm, 11.3-5.6-5.0 mm, 11.0-4.9-4.2 mm, 10.9-5.2-4.4 mm, 10.9-4.8-4.0 mm, 10.8-5.3-4.5 mm, 9.6-4.2-3.9 mm, 8.8 mm, 7.3-3.4-3.0 mm, 7.2-3.1-2.6 mm, 6.8-3.1-3.0 mm, 5.9-2.9-2.6 mm, 5.0-2.3-2.1 mm, and 4.0-2.0-1.9 mm; dead shells: 12.6-6.1-5.7 mm, 11.8-5.8-5.2 mm, 10.9-5.5-4.8 mm, and 7.0-3.5-3.1 mm, all from the type locality, 2007-11-07 – 0 (Fig. 4A-B). Some specimens from IPUW3876, 26 m, Safaga, 1987 02 19 – colour slide 36 (Fig. 6); 1987 02 26 – colour slide 6, Safaga (Fig. 7 top); 1993-11-15 – colour slide 2, 41 m, Zabargad Island, northern Red Sea (Fig. 7 bottom).

Geographic distribution: Northern Red Sea and probably New Caledonia.

Discussion

Gohar & Soliman (1963a) reported on Lithophaga cuminigiana Dunker, L. hanleyana Dunker, and L. lima Jousseamea boring in live coral near the Marine Biological Station at Al-Ghardaqa (= Hurgada). All three are only manuscript names and do not belong to the species of the actual authors, L. cuminigiana (Reeve, 1857), L. hanleyana (Reeve, 1857), and L. lima Lamy, 1919 (Kleemann 1980, 1983). The difficulty in determining specimens and species is a general problem, not only in Bivalvia or Scleractinia. Thus, some names mentioned herein may not belong to generally accepted species, e. g. Montipora lamingtonosa Bernard, 1897 (Soliman 1969), and M. erythraea Marenzeller, 1907 (Brickner et al. 1993) Both are listed neither in Cairns et al. (1999) nor in Veron (2006).

Gohar & Soliman (1963a) recorded Lithophaga lima (non Lamy, 1919) to bore in Montipora, together with L. hanleyana (non Reeve, 1857; = L. laevigata (Quoy & Gaimard, 1835)), and in a few cases in Cyphastrea. Their L. lima was described as a distinct species, L. (Leiosolemus) purpurea Kleemann, 1980, but is herein restricted to specimens from the host genus Montipora only. As noted by Gohar & Soliman (1963a), L. purpurea may bore in Montipora together with L. laevigata. In M. cf. flowerti Wells, 1954 (Kleemann 1990: fig. 5) and M. tuberculosa (Lamarck, 1816) (Kleemann 2001: fig. 5a), L. purpurea was found in co-existence and competition with the pectinid Pedum. Rather exceptionally, one M. corbettensis from Safaga contained only two L. laevigata individuals and no L. purpurea. In contrast, Montipora samples from the Maldives, e. g., M. venosa (Ehrenberg, 1834), and the GBR, Australia, have so far contained only specimens of L. laevigata but no L. purpurea (Fig. 1, bottom middle).
All figures provided for L. lima by Gohar & Soliman (1963a: text-figs. 14-15, pl. 1, fig. 1, right specimen) depict L. purpurea in the present sense (Kleemann 1980: figs. 9-10). Gohar & Soliman (1963a: pl. 1 fig. 1, right specimen) figured most likely the largest known specimen, recording a length of 35 mm in table 4. Bruckner & al. (1993) noted 33.5 mm for their largest specimen from Montipora.

In L. purpurea, the range of host corals now seems restricted to a single genus of Acroporidae, Montipora, which housed the types. Similarly, L. (L.) kuechelti Kleemann, 1977, occurs only in the acroporid Isopora (Kleemann 1995: tab. 1). Caribbean L. (L.) dixonae Scott, 1986, from astroecoid Madracis species, is another narrow-spectrum borer, but so far only L. dhabensis n. sp. appears to be restricted to a single host species, the astroecoid Stylocoeniella guentheri. Other L. (Leiosolenus) have a wider host spectrum, e.g., L. lessepsiana (Vaillant, 1865) known from pocilloporid Stylophora and Pocillopora species (Kleemann 1980, Loya 1981, Morais et al. 1991), and further from the dendrophyllid Heteropoxammia cochlea (Spengler, 1781) [Arnaud & Thomassin 1976, Kleemann 1980; in both references as H. michelini (Meine Edwards & Haim, 1848) (Kleemann 1995)]. Probably the widest range of hosts is exhibited by L. laevigata and L. lima (Morton 1990, Kleemann 1995: tab. 1).

In the northern Red Sea, L. (Leiosolenus) individuals inhabiting the favid Cyphastrea and Echinopora generally belong to L. paraparupurea n. sp.; occasionally, L. laevigata co-occurs in small numbers. Compare IPUW3861, containing the types (Fig. 2E-F).

Echinopora mambformis (Nemenzo, 1959), IPUW3900, collected 1991 11 27, from Lizard Is., GBR, contains some unidentified Lithophaga specimens. The respective borehole orifices lie within corallites, while in E. lamellosa from the northern Red Sea the orifices of L. paraparupurea n. sp. lie in the coenostem between corallites (Fig. 3). The former may indicate a different species associated with E. mambformis.

Kleemann (1995), based solely on the dark colour of small bivalve specimens in Stylocoeniella guentheri, considered this astroecoid coral as another host of 'L. purpurea'. This was a mistake because, a more careful investigation of larger bivalve specimens obtained from the sample collected at Rick's Reef and including the types, made the description of a new species necessary. This L. dhabensis n. sp. is quite similar to or even synonymous with L. bifrons Kleemann, 2004 from New Caledonia. But the latter lacking both a proper description and selection of types (Kleemann 2004: 30), must be regarded as a nom. nud. Furthermore, the type of inhabited substratum, dead or live coral, is unknown to the author, who received only the shells for determination from Ph. Bouchet. In the northern Red Sea, L. dhabensis n. sp. occurs in high numbers per host colony (depth ca. 10 to over 40 m). Distinct size differences of the bivalves indicate several, probably yearly infestations. Dense settlement is no doubt an advantage for high reproduction rates, increasing the chance of fertilisation and larval (veliger) development when sperm and eggs are released into the water column simultaneously. On the other hand, too close settlement leads to intra-specific competition for food and space; while this may kill some individuals, the trade-off is apparently positive.

Interestingly, L. dixonae Scott, 1986 is also associated with an astroecoid genus, inhabiting three Madracis species in the Caribbean (Scott 1986). This bivale is similar to L. dhabensis n. sp. in outline, lack of posterior encrustation and even its depth distribution. Judging from close-up photographs, S. guentheri colonies from up to over 40 m depth at the deep drop off at Ras Abu Somar, north of Safaga, were riddled with L. dhabensis n. sp. like the sample from 16 m at Rick's Reef, the type locality north of Dahab (Fig. 4A-B, 5, 6, 7). Scott (1986) reported a maximum density of L. dixonae in 20 to 25 m on the fore reef within a range of 9 to 40 m depth at Discovery Bay, Jamaica, but found no statistically significant relationship between bivalve abundance and depth. Both Stylocoeniella and Madracis seem to prefer deeper parts of the reef slope. Colonies of Cyphastrea as well as Echinopora from over 40 m, IPW3899 and IPW3913 respectively, also show a dense bivalve population based on numerous borehole orifices.

Boreholes of L. dhabensis n. sp. may be solidly lined wherever the respective bivalve needed this. This ability is a major difference to Lithophaga s.s., whose members are unable to secrete linings and shell encrustations. Scott (1986: 56, fig. 2c) stated that boreholes are not lined, but I am not convinced this is generally true for L. dixonae. Otherwise it might not be regarded as a member of Leiosolenus.

Conclusions

The former 'L. purpurea' was a mixture of three species, herein separated according to morphological differences in shell encrustation and host coral selection. In the present sense, L. purpurea is restricted to acroporid Montipora species and is currently known only from the northern Red Sea. The latter is also the case for L. dhabensis n. sp., which is apparently even restricted to a single species, the astroecoid Stylocoeniella guentheri. Favidi Cyphastrea spp. and Echinopora lamellosa serve as hosts for L. paraparupurea n. sp. In C. microphthalmus, probably the preferred host, it occurred not only in the northern Red Sea but also at the Maldives and New Caledonia. Occasional co-occurrence with L. laevigata, a wide-spectrum borer, was noted in Montipora, Cyphastrea and Echinopora.

Acknowledgements

Primarily, I would like to thank M. Fouad, Nature Conservation Sector at the Egyptian Environmental Affairs Agency, for approving my research fieldwork in the Dahab area and the permit to collect some samples. Thanks are also due to
Fig. 7: *Stylococenella guentheri* with numerous borehole orifices of *L. (L.) dahabensis* n. sp., (top) 41 m at Zabargad Island, Egypt, (bottom) in ~ 30 m at Ras Abu Soma, north of Safaga, Egypt. Frame sizes 25x18 cm.
References


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