Review Paper

The nutritional and aquafeed potential of *Marphysa iloiloensis* Glasby et al., 2019: A review on the role of polychaetes as a protein source in aquaculture

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ABSTRACT

Polychaetes are considered high-value feed resources in aquaculture because of their high protein content, well-balanced amino acid and fatty acid profiles, and diverse bioactive compounds. Their inclusion in diets has been consistently associated with enhanced reproductive output, larval quality, and feed efficiency in both crustacean and finfish culture. The recently described mud polychaete *Marphysa iloiloensis* Glasby et al., 2019 is endemic to the Philippines and is one such species that is showing potential as a sustainable protein source in aquaculture. This review synthesizes existing literature on the nutritional composition, biology, aquafeed applications, and rearing potential of *M. iloiloensis* and related *Marphysa* species. The available evidence suggests that *M. iloiloensis* may serve as a sustainable protein source that can be cultured using low-cost inputs within circular economy frameworks. However, the broader application of *M. iloiloensis* in hatcheries is constrained by several knowledge gaps. These include the need for complete fatty acid and amino acid profiling, digestibility and palatability assessments in target species, determination of optimal dietary inclusion levels, evaluation of the effects of processing and preservation methods on nutrient stability, and hatchery-scale cost-benefit analyses in local hatchery systems. This review consolidates current knowledge and identifies these gaps to support the development of *M. iloiloensis* as a reliable and sustainable aquafeed ingredient.

Keywords: aquafeed, broodstock, digestibility, fatty acids, hatchery, sustainability

INTRODUCTION

The rapid growth of aquaculture as one of the primary food-producing sectors threatens the global fishery resources. Sharma et al. (2025) reported that 35.5% of global fishery stocks are now labeled as overfished, placing increasing pressure on capture fisheries while aquaculture production continues to expand to meet rising seafood demand (Subasinghe et al. 2009). Fishmeal is traditionally used as the main protein source in aquaculture feed due to its balanced amino acid and high digestibility (Olsen and Hasan 2012); however, the reliance on fishmeal may pose risks to the long-term sustainability of aquaculture.

Although Food and Agriculture Organization (FAO) implements responsible and sustainable fishing practices as a solution to this problem (FAO 2022), there remains a critical need to investigate alternatives to fishmeal as another way of alleviating this issue. Various protein sources have already been tested to replace fishmeal (Macusi et al. 2023). These include plant-based protein sources such as soybeans, rapeseed, and pulses (Kaushik and Hemre 2008), microalgae (Ma and Hu 2024), and animal products and by-products (Luthada-Raswiswi et al. 2021). The varying levels of proteins, lipids, and carbohydrates of these alternatives affect their nutritional performance (Aragão et al. 2022; Wang et al. 2023; He et al. 2024), which can determine their suitability as an aquafeed ingredient.

Among these alternatives, polychaetes typically have high protein content that matches the protein level of fishmeal while also possessing balanced amino acid profiles and high levels of polyunsaturated fatty acids (PUFA) (Meunpol et al. 2005; Yang et al. 2022; Gao et al. 2024; Wang 2025). Despite these advantages, trials on polychaete inclusion in commercial feed formulations are limited as studies necessary for targeted cultivation and feed development are still scarce (Heydtmann et al. 2026); therefore, many aspects of their application require further study (Santos et al. 2025). One promising polychaete species that can potentially replace fishmeal is the recently described *Marphysa iloiloensis* Glasby, Mandario, Burghardt, Kupriyanova, Gunton & Hutchings, 2019 from the Philippines. *Marphysa iloiloensis* is traditionally collected as fish bait and well-known as a natural sediment cleaner found in brackish water ponds and mudflats (Glasby et al. 2019). More recently, it has been recognized for its successful application to hatcheries (Mandario 2020; Estante-Superio et al. 2023), although it has not yet been used in commercial-scale aquaculture (Bailon et al. 2025). Recent observations of its use in hatcheries suggest potential applications beyond traditional uses; however, thorough analyses should be conducted.

Given the lack of a consolidated synthesis for this species, this review aimed to compile and critically examine existing information on *M. iloiloensis* and related species within the genus *Marphysa*. Specifically, it sought to describe its biological and ecological characteristics, examined its nutritional composition using available species-specific data and information supplemented from related taxa, assessed its relevance and potential role in aquaculture systems, and identified knowledge gaps and future research directions. The review first summarizes general polychaete use in aquaculture, then discusses the biology and culture of *M. iloiloensis*, compares available nutritional data across *Marphysa* and benchmark polychaetes, and finally evaluates production feasibility, sustainability, and future research needs.

LITERATURE REVIEW METHODOLOGY

This review evaluates the prospects of using *M. iloiloensis* as a local resource in the context of the current and future status of the development of aquaculture in the Philippines. Literature was searched in Scopus, Google Scholar, and PubMed, with additional full texts accessed through institutional repositories and ResearchGate when necessary. Studies published from 2000 to 2026 were considered, while earlier taxonomic references were included when needed. Search terms included combinations of "*Marphysa iloiloensis*," "*Marphysa*," "polychaete," "aquaculture," and "aquafeed." Records were screened based on relevance to polychaete biology, culture, nutritional composition, aquafeed use, biosecurity, or sustainability. The scientific name and taxonomic authority of aquaculture and polychaete species mentioned were validated from the World Register of Marine Species (WoRMS). A total of 497 records were retrieved; after duplicate removal and relevance screening, 108 sources were included in the review.

OVERVIEW OF POLYCHAETES IN AQUACULTURE

Polychaetes, commonly known as bristle worms, are a diverse group of segmented marine annelids that occupy a wide range of ecological niches, from intertidal zones to deep-sea environments (Díaz-Castañeda and Reish 2009). They are harvested for several reasons such as bait for recreational fishing (Cole et al. 2018); for human food consumption especially in some Asian countries (Santos et al. 2025); used for marine aquarium trade either as ornamentals or scavengers (Costa et al. 2003); and as live feeds for shrimps and fishes (Leelatanawit et al. 2014; Selvam 2021). In aquaculture, polychaetes have been widely utilized as feed inputs, whether in live or processed form, particularly in hatchery systems for fish and shrimp (Binh et al. 2008; Leelatanawit et al. 2014; Li et al. 2025).

Among more than 13,000 described species of polychaete (Jumars et al. 2015), those under the genus *Perinereis* are the most commonly cultured and utilized in hatcheries, particularly in Southeast Asia (Poltana et al. 2007; Chowdhury et al. 2025). *Perinereis nuntia* (Lamarck, 1818) is frequently cultivated in Thailand (Poltana et al. 2007; Leelatanawit et al. 2014), Malaysia (Selvam 2021), and Bangladesh (Chowdhury et al. 2025); while other species such as *Perinereis aibuhitensis* (Grube, 1878) and *Perinereis gualpensis* Jeldes 1963 have also been evaluated for aquaculture applications (Yang et al. 2015; Yang et al. 2022; Gómez et al. 2023). These efforts constitute the development of established culture practices (Poltana et al. 2007; Yang et al. 2015; Fang et al. 2016; Gomez et al. 2023; Chowdhury et al. 2025; Shakib et al. 2025) and the integration of *Perinereis* spp. into aquaculture systems (Palmer et al. 2014; Liu et al. 2020) to meet hatchery demands.

Despite their widespread use, risks remain when live polychaetes are used as a live food source (Vijayan et al. 2005; Haryadi et al. 2015; Liu et al. 2020; Krishnan et al. 2021; Spencer et al. 2021). A primary concern is the potential transfer of diseases, like the white spot syndrome virus (Vijayan et al. 2005; Haryadi et al. 2015), which may compromise hatchery biosecurity. FAO (2003) recommended the use of pathogen-screened or hatchery-produced polychaetes to mitigate this risk. Otherwise, implementation of strict bio-security protocols like quarantine and disinfection treatments is necessary. Processing methods such as freeze-drying, oven-drying, and pelletizing can also lessen the said risk.

Polychaetes in different processed forms have been evaluated as aquaculture feed in many studies. For instance, freeze-dried and oven-dried sand worm *Neanthes japonica* (Izuka, 1908) were used to partially replace fishmeal in the diets of juvenile tiger puffer *Takifugu rubripes* (Temminck & Schlegel, 1850) (Gao et al. 2024). There were no significant changes in growth of tiger puffer observed, but feed intake and amino acid transporter expression increased. Meanwhile, fan worm *Sabella spallanzanii* (Gmelin, 1791) was successfully formulated into pelleted feeds for clownfish *Amphiprion ocellari* Cuvier, 1830 (Arduini et al. 2023). Administration of pelleted feeds to the clownfish showed comparable results to that of commercial feeds. These studies suggest that using processed forms of polychaetes as feed can provide additional functional benefits but is not optimal for growth parameters. Evidently, in the study of Monteiro et al. (2023), sand worm *Alitta virens* (M. Sars, 1835) was used to replace 40% of fishmeal in diets for European seabass *Dicentrarchus labrax* (Linnaeus, 1758), resulting in significant alterations to gut microbiota and associated metabolic pathways.

In the Philippines, hatcheries relied on imported frozen *P. nuntia* from Thailand (Francisco 2020); however, the discovery of *M. iloiloensis* has shifted toward local alternatives. While several *Marphysa* species including *Marphysa gravelyi* Southern, 1921 (Kannapan et al. 2021), *Marphysa sanguinea* (Montagu, 1813) (Garcês and Pereira 2011; Parandavar et al. 2015), and *Marphysa maxidenticulata* Liu, Hutchings & Kupriyanova, 2018 (Yang et al 2022; Li et al. 2025) have already been studied for aquaculture applications, recent developments highlight the potential of *M. iloiloensis* as a local alternative. Trials on the inclusion of live *M. iloiloensis* in feeds for Indian white shrimp *Penaeus indicus* H. Milne Edwards, 1837 were conducted that yielded similar results of improved broodstock performance and produced offspring that have an increased level of resistance (Estante-Superio et al. 2023). This effort emphasizes the importance of using indigenous species to reduce reliance on imported inputs and promote environmentally sustainable and low-cost inputs in hatcheries in the country.

BIOLOGY, TAXONOMY, AND CULTURE

In 2019, a new species of polychaete named *M. iloiloensis* was formally identified and described by Glasby et al. (2019). It is named after the province, Iloilo, in the Philippines where this species was collected. *Marphysa iloiloensis* is classified under the family Eunicidae and is believed to be the first recorded species under the group Sanguinea in the country (Glasby et al. 2019). It is characterized by an iridescent body with pinkish to reddish coloration, a cream-colored posterior region with contrasting red branchial filaments, and a rounded prostomium bearing two palps and three antennae. This species is morphologically similar to *Marphysa hongkongensa* Wang, Zhang & Qiu, 2018; however, they differ in the presence of eyes, the number of branchial filaments, and the structure of the jaws and chaetae.

Marphysa iloiloensis, locally known as “ulod-ulod”, can be typically found in mudflats, as well as mangrove forests. They are usually collected by fishermen to be used as fish bait (Glasby et al. 2019). This species functions as both a surface and subsurface deposit feeder, ingesting particulate organic matter, uneaten feeds, fecal wastes, and dead organisms (Mandario 2020). Its feeding strategy helps with bioturbation and sediment detoxification (Mandario et al. 2019), and most likely enables it to recycle protein-rich organic materials (Mandario 2020). Hence, this species would certainly be valuable when integrated into aquaculture systems due to its nutrient recycling and sediment management capability.

In terms of reproduction and development, *M. iloiloensis*, as a member of the Sanguinea group, has several advantages over nereidids like *P. nuntia*. *Marphysa iloiloensis* is gonochoric, sexually monomorphic, and can spawn multiple times throughout its life cycle (iteroparous) (Mandario 2018; Olive et al. 2024), while nereidids are generally capable of spawning only once (semelparous) (Sato 2017). Moreover, *M. iloiloensis* produces gelatinous egg cocoons with approximately 5,000 to 10,000 eggs per cocoon (Glasby et al. 2019), which may offer an advantage not only in terms of quantity but also in quality due to increased survivability provided by the cocoons. Larval development of *M. iloiloensis* follows a series of distinct stages from larval to juvenile stages until individuals become capable of spawning (Glasby et al. 2019). In hatchery conditions, larvae are typically reared in nursery systems for approximately one month, after which juveniles are transferred to grow-out tanks for an additional four to five months. Sexual maturity is generally reached after about five months, at which point individuals are capable of spawning. Spawning can occur year-round under suitable environmental conditions (Glasby et al. 2019).

Due to the benefits offered by *M. iloiloensis*, attempts to culture this species were initiated leading to understanding its early developmental biology. Studies determined that this species exhibits very high photo-negative behavior, reflecting its behavior as a burrowing organism (Mandario et al. 2021), which was used as a guide for further developing more efficient ways of larval rearing in hatcheries. Success in previous trials encouraged further tests at the production level. Mandario et al. (2022) conducted grow-out trials under controlled conditions, resulting in promising survival rates of as high as 45% and efficiency in biomass production. A series of studies was done that established the protocols for the culture of *M. iloiloensis* particularly including supplementation of biofloc, UV-treated recirculated seawater, and low-light conditions, which yielded 83% survival over 30 days. Collectively, these represent the first successful attempts at culturing this native polychaete species, with implications of using it as a live or processed feed source for shrimp, crab, and other high-value aquaculture species.

NUTRITIONAL COMPOSITION AND FEEDING EFFICACY

The suitability of *M. iloiloensis* as a sustainable feed resource for fish and shrimp aquaculture can primarily be determined through its nutritional profile. Two studies reported and summarized its proximate composition (Table 1). Mandario (2020) reported crude protein values ranging from 60.88% to 69.80% and crude lipid values from 3.49% to 13.18% on a dry matter basis (DMB), while Estante-Superio et al. (2023) reported a protein value of 58.77% DMB and a crude lipid content of 15.84% DMB. Ash and moisture content, on the other hand, were 7.99% and 5.33%, respectively (Estante-Superio et al. 2023). This suggests a balanced mineral content and low water activity which favor feed stability (Umar et al. 2013; Maksimenko et al. 2024). Lipid content is also particularly important to determine as it is central to membrane integrity, signaling pathways, and reproductive processes (Thiruvasagam et al. 2024; Barua et al. 2025). Within this category, PUFA are necessary in aquaculture diets (Tocher 2015; Carr et al. 2023; Glencross et al. 2025). Although there are no specific data on PUFA for *M. iloiloensis*, evidence from related polychaetes suggests that the species likely contains relevant fatty acid components. Figure 1 summarizes the nutrient-physiology pathways (amino acids, LC-PUFA, bioactives) that plausibly link polychaete inputs to broodstock and larval performance endpoints.

Table 1. Proximate nutrient composition of polychaetes. WWB = wet weight basis; DMB = dry matter basis.

Species	Protein (%)	Lipid (%)	Ash (%)	Moisture (%)	PUFA (%)	Total Fatty	Basis	Remarks	Reference

						Acid (%)			
Marphysa gravelyi	33	13			61.23	98.31	WWB	Cultured adult specimens	Kannappan et al. 2021
Marphysa iloiloensis 1	58.77	7.21	7.99	5.33			DMB	Specimens reared on a diet of *Penaeus indicus*	Estante-Superio et al. 2023
Marphysa iloiloensis 2	60.88-69.80	3.49-13.18					DMB	Specimens maintained on a formulated diet containing feed mill sweepings for 180 days	Mandario 2020
Marphysa mossambica	51.14	27.98	3.12	70			DMB	Wild-caught adult specimens	Selvam 2021
Marphysa sp. *1*	50.9	5.25		8.04	20.38	53.52	DMB	Freeze-dried specimens	Meunpol et al. 2005
Marphysa sp. *2*	64.1	8	14	82	32.89	21.66	DMB	Wild adult specimens	Wang et al. 2025
Alitta virens	65.5	10.9	16.4		0.8		DMB	Spray-dried polychaete meal fed on *Dicentrarchus labrax*	Monteiro et al. 2023
Neanthes japonica	73.08	5.66	9.34	88.77 (WWB)			DMB	Specimens reared on a diet of *Takifugu rubripes*	Gao et al. 2024
Perinereis sp.	63.87	14.19		9.26	19.73	64.32	DMB	Wild adult specimens	Meunpol et al. 2005

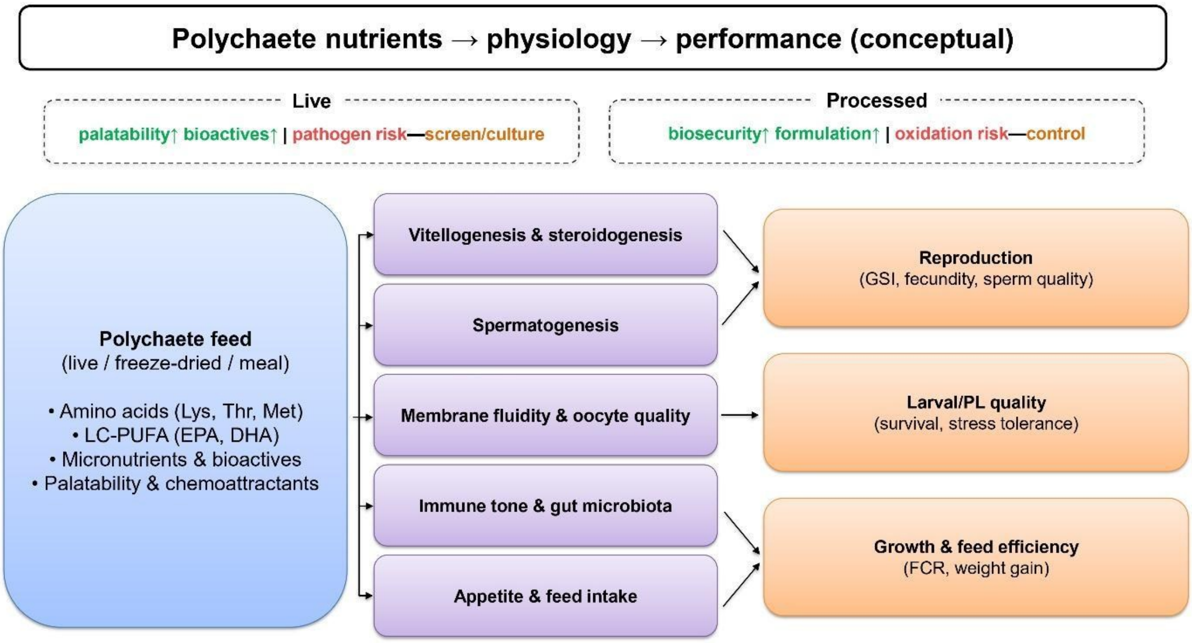

Figure 1. Why polychaetes work: nutrient-physiology-performance pathways. Polychaetes supply indispensable amino acids [e.g., lysine (Lys), threonine (Thr), methionine (Met)], long-chain polyunsaturated fatty acids (LC-PUFA) [eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)], lipids, micronutrients, and bioactives such as taurine. These support vitellogenesis and spermatogenesis, enhance membrane quality and immune tone, and improve appetite, leading to better reproduction, larval robustness, and feed efficiency. Processing alters this pathway as live worms boost palatability and bioactives but carry pathogen risks, while meals offer safer formulation control yet risk highly unsaturated fatty acid (HUFA) loss unless oxidation is managed. (Legend: GSI – gonadosomatic index; PL – post larvae; FCR – feed conversion ratio).

Comparative data from other *Marphysa* species can support the nutritional viability of *M. iloiloensis*. Two studies reported on the nutritional composition of *Marphysa* species: *Marphysa mossambica* (Peters, 1854) (Selvam 2021) and an unidentified *Marphysa* sp. (Meunpol et al. 2005). Protein values were comparable between the two, with *M. mossambica* reported at 51.14% DMB (Selvam 2021) and *Marphysa* sp. at 50.90% DMB (Meunpol et al. 2005), aligning closely with *M. iloiloensis*. Lipid content, however, was highly variable among the species tested. In *M. mossambica*, lipid levels reached up to 27.98% DMB (Selvam 2021), whereas lower values of 5.25% DMB were reported for *Marphysa* sp. (Meunpol et al. 2005). Similarly, PUFA values for two unidentified species were as high as 20.38% (representing the sum of n-3 and n-6 fatty acids) (Meunpol et al. 2005) and 32.89% (Wang et al. 2025). Total fatty acids were similarly high with values ranging from 21.66% (Wang et al. 2025) to 53.52% DMB (Meunpol et al. 2005) and 98.31% wet weight basis (WWB) (Kannappan et al. 2021). While these data support the ability of the genus to meet both energy and functional lipid requirements in aquaculture feeds, these also indicate potential species-specific optimization in feed formulations.

Compared to *A. virens*, *N. japonica*, and *Perinereis* sp. which are common species used in European and East Asian aquaculture (Monteiro et al. 2023; Gao et al. 2024; Santos et al. 2025), *Marphysa* species have comparable crude protein levels, lipid, and fatty acid content (Table 1). *Alitta virens* which has been processed into spray-dried polychaete meal, for instance, has 65.5% protein and 10.9% lipid on a dry matter basis but has only 0.8% PUFA content (Monteiro et al. 2023), possibly due to oxidative degradation during processing. The PUFAs are highly susceptible to oxidation, as their unsaturated bonds can allow the formation of reactive oxygen species and various degradation metabolites (Islam et al. 2023). In contrast, *N. japonica* has a relatively higher protein level of 73.08% and a lipid level of 5.66%; however, it presents with an increased moisture content of 88.77% on a WWB (Gao et al. 2024). Although this high moisture value is expected given the wet weight basis of measurement, it may still limit feed shelf stability by promoting undesirable microbial, chemical, and enzymatic reactions (Awulachew 2021). In general, the balanced lipid composition, retention of PUFAs, and lower moisture content can be considered as advantages of *Marphysa* species that position them as a more functionally reliable ingredient for aquafeed formulations.

In terms of lipid and amino acid, polychaetes are known to possess long chain-polyunsaturated fatty acids (LC-PUFA), particularly arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid (Wang et al. 2019; Jerónimo et al. 2021; Villena-Rodríguez et al. 2025). These LC-PUFA are important in aquaculture nutrition, but many cultured species have limited capacity to synthesize them; therefore, they must be supplied through diet (Tocher 2015). Feeding studies demonstrate their functional relevance. In the study of Yang et al. (2022), four polychaete species, *M. maxidenticulata*, *Cheilonereis cyclurus* (Harrington, 1897), *Nereis vexillosa* Grube, 1851, and *P. aibuhitensis*, were evaluated as feeds. Results showed that polychaete-based diets alone were sufficient to sustain gonadal development in Pacific white-leg shrimp *Litopenaeus vannamei* (Boone, 1931). *Nereis vexillosa* contained the highest proportions of PUFA, particularly arachidonic acid (20:4 n-6) and eicosapentaenoic acid (20:5 n-3), the latter reaching up to an 8-fold value higher than in the other species. These fatty acids are directly associated with reproductive processes such as ovarian maturation and spawning in crustaceans (Dildar et al. 2025), showing the importance of polychaetes not only as protein alternatives but also as maturation diets.

Specific lipid and amino acid profiles for *M. iloilensis* are lacking; however, insights from other *Marphysa* species provide a useful basis for inference. Table 2 presents the amino acid profiles reported on studies on *Marphysa* (Kannapan et al. 2021; Santander-Avanceña et al. 2023; Wang et al. 2025). *Marphysa gravelyi* reared under controlled conditions, has a 42.55% total content of essential amino acids (EAA), among which are leucine (11.90%), lysine (10.90%), and threonine (8.90%) (Kannappan et al. 2021). These essential amino acids are considered important in animal nutrition due to several reports on their association with broodstock reproduction success and improved health (Feng et al. 2013; Wang et al. 2022; Dou et al. 2023). In contrast, analysis of the total soluble fraction of *Marphysa* sp. collected in estuarine ponds in the Philippines showed a total EAA content of 30.56% (Santander-Avanceña et al. 2023). This soluble fraction, comprising readily bioavailable compounds such as free amino acids and small peptides, was shown to enhance sperm counts and improve spermatophore biochemical composition in male *P. indicus* broodstock (Santander-Avanceña et al. 2023). These differences were also observed in their non-essential amino acid (NEAA) profiles. *Marphysa gravelyi* has a total NEAA content of 55.08% with high concentrations of cysteine (21.40%), proline (15.90%), and aspartic acid (8.80%) (Kannappan et al. 2021), while the two other unidentified *Marphysa* spp. depict lower values across most NEAA, totaling 27.32% (Wang et al. 2025) and 52.37% (Santander-Avanceña et al. 2023). Unlike EAAs, NEAAs can be synthesized endogenously and thus are not strictly required from dietary sources (Aragão et al. 2025). However, the demand for functional amino acids such as cysteine and proline may exceed endogenous capacity (Carvalho et al. 2023). Due to the essential functions of amino acids particularly in regulating biological processes including feed intake regulation, metabolism, cell signaling, and immune function in many cultured aquaculture species (Feng et al. 2013; Mukhtar et al. 2017; Dou et al. 2023; Bano et al. 2025), it is important to formulate aquafeeds that are nutritionally-balanced and performance-oriented. These data stress the amino acid diversity present within *Marphysa* spp., and by extension, these results may indicate that *M. iloiloensis* likely possesses comparable nutritional potential, although species-specific profiling remains necessary to fully establish its value.

Table 2. Amino acid profiles of *Marphysa* species.

Amino Acids (g%)	***Marphysa sp.*** (Kannapan et al. 2021)	***Marphysa* sp.** (Santander-Avanceña et al. 2023)	***Marphysa gravelyi*** (Wang et al. 2025)
Essential Amino Acids			
Leucine	3.66	5.46	11.9
Lysine	3.12	6.16	10.9
Threonine	2.1	3.34	8.9
Phenyl Alanine	1.97	3.59	2.8
Histidine	1.24	2.02	2.1
Valine	2.11	3.63	1.8
Isoleucine	1.96	2.64	1.98
Arginine	3.3	1.51	1.98
Methionine		2.18	0.002
Tryptophan	0.86	0.03	0.19
Total	17.32	30.56	42.55
Non-Essential Amino Acids			
Cysteine	0.45	7.94	21.4
Proline	1.31	1.31	15.9
Aspartic acid	5.46	1.75	8.8

Glutamic acid	6.86	12.99	4.88
Asparagine			3.5
Glycine	3.95	18.32	0.44
Serine	2.04	6.71	0.12
Alanine	2.66		0.04
Tyrosine	1.27	1.84	
Total	27.32	52.37	55.08

HATCHERY AND CULTURE SUSTAINABILITY

The culture of the native polychaete, *M. iloiloensis*, has become one of the most promising solutions to the increasing demand for high-quality and pathogen-free live feeds in aquaculture. This was initiated by the Southeast Asian Fisheries Development Center (SEAFDEC), a regional institution that plays a central part in aquaculture research and development across Southeast Asia. After successful small-scale experimental rearing trials, SEAFDEC reported that *M. iloiloensis* can be reared from cocoon to juvenile stages under controlled conditions.

In the study of Mandario (2021), baseline requirements for cocoon handling, photoperiod, feeding, and sediment composition were established for standardized hatchery protocol. For instance, jelly cocoons should be collected from broodstock tanks and inspected under a microscope for egg viability after 24 hours, then viable cocoons are transferred for larval stocking. Trochophore larvae are best reared at UV-treated seawater at 27-30 ppt, at a density of about 15 ± 0.25 larvae per 200 mL, with 25-50% water exchange every other day. Moreover, light conditions need to be maintained low, ideally < 3.4 μmol m^{-2} s^{-1} or between 0 to 50 lux, since the survival is highest under dark or near-dark conditions. For feeding, bioflocs may be recommended as the main diet, considering its outstanding performance against the diatom-based feeds (Mandario 2020). Bioflocs can be produced at a carbon-to-nitrogen ratio of 20-40 using feed mill sweepings, with about 40.26% crude protein, and sugarcane molasses maintained in 1-ton circular tanks with continuous aeration, yielding microbial flocs. In this context, the ensuing system should maintain suspended solids within 300-700 mg/L, with water quality parameters within the optimal range, that is, dissolved oxygen of 3.5-5.8 mg/L, 27-30°C temperature, 25-35 ppt salinity, and pH 7.5-8.5.

In semi-intensive systems, *M. iloiloensis* can be cultured using fishpond sediments and feed derived from agricultural sweepings such as feed mill sweepings and biofloc residues. Polychaetes reared for up to 180 days reached harvestable sizes with satisfactory biomass production (Mandario 2020; Mandario et al. 2022). Further experiments focused on comparative feeding and mode of rearing indicated that culturing from a biofloc (BF) nursery system followed by transfer to grow-out in sediment tanks utilizing feed mill sweepings (FS) significantly improved results. Specifically, significantly increased survival (up to 70%) and biomass (175.73 ± 42.25 g per tank), exceeding that of BF or FS alone (Mandario 2020).

During the grow-out phase, feeding rate and sediment depth can affect outcomes of production. A feeding rate of 50 g m^{-2} combined with a sediment depth of 3 to 5 cm resulted in the highest survival (up to 45%) and biomass, while over-feeding or deeper sediments led to poor water quality and reduced survival (Mandario et al. 2022). Standardization of such parameters can ensure consistent output in future production systems. In addition, related research findings in hatching culture studies with other *Marphysa* species can strengthen this conclusion. For example, *M. gravelyi* has been successfully reared using indoor grow-out practices in artificial conditions (Kannappan et al. 2021). This paves the way for application of *M. iloiloensis* in integrated aquaculture systems.

This species also has the capability for bioremediation in aquaculture. Large polychaetes averaging about 139 mg and 1.5 mm in width significantly reduced organic matter by 27%, sulfur by 71%, and iron by 70–73% in fishpond sediments over 30 days, while improving water pH (0.53-0.69) (Mandario et al. 2019). Serving a dual role as both a feed and a sediment cleaner, *M. iloiloensis* stands out as a valuable component in integrated hatchery systems.

Aside from the support of a strong aquaculture sector, availability of coastal sedimentary sites, and an established shrimp broodstock industry enable the feasibility of polychaete hatcheries in the Philippines. SEAFDEC has initiated programs aimed for mass production of pathogen-free *Marphysa* under controlled systems, mainly addressing bio-security concerns associated with the use of wild-caught polychaetes (Mandario 2018). Overall, the support of institutional infrastructure and a receptive industry may strengthen the case for local hatchery expansion of *M. iloiloensis*.

COST AND SUSTAINABILITY

In comparison to conventional feed sources, *M. iloiloensis* offers significant promise as an aquafeed ingredient in terms of its economic and environmental sustainability. Hatcheries frequently rely on fishmeal, imported polychaete baits, or processed commercial feeds to meet broodstock nutritional needs (Santos et al. 2025). These are expensive, typically affected by supply chain fluctuations, and are many times linked to high environmental costs (Rana et al. 2010). In contrast, *M. iloiloensis* is locally sourced, adaptable to organic feed inputs, and compatible with Philippine hatchery systems. To structure the economic and environmental discussion, a farm-gate life cycle assessment (LCA) boundary for polychaete supply relative to fishmeal and soymeal is shown in Figure 2. This framework demonstrates the full production chain, starting with sourcing (either wild harvest or hatchery-based culture), then grow-out, harvest and processing, transport and storage, and finally the farm-gate stage. Each stage identifies inputs and processes, including broodstock management, sediment-based culture systems, feeding regimes, and post-harvest handling methods. Moreover, major environmental and economic drivers are highlighted, particularly energy use, feed inputs, and transport distance. Corresponding control strategies are also indicated, such as quarantine protocols, feeding optimization, use of low-temperature processing, and improved logistics. In contrast to conventional protein sources that are associated with extractive fishing pressure (fishmeal), as well as land and water use (soybean meal), the use of polychaetes shifts these environmental impacts toward operational aspects.

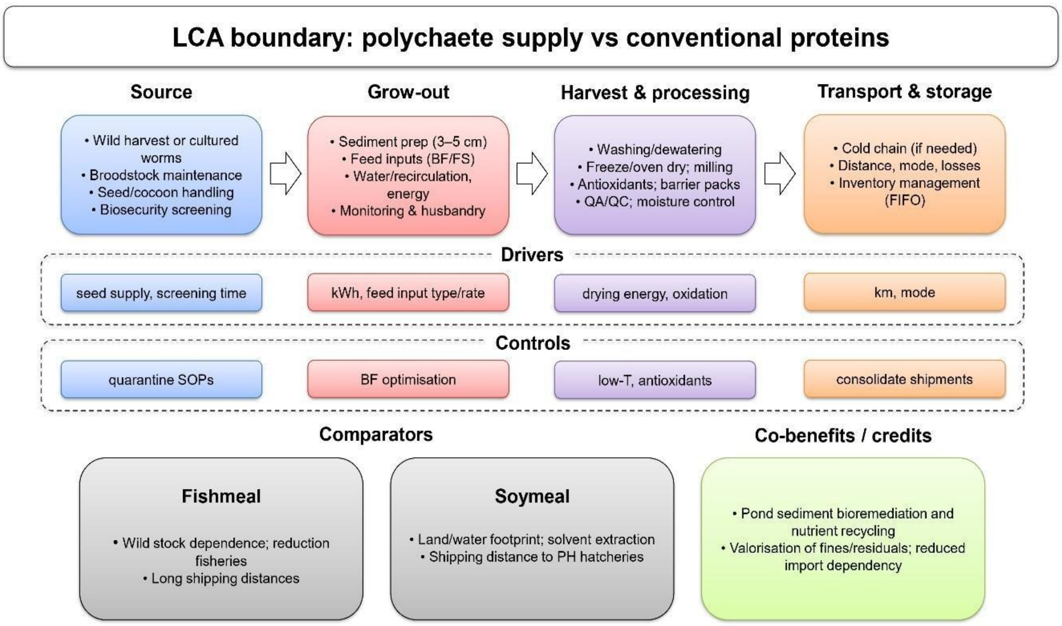

Figure 2. Life cycle assessment (LCA) boundary for polychaete supply vs conventional proteins. The life cycle boundary covers sourcing (wild harvest or culture), grow-out, harvest and processing, transport and storage, and farm-gate use. Key points are in energy for recirculation and drying, transport distance, and feed inputs, while co-benefits include pond sediment bioremediation, valorization of residues, and reduced import dependence. Compared with fishmeal and soymeal, polychaete culture shifts the footprint from extractive fishing and land use toward process energy and handling, but with local sustainability gains. (Legend: BF – biofloc; FS – formulated feed; QA – quality assurance; QC – quality control; FIFO – first in, first out; kWh – kilowatt-hour; km – kilometer; SOPs – standard operating procedures; low-T – low temperature; PH – Philippines).

Several economic benefits may arise from incorporating polychaetes into aquaculture production. In May 2008, the global price of fishmeal was estimated at USD 1,210 per tonne (Rana et al. 2010). In comparison to fishmeal, biomass from polychaetes cultivated on organic substrates (Palmer 2011; Mandario et al. 2019;

Jerónimo et al. 2021; Arduini et al. 2026) may be produced more affordably within integrated systems and presents the opportunity to decrease expenses related to feed. Consistent with this, a study has shown that polychaete meal can substitute fishmeal partially (3-9%) while maintaining or slightly improving feed conversion ratios (FCR), with reported values generally ranging from 1.47 to 1.59 in *T. rubripes* (Gao et al. 2024). This may translate to reduced feed input per unit biomass gain aside from potential feed cost savings, further strengthening the potential economic advantage of integrating *M. iloiloensis* into hatchery systems. In addition, the polychaete market reported 15% to 40% increase in 2022, indicating high demand and scarcity in supply (Santos et al. 2025), making them a worthwhile resource for an alternative feed ingredient. Although direct cost data for *M. iloiloensis* culture are not yet available, studies on other polychaete meals suggest that partial fishmeal replacement may maintain feed performance at low inclusion levels. This supports the need for local cost-benefit trials rather than direct economic claims at this stage.

Beyond immediate feed replacement, localized cultivation of polychaetes would have high market value as an additional incentive. Collectively, polychaete bait fisheries are estimated to yield over 121,000 tonnes globally per year, valued at approximately USD 8.03 billion, which surpasses the economic scale of several finfish fisheries (Watson et al. 2017). In 2015, the five most expensive polychaetes sold globally by UK-based ragworm fisheries were *Glycera dibranchiata* Ehlers, 1868 (USD 237 kg^{-1}), *Diopatra aciculata* Knox & Cameron, 1971 (USD 150 kg^{-1}), *A. virens* (USD 96 kg^{-1}), *M. sanguinea* (USD 85 kg^{-1}), and *Arenicola defodiens* Cadman & Nelson-Smith, 1993 (USD 82 kg^{-1}) (Mandario 2018). While these figures come from other polychaete species, these reflect the potential profit that might be accrued with *M. iloiloensis* if it becomes a domestic resource, rather than relying on importation and thereby creating added value to the local economy.

Sustainability also means avoiding costs. Studies show the species can be reared using low-cost inputs such as biofloc and feed mill sweepings (Mandario 2020), which may lower feed input costs compared to conventional protein sources. Unlike extractive bait worm collection that destroys habitats and depletes natural stocks (Carvalho et al. 2013), controlled culture of *M. iloiloensis* allows the recycling of organic-rich sediments into biomass (Mandario et al. 2019), aligning with circular economy principles. The LCA studies of polychaete culture in other regions further support this. *Alitta virens* and *N. japonica* production was found to have lower environmental burdens than fishmeal, especially when reared within local systems (Monteiro et al. 2023; Gao et al. 2024). By contrast, the demand for alternative sources of feed ingredients has become even more necessary due to traditional marine-sourced feed ingredients such as fishmeal, fish oil, and fish hydrolysates (Boyd et al. 2020). These inputs can cause issues in sustainability and safety, including limited supply, contaminant load, and microplastic or nanoplastic risks (FAO and WHO 2019). In this context, the use of live and processed worm products is an important consideration. Processing live polychaetes can cause the oxidation of PUFAs (Jacobsen 2010) and the breakdown of sensitive bioactive compounds (Iheanacho et al. 2025), while the use of live worms may carry potential pathogen risks if not adequately screened. Hatchery-based production of *M. iloiloensis*, with appropriate bio-safety protocols, can provide a pathway through which such risk factors can be minimized while also ensuring nutritional quality, reducing impacts on the environment, and providing reliable cost-efficient feed sources.

From a feed utilization perspective, the use of *M. iloiloensis* as a means of enhancing the reproductive performance of aquaculture species may influence feed conversion indirectly. A 60-day hatchery trial in Indian white shrimp *P. indicus* showed that even once-a-week inclusion of *M. iloiloensis* significantly enhanced reproductive performance, such as a 40% increase in fertilization rate and a 39.8% increase in spawning rate. Moreover, post-larvae showed significantly higher survival during salinity stress, with 0% mortality after 30 minutes in polychaete-fed groups versus 100% mortality in the control (Estante-Superio et al. 2023). Such advantages lead to less dependence on expensive additives or imported maturation diets.

The integration of *M. iloiloensis* into hatchery operations offers a dual benefit of reducing direct feed and import costs while minimizing hidden environmental and management expenses. Although more formal cost-benefit analyses should be done, current studies place this species as a cost-effective and sustainable alternative for local aquaculture.

RESEARCH OUTLOOK AND KNOWLEDGE GAPS

Indeed, *M. iloiloensis* has great potential as a sustainable aquaculture feedstock; however, there are several knowledge gaps that need to be resolved before its use in hatchery systems. Although the nutritional profile for related species has already been tested, establishing species-specific benchmarks for *M. iloiloensis* must be prioritized. This includes comprehensive proximate analysis and complete fatty acid and amino acid determination, which may identify possible unique bioactive compounds. Moreover, performance evaluation should be conducted through controlled digestibility trials in relevant target species such as finfish and shrimp. This includes apparent digestibility coefficients, optimal dietary inclusion levels, growth performance, FCR, survival rate, and reproductive parameters.

Processing and storage methods must also be optimized to preserve its nutritional quality before its hatchery application and possible commercialization. Lipid oxidation, PUFA retention, stability of bioactive compounds, moisture content, and shelf-life should be fully understood. Similarly, biosecurity and handling protocols must be refined to ensure completely safe hatchery use, which may include pathogen screening, microbial load assessment, and disinfection or depuration techniques.

In terms of economic feasibility, pilot-scale cost-benefit analysis in Philippine hatcheries would provide critical insights into production viability through the assessment of production costs, feed cost reduction compared to fishmeal-based diets, cost per unit biomass gain, return on investment, and sensitivity input cost fluctuations. Finally, ecological impacts related to collecting wild polychaetes or controlled rearing must also be taken into account.

Although initial setup and research require extensive effort from different local sectors, these could provide long-term economic and ecological benefits. Broader application will most likely depend on collaboration between research institutions, government agencies, and industries, specifically, the Bureau of Fisheries and Aquatic Resources (BFAR) may help introduce *M. iloiloensis* to small hatcheries. Currently, SEAFDEC is an institution working on developing this species (Ledesma 2020), with recent efforts dedicated to scaling up from production to ensure consistency in outputs from hatchery modules (Bailon et al. 2025). These insights are important in setting realistic production targets and meeting the growing feed demands of the aquaculture sector in the Philippines.

In the face of declining fishery resources, the need for sustainable fishmeal alternatives becomes more important. Among the candidates for sustainable aquafeed ingredients are the polychaetes, which have long been used as fish bait. The growing interest in this group, mostly driven by their application in aquaculture, calls for greater attention to novel and region-specific species. A newly described species endemic to the Philippines, *M. iloiloensis*, has recently drawn attention due to its high crude protein content and successful hatchery trials. Currently, limited studies have comprehensively identified its nutritional, functional, and hatchery-related qualities. This review consolidates the present understanding on nutritional composition, feed potential, and hatchery application of *M. iloiloensis.*

Evidence reviewed in this study supports the high crude protein and crude lipid content of *M. iloiloensis*, while amino acid and fatty acid profiles remain to be fully determined for the species. Its application as live feed for shrimp broodstock has also shown positive outcomes in reproduction. Furthermore, *M. iloiloensis* was observed to have an added role in nutrient recycling and improving sediment quality, which is sometimes overlooked in feed-related assessments. Moreover, these findings could add to the growing body of evidence supporting the role of polychaetes in aquaculture and position the genus *Marphysa* as a promising group of natural resources with nutritional and ecosystem-level benefits.

From a local perspective, the use of *M. iloiloensis* shows clear advantages. Being a native species, its integration into aquaculture operations reduces dependence on imported feeds while providing opportunities for the country to maximize its economic valuation. The existing global demand for *Marphysa* species in the baitworm trade further supports the feasibility of developing a small- to medium-scale industry centered on this species.

Nevertheless, wider application of *M. iloiloensis* requires additional research. Addressing the remaining knowledge gaps such as complete fatty acid and amino acid profiles of *M. iloiloensis*, long-term economic analyses, and scalability of culture systems should be prioritized. Overall, the combined nutritional, ecological, and cultural relevance of *M. iloiloensis* suggests that it holds meaningful potential as part of a more resilient and locally grounded aquaculture feed strategy in the Philippines.

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GENERATIVE AI STATEMENT

The authors hereby declare that this review paper was their own conceptualization and writing. A large language model such as Grammarly is used for checking grammar and refining sentence-level coherence and cohesiveness.

ETHICAL CONSIDERATIONS

This review paper did not use any human or animal participants and informed consent is not required.

DECLARATION OF COMPETING INTEREST

The authors declare that there are no competing interests to any authors.

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