沖縄島大浦湾より採集された日本初記録となるシロエリゴカイ (新称) Perinereis suluana (環形動物門, ゴカイ科)

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First record of *Perinereis suluana* (Annelida, Nereididae) from Oura Bay, Okinawa Island, Ryukyu Islands, Japan

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Abstract. The nereidid polychaete *Perinereis suluana* (Horst, 1924), which has been widely but sporadically reported throughout the Indo-West Pacific, was recorded for the first time from Japanese waters based on five specimens collected from Oura Bay, on the east coast of Okinawa Island. This record represents the northern-most record for the species. This species is distinguishable from its congeners most notably by (i) the absence of paragnaths in Areas VII–VIII of proboscis and (ii) the presence of a longitudinal brown streak on the tentacular and anal cirri. This report describes the morphology of *P. suluana* based on the material obtained, as well as its habitat information and geographical distribution worldwide.

Introduction

Polychaetous annelids are a major component of marine benthos in terms of the number of both individuals and species (Hutchings 1998). Because they are an important part of the marine food chain at all levels, a diverse polychaete assemblage is a good indication of the quality of the marine environment (Giangrande et al. 2005; Hutchings et al. 2014). Furthermore, some polychaete species have commercial value and are used as fish bait, aquaculture food, or as ornamental aquarium animals (Gambi et al. 1994; Olive 1994; Murray et al. 2012). Therefore, regional inventories of this significant group with finer taxonomic resolution are ecologically (Bailey-Brock 2003) and economically (Idris & Arshad 2013) crucial.

Nereididae is one of the most species-rich taxa within polychaetes; it currently comprises approximately 720 nominal species worldwide (Bakken & Wilson 2005; Ramírez-Hernández et al. 2015). This family is also one of the most diverse groups of polychaetes in the tropical Indo-West Pacific, including southern Japanese waters (Hartman 1974; Glasby et al. 2000; Salazar-Vallejo et al. 2014). The nereidid genus *Perinereis* Kinberg, 1865 includes over 70 species (León-González & Goethel 2013) that mainly inhabit shallow sandy to muddy bottoms, among sessile organisms, or under boulders (Hutchings et al. 1991; Glasby & Hsieh 2006).

The Japanese nereidid fauna has been taxonomically well-studied by Imajima (1972, 1996), who performed monographic studies; the following three species and three subspecies of *Perinereis* were documented by Imajima: *P. aibuhitensis* (Grube, 1878; originally described as *P. vancaurica tetradentata* in Imajima 1972), *P. cultrifera* (Grube, 1840), *P. c. floridana* (Ehlers, 1868), *P. neocaledonica* Pruvot, 1930, *P. nuntia brevicirris* (Grube, 1866), and *P. n. vallata* (Grube, 1858). Subsequent taxonomic studies classified the last two species as *P. mictodonta* (Marenzeller, 1879) and *P. wilsoni* Glasby & Hsieh, 2006, respectively (Glasby & Hsieh 2006; Yamanishi & Sato 2007; Saito et al. 2014) and *P. aibuhitensis* as *P. linea* (Treadwell, 1936) (Arias et al. 2013; Saito et al. 2014). However, further taxonomic studies of *Perinereis* in Japan are necessary, since another species, *P.* cf. *weijhounensis*, was collected from the Awase tidal flat in the northern part of Nakagusuku Bay, Okinawa Island (Yamanishi & Sato 2007); more recently, many unrecognized species of *Perinereis* have been found chiefly in southern Japan (Henmi et al. 2014; T. Sakaguchi & M. Sato, unpublished data).

Recent intensive surveys have indicated that Oura Bay on the east coast of Okinawa Island, the Ryukyu Islands, harbors extraordinary biodiversity because of the presence of a wide variety of habitats (Obuchi 2015). Example remarkable organisms discovered from this bay range from cnidarians to fishes and algae, however annelids have not yet been taxonomically investigated (Sato 2015). During the field workshop “Umisawa-kai” held at Oura Bay in 2014 to investigate the marine invertebrate fauna, five brightly colored nereidid worms were collected from coral rubble. Morphological examination identified these specimens as *Perinereis suluana* (Horst, 1924), which, to our knowledge, is reported here for the first time in Japanese waters.

Material and methods

The worms were obtained from several large pieces of fragile coral rubble that were collected by Dr. K. Kakui during SCUBA dives at three sites at Oura

Bay in January 2014. The specimens were anesthetized with menthol, photographed, fixed in approximately 10% seawater formalin, and stored in 70% ethanol. All of the specimens are deposited at the University Museum Fujukan, University of the Ryukyus (RUMF).

Morphological observations were made using a stereoscope and a light microscope. The body length (BL) and body width (BW) in millimeters at chaetiger 10 excluding parapodia were measured using a digital caliper; the number of chaetigers (NC) was counted for each specimen. RUMF-ZO-00010 contains three specimens; they were identified as Specimen 1 (BL, 55; BW, 1.6; NC, 75), Specimen 2 (BL, 45; BW, 1.4; NC, 70), and Specimen 3 (BL, 38; BW, 1.1; NC, 72). Left parapodia 3, 10, 25, and 50 were detached from Specimen 1 of RUMF-ZO-00010 and examined for comparison with the descriptions of Hutchings et al. (1991). The general terminology follows Glasby et al. (2000), Bakken & Wilson (2005), and Bakken et al. (2009).

Taxonomic Account

Family Nereididae Blainville, 1818
Genus *Perinereis* Kinberg, 1865
***Perinereis suluana* (Horst, 1924)**
[New Japanese name: Shiroeri-gokai]
(Figs 1–2)

Nereis (*Perinereis*) *suluana* Horst, 1924: 175–176, pl. 33, fig. 9; Monro 1926: 318.
Perinereis suluana: Fauvel 1932: 102–103; Fauvel 1951: 525; Fauvel 1953: 204–205, fig. 105e; Chlebovitsch 1963: 58, 73, pl. 5, figs. Ж–Л; Sun et al. 1978: 150–151, figs. 16–17; Wu et al. 1985: 204–206, figs. 116–117; Hutchings et al. 1991: 263–265, fig. 16; Sun & Yang 2004: 196–198, figs. 113–114; Glasby et al. 2013: 258, fig. 6B; Glasby 2015: 228.

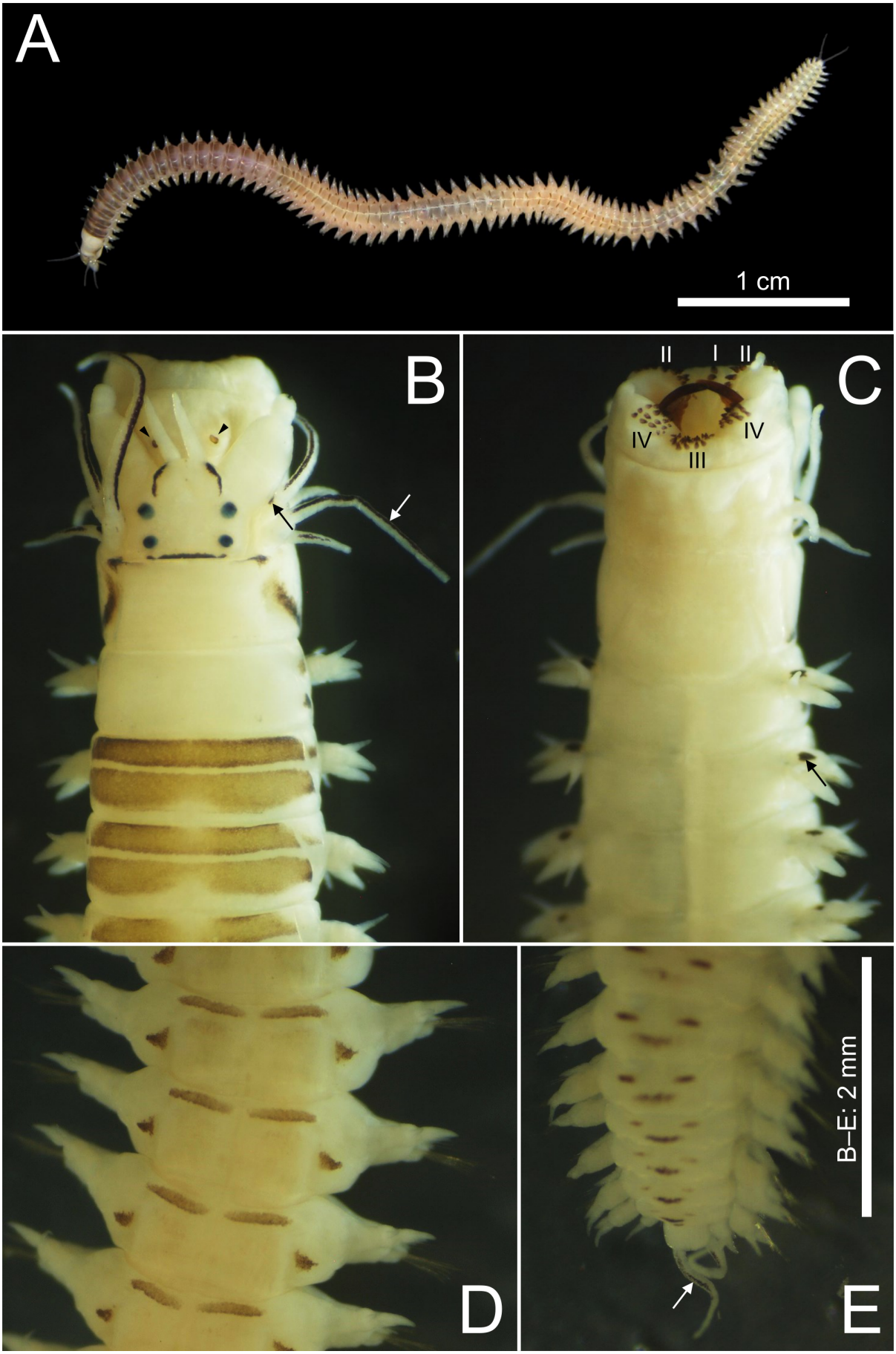
Material examined. RUMF-ZO-00010, BL 38–55, BW 1.1–1.6, CN 70–75, three specimens of unknown sex, coral rubble from off Camp Schwab (Tettô-Oki Point), 26°31'51.10"N, 128°3'10.45"E, 7–35 m, 27.i.2014, coll. M. Tanaka; RUMF-ZO-00011, BL 25, BW 1.2, CN 72, one specimen of unknown sex, coral rubble from off Thima (Nyûmonsha Point), 26°32'0.81"N, 128°3'49.61"E, 7–33 m, 28.i.2014, coll. M. Tanaka; RUMF-ZO-00012, BL 31, BW 1, CN 72, one specimen of unknown sex, same data as RUMF-ZO-00011, 26°32'0.75"N, 128°3'49.17"E, 7–20 m, 28.i.2014, coll. M. Tanaka.

Diagnosis. Group 1B *Perinereis* species without paragnaths in Areas VII–VIII; longitudinal brown streak present on tentacular and anal cirri; dorsally two transverse brown bands appearing from chaetiger 2.

Description. All specimens examined complete, atokous worms; BL ranging from 25 to 55; BW from 1 to 1.6; and NC from 70 to 75. Specimens of RUMF-ZO-00010 somewhat flattened dorsoventrally, probably due to fixation. Conspicuous brown streak present on tentacular and anal cirri, and edges of prostomium (Fig. 1A, B, and E); in Specimen 2 of RUMF-ZO-00010, additional longitudinal streak visible on middle of anterior prostomium; streak often inconspicuous on ventral tentacular cirri. Brown pigments present on dorsal edge and lateral sides of peristomium and on dorsal and dorsolateral sides of each chaetiger; intensity of chaetiger pigments faded posteriorly (Fig. 1A, B, D, and E). Dorsal pigmentation appearing from chaetiger 2, consisting of two transverse bands on each chaetiger, often merged with dorsolateral pigments anteriorly; anterior band becoming narrower and dividing into two transverse bands posteriorly; broader posterior band considerably faded and often inconspicuous in middle chaetigers (Fig. 1A, B, D, and E). Intense brown pigment also present on tentaculophores and frontal side of each parapodium in first few chaetigers (Figs. 1B, C and 2A). White pigments visible on tentaculophores and dorsal side of anterior to middle parapodia in live animals (Fig. 1A), but not noted in preserved ones.

Prostomium slightly wider than long, trapezoidal shape (Fig. 1B). Paired antennae narrow, two-thirds

Fig. 1. *Perinereis suluana* (Horst, 1924) obtained from Oura Bay, Okinawa Island, the Ryukyu Islands (Specimen 1 in RUMF-ZO-00010). A, dorsal view of the entire animal, alive. B–E, same animal, after fixation; B, dorsal view of the anterior end; C, ventral view of the anterior end; D, dorsal view of the middle chaetigers; and E, dorsal view of the posterior end. Roman numerals I to IV indicate four areas of paragnaths on proboscis; arrowheads indicate short bar-shaped paragnaths in Area VI; black arrows indicate intense brown pigment on tentaculophores and parapodia; and white arrows indicate a longitudinal brown streak on tentacular and anal cirri.
図 1. 沖縄島大浦湾から採集されたシロエリゴカイ (RUMF-ZO-00010 中の 1 標本). A, 生時の全体背面観. B–E, 固定後の同個体; B, 前端部の背面観; C, 同腹面観; D, 体中部剛毛節の背面観; E, 後端部の背面観. I から IV のローマ数字は口吻上に存在する顎片の 4 区域を, 矢頭は VI 区の短い棒状顎片を, 黒矢印は感触糸基節と疣足前面に存在する濃褐色色素を, そして白矢印は感触糸と肛触糸に存在する褐色の縦条を, それぞれ示す.


A
1 cm
B
C
II
I
II
IV
IV
III
D
E
B–E: 2 mm

prostomium in length (Fig. 1B). Paired palps with small palpostyles, spheroidal, approximately same length of prostomium (Fig. 1B). Two pairs of black eyes (bright brown in RUMF-ZO-00012), spherical, arranged in near-square (Fig. 1B). Four pairs of tentacular cirri with short tentaculophores, unequal in length; postero-dorsal ones being longest (Fig. 1B), reaching up to posterior margin of chaetiger 4 in RUMF-ZO-00011 and RUMF-ZO-00012. Paired jaws brown; four to six rounded teeth countable without dissection (Fig. 1C). Paragnaths pale brown; conical paragnaths on maxillary ring and short smooth bars on oral ring arranged as follows: Area I = 2–3 in line; Area II = 11–20 on each side in arc; Area III = 19–25 in near-square patch; Area IV = 15–24 on each side in triangular patch; Area V = 0; Area VI = 1 on each side (two on left side in RUMF-ZO-00011); Areas VII–VIII = 0 (Fig. 1B–C).

First two parapodia uniramous with neuroacicula, remaining ones biramous with notoacicula and neuroacicula. All parapodia composed of dorsal cirrus, dorsal and ventral notopodial ligules (ventral one absent in first two parapodia), acicular and postchaetal neuropodial lobes, neuropodial ventral ligule, and ventral cirrus (Fig. 2A–D); dorsal cirrus inserted proximally, as long as or slightly longer than dorsal notopodial ligule in first few parapodia (Fig. 2A) and shorter than ligule in remaining ones (Fig. 2B–D); dorsal and ventral notopodial ligules digitate, both nearly having same length in first few parapodia (Fig. 2A), former becoming longer than latter in remaining ones and well developed posteriorly (Fig. 2B–D); acicular and postchaetal neuropodial lobes of similar shape, low, rounded, unmodified throughout (Fig. 2A–D); neuropodial ventral ligule digitate, as long as notopodial ligules in first few parapodia (Fig. 2A), and shorter than those on remaining parapodia (Fig. 2B–D); ventral cirrus inserted proximally, as long as or slightly shorter than dorsal one throughout (Fig. 2A–C).

Chaetation uniform throughout; all notochaetae homogomph spinigers (Figs. 2E); upper neurochaetae composed of homogomph spinigers and heterogomph falcigers (Fig. 2F, un); lower neurochaetae composed of heterogomph spinigers and heterogomph falcigers (Fig. 2F, ln).

Pygidium cylindrical with paired anal cirri (Fig. 1E).

Remarks. Characters observed in the present specimens are consistent with the original description (Horst 1924) and the subsequent accounts listed in the above synonymy. No epitokous specimens, which have an importance in nereidid systematics, especially to distinguish cryptic species (Sun et al. 1978; Read 2007; Glasby et al. 2013; Pamungkas & Glasby 2015) were obtained. The descriptions of the male epitokes of *P. suluana* are available in Fauvel (1951), Sun et al. (1978), Wu et al. (1985), Hutchings et al. (1991), and Sun & Yang (2004); according to these studies, the epitokes were collected during March to July, and the reproductive swarming occurs during the night. The female epitokes remain to be described.

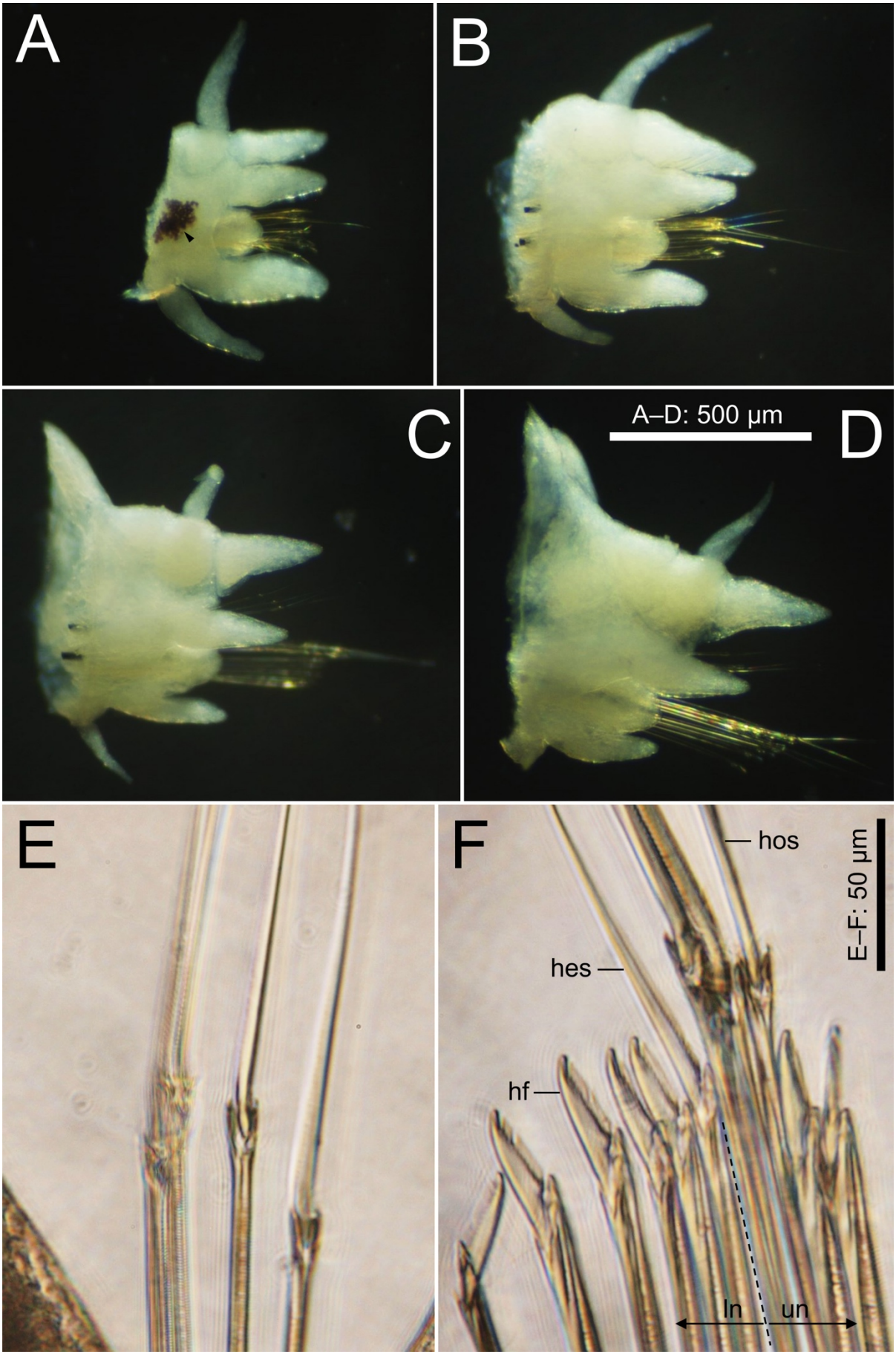
In their extensive taxonomic revision of *Perinereis*, Hutchings et al. (1991) created six informal groups in this genus. They included *P. suluana* into Group 1B, which is defined as having (i) single bar-shaped paragnath in Area VI and (ii) remarkably expanded dorsal notopodial ligules on posterior chaetigers. Of the 17 species in Group 1B *Perinereis*, *P. suluana* is the only species lacking paragnaths in Areas VII–VIII (Hutchings et al. 1991; León Gónzález & Solís-Weiss 1998).

Recently, Glasby et al. (2013) described a cryptic species, *P. pictilis* Glasby, Wei & Gibb, 2013 within the previous morphological concept of *P. suluana*, namely *P. suluana* species-group; consequently, these two species are distinguished morphologically by the distinct color pattern [e.g., presence of a longitudinal brown streak on tentacular and anal cirri in *P. suluana* vs. absence in *P. pictilis*; see Glasby et al. (2013) and Glasby (2015) for details]. Because the present material well retained their coloration even in a preserved state (Fig. 1A–E), these can be identified with certainty as *P. suluana* sensu stricto.

Although the morphological distinctions of *P. suluana* among its congeners are clear, Hutchings et al. (1991) and Glasby et al. (2013) questioned its generic placement; that is, the bar-shaped paragnaths in Area VI of *P. suluana* are very short, and this is

Fig. 2. Left parapodia of *Perinereis suluana* (Specimen 1 in RUMF-ZO-00010), frontal view. A, parapodium at chaetiger 3 with brown pigment (arrowhead); B, parapodium at chaetiger 10; C, parapodium at chaetiger 25; D, parapodium at chaetiger 50; E, notochaetae of parapodium at chaetiger 25, showing homogomph spinigers; and F, neurochaetae of the same parapodium. Abbreviations: hes, heterogomph spiniger; hf, heterogomph falciger; hos, homogomph spiniger; ln, lower neurochaetae; and un, upper neurochaetae.

図 2. シロエリゴカイ (RUMF-ZO-00010 中の 1 標本) の左側疣足, 正面観. A, 第 3 剛毛節, 濃褐色色素を矢頭で示す; B, 第 10 剛毛節; C, 第 25 剛毛節; D, 第 50 剛毛節; E, 第 25 剛毛節疣足の背剛毛, 針状複剛毛 (関節部相称形) を示す; F, 同疣足の腹剛毛. 略号: hes, 針状複剛毛 (関節部非相称形); hf, 短複剛毛 (関節部非相称形); hos, 針状複剛毛 (関節部相称形); ln, 足刺下部の腹剛毛; un, 足刺上部の腹剛毛.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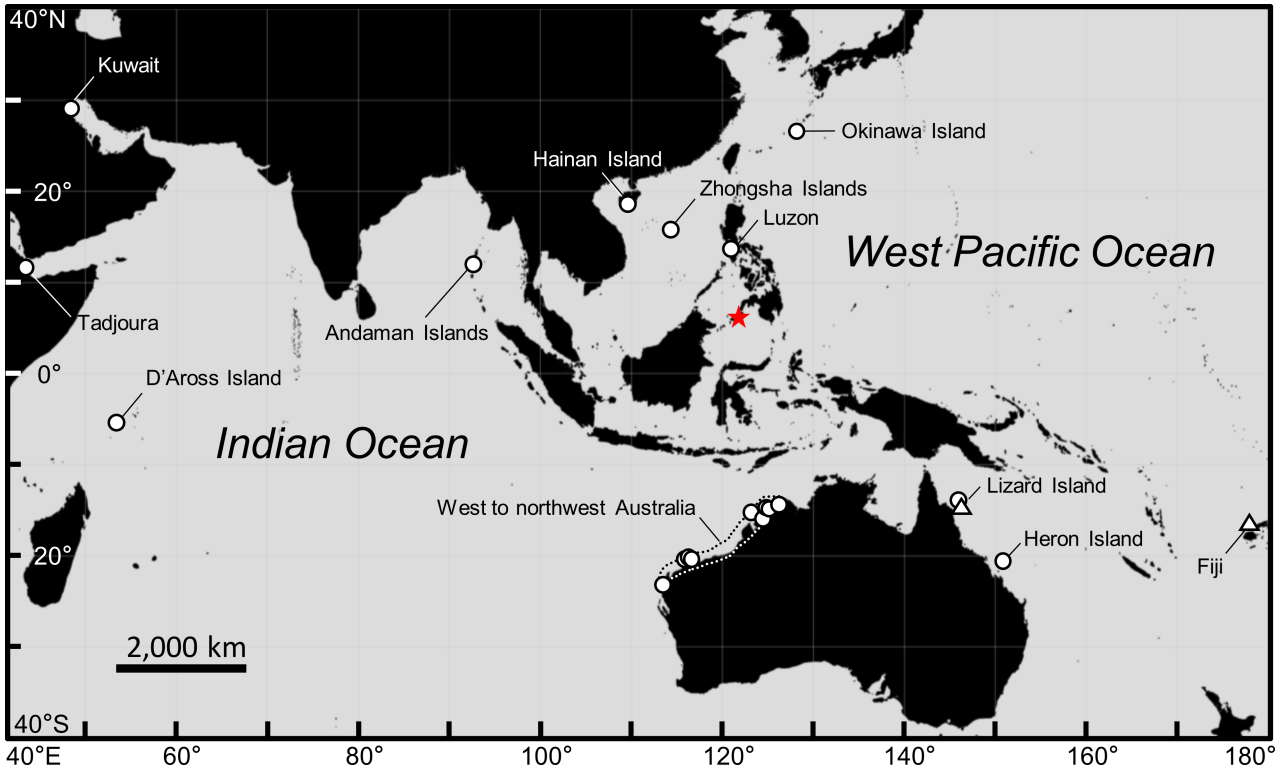

Fig. 3. Geographical distribution of *Perinereis suluana* (indicated by circles) and the closely allied *P. pictilis* (indicated by triangles) based on the literature and present study findings. The star indicates the type locality of *P. suluana* (Sulu Archipelago, Philippines).
図 3. 過去の文献記録と本研究の結果に基づくシロエリゴカイ (丸で示す) とその近似種 *Perinereis pictilis* (三角で示す) の地理的分布. 星印はシロエリゴカイのタイプ産地 (スールー諸島, フィリピン) を示す.

not the typical form compared to that present in other *Perinereis* species. In fact, Bakken & Wilson (2005) showed that the genus *Perinereis* is polyphyletic based on their cladistic analyses, and Glasby et al. (2013) also found that all *Perinereis* species [*P. helleri* (Grube, 1878), *P. nuntia* (Lamarck, 1818), *P. pictilis*, and *P. suluana*] included in their molecular phylogenetic analyses were not monophyletic. The generic assignment of *P. suluana* should be reassessed through future systematic revision of Nereididae with comprehensive phylogenetic analyses.

Geographical distribution. This species has been widely, but sporadically, reported throughout the Indo-West Pacific (Fig. 3): Tadjoura, Gulf of Aden (Fauvel 1951); Kuwait, Persian Gulf (Mohammad 1976); D'Arros (= Darros) Island, the Seychelles (Monro 1926); Andaman Islands (Fauvel 1932); Hainan Island (Chlebovitsch 1963; Wu et al. 1985) and Zhongsha Islands (Sun et al. 1978), the South China Sea; Luzon (Glasby et al. 2013) and Sulu Archipelago (the type locality; Host 1924), the Philippines; Lizard Island (Glasby 2015) and Heron Island (Glasby et al. 2013), Great Barrier Reef, and west to north-western coast (Hutchings et al. 1991; Glasby et al. 2013; Hutchings et al. 2014) of Australia; and Okinawa Island, the Ryukyu Islands (present study). Of these, the previous northern-most record from Kuwait (Mohammad 1976) is obscure because no morphological account is provided; thus, the present records represent a solid evidence for the northern-most geographical distribution of this species.

Although *P. suluana* is widespread in the Indo-West Pacific, the closely related species, *P. pictilis*, is currently only known from Lizard Island and its vicinity, Great Barrier Reef, and Fiji (Glasby et al. 2013; Glasby 2015; Fig. 3). Most recently, Glasby (2015) reported a sympatric occurrence of the two species at a reef on the northeastern side of South Island, Great Barrier Reef (Collection Event Code is MI QLD 2423; see Ribas & Hutchings 2015).

Habitat. Most previous studies reported that this species has been obtained from dead coral or coral rubble secured from shallow slopes (frequently around 10 m in depth; Hutchings et al. 1991; Glasby et al. 2013; Hutchings et al. 2014; Glasby 2015); this did hold in the present study. More details on its microhabitat on coral rubble remain to be studied. Mohammad (1976) reported that this species was

one of the fouling species of the pearl oysters in Kuwait, but this needs to be confirmed for the above reason. Wu et al. (1985, p. 206) reported that this species "was digged under the stones in middle region of the littoral zone" (see also Chlebovitsch 1963); although such habitat seems to be unusual for this species, further observations are required for understanding its biology.

Cryptic animals associated with coral rubble in the Ryukyu Islands have been previously investigated for ecological purposes, however, coarse identification of small invertebrates, including polychaetes, was often overlooked probably because of the difficulties associated with their identification (e.g., Takada et al. 2007, 2008, 2012, 2014). Therefore, the discovery of this conspicuous worm highlights the insufficient inventories of these neglected taxa living in the coral reef regions of Japan, as has been suggested in the recent studies of amphipods (White & Reimer 2012a, b, c) and zoantharians (Fujii & Reimer 2011). More attention needs to be paid to their taxonomy since these lesser-known invertebrates also play an important role in the coral reef ecosystem (Hutchings 1983, 1986; Stella et al. 2011; Ribas & Hutchings 2015).

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沖縄島大浦湾より採集された日本初記録となるシロエリゴカイ（新称）*Perinereis suluana* (環形動物門, ゴカイ科)

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要旨. 沖縄島東岸の大浦湾から得られた 5 個体の標本に基づき, 環形動物門ゴカイ科イソゴカイ属の 1 種 *Perinereis suluana* (Horst, 1924) を本邦初記録として報告した. 本種は (i) 口吻の VII–VIII 区に顎片を欠くこと, および (ii) 感触糸と肛触糸に褐色の縦条を備えることにより, 同属の他種から識別される. 本報告では, 得られた標本の形態記載を行うとともに, 本種の生息環境と地理的分布についても記述した. なお, 本種にはこれまで和名が与えられていないため, 体前部背面の色彩のコントラストにちなみ, 新和名「シロエリゴカイ」を提唱する.

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