

PRELIMINARY ASSESSMENT OF THE SPECIES OF *MARPHYSA* (ANNELIDA: POLYCHAETA: EUNICIDAE) WITH POTENTIAL ECONOMIC INTEREST

CHE ENGKU SITI MARIAM CHE-ENGKU-ABDULLAH¹, PAT HUTCHINGS^{2,3,4}, AFIQ DURRANI MOHD FAHMI⁵, TURNI HANDAYANI⁶ AND IZWANDY IDRIS^{7*}

¹Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia. ²Australian Museum Research Institute, Australian Museum, 1 William Street, Sydney, 2010 Sydney, New South Wales, Australia. ³Marine Ecology Group, School of Natural Sciences, Wallumattagal Campus, Macquarie University, 2109 Sydney, New South Wales, Australia. ⁴School of Life and Environmental Sciences, The University of Sydney, 2006 New South Wales, Australia. ⁵Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia. ⁶Blue Archipelago Bhd., Bandar Permaisuri, 22100 Setiu, Terengganu, Malaysia. ⁷South China Sea Repository and Reference Centre, Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.

*Corresponding author: izwandy.idris@umt.edu.my

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Abstract: Annelid polychaetes from several families are commercially exploited as fishing bait or food supplements for crustacean and finfish brood stock. Due to their large adult sizes and ease of collection, these commercially valuable polychaetes are traded internationally. Despite the growing knowledge of polychaetes as marine resources, some species remain unexploited, including those belonging to *Marphysa* (Annelida: Polychaeta: Eunicidae), with only 16% of species recorded as commercially exploited. Accordingly, a thorough analysis of more than 90 papers revealed 10 more species of *Marphysa* potentially fulfilling these criteria required to be suitable for commercial exploitation.

Keywords: Polychaeta, *Marphysa*, bloodworms, baitworms, commercial application, sustainable harvesting.

Introduction

Some species of polychaetes are among the most heavily harvested marine invertebrates (Cabral *et al.*, 2019), being most often collected in sediment ranging from muddy to coarse sand in intertidal coastal areas and estuaries. Notably, they have a substantial economic value as live fishing baits and food supplements in aquaculture (Pombo *et al.*, 2018; Cabral *et al.*, 2019; Simon *et al.*, 2021; Hutchings *et al.*, 2024). Globally, species of Arenicolidae, Glyceridae, Lumbrineridae, Nereididae, Nephthyidae, Onuphidae, and Eunicidae are among the most widely exploited as fish baits (Cole *et al.*, 2018; Pombo *et al.*, 2018; Cabral *et al.*, 2019; Simon *et al.*, 2021). Hence, it has led to some attempts to develop polychaetes cultures in Europe, Asia, and Australia, with high demand for fishing baits and aquaculture food supplements (Pombo *et al.*, 2018). For example, the nereidids *Alitta virens* (M. Sars, 1835) and *Perinereis brevicirrata* (Treadwell, 1920), and the onuphid *Diopatra aciculata* (Knox & Cameron, 1971) are farmed for local use and export (Watson *et*

al., 2017; Cole *et al.*, 2018; Pombo *et al.*, 2018). Apart from their large and firm body, which indicates that fishing hooks are retained (Martin *et al.*, 2020), these species also have nutritional components. This includes Polyunsaturated Fatty Acids (PUFA) or omega-3, which play a key role in gonad maturation, diet improvement, and larval survival in cultured fish, shrimps, and other crustaceans (Pombo *et al.*, 2018; Martin *et al.*, 2020; Estante-Superio *et al.*, 2023).

Within Eunicidae, several species of *Marphysa* (Quatrefages, 1865) are commonly harvested for sale as fishing bait for recreational fishing (Lavesque *et al.*, 2017; Liu *et al.*, 2018; Wang *et al.*, 2018; Martin *et al.*, 2020; Hutchings *et al.*, 2024). The species of *Marphysa*, also known as bloodworms, occur worldwide in a wide range of habitats, ranging from soft sediments to rocky grounds, and from intertidal to deep water. It is also predominantly found in estuarine or sheltered habitats (Zanol *et al.*, 2016; Martin *et al.*, 2020; Lavesque *et al.*,

2022). The type species *Marphysa sanguinea* was described as *Nereis sanguinea* by Montagu (1813) based on a specimen collected from the rocky coasts of Devonshire, England (Hutchings & Karageorgopoulos, 2003). At present, *Marphysa* consists of 89 species, the second most speciose genus in Eunicidae, after *Eunice* Cuvier, 1817 (Read & Fauchald, 2024).

Marphysa is characterised by having a single or bilobed prostomium, five prostomial appendages without articulations, maxillary apparatus with four pairs of maxillae and one unpaired on the left side, peristomium without peristomial cirri, and the presence of branchiae on some chaetigers (Molina-Acevedo & Carrera-Parra, 2017; Molina-Acevedo & Idris, 2020, Lavesque *et al.*, 2022). The genus includes five species groups based on the presence or absence of different types of subacicular compound chaetae: Group A (*mossambica*), without compound chaetae; Group B (*sanguinea*), with only compound spinigers; Group C (*aenea*), with only compound falcigers; Group D (*belli*), with both compound spinigers and falcigers; and Group E (*gravelyi*), with only compound spinigers and limbate subacicular chaetae present in the anterior and posterior chaetigers (Fauchald, 1970; Glasby & Hutchings, 2010; Molina-Acevedo & Idris, 2021).

Some species of *Marphysa* are key bioindicators widely used in environmental monitoring (Mdaini *et al.*, 2022). Other species are also used as a food supplement to improve the hatchery performance of the Indian white shrimp, *Penaeus indicus* Milne Edwards, 1837, due to their high content of protein, PUFA, and other hormonally active compounds. Meanwhile, those extracted from *M. moribidii* Idris, Arshad & Hutchings, 2014 seem to be useful for wound healing and bio-catalyst of gold and silver nanoparticles (Ee Pei *et al.*, 2020; Rapi *et al.*, 2020; Rosman *et al.*, 2020; Ibrahim *et al.*, 2022).

There may be many more species of *Marphysa* of economic interest. However, they are still unknown due to the lack of information and taxonomic identifications. In this review,

we examine the species of *Marphysa* known to date as having commercial applications while highlighting other species that potentially could be used.

Methodology

This study follows a systematic search process based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline (Moher *et al.*, 2010). In particular, this review aims to identify commercially known species of *Marphysa* and list other large-sized *Marphysa* species that should also be investigated.

Data Collection

From January 2021 to June 2024, various search engines are utilised (Google Scholar, World Register of Marine Species (WoRMS), Scopus, Web of Science, Science Direct, and Biodiversity Heritage Library) to obtain the existing information on currently valid species of *Marphysa*. Furthermore, these reference terms are also used: *Marphysa*, fish bait, marine annelids, marine worms, polychaete aquaculture, bloodworms, and authors' names to obtain details on their habitat, body size, and potential commercial application from the original descriptions and current published papers (unknown data indicated with a question mark).

Accordingly, this search identified 2,753 records. After removing duplicates with similar titles, a total of 2,432 unique publications from the various sources mentioned above were included for screening. Note that records without full text were excluded (n = 1,560). In addition, articles related to the species' original description, their habitat, and global distribution, as well as their commercial exploitation and other potential uses are considered to be utilised for this work. Hence, articles with irrelevant topics or abstracts were removed from the remaining records. Ultimately, 93 reports and studies were included in this review. The overview of the data collection process is summarised in the PRISMA chart in Figure 1.

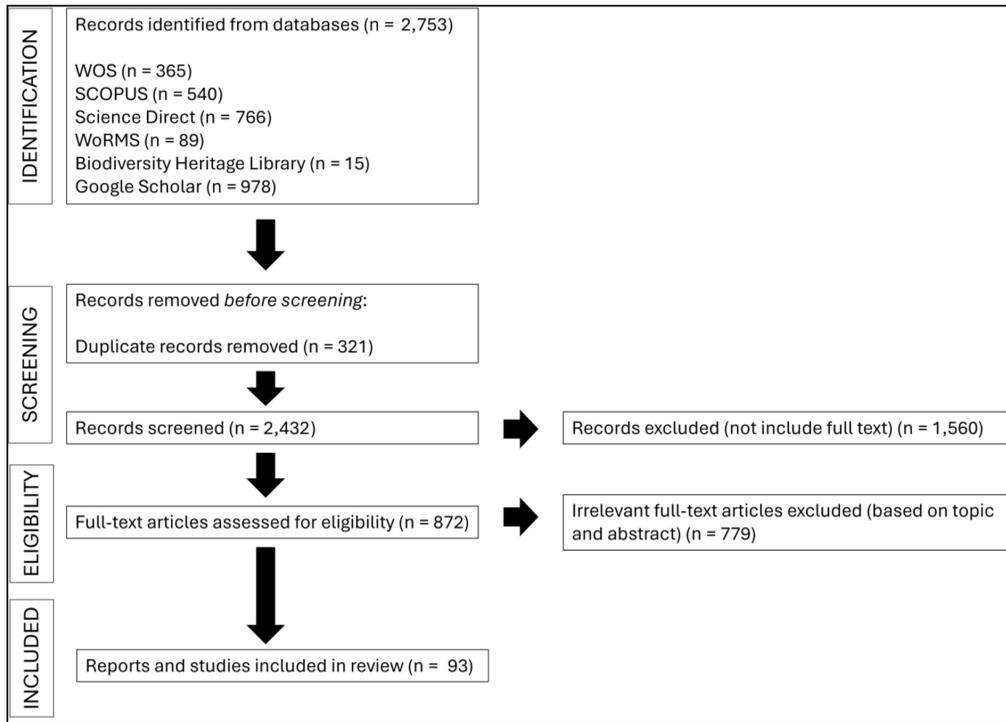


Figure 1: Data collection process of accepted *Marphysa* species in the literature using the PRISMA technique (modified from Moher et al., 2010)

We have sorted the existing information in the literature on the species of *Marphysa* to build a list of large-sized species to analyse their potential commercial use. The list of currently accepted and verified species was downloaded from the World Polychaete Database (www.marinespecies.org/polychaeta) (Read & Fauchald, 2024) as an offshoot of the WoRMS to build a database from January 2021 to June 2024. This includes the current status, correct spelling, records, and authorities (Read & Fauchald, 2024). Additionally, all species were sorted according to five morphological groups mentioned in the introduction following Fauchald (1970) and Glasby and Hutchings (2010), with the chaetal types extracted from the original descriptions.

The characteristics determining the species with potential commercial interest (e.g., body size, habitat accessibility) following Pombo et al. (2018). Total Length (TL), length to chaetiger

10 (L10), and width (at the widest chaetiger or chaetiger 10 (W10) with or without parapodia in millimetres were compared with the smallest size of a known species of *Marphysa* harvested for commercial use. Overall, intertidal species were considered easy to harvest while subtidal species were regarded as unsuitable. Meanwhile, species lacking body size and habitat data in their original description were not included until additional information became available.

Results

We identified 89 accepted species of *Marphysa*, with the *sanguinea* group emerging as the dominant subgroup, comprising 50 species. Correspondingly, 24 of the 89 (27%) currently accepted species of *Marphysa* exhibit large body sizes and inhabit intertidal zones (highlighted in bold in Table 1). Among these, only 14 species are currently exploited (Table 2), with sizes

Table 1: List of accepted species of *Marphysa*. Abbreviations: L10: Length to chaetiger 10; W10: Width at chaetiger 10; TL: Total body length; TW: Total body width; ?: Data not available. Bold characters: species with potential for commercial use

Species Group	Species	Type Locality (TL) and Habitat	Tidal Characteristics	Largest Size (Mm)	Commercial Use
A (<i>mossambica</i>)	<i>M. fijiensis</i> (Molina-Acevedo & Idris, 2021)	Suva Harbour, Fiji (possibly coral reefs or mudflats)	Subtidal	L10: 8.2 W10: 2.5	?
	<i>M. kertehensis</i> (Che-Engku-Abdullah, Idris, Fahmi, Flaxman & Hutchings, 2024)	Kerteh River, Malaysia (in slightly gravelly muddy sand and driftwood)	Intertidal	L10: 12 W10: 4.8	?
	<i>M. moribidii</i> (Idris, Hutchings & Arshad, 2014)	Morib mangrove, Malaysia (in mangrove areas with <i>Rhizophora</i> spp., <i>Avicennia alba</i> , and <i>Sonneratia caseolaris</i>)	Intertidal	L10: 20 W10: 8.2	- Fishing bait - Wound healing product (Rapi <i>et al.</i> , 2020) - Bio-catalyst for gold and nanoparticles (Ee Pei <i>et al.</i> , 2020; Rosman <i>et al.</i> , 2020; Ibrahim <i>et al.</i> , 2022)
B (<i>sanguinea</i>)	<i>M. mossambica</i> (Peters, 1854)	Mozambique (common in the sand on the coast)	Intertidal to 30 cm depth	L10: 11.5 W10: 8.1	Fishing bait (Zanol <i>et al.</i> , 2016; Martin <i>et al.</i> , 2020)
	<i>M. acicularum</i> (Webster, 1884)	Bermuda, British Overseas Territory (muddy sediment and coralline rocks)	Intertidal	L10: 15.8 W10: 5.2	?
	<i>M. aegypti</i> (Elgetany, El-Ghobashy, Ghoneim & Struck, 2018)	AI Ferdan, Suez Canal off Alexandria, Egypt (mud flats)	Intertidal to 5 m depth	W10: 6	Fishing bait
	<i>M. americana</i> (Monro, 1933)	Pacific Panama (inshore pools)	Intertidal	L10: 12 W10: 5.8	?
	<i>M. aransensis</i> (Treadwell, 1939)	Port Aransas, Texas, USA	Intertidal	L10: 6.5 W10: 3	?

<i>M. banana</i> (Lavesque, Daffe, Glasby, Hourdez & Hutchings, 2022)	South Pacific Ocean, Papua New Guinea	Deep sea: 273 m - 324 m	TL: 71-157 W10: 2.1-5.4	?
<i>M. baileybrockae</i> (Molina-Acevedo & Idris, 2020)	Honolulu, Hawaii, USA (coral sand)	Subtidal	L10: 11.7 W10: 3.8	?
<i>M. baudini</i> (Lavesque, Zanol, Daffe, Flaxman & Hutchings, 2023)	Port River, Adelaide, Australia (sandy mud)	Intertidal	TL: 116 W10: 9.5	?
<i>M. bernardi</i> (Rullier, 1972)	New Caledonia, French Overseas Territory	?	TL: 8	?
<i>M. birgeri</i> (Molina-Acevedo & Idris, 2020)	Trieste and Cres Island, Adriatic Sea (port area)	Subtidal	L10: 10.4 W10: 4.8	?
<i>M. borradalei</i> (Pillai, 1958)	Negombo Lagoon, Sri Lanka (burrowing in brackish water of mangrove swamps)	Intertidal	?	?
<i>M. brasiliensis</i> (Hansen, 1882)	Brazil	?	TL: 100 TW: 5-6	?
<i>M. brevibranchiata</i> (Treadwell, 1921)	Bermuda, British Overseas Territory (mud flats, in Flatts Inlet, Ely's Harbor, and Fairyland Creek)	Intertidal	L10: 14.2 W10: 4	?
<i>M. brevitentaculata</i> (Treadwell, 1921)	Tobago, Quintana Roo, Mexico Bermuda, British Overseas Territory (mud flats)	Intertidal	L10: 10 W10: 3.6	?
<i>M. californica</i> (Moore, 1909)	San Diego County, California, USA (sand bar)	Intertidal	L10: 19 W10: 10.3	?
<i>M. chirigota</i> (Martín, Gil & Zanol, 2020)	Cádiz Bay, Spain (sandy shores, 10 cm depth in soft sediment)	Intertidal	TL: 265 TW: 7.9	Fishing bait
<i>M. durbanensis</i> (Day, 1934)	Durban, South Africa (between the tidemarks in Durban Bay and Umkomaas)	Intertidal	L10: 14 W10: 3.6	?

B (*sanguinea*)

<i>M. fauchaldi</i> (Glasby & Hutchings, 2010)	Ardatek Barrumundi Farm, NT, Australia (mangrove mud, mud in <i>Rhizophora</i> spp., zone)	Intertidal	TL: 190 TW: 6	?
<i>M. furcellata</i> (Crossland, 1903)	Zanzibar, Tanzania (between tide marks near the town, Zanzibar Channel, the bottom being mud)	Intertidal	TL: 40-120 TW: 4	?
<i>M. gaditana</i> (Martin, Gil & Zanol, 2020)	Cadiz Bay, Spain (muddy shore)	Intertidal	TL: 121.7 TW: 6.5	Fishing bait
<i>M. gayi</i> (Quatrefages, 1866)	Lima, Peru, or Valparaiso, Chile	?	?	?
<i>M. haemasona</i> (Quatrefages, 1866)	Cape of Good Hope, South Africa (burrows in sediment typically grey/black medium to coarse grains and rich in sulphur, sandy sediment, sand burrows under boulders, lower intertidal zones of sheltered bays and in rock pools, burrows up to 1 m deep)	Intertidal	L10: 12.3 W10: 7	Fishing bait (Simon <i>et al.</i> , 2019; Kara <i>et al.</i> , 2020)
<i>M. hongkongensa</i> (Wang, Zhang & Qiu, 2018)	Tolo Harbour, Hong Kong, China (sandy shores)	Intertidal	L10: 11 W10: 5.3	?
<i>M. iloiloensis</i> (Glasby, Mandario, Burghardt, Kupriyanova, Gunton & Hutchings, 2019)	Tigbauan, Iloilo Province, Philippines (soft, fine, and muddy sediment in aquaculture tanks, brackish water milkfish ponds, and mangrove areas adjacent to discharge/intake points)	Intertidal	W10: 2.6	?
<i>M. januarii</i> (Grube, 1881)	Tobago Island, Trinidad, and Tobago	?	TL: 80 TW: 9	?
<i>M. johnsoni</i> (Langerhans, 1880)	Madeira, Portugal	?	TL: 10	?
<i>M. kristiani</i> (Zanol, da Silva & Hutchings, 2016)	Cowan Creek, NSW, Australia (in muddy sediment)	Intertidal to 12 m deep on mudflats	L10: 13	?

B (*sanguinea*)

<i>M. leidi</i> de (Quatrefages, 1866)	Great Egg Harbor, New Jersey, USA (under stones, oyster bed at low-water mark, more common on shelly bottoms in shallow water offshore, stiff clay)	Intertidal	L10: 17 W10: 5.3	?
<i>M. macintoshi</i> (Crossland, 1903)	Zanzibar, Tanzania (in sand between tide marks on both east and west coasts)	Intertidal	L10: 8.1 W10: 2.7	?
<i>M. mangeri</i> (Augener, 1918)	West Africa, Atlantic Ocean	?	TL: 36 TW: 2	?
<i>M. merchangensis</i> (Che-Engku-Abdullah, Idris, Fahmi, Flaxman & Hutchings, 2024)	Merchang mangrove estuary, Malaysia (in gravelly and slightly gravelly sand, burrowing in decayed roots of the mangrove <i>Exocoecaria agallocha</i> (Malay: Bebuta), and in the sediments within an area populated with <i>Talipariti tiliaceum</i>)	Intertidal	TL: 5.25 W10: 2.85	?
<i>M. minima</i> (Hansen, 1882)	Brazil	?	?	?
<i>M. mullawa</i> (Hutchings & Karageorgopolous, 2003)	Moreton Bay, Fisherman's Island, Qld, Australia (mudflats and seagrass beds)	Intertidal to 12 m deep mudflats	TL: > 140 TW: 10	Fishing bait
<i>M. multiplectinata</i> (Liu, Hutchings & Sun, 2017)	Shimen, Republic of China (Taiwan)	Intertidal	L10: 15.25 W10: 4.6	?
<i>M. mizingazia</i> (Kara, Molina-Acavedo, Macdonald, Zanol & Simon, 2023)	KwaZulu-Natal, South Africa (in crevices of muddy rocks) on banks of the Mzingazi canal	Intertidal	L10: 4 W10: 3	?
<i>M. nobilis</i> (Treadwell, 1917)	Florida, USA (in sand and sediment with seagrass)	Intertidal (extreme low tide)	L10: 13.6 W10: 6.5	?
<i>M. orientalis</i> (Willey, 1905)	Cheval Paar, Gulf of Manaar, Sri Lanka	?	TL: 21 TW: 1	?

B (*sanguinea*)

<i>M. parishii</i> (Baird, 1869)	Brazil	?	L10: 17.2 W10: 9.5	?
<i>M. peruviana</i> (Quatrefages, 1866)	Lima, Peru	?	?	?
<i>M. regalis</i> (Verill, 1900)	Bermuda, British Overseas Territory	?	L10: 10 W10: 7	?
<i>M. sanguinea</i> (Montagu, 1813)	South coast of Devonshire, England (in mud and gravel at low water mark, in burrows in rock crevices)	Intertidal	L10: 20.4 W10: 11	Fishing bait
<i>M. schmardai</i> (Gravier, 1907)	Lima, Peru	?	TL: 15 TW: 1	?
<i>M. setiuensis</i> (Che-Engku-Abdulah, Idris, Fahmi, Flaxman & Hutchings, 2024)	Setiu Wetlands estuary, Malaysia (in slightly gravelly sand, burrowing in decayed roots of mangrove trees (<i>Sonneratia</i> spp.), and area within <i>Talipariti tiliaceum</i>)	Intertidal	L10: 2.7 W10: 1.8	?
<i>M. simplex</i> (Langerhans, 1884)	Madeira, Portugal	?	TL: 20	?
<i>M. stylobranchiata</i> (Moore, 1909)	Monterey Bay, California, USA	Intertidal	TL: 110 TW10: 4.5	?
<i>M. tamurai</i> (Okuda, 1934)	Onomichi, Hiroshima, Japan	Intertidal	TL: > 440	Fishing bait
<i>M. teretiuscula</i> (Schmarda, 1861)	Sri Lanka	?	L10: 12.4 W10: 5	?
<i>M. tribranchiata</i> (Liu, Hutchings & Sun, 2017)	Wanli, Republic of China (Taiwan)	Intertidal	L10: 10 W10: 3.3	?
<i>M. tripectinata</i> (Liu, Hutchings & Sun, 2017)	Beihai, China	Intertidal	L10: 12.3 W10: 5	Fishing bait
<i>M. victori</i> (Lavesque, Daffe, Bonifacio & Hutchings, 2017)	Arcachon Bay, France (mudflats, under or close to oyster reefs or abandoned oyster farms, 5 cm to 60 cm depth, in old piece or driftwood)	Intertidal	L10: 12 W10: 11	Fishing bait

B (*sanguinea*)

<i>M. viridis</i> (Treadwell, 1917)	Key West Harbor, Boca Grande, Florida, USA (in sandy mud)	Intertidal	L10: 11 W10: 3.5	?
<i>M. aenea</i> (Blanchard in Gay, 1849)	San Carlos and Castro, Chile (found on the seashore under the stones)	Intertidal	?	?
<i>M. atlantica</i> (Kinberg, 1865)	South Atlantic, La Plata, Argentina (near river mouth with a stony and sandy bottom)	Intertidal	TL: 100	?
<i>M. bifurcata</i> (Kott, 1951)	Point Peron, WA, Australia (limestone reef and sand)	Intertidal to 15 m deep	L10: 5 W10: 3	?
<i>M. bonhardi</i> (McIntosh, 1885)	Virgin Island, USA (dredged off Sombbrero and St. Thomas, in 860 and 713 m)	Deep sea: Depth > 700 m	L10: 3.1	?
<i>M. capensis</i> (Schmarda, 1861)	Cape of Good Hope, South Africa	?	TL: > 150 TW: 10	?
<i>M. corallina</i> (Kinberg, 1865)	Hawaii, USA (under rocks, in rock pools, burrows in sediment under rocks)	Intertidal	TL: > 120	Fishing bait
<i>M. davidattenboroughi</i> (Lavesque, Zanol, Daffe, Flaxman & Hutchings, 2023)	Inverloch, Vic, Bass Strait, Australia (in sediment between stones)	Intertidal	TL: 120 W10: 5.5	?
<i>M. fragilis</i> (Treadwell, 1911)	Grand Caribbean Region (in crevices of soft coquina rock left bare by the tide)	?	L10: 9 W10: 5	?
<i>M. gallucci</i> (Orensanz, 1990)	Río de la Plata, Argentina	?	?	?
<i>M. hamata</i> (Schmarda, 1861)	Cuba, Caribbean Sea (on the coral reef)	?	TL: 25	?
<i>M. mortenseni</i> (Monro, 1928)	Taboga, Panama (sandy shore)	Intertidal	TL: > 47 TW: 3	?
<i>M. papuaensis</i> (Lavesque, Daffe, Glasby, Hourdez & Hutchings, 2022)	Papua New Guinea (the Solomon Sea, between 250 and 1,200 m, mostly found inside sunken woods)	Deep sea: Depth between 250 m and 1,200 m	TL: 41-80 W10: 2.5-2.8	?

	<i>M. pseudosessilota</i> (Zanol, da Silva & Hutchings, 2017)	Careel Bay, NSW, Australia (mud in seagrass beds of <i>Zostera capricorni</i>)	Intertidal	TL: 164	?
	<i>M. quadrioculata</i> (Grube, 1856)	Puntarenas, Costa Rica	?	?	?
	<i>M. sessilobranchiata</i> (Hartmann-Schroder, 1984)	Albany, Western Australia (fine sand close to <i>Avicennia</i> spp., covered with shell pieces or in seagrass bed of <i>Posidonia sinuosa</i>)	Intertidal to 3 m deep	TL: 64 TW: 2.9	?
	<i>M. soembaensis</i> (Augener, 1933)	Southwest Pulau Sumba (Soemba), Indonesia (detached from marl-like masses lying between low and high tide on the beach)	Intertidal	TL: 62 TW: 7.5	?
C (<i>aenea</i>)	<i>M. striata</i> (Kinberg, 1865)	St. Jose Island, Panama	?	?	?
	<i>M. teres</i> (Treadwell, 1922)	Pago Pago Harbour, American Samoa	?	TL: 75 TW: 0.75	?
	<i>M. unibranchiata</i> (Knox & Cameron, 1970)	Kaikoura & Banks Peninsula, Open Bay Island, New Zealand	Intertidal	TL: 22	?
	<i>M. zanolae</i> (Lavesque, Daffe, Glasby, Hourdez & Hutchings, 2022)	Papua New Guinea (the Solomon Sea, between 350 m and 616 m depth, among pumice rocks, inside sunken wood)	Deep sea; 350 m-616 m	TL: 101 W10: 4.1	?
	<i>M. angelensis</i> (Fauchald, 1970)	Puerto Refugio, Baja California, Mexico (soft bottom habitat)	?	L10: 5.4 W10: 1.7	?
	<i>M. chevalensis</i> (Willey, 1905)	Southeast of Cheval Paar, Gulf of Manaar, India	?	TL: 25 TW: 2.75	?
D (<i>belli</i>)	<i>M. depressa</i> (Schmarda, 1861)	Auckland Harbour, New Zealand	?	L10: 11.5 W10: 4.8	?
	<i>M. digitibranchia</i> (Hoagland, 1920)	Hong Kong, China	Intertidal	TL: 20 TW: 2	?
	<i>M. emiliae</i> (Molina-Acevedo & Carreira-Parrá, 2017)	Rio Lagartos, Yucatan, Mexico	?	L10: 5.4 W10: 4	?

D (<i>belli</i>)	<i>M. formosa</i> (Steiner & Amaral, 2000)	Sao Sebastiao Channel (Sao Francisco & Barra Velha Beach), State of Sao Paulo, Brazil	Intertidal	TL: 55	?
	<i>M. mauritanica</i> (Gillet, 1990)	Mauritania	?	TL: 10	?
	<i>M. maxidenticulata</i> (Liu, Hutchings & Kupriyanova, 2018)	Caofeidian coast, Tangshan, China (in mud)	Intertidal	L10: 8.7 W10: 7	Fishing bait
E (<i>graveleyi</i>)	<i>M. orensanzi</i> (Carrera-Parra & Salazar-Vallejo, 1998)	Cayo Valencia, Bahia Ascension, Quintana Roo, Mexico (in rock, in sandy sediment, 1 m)	?	L10: 2.6 W10: 1.4	?
	<i>M. orientalis</i> (Treadwell, 1936)	Xiamen, China (Taiwan Strait)	Intertidal	L10: 13.25 W10: 5	?
	<i>M. sebastiana</i> (Steiner & Amaral, 2000)	Sao Sebastiao Channel Sao Paulo, Brazil (in sediments varying from sand to mud, sand mixed with stones, gravel, and shell particles)	Intertidal	TL: 120	?
	<i>M. sherlockae</i> (Kara, Molina-Acevedo, Zanol, Simon & Idris, 2020)	Langebaan Lagoon, South Africa (fringing rocky zones in sheltered bays, in rock crevices)	Intertidal	TL: 67	?
	<i>M. graveleyi</i> (Southern, 1921)	Pulikat Lake, India (burrows in mud)	Intertidal	TL: 172	- Fishing bait - Aquaculture feed (Kannappan et al., 2021)
E (<i>graveleyi</i>)	<i>M. ibaiensis</i> (Che-Engku-Abdullah, Idris, Fahmi, Flaxman & Hutchings, 2024)	Kuala Ibai mangrove estuary and lagoon	Intertidal	L10: 4.5 W10: 2.85	?
	<i>M. madrasi</i> (Hutchings, Lavesque, Priscilla, Daiffe, Malathi & Glasby, 2020)	Ennore Creek, Chennai, Tamil Nadu, India (mud flats)	Intertidal	L10: 311 W10: 3.9	-

L10: Length to chaetiger 10; W10: Width at chaetiger 10; TL: Total body length;

TW: Total body width; ? : Data not available; Bold characters: Species with potential for commercial use.

Table 2: Species of *Marphysa* with known commercial application. TL: Total Length; L10: Length to chaetiger 10; W10: Width at chaetiger 10. *Smallest TL, L10, TW & W10

Species Group	Species	Size (Mm)	Type Locality	Fish Bait	Commercial Application		
					Aquaculture Feed	Acute Wound Healing	Biosynthesis of Gold Nanoparticles
<i>mossambica</i> (Group A)	<i>M. moribidii</i>	L10: 20 W10: 8.2	Malaysia	✓	✓	✓	
	<i>M. mossambica</i>	L10: 11.5 W10: 8.1	Mozambique	✓			
	<i>M. aegypti</i>	W10: 6	Egypt	✓			
	<i>M. chirigota</i>	TL: 265 TW: 7.9	Spain	✓			
	<i>M. gaditana</i>	TL: 121.7 *TW: 6.5	Spain	✓			
<i>sanguinea</i> (Group B)	<i>M. haemasona</i>	L10: 12.3 W10: 7	South Africa	✓			
	<i>M. mullawa</i>	TL: 140 TW: 10	Australia	✓			
	<i>M. sanguinea</i>	L10: 20.4 W10: 11	United Kingdom	✓	✓		
	<i>M. tamurai</i>	TL: > 440	Japan	✓			
<i>aenea</i> (Group C)	<i>M. tripectinata</i>	L10: 12.3 *W10: 5	China	✓			
	<i>M. victori</i>	L10: 12 W10: 11	France	✓			
<i>belli</i> (Group D)	<i>M. corallina</i>	*TL: > 120	USA (Hawaii)	✓			
	<i>M. maxidenticulata</i>	*L10: 8.7 W10: 7	China	✓			
<i>graveyi</i> (Group E)	<i>M. graveyi</i>	TL: 172	India	✓	✓		

TL: Total Length; L10: Length to chaetiger 10; W10: Width at chaetiger 10. *Smallest TL, L10, TW, & W10.

ranging from > 120 mm to 440 mm (TL), 8.7 mm to 20.4 mm (L10), and 5 mm to 11 mm (W10). Based on the global distribution of *Marphysa* species (Figure 2), the remaining 10 large-sized intertidal species are slightly more prevalent in developed countries (54%) than in developing countries (46%). Additionally, the *sanguinea*

group has the highest distribution of large-sized species with known commercial use, followed by the *mossambica* group. Simultaneously, the *aenea*, *belli*, and *gravelyi* groups have the same number of commercially known species (Figure 3).

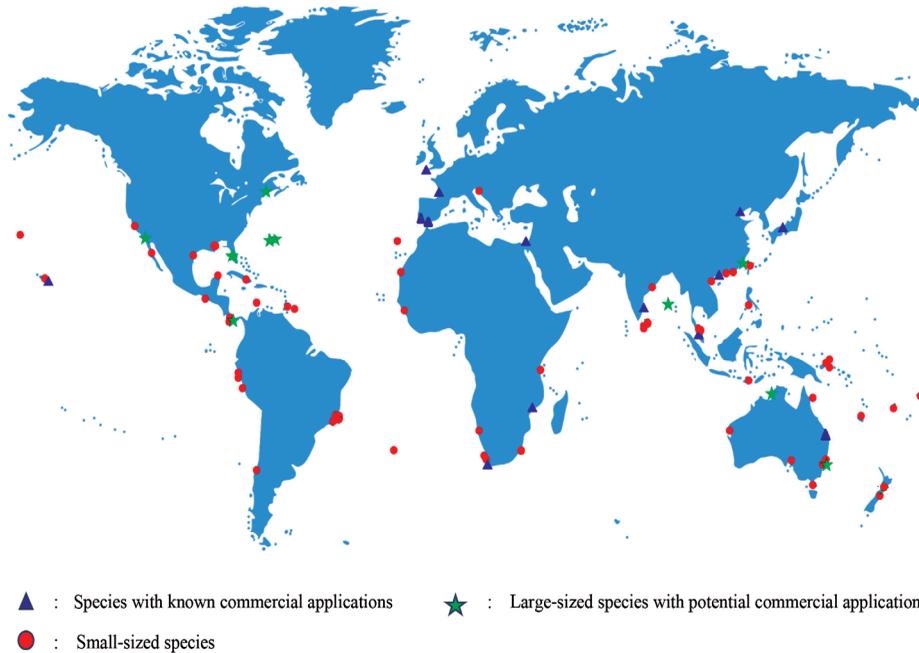


Figure 2: Regional distribution of the species of *Marphysa*

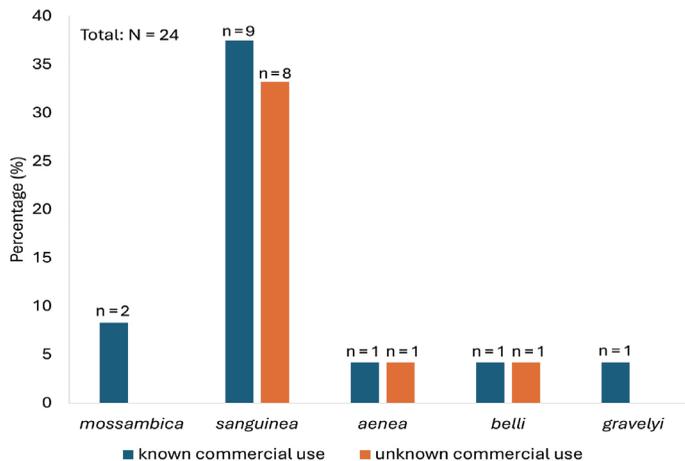


Figure 3: Distribution of large-sized species of *Marphysa* with known and potential commercial use according to species groups

Discussion

A species of *Marphysa* (incorrectly identified as *M. sanguinea*) from Portugal has been reported as the most commercially valuable species of polychaete. Particularly, it is sold in the global fisheries market with a retail price extending 60USD per kg (Watson *et al.*, 2017) while the annual harvest of *M. mossambica* in Kenya represented 352USD (Kihia *et al.*, 2016). These two numbers are indicative of the high market value of some species of *Marphysa* as well as the existence of an increasing demand for commercial purposes. However, this study reveals the existence of many more potential species of commercial interest.

Within developed countries such as the UK, USA, Netherlands, Portugal, France, and Australia, there are only a few records of species of *Marphysa* being utilised as fishing bait. For example, *M. mullawa* (Moreton Bay, Australia) and *M. victori* (Arcachon Bay, France), with approximately 1.3 tonnes to 2.5 tonnes (wet weight) or 400,000 individuals of the latter being harvested annually and shipped alive to the French Mediterranean recreational fishing community (Hutchings & Karageorgopoulos, 2003; Lavesque *et al.*, 2017; Hutchings *et al.*, 2024).

Furthermore, polychaetes harvested in the wild for local use and exported from developed countries are limited to a few species such as *A. virens* and *Glycera dibranchiata* Ehlers, 1868, which are also occasionally mass-cultured commercially. According to Saito *et al.* (2014) and Font *et al.* (2018), detailed information on their life cycle and growth rates makes these polychaetes suitable for farming. Thus, having information on the reproductive strategy and optimal living conditions of these and other commercially exploited species may facilitate culturing and managing them for continuous production (Saito *et al.*, 2014; Cole *et al.*, 2018; Font *et al.*, 2018; Simon *et al.*, 2021; Broquard *et al.*, 2022; Hutchings *et al.*, 2024).

The high percentage of large-sized species of *Marphysa* with unknown applications in developed countries suggests an overall

lack of applied research. In contrast, the occurrence of species such as *M. californica* and *M. hongkongensa* in intertidal areas could benefit local baitworm fisheries if they are commercially exploited. Furthermore, the ability of some species of *Marphysa* to act as bioremediations in aquaculture systems by enhancing and maintaining optimal culture conditions (Mandario *et al.*, 2019) should be further investigated. This is attributable to the fact that this may reduce production costs and increase aquaculture yields.

Marphysa species harvested in developing countries are used mainly locally, being a fundamental income source (Cole *et al.*, 2018). Although usually not the primary source, it is sufficient to supplement household expenditure, as it occurs with *M. mossambica*, the most harvested species in Kenya (Simon *et al.*, 2021) or *M. moribidii* in Malaysia (Idris *et al.*, 2014). Notably, *M. moribidii* could also be utilised for medical applications in human health and as a catalyst for nanoparticle biosynthesis (Ee Pei *et al.*, 2020; Rapi *et al.*, 2020; Rosman *et al.*, 2020; Ibrahim *et al.*, 2022). In addition, several species of *Marphysa* are exported to other countries such as from China to Australia (but frozen due to biosecurity issues) and Japan (Liu *et al.*, 2018) as bait for recreational fisheries.

Developing countries, including the Philippines and India are actively exploring the viability of culturing *M. madrasi* (sometimes identified as *M. gravelnyi*) and *M. iloiloensis* through grow-out practice, as well as by wild harvesting (Mandario, 2020; Kannappan *et al.*, 2021) to satisfy the current demand for polychaetes. Both species are known to provide essential food supplements in fish and shellfish aquaculture (Malathi *et al.*, 2011; Estante-Superio *et al.*, 2023). This contributes essential nutrients to produce healthy fish or shrimp juveniles and broodstock (Kannappan *et al.*, 2021; Estante-Superio *et al.*, 2023). Concurrently, successfully culturing these species may contribute in eliminating biosecurity concerns by preventing the potential

risks of transboundary disease transmissions by non-native species, reducing the loss of natural resources, and providing effective substitutes for wild harvesting (Mandario, 2020). Moreover, other *Marphysa* species discovered in these developing regions that meet the commercialisation criteria may also serve as promising candidates for cultivation (Table 1).

Nevertheless, there are major taxonomic concerns when dealing with commercial bait worm species, particularly within the worldwide harvested *sanguinea* complex (Lavesque et al., 2019). Many worms exported alive were identified as *M. sanguinea*, which was considered a cosmopolitan species (Hutchings & Kupriyanova, 2018). However, after the redescription and designation of a neotype specimen of *M. sanguinea* (Hutchings & Karageorgopoulos, 2003), the actual distribution of this species was determined as being restricted to the English Channel and the Bay of Biscay (Martin et al., 2020).

Subsequently, many populations of *Marphysa* initially identified as *M. sanguinea* have been described as new species. For example, the species of *Marphysa* exported from China to Southeast Asia by one bait collector were reported to represent five undescribed species (Liu et al., 2017; 2018). Thus, correct taxonomic identifications are key for these commercially exploited species as, in many cases, they exhibit differences in habitat, reproduction, and growth (Martin et al., 2020; Hutchings et al., 2024). This is critical for implementing correct commercialisation procedures (Font et al., 2018; Hutchings et al., 2024).

Conclusions

Species of *Marphysa* are well-known as valuable assets for fishing (as baits), aquaculture feed, wound healing, and bio-catalysts in the synthesis of gold and silver nanoparticles. Of the 89 species identified worldwide, 24 (16%) have large body sizes when adult, while only 14 (58%) are currently known to have commercial applications. However, the potential

applications of the remaining 10 species have yet to be investigated. Hence, additional research is certainly required, especially on their reproductive strategies and growth, to assess their possible commercial applications. Nevertheless, taxonomic studies are required in numerous regions worldwide to accurately document species distributions, particularly in developing countries, where many species remain to be described.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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