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A new species of *Exochomoscirtes* Pic, 1916 from Malaysia (Insecta: Coleoptera: Scirtidae) with biological notes on the bamboo-inhabiting members of the genus

With 21 figures and 3 tables

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Abstract

Seven *Exochomoscirtes* species inhabiting phyto- or lithotelmata in West Malaysia and North Thailand were reared from larvae. *E. hashimi* spec. nov. from W. Malaysia was described and *E. carinensis* and *E. meghalayensis* were new records for Thailand. Larvae of *E. meghalayensis* inhabited water-filled tree holes and forest rock pools, while *E. hajeki*, *E. jaechi*, *E. chiangmaiensis*, *E. carinensis*, *E.* cf. *luteosuturaloides* and *E. hashimi* spec. nov. occurred in water-filled bamboo stems. Bamboo-inhabiting species occupied different types of bamboo habitats such as mature bamboo stems (inhabited internodes up to 21 m high), dead bamboo stems or bamboo stumps. Internodes of nutrient-rich bamboo shoots were not colonized. Adult *Exochomoscirtes* entered enclosed internode cavities through holes created by insects, woodpeckers and other animals or cracks in bamboo walls. Larvae living in open phytotelmata such as water-filled tree holes or bamboo stumps created pupal chambers made of soil or detritus in the vicinity of their habitats. In species inhabiting enclosed internodes pupal chambers were absent. Larvae pupated inside the internodes firmly attached to the bamboo walls close above water surface. Total development time of bamboo-inhabiting species was about 3 months. Predators of *Exochomoscirtes* species dwelling in enclosed internodes were chironomid larvae (*Dasyhelea*), mosquito larvae (*Toxorhynchites*), small water striders (*Lathriovelia*), rove beetles (*Acylophorus*), jumping spiders (*Paracyrba*), web-building spiders (Theridiidae) and web-building larvae of fungus gnats (*Truplaya*).

Taxonomic acts

E. hashimi spec. nov.– urn:lsid:zoobank.org:act:4D2AA5A6-DB2D-4B5F-AE91-E8C985FFA4DD

Key words

Scirtidae, *Exochomoscirtes*, Malaysia, Thailand, new species, new records, phytotelmata, lithotelmata, bamboo, life cycle, predators

Zusammenfassung

Sieben phyto- und lithotelmen-bewohnende *Exochomoscirtes*-Arten aus West-Malaysia und Nord-Thailand wurden gezüchtet. *E. hashimi* spec. nov. aus West-Malaysia wurde beschrieben, und *E. carinensis* and *E. meghalayensis* waren Neunachweise für Thailand. Die Larven von *E. meghalayensis* lebten in wassergefüllten Baumlöchern und Felsenbecken, während *E. hajeki*, *E. jaechi*, *E. chiangmaiensis*, *E. carinensis*, *E.* cf. *luteosuturaloides* und *E. hashimi* spec. nov. in wassergefüllten Bambushalmen vorkamen. Bambusbewohnende Arten bevorzugten verschiedene Typen von Bambushabitaten, z. B. ausgewachsene Bambushalme (bewohnte Internodien bis 21 m hoch), tote Bambushalme oder Bambusstümpfe. Internodien nährstoffreicher Bambusschösslinge wurden nicht besiedelt. Adulte *Exochomoscirtes* gelangten in abgeschlossene Bambusinternodien durch Löcher, die von Insekten, Spechten oder anderen Tieren erzeugt wurden, oder durch Risse in der Bambuswand. Larven, die sich in offenen Phytotelmen wie wassergefüllten Baumlöchern oder Bambusstümpfen entwickelten, bauten Puppenkammern aus Erde oder Detritus in der Nähe ihrer Habitate. Larven, die in geschlossenen Internodien lebten, bauten keine Puppenkammern. Sie verpuppten sich in den Internodien-Hohlräumen und hefteten sich an die Bambuswand dicht über der Wasseroberfläche. Die Gesamt-Entwicklungszeit der bambusbewohnenden Arten betrug etwa drei Monate. Fressfeinde von *Exochomoscirtes*-Arten, die in abgeschlossenen Internodien lebten, waren Chironomidenlarven (*Dasyhelea*), Stechmückenlarven (*Toxorhynchites*), Wasserläufer (*Lathriovelia*), Kurzflügelkäfer (*Acylophorus*), Springspinnen (*Paracyrba*), netzbauende Spinnen (Theridiidae) und netzbauende Larven von Langhornmücken (*Truplaya*).

Introduction

Marsh beetles (Scirtidae) of the genus *Exochomoscirtes* Pic, 1916 are small (2.20–5.90 mm), rounded beetles that have enlarged hind femora and are capable of jumping. Their elytra are uniformly yellow, brown or black colored or brightly patterned with red, orange, yellow or black spots.

The genus is distributed in the Oriental Region with most species occurring in Southeast Asia. One species extends to New Guinea and Australia and one species is confined to Japan (Ruta & Yoshitomi 2010). Six species are perhaps Palaearctic, because they have only been recorded from the northern border of the Oriental Region.

Ruta & Yoshitomi (2010) presented a revision of the genus *Exochomoscirtes* and recognized 35 species. Since then eleven new species have been described: three species from Laos, Northeast India and Java (Klausnitzer 2010b), two from Laos and Nepal/North India (Klausnitzer 2010c), one from Thailand (Ruta 2011a), two from Malaysia and Myanmar (Ruta 2011b) and three from Palawan, Philippines (Zwick 2011).

Exochomoscirtes larvae are aquatic detritus feeders living in phytotelmata, i.e., small water bodies in plants. Larval habitat was known in 7 out of 46 species. Five species were recorded from water-filled tree holes and buttress roots (*E. fuscus*, *E. niger*, *E. palawanicus*, *E. ruforotundus*, *E. takizawai*; Ruta & Yoshitomi 2010, Zwick 2011) and three species from bamboo internodes (*E. ruforotundus*, *E. discoidalis* and *E. klausnitzeri*; Ruta & Yoshitomi 2010, Watts 2004).

In the present paper we describe *Exochomoscirtes hashimi* spec. nov. and outline the biology of seven mainly bamboo-inhabiting *Exochomoscirtes* species from Malaysia and Thailand, particularly their habitat preferences, life cycles and predators.

Materials and methods

Field study sites and collecting. In West Malaysia field work was carried out in 1989, 1991, 1993, 1994 and 1995. The study site was located at the Ulu Gombak Field Study Centre (UFSC) of the University of Malaya (West-Malaysia, Selangor Darul Ehsan). In north Thailand observations were carried out in 2011, 2012 and 2014. The collecting sites were located in the Mae Hong Son Province, district of Pangmapha. Bamboo host species were *Gigantochloa scortechinii* Gamble (West Malaysia), *Bambusa polymorpha* Munro, *Dendrocalamus strictus* (Roxburgh) Nees and other *Dendrocalamus* spp. and *Cephalostachyum pergracile* Munro (North Thailand).

Exochomoscirtes larvae were collected from water-filled bamboo internodes, tree holes and forest rock pools. Larvae were retrieved by taking out leaves and inspecting the leaf surface and by sucking up water and detritus with a large pipette. Subsequently, larvae were hand sorted from a flat tray using a pair of soft tweezers. The larvae were transported to the laboratory in plastic bags containing wet leaves. Bamboo internodes were investigated both in Malaysia and Thailand, water-filled tree holes and rock pools only in Thailand.

For collecting specimens from living bamboos, culms were felled and internodes cut open with a saw and a large knife (parang). The height of the colonized internodes, internode dimensions, amount of water as well as the size and shape of naturally occurring holes in the bamboo wall were recorded.

Breeding. In laboratory larvae were kept in water-filled cut bamboo internodes containing detritus from the place of origin. The bamboo containers were placed in tightly sealed plastic boxes as protection against ants and in order to prevent larvae from escaping. The bottom of

the plastic boxes was covered with moistened tissue, thus providing a hiding place for pupating larvae and keeping the air humidity high. Temperature and light conditions in the laboratory were about the same as in the field, i.e., 23–33 °C in Malaysia and 20–36 °C in North Thailand. Breeding boxes were inspected daily. Freshly eclosed beetles were isolated and kept alive for at least three days until they were fully pigmented.

Long-term observations in the field. Natural succession, occurrence of different developmental stages and predators of *Exochomoscirtes* and other bamboo inhabitants were investigated during 3 long-term studies in Malaysia employing the giant bamboo *Gigantochloa scortechinii*:

a) Long-term study I. For observations of *Exochomoscirtes* larvae living in dead bamboo culms 100 internodes were used ("experimental internodes", see Kovac & Streit 1996). Experimental internodes had a lid which could be opened or closed for examination or collecting of prey items (Fig. 16).
Ten bamboo culms, each containing 10 experimental internodes were set up in a horizontal position at different locations in the vicinity of the UFSC. Experimental internodes were checked daily over a period of more than six months (1991-05-18 until 1991-12-07) in order to record, whether *Exochomoscirtes* adults, larvae or pupae were present in the internodes. Predators feeding on *Exochomoscirtes* specimens were collected together with their prey and identified in the laboratory.

b) Long-term study II. For observation of *Exochomoscirtes* larvae inhabiting mature bamboo culms (2 years or older) hundred 9 mm circular holes were bored in lower internodes of bamboo culms using a battery-operated drill. The holes were bored in August 1993 and the cavities were checked using an endoscope once a week for more than two months between 1994-06-07 and 1994-08-16. Specimens could not be retrieved from the internodes for identification during the ongoing study.

c) Long-term study III. For observation of internode cavities in bamboo shoots (height ca. 3 m or taller) hundred circular holes were drilled in the same way as above and internode cavities were checked daily by an endoscope for 4.7 months between 1993-08-13 and 1994-01-4.

Preservation, preparation, terminology and depositories. Fully pigmented adults were killed with ethanol acetate and mounted on cards or preserved in 70 % ethanol. Larvae and pupae were preserved in 70 % ethanol. For genital examination the abdomen was cleared in cold KOH (4 %) and genitalia mounted on microscop slides in Euparal.

Terminology follows Klausnitzer (2009) and Ruta & Yoshitomi (2010). Measurements are given in millimetres.

Type material is deposited in Senckenberg Deutsches Entomologisches Institut (Holotypus) and in coll. Klausnitzer (Paratypus).

Results

Taxonomy and Faunistics

Exochomoscirtes hajeki Ruta, 2011

Material examined: 1 ♂, Pangmapha, near Ban Nam Rin, 2011-11-25, in decaying bamboo stem, internode with narrow slit, B1/11b; 1 ♂, Malaysia, Selangor Darul Ehsan, Genting Highlands, 1991-05-06, ca. 1000 m, dead bamboo culm (experimental internode), BHe1; 1 ♂, Selangor Darul Ehsan, Ulu Gombak Field Studies Centre, 1991-11-07, 250 m, dead bamboo culm of *Gigantochloa scortechinii* (experimental internode), BHe5; 1 ♂ + 2 specimens (1 ex larva), Ulu Gombak, Field Studies Centre, 1999-09-13, rotting bamboo internode; all leg. D. Kovac.

Habitat: Water-filled decaying bamboo internodes with small holes.

Host plants: *Bambusa polymorpha*, *Cephalostachyum pergracile*, *Dendrocalamus* sp., *Gigantochloa scortechinii*.

Distribution: Malaysia (Perak, Cameron Highlands, so far only known from type locality, (Ruta 2011b). First record for Thailand.

Exochomoscirtes jaechi Ruta & Yoshitomi, 2010

Material examined: 1 ♂ (ex larva), Thailand, Mae Hong Son, Pangmapha, near Ban Pha Mon, larva collected on 2011-11-2, adult eclosed on 2011-11-12, in bamboo stump, Z13/3/11b; 1 ♂, 1 ♀ (ex larvae), Pangmapha, near Pha Mon, larvae collected on 2014-06-07, adults emerged on ca. 2014-06-18, in forest rock pool, Z 26/3/14a; all leg. D. Kovac.

Habitat: Dead bamboo stems with large openings, bamboo stumps, forest rock pools.

Distribution: N Thailand (Chiang Mai prov., Ruta & Yoshitomi, 2010 and Mae Hong Son prov., present study), Laos (Bolixhamxai prov., Ruta & Yoshitomi, 2010).

Host plant: *Bambusa polymorpha*.

Exochomoscirtes chiangmaiensis Ruta, 2011

Material examined: 1 ♂ (ex larva), Thailand, Mae Hong Son, Pangmapha, near Ban Nam Rin, larva collected on 2011-10-21, adult emerged on 2011-10-27, water-filled bamboo stump, Z 19/1/11b, leg. D. Kovac.

Habitat: Bamboo stumps.

Host plant: *Bambusa polymorpha*, *Dendrocalamus* sp.

Distribution: Thailand (Chiang Mai prov., Ruta 2011a and Mae Hong Son prov., present study).

Exochomoscirtes carinensis Ruta, 2011

Material examined: 1 ♂, 1 ♀ (both ex larva), Thailand, Mae Hong Son, Pangmapha, near Ban Rai, larvae collected on 2011-11-03, adults emerged on 2011-11-11, in water-filled bamboo stump, Z 25/2/11b, leg. D. Kovac.

Habitat: Water-filled bamboo stumps.

Host plant: *Dendrocalamus* spec.

Distribution: Myanmar ("Carin"), so far only known from type locality (Ruta 2011b). First record for Thailand.

Exochomoscirtes meghalayensis Ruta & Yoshitomi, 2010

Material examined: 1 ♂ (ex larva), Thailand, Mae Hong Son, Pangmapha, near Soppong, larvae collected on 2011-11-02, adult emerged on 2011-11-12, in water-filled depressions on big fallen tree, Z 24/2/11b; 1 ♀ (ex larva), from the same batch of larvae as before, adult emerged on 2011-11-17, Z 24/4/11b; from the same batch of larvae as before, adult emerged on 2011-11-24, Z 24/5/11b; 1 ♀ (ex larva), Pangmapha, near Ban Pha Mon, larvae collected on 2011-11-13, adult emerged on 2011-11-19, Z 8/14/11b; all leg. D. Kovac.

Habitat: Tree holes and rock pools.

Distribution: NO-India (Meghalaya), so far only known from two specimens from the type locality (Ruta & Yoshitomi, 2010). First record for Thailand.

Exochomoscirtes cf. *luteosuturaloides* Ruta & Yoshitomi, 2010

Material examined: 2 ♀♀ (1 specimen ex larva), Malaysia, Selangor Darul Ehsan, Ulu Gombak Field Studies Centre, 1989-04-30, dead bamboo stem, leg. D. Kovac.

Habitat: Water-filled internodes of living or dead bamboo culms.

Host plant: *Gigantochloa scortechinii*.

Distribution: Malaysia (Sabah), only known from one male (Ruta & Yoshitomi, 2010).

Exochomoscirtes hashimi Klausnitzer spec. nov.

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Holotype: ♂ (ex larva), Malaysia, Selangor Darul Ehsan, Ulu Gombak Field Studies Centre, 1989-04-30, water-filled internode in dead bamboo stem, leg. D. Kovac.
Paratype: 1 ♂ (ex larva), Malaysia, 1989-04-30, Selangor Darul Ehsan, Ulu Gombak Field Studies Centre, water-filled internode in dead bamboo stem, leg. D. Kovac.

Habitat: Water-filled dead bamboo stems with small holes or cracks in the wall.

Host plant: *Gigantochloa scortechinii*.

Distribution: Peninsular Malaysia (Selangor Darul Ehsan).

Body uniformly reddish brown (Fig. 1), oval (total length/greatest body width = Holotype: 1.50; Paratype: 1.71). Total length = Holotype: 4.72 mm; Paratype: 4.69 mm.
Head densely and finely punctate; pilosity dense, somewhat protruding and light-colored. Distance between eyes 0.67; 0.63 mm. Antenna reddish brown.
Pronotum densely and finely punctate, surface between punctures smooth (x 100 magnification); pilosity dense and light-colored, especially on front and side margins. Length in the center of pronotum 0.77; 0.79 mm; maximum width of pronotum 2.00; 1.98 mm. Scutellum punctate and pilose as pronotum.
Elytra punctate as pronotum, surface between punctures smooth (x 100 magnification), pilosity light-colored, with faint marks of two longitudinal ridges. Maximum width of elytra 3.14; 2.75 mm; maximum length of elytra 3.95; 3.90 mm.
Larger metatibial spur straight, only apex slightly curved, length 0.47; 0.42 mm; shorter spur slightly curved, length 0.27; 0.24. Length of metatibia 1.30 mm, length of first segment of metatarsus 0.50 mm.
Sternites yellowish brown; front edges of sternites 3-6 narrow dark brown. Posterior margin of sternite 7 slightly truncate in middle (Fig. 2). Total length 1.71; 1.47 mm; greatest width 0.57; 0.51 mm.
Sternite 9 composed of two oblong sclerites, tapering caudally, densely covered with bristles at apex. Sternite 9 truncate between sclerites (Fig. 3). Each hemisternite weakly reinforced by a rod-shaped structure located in centre front. Shape of sternite 9 resembles *Elodes*: a narrow

shaft, broad plate parallel on sides, caudally covered with setae. Total length of sternite 9: 0.47; 0.52 mm; greatest width 0.18; 0.21 mm.
Tergite 7 composed of a broad plate and strongly sclerotized Bacilla lateralia curved inward (Fig. 4). Central part of posterior edge sclerotized and truncate (rear width of tergite 7: 0.10 mm), tapering into inclined, pointed apices (front distance between apices 0.18 mm) (Fig. 5).
Tergite 8 composed of a rounded plate with indented posterior margin and strongly sclerotized, very faintly curved Bacilla lateralia, which are arched and interconnected in the center of the plate (Fig. 6). Edge of indentation 0.04 mm deep, bearing small teeth. Total length of tergite 8: 1.05; 0.97 mm; greatest width of plate 0.53; 0.60 mm. Length of Bacilla lateralia 0.88; 0.90 mm.
Plate of tergite 9 weakly sclerotized, rear part densely covered with pointed microtrichia. Bacilla lateralia almost straight (Fig. 7). Total length of tergite 9: 0.60; 0.62 mm; greatest width of plate 0.31; 0.32 mm.
Tegmen with transverse capulus, indented on sides (width 0.26; 0.20 mm). Parameres outwardly directed, approximately half-way angled inwards (Fig. 8), lobe-shaped in posterior part. Middle projection almost 3/4 as long as parameres, apically rounded. Total length of tegmen 0.43; 0.47 mm; greatest width 0.36; 0.24 mm; Length of middle projection from base 0.22; 0.23 mm.
Penis with triangular pala and narrow edge, almost straight in front, tapering backward (Fig. 9). Parameroides distinctly separated. Total length of penis 0.36; 0.35 mm; greatest width of pala 0.13; 0.12 mm.

Etymology: The species is named after Dr. Rosli Hashim from the University of Malaya, who supported DK in the field in his capacity as head of the Ulu Gombak Field Studies Centre.

Diagnosis

Body oval, elytra monochromatic, color of elytra and pronotum identical, antenna filiform. Metatibia lacking specific modifications. Special feature present on posterior margin of tergite 7, namely a truncate, elevated sclerotized structure, which is not prolonged caudally (Figs 4, 5). The sclerotized structure on tergite 7 suggests a comparison between *E. hashimi* spec. nov. and four *Exochomoscirtes* species possessing a process in the same position. In *E. quadripartitus* Ruta & Yoshitomi, 2010 and *E. sondaicus* Klausnitzer, 2010 the process has a complicated structure, while in *E. retusus* (Champion, 1918) and *E. ruforotundus* (Watts, 2004) the process is rectangular. A comparison of the two latter species with *E. hashimi* spec. nov. shows (Table 2), that especially the tegmen of *E. retusus* and *E. hashimi* spec. nov. are similar, while the posterior margins of tergite 7 are totally different. The shape of penis and further details of tegmen are also different. *E. hashimi* spec. nov. is also well distinguishable from other *Exochomoscirtes* species on the basis of size and proportions of tergite 8, indentation on tergite 8 bearing small teeth (Fig. 6), and the shape of sternite 9 (Fig. 3).

Habitat: Water-filled internodes of decaying bamboo culms.

Host plant: *Gigantochloa scortechinii*.

Distribution: West Malaysia.

Biology

Habitat: As indicated in Table 2 *Exochomoscirtes* larvae were collected from water-filled tree holes (Fig. 10), depressions in fallen trees (Fig. 11) forest rock pools (Fig. 17) and bamboo internodes in mature culms (Fig. 12), dead culms (Fig. 13) or bamboo stumps (Fig. 14).
Enclosed bamboo internodes (in contrast to open bamboo stumps) were colonized through holes made by insects, woodpeckers or small mammals. Entrance holes in bamboo shoots were made by moth larvae belonging to Crambidae (Lepidoptera; hole size 3 x 2 mm) or Chrysomelidae (Coleoptera; in Malaysia: *Lasiochila goryi* (Guérin-Méneville, 1840)); hole size ca. 6 x 3 mm, Fig. 12). In mature culms holes were created by Cerambycidae (Coleoptera; *Abryna regispetri* Paiva, 1860, circular hole, ca. 1 cm in diameter) and woodpeckers (feeding holes of different sizes and entrances of nesting internodes, ca. 6 x 4 cm).
Cracks in the wall, for example, narrow slits which resulted from splitting of dead bamboo culms due to low humidity in the dry season were also suitable as entrance openings. The narrow slits were almost as long as the internodes and 1–2 mm wide. They were located approximately in the middle of the fallen, more or less horizontal dead bamboo culms (Fig. 13), thus allowing water to collect at the bottom of the internodes.
In dead bamboo culms *Exochomoscirtes hajeki* and *E. hashimi* spec. nov. were common, while *Exochomoscirtes* cf. *luteosuturaloides* was rare and *E. jaechi* and *E. chiangmaiensis/carinensis* were found only once. The latter two species were found in the same internode possessing a large opening created by a fallen tree branch (Fig. 15). During the long-term study I (see Methods) 86 out of 100 internodes were occupied by *Exochomoscirtes* 6 months after the holes were bored. In 31 internodes *E. hajeki* hatched out, in 15 internodes *E. hashimi* spec. nov. and in one internode *E.* cf. *luteosuturaloides*. Specimens inhabiting the remaining occupied internodes could not be determined, because they were still in the larval stage at the end of the study period. In most internodes freshly emerged adults belonged just to one *Exochomoscirtes* species, but in one case *E.* cf. *luteosuturaloides* and *E. hajeki* were reared from the same internode.

In mature bamboo culms larvae of *E.* cf. *luteosuturaloides* were found in a deserted nesting internode of a woodpecker. The base of the inhabited internode was 20.86 m above ground. During the long-term study II (see Methods) sixty-nine out of hundred internodes were occupied by *Exochomoscirtes* larvae ca. 13 months after the holes were bored. During the relatively short observation period (about two months, checks once per week) only six freshly eclosed *Exochomoscirtes* adults were observed. They probably belonged to *E. hashimi* spec. nov., however, specimens could not be retrieved from the internodes for accurate determination. Sometimes, large and very small *Exochomoscirtes* larvae were found in the same internodes. In felled bamboo culms the water amount was less than 600 ml per internode in the rainy season in Malaysia, while in the dry season many internodes were dried up.

Exochomoscirtes larvae were never found in bamboo shoots, neither in freshly felled shoots both in Malaysia and Thailand, nor during the long-term study III, in which 100 shoot internodes were observed daily for more than 4 months.

In bamboo stumps *E. chiangmaiensis* / *E. carinensis* were most common. These two species looked very similar and could only be distinguished by male genitalia. Other species found in bamboo stumps were *Exochomoscirtes jaechi* (n = 1) and *E. hajeki* together with *E. chiangmaiensis* / *E. carinensis* (n = 1).

Behaviour and life cycle

Exochomoscirtes larvae were hidden between debris in the daytime (especially in open phytotelmata), while in the night time they walked around on the bottom of the internodes, on the internode walls or underside of the water surface. Submerged specimens carried an air bubble at the tip of their abdomen (Fig. 16) and replenished their air supply at the water surface from time to time. Larvae fed on detritus at the bottom of the internodes, on the internode walls or under the water surface. In experimental internodes there were about 20-30 larvae per internode.

Mature *Exochomoscirtes* larvae climbed on land for pupation and had their long antennae broken off (Fig. 18). Larvae living in open phytotelmata pupated in crevices or in the ground in the vicinity of their habitats. Prior to pupation they always constructed pupal chambers made of soil or debris (Fig. 18). In *E. chiangmaiensis* pupal chambers were found on the outside wall of bamboo stumps (n = 3) or inside the bamboo stump ca. 3 cm above the water surface (n = 1).

In enclosed bamboo internodes larvae pupated inside the internode cavities (*Exochomoscirtes hajeki*, *E.* cf. *luteosuturaloides* and *E. hashimi* spec. nov.). They pupated ca. 2 days after leaving water. The pupae were freely attached to the bamboo wall 1–2 cm above the water surface with their heads pointing downwards (Figs 17, 19). If disturbed, they reacted by fierce up and down movements of their bodies. In rare cases mature larvae of *Exochomoscirtes hajeki*, *E.* cf. *luteosuturaloides*, and *E. hashimi* spec. nov. started to build a pupal chamber, but they usually did not finish it. Thus, pupae were surrounded by an oval wall made of debris (Fig. 19). In laboratory larvae of all species pupated between moist tissues, because there was no material available for the construction of pupal chambers.

Colonization and development of *Exochomoscirtes* inhabiting dead bamboo culms was observed during the long-term study I ("experimental internodes", see methods and Fig. 16). In general, adult beetles stayed on the internode wall close above the water surface and remained in the internode cavities just for one day. Eggs were not detected in the field, but 22 tiny eggs and 5 freshly hatched larvae were found in a vial containing one *E.* cf. *luteosuturaloides* female. The first two *Exochomoscirtes* beetles, *E. hajeki* and *E. hashimi* spec. nov., arrived six days after beginning of the observation. The first relatively large larvae were detected 25 days after beginning of the observation. The period from the first larval observation to the first observation of pupae in the respective internodes was 69/ 63/ 79/ 64/ 78/ 64 days (*E. hajeki*) and 74/ 67/ 81 days (*E. hashimi* spec. nov.).

Exochomoscirtes larvae pupated about two days after they had left water. Pupal stage lasted 2–4 days: *E. hashimi* spec. nov.: 2–3 days (n = 14), *E. hajeki*: 3–4 days (n = 4), *E. chiangmaiensis/carinensis* 4 days (n = 2) and *E. meghalayensis*: 2–4 days (n = 4). The period between the beginning of the long-term study (boring of the holes) and the first detection of freshly emerged adults in different internodes was 100–135 days (n = 16). In two internodes the period between detection of a probably egg-laying female and eclosion of the first adult belonging to *E. hajeki* was 88 and 95 days.

Predators

Fifty-two predators were collected from dead or living internodes during the long-term studies I and II (see Methods). They fed on *Exochomoscirtes* when the internodes were inspected or the prey items were detected in spider or mycetophilid nets. Captured *Exochomoscirtes* adults belonged to *E.* cf. *luteosuturaloides*, *E. hajeki* and *E. hashimi* spec. nov.

Table 3 shows that all *Exochomoscirtes* stages inhabiting experimental internodes were preyed upon by various aquatic, semi-aquatic or terrestrial predators. Small *Exochomoscirtes* larvae were quickly grabbed by aquatic larvae of the tiny midge *Dasyhelea* Kieffer, 1911 (Diptera, Chironomidae), which slowly crawled at the bottom of the internode. Larger *Exochomoscirtes* larvae were preyed upon by mosquito larvae belonging to *Toxorhynchites metallicus* Leicester, 1904 and *T. leicesteri* Theobald, 1904 (Diptera, Culicidae). They

hunted *Exochomoscirtes* larvae at the bottom of the internodes as well on the side walls or underside of the water surface.

The small waterstrider *Lathriovelia rickmersi* Kovac & Yang, 2000 (Heteroptera, Veliidae) seized *Exochomoscirtes* larvae walking on the underside of the water surface (Kovac & Krocke 2013). The semiaquatic rove beetle *Acylophorus* Nordmann, 1837 (Coleoptera, Staphylinidae) hunted on or near the edge of the water surface and seized *Exochomoscirtes* larvae replenishing their air supply, climbing on land for pupation or pupae attached to the bamboo wall.

The terrestrial jumping spider *Paracyrba wanlessi* Zabka & Kovac, 1996 (Araneae, Saltididae) seized submerged *Exochomoscirtes* larvae from the edge of the water surface as well as larvae climbing on land, pupae or freshly emerged adults (Zabka & Kovac 1996). Web-building spiders (Theridiidae) captured *Exochomoscirtes* larvae crawling on land or pupae and deposited them in their webs.

In living bamboo culms *Exochomoscirtes* adults were hunted by larvae of *Toxorhychites magnificus* (Leicester), 1908, web-building Theridiidae and larvae of the mycetophilid fly *Truplaya ferox* Kovac & Matile, 1997 (Diptera, Keroplatidae), which constructed slimy webs in the terrestrial part of the internode cavities (Kovac & Matile 1997).

Discussion

Exochomoscirtes species were known to inhabit water-filled trees holes, buttress roots and bamboo internodes (Watts 2004, Ruta & Yoshitomi 2010, Zwick 2011). In the present study larvae were also detected in depressions of large fallen trees (Fig. 11), forest rock pools (Fig. 17) and different types of bamboo phytotelmata, for example, internodes of mature culms up to a height of ca. 20 m.

The main focus of the study was on the ecology and biology of *Exochomoscirtes* species inhabiting bamboo. Bamboo phytotelmata were divided into sub-habitats on the basis of the accessibility of bamboo internodes (open internodes vs. enclosed internodes possessing small entrance holes), availability of nutrients and durability of the habitats. In preceding studies different bamboo habitat types were found to harbour different animal communities (Kovac & Streit 1996).

Bamboo shoots were a short-lived habitat existing just for a few weeks or months, mature bamboo culms existed up to ten years and were colonized by *Exochomoscirtes* over and over again and dead bamboo culms or bamboo stumps decomposed or were not functional after 1–2 years, depending on the position of the culm (upright or lying on the ground) and humidity (Kovac & Streit 1996). In open phytotelmata such as bamboo stumps or water-filled tree holes nutrient input consisted mainly of fallen leaves, while in enclosed bamboo internodes (smallest entrance holes 3 x 2 mm) nutrient input consisted of dead bamboo inhabitants, material brought into the internode cavities for example by ants or substrate from decomposing bamboo walls. Most bamboo phytotelmata, especially water-filled internodes of mature bamboo culms, were nutrient-poor, whereas the soft-walled bamboo shoot phytotelmata were nutrient-rich (Kovac & Streit 1996).

Although the number of habitat records was small, it seems that *Exochomoscirtes* species preferred certain phytotelmata types (Table 2). Thus, *E. meghalayensis* larvae only occurred in water-filled tree holes and rock pools, *E. hajeki* was abundant in enclosed internodes of dead bamboo culms and *E. chiangmaiensis* and *E. carinensis* were most common in bamboo stumps. *E. hashimi* spec. nov. was abundant in dead bamboo internodes and perhaps even more common in living bamboo culms, since all emerged adults observed during the long-term study II were *E. hashimi* spec. nov. It is noticeable that *Exochomoscirtes* larvae were always absent in nutrient-rich bamboo shoot internodes.

Species primarily inhabiting open phytotelms apparently did not colonize enclosed internodes. Thus, *E. meghalayensis* only occurred in open phytotelmata, and *E. jaechi* was just found in a rock pool, a bamboo stump and a dead internode possessing a very large opening (Fig. 15). The reason for this may be that species living in open phytotelmata possibly use reflections of the water surface in order to detect their habitats. Species living in enclosed internodes probably employ a different search strategy, since they need to approach bamboo culms, walk along stems and search for small entrance holes in order to find a water-filled internode.

Our results indicate that single internodes were usually colonized just by one species, but occasionally two *Exochomoscirtes* species were found in the same phytotelm, for example, *E. hajeki* and *E. hashimi* spec. nov. (dead internode), *E. hajeki* and *E.* cf. *luteosuturaloides* (dead internode) or *E. chiangmaiensis* and *E. carinensis* (bamboo stump).

Exochomoscirtes living in open phytotelms constructed pupal chambers in the vicinity of their habitats (*E. meghalayensis*, *E. chiangmaiensis/carinensis*), while those developing in enclosed bamboo internodes pupated attached to the bamboo wall of the internode cavity (*E.* cf. *luteosuturaloides*, *E. hajeki* and *E. hashimi* spec. nov.). Occasionally, they started to build pupal chambers prior to pupation, but they rarely finished them, although construction material was available. Therefore, some pupae were enclosed by a detritus wall rather than a pupal chamber (Fig. 21). It may be that *Exochomoscirtes* living in enclosed and dark internodes were less vulnerable to predation and therefore could afford to give up constructing pupal chambers.

The length of the life cycle was roughly estimated for *E. hajeki*. In two cases the period between detection of a

female possibly laying eggs and eclosion of the first adult of the next generation lasted 88 and 95 days, i.e., the total development time was about 3 months or longer.

The main predators of *Exochomoscirtes* inhabiting enclosed bamboo internodes were *Toxorhynchites* mosquito larvae and jumping or web-building spiders (Table 3). *Exochomoscirtes* were most often captured in the submerged larval stage, followed by larvae staying on land, pupae and adults (Table 3). Larvae staying on land were probably less vulnerable to predators then submerged ones, because they did not move much. Pupae also usually did not move and were partially protected by their shed exuviae or sometimes a detritus wall. Finally, adults were probably less vulnerable to predators because of their hard cuticle and their ability to jump.

In summary, our results show that bamboo phytotelmata provide a major habitat for *Exochomoscirtes* and that bamboo scirtids would merit further investigation.

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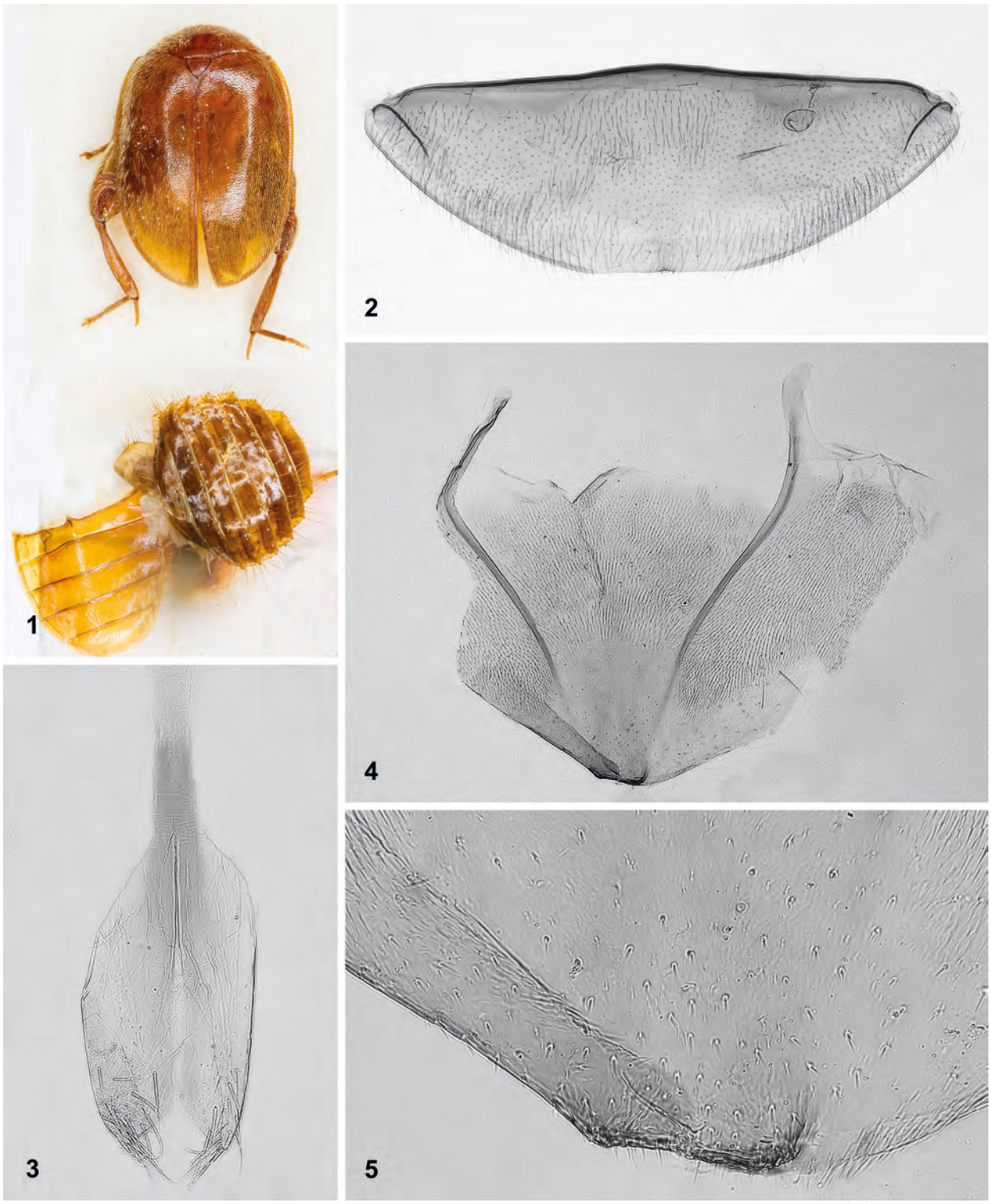
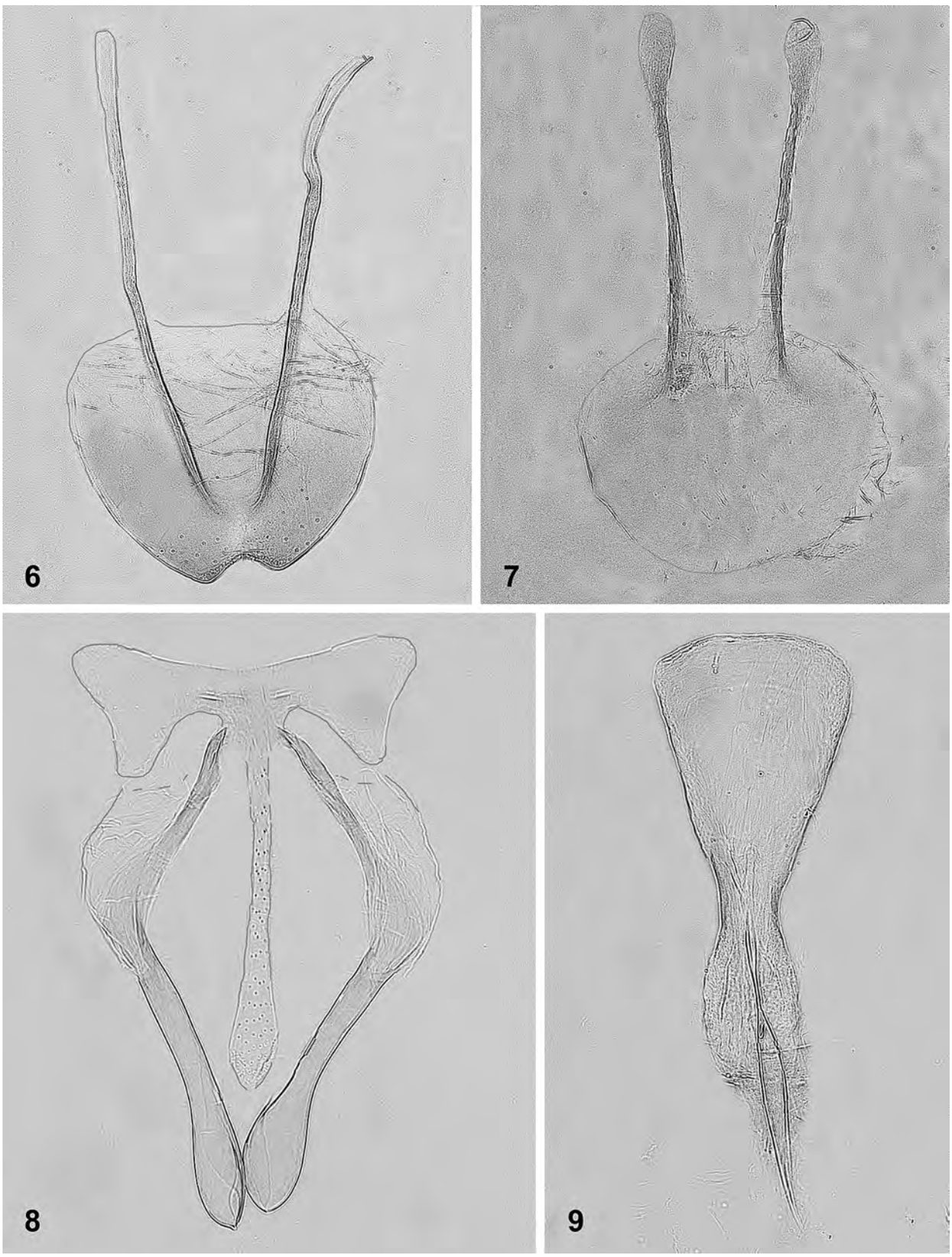


Figs 1–5: *Exochomoscirtes hashimi* spec. nov.: (**1**) Habitus, dorsal, including exuviae and detached abdomen; (**2**) Sternite 7; (**3**) Sternite 9; (**4**) Tergite 7; (**5**) Tergite 7, posterior margin.



Figs 6–9: *Exochomoscirtes hashimi* spec. nov.: (**6**) Tergite 8; (**7**) Tergite 9; (**8**) Tegmen; (**9**) Penis.

Figs 10–17: *Exochomoscirtes* habitats in Malaysia (Figs 12, 16) and Thailand (Figs 10, 11, 13–15, 17). Species found in depicted habitat types are bracketed. (**10**) Water-filled tree hole (*E. meghalayensis*). (**11**) Water-filled depression in a fallen tree (*E. meghalayensis*). (**12**) Internode of a living bamboo culm provided with an exit hole of the leaf beetle *Lasiochola goryi* (*E. hashimi* spec. nov.). (**13**) Fallen, decaying bamboo culm with a slit used as entrance (*E. hajeki*, *E. hashimi* n. sp.). (**14**) Water-filled bamboo stump (*E. chiangmaiensis*, *E. carinensis*). (**15**) Decaying bamboo culm with large opening (*E. jaechi*, *E. chiangmaiensis/carinensis*). (**16**) "Experimental internode" which could be opened for inspection (*E. hashimi* spec. nov., *E. hajeki*, *E.* cf. *luteosuturaloides*). (**17**) Forest rock pool (*E. meghalayensis*).

Figs 18–21: Developmental stages of *Exochomoscirtes*. (**18**) *E. hajeki*, submerged larva. Note the long antennae and the air bubble at the tip of abdomen. (**19**) *E. hashimi* spec. nov., developmental stages seen on bamboo wall above the water surface: one larva ready for pupation, one pupa, two freshly emerged adults, one pale adult still connected to larval exuvia, four exuviae remains. (**20**) *E. chiangmaiensis/ carinensis* larva with broken off antennae, enveloped by a pupal chamber made of debris (front part of pupal chamber removed). (**21**) *E. hajeki* pupa attached to the bamboo wall inside the unfinished pupal chamber.

Tab. 1: Comparison between *Exochomoscirtes hashimi* spec. nov. and two similar species possessing a rectangular process on tergite 7, *E. retusus* and *E. ruforotundus*. Characters referring to *E. retusus* were adopted from the redescription presented by Yoshitomi (2008), *E. ruforotundus* characters were taken from the original description and from Ruta & Yoshitomi (2010). Measurements in mm.

Characters	***E. retusus***	***E. ruforotundus***	***E. hashimi* spec. nov.**
Parameres	long, slender, gently arcuate in proximal half, apex expanded triangularly in apical part	thin, sinuate, apex bulbous at tips	directed outward, approximately half-way angled inwards (Fig. 8), apex lobe-shaped)
Tegmen	L 0.42; W 0.20	L 0.47; W 0.23	L 0.43; W 0.36
Tergite 7, posterior edge	apex with a small projection	apex with a small projection	apex with elevated and truncated sclerotized edge (Figs 4, 5)
Tergite 8	L 0.49; W 0.37	L 0.51; 0.37	L 1.05; W 0.53
Tergite 8, posterior edge	almost straight	almost straight	indentation (depth 0,04 mm) covered with small teeth (Fig. 6)
Index L:W	1.32	1.38	1.98
Tergite 9	L 0.50; W 0.21	L 0.55; W 0.28	L 0.60; W 0.31
Sternite 9	L 0.38; W 0.17	L 0.42; W 0.19	L 0.47; W 0.18
Penis	L 0.35; W 0.14	L 0.45; W 0.15	L 0.36; W 0.13
Metatibia, dorsal spur	gently curved laterally	relatively long, broad	straight, only apex weakly curved, L 0.47
Body length	3.88	3.2–4.7	4.72
Body length/greatest width	1.35		1.50
Distribution	Indonesia (Ceram)	Australia, New Guinea, Bali	Malaysia

Tab. 2: Habitats of *Exochomoscirtes* species recorded in the present study. Numerals indicate the number of phytotelmata from which larvae were reared or in which adults emerged during the long term studies. Females of *E. chiangmaiensis* and *E. carinensis* could not be differentiated. The six *E. hashimi* spec. nov. from mature bamboo culms were observed by an endoscope.

***Exochomoscirtes* species**	**Bamboo shoots**	**Mature bamboo culms**	**Dead bamboo culms**	**Bamboo stumps**	**Tree holes**	**Depressions in fallen trees**	**Rock pools**
Thailand					–		
E. hajeki	–	–	12	1	–	–	–
E. jaechi	–	–	1	1	–	–	1
E. chiangmaiensis	–	–	1	1	–	–	–
E. carinensis	–	–	–	1	–	–	–
E. chiangmaiensis or *carinensis*	–	–	–	3	–	–	–
E. meghalayensis	–	–	–	–	3	1	3
Malaysia							
E. hajeki	–	–	36	–	–	–	–
E. hashimi spec. nov.	–	6	20	–	–	–	–
E. cf. *luteosuturaloides*	–	1	2	–	–	–	–

Tab. 3: Aquatic, semiaquatic and terrestrial predators preying upon *Exochomoscirtes* in internode cavities of dead or living bamboo culms in West Malaysia. The captured *Exochomoscirtes* adults belonged to *E.* cf. *luteosuturaloides*, *E. hajeki* and *E. hashimi* spec. nov. Numerals indicate the number of prey items collected from experimental internodes or observed by an endoscope in living culms.

Predators	***Exochomoscirtes* larva submerged**	***Exochomoscirtes* larva on land**	***Exochomoscirtes* pupa**	***Exochomoscirtes* imago**
Dead bamboo culms				
Dasyhelea spec.	1	–	–	–
Toxorhynchites metallicus and *T. leicesteri*	12	–	–	–
Lathriovelia rickmersi	2	–	–	–
Paracyrba wanlessi	8	1	2	1
Acylophorus spec.	–	–	1	–
Theridiidae	–	9	6	–
Mature bamboo culms				
Toxorhynchites magnificus	5	–	–	–
Truplaya ferox	–	–	–	2
Theridiidae	–	2	–	–

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