Acta Arachnologica, 69 (1): 37–41, June 20, 2020

A new species of the genus *Agorius* (Araneae: Salticidae) from Sarawak, Borneo

Takeshi Yamasaki[1, 2*], Yoshiaki Hashimoto[1], Tomoji Endo[3], Fujio Hyodo[4], Takao Itioka[5] & Paulus Meleng[6]

[1] *Museum of Nature and Human Activities, Hyogo, University of Hyogo, 6 Yayoigaoka, Sanda-shi, 669-1546 Japan.*
[2] *Makino Herbarium, Tokyo Metropolitan University, 1-1 Minami-osawa, Hachioji-shi, 192-0397 Japan.*
[3]*School of Human Sciences, Kobe College, Okadayama 4-1, Nishinomiya, Hyogo, 662-8505, Japan.*
[4]*Research Core for Interdisciplinary Sciences, Okayama University, 3-1-1, Tsushimanaka, Okayama, 700-8530, Japan.*
[5]*Graduate School of Human and Environmental Studies, Kyoto University, Yoshida-nihonmatsu-cho, Sakyo-ku, Kyoto, 606-8501 Japan.*
[6]*Research Development and Innovation Division, Forest Department Sarawak, Kuching, KM 10, Jalan Datuk Amar Stephen Kalong Ningkan, 93250 Kuching, Sarawak, Malaysia.*
*E-mail: k0468874@kadai.jp, * Corresponding author*

Abstract — *Agorius hyodoi* sp. nov. (Araneae: Salticidae) is described here on the basis of male and female specimens collected from the Lambir Hills National Park, Sarawak, Borneo. The conspecificity of the male and female was confirmed by DNA barcoding.

Key words —ant mimicry, jumping spiders, mitochondrial COI, taxonomy

Introduction

The genus *Agorius* Thorell 1877 comprises of twelve named species, which are distributed mainly in Southeast Asia. With their constricted abdomen and ant-like behavior (antennae-like movement of leg I) they are considered to be an example of ant-mimicry (Murphy & Murphy 2000; Maddison 2015). Even though a study of the evolution of this ant-mimic genus would be of much interest, such a study would be difficult. The fact that seven *Agorius* species have each been described on the basis only of one sex implies the imperfect situation of the taxonomy of this genus. At the higher taxonomic level, *Agorius* is part of the tribe Agoriini Simon, 1901, together with the genus *Synagelides* Strand, 1906 (Maddison et al. 2014; Maddison 2015).

From 2004 to 2014, we investigated the relationship between ant-mimicking spiders and ants in several sites in Borneo, and discovered an undescribed *Agorius* species. In Borneo, two *Agorius* species have been recorded: *A. borneensis* Edmund & Prószyński 2001, and *A. saaristoi* Prószyński 2009. These two species are known only on the basis of male specimens. The undescribed species from Lambir Hills National Park differs from the two Bornean species in several morphological characters and we therefore describe the species here, on the basis of both male and female specimens.

Materials and Methods

Spiders were collected from low vegetation and the forest floor in the Lambir Hills National Park, Sarawak, Borneo. For specimens collected in 2014, right legs were removed from the body and preserved in 99 % ethanol for DNA analysis, and the remaining body in 75 % ethanol for morphological studies. The specimens were examined using a Nikon SMZ1270 stereoscope. Female genitalia were removed from the bodies, and cleared by immersing 10 % KOH solution for 12–24 hours. Cleared genitalia were observed in glycerin on temporary cavity slides using a Nikon Eclipse E600. Images were captured using a Canon 60D digital camera attached to a Nikon SMZ1270 or Nikon Eclipse E600, and focal planes of single image series were combined using Helicon focus 4.2.9. Habitus images of living specimens were obtained using a Canon 60D digital camera with a macro lens (Canon MP-E 65mm F2.8 1-5x).

Specimens used for sequencing analysis are shown in Table 1. For the methodology of molecular analysis, we followed Yamasaki et al. (2018), with a primer combination of C1-J-1718 (Simon et al. 1994) and C1-N-2776 (Hedin & Maddison 2001). The assembled sequences were aligned using MUSCLE (Edgar 2004) built in MEGA 7.0.26 (Kumar et al. 2016). The genetic divergence between specimens in the K2P model (Kimura 1980) was calculated by the pairwise comparison method. The mitochondrial COI sequences obtained in the present study are deposited in the DNA Data Bank of Japan (DDBJ), and accordingly will also be available through GenBank.

All measurements are provided in millimeters. Descriptions of coloration are based on specimens preserved in 75 % ethanol. The abbreviations used for morphological descriptions are as follows; ALE, anterior lateral eye; AME,

anterior median eye; PLE, posterior lateral eye; PME, posterior median eye; pv, pro-ventral; RTA, retrolateral tibial apophysis; rv, retro-ventral. The holotype and one paratype are deposited at Forest Research Centre, Sarawak, Malaysia (FRSC), and other paratypes at the Museum of Nature and Human Activities, Hyogo, Japan (HNHAH). The specimen codes beginning from "LAg" and "LMy" have been inserted and used by the authors to assist them with the ecological studies, they have not been provided by the depositories.

The DNA analysis and descriptions have been carried out by the first author; all authors participated in obtaining the specimens.

Results

We obtained 954 bp fragments of the mitochondrial COI region from each specimen. There was no genetic divergence between a male (LAg20140331-E3: designated as the holotype) and a female (LAg20140331-E5: designated as one of paratypes).

Taxonomy

Genus *Agorius* Thorell 1877
Agorius hyodoi Yamasaki sp. nov.
(Figs. 1A–B, 2A–F, 3A–H)

Type material. Holotype male (DDBJ Accession No.: LC431808; LAg20140331-E3; FRCS), Sungai Liku, Lambir Hills National Park, Sarawak, Borneo, 31.III.2014, T. Endo leg.

Paratypes: 1 female (DDBJ Accession No.: LC431809; LAg20140331-E5; FRCS), same data as holotype; 1 male (LAg20070822-AMS1), 22.VIII.2007, Y. Hashimoto & T. Endo leg.; 1 female (LAg20071221-I3), 21.XII.2007, T. Itioka leg.; 1 male (LAg20121207-Kata), around Tamiji house, 7.XII.2012, M. Katayama leg.; 1 male (LAg20121203-AMS2), 3.XII.2012, Y. Hashimoto & T. Endo leg.; 1 male (LAg20121018-Kata), around Tamiji house, 18.X.2012, M. Katayama leg.; 1 male (LAg20140328-Ag2) and 1 female (LAg20140328-Ag1), Sungai Liku, 28.III.2014, T. Yamasaki leg.; 1 male (LMy20140329-Ag3), same loc., 29.III.2014, T. Yamasaki leg.; 1 male (LAg20140331-TY2), same data as in holotype, T. Yamasaki leg.; 1 female (LAg20140331-E4), same data as in holotype.

Etymology. The specific name is given in honor of Dr. Fujio Hyodo (Okayama University, Japan), who, through his stable isotope analyses, has contributed to our understanding of the ecology of ant-mimicry.

Diagnosis. The male palpal structure of *A. hyodoi* sp. nov. is similar to those of *A. borneensis*, *A. saaristoi* and *A. tortilis* Cao & Li in Cao, Li and Żabka 2016. However, *A. hyodoi* sp. nov. can be distinguished from *A. borneensis* and *A. saaritoi* by the shape of the RTA: the RTA apex in *A. borneensis* and *A. saaristoi* is slightly bifurcated, whereas the RTA apex of *A. hyodoi* sp. nov. is without a bifurcation (Figs. 2E–F). *A. hyodo*i sp. nov. can be distinguished from *A. tortilis* by the degree of coiling of the embolus: in *A. tortilis* the embolic coiling is tighter than in *A. hyodoi* sp. nov. In the female, *A. hyodoi* sp. nov. can be distinguished from other *Agorius* species by the unique copulatory atrium: this copulatory atrium is longitudinally slender, with pear-shaped margin (Figs. 3D–E).

Measurements (Male/Female). Total length 7.9–8.5/ 7.3–9.1. Carapace length 2.80–2.83/ 3.05–3.35, width 1.68–1.75/ 1.90–1.97. Width of eye row I 1.80–1.93/ 1.98–2.05; II 1.35–1.37/ 1.48–1.55; III 1.73–1.75/ 1.93–2.03. ALE–PLE 1.40–1.45/ 1.53–1.60; ALE–PME 0.65–0.70/ 0.73. Eye size: AME 0.58–0.60/ 0.65–0.73; ALE 0.35–0.37/ 0.40; PME 0.08–0.12/ 0.09–0.10; PLE 0.33–0.35/ 0.36–0.38. Abdomen 5.2–5.5/ 4.4–5.6.

Male (Figs. 1A, 2A–F). Carapace almost parallel-sided. Chelicera small, with one prolateral and one retrolateral tooth on the fang furrow. Abdomen longer than carapace, constricted at middle part; entire surface, except for posterior end, sclerotized.

Male palp (Figs. 2D–F). Embolus long, coiled in a horizonal plane; a sclerotised and laterally flattened structure on the anterior bulbus (Fig. 2D). In ventral view, the prolateral corner of the posterior part of bulbus well-developed, projecting; retrolateral surface of bulbus weakly sclerotized. (Fig. 2D). Anterior margin of tibia well-developed and, in retrolateral view, strongly projecting (Fig. 2F). RTA long, thick, curved, and with a very slender structure visible within (Figs. 2D–F). In dorsal view, mid-posterior part of cymbium bears a distinct projection (Figs. 2E–F).

Leg macrosetae. Tibia I pv 5, rv 5; metatarsus I pv 2, rv 0. No macrosetae on the other segments.

Coloration and setation (Figs. 2A–C). Carapace amber color, sparsely covered with fine setae; surroundings of eyes black, with sparse long setae. Chelicera, labium, maxilla yellowish brown. Sternum light amber color. Legs amber color to yellowish brown. Abdomen dark brown, covered with long setae. Coloration of living specimen shown in Fig. 1A.

Female (Figs. 1B, 3A–H). Carapace almost same as in male (Figs. 3A–B). Chelicera small, with two prolateral and one retrolateral teeth on fang furrow. Abdomen elongated oval, not sclerotized (Figs. 3A–B).

Female genitalia (Figs. 3D–H). Copulatory atrium slender, longitudinally extending, with pear-shaped margin; copulatory duct extending laterally from atrium, visible through sclerotized surface. Copulatory duct connected to oval spermatheca.

Leg macrosetae. Tibia I pv 5, rv 5; metatarsus I pv 2, rv 0. No macrosetae on the other segments.

Coloration and setation (Figs. A–C). Carapace almost same as in male; posterior triangular area covered with short white setae. Chelicera, maxilla, labium and sternum almost same as in male. Abdomen grey, covered with black setae. Coloration in living condition shown in Fig. 1B.

Distribution. Borneo: the species is known only from the forest floor in the Lambir Hills National Park, Sarawak.

Remarks. Conspecificity of the male and female of *Agorius hyodoi* sp. nov. was confirmed by DNA anal-

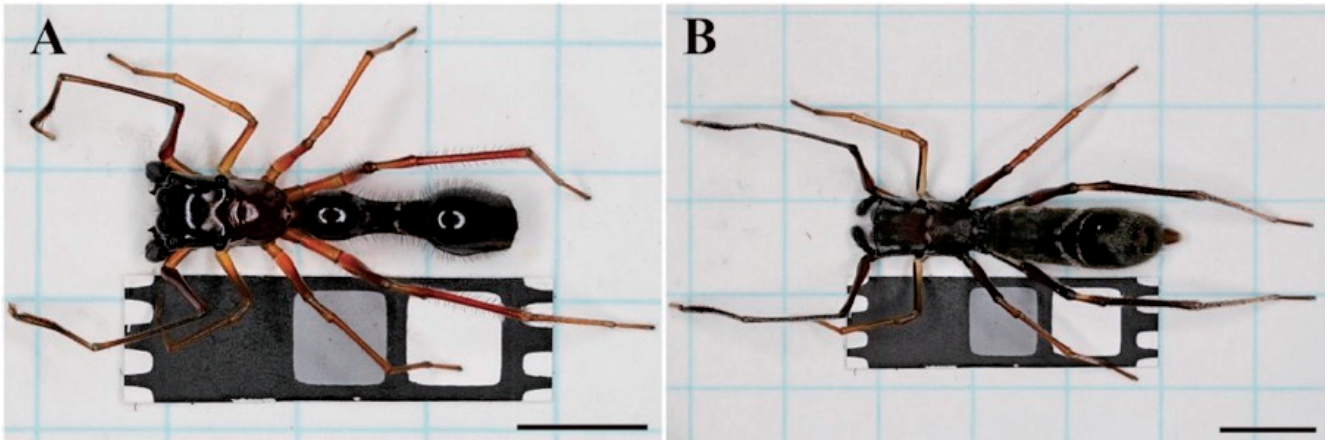

Fig. 1. *Agorius hyodoi* **sp. nov.** A, paratype male (LMy20140329-Ag3), dorsal view; B, paratype female (LAg20140328-Ag1), dorsal view. Scales A–B = 4 mm.

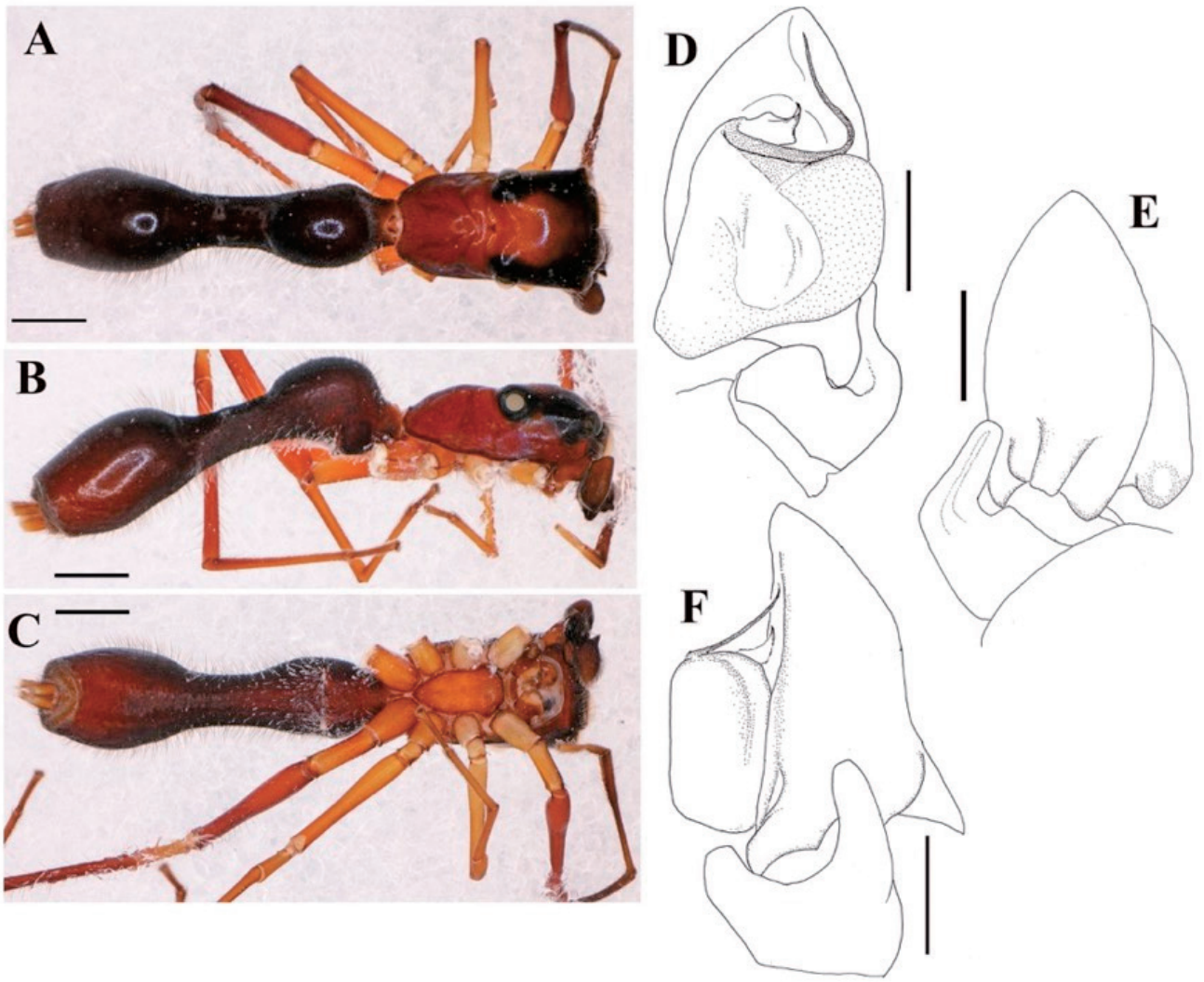

Fig. 2. *Agorius hyodoi* sp. nov., holotype male (LAg20140331-E3), Sarawak, Borneo. A, habitus, dorsal view; B, same, lateral view; C, same, ventral view; D, left palp, ventral view; E, same, dorsal view; F, same, retrolateral view. Scales A–C = 1 mm; D–F = 0.25 mm.

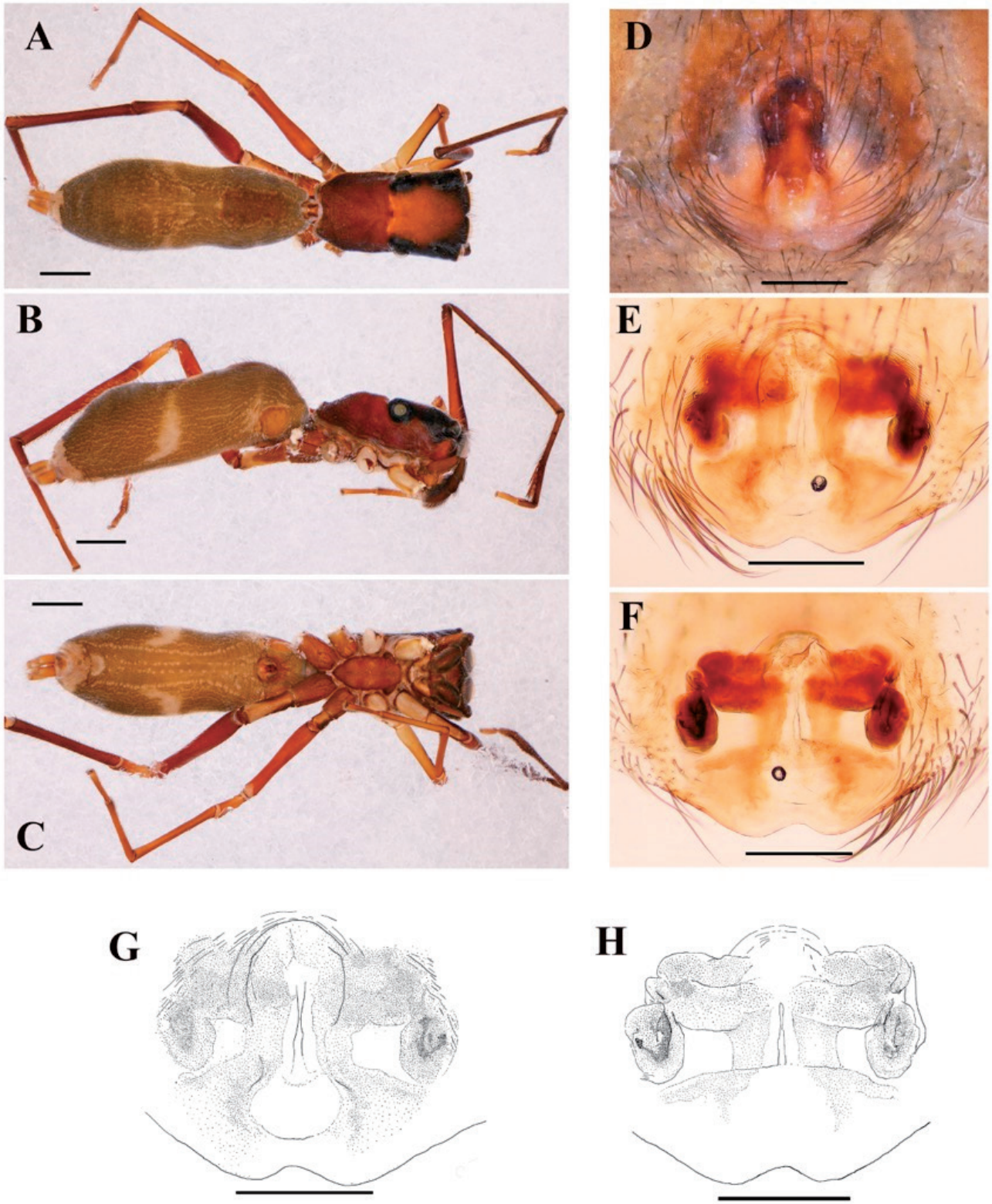

Fig. 3. *Agorius hyodoi* sp. nov., female paratype (LAg20140331-E5), Sarawak, Borneo. A, habitus, dorsal view; B, same, lateral view; C, same, ventral view; D, epigyne, ventral view; E, G, copulatory organs, ventral view; F, F, copulatory organs, dorsal view. Scales A–C = 1 mm; D–H = 0.2 mm.

ysis. There was no genetic difference between a male (holotype, LAg20140331-E3) and a female (paratype, LAg20140331-E5).

On the forest floor, *A. hyodoi* sp. nov. occurs sympatrically with ants belonging to the genus *Leptogenys* Roger, whose members are suitable for models in Batesian mimicry because they have a strong and painful sting. While *A. hyodoi* sp. nov. is moving around forest floor, their appearance is very similar to *Leptogenys* ants. Some spider species mimic ants in morphology or in chemical components on the body to feed on ants (Cushing 2012). Hyodo et al. (2018) shows a result that $\delta^{15}N$ values of *A. hyodoi* sp. nov. (as *Agorius* sp. 5) is lower than that of sympatric *Leptogenys* species, and it means *A. hyodoi* sp. nov. does not feed on *Leptogenys* ants.

Acknowledgements

Our study was conducted in accordance with the Memoranda of Understanding signed between the Sarawak Forestry Corporation (SFC; Kuching, Malaysia) and the Japan Research Consortium for Tropical Forests in Sarawak (JRCTS; Sendai, Japan), and between the Sarawak Forest Department (SFD; Kuching, Malaysia) and JRCTS. We would like to thank Noriaki Murakami and Katsuyuki Eguchi (Tokyo Metropolitan University, Japan) for offering laboratory facilities, and David J. Court (Lee Kong Chian Natural History Museum, Singapore) for checking this manuscript. We also thank the anonymous reviewers for their comments on the manuscript. The study was supported by JSPS KAKENHI Grant Number 16657028, 19570094, 24570109, 14J04245 and Sumitomo Foundation Grant for Basic Science Research Projects No. 130648.

References

Bösenberg, W. & Strand, E. 1906. Japanische Spinnen. Abh. Senckenb. Naturforsch. Ges., 30: 93–422.

Cao, Q., Li, S. Q. & Żabka, M. 2016. The jumping spiders from Xishuangbanna, Yunnan, China (Araneae: Salticidae). ZooKeys, 630: 43–104.

Cushing, P. E. 2012. Spider-ant associations: an updated review of myrmecomorphy, myrmecophily, and myrmecophagy in spiders. Psyche: A Journal of Entomology, 2012: 1–23.

Edmunds, M. & Prószyński, J. 2001. New species of Malaysian *Agorius* and *Sobasina* (Araneae: Salticidae). Bull. Br. Arachnol. Soc., 12: 139–143.

Edgar, R. C. 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Res., 32: 1792–1797.

Hedin, M. C. & Maddison, W. P. 2001. A combined molecular approach to phylogeny of the jumping spider subfamily Dendryphantinae (Araneae: Salticidae). Mol. Phylogenet. Evol., 18: 386–403.

Hyodo, F., Yamasaki, T., Iwasa, T., Itioka, T., Endo, T. & Hashimoto, Y. 2018. Stable isotope analysis reveals the importance of plant-based diets for tropical ant-mimicking spiders. Entomol. Sci., 21: 461–468.

Kimura, M. 1980. A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. J. Mol. Evol., 16: 111–120.

Kumar, S., Stecher, G. & Tamura, K. 2016. MEGA 7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Mol. Biol. Evol., 33: 1870–1874.

Maddison, W. P. 2015. A phylogenetic classification of jumping spiders (Araneae: Salticidae). J. Arachnol., 43: 231–292.

Maddison, W. P., Li, D., Bodner, M., Zhang, J., Xu, X., Liu, Q. & Liu, F. 2014. The deep phylogeny of jumping spiders (Araneae, Salticidae). ZooKeys, 440: 57–87.

Murphy, F. & Murphy, J. 2000. An introduction to the spiders of South East Asia with notes on all the genera. Malaysian Nature Society Kuala Lumpur, 388 pp.

Prószyński, J. 2009. Comments on the Oriental genera *Agorius* and *Synagelides* (Araneae: Salticidae). Pp. 281–295. *In*: Makarov, S. E. & R. N. Dimitrijević (Eds.) Advances in Arachnology and Developmental Biology. Institute of Zoology, Bulgarian Academy of Sciences Monographs 12.

Simon, C., Frati, F., Beckenbach, A., Crespi, B., Liu, H. & Flook, P. 1994. Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Ann. Entomol. Soc. Am., 87: 651–701.

Thorell, T. 1877. Studi sui Ragni Malesi e Papuani. I. Ragni di Selebes raccolti nel 1874 dal Dott. O. Beccari. Ann. Mus. Stor. Nat., Genova, 10: 341–637.

Yamasaki, T., Hashimoto, Y., Endo, T., Hyodo, F., Itioka T. & Meleng, P. 2018. New species of the ant-mimicking jumping spiders, the genus *Myrmarachne* MacLeay, 1839 (Araneae: Salticidae) from Sarawak, Borneo. Zootaxa, 4521: 335–356.

Received August 31, 2019 / Accepted April 24, 2020