Uttar Pradesh Journal of Zoology

Volume 46, Issue 2, Page 66-76, 2025; Article no.UPJOZ.4526
ISSN: 0256-971X (P)

Taxonomical Characteristics and Biochemical Properties of *Namalycastis abiuma*: A Promising Nutritional Resource for Aquaculture

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2025/v46i24763

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4526

Original Research Article

Received: 09/11/2024
Accepted: 13/01/2025
Published: 18/01/2025

ABSTRACT

Namalycastis abiuma polychaete species is generally found in mangrove mud flats, whereas ten specimens were observed, with six being complete, ranging from 128 to 135 chaetigers. The species exhibits an elongated body with a convex dorsum and flat ventral surface. The prostomium is trapezoidal with a distinct anterior cleft, and the antennae are short and subconical. Moreover, the species has two pairs of eyes, tentacular cirri with smooth cirrostyles, and a button-shaped pygidium with two smooth anal cirri. The determination of proximate composition widely accepted standard methods were followed, whereas it revealed rich protein content with 54.24 ± 2.4%, and

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Cite as: *Mariyappan, Selvarasu, and Perumal Murugesan. 2025. "Taxonomical Characteristics and Biochemical Properties of Namalycastis Abiuma: A Promising Nutritional Resource for Aquaculture". UTTAR PRADESH JOURNAL OF ZOOLOGY 46 (2):66-76. https://doi.org/10.56557/upjoz/2025/v46i24763.*

moderate lipid at 32.3 ± 1.2%, a lesser amount of carbohydrate with 17.2 ± 0.7%, and an ash percentage of 7.2 ± 0.5%. The fatty acid profile revealed that 30 numbers of fatty acids belong to SFA, MUFA, and PUFA; at the same time, omega-3 fatty acids, including EPA and DHA, are notable fatty acids that comprise 12.64 ± 1% of the total fatty acids. Unlike other polychaetes, the species of *Namalycastis abiuma,* generally found in mangrove environments, plays a significant role in nutrient cycling, giving crucial support to the coastal ecosystem's health, and the species has also shown great potential of biochemical profile, including protein, lipid, and carbohydrates, and specifically the presence of higher amounts of protein and omega-3 fatty acids, which collectively gives great attention to this species as a promising nutrient source that would support the aquaculture-adapted species like shrimp and fish in their immune system enhancement, reproduction, and growth. This study highlighted that this species is an alternative source for formulating feed, in contrast to reliance on traditional fishmeal, which may create more sustainable and affordable aquaculture practices.

Keywords: Taxonomy; proximate composition; fatty acid profile.

1. INTRODUCTION

The subfamily Namanereidinae (Annelida: Nereididae) comprises 50 recognized species within the two genera, Namalycastis contains the most numbers with 26 recognized species (Read & Fauchald, 2017). Species like *Namalycastis abiuma* (Grube, 1872) are one of the most widely distributed taxa of the subfamily Namanereidinae and occur in tropical and subtropical coastal regions globally (Hartman, 1959; Glasby, 1999). Glasby, (1999) recognized significant morphological variation within this species in the revision of the subfamily Namanereidinae and described the *N. abiuma* species groups, raising the possibility of this species being represented by a complex of cryptic species. *Namalycastis abiuma* has an elastic and fragile body and it is widely distributed in freshwater, estuarine, and marine habitats from tropical to subtropical regions (Glasby & Timm, 2008; Fu et al., 2009).

The group is defined by several characteristics, including a trapezoidal prostomium with an aperture on the anterior margin, the presence of notochaetae, short and conical antennae, four pairs of tentacular cirri with distinct cirrophores, the same number of falcigerous and spinigerous chaetae, and coarsely serrated spinigerous on the posterior part of the body. The dorsum of the body has brown epidermal pigmentation (Alves et al., 2024). Assessment of the overall body length in polychaetes with more delicate and frequently broken bodies, like *N. abiuma*, is more essential in determining the reproductive stage, including maturation and fecundity, especially for aquaculture purposes, because of its economic value for fishing bait. They are sediment-dwelling deposit feeders and consume decaying wood and other settled organic matter that may be generated from primary producers. Therefore, high densities and biomass of *N. abiuma* were observed within mangrove sediments (Fu et al. 2009). Namalycastis is highly recognized as a potential nutritional source for broodstock development in the aquaculture industries (Junardi et al., 2020). The family Nereididae has a rich amount of protein as well as polyunsaturated fatty acids (PUFA), which are crucial components in aquafeeds (Olive, 1999; Narciso & da Fonseca, 2000; Shucksmith et al., 2006; Bischoff et al., 2009; Brown et al., 2011; Santos et al., 2016). These worms balanced nutritional profile makes them ideal for fish hatchery diets (Palmer et al., 2014) and they are also essential supplements for the fish and shrimp broodstock development in hatcheries (Binh et al., 2008; Santander-Avanceña et al., 2022). Therefore, the polychaete species *Namalycastis abiuma* was selected to evaluate its potential nutritional value, including proximate composition and fatty acid profile, for commercial applications in the shrimp aquaculture industry.

2. MATERIALS AND METHODS

The study site was located in TS Pettai (11°25'26.70"N, 79°46'55.00"E and 11°24'58.60"N, 79°47'38.28"E), which is near the Pichavaram mangrove forest, where the *Namalycastis abiuma* species were collected in hard clay mudflats.

The samples were collected by digging using a shovel, and specimens were collected for morphological measurements, proximate analysis, and fatty acid analysis. Before measurement, five specimens were anesthetized in 4% ethanol to prevent body elasticity, after which they were preserved in 7% formalin. The

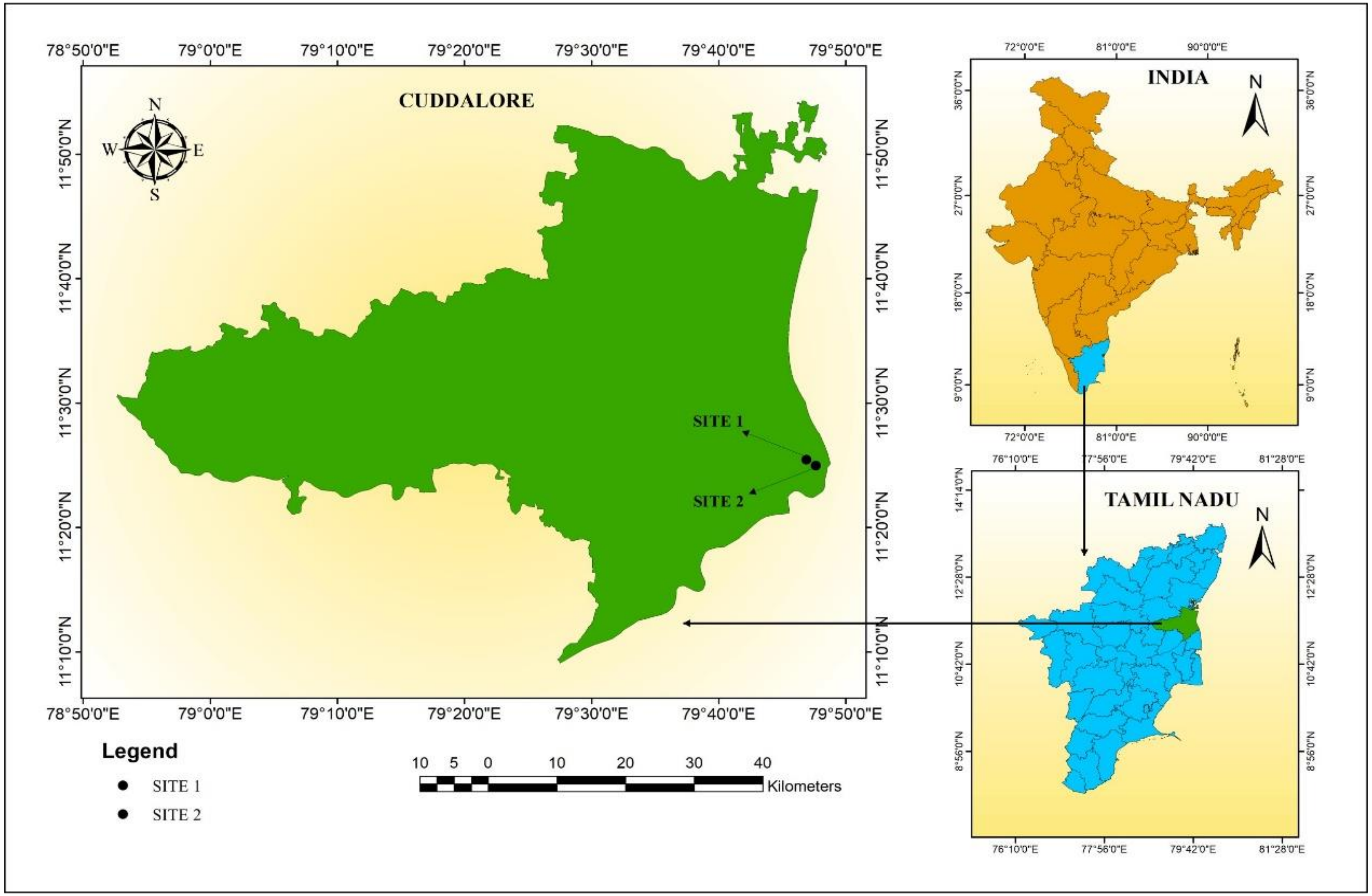

Fig. 1. Map showing the sampling sites in the TS Pettai near the Pichavaram mangrove forest

specimens were dissected to expose selected parapodia, which were examined for parapodial structures using a MAGNUS MX21iLED microscope. and both the anterior and posterior parts were taken with a Stereo microscope. Parapodia from the 1st Chaetiger, the 15th Chaetiger, and the 60th Chaetiger were among the three parapodia reviewed for every specimen. The samples were carefully selected, gently washed in seawater, and starved for 48 hours to clear the digestive tract before drying. The specimens were then oven-dried and ground into a powder. All analyses and calculations were based on the dry weight of each sample, measured per 100 g. Moisture and ash contents were determined by the weight loss method, as outlined by AOAC, (2007). The initial weight of the sample was accurately weighed in a flat dish and dried in an oven at 105°C for 1h or until constant weight was reached. After cooling in a desiccator, the sample was reweighed, and the weight loss was calculated. Protein content was estimated using the method of Lowry et al., (1951), lipids were extracted using the chloroform-methanol method described by Folch et al., (1957), and carbohydrates were measured using the Phenol-sulfuric acid Method of M. Dubois et al., (1956). The dried samples of polychaete were ground finely with a pestle and mortar and the preparation and analysis of fatty acid methyl esters (FAME) from these polychaete samples were performed according to the method described by Anon, (2000) and Sahin et al., (2000).

3. RESULTS

3.1 Morphological Study

A total of ten specimens were observed, of which six were complete, ranging from 128 to 135 chaetigers. The bodies are elongated, with a convex dorsum and flat ventral. Preserved specimens appear light brown in 70% ethanol, with epidermal pigment present only at the posterior end and on the pygidium. The prostomium is trapezoidal, with an anterior cleft, associated with a longitudinal groove extending to the mid-posterior prostomium. The antennae are short and subconical, located on the lateral sides of the species, and aligned with the palp's insertion in the middle. There are two pairs of eyes, the posterior pair being small and aligned almost transversely to the prostomium. The tentacular cirri have distinct cirrophores and smooth cirrostyles. The posterodorsal pair extends to chaetiger 2-3 (Fig. 2 A). A bilobed acicular neuropodial ligule is present in every parapodium. There are notopodial cirrophores, which gradually enlarge as one moves toward the back. The dorsal cirri measure 0.3 mm in parapodia of chaetiger 1, 0.5 mm in chaetiger 15, and 0.9 mm in chaetiger 60. Ventral cirri with nearly the same size are similar in all chaetigers. Notopodial chaetae are absent. Supra-neuroascicular chaetae consist of sesquigomph spinigers on postascicular fascicles and heterogomph falcigers on preacicular fascicles. Sub-neuroacicular chaetae are heterogomph spinigers on postacicular fascicles and heterogomph falcigers on preacicular fascicles across all parapodia. The pygidium is button-shaped with a terminal anus. The two subconical anal cirri are smooth, ventrolateral, and 0.5–0.8 times as wide as the width of the pygidium (Fig. 2 B).

3.2 Proximate Composition

The proximate composition of *Namalycastis abiuma* is illustrated in Table 1. The moisture content of the species was 42.33g which is consistent with other marine invertebrates. The protein content was found to be very high, averaging 54.24 ± 2.4% basis on dry weight. The lipid content was moderate, at 32.3 ± 1.2% while carbohydrates were found to be only 17.2 ± 0.7% and the ash content was 7.2 ± 0.5% dry weight.

3.3 Fatty Acid Analysis

Fatty acid analysis of *N. abiuma* revealed a total of 30 fatty acids, including both saturated and unsaturated types. The most abundant fatty acid was palmitic acid (C16:0), which made up 9.54 ± 0.8% of the total fatty acids. It was followed by

Table 1. Proximate composition of polychaete species *Namalycastis abiuma*

Proximate composition	(%) on Dry matter basis
Protein	54.24 ± 2.4
Lipid	32.3 ± 1.2
Carbohydrate	17.2 ± 0.7
Ash	7.2 ± 0.5
Moisture	42.33 ± 2.4

Table 2. Fatty acid composition of polychaete *Namalycastis abiuma*

S. No.	Fatty Acid	Lipid Number	Fatty Acid Percentage (%)
SFA (Saturated Fatty Acids)			
1	Caprylic acid	C8:0	2.98 ± 0.4
2	Capric acid	C10:0	1.79 ± 0.2
3	Undecanoic acid	C11:0	1.21 ± 0.1
4	Lauric acid	C12:0	3.05 ± 0.7
5	Myristic acid	C14:0	8.3 ± 0.9
6	Pentadecanoic acid	C15:0	1.4 ± 0.1
7	N-Hexadecenoic acid	C16:0	2.42 ± 0.3
8	Palmitic acid	C16:0	9.54 ± 0.8
9	Heptadecanoic acid	C17:0	3.92 ± 0.5
10	Arachidic acid	C20:0	0.23 ± 0.1
11	Heneicosanoic acid	C21:0	1.7 ± 0.1
12	Tricosanoic acid	C23:0	0.7 ± 0.1
Total SFA (%)			**37.24 ± 4.3**
MUFA (Monounsaturated Fatty Acids)			
13	Myristoleic acid	C14:1	0.29 ± 0.1
14	cis-10-Pentadecenoic acid	C15:1	2.57 ± 0.5
15	Palmitoleic acid	C16:1	6.93 ± 0.3
16	cis-10-Heptadecenoic acid	C17:1	3.13 ± 0.1
17	Eluidic acid	C18:1 ω-9	0.20 ± 0.2
18	Oleic acid	C18:1 ω-9	9.29 ± 0.7
19	Erucic acid	C22:1 ω-9	1.72 ± 0.2
20	Nervonic acid	C24:1 ω-9	0.49 ± 0.1
Total MUFA (%)			**24.62 ± 2.2**
PUFA (Polyunsaturated Fatty Acids)			
21	cis-5,8,11,14,17- Eicosapentaenoic acid (EPA)	C20:5 ω-3	7.48 ± 0.5
22	cis-11,14,17-Eicosatrienoic acid	C20:3 ω-3	0.21 ± 0.1
23	α-Linolenic acid (LNA)	C18:3 ω-3	2.56 ± 0.2
24	Docosahexaenoic acid (DHA)	C22:6 ω-3	5.16 ± 0.5
25	9,12-Octadecadienoic acid	C18:2 ω-6	4.27 ± 0.3
26	Linoleic acid (LA)	C18:2 ω-6	2.48 ± 0.1
27	g-Linolenic acid	C18:3 ω-6	0.21 ± 0.1
28	cis-11,14-Eicosadienoic acid	C20:2 ω-6	1.72 ± 0.3
29	Arachidonic acid (AA)	C20:4 ω-6	9.46 ± 0.9
30	cis-13,16-Decosadienoic acid	C22:2 ω-6	4.8 ± 0.5
Total PUFA (%)			**38.35 ± 3.5**

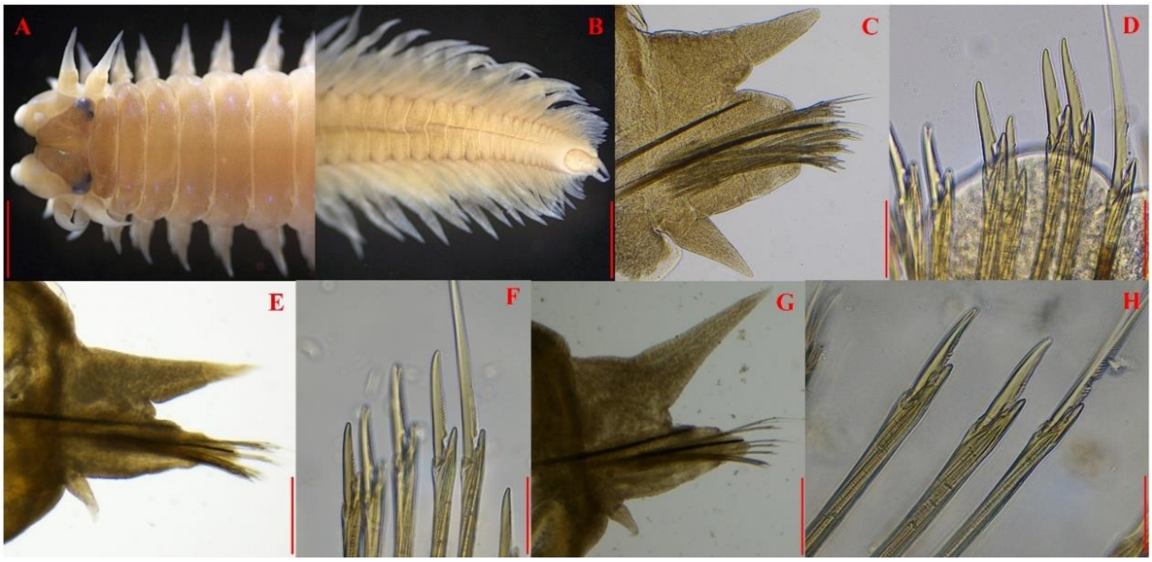

Fig. 2. *Namalycastis abiuma* (Grube, 1872). A) anterior view; B) posterior view C) 1st parapodia, D) Sub-neuroacicular spinigers and sub-neuroacicular falcigers from 1st chaetiger; E) 15th parapodia; F) Sub-neuroacicular spinigers and sub-neuroacicula falcigers from 15th chaetiger, G) 60th parapodia; H) Sub-neuroacicular spinigers and sub-neuroacicular falcigers from 60th chaetiger. Scale bar: A&B, 1.0mm; C, E & G, 0.1mm; D, F & H, 0.05mm.)

Arachidonic acid (C20:4), which contributed 9.46 ± 0.9%, and Oleic acid (C18:1) which made 9.29 ± 0.7%. Saturated fatty acids accounted for 37.24 ± 4.3% of the total, with palmitic acid (C16:0), Myristic acid (C14:0), Heptadecanoic acid (C17:0) and Lauric acid (C12:0) being the major contributors. Monounsaturated fatty acids represented 24.62 ± 2.2% of the total composition. Among the monounsaturated fatty acids, Oleic acid (C18:1), palmitoleic acid (C16:1) and cis-10-Heptadecenoic acid (C17:1) were significant, contributing 9.29 ± 0.7%, 6.93 ± 0.3% and 3.13 ± 0.1% respectively. Polyunsaturated fatty acid represented 38.35 ± 3.5 of the total composition. Among them, Arachidonic acid (C20:4), cis-5,8,11,14,17-Eicosapentaenoic acid (C20:5), Docosahexaenoic acid (C22:6) and 9,12-Octadecadienoic acid (C18:2) were significant, contributing 9.46 ± 0.9%, 7.48 ± 0.5%, 5.16 ± 0.5% and 4.27 ± 0.3% respectively. Omega-3 fatty acids, including EPA and DHA, together accounted for 12.64± 1% of the total fatty acids.

4. DISCUSSION

Namalycastis abiuma has been recorded as a globally distributed species, occurring in most tropical and subtropical mangroves and estuarine environments (Hartman, 1959; Glasby, 1999). However, this status has been questioned in several publications, which indicate that several distinct species are being identified under the name *N. abiuma.* The morphological variations of the present study species are consistent with previous studies of *N. abiuma* by Mahesh et al., (2014) in India, Glasby 1999 in New Zealand, and Alves et al., 2024 in Brazil. *N. abiuma*, the study's target species, exhibits distinct differences from other related Namaligastis species reported in earlier research (Abe et al., 2017; Alves et al., 2016; Goren et al., 2020; Alves et al., 2024). Morphological examination of the ten observed specimens reveals unique and consistent characteristics that contribute to the identification and differentiation of the species *N. abiuma*. These features provide important taxonomic insights that align with prior descriptions while highlighting subtle variations that may indicate population-level or species-level differences. The elongated body structure with a convex dorsal and flat ventral surface is a characteristic trait of many *Namalycastis species*, which may be associated with their specific ecological adaptations. The light brown coloration in preservation and the concentration of epidermal pigment at the posterior end and pygidium could serve as distinguishing features when compared to other morphologically similar taxa. Such pigmentation patterns are often used in polychaete taxonomy and may reflect adaptive responses to environmental conditions.

The *Namalycastis abiuma* species are widely distributed in both estuarine and marine habitats, and it has shown great attention in their varied biochemical profile, that includes proteins, lipids, carbohydrates, and essential amino acids, which attributes are often reflected by their specific habitats and ecological roles (Lim et al., 2021). In this study, the obtained protein content was to be 54.24% on a dry matter basis, which shows strong evident results to the other polychaete species, such as *Nereis diversicolor* (54–58%) Wang et al., (2019) and *Perinereis gualpensis* (52–58%) Gómez et al., (2023). There are many similar findings that have been found in other polychaetes, *N. vexillosa* (58%) and *P. aibuhitensis* (61%), which are used as feed in shrimp culture (Yang et al. 2022). The reason behind the higher content of protein found in this current study might be the presence of (gametes) either ovum or sperm Pamungkas et al., (2015). Further, while compared with the other biochemicals, proteins are a more necessary component during the polychaete maturation stages, which are largely supported for the synthesis of peptide hormones, enzymes, and egg yolk proteins (Schenk & Hoeger, 2020; Yang et al., 2022). As supported by the previous investigation of Teles et al., 2020, the present study protein content is a highly suitable value for most of the aquaculture-based species protein requirements.

Like other vital biochemicals, lipids are also one of the major and essential biochemical in polychaetes, which plays significant roles in serving as an initial energy source reserve, structural components for cell membranes, and lipids have performed as precursors for signalling molecules Jeronimo et al., 2021. The present study revealed lipid content was to be 32.3% in *Namalycastis abiuma*, which is higher than the earlier reported species values such as *Perinereis cultrifera* 13.4% (Dorgham et al., 2015), 10.7% lipid content found in *P. anomala* (Dorgham et al. 2014); *Perinereis nuntia* showed 13.4% (Limsuwatthanathamrong et al., 2012); lipid levels ranged between 9.1-13% in *P. helleri* (Palmer et al., 2014); and 10.0% of lipid content reported in *Diopatra neapolitana* (Luis & Passos, 1995).

Another critical biochemical property of carbohydrates is also a significant component in the polychaete growth and development. The present study found the carbohydrate value to be 17.2% based on dry weight. As strong support for the current result, the more or less similar findings were reported in some of the other polychaete species, like *P. cultrifera*, which had CHO content of 8.3-14.8% (Dorgham et al., 2015), and *Laeonereis ankyloseta*, which had 9.4% of carbohydrate (Balasubramanian et al., 2012), and *P. anomala* species had 6.5-18.7% of carbohydrate reported by Dorgham et al., 2014. Further, *Perinereis quatrefagesi* showed a higher amount of carbohydrate, 24.61% (Selvam et al., 2021), which is higher than the present study. The variation of biochemical properties could be reflected by their respective environments and habitats where they live; moreover, gender can also be a reason for their chemical composition variations Rodrigues et al. 2009.

Ash and water contents were 7.2% and 42.33, respectively. On the other hand, compared with the polychaete, *Diopatra neapolitana* (3.12%) and 71.38% moisture content reported Selvam et al., 2021, the present result is slightly higher in amount, and in addition, *P. cultrifera* (14.7%) in the autumn season and 20.53% of ash content was recorded in the spring season (Dorgham et al., 2015), there is a significant difference with the present study species. The ash content found in the present study is likely reflected by the availability of essential minerals, including calcium, phosphorus, and magnesium; these elements have been a vital component for the aquatic organism’s skeleton formation, enzymatic activity, and also help osmoregulation (FAO, 2020).

Another critical biochemical fatty acid has been the foundation for the polychaete's growth, development, and reproduction. The current investigation of fatty acid analysis of *Namalycastis abiuma* revealed various profiles that comprise 30 numbers of fatty acids, which are classified under the saturated fatty acids (SFA), which assist the stability of the cell membrane and help to store the energy. Monounsaturated fatty acid (MUFA) could help to maintain the fluidity of the cell membrane, also regulating the energy metabolism and Polyunsaturated fatty acids (PUFAs) might assist in enhancing the immune system and also can support the growth and reproduction of an aquatic-based organism Carvalho et al., 2018; Al-Khalaifah, 2020; Zhukova, 2023; Farías et al., 2023 and Monteiro et al., 2024. PUFA has contributed a maximum percentage of 38% among all the other fatty acids found in this study; on the other hand, among the detected saturated fatty acids, palmitic acid (C16:0) was 9.54% abundant in total percentage, whereas the availability of higher content might be reflected by the organisms’ energy-storing capability and membrane stability as evident by Kainz et al., 2009 and Stillwell, 2016). In the earlier observation, similar patterns were detected in N. virens, *Glycera* sp., and *P. cultrifera* species (Bharath et al., 2021), and further the species showed similar results: *P. cultrifera* (Dorgham et al., 2015) and *Nereis* sp. (Sahu et al., 2017). MUFA (monounsaturated fatty acids) are another critical fatty acid, which contributes 24% to total fatty acid composition, whereas the highest concentration was oleic acid (C18:1 ω-9) with 9.29%, whereas this result is slightly lower than the previous study observed in species like N. virens, *Glycera* sp., and *P. cultrifera* Bharath et al., 2021. Moreover, one of the essential fatty acids, MUFA, maintains the fluidity of the cell membrane and also assists the energy metabolism (Peeters & Jellusova, 2024). In the present investigation, PUFA has contributed 38% to total fatty acid composition, whereas (EPA) Eicosapentaenoic acid has (C20:5 ω-3) at 7.48% and (DHA) Docosahexaenoic acid (C22:6 ω-3) at 5.16%. The essential fatty acids, like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are important for the growth, development, and health of the aquatic animals (Jerónimo et al., 2021; Vítor et al., 2023; Barreto et al., 2024; Rodríguez et al., 2025).

5. CONCLUSION

The morphological and biochemical analysis of *Namalycastis abiuma* revealed distinct features and compositional characteristics that contribute to our understanding of this species. The morphological traits, such as the trapezoidal prostomium, the distinct antennae and cirri, and the presence of bilobed acicular neuropodial ligules, provide important insights into its taxonomy and adaptation. The proximate composition data indicate a high protein content (54.24%) and moderate lipid content (32.3%), suggesting that *N. abiuma* is rich in nutritional value, which could be significant in ecological and dietary contexts. The fatty acid analysis further revealed a complex profile with notable contributions from both saturated (37.24%) and unsaturated (62.76%) fatty acids, including significant amounts of omega-3 fatty acids, such as EPA and DHA (12.64%). This study highlighted that this species is an alternative source for formulating feed, in contrast to reliance on traditional fishmeal, which may create more sustainable and affordable aquaculture practices.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. **Quillbot:** Used for grammar checking, paraphrasing, and sentence restructuring to enhance clarity and flow.
2. **Grammarly:** Utilized for grammar checking, spelling corrections, and improving sentence-level coherence and conciseness.

ACKNOWLEDGMENT

Authors are grateful to the Director & Dean, CAS in Marine Biology & authorities of Annamalai University for providing the necessary facilities. The author acknowledges gratefully the Ministry of Environment, Forests and Climate Change of the Government of India (MoEF&CC) for the financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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