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Article

A new genus and species, *Simalurapolipus hiraii* (Acari: Heterostigmatina: Podapolipidae) parasitic on *Simalura coerulea* (Coleoptera: Tenebrionidae) in Japan

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Abstract

Simalurapolipus hiraii **n. gen., n. sp.** (Acari: Podapolipidae) collected in Shizuoka Prefecture, Japan is described from *Simalura coerulea* (Lewis) (Coleoptera: Tenebrionidae) and compared with *Tenebrapolipus ceropriae* Kurosa and Husband, 2001 from *Ceropria induta* (Wiedemann, 1819) and *T. imasakai* Kurosa and Husband, 2001 from *Ceropria laticollis* Fairmaire,1903 collected in Japan. The unusual occurence of many larval females of the species on the host body surface is reported.

Key words: Acari, Podapolipidae, *Simalurapolipus,* new genus*,* new species, beetle parasite, *Simalura coerulea*, Tenebrionidae, systematics, Japan

Introduction

Including the species described herein, 251 species in the family Podapolipidae are parasites of five orders of insects: Blattodea, Orthoptera, Heteroptera, Hymenoptera and Coleoptera. The genus *Tenebrapolipus* was described with two new species and relationships with similar podapolipid species were discussed by Kurosa and Husband (2001). Eleven *Podapolipus* species, two *Tenebrapolipus* species, and the species of *Simalurapolipus* described in this paper, are subelytral and abdominal parasites of tenebrionid beetles. It is the purpose of this paper to describe a new genus of mite parasitic on a tenebrionid beetle, *Simalurapolipus*, describe a new species of *Simalurapolipus* from Japan and discuss its relationships with related podapolipid mites from tenebrionid beetles.

Materials and methods

Examination of three specimens of *Simalura coerulea* (Lewis) collected by Takeo Hirai in Shizuoka Prefecture, Japan yielded about 190 specimens of podapolipid mites. Mites were collected mainly from under the elytra, but also from the body surface (especially dorsum of elytra) of the host beetles. Excepting about 110 specimens used for temporal mounting, they were cleared in Nesbitt's fluid and mounted in Andre's fluid (modified Hoyer's medium). Measurements were taken with the aid of a Zeiss compound phase contrast microscope with an ocular micrometer. Length of gnathosoma was measured along the sagittal line from the tip of the anteromedial protuberance to the level of the most basal point of the gnathosoma.

All measurements refer to the length in μm unless otherwise stated. Setae no longer than the diameter of their setal acetabulae are labeled as microsetae (m) and setae represented only by

acetabulae are labeled as vestigials (v). Setae are frequently obscured, broken, bent, vertical or with extremely fine tips, which makes measurement difficult. Setae are at least as long as indicated. The terminology follows Lindquist (1986).

Taxonomy

Family Podapolipidae Ewing, 1922

***Simalurapolipus* n. gen.**

Type species: *Simalurapolipus hiraii* n. sp.

Female. Pharynx thick, 3/5 width of gnathosoma, small stigmata posterolateral to gnathosoma, opisthosoma with divided plates C, D and EF, leg II smaller than leg I, with 5 segments. Without tibia I seta *l'*, tarsal subunguinal seta *s* strongly hooked, ambulacrum I weakly developed.

Male. Gnathosomal setae *su* and ch_1 short. Idiosomal setae v_1 short, distance between v_1–v_1 equal to width of apex of genital capsule. Setae v_2 vestigial, sc_1 absent. Genital capsule extending to the level of setae v_1 rather than over part or all of the gnathosoma in genera *Locustacarus, Tetrapolipus* and *Podapolipus*. Width of genital capsule at the level of the bases of setae sc_2 less than 1/2 of distance between setae sc_2. Setae c_2, *e* not evident. With femur I setae *l*', genua I setae *l'* and *l''* and genu II *l'*. Tibiae II, III with setae *v''* thin and as long as the widths of the tibiae II, III, ambulacra II, III with well developed claws.

Larval female. Prodorsal plate setae v_1 long (30–40), sc_1 absent. Plate EF setae *e* long (30–36), with setae h_2 short (2–3). With femur I *l'*, genua I setae *l', l''* and genu II *l'*.

Simalurapolipus hiraii Kurosa and Husband sp. nov. (Figs. 1–5)

Differential diagnosis. Adult female *Simalurapolipus hiraii* bears divided plates C, D and EF in contrast to no plates in *Tenebrapolipus ceropriae*. Ambulacrum I is faint in *S. haraii* while more developed and conspicuous in female *T. ceropriae*. Tarsus II of female *S. hiraii* is longer and with a more conspicuous spine-like terminal seta. The genital capsule of male *S. haraii* is narrower than genital capsules of *T. ceropriae* and slightly broader than *T. imasakai*. Gnathosomal setae ch_1 are longer in male *S. hiraii* than in *T. ceropriae* or *T. imasakai* (Table 1). Ambulacral claws II and III are more developed in male and larval female *S. hiraii.* Tibia III setae *d* is two times longer in male *S. hiraii* than in *T. imasakai*. Setae *e* on plate EF are at least two times longer in larval female *S. hiraii* than in larval *T. ceropriae* and are more than four times longer than in larval *T. imasakai*. Coxal setae 2*a* longer than ½ width of base of tarsi II in larval *S. hiraii* and shorter than ½ base of tarsi II in *T. ceropriae.*

Description.

Female (Fig. 1, n=9). Gnathosoma length 42–65, width 47–54. Cheliceral stylets at an angle and with broken tips, length 20–22. Pharynx thick, length 22–28, width 30–33 (Table 1). Small, poorly sclerotized palpi without setae.

Idiosoma. Stigmata lateral to gnathosoma, weakly sclerotized, without atria or trachea. Idiosoma broadly oval, length 470–520, width 422–520. No idiosomal setae. Plate C divided, length 52–70, width 78–88, plate D divided, length 40–50, width 62–74, plate EF divided, length 48–57, width 72–85. Length of genital tract 165–180.

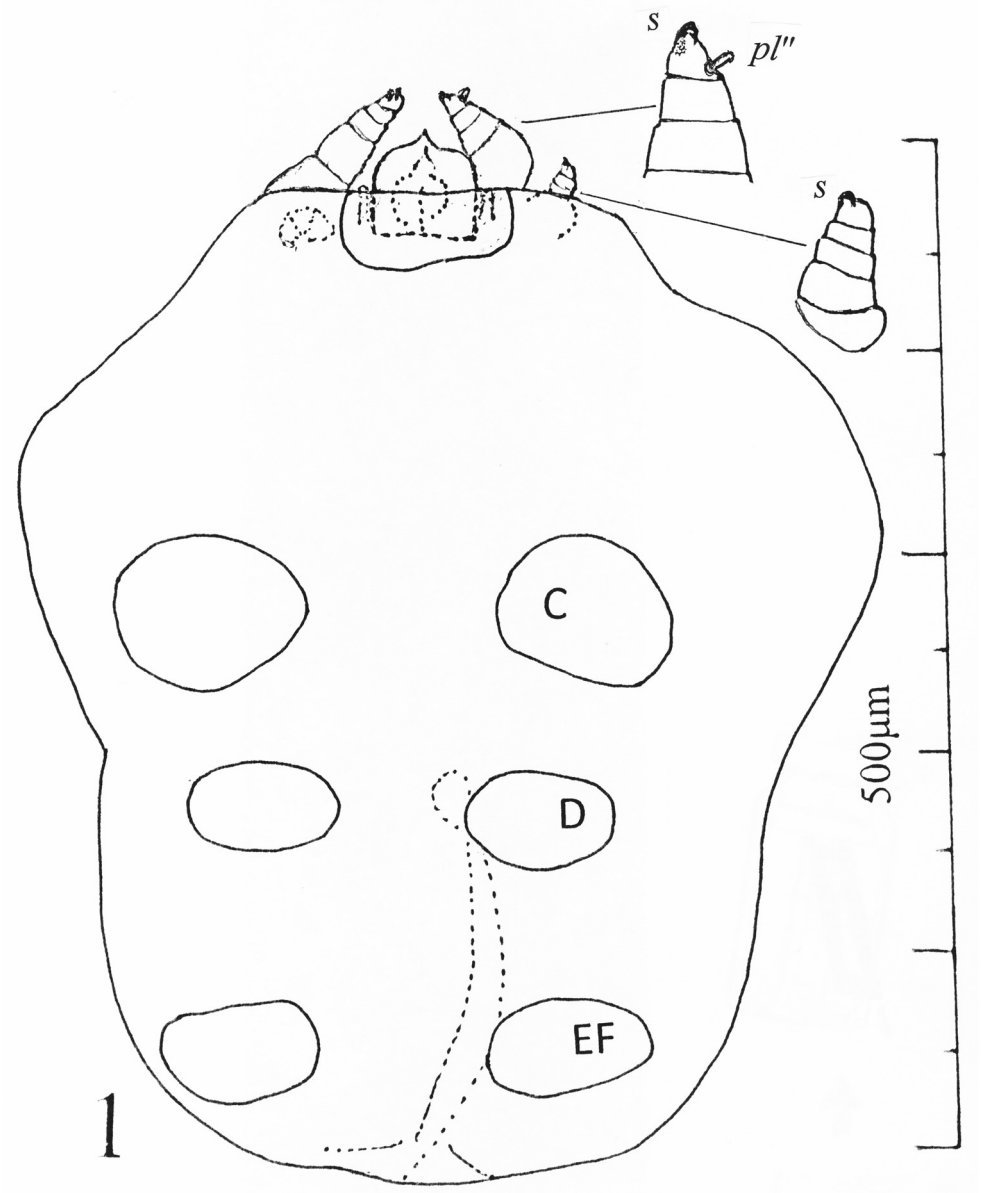

FIGURE 1. *Simalurapolipus hiraii* Kurosa and Husband **gen. nov**., **sp. nov.**, adult female, dorsal view.

Legs. No setae on femur I, genu I and tibia I. Tarsus I subunguinal setae *s* strongly hooked, tarsus I setae *pl"* broad, weakly sclerotized. Leg II about ½ size of leg I, with five segments, tarsus II subunguinal setae *s* strongly hooked.

Male (Figs. 2–3, n=17). *Gnathosoma* length 30, width 28–35. Cheliceral stylets 13–15, pharynx width 10. Setae ch_1 5, *su* 3–5. Small palpi, two segments, each with a small seta.

Idiosoma. Length 133–230, width 138–206. Prodorsal setae v_1 4–5, v_2 vestigial, sc_2 45–60, distance v_1–v_1 20–23, sc_2–sc_2 63–82, Plates CD fused, setae c_1, *d* vestigial. Genital capsule emerging from anterior margin of plate CD, extending over prodorsum to prodorsal setae v_1, length 40–57, width at level of bases of sc_2–sc_2 37–43. Venter with apodeme II well developed, not extending to presternal apodeme. Setae 1*a*, 2*b*, 3*b* vestigial, 2*a* 2–5.

Legs. Setation for femur, genu, tibia, tarsus of legs I, II, III 2-2-6-7, 0-1-4-5, 0-0-4-5, respectively. Ambulacrum I with one claw, ambulacra II, III with two well developed claws. Femur I setae *l'* m-3, *d* 2–4. Tibia I seta *d* 23–25, seta *v*' spine-like 5, solenidion φ basal 3–4.

Tarsus I solenidion ω not evident, setae *tc', tc"* thick, with blunt tips 10. Femur II without setae, genu II with seta *l'* 5, tibia II *setae v'*, *l"* spine-like 5. Tarsus II with spine-like setae *tc'*, apex of *u'* bifid 5, seta *pl"* 30. Femur III, genu III without setae, tibia III setae *v'*, *l"* spine-like 5, d 30. Tarsus III seta *pl"* 25–30, apex of seta *u*' bifid 5.

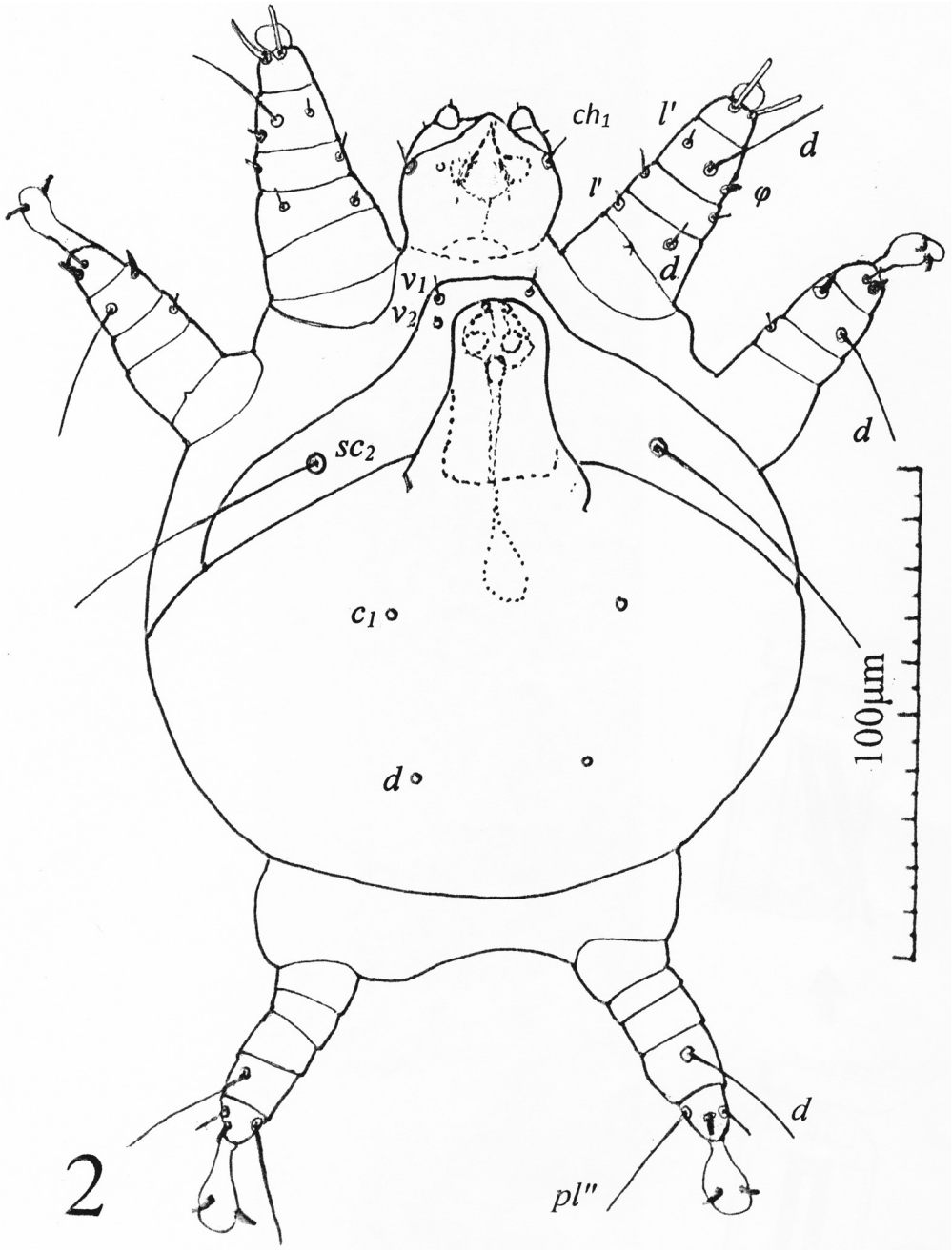

FIGURE 2. *Simalurapolipus hiraii* Kurosa and Husband **gen. nov.**, **sp. nov.**, male, dorsal view.

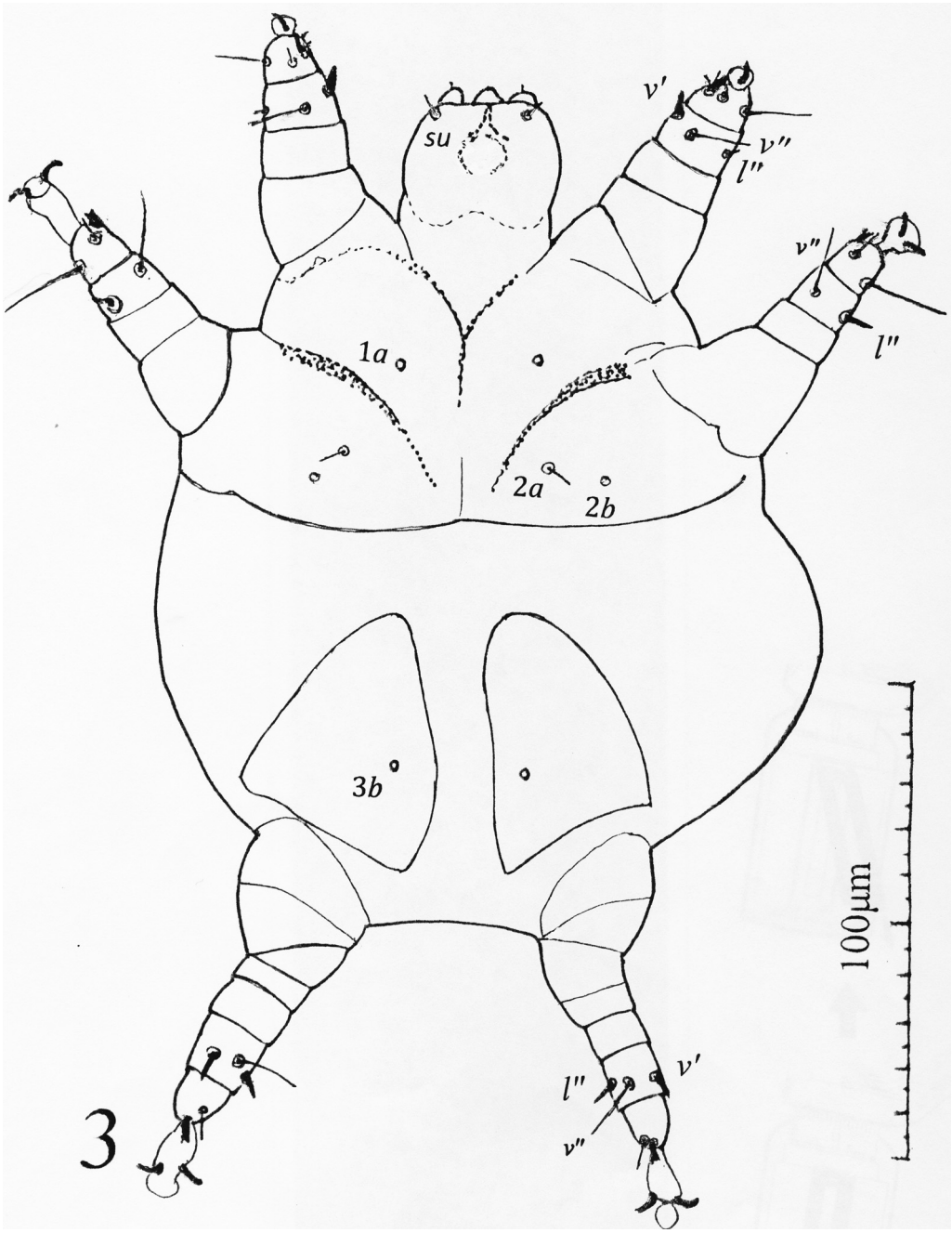

FIGURE 3. *Simalurapolipus hiraii* Kurosa and Husband **gen. nov.**, **sp. nov.**, male, ventral view.

Larval female. (Figs. 4, 5, n=25). *Gnathosoma* length 44–60, width 58–62. Cheliceral stylets length 50–53, setae ch_1 30–40, *su* 12–20, palpi short, two segmented, short seta on each segment. Pharynx width 15.

Idiosoma. Length 180–188, width 150–159 (Table 1). Prodorsal seta v_1 30–40, v_2 vestigial, distance v_1–v_1 56–61, sc_2 90–105. Plate CD, seta c_1 anterior 10–11, c_2 ventrolateral m–5, *d* 6–10.

Plate EF length 40, width 58, seta *e* 30–36. Plate H seta h_1 90–97, h_2 2–3, distance h_2–h_2 10. Venter with apodemes I, II weakly developed, apodemes II not extending to presternal apodeme. Coxal setae 1*a,* 2*b* vestigial, setae 2*a* 11–18, 3*b* 5–9.

TABLE 1. Comparison of selected maximum measurements of podapolipid parasites of tenebrionid beetles: *Podapolipus khorasanicus* (*Pkh*), *Tenebrapolipus ceropriae* (*Tc*) , *T. imasakai* (*Ti*) and *Simalurapolipus hiraii* (*Sh*).

Character	*Pkh*	*Tc*	*Ti*	*Sh*
FEMALE				
Idiosoma length	1,050	579	no female	520
Idiosoma width	577	460		520
Cheliceral stylet	26	27		22
Pharynx width	28	28		33
Gnathosoma width	44	51		54
Femur I seta *l*	*?*	15	0	0
Leg II length	no leg II	near 15		6
MALE				
Idiosoma length	134	182	164	230
Idiosoma width	116	165	132	206
Pharynx width	14	9	5	10
Gnathosomal seta ch_1	5	2	0	5
Setae: v_1	m	3	4	5
c_1	5	v	v	v
d	5	v	v	v
Tarsus III seta *pl"*	10	27	21	30
Genital capsule width	25(near)	56	35	43
Gen. cap. anterior to v_1	+	–	–	–
LARVAL FEMALE				
Idiosoma length	163	225	180	188
Idiosoma width	126	132	133	159
Cheliceral stylet	24	56	66	53
Pharynx width	15	16	14	15
Gnathosoma width	37	58	71	62
Gnathosomal seta ch_1	31	39	23	40
Subcapitular seta *su*	14	17	15	20
Setae: v_1	5	50	28	40
v_2	5	v	v	v
c_2	5	0	0	5
d	5	5	8	10
e	3	7	17	36
Coxal seta *2a*	6	10	8	18
Femur I *d*	26	32	29	12
Tibia III *d*	40	39	29	50
Tarsus III *pl"*	88	27	31	23

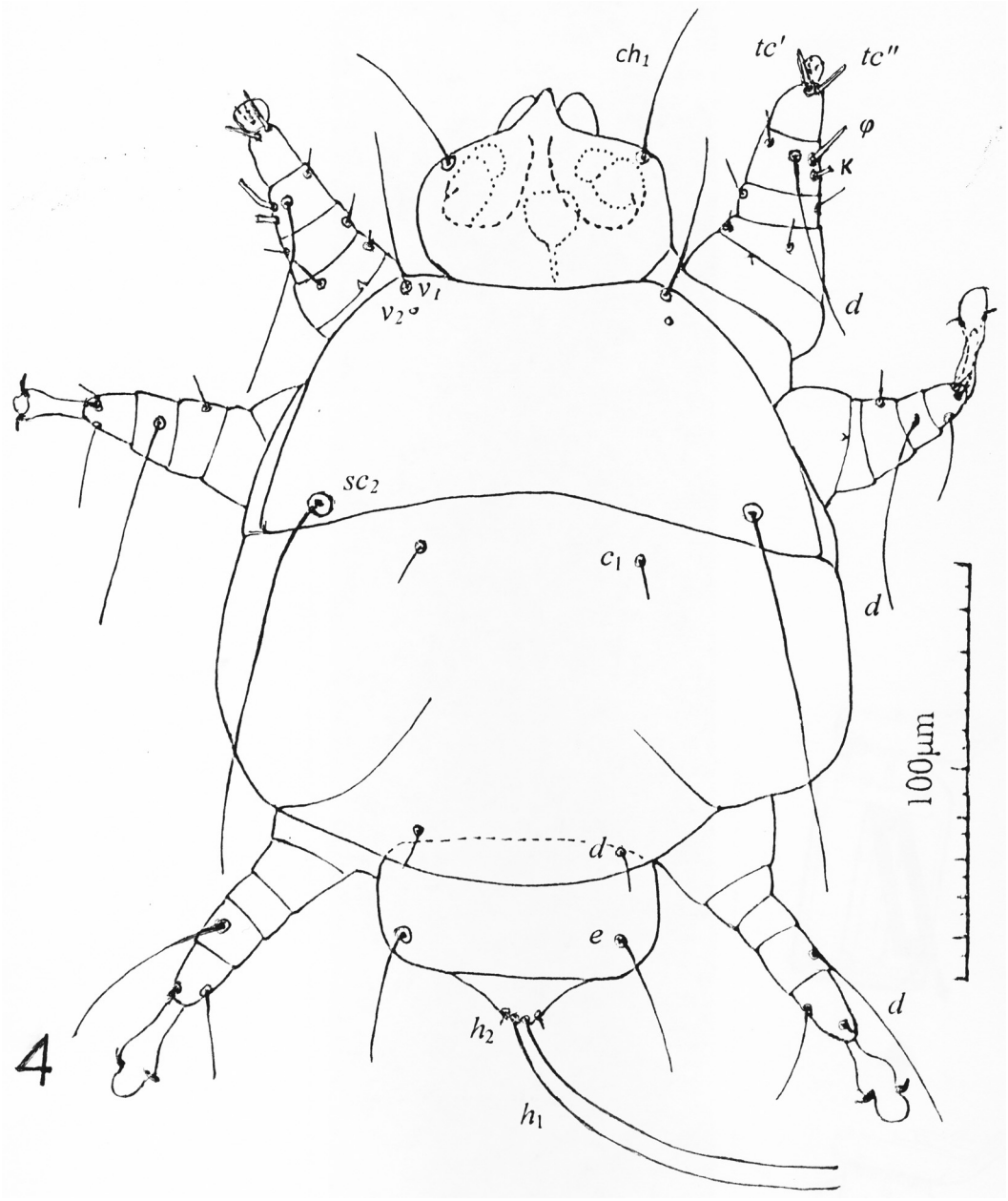

FIGURE 4. *Simalurapolipus hiraii* Kurosa and Husband **gen. nov.**, **sp. nov.,** larval female, dorsal view.

Legs. Setation for femur, genu, tibia, tarsus of legs I, II, III 2-2-7-7, 0-1-4-5, 0-0-4-5 (Table 2). Ambulacra I, II, III each with two claws. Femur I seta *d* 5–12, *l'* 2–3, genu I with setae *l'* and *l"* 5–8. Tibia I seta *d* 37–45, solenidion φ 10–15, lateral to seta *d*, seta *k* proximal to solenidion φ, thick 5. Tarsus I setae *tc'* 10, *tc"* 8, solenidion ω not evident. Genu II seta *l'* 8. Tibia II, III setae *d* 40–50. Tarsi II, III setae *tc'* spine-like, subterminal 3, setae *u'* spine-like, terminal, bifid 5–6, seta *pl"* 20–23.

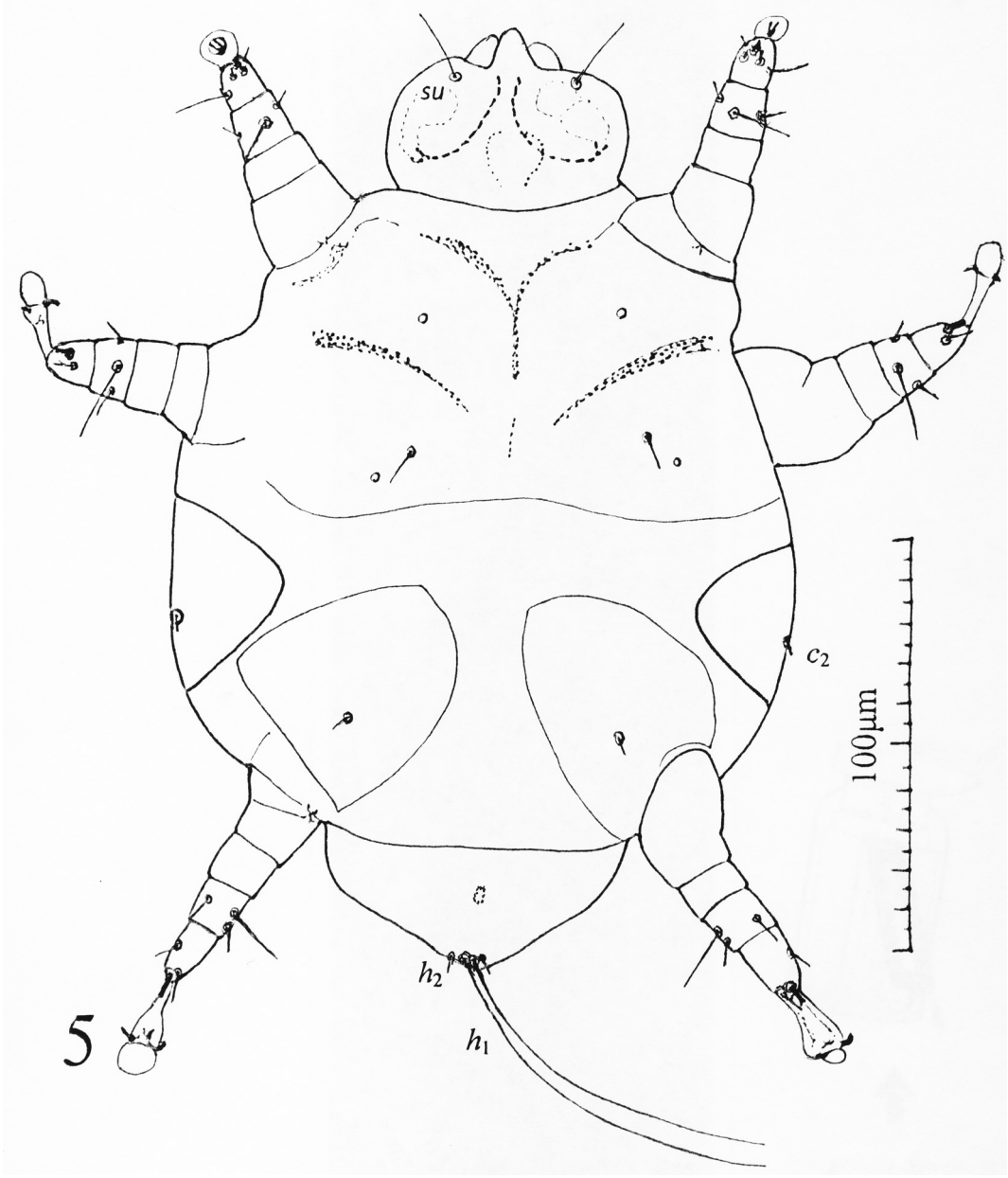

FIGURE 5. *Simalurapolipus hiraii* Kurosa and Husband **gen. nov.**, **sp. nov.,** larval female, ventral view.

Etymology. The names of the genus and species, *Simalurapolipus hiraii*, are derived from the genus of the host beetle, *Simalura* and the collector of the beetle hosts, Dr. Takeo Hirai.

Host. Specimens examined were found mainly on the underside of elytra, hind wings and abdominal dorsum of three specimens of *Simalura coerulea* (Lewis, 1894) (Coleoptera: Tenebrionidae), but not a few number (7, 12 and about 50, respectively) of immature (probably unfed) larval females were also found on the body surface (mainly on elytra) of the same beetles. According to Dr. Hirai, the collector of the host beetles, the above-mentioned larval female mites were discovered to creep about on the body surface of living beetles. Further, he noticed that the

larval female mites crept about on the body surface of the just killed, immobile beetles in an ethyl acetate gas bottle. A host beetle specimen (# 4938) was photographed before removing the podapolipid mites on it, but the photograph was lost.

TABLE 2. Leg setation for femur, genu, tibia and tarsus of larval female *Podapolipus khorasanicus Tenebrapolipus ceropriae, Tenebrapolipus imasakai* and *Simalurapolipus hiraii.* Tibia I solenidion φ is designated as lateral (L) or proximal (P) in reference to its position in relation to tibia I seta *d*.

	Leg I				Leg II				Leg III			
	F	G	Tibia	Tarsus	F	G	Tibia	Tarsus	F	G	Tibia	Tarsus
Podapolipus khorasanicus	3	1	6 (+1L)	7(+1)	2	1	4	5	0	1	4	5
Tenebrapolipus ceropriae	1	0	6 (+1P)	7	0	0	4	5	0	0	4	5
Tenebrapolipus imasakai	1	0	6 (+1P)	7	0	0	4	5	0	0	4	5
Simalurapolipus hiraii	2	2	6 (+1L)	7	0	1	4	5	0	0	4	5

Type material. Holotype, adult female (4940-8) and allotype male (4939-12) from *Simalura coerulea* (Lewis) (Coleoptera: Tenebrionidae), Hirayama, Aoi-ku, Shizuoka-shi, Shizuoka Prefecture, Japan, 25-VI-2012, collected by Takeo Hirai. Deposited in the collection of the National Museum of Nature and Science, Tsukuba (NSMT), Tsukuba 305-0005, Japan. Paratypes, seven adult females, 11 males and 19 larval females with same data as allotype from beetle #4939; eight adult females, five males and 26 larval females with same data as holotype from beetle #4940. Four adult females, eight males and 12 larval females are deposited in the Acarology Collection of Adrian College. The remaining paratypes are currently in the Kurosa Collection, Nishi-Ikebukuro 5-21-15, Tokyo 171-0021, Japan, and will be deposited in NSMT later.

In addition, 17 adult females, eight males and about 90 larval females from beetle #4938 with same data as 4939 and 4940 but 10-VIII-2012 were studied in temporary preparations; they are not designated as types.

The host beetle (Kurosa #4940) is kept in NSMT

Discussion

Of 31 genera of Podapolipidae, those genera with males with the apex of the genital capsule extending at least to the level of prodorsal setae v_1 are: *Cydnipolipus, Locustacarus, Podapolipus, Rhynchopolipus, Simalurapolipus and Tenebrapolipus*. Males of *Rhynchopolipus* and *Locustacarus* have genital capsules which extend over the gnathosoma. The genital capsules of males of *Podapolipus* extend to or over the base of the gnathosoma and emerge from under the prodorsal plate in a majority of species. The genital capsules of males of *Cydnipolipus* extend over the prodorsal plate and terminate at the base of the gnathosoma.

Males of *Tenebrapolipus* and *Simalurapolipus* possess genital capsules that extend over the prodorsal plate to the level of prodorsal setae v_1.

Eleven *Podapolipus* species, two *Tenebrapolipus* species and one species of *Simalurapolipus* are subelytral and abdominal parasites of tenebrionid beetles. Species of *Podapolipus* that parasitize tenebrionid beetles occur in Africa, North and South America, Australia, Asia and Europe (Hajiqanbar, 2013). *Tenebrapolipus ceropriae, T. imasakai* (Kurosa and Husband, 2001) and *Simalurapolipus hiraii* occur in Japan.

Other than *Tenebrapolipus ceropriae* and *T. imasakai*, there are no species of Podapolipidae with adult females with two pairs of legs that include males and larval instars with one seta on femur I and no setae on femora II, III, genua I, II, III and no setae h_2 of larval female instars. Data for leg setation for Podapolipidae with adult females with two pairs of legs was summarized in Table 1 of Kurosa and Husband (2001).

The genus *Tetrapolipus* (parasites of Cerambycidae) has species with larval females with two setae on femur and genu I and one seta on genu II. This is similar to the pattern for *Simalurapolipus hiraii* described herein. Male *Tetrapolipus* species have short genital capsules that do not extend to the level of prodorsal setae v_2 or sc_1. One additional species, *Stigmacarus stantoni* Husband 1986, (parasite of Curculionidae) has males with two femur I and genu I setae but lacks setae on genu II. Males of *Stigmacarus* possess prodorsal setae v_2 and sc_1 and pointed genital capsules that extend slightly beyond the level of setae sc_2 of the prodorsal plate.

Characters of adult female *S. hiraii* that may be considered plesiomorphic are: short but more prominent legs II than for female *T. ceropriae*, and presence of idiosomal plates C, D and EF. Adult females of both *T. ceropriae* and *S. hiraii* lack femur I setae *l'* (synapomorphies).

The adult female instar of *T. imasakai* has not been collected.

The two species of *Tenebrapolipus* have males with synapomorphies: v_2, c_1, *d* vestigial and setae sc_1 and tarsi I solenidion ω absent. Because of its proximal position in respect to tibia I seta *d* and thick blunt shape, we consider the single seta remaining on the posterolateral border of tibia I of male instars to be solenidion φ. The basal position for solenidion φ of tibia I in males of *Tenebrapolipus* and *Simalurapolipus* and lack of tarsus I solenidia ω in both males and larval females are considered synapomorphies. The widths of genital capsules over the prodorsal plates of the two species of *Tenebrapolipus* at the level of setae sc_2 are at least as broad as 1/3 the distance of sc_2–sc_2. The lengths of genital capsules of males of *Tenebrapolipus* and *Simalurapolipus* are nearly as long as the length of the prodorsal plate (synapomorphies). Male *S. hiraii* have tibiae II, III setae *v"* filiform (plesiomorphy) in contrast to these setae thickened or spine-like (apomorphy) for male *T. ceropriae* and *T. imasakai*. Conspicuous ambulacral claws II, III are present in males of *Simalurapolipus* and *Tenebrapolipus* (plesiomorphy).

Larval female instars of *Simalurapolipus* and *Tenebrapolipus* share lack of prodorsal setae sc_1 and possess vestigial setae 1*a*, 2*b* and prodorsal setae v_2 (synapomorphies). Tibia I solenidia φ are proximal to tibia setae *d* in *T. ceropriae* (apomorphy) but lateral to setae *d* in *T. imasakai* and *S. hiraii* (plesiomorphy). Solenidia φ are at least as long as ½ the width of the base of tarsi I (apomorphies) for *Simalurapolipus* and *Tenebrapolipus*. Larval female *S. hiraii* have setae h_2 (plesiomorphy) in contrast to larval *T. ceropriae* and *T. imasakai* without setae h_2 (apomorphy). Larval female *S. hiraii* have femur I setae *l'*, genu I setae *l'*, *l"* and genu II seta *l'* (plesiomorphy). Conspicuous ambulacral claws II, III are present in *Simalurapolipus* and *Tenebrapolipus*. Characters not evaluated for apomorphic or plesiomorphic status are: larval females of *T. ceropriae* and *S. hiraii* with setae v_1 as long as the length of gnathosoma in contrast to near 1/2 length of gnathosoma for *T. imasakai* and setae *e* longer than length of plate EF for *S. hiraii* in contrast to near 1/2 length of plate EF for *T. imasakai* and less than 1/4 length of plate EF for *T. ceropriae*. Femur I seta *d* does not extend to the base of tibia I for *S. hiraii* in contrast to extending nearly to the base of tarsi I for *T. ceropriae* and *T. imasakai*.

With two species of the genus *Tenebrapolipus* and one species of *Simalurapolipus* described and with characteristic plesiomorphic and apomorphic characters for each species, it is difficult to draw conclusions about relationships among podapolipid parasites of Tenebrionidae at this time. Studies of the relationships among podapolipid parasites of the family Carabidae by Regenfuss (1967, 1974) and others later suggest there is much to be learned. A small fraction of the thousands

of species of beetles in the family Tenebrionidae have been examined for podapolipid mites. We anticipate many discoveries and advances in the knowledge of podapolipid parasites of this family.

Acknowledgments

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