

A taxonomic review of the genus *Acteniceromorphus* Kishii, 1955 (Coleoptera; Elateridae) in Korea

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Abstract

The genus *Acteniceromorphus* is taxonomically reviewed for the first time in Korea. From the previously recorded three species, two species, *A. selectus* (Candèze, 1894) and *A. fulvipennis* (Lewis, 1894) are confirmed as misidentification of species which are endemic to Japan. Another species, *A. chlamydatus* (Lewis, 1894) is unavailable any Korean specimens. Additionally, we found *A. ferrugineipennis* (Candèze, 1879) as new to Korea. We also provide a comparison of DNA barcoding for two species previously misidentified and the newly recorded species, except *A. chlamydatus*. DNA barcoding result shows that each species is clearly delimited at species-level from each other by large interspecific genetic distance over 7.2%.

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Introduction

The members belonging to the genus *Acteniceromorphus* Kishii, 1955 have been known 21 species in the world (Tarnawski, 2000). Taxonomically, Kishii (1955) established this genus based on the genotype, *Corymbites selectus* Candèze, 1865 in Japan. At that time, he transferred six Japanese species among three genera (*Corymbites*, *Ctenicera*, *Actenicerus*) into *Acteniceromorphus* and also regarded *Corymbites* (*Selatosomus*) *tengu* Miwa, 1934 with the member of same genus in 1956. After Kishii's frame works, the congeners were additionally describe, eight species from Japan (Kishii 1966, 1982, 1986, 2004a; Ôhira 1963, 1970, 1973, 1996), two species from Nepal (Ôhira and Becker 1973).

Gurjeva (1986) treated the genus as a subgenus of *Liotrichus* Kiesenwetter, 1858, with describing two species from Kyrgyzstan and Afghanistan. Gurjeva (1989) also transferred four Nearctic species into *Acteniceromorphus* treated as subgenus. However,

the consideration for taxonomic rank of *Acteniceromorphus* has been conflicted to be treated at a subgeneric level (e.g., Tarnawski, 2000) or a valid generic level (e.g., Kishii, 1999). Despite the many controversies, any phylogenetic examination of *Acteniceromorphus* has been not attempted. Therefore, we followed the treatment of independent generic status of *Acteniceromorphus* according to Kishii (1999) in this study.

In Korea, three species, *A. selectus*, *A. fulvipennis* and *A. chlamydatus*, have been reported through previous faunistic studies (Kim and Kim, 1972; Kim, 1981; Kim, 1984; Lee *et al.*, 1985; Paik *et al.*, 1993). But there were providing only species lists, no any taxonomic works and considerations despite all of the recorded species are known as the Japanese endemic species. This study therefore was carried out a taxonomic review on the species of *Acteniceromorphus* with DNA barcoding to reveal more reliable species diversity in Korea and to assist in the rapid species identification in the further.

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Table 1. List of 18 COI sequences of four species belonging to *Acteniceromorphus* and *Liothricus*.

No. of indcs.	Genus and species	Voucher no.	Locality	Date collected	GenBank Accession No.	References
1	<i>Acteniceromorphus selectus</i> (Candèze, 1865)	2138	Japan: Hokkaido, Jozankei Nature Village 380m	30. VI. 2009	KJ433132	Han et al. (2015, unpublished)
2	<i>A. selectus</i> (Candèze, 1865)	2139	Japan: Hokkaido, Jozankei Nature Village 380m	30. VI. 2009	KJ433133	Han et al. (2015, unpublished)
3	<i>A. selectus</i> (Candèze, 1865)	2141	Japan: Hokkaido, Okusawa, Suigenchi otaru 223m	1. VII. 2009	KJ433134	Han et al. (2015, unpublished)
4	<i>A. selectus</i> (Candèze, 1865)	2142	Japan: Hokkaido, Okusawa, Suigenchi otaru 223m	1. VII. 2009	KJ433135	Han et al. (2015, unpublished)
5	<i>A. selectus</i> (Candèze, 1865)	2143	Japan: Hokkaido, Okusawa, Suigenchi otaru 223m	1. VII. 2009	KJ433136	Han et al. (2015, unpublished)
6	<i>A. selectus</i> (Candèze, 1865)	2144	Japan: Hokkaido, Okusawa, Suigenchi otaru 223m	1. VII. 2009	KJ433137	Han et al. (2015, unpublished)
7	<i>A. selectus</i> (Candèze, 1865)	2145	Japan: Hokkaido, Okusawa, Suigenchi otaru 223m	1. VII. 2009	KJ433138	Han et al. (2015, unpublished)
8	<i>A. selectus</i> (Candèze, 1865)	2160	Japan: Hokkaido, Okusawa, Suigenchi otaru	1. VII. 2009	KJ433139	Han et al. (2015, unpublished)
9	<i>A. selectus</i> (Candèze, 1865)	–	Japan: Hokkaido, Kushiro, Lake Harutori	–	KM612288	Oba et al. (2015)
10	<i>A. ferrugineipennis</i> (Candèze, 1879)	885	Korea: GW, Injae, Temple Bukdaesa, Mt. Seolak	28. V. 2009	KF317226	Han et al. (2015, unpublished)
11	<i>A. ferrugineipennis</i> (Candèze, 1879)	2811	Korea: GW, Injae, Temple Bukdaesa	27. V. 2008	KJ433140	Han et al. (2015, unpublished)
12	<i>A. kurofunei</i> (Miwa, 1934)	–	Japan: Honshu, Nagano, Ina, Nishikomagatake	–	AB375511	Oba et al. (2008)
13	<i>A. kurofunei</i> (Miwa, 1934)	–	Japan: Tochigi, Nasushobara, Momura, Ohkawa rindo	–	KM612286	Oba et al. (2015)
14	<i>A. kurofunei</i> (Miwa, 1934)	–	Japan: Yamagata, Nishiokitama, Iide, Hirokawara	–	KM612285	Oba et al. (2015)
15	<i>A. kurofunei</i> (Miwa, 1934)	–	Japan: Nagano, Iida, Kami, Shirabiso-kogen	–	KM612284	Oba et al. (2015)
16	<i>A. kurofunei</i> (Miwa, 1934)	–	Japan: Ehime, Niihama, Mt. Besshi Dozangoe	–	KM612283	Oba et al. (2015)
17	<i>Liothricus affinis</i> (Paykull, 1800)*	–	Finland: Lapland, Regio kuusamoensis, Salla, Vaerioe	–	KJ966497	Pentinsaari et al. (2014)
18	<i>L. affinis</i> (Paykull, 1800)*	–	Finland: Lapponia inarensis, Inari, Ivalo	–	KJ963940	Pentinsaari et al. (2014)

Asterisks indicate outgroup taxa.

Materials and Methods

We collected specimens belonging to the genus *Acteniceromorphus* through field works in Korea since 2006 and surveyed the specimens used in the previous faunistic studies across visiting the related institutions such as Sungshin Women's University in Seoul, Jeju National University and Folklore & Natural Museum in Jeju (FNMJ) for 2009 and 2010. We also examined reference specimens of three Japanese species, *A. selectus*, *A. fulvipennis* and *A. chlamydatius*, which were offered from Prof. Jong Wok Lee, Yeongnam University, Daegu, Korea and Dr. Hitto Ôhira, Okazaki, Japan. We complied with the methods for morphological examination of specimens and DNA barcoding represented in Han *et al.* (2009, 2013). Especially, the analysis of DNA barcoding was performed to reconfirm reliable species identification or specific ranks within and between the examined morphospecies. We also used eight COI sequences of two species of *Acteniceromorphus* and a species of *Liotrichus*, as outgroup, extracted from GenBank (Oba *et al.*, 2015; Pentinsaari *et al.*, 2014). The used specimens in DNA barcoding and Accession numbers are given as Table 1.

Results

Taxonomic Account

Family Elateridae Leach, 1815

Subfamily Denticollinae Stein and J. Weise, 1877 (1856)

Tribe Ctenicerini Fleutiaux, 1936 (1863)

Genus *Acteniceromorphus* Kishii, 1955 뿔망아벌레속(신칭)

Acteniceromorphus Kishii, 1955: 20, 21. Type-species: *Corymbites selectus* Candèze, 1865: 53 (Japan); Kishii, 1987: 112; Kishii, 1999: 45.

Liotrichus (*Acteniceromorphus*): Gurjeva, 1989: 45; Cate, 2007: 177 (Catalogue).

Description. Body medium, weakly metallic luster; frontal carina distinct only on antennal sulci; antenna serrate from the 3rd antennomere; pronotum generally with a median longitudinal canalization, or rarely absent, lateral sides narrowly marginate (not flat), hind angles well developed, with a carina, rarely obsolescent, basal incisures of posterior margin distinct; pronotosternal sutures single, sometimes double like only at

base; hind angle of hypomeron elongate, posterior margin clearly and broadly emarginated near hind angle; prosternal process longitudinally depressed between procoxae, weakly bent behind procoxae, then nearly straightly extending posteriorly; inner sides of elytral sutures narrowly marginate; parameres of aedeagus simple at apexes (Kishii, 1955, 1987).

Description. Korea, Japan, the Russian Far East, Nepal, Afghanistan, Kyrgyzstan and N. America.

Key to species of the genus *Acteniceromorphus* in Korea

1. Body stout; 3rd antennomere about 2.0 times longer than 2nd; pronotum a little longer than wide; scutellum flat on disc (Korea and the Russian Far East).....*A. ferrugineipennis*
- Body slender, parallel sided; 3rd antennomere about 1.7 times longer than 2nd; pronotum clearly longer than wide; scutellum convex anteriorly (Japan, Korea (?)).....*A. chlamydatius*

Acteniceromorphus ferrugineipennis (Candèze, 1879)

붉은날개뿔망아벌레(신칭)

Corymbites ferrugineipennis Candèze, 1879: 281 (Amur).

Corymbites (*Haplotarsus*) *ferrugineipennis* (Candèze, 1879): Schenkling 1927: 382.

Corymbites patruus Heyden, 1884: 294.

Acteniceromorphus ferrugineipennis (Candèze, 1879): Gurjeva, 1982: 542.

Description. Male (no. 885; Fig. 1A) 12.0 mm long, 2.8 mm wide. Body cylindrical, weakly convex; color black, metallic lustrous, with elytra, apex of mandibles and legs reddish brown, except tarsomeres dusky brown; pubescence short, thin, erect or sub-recumbent, white to pale yellow hairs wholly covered. Head weakly depressed longitudinally between eyes, downwardly declined from eyes to anterior; frontal margin round, depressed at middle, carina complete across front, but obsolete at middle, bifurcate before eyes; punctures small, umbilicate, very dense; intervals reticulate, extremely narrower than diameter of punctures; surface coarse; pubescence short, erect, a little longer than those on pronotum; eyes prominent, with ocelli weakly convex; frontal groove excavated near antennal sulci, then produced forwards, with large umbilicate punctures, narrow medially in anterior view. Antennae rather elongate, from a half of 10th antennomere exceeding beyond

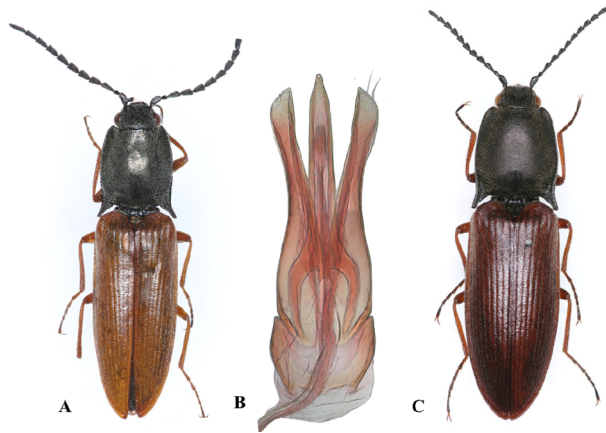


Fig. 1. Adults of *Acteniceromorphus ferrugineipennis* in Korea. A: male, B: aedeagus, C: female.

hind angles of pronotum, serrated from 4th to 10th; 1st sub-cylindrical, anterior margin arched; 2nd smallest, obconic, as long as wide; 3rd triangular, 2.0 times as long as wide, 20. times as long as 2nd, 1.5 times as long as 4th; from 4th to 10th each antennomere becoming gradually longer, not narrower to apical; 11th cylindrical, longest. Pronotum quadrate, longer than wide, widest at apex of hind angles, with shallow median longitudinal furrow narrowly; punctures umbilicate, circular, small, very dense wholly, intervals reticulate wholly; surface rugose; anterior margin truncate; anterior angles simple, slightly prominent forwards, antero-lateral margin smoothly curved inwards; lateral sides well marginate narrowly; lateral margins entirely, distinctly carinate, wholly visible in dorsal view, weakly arched, clearly sinuate at base of hind angles; hind angles elongate, diverged latero-posteriorly, slightly bent downwardly in lateral view, apex sharply pointed, with clearly ridged carina; posterior margin with distinct incisures near base of hind angles, with basal notch in front of scutellum. Prosternum convex, narrowest at base, with punctures umbilicate, large, a little smaller than those on pronotum, anterior collar elongate, round, well carinate, slightly bent ventrally, surface smooth, with punctures umbilicate, exceeding to apex of hypomera; posterior process rather cylindrical, narrow, coarse with a little smaller punctures than those of prosternum between procoxal cavities, bent behind, then straightly extending to apex, posterior apex roundly pointed, with an obvious longitudinal furrow extending near apex on each lateral sides in lateral view; procoxal cavities widely open posteriorly; pronotosternal sutures straight, gradually broad to anterior, double at base only, anterior portion simple,

closed; hypomeron with umbilicate, smaller, denser than those on pronotum; posterior margin emarginated near procoxal cavities, then nearly straight medially, then clearly and deeply emarginated near hind angles, hind angles slender, truncate at apices. Scutellum tongue shaped, elongate, narrow 1.3 times as long as wide, widest at anterior margin; anterior margin indistinctly carinate; lateral sides gradually convergent posteriorly; posterior margin round; dorsal surface weakly convex at anterior portion, coarse, puncture small, umbilicate, very dense, with dense hairs. Mesosternum with transverse carinae at each anterior sides, groove large, longitudinal quadrate. Mesocoxal cavities narrowly connected with mesepimeron and broadly touched with mesepisternum, interval between mesocoxae broad. Metasternum convex; median longitudinal suture fine, entire, carinate; hind coxal plates widest at insertion of trochanter, outer-margin slightly convergent to outsides. Legs slender; hind femur sub-equal in length to hind tibia; hind tarsus a little shorter than hind tibiae; hind tarsomeres simple, gradually decreased to 4th; 1st to 5th moderately pilose ventrally; claws simple. Elytra cylindrical, 1.5 times as long as combined length of head and pronotum, 2.25 times as long as wide, flat above, as wide as width of between apices of hind angle of pronotum, widest at two thirds; anterior edge convex; sutural line flat; striae distinctly punctate as circular, finely furrowed; strial intervals convex, smooth, with minute punctures. Abdomen each lateral margin finely carinate, lacking crenulate; sternite 7, semi-elliptic, 1.3 times as wide as long. Aedeagus (no. 885; Fig. 1B) slender, elongate, 2.93 times as long as wide; median lobe sub-cylindrical, gradually convergent to apex, then abruptly narrow at apex, apex roundly pointed, a little longer than parameres; parameres slender, simply pointed at apex, apex portions slightly curved inwards, sharply pointed, with two visible setae, lateral outer-margins sinuate from posterior two thirds, inner-margins slightly arched; basal strut elongate, reaching median of basal piece; basal piece quadrate, short, widest at anterior third, 1.5 times as long as wide, 0.22 times of length of aedeagus. Female (Fig. 1C). Body size 11.5~16.0 mm long, 2.4~3.5 mm wide, generally larger, stouter than male; antennae clearly shorter, barely reaching before base of hind angles, more weakly serrate, 11th antennomere, shorter, oval shaped, not cylindrical, a little longer than 3rd; lateral margins of pronotum more distinctly arched and stout than male. Reproductive organs: ovipositor short, triangular, cylindrically elongate from middle

to apex, with visible setae, apices with short, stout styli; vagina elongate; uterus enlarged at anterior, with weakly developed ballon-like colleterial glands bearing from base, with barely visible sclerotised bands; bursal copulatrix ballon-liked, smaller than uterus, longer than wide, distinctly wrinkled at base, a accessory gland short, separately bearing at anterior and below a gland containing another accessory gland and tubular extension, tubular extension elongate, weakly tangled.

Specimens examined. A total of 16 individuals: <Gyeonggi-do> female, Temple Bukdae-sa in Mt. Odae, Dongsan-ri, Jinbu-myeon, Pyeongchang-gun. 27. V. 2008. S. W. Park leg. (DNA 2811); male, 2 females, ditto, 28. V. 2009. S. W. Park leg. (DNA 885, 2244, 2249); male, 3 females, ditto, 29. V. 1996. S. M. Lee leg.; female, ditto, 30. V. 1995. J. W. Kim leg.; 2 females, Hangyeryong, Injae. 10. VI. 1994. J. Y. Choi leg.; male, Hongcheon. 10. VI. 1995. Y. C. Jeon leg.; female, Mt. Gachilbong, Hongcheon. 6. VI. 1995. G. S. Im leg. <Gyeongsangbuk-do> female, Bonghwa. 28. V. 1993. D. S. Ku leg.; male, Mt. Sobaek, Yeongju 6. VI. 1981. I. Y. Choi leg. <Jeollabuk-do> male, Daebul-ri, Seolcheon-myeon, Muju 26. V. 1993. J. I. Kim leg.

Distribution. Korea (new to fauna) and the Russian Far East.

Remarks. This species is recorded in Korea for the first time and usually collected mountainous area in Korea.

***Acteniceromorphus chlamydatus* (Lewis, 1894)**

애붉은큰뿔방아벌레

Corymbite chlamydatus Lewis, 1894: 263 (Yuyama, Japan).

Acteniceromorphus chlamydatus (Lewis): Kishii, 1955: 19, 22.

Korean records

Liotrichus (Acteniceromorphus) chlamydatus (Lewis): Shin and Yoon, 1994: 159 (Checklist).

Acteniceromorphus chlamydatus (Lewis 1894): Kishii, 1999: 46 (Checklist).

Specimens examined. Any Korean specimen of *A. chlamydatus* is unavailable in this study.

Reference specimens. *Acteniceromorphus chlamydatus* (Lewis, 1894): 2 males, Wandodani, Sakauchi, Gifu Pref., Japan. 16. V. 1989. I. Kiriya leg., identified by Dr. H. Ôhira; male, Sagawai, Oyama, Honshu, Japan. 25. IV. 1972. Y. Miyake leg., identified by Dr. H. Ôhira.

Distribution. Japan (endemic) and Korea (?)

Remarks. The species is an endemic species to Japan occurring from Honshu, Shikoku and Kyushu. We could not examine the presence of the species in the Korean fauna and the further study is needed for this species.

***Acteniceromorphus selectus* (Candèze, 1865)**

산꽃큰뿔방아벌레

Corymbites selectus Candèze, 1865: 53 (Japan).

Acteniceromorphus selectus (Candèze): Kishii, 1955: 19, 22.

Korean records

Acteniceromorphus selectus Candèze: Kim and Kim, 1972: 78, 99 (Fauna: 3 ex., Mujugucheondong, JB), misidentification of *Hemicrepidius (Hemicrepidius) oblongus* (Solsky, 1870).

Acteniceromorphus selectus (Candèze 1865): Kim, 1984: 206 (Fauna: Is. Jeju), misidentification considered by Kishii, 2004b: 2.

Acteniceromorphus selectus (Candèze, 1865): Lee *et al.*, 1985: 407 (fauna: Is. Jeju), misidentification considered by Kishii, 2004b: 2.

Acteniceromorpha [!] *selectus* (Candèze 1865): Paik *et al.*, 1993: 126 (Fauna: Is. Jeju, “산꽃큰뿔방아벌레” named in Korean), misidentification (?).

Liotrichus (Acteniceromorphus) selectus (Candèze): Shin and Yoon, 1994: 159 (Checklist).

Specimen examined. Any Korean specimen of *A. selectus* is unavailable in this study.

Reference specimens. *Acteniceromorphus selectus* (Candèze, 1865): male, female, Jozankei nature village 380 m, Hokkaido, Japan. 30. V. 2009. J. W. Lee leg. (DNA 2138~2139), identified by T. M. Han; male, female, Hokkaido, Japan. 13. V. 1995. A. Kashizaki leg., identified by Dr. H. Ôhira; 5males, female, Suigenchi otaru 223 m, Okusawa, Hokkaido, Japan. 1. VII. 2009. J. W. Lee leg. (DNA 2141~2145, 2160), identified by T. M. Han.

Distribution. Japan (Hokkaido, endemic)

Remarks. *A. selectus* is an endemic species to Japan occurring only in Hokkaido (Ôhira 1995, Ôhira and Yasuda 1999). Kishii (2004b) pointed out that *A. selectus* was previously recorded from Is. Jeju by Kim (1984) and Lee *et al.* (1985), but the

true specimen of *A. selectus* was not examined from the used materials of two previous workers. He considered that the reports of *A. selectus* from Is. Jeju may be misidentification of an elaterid species. In this study, *A. selectus* was not found in the elaterid materials stored at FNMJ and Jeju National University in 2009 and 2010, and not collected from Is. Jeju during the past 30 years. Therefore, we proposed that *A. selectus* may be excluded from the Korean fauna.

***Acteniceromorphus fulvipennis* (Lewis, 1894)**

붉은큰뿔방아벌레

Corymbites fulvipennis Lewis, 1894: 258 (Miyanoshita, Japan).

Acteniceromorphus fulvipennis (Lewis): Kishii, 1955: 19, 22.

Korean records

Actenicerus fulvipennis Lewis: Kim, 1981: 343 (Fauna: Mt. Chukryeong-san, Sudongmyeon, GG), misidentification of *Hemicrepidius oblongus*.

Liotrichus (Acteniceromorphus) fulvipennis (Lewis): Shin and Yoon, 1994: 159 (Checklist, “붉은큰뿔방아벌레” named in Korean).

Acteniceromorphus fulvipennis (Lewis, 1894): Kishii, 1999: 46 (Checklist).

Specimen examined. Any Korean specimen of *A. fulvipennis* is unavailable in this study.

Distribution. Japan (endemic).

Remarks. The first Korean record of the species by Kim (1981) was a misidentification of *H. oblongus* Solsky. Therefore, *A. fulvipennis* is proposed to be excluded from the Korean fauna. Ôhira (1973) provided taxonomic information in detail.

DNA barcode profile

NJ tree (Fig. 2) for 16 COI sequences of three ingroup taxa of *Acteniceromorphus*, except for *A. chlamydatus*, showed that each species was clustered as reciprocally monophyletic group with large interspecific genetic distance (range 7.2–10.5%). Therefore, we recognized that three species of *Acteniceromorphus* have well defined species-level identification in DNA barcode as well as morphology. This information will be helpful to rapid species identification of them, not confuse as in the previous faunistic surveys based on morphology.

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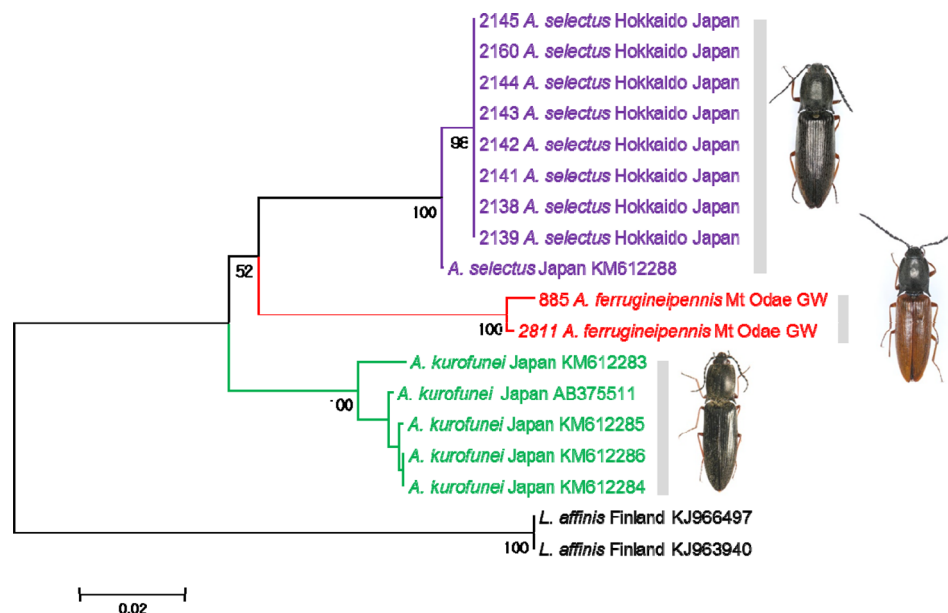


Fig. 2. Neighbor-joining tree inferred from COI partial sequence of DNA barcoding. Numbers under each node are bootstrap values.

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