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Two new records of polychaete genus *Pseudonereis* Kinberg, 1865 (Polychaeta: Nereididae) from Shamal Bandar (Pasni), Balochistan(Makran) coast of the Northern Arabian Sea

Qadeer Mohammad Ali[1], Quratulan Ahmed[1]*, Eulogio H. Soto Oyarzún[2], Ivan Marin[3], Hafsa Qazi[1], Ateeqa Baloch[1], Shumaila Mubarak[1], Iqra Shaikh[1], Levent Bat[4]

[1]The Marine Reference Collection and Resources Centre, 75270, Karachi, Pakistan
[2]Centro de Observación y Análisis del Océano Costero, Facultad de Ciencias del Mar y de Recursos Naturales, Universidad de Valparaíso, Chile
[3]A.N. Severtsov Institute of Ecology and Evolution of RAS, Moscow 119071, Russia.
[4]Department of Hydrobiology, Faculty of Fisheries, Sinop University, TR57000 Sinop, Türkiye
*Corresponding author: quratulanahmed_ku@yahoo.com

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Abstract

The presented article provides two new records of polychaete worms *Pseudonereis gallapagensis* Kinberg, 1865 and *Pseudonereis* sp., which were collected during coastal monitoring at Shamal Bandar, Pasni along the Makran coast of the Northern Arabian Sea (Pakistan). These species were identified through a detailed morphological study, focusing on features of their heads, jaws, and parapodia. This study has led to a better understanding of their taxonomic classification and morphological traits and has contributed to a more comprehensive understanding of the polychaete fauna in the Makran region. This research has resulted in a significant addition to our knowledge about the distribution and composition of polychaetes on the Balochistan (Makran) coast of the Northern Arabian Sea, as well as highlights the importance of further research in this area, as it may lead to the discovery of new species.

Key words: Polychaete, Nereididae, *Pseudonereis*, New record, Shamal Bandar, Makran coast.

1. Introduction

The family Nereididae (Annelida: Polychaeta), formerly known as Nereidae, is one of the most diverse among the polychaete worms, also known as Ragworms or Clamworms.

Nereidids can be found in a wide variety of habitats, ranging from shallow marine ecosystems estuaries, and freshwater streams to the deep-sea (Bakken *et al.,* 2022; Rouse *et al.,* 2022). Nereidid worms greatly vary in size from a few millimeters in *Micronereis* Claparède, 1863 (Paxton, 1983) to two metres in *Paraleonnatesus chakovi* Chlebovitsch & Wu, 1962 (Khlebovich & Wu, 1962; Hong *et al.,* 2012). These worms have a diverse range of morphological variations, including differences in the pharynx and parapodia, as well as coloration. Some species also exhibit differences in reproductive biology, for example, *Neanthes glandicincta* (Southern, 1921), *Perinereis nuntia var. brevicirris* (Grube 1857) (Yoshida, 1984; Hardege & Bartels-Hardege, 1995; Villalobos-Guerrero & Idris, 2020; Azmi *et al.*, 2021; Wilson *et al.*, 2023). These variations in morphology and biology make the Nereididae a fascinating group of organisms with a wide range of adaptations to different environments.

The family Nereididae currently comprises 45 genera and approximately 719 species (Read & Fauchald, 2023). Furthermore, this family exhibits remarkable diversity in the Indian Ocean, comprising approximately 104 species (Hartman, 1974). Numerous species are used as valuable resources. For example, for fishing bait, aquaculture feed, and as test subjects in various fields such as physiology, endocrinology, and environmental research (Bakken & Wilson, 2005). However, recent taxonomic studies on Nereididae within the Pakistani coastal waters are scarce, notable contributions include a study represented by Aslam *et al.* (2020). So far, only 23 nereididae species from 10 genera, namely *Ceratonereis* Kinberg, 1865*, Leonnates* Kinberg, 1865*, Neanthes* Kinberg, 1865*, Nereis* Linnaeus, 1758*, Namalycastis* Hartman, 1959*, Perinereis* Kinberg, 1865*, Platynereis* Kinberg, 1865*, Tylonereis* Fauvel, 1911*, Pseudonereis* Kinberg, 1865*, Tambalagamia* Pillai, 1961? are known to occur in coastal waters of Pakistan (Kazmi*et al.*, 2022).

The genus *Pseudonereis* Kinberg, 1865 occurs predominantly in tropical and subtropical waters (Bakken, 2007). The genus is characterized by having paragnaths in both the maxillary and oral rings, especially cones or pointed bars (P-bars) arranged in comb-like rows in the maxillary ring, and notopodial dorsal ligules increasing greatly in size toward the posterior end (Fauchald, 1977; Bakken & Wilson, 2005; Villalobos-Guerrero & Idris, 2020; Wilson *et al.,* 2023). Besides the comb-like rows of paragnaths in the areas II–IV, *Pseudonereis* species can have shield-shaped paragnaths in areas VI, and P-bars in the areas II–IV and VII–VIII (Bakken, 2007; Bakken *et al.*, 2009), but the P-bars are also observed in other genera like *Neanthes* (Bakken *et al.*, 2009; Villalobos Guerrero & Carrera-Parra, 2015). Therefore, the comb-like rows in the maxillary ring are the most reliable feature to regard them as congeneric (Bakken & Wilson, 2005; Bakken, 2007; Conde-Vela, 2018; Villalobos-Guerrero & Idris, 2020).

Currently, the genus *Pseudonereis* is comprised of 21 species worldwide (Read & Fauchald, 2024), among which *Pseudonereis anomala* Gravier, 1989, *Pseudonereis gallapagensis* Kinberg, 1865, *Pseudonereis rottnestiana* (Augener, 1913), *Pseudonereis variegata* (Grube, 1857) and *Pseudonereis trimaculata* Horst, 1924 were reported from Indian Ocean (Fauvel, 1953; Wehe & Fiege, 2002; Yousefi *et al.*, 2011), and only two species of the genusare known from Pakistan, e.g. *P.anomala* and *P. variegata* (Siddiqui & Mustaquim, 1988). The present study describes two new records of the family Nereididae; (*P. gallapagensis* and *P. sp.*) from Shamal Bandar, Pasni, along the Makran coast in Pakistan.

2. Materials and methods

Study area. The sampling site, Shamal Bandar (25°14'11"N 63°04'38"E) (Fig. 1), is part of a small shallow bay of the Ras Shamal cape, located at approximately 36 kilometers west of Ras Zarrain and Ras Juddi at Pasni. The sampling area is a combination of sandy and rocky terrain, with rolling rocks, boulders, and pebbles. During low tide on 31 January 2022, an

area approximately 110 meters wide and 590 meters long was monitored.

According to the published literature/information the coast of Makran is one of the few coastlines in the world that experiences high rates of tectonic uplift and exhibits interesting interactions between active sedimentation, erosion and tectonics (Normand *et al.*, 2019). The principal geomorphic features of the Makran coast include cliffs, headlands, stacks, spits, terraces, raised beaches and mud volcanoes. From a geological perspective, the Balochistan (Makran) coast is an active coast that is rising at a rate of 1.5 to 2 mm/year (Page *et al.*, 1979).

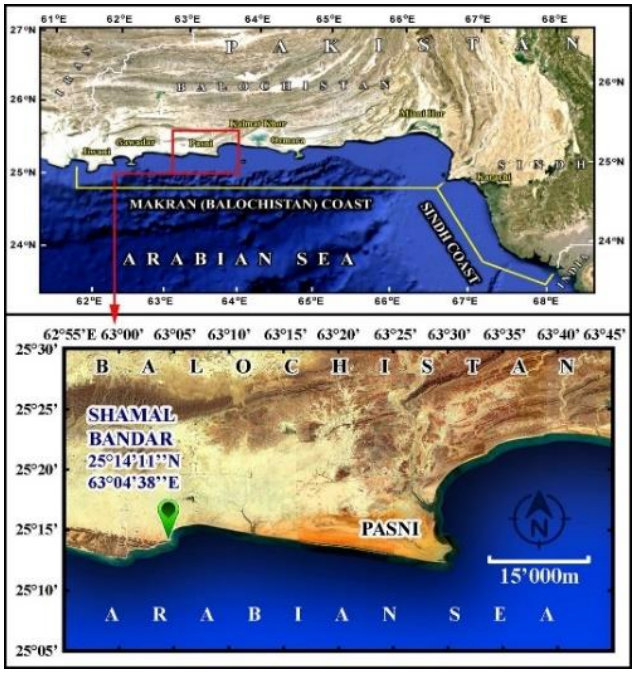

Figure 1. Map of the study area: Shamal Bandar, 25°14'11"N, 63°04'38"E, Pasni, Makran coast, Pakistan

The Makran coastal region is an accretional wedge of deformed sediments that range in age from the late Cretaceous to the recent time. The rocks exposed along the coast, in the headlands, terraces and coastal cliffs, are composed of sandstone, shale and mudstone. These rocks are part of the Late Tertiary formation, which differs in mineral composition from the gypsum-rich series of Loftus. The Makran rocks are also highly fossiliferous.

The climate of the Makran coast is mainly characterized as dry to hyper-dry (Salma *et al.*, 2012) and is strongly influenced by tropical cyclones, winter weather disturbances (cyclonic, anticyclonic, and meridional) in the Mediterranean Sea, the reversal of the monsoon, and the seasonal migration of the Inter-Tropical Convergence Zone (ITCZ). Annual rainfall is less than 254 mm (Snead, 1986; Sheppard *et al.,* 1992; Djamali *et al.*, 2010; Rojas *et al.*, 2013).

Sample collection. Polychaete samples were collected from under the rocks (Fig. 2) using forceps, during a coastal monitoring survey of Makran coast, from December 2, 2021, to October 28, 2022, at low tide (at -0.013 at 15:35). The samples from the intertidal zone of Shamal Bandar (25°14'11"N, 63°04'38"E), Pasni, along the Makran coast (Fig. 1) on January 31, 2022. All samples then were preserved in 5% formaldehyde, washed, arranged and stored in 70% alcohol for further study.

Processing. The specimens were measured using a ruler and photographed using a

camera (FujiFilim 16MP). For species-level identification, the samples were dissected and examined under a stereo-zoom microscope (Wild 181300, Switzerland) at a magnification of 10x50. Temporary mounts of the parapodia were studied under an upright microscope (Nikon LABOPHOT-2) at magnifications of 10x4 and 10x10, and illustrations were made using a drawing tube (camera lucida). The specimens were identified up to the species level using literature and taxonomic keys (Bonyadi-Naeini et al., 2017; Conde-Vela, 2018; Villalobos-Guerrero & Idris, 2020). They were cataloged (MRC&RC-UOK-ANNE-29 and MRC&RC-UOK-ANNE-30), and placed in the Marine Reference Collection and Resource Centre repository at the University of Karachi, Pakistan.

Figure 2. Study area, Shamal Bandar (25°14'11''N 63°04'38''E), Pasni, Makran coast.

3. Results

Taxonomy

ClassPolychaeta Grube, 1850
Subclass Errantia Audouin & Milne-Edwards, 1832
Order Phyllodocida Dales, 1962
Family Nereididae Blainville, 1818
Genus *Pseudonereis* Kinberg, 1865
***Pseudonereis gallapagensis* Kinberg, 1865**
(Figs 3, 4)

Material Examined: 3 specimens (catalogue number MRC&RC-UOK-ANNE-30), Shamal Bandar, 25°14'11''N, 63°04'38''E, collected from intertidal rocky shores, January 31, 2022.

Diagnosis: Total length: 5.2-6.0 cm with 72-80 chaetigers. Brown color in spirit. Body soft, translucent in mid body, pigmentation absent (Fig. 3A). Prostomium as long as wide (Fig. 3B-4B); antennae cirriform, half as long as prostomium, not passing the palps; eyes black, rounded, subequal, in rectangular arrangement. Four pairs of anterior cirri, cirrophores conspicuous, longest one reaching chaetiger 4. Achaetous ring as long as first chaetiger. Pharynx everted (Fig. 3B-C, 4A-C); jaws dark brown, cutting edge dentate. Maxillary ring: I= 2 cones in vertical line; II= 3-3 comb-like rows in triangle; III= 4 comb-like rows in triangle; IV= 5-5 comb-like rows and additional cones, merged cones and P-bars, in sigmoid (Fig. 3B-

C, 4C-D). Oral ring: V= 1 cone; VI=1-1 large transversal paragnath; VII–VIII= one furrow row with 12 P-bars and one ridge row with 9 cones in a single band, rows vertically displaced; furrow and ridge regions with one paragnath.Each parapodia (Fig. 3E, 4D-F), in the central region have digitiform dorsal cirrus two black acicules and short ventral cirrus. Dorsal cirri longer than notopodial dorsal ligules in anterior region, becoming shorter toward posterior end; basally inserted to dorsal ligules in most anterior segments (chaetiger 10 to chaetiger 14), displaced medially in medial segments, subdistal in posterior segments and distal in posterior ones, extending beyond notopodial dorsal ligules throughout body. Ventral cirri subequal and basally inserted to neuropodial ventral ligules throughout body. In anterior chaetigers, dorsal cirrus medial, 1.2 times longer than notopodial dorsal ligule. In middle chaetiger, dorsal cirrus medial, as long as notopodial dorsal ligule.In posterior chaetigers, dorsal cirrus distal. The notopodial homogomphspiniger with lightly serrated blade, evenly spaced (Fig. 3H, 4J), the neuropodial heterogomph falcigers with internal teeth and the heterogomph falcigers with a long blade, supraacicular falciger stouter than sub-acicular ones (Fig. 3F, 4G-I). Pygidium crenulated; anal cirri cirriform (Fig. 3D).

Habitat: Rocky intertidal area.

Distribution: Galapagos Islands and Baja California in the Pacific Ocean, Caribbean Sea, South Africa, Madagascar, and Red Sea (Bakken, 2007).

Pseudonereis sp.

(Figs5,6)

Material Examined: 1 specimen(catalogue number MRC&RC-UOK-ANNE- 29), Shamal Bandar, 25°14'11''N, 63°04'38''E, collected from intertidal rocky shores, January31, 2022.

Diagnosis: Total body length 3 cm, with 48 chaetigers. Light brown colour in spirit. Body elongated and cylindrical (Fig. 5A), with coloration having light brown. Frontal antennae present, 1 pair, cirriform. Prostomium (Fig. 6B), with entire anterior margin. Eyes present, 2 pairs in trapezoidal arrangement. Achaetous ring greater than the length of chaetiger 1. Tentacular cirri with distinct cirrophores, longest tentacular cirri extend back to chaetiger 5–7. Jaws with dentate cutting edge, brown, with 5–6 teeth. Maxillary ring of pharynx with paragnaths (Fig. 6B-C), arranged in discrete areas, Areas II–IV arranged in regular comb-like rows. Area I = 1 conical paragnaths, in a longitudinal row when 2; Area II = 23–38 p-bar paragnaths in 4 rows; Area III = 60 p-bar paragnaths in 4 rows; Area IV = 78– 72 including p-bar paragnaths in 4 rows additional cones and 2–4 p-bars towards jaws. Oral ring paragnaths are present, and Area V and VI present as distinct groups. Area V = 3 large conical paragnaths present, arranged in a triangular pattern; Area VI = cones present forming a shield shape appearance. Area VII–VIII = 24 large conical paragnaths of similar size and interspersed p-bars present in two alternating rows. Notopodium with dorsal notopodial ligule digitiform rounded as long as ventral neuropodial ligule in anterior chaetiger 12 (Fig. 6E, 6D). Mid-body parapodia, chaetiger 30 having intermediate form (Fig. 6E). Posterior chaetiger 56, notopodial ligules larger and longer than anterior ones (Fig. 6F). Neuropodial inferior lobe prominent in anterior chaetigers, a small superior lobe present. Neuropodial post-chaetal lobe present. Notochaetae: homogomph spinigers present (Fig.5G, 6I-H). Neurochaetae, dorsal fascicle: homogomph spinigers with lightly serrated blades throughout the body (Fig. 6I-H), heterogomph falcigers on anterior and posterior (Fig. 5F-G, 6G-H) chaetigers present, blades serrated. Neurochaetae, ventral fascicle: heterogomph spinigers present from about chaetiger 30 (Fig. 6G), heterogomph falcigers with short blades present throughout. Pygidium crenulated; anal cirri cirriform (Fig. 5D).

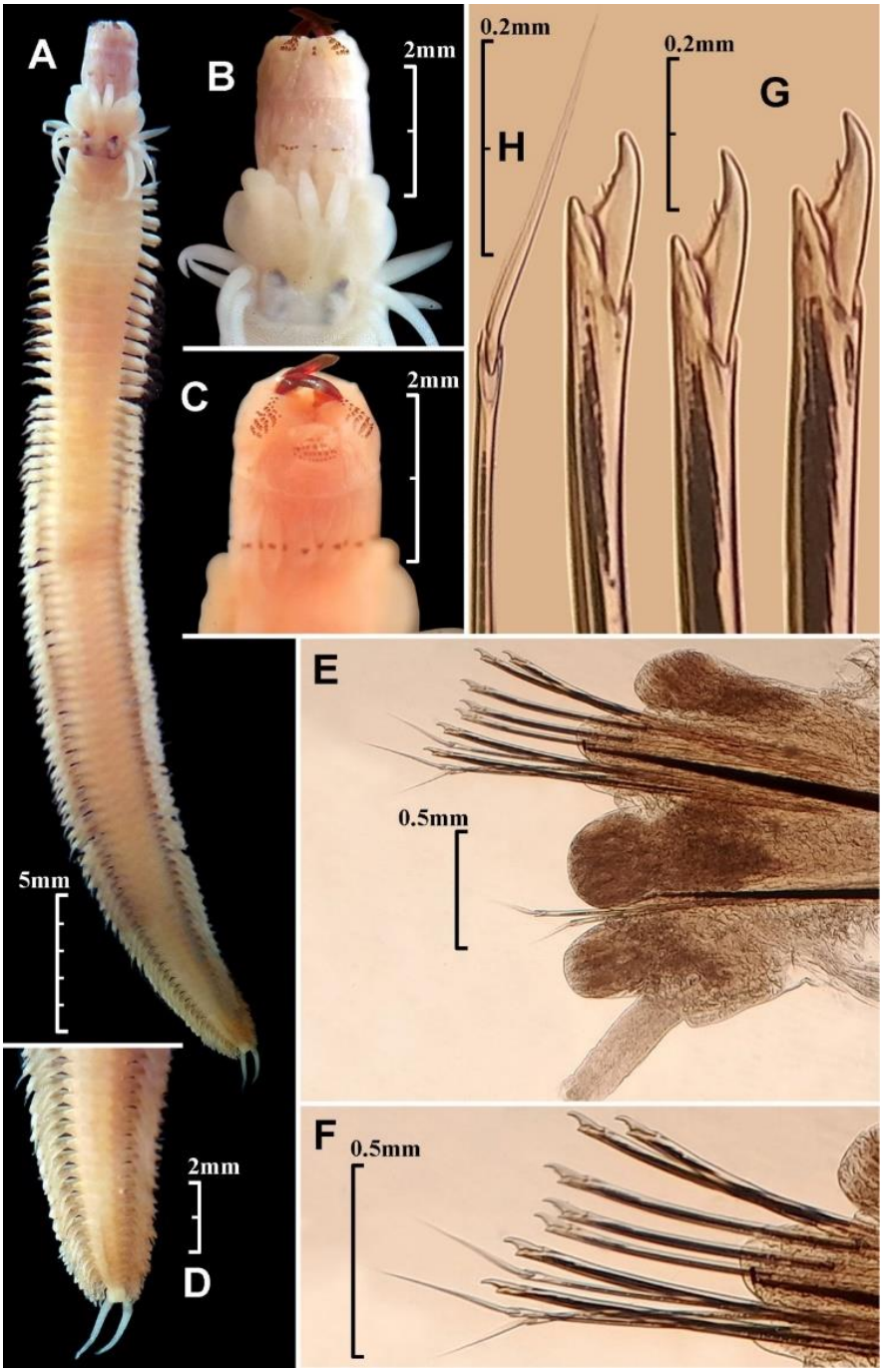

Figure 3. *Pseudonereis gallapagensis* Kinberg 1865: **A,** general dorsal view;**B,** Anterior end, Pharynx, dorsal view; **C**, Pharynx, ventral view; **D**, Posterior end, dorsal view; **E**, Chaetiger 15, left parapodium; **F**, **H**eterogomph falcigers with a long blade, chaetiger 15; **G,** Sub-acicular heterogomph falcigers, chaetiger 30**; H,** Notopodial homogomph spinigers, chaetiger 30.

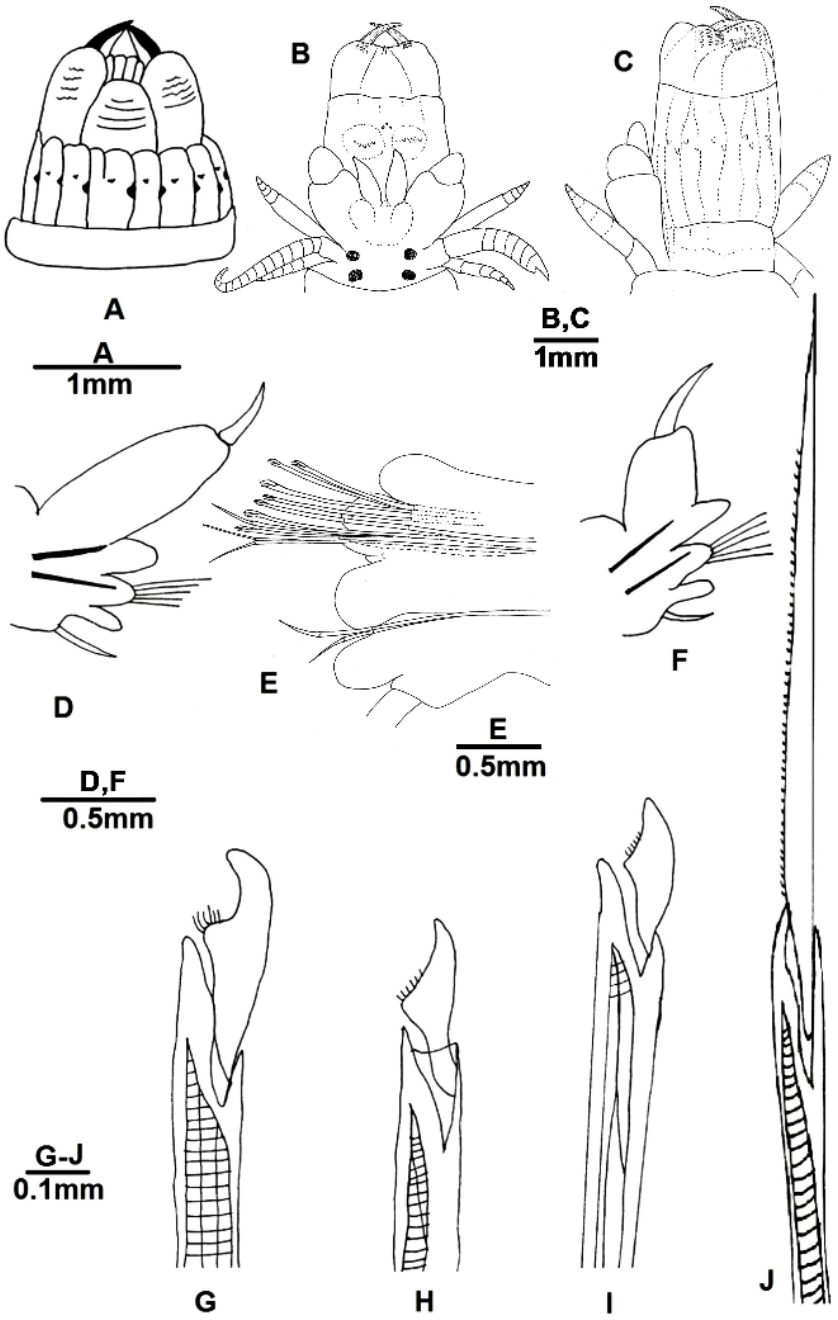

Figure 4. *Pseudonereis gallapagensis* Kinberg 1865: **A,** Pharynx, ventral view; **B**, Anterior end, dorsal view; **C**, Pharynx ventral view; **D**, Chetiger30, left parapodia; **E,** Chaetiger 15, left parapodium; **F,** Chetiger 40, left parapodia **G-I**, Sub-acicular heterogomph falciger, chaetiger 30; **J**, Notopodial homogomph spinigers, chaetiger 30.

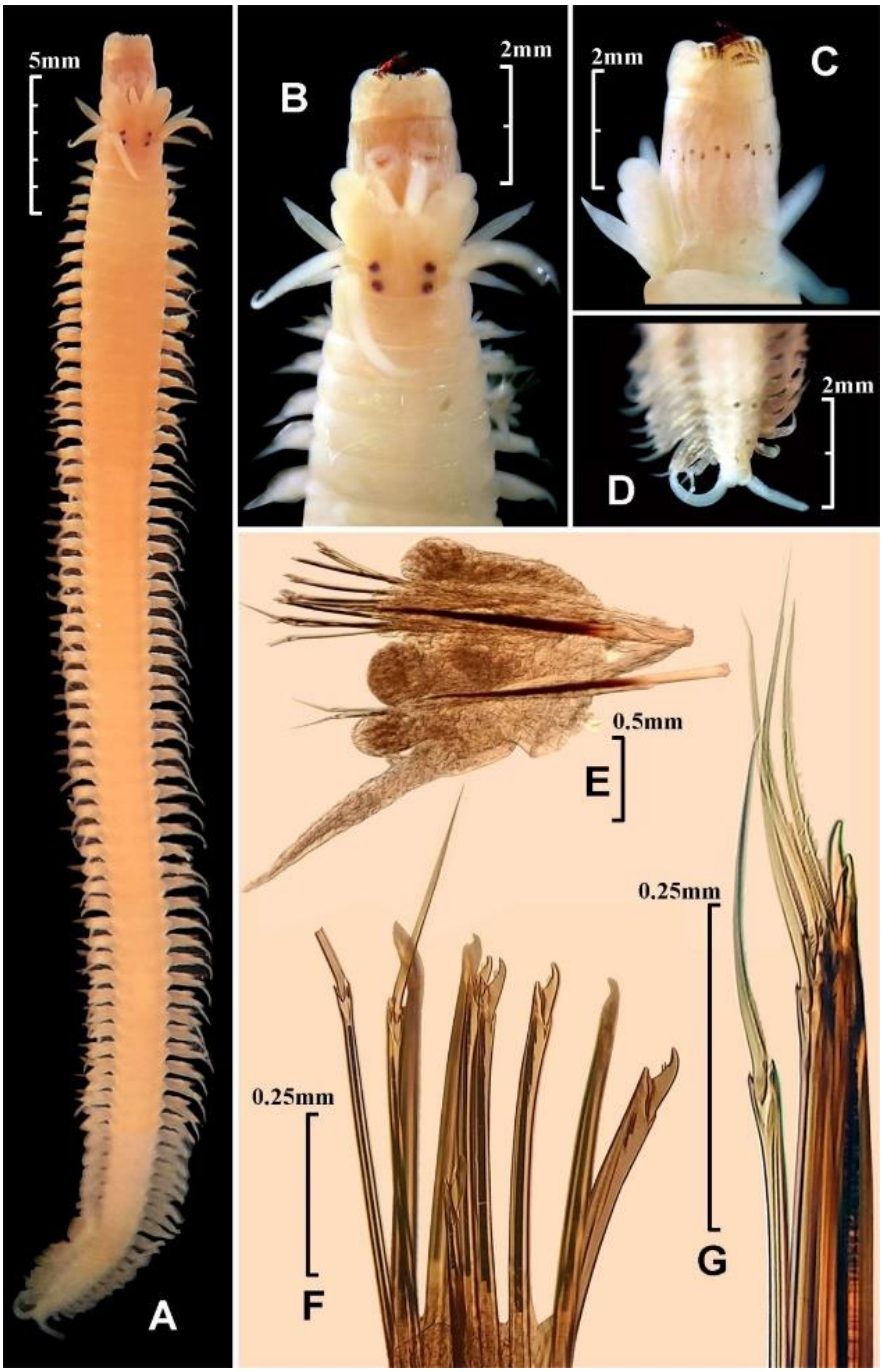

Figure 5. *Pseudonereis* sp.: **A**, general dorsal view; **B,** Anterior end, Pharynx, dorsal view; C, Pharynx, ventral view; **D**, Posterior end, dorsal view; **E**, Chaetiger 12, left parapodium; **F**, Subacicular heterogomph falcigers, chaetiger 30; **G,** Heterogomph falcigers with a long blade with notopodial homogomph spinigers chaetiger 30.

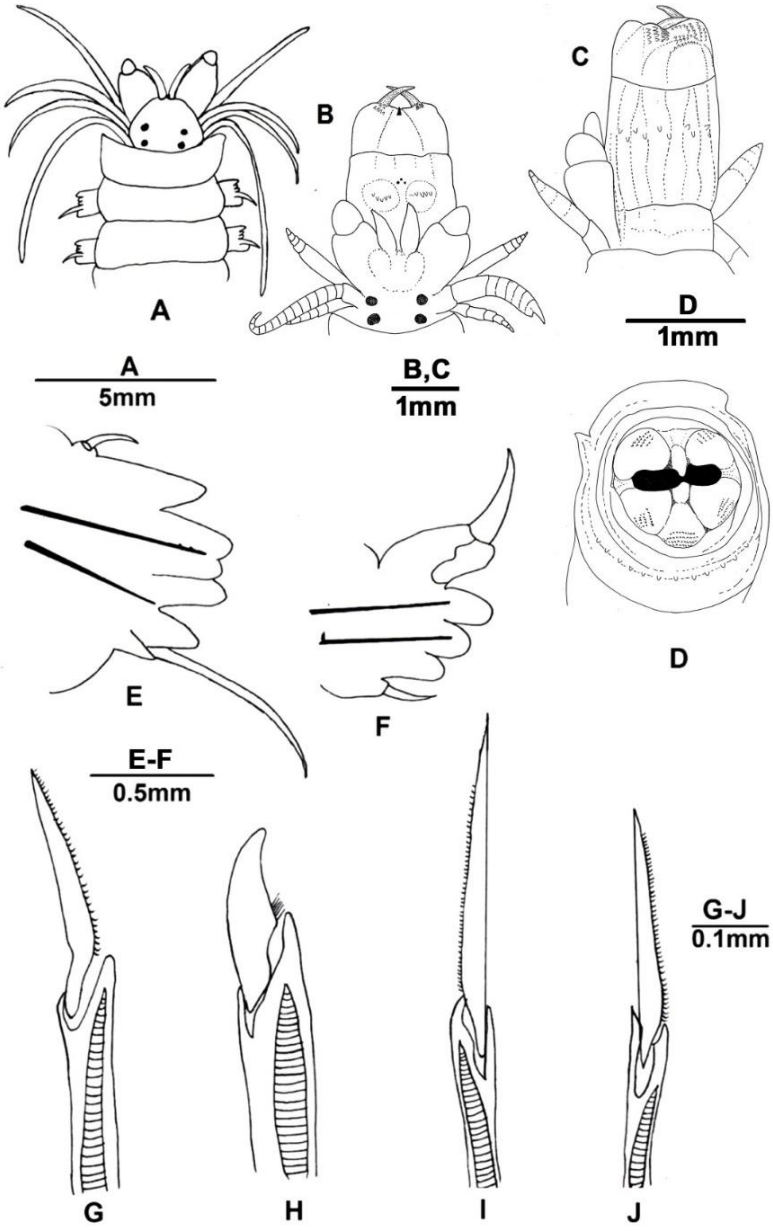

Figure 6. *Pseudonereis* sp.: **A,** Anterior body, dorsal view; **B**, Paragnaths of the pharynx, dorsal view; **C**, Paragnaths of the pharynx, ventral view; **D,** Paragnaths of the pharynx, frontal view; **E- F** Chaetiger 12, 30, 56, left parapodia; **G,** Heterogomph spiniger neuropodial ventral fascicle, chaetiger 30; **H,** Heterogomph falciger neuropodial dorsal fascicle, chaetiger 30; **G-J,** Homogomph spiniger neuropodial dorsal fascicle, chaetiger 30.

Habitat: Boulder and sandy-rocky shore habitats.

Distribution: Shamal Bandar (Present study)

Remarks: The studied specimen was found morphologically similar to the description documented by (Bakken, 2007; Yousefi *et al.*, 2011; Hsueh, 2019) except for area VI; have cones rather than shield shaped bars in our specimen collected from Shamal Bandar, Pakistan. The specimen described in the present study has a close resemblance to *Pseudonereis anamola* but could be differentiated with the presence of 3 cones forming triangle in area V as present in the specimen studied by Fauvel, 1953; Siddiqui & Mustaquim, 1988. The studied specimen was distinguished from the specimens found in the Arabian Sea which is why could not place this specimen to the lowest possible taxonomic level.

4. Discussion

Only two species of the genus *Pseudonereis*, namely *Pseudonereis variegata* (Grube, 1857) and *Pseudonereis anomala* Gravier, 1899*,* have been reported from Pakistan waters before the present study (Siddiqui & Mustaquim, 1988). The study represent two more species of the genus: *Pseudonereis gallapagensis* Kinberg 1865 and *Pseudonereis sp.*

The original description of *P. gallapagensis,* represented by Kinberg (1865) is quite brief and mainly focuses on the head structure. The detailed figures of the anterior end, the pharynx, a parapodium from chaetiger 10, a spiniger, and a falciger were added in a later publication (Kinberg, 1910). Hartman, (1948) described the distal attachment of dorsal cirri in posterior chaetigers, as well as the presence of spinigers and falcigers in neuropodia, referring to previous redescriptions from Peru by Gravier, (1909) and the Gulf of Guinea by Fauvel, (1914). Bakken, (2007) re-described *P. gallapagensis* based on the type material of the species. The features discussed by Bakken (2007) for *P. gallapagensis*, such as the patterns of paragnaths in different areas of the pharynx, can be seen, but it is not possible to count the numbers of these features. One heterogomph spiniger was observed in ventral fascicle in mid-body and posterior chaetigers.

Pseudonereis gallapagensis is most closely related to *Pseudonereis variegata* and *Pseudonereis atopodon* Chamberlin, 1919, but can be distinguished from *P. variegata* by the longer dorsal cirrus, ventral neuropodial ligule, which is up to half the length of the acicular ligule in the posterior chaetiger (opposed to as long as the acicular ligulein *P. variegata*), compared to the same length as in *P. variegata*. Furthermore, *P. gallapagensis* has fewer paragnaths in area IV than *P. variegata*. Areas VII-VIII in *P. variegata* have at least double the number of paragnaths and these are arranged in a double row when compared to *P. gallapagensis* (Conde Vela, 2018).

Rozbaczylo & Bolados (1980) provided a brief description of *P. gallapagensis* from Iquique, in northern Chile, which included some differences from the description presented above. Area I has one paragnath. The Iquique specimens, whereas it has two paragnaths in our specimens. Furthermore, in Iquique specimens, regions VI have crescent-shaped bars, whereas the specimens studied by us have large transversal paragnath. Furthermore, ventral cirri are longer than neuropodial ventral ligules until the third posterior of the body in the specimens from Iquique, whereas they are shorter in our specimens. Finally, neuropodial heterogomph spinigers in sub-acicular fascicles were not observed in Iquique specimens, although they were observed in the studied specimens from the middle chaetigers. As a result, the specimens from Iquique most likely belong to a distinct species, but not to *P.*

gallapagensis. The present study and Ramírez *et al.* (2012) exhibit notable similarities in general parapodial morphology and chaetal arrangement. Both studies describe digitiform dorsal cirri, two black aciculae, and short ventral cirri in the central parapodial region. However, discrepancies emerge in the paragnath patterns. While both descriptions report conical paragnaths on area I and pectinate bars in areas II-IV, the alignment and number of rows differ slightly. Conde Vela's (2018) description closely matches the present study in prostomium proportions, cirri arrangement, and paragnath patterns. Both studies document antennae that are cirriform and half the length of the prostomium, with anterior cirri reaching chaetiger 4. Pharyngeal paragnath patterns are strikingly similar, particularly in the maxillary ring and oral ring, with comparable arrangements in areas VII and VIII. However, Conde Vela notes a slight variation in the dorsal cirri pattern, with the posterior cirri extending further beyond notopodial ligules, whereas the present study reports a gradual shortening toward the posterior end.

The studied specimen of *Pseudonereis* sp. was found morphologically similar to the description documented by Bakken, 2007; Yousefi *et al.*, 2011; Hsueh, 2019 except area VI; has cones rather than shield shaped bars in our specimen collected from Shamal Bandar, Pakistan. The specimen described in the present study has a close resemblance to *Pseudonereis anamola* but could be differentiated with the presence of 3 cones forming triangle in area V as present in the specimen studied by Fauvel, 1953; Siddiqui & Mustaquim, 1988. Our studied specimen shows resemblance to *P. trimaculata* with brown colored 5–6 teeth and three conical parapodia in Area V, while other taxa in this group have a single large parapodium. However, the species described above from Pakistan is highly similar to *P. trimaculata* from intertidal habitats in the Gulf of Oman, Iran (after Yousefi *et al.,* 2011) and from eastern Indonesia and north-west Australia (Bakken, 2007). The studied specimen was distinguished with the specimens found in the Arabian Sea that's why could not place this specimen to lowest possible taxonomic level.

It is also worth noting specifically that it is very likely that we are dealing with the complexes of cryptic or pseudocriptic species within *Pseudonereis,* where these morphological differences may be unique to certain geographic locations. Additional DNA data may further support this hypothesis in future studies.

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Conflict of interests

The authors declare that they have no competing interests.

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