

## SHORT COMMUNICATION

# *Gastrochaenolites hospitium* isp. nov., trace fossil by a coral-associated boring bivalve from the Eocene and Miocene of Austria

KARL KLEEMANN

Paleontology, Centre of Earth Sciences, University of Vienna, Althanstr. 14, A1090 Vienna, Austria; karl.kleemann@univie.ac.at

(Manuscript received February 19, 2009; accepted in revised form June 25, 2009)

**Abstract:** *Gastrochaenolites hospitium* isp. nov. is a domichnial boring showing the so-called false floors in scleractinian coral skeletons. The borings are semi-circular in mid-longitudinal section. They are produced by the mytilid *Lithophaga* (*Leiosolenus*) and keep up with further growth of their hosts for years. The false floors, being a retrusive equilibrium trace, are related to annual events.

**Key words:** Ichnology, trace fossils, domichnia, lebensspuren, corals, bivalves, *Lithophaga*, *Leiosolenus*.

## Introduction

Apart from rare informal notes of “*Lithodomus*” in live corals, Kühnelt (1931) was the first who described and correctly interpreted such an association in the fossil record (Kleemann 1982). Kelly & Bromley (1984) provided an ichnological nomenclature of clavate borings, covering many domichnia produced by bivalves, including *Lithophaga*. Some of the latter produce *Gastrochaenolites torpedo* Kelly & Bromley, 1984. Edinger & Risk (1994) noted the fossil borings of *Lithophaga bisulcata* in Oligocene Caribbean corals such as *Gastrochaenolites vivus* [*Lithophaga bisulcata* (Orbigny 1853, non 1842) is a junior synonym of *L. (Leiosolenus) appendiculata* (Philippi, 1846) (Kleemann 2009)]. However, without a holotype designation, their new ichnospecies must be regarded as a *nomen nudum* (see Discussion). This paper describes *G. hospitium* isp. nov. from the Eocene and Miocene strata of Austria (Fig. 1). The types and other material are stored in the collection of the Institute of Paleontology, University of Vienna (IPUW).

## Systematic ichnology

Ichnogenus *Gastrochaenolites* Leymerie, 1842

**Diagnosis:** (Kelly & Bromley 1984: p. 797): Clavate borings in lithic substrates. The apertural region of the boring is narrower than the main chamber and may be circular, oval, or dumb-bell shaped. The aperture may be separated from the main chamber by a neck region which in some cases may be widely flared. The main chamber may vary from subspherical to elongate, having a parabolic to rounded truncated base and a circular to oval cross-section, modified in some forms by a longitudinal ridge or grooves to produce an almond- or heart-



**Fig. 1.** The locality Waschberg or Seggauberg within a line drawing of Austria.

shaped section. (For the general range in morphology of species of *Gastrochaenolites* see Kelly & Bromley 1984: text-fig. 3A–H.)

**Type ichnospecies:** *Gastrochaenolites lapidicus* Kelly & Bromley, 1984: 797–798, text-figs. 3A, 4A–B.

*Gastrochaenolites hospitium* isp. nov.  
(Figs. 2–6)

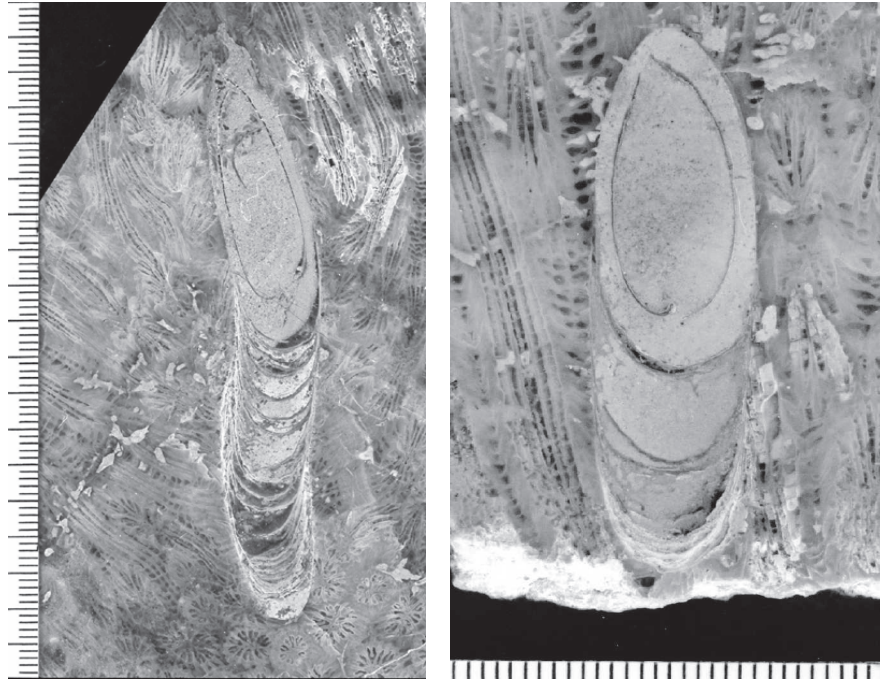
*Gastrochaenolites vivus* n.n. — Edinger & Risk, 1994, p. 584, 587, 588, 592, figs. 9 (far left), 14

**Derivation of name:** From Latin *hospitium*, hospitality, which the trace producers obtain lifelong from their hosts.

**Types:** Holotype IPUW 200900010001, a sediment-filled *Lithophaga* (*Leiosolenus*) boring within the coral *Favia magnifica* Reuss, 1871, collected from the Waschberg by H. Zapfe (pers. comm.). The boring is illustrated in longitudinal section (Fig. 2; Kleemann 1994: pl. 16, fig. 7). Sixteen false floors, somewhat semi-circular in midline-section, can be counted in the extended basal part of the boring (below the shell). The shell remains are about 30 mm long. The sectioned part of the boring is about 80 mm long and 10 to 12 mm wide, increasing very little from the base. Note the slight S-like bending in the

► **Fig. 2.** Holotype of *Gastrochaenolites hospitium* isp. nov., IPUW 200900010001, in skeleton of *Favia magnifica* Reuss, 1871, Lower Eocene (Waschberg Zone, Waschberg limestone), Waschberg, Lower Austria. Scale in cm. Previously figured in Kleemann (1994: pl. 16, fig. 7).

►► **Fig. 3.** Paratype of *G. hospitium* isp. nov., IPUW 200900010002, in same host colony as the holotype. Note seven false floors below obliquely cut valves. Scale in mm.



basal, old part of the boring. It indicates an adaptation of the boring axis to the change in direction of host coral growth.

Paratype IPUW 200900010002 is observed in an oblique section of another *Lithophaga* boring in the same host colony as in Fig. 2. Filled with fine-grained sediment, the boring is observed in oblique section as an elongated oval, about 40 mm long and 12 mm wide, depicting seven false floors below the bivalve (Fig. 3).

**Type horizon:** Waschberg limestone, the only marine stratigraphic unit within the Waschberg Zone (Wessely 2006: p. 71). The Waschberg limestone is Early Eocene (Ypresium, L. Krystyn, pers. comm.) in age.

**Type locality:** Waschberg, Lower Austria (Fig. 1). No detailed information about the precise locality was provided by H. Zapfe. The Waschberg (388 m) lies south and next to the village Wollmannsberg (236 m) in Lower Austria, north of Vienna.

**Type host coral:** *Favia magnifica* Reuss, 1871.

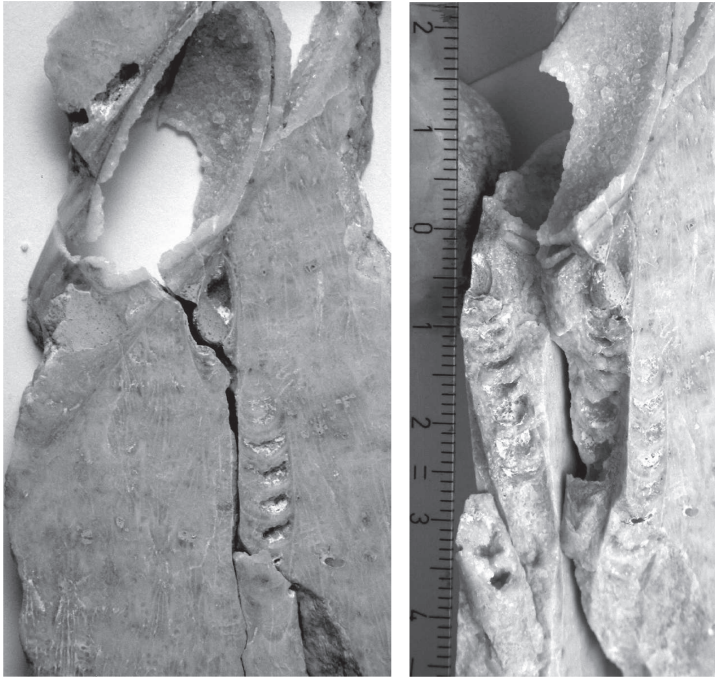
**Diagnosis:** Elongated, sub-cylindrical bivalve boring within a host coral skeleton, with two or more hemi-spherical bottoms, piled in each other, at the basal end. In casts of the borings, this is mirrored by ring-shaped constrictions/elevations near the rounded base, resembling a pile of mini-cups. In longitudinal section, the boring is an elongated to ribbon-shaped oval, with semi-circular or bow-shaped lines towards the basal end (Figs. 2–4).

**Description:** Boring of an adult mytilid *Lithophaga* (*Leiosolenus*), which kept up with the growth of its host for one or more years, resulting in an elongated basal part of the boring with at least two so-called false floors (Kühnel 1931: text-fig. 2; Kleemann 1980: fig. 37; Kleemann 1982: pl. 2, fig. 6, pl. 3, fig. 8). This characteristic feature, being an equilibrium structure (Frey & Pemberton 1985), easily distinguishes *G. hospitium* isp. nov. from all other *Gastrochaenolites* spp., which lack them (Kelly & Bromley 1984; Edinger & Risk 1994: fig. 9). The short siphonal part of the boring, becoming

the neck of the trace, is narrower than the main chamber, leading to a dumbel-shaped aperture. In the fossil situation, the neck part may be inconspicuous or lost. In casts, the false floors are hidden inside. Nevertheless, their presence may be indicated by a surface ornamentation through constrictions and widenings of the boring's basal part through constrictions and widenings of the boring's basal part, resembling a dowel (Kühnel 1931: pl. 24, fig. 6a–e). The general form of casts is more or less elongated ellipsoidal to cylindrical. The false floors result from former positions of the producers (see Discussion). In longitudinal section through the axis of the bivalve borings basal part, the decisive and significant feature is two to several bow-shaped or semi-circular lines, representing the “Zwischenböden” or “Kappen” of Kühnel (1931).

The dimensions of *G. hospitium* isp. nov. vary according to the size and longevity of the respective trace maker and to the growth rate of the respective host. The former influences particularly the number, the latter the distance between false floors. The diameters of these trace fossils, as known so far, range from a few to about 25 mm. Their length may reach a few millimeters to, in Recent examples, over 150 mm.

**Other material:** Several pieces of a big colony of *Montastrea* from the Miocene (Badenian) in the Tittenbacher quarry at Seggauberg (Fig. 1), near Leibnitz in southern Styria, Austria (Kleemann 1994: text-fig. 1, pl. 15, fig. 1), were cut to find more *G. hospitium* isp. nov., IPUW 4453, 4454. IPUW 4453/1–3, contain this boring, which shows two distinct size-classes. In a particular case, these borings interfere with each other (Fig. 4.1–2). The wider one on top of the figure is about 15 mm wide and displays remains of only four false floors (more may have been present before cutting). It crosses and terminates two other slender borings belonging to the same ichnospecies. These are only about 5 mm wide but show eight to nine false floors below the shell remains or their casts, over a length of about 25–30 mm (Fig. 4.2). The wider boring was caused by *L. coralliophila* Kleemann, 1994, the smaller ones



**Fig. 4.** *Gastrochaenolites hospitium* isp. nov., in Miocene (Badenian) *Montastrea* from Seggauberg, Styria. **1** — A wide boring, in the left upper corner, crosses and terminates a slender one, coming up almost straight. **2** — Fracture area, of the specimen shown in Fig. 4.1, which exhibits a second slender boring, almost parallel to the first. Both borings have eight to nine false floors in the cut or split open basal part (see Discussion).

by a different species (Fig. 4.1–2, see Discussion). The slab IPUW 4454 contains a fragment of a single, small boring, whose remaining part is in the counterpart slab. The shell is approximately 8 mm long. It lies above five false floors that occur over a distance of 18 mm. This boring shows a widening from three to five millimeters. Two slab pieces, IPUW 4467/1–2, of an unidentified coral of unrecorded age are riddled with *L. (Leiosolenus)* borings; they contain borings with shell remains, some of them accompanied by false floors (Fig. 5).

## Discussion

*Gastrochaenolites*, not mentioned in the 2<sup>nd</sup> edition of Trace Fossils (Bromley 1996), is a member of domichnia (Bromley 1996: p. 192). Edinger & Risk (1994: pp. 584–585) noted: “Coral associates showed no evidence for host specificity with the exception of *Gastrochaenolites vivus* n. isp., the boring made by *Lithophaga bisulcata* in live corals, producing false floors in the borehole (figs. 9, 14). This bivalve boring occurred in Oligocene *Diploastrea crassolamellata* and *Montastrea tampaensis*, and Miocene *Psammocora trinitatis*. Modern *L. bisulcata* in the Caribbean bore into many species of dead corals, but their primary habitat is in live *Siderastrea siderea* and *Stephanocoenia intersepta* (Scott 1988). This limited species specificity apparently had no effect on the bivalve’s survival.” The legend of their fig. 14 reads: “*Gastrochaenolites vivus* n. isp. in the Miocene coral *Psammocora trinitatis*. Brizas del Caribe site” (Edinger & Risk 1994: p. 592). Nothing

else, particularly no holotype designation was provided, resulting in a *nomen nudum* for their ichnospecies.

*G. hospitium* isp. nov. is a trace fossil, produced by mytilid bivalves belonging to small to middle-sized *Lithophaga (Leiosolenus)* species associated with various living host corals. Like all members of this subgenus, they can line their borings, including voids in the dwelled substrate, with calcareous deposits. Adults that live in living corals keep pace with the host’s growth by stepwise moving up in their borings. Thus, *G. hospitium* isp. nov. belongs to domichnia as well as equilibrichnia.

Most likely, a new false floor is produced once annually by depositing calcareous secretions that then consolidate, mainly in front of the shell and laterally at the boring margins. The floors mirror the somewhat hemi-spherical anterior end of the shell (Kleemann 1982: pl. 2, fig. 6, pl. 3, fig. 8; Scott 1988: fig. 4C). Because of the longevity of more or less fully grown individuals, the borehole diameters apparently remain the same for longer trace fossils. At the same time, the number of false floors may attain over 15 (Fig. 2) or even more in a Recent sample (Kleemann 1982: pl. 2, fig. 6). In the latter, some floors appear to be merely detrital accumulations and not solid linings. Borings of *L. (Leiosolenus)* in a Recent head-sized *Astreopora* from the northern Red Sea, show very long (twice the shell length) basal parts with relatively few false floors, probably indicating fast coral growth and little detrital influx (Fig. 6).

Considering (1) the type locality, where the Waschberg limestone is the only marine stratigraphic unit within the Waschberg Zone (Wessely 2006: p. 71), and (2) that voids in the host coral and its borings are filled by a light coloured, carbonate and bioclastic sediment, the fossil material is probably related to this unit (L. Krystyn, pers. comm.).

In the rather crumbly to chalky substrate of Badenian age at Müllendorf in Burgenland, bivalve borings are mainly preserved as casts (Kühnelt 1931: pl. 24). When fragmented, the basal part alone is sufficient to indicate *G. hospitium* isp. nov., whereas the bivalve part alone belongs to *G. torpedo*. The lat-



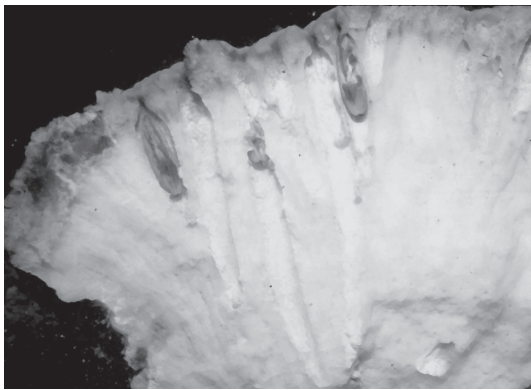
**Fig. 5.** IPUW 4467/1, a fossil coral piece of unknown locality and age, exhibits mainly *G. torpedo* Kelly & Bromley, 1984, and a few *G. hospitium* isp. nov. Scale in cm.

ter is the case in all fossils, in which the individual bivalve has not (yet) produced false floors (Fig. 5) as in Recent examples figured in Kleemann (1980: fig. 41; 2008: fig. 1 middle).

The interior of a big colony of Badenian *Montastrea* exhibits many borings produced by bivalves, not only of the dominant *Lithophaga coralliophila* (Kleemann 1994: text-fig. 1, pl. 15, fig. 1). In IPUW 4453, the wide boring of *L. coralliophila* obliquely crosses and terminates two slender *G. hospitium* isp. nov. of a different, probably new species. As their diameters do not noticeably widen, they indicate adult-sized producers, distinctly smaller than the *L. coralliophila* crossing above. The small bivalves have to be regarded as being adult, because their size remained more or less stable for at least 8–9 years. They most likely died due to interspecific space competition. Parts of the bivalve shells and their casts are also visible. Their size, compared with the shell in the larger boring, also indicates that two species of *Lithophaga* (*Leiosolenus*) bored in the host simultaneously (Fig. 4.1–2). In IPUW 4467/1–2, most borings have to be determined as *G. torpedo* Kelly & Bromley, 1984, and only a few as *G. hospitium* isp. nov., although most likely produced by members of the same *Lithophaga* (*Leiosolenus*) species (Fig. 5).

Co-existing bivalve species can be observed occasionally in Recent corals, but this generally seems to be avoided (Kleemann 2008). Nevertheless, intraspecific competition for space and food may become a problem for individual borers under crowded situations. The advantage of dense settlement in hosts is assumed to be a substantially increased reproductive success because simultaneous spawning can occur in close range. Many bivalve specimens in living corals do not live long enough to create false floors. In the fossil record, only the latter can be determined as *G. hospitium* isp. nov., while the former must be attributed to *G. torpedo* (Kelly & Bromley 1984). Thus, the decisive feature of *G. hospitium* isp. nov., is the presence of false floors.

During the life time of associated bivalves, boring apertures open onto the living coral surface. After a bivalve's death, the host closes the opening by further growth. Examples of *G. hospitium* isp. nov. can be found not only in adjacent positions but also in different depths or even above each other within the same host skeleton, indicating successive generations of dwellers (Fig. 4.1–2; cf. Kleemann 1994: text-fig. 1, pl. 15, fig. 1).



**Fig. 6.** Elongated borings of living *Lithophaga* (*Leiosolenus*) *simplex* Iredale, 1939, in split-open host coral *Astreopora* sp., Safaga, northern Red Sea. Frame about 13×18 cm.

As shown by Goreau et al. (1972: pl. 2), the mytilid *Fungiacava eilatensis* Goreau et al., 1968, exclusively associated with fungiid corals (Hoeksema & Kleemann 2002), may also produce aragonitic deposits indicating the pathway within its boring. Nonetheless, no obvious false floors are developed in the *Fungiacava* borings. Their shape is not cylindrical, but rather changes from ovoid to a dorso-ventrally flattened heart-shape (Goreau et al. 1972: p. 59). Thus, even if this Recent form was found in the fossil record, its traces could not be ascribed to *G. hospitium* isp. nov.

**Acknowledgments:** Helpful criticism and comments on the first draft by two reviewers, Á. Dávid and particularly A. Uchman, improved the paper substantially. Michael Stachowitsch kindly improved the English of the second version.

## References

- Bromley R.G. 1996: Trace fossils. Biology, taphonomy and applications. 2<sup>nd</sup> Ed., Chapman & Hall, London, xvi+361.
- Edinger E.N. & Risk M.J. 1994: Oligocene-Miocene extinction and geographic restriction of Caribbean corals: roles of turbidity, temperature, and nutrients. *Palaios* 9, 576–598.
- Frey R.W. & Pemberton S.G. 1985: Biogenic structures in outcrops and cores. I. Approaches to ichnology. *Bull. Canad. Petrol. Geol.* 33, 72–115.
- Goreau T.F., Goreau N.I. & Yonge C.M. 1972: On the mode of boring in *Fungiacava eilatensis* (Bivalvia: Mytilidae). *J. Zoological Soc. London* 166, 55–60.
- Hoeksema B.W. & Kleemann K. 2002: New records of *Fungiacava eilatensis* Goreau et al., 1968 (Bivalvia, Mytilidae) boring into Indonesian mushroom corals (Scleractinia, Fungiidae). *Basteria* 66, 25–30.
- Iredale T. 1939: Mollusca I. *Scientific Reports of the Great Barrier Reef Expedition 1928–29*, 5 (6), 209–425.
- Kelly S.R.A. & Bromley R.G. 1984: Ichnological nomenclature of clavate borings. *Palaeontology* 27, 793–807.
- Kleemann K.H. 1980: Boring bivalves and their host corals from the Great Barrier Reef. *J. Molluscan Studies* 46, 13–54.
- Kleemann K.H. 1982: Ätzmuscheln im Ghetto? *Lithophaga* (Bivalvia) aus dem Leithakalk (Mittel-Miozän: Badenian) von Müllendorf im Wiener Becken, Österreich. *Beitr. Paläont. Österr.* 9, 211–231.
- Kleemann K. 1994: Mytilid bivalve *Lithophaga* in Upper Triassic coral *Pamiroseris* from Zlambach Beds compared with Cretaceous *Lithophaga alpina*. *Facies* 30, 151–154.
- Kleemann K. 2008: *Lithophaga* (*Leiosolenus*) *purpurea* (Bivalvia: Mytilidae): one species becomes three. *Club Conchylia Informationen* 39 (3/4), 32–45.
- Kleemann K. 2009: *Lithodomus bisulcata* Orbigny, 1853, a junior synonym of *Modiola appendiculata* Philippi, 1846. *Conchylia* 40 (1/2), (in print).
- Kühnel W. 1931: Über ein Massenvorkommen von Bohrmuscheln im Leithakalk von Müllendorf im Burgenland. *Paläobiologica* 4, 239–250, 22–24.
- d'Orbigny A.D. 1853: Mollusques. In: Sagra, Histoire physique, politique et naturelle de l'île de Cuba. *Atlas*, 28 + 1 col pls., 2, 380.
- Philippi R.A. 1846–47: *Modiola*. In: Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien 2 (5), 1/147–4/150, pl. 1 (1846); 3 (1), 5/18–8/22, pl. 2 (1847). (Publ. dates fide Clapp & Kenk 1963: 483.)
- Reuss A.E. von 1871: Die fossilen Korallen des österreichischen Miozäns. *Denkschr. Österr. Akad. Wiss., Math.-Naturwiss. Kl.* 31, 197–270, 1–21.
- Scott P.J.B. 1988: Distribution, habitat and morphology of the Caribbean coral- and rock-boring bivalve, *Lithophaga bisulcata* (d'Orbigny) (Mytilidae: Lithophaginae). *J. Molluscan Studies* 54, 83–95.
- Wessely G. 2006: Niederösterreich. *Geol. Bundesanst., Wien*, 1–416.