**Supp. file 1.** Supplementary information. <https://doi.org/10.5852/ejt.2022.855.2023.8323>

**1. Mtgenome analyses of the Luciolinae (addressing *Luciola cruciata* and *L. owadai*).**

Here we follow Ballantyne *et al.* (2019) for an overview of Luciolinae genera and species and their nomenclature. The following papers do not always refer to the most recent taxonomic categories, and in considering information in papers published prior to 2019, relationships of *Luciola cruciata,* and *L. owadai* should be reassessed in light of certain name changes to genus and species, especially the genus *Aquatica* to which *Luciola lateralis* was assigned (Fu *et al*. 2010).

The same mitogenome of *Luciola substriata* (KP313820) has been used in many analyses, and the initial designation by Mu *et al.* (2015) of this mtgenome as *L. substriata,* using the current taxonomy of the time*,* has created difficulties in subsequent interpretation of results as both the generic and specific status have changed. *Luciola substriata* (KP313820) was transferred to the genus *Sclerotia* (Ballantyne *et al*. 2016). Hu & Fu (2018) indicated that KP313820 is *Sclerotia flavida*.

The category of *Luciola* s. str. is defined in Supplementary information 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Authors** | **Year** | **No. of Taxa** | **Results** | **literature** |
| Choi *et al.* | 2003 | 7 | Main focus luciferase gene analysis; concentrated on *Hotaria* but showed relationship of *cruciata* to *lateralis* and as outgroup of *Hotaria* | Choi, Y.S., Bae, J.S., Lee, K.S., Kim, S.R., Kim, I., Kim, J.G., Kim, K.Y., Kim, S.E., Suzuki, H., Lee, S.M., Sohn, H.D. & Jin, B.R. 2003. Genomic structure of the luciferase gene and phylogenetic analysis in the *Hotaria*-group fireflies. *Comparative Biochemistry and Physiology B Biochemistry & Molecular Biology* 134B(2): 199‒214. |
| Fan & Fu | 2017 |  8 | *cruciata* alongside *Aquatica* sp. | Fan, Y. & Fu, X. 2017. The complete mitochondrial genome of the firefly, *Pteroptyx maipo* (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 2(2): 795‒796. |
| Ge *et al.* | 2021 | 16 | Possible misinterpretation of results; *Emeia* in Lampyrinae and Vesta in Luciolinae; *cruciata* alongside *Aquatica* sp. | Ge, X., Yuan, L., Kang, Y., Liu, T., Liu, H. & Yang, Y. 2021. Characterization of the first complete mitochondrial genome of Cyphonocerinae (Coleoptera: Lampyridae) with Implications for phylogeny and evolution of fireflies. *Insects* 12(7): 570. |
| Han *et al.* | 2020 | 12 | Main focus *Hotaria*; *cruciata* alongside *lateralis* | Han, T., Kim, S.-H., Yoon, H.J., Gyun Park, I. & Park, H. 2020. Evolutionary history of species of the firefly subgenus *Hotaria* (Coleoptera, Lampyridae, Luciolinae, *Luciola*) inferred from DNA barcoding data. *Contributions to Zoology* 89(2): 127–145. |
| Hu & Fu | 2018a | 9 | *cruciata* alongside *Aquatica* sp. | Hu, J. & Fu, X. 2018a. The complete mitochondrial genome of the firefly, *Abscondita anceyi* (Olivier) (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 3(1): 442–443. |
| Hu & Fu | 2018b | 9 | *cruciata* alongside *Aquatica* sp. | Hu, J. & Fu, X. 2018b. The complete mitochondrial genome of the firefly, *Luciola curtithorax* (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 3(1): 378-379. |
| Kim, Park & Kim | 2020 | 16 | *cruciata* alongside *Aquatica* sp. | Kim, M.J., Park, J.S. & Kim, I. 2020. Complete mitochondrial genome of the Korean endemic firefly, *Luciola unmunsana* (Coleoptera: Lampyridae). *Mitochondrial DNA Part* B 5(3): 3165-3167. |
| Kim *et al.*  | 2004 | 7 | Main focus luciferase gene analysis; concentrated on *Hotaria*; *cruciata* alongside *lateralis* | Kim, J.G., Choi, Y.S., Kim, K.Y., Bae, J.S., Kim, I., Sohn, H.D. & Jin, B.R. 2004. Genomic structure and phylogenetic analysis of the luciferase gene of the firefly, *Luciola lateralis* (Coleoptera: Lampyridae). *European Journal of Entomology* 101(1): 1‒11. |
| Li *et al.* | 2006 | 17 | Both *cruciata* and *owadai* together next to *lateralis* | Li, X., Yang, S., Xie, M. & Liang, X. 2006. Phylogeny of fireflies (Coleoptera: Lampyridae) inferred from mitochondrial 16S ribosomal DNA, with references to morphological and ethological traits. *Progress in Natural Science* 16(8): 817‒826. |
| Liu & Fu | 2020 | 16 | Possible incorrect interchange of mtgenome and 18s RNA; *Vesta* sp in Luciolinae and one var *Emeia* in Lampyrinae; *cruciata* alongside *Aquatica* sp. | Liu, Q. & Fu, X. 2020. The genetic variations in the mitochondrial genomes of three Luciolinae fireflies. *Mitochondrial DNA Part B* 5(3): 3210‒3214. |
| Luan & Fu | 2016 | 5 | *cruciata* alongside *Aq. leii* | Luan, X. & Fu, X. 2016. The complete mitochondrial genome of the firefly, *Asymmetricata circumdata* (Motschulsky) (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 1(1): 553‒555. |
| Maeda *et al.* | 2017a | 7 | Specific *cruciata* mtgenome; *cruciata* alongside *Luciola lateralis* | Maeda, J., Kato, D.I., Arima, K., Ito, Y., Toyoda, A. & Noguchi, H. 2017a. The complete mitochondrial genome sequence and phylogenetic analysis of *Luciola lateralis*, one of the most famous firefly in Japan (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 2(2): 546‒547. |
| Maeda *et al.* | 2017b | 7 | *cruciata* alongside *lateralis* | Maeda, J., Kato, D.I., Arima, K., Ito, Y., Toyoda, A. & Noguchi, H. 2017b. The complete mitogenome and phylogenetic analysis of Japanese firefly 'Genji Botaru' *Luciola cruciata* (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 2(2): 522‒523. |
| Martin *et al.* | 2017 | 11 | *cruciata* in a clade with *lateralis* | Martin, G.J., Branham, M.A., Whiting, M.F. & Bybee, S.M. 2017. Total evidence phylogeny and the evolution of adult bioluminescence in fireflies (Coleoptera: Lampyridae). *Molecular Phylogenetics and Evolution* 107: 564‒575. |
| Sriboonlert & Wonnapinij | 2019 | 11 | *cruciata* alongside *Aquatica* sp | Sriboonlert, A. & Wonnapinij, P. 2019. Comparative mitochondrial genome analysis of the firefly, *Inflata indica* (Coleoptera: Lampyridae) and the first evidence of heteroplasmy in fireflies. *International Journal of Biological Macromolecules* 121: 671‒676. |
| Stanger Hall *et al.* | 2007 | 12 | Included *Pristolycus*; *cruciata* and *owadai* together alongside *lateralis* | Stanger-Hall, K.F., Lloyd, J.E. & Hillis, D.M. 2007. Phylogeny of North American fireflies (Coleoptera: Lampyridae): implications for the evolution of light signals. *Molecular Phylogenetics and Evolution* 45(1): 33‒49. |
| Suzuki | 1997 | 10 | Included *Pristolycus*; two species listed as *Hotaria*; *cruciata* and *owadai* together alongside *lateralis* | Suzuki, H. 1997. Molecular phylogenetic studies of Japanese fireflies and their mating systems (Coleoptera: Cantharoidea). *Tokyo Metropolitan University Bulletin of Natural History* (3): 1‒53. |
| Suzuki *et al.* | 2004 | 3 | *cruciat*a and *owadai* together alongside *lateralis* (Japanese and Korean lineages) | Suzuki, H., Sato, Y., Ohba, N., Bae, J-S., Jin, B-R., Sohn, H-D., & Kim, S-E. 2004. Phylogeographic analysis of the firefly, Luciola lateralis, in Japan and Korea based on mitochondrial cytochrome oxidase II gene sequences (Coleoptera: Lampyridae). *Biochemical Genetics* 42 (9/10): 287‒300.  |
| Suzuki | 2001 | 9 | Two species listed as *Luciola* (*Hotaria*); *cruciata* and *owadai* together alongside *Luciola lateralis* | Suzuki, H. 2001. Studies on biological diversity of firefly in Japan. *International Journal of Industrial Entomology* 2(2): 91–105. |
| Wang, Wu & Wang | 2021 | 16 | *cruciata* alongside *Aquatica* sp. | Wang, L.J., Wu, Y.W. & Wang, T.Y. 2021. Characterization of the complete mitochondrial genome of *Abscondita cerata* (Olivier, 1911) (Coleoptera: Lampyridae) and its phylogenetic implications. *Mitochondrial DNA Part B* 6(9): 2528‒2530. |
| Wang & Fu | 2019 | 11 | *cruciata* alongside *Aquatica* sp. | Wang, J. & Fu, X. 2019. The complete mitochondrial genome of the firefly, *Abscondita chinensis* (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 4(1): 1599‒1600. |
| Zhang & Fu | 2019 | 11 | *cruciata* alongside *Aquatica* sp.­­ | Zhang, J. & Fu, X. 2019. The complete mitochondrial genome of the firefly, *Curtos costipennis* (Coleoptera: Lampyridae). *Mitochondrial DNA Part B* 4(1): 1578–1579. |

Additional reference.

Mu, F.J., Ao, L., Zhao, H.B. & Wang, K. 2015. Characterization of the complete mitochondrial genome of the firefly, *Luciola substriata* (Coleoptera: Lampyridae). *Mitochondrial DNA A*. 27: 3360‒3362.

**2. List of species of *Luciola* s. str.**

The currently accepted name is as outlined in Ballantyne *et al.* (2019), and Jusoh *et al.* (2021).

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| --- | --- | --- |
|  | **Currently accepted name** | **Reference to original description of species** |
| 1 | *Luciola antipodum* (Bourgeois, 1884) | Bourgeois, J. Dascillides & Malacodermes de Nouvelle-Calédonie. Revue d’entomologie 1884, 3, 278–290 |
| 2 | *Luciola aquilaclara* Ballantyne, 2013 in Ballantyne *et al.* 2013 | Ballantyne, L.A.; Lambkin, C.L. Systematics and phylogenetics of Indo-Pacific Luciolinae fireflies (Coleoptera: Lampyridae) and the description of new genera. Zootaxa 2013, 3653, 1–162.  |
| 3 | *Luciola chapaensis* Pic, 1923 | Pic, M. Deuxième addenda. Faune Entomol. l’Indo-Chine Française 1923, 6, 58–63. |
| 4 | *Luciola curtithorax* Pic, 1927 | Pic, M. Malacodermes exotiques. L’Échange Revue Linnéenne 1927, XLIII, 49. |
| 5 | *Luciola filiformis* Olivier, 1913 | Olivier, E.H. Sauter’s Formosa-Ausbeute: Lampyridae (Col.). Entomol. Mittellungen 1913, II, 271. |
| 6 | *Luciola horni* Bourgeois, 1905 | Bourgeois, J. Voyage du D.W. Horn à Ceylan. Malacodermes et Lymexylonides. II. Lampyridini. Ann. Société Entomol. Fr. 1905, 74, 127. |
| 7 | *Luciola hypocrita* Olivier, 1888 | Olivier, E. Etudes sur les Lampyrides IV. Descriptions d’espèces nouvelles. Ann. Société Entomol. Fr. 1888, 6, 47–62.  |
| 8 | *Luciola jengai* Nada, 2019 in Ballantyne *et al.* 2019 | Ballantyne, L.A.; Lambkin, C.L.; Ho, J.Z.; Jusoh, W.F.A.; Nada, B.; Nak-Eiam, S.; Thancharoen, A.; Wattanachaiyingcharoen, W.; Yiu, V. The Luciolinae of S. E. Asia and the Australopacific region: A revisionary checklist (Coleoptera: Lampyridae) including description of three new genera and 13 new species. Zootaxa 2019, 4687, 1–174. |
| 9 | *Luciola kagiana* Matsumura, 1928 | Matsumura, M. The fireflies. In *Using Interesting Insects as Teaching Tool*; Tokyodô Shoten: Tokyo, Japan, 1928; pp. 39–70. (In Japanese)  |
| 10 | *Luciola niah* Jusoh, 2019 in Ballantyne *et al.* 2019 | Ballantyne, L.A.; Lambkin, C.L.; Ho, J.Z.; Jusoh, W.F.A.; Nada, B.; Nak-Eiam, S.; Thancharoen, A.; Wattanachaiyingcharoen, W.; Yiu, V. The Luciolinae of S. E. Asia and the Australopacific region: A revisionary checklist (Coleoptera: Lampyridae) including description of three new genera and 13 new species. Zootaxa 2019, 4687, 1–174. |
| 11 | *Luciola oculofissa* Ballantyne, 2013 in Ballantyne 2013 | Ballantyne, L.A.; Lambkin, C.L. Systematics and phylogenetics of Indo-Pacific Luciolinae fireflies (Coleoptera: Lampyridae) and the description of new genera. Zootaxa 2013, 3653, 1–162. |
| 12 | *Luciola pallidipes* Pic, 1928 | Pic, M. Malacodermes exotiques. L’Échange, Rev. Linnéenne 1928, XLIV, 58–63. |
| 13 | *Luciola papariensis* Doi, 1932 (provisional) | Doi, H. A new species of Luciola from Korea. *Luciola papariensis* sp. nov. J. Chosen Nat. Hist. Soc. 1932, 14, 64 |
| 14 | *Luciola parvula* Kiesenwetter, 1874 | Kiesenwetter, H. Die Malacodermen Japans nach den Ergebnisse der Sammlungen des Herrn L. Lewis während der Jahre 1869–1871. Dtsch. Entomol. Z. 1874, 18, 241–288. |
| 15 | *Luciola satoi* Jeng and Yang, 2003 in Jeng *et al.* 2003 | Jeng, M.-L.; Yang, P.-S.; Lai, J. Notes on the genus *Luciola* (Coleoptera, Lampyridae, Luciolinae) of Taiwan. Spec. Bull. Jpn. Soc. Coleopterol. 2003, 6, 247–262. |
| 16 | *Luciola singapura* Jusoh & Ballantyne in Jusoh *et al.* 2021 | Jusoh, W.F.A.; Ballantyne, L.; Chan, S.H.; Wong, T.W.; Yeo, D.; Nada, B.; Chan, K.O. Molecular Systematics of the Firefly Genus *Luciola* (Coleoptera: Lampyridae: Luciolinae) with the Description of a New Species from Singapore. Animals 2021, 11, 687. https://doi.org/10.3390/ani11030687 |
| 17 | *Luciola tiomana* Ballantyne, 2019 in Ballantyne *et al.* 2019 | Ballantyne, L.A.; Lambkin, C.L.; Ho, J.Z.; Jusoh, W.F.A.; Nada, B.; Nak-Eiam, S.; Thancharoen, A.; Wattanachaiyingcharoen, W.; Yiu, V. The Luciolinae of S. E. Asia and the Australopacific region: A revisionary checklist (Coleoptera: Lampyridae) including description of three new genera and 13 new species. Zootaxa 2019, 4687, 1–174. |
| 18 | *Luciola tsushimana* Nakane, 1970 (provisional) | Nakane, T. On the Cantharoid Coleoptera found in the islands of Tsushima (Insecta). Mem. Natl. Sci. Mus. 1970, 3, 287–288.  |
| 19 | *Luciola tuberculata* Yiu, 2017 | Yiu, V. A study of Rhagophthalmidae and Lampyridae in Hong Kong with descriptions of new species (Coleoptera): Part 2. Lampyrid 2017, 4, 67–119. |
| 20 | *Luciola unmunsana* Doi, 1931 (provisional) | Doi, H. A new species of Luciola from Korea. *Luciola unmunsana* sp. nov. J. Chosen Nat. Hist. Soc. 1931, 12, 54–55.  |

**3. List of Japanese Luciolinae.**

This list of Japanese Luciolinae is based on Kawashima *et al.* (2003), Ballantyne *et al*. (2019) and this work.

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| --- | --- | --- | --- | --- | --- |
| **Currently accepted name** | **Original taxon name or name-bearing type** | **Type locality (status)** | **Type depository** | **Reference to original description** | **Synonym(s)** |
| *Aquatica lateralis* *(*Motschulsky 1860) | *Luciola lateralis* Motschulsky 1860 | Daourie | Zoology Museum Moscow Lomonosov State Museum | Motschulsky 1860 | *L. vitticollis* Kiesenwetter |
| *Curtos costipennis*(Gorham 1880) | *Luciola costipennis* Gorham 1880 | FoochowChina | Natural History Museum London | Gorham 1880 | *C. iwasakii* Matsumura |
| *Curtos okinawanus*Matsumura 1918*s* | *Curtos okinawanus* Matsumura 1918 | Naha Ryukyu Islands Japan | Hokkaido University Sapporo | Matsumura 1918 | *C. okinawana* Matsumura*C. okinawae* Matsumura *L. okinawae* Nakane |
| *Luciola filiformis*Olivier 1913  | *Luciola filiformis* Olivier 1913 | Formosa | Museum national d’Histoire naturelle, paris | Olivier 1913 | *Luciola filiformis yayeyamana* Matsumura*L. yayeyamana*Matsumura |
| *Luciola parvula*Kiesenwetter 1874 | *Luciola parvula* Kiesenwetter 1874 | Japan | Natural History Museum London | Kiesenwetter 1874 | *L. paruula**Hotaria parvula**L. (Hotaria) parvula**L. ibukiyamana* |
| *Luciola tsushimana* Nakane 1970 | *Luciola tsushimana* Nakane 1970 | Japan Sasuna Tushimana island  | Collection of T. Nakane in the Hokkaido University Sapporo | Nakane 1970 | *Hotaria tsushimana**Luciola (Hotaria) tsushimana**Hotaria papariensis* |
| *Nipponoluciola cruciata* (Motschulsky, 1854) | *Luciola cruciata* Motschulsky, 1854 | Japan (neotype) designated herein | Kanagawa Prefectural Museum of Natural History | Motschulsky 1854 | *Luciola picticollis*Kiesen-wetter 1874 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Nipponoluciola owadai* (Satô & Kimura 1994) | *Luciola owadai* Satô & Kimura 1994 | Japan Kume-jima Island, Ryukyu Islands | Kanagawa Prefectural Museum of Natural History | Satô & Kimura 1994 | *Luciola owadai* Satô & Kimura 1994 |
| **Taxonomic issues unresolved** |  |  |  |  |  |
| *Luciola kuroiwae* Matsumura 1918 | *Luciola kuroiwae* Matsumura 1918 | Japan Okinawa-jima island | Faculty of Agriculture Hokkaido University Sapporo | Matsumura 1918 | - |

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**4. The identity of *Luciola lateralis* Motschulsky 1860**

***Aquatica lateralis* (Motschulsky 1860)**

*Luciola lateralis* Motschulsky, 1860: 114. 1866: 167 (list). Okada 1928:101 (larval morphology); 1931:146 (check list). Kanda 1935: 65 (morphology). Kôno 1935: 97. Kishida 1936: 12, 20 (list). Hasama 1942a: 366 (histology, electrophysiology); 1943: 39, 42 fig. 6 (life history). Nakane 1959: 85, plate 85; 1960: 36; 1968: 5 (taxonomy); 1970: 285 (taxonomy); 1981: 93 (taxonomy). Satô 1974:133 (check list); 1978: 47, 48 (taxonomy); 1985: 123, pl. 20, fig. 17 (taxonomy); 1989: 352 (check list). Ohba, 1978: 15 (morphology); 1986: 6. Ohba *et al.* 2001: 91 (morphology, ecology). Matsuda & Ohba 1991: 7 (morphology). Jeng *et al.* 2003: 546 (taxonomy). Kim *et al.* 2001: 141; 2004: 1. Kawashima *et al*. 2003; 248 (check list). Suzuki *et al.* 2004: 287 (phylogeny).

*Luciola lateralis* Motschulsky. PARTIM. Olivier 1902a:82; 1907: 53. McDermott 1966: 108. Takakura 1977: 7, fig. 2k.

*Luciola vitticollis* Kiesenwetter 1874: 261. Olivier 1902b:189. Okada 1931:132 synonymy.

*Luciola picticollis* Kiesenwetter. *Sensu* Gorham 1883: 409. Matsumura, 1918:83, 85 fig. 2-1 and 2, 87 fig. 4-10 and 11; 1928: 59, Pl. 6 fig. 10 and 11, Pl. 7 fig. 7. Okada 1931: 146.

*Luciola cruciata* Motschulsky. Olivier 1902b:189. New synonymy.

*Luciola cruciata* var. *vitticollis* Kiesenwetter. Olivier 1907: 51; 1910: 41, 42. Matsumura 1928:60. McDermott 1966:102.

*Luciola parvula* Matsumura 1905: 207. Okada 1931: 146.

*non Luciola vitticollis* sensu Gorham 1883: 409. (= *cruciata*).

*Aquatica lateralis* (Motschulsky). Fu *et al.* 2010:8. Kazantsev, 2011:393. Ballantyne *et al.* 2019: 43.

Type. RUSSIA. Dahourie. ZMMU. Not examined by these authors.

Diagnosis. One of three aquatic Luciolinae fireflies from Japan (i.e. having aquatic larvae with lateral abdominal gills). Famous throughout Japan as the Heike- botaru. Males with black elytra and mesoscutellum, and pinkish pronotum which has a wide median black band reaching from anterior to posterior margins (Fig. 4A); ventral body black except for white LO inV6 and V7 where it is retracted to the anterior half or less of V7; area immediately posterior to V7 LO may have white fat body beneath cuticle; median posterior area of V7 black (Fig. 4B). Often confused in the literature (see table above) with *Luciola cruciata* from which it is distinguished by features outlined in sections of the preceding paper and Figs 2C, 4 A‒D. The most obvious distinction is in the outline of the pronotal dark marking which is either uniformly wide in *Aq. lateralis,* ornarrowing a little towards the posterior end, or as in *cruciata* where it narrows both anterior and posterior to the median expansion (which is the transverse section of the cross); Figs 2C, 4A. Aedeagus with median area of BP slightly truncated, but not emarginated, inner dorsal margins of LL at base with teeth, and apices of LL in-turned. (Fig. 4D).

Remarks. We rely here on Okada’s (1931) examination of Motschulsky cotypes of *Luciola lateralis* in MNHN, and also his further examination of type specimens of *L. picticollis* and *L. vitticollis* at NHMUK. He confirmed the cross notation of body length between *picticollis* and *vitticollis,* and that in his opinion *lateralis = vitticollis* and *picticollis = cruciata*. While it also appears that specimens in the Olivier collection in MNHN , which were compared with the types, agree with our interpretations, the possible errors made by Olivier in his catalogues are listed in the synonymic tables associated with this species and *Nipponoluciola cruciata* gen. et comb. nov.

Both coauthors IK and HS considered the Gorham (1883:409) reference to *Luciola picticollis* from Hakodaté, Junsai and Samegai in July is to *Luciola lateralis*, not *cruciata/picticollis.* Gorham’s (1883) reference to *Luciola vitticollis* from Tokio, Yuyama, Hitoyoshi and Nikko in May they considered would be *cruciata*, thus confirming Okada’s (1931:146) suggestions based on his examination of type material.

The aedeagal diagram of Takakura (1977 fig. 2k) could not be attributed *to Luciola lateralis.*

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Ohba, N. Kim, S-E. & Kim, J-G. 2001. Flash patterns and morphology of the firefly, *Luciola lateralis* in Japan and Korea. *Science Report of the Yokosuka City Museum (*48), 91‒116. (In Japanese with English abstract). https://www.museum.yokosuka.kanagawa.jp/wp/wp-content/uploads/2020/08/s48-7\_Ohba\_et\_al\_2001.pdf