Feeding habits and natural diet changes of the tropical sand goby (*Acentrogobius caninus*) in Thi Nai Lagoon, Gia Lai Province

ABSTRACT

This study was conducted to determine the natural diet and feeding habit variations of the tropical sand goby (*Acentrogobius caninus*) in Thi Nai Lagoon, Gia Lai Province. A total of 590 individuals were collected for analysis, including 280 individuals in the dry season and 310 individuals in the rainy season. The relative length of gut (RGL) ranged from 0.73 to 0.87 in the dry season and from 0.75 to 0.89 in the rainy season, indicating the carnivorous feeding habit of the fish. This index tended to decrease with increasing fish size. The natural diet confirms that this species is carnivorous, comprising prey groups such as fish, shrimp, snails, crabs, squid, and unidentified food items. The natural diet of the goby varied clearly among size groups. Snails were the most important food item during the dry season; however, their contribution to the diet gradually decreased from smaller to larger size groups (88.29% in fish ≤9.9 cm, 69.92% in fish 9.9–11.9 cm, and 65.07% in fish ≥11.9 cm). Shrimp played a dominant role during the rainy season and also varied among the three size groups, with the highest IRI observed in fish ≥11.9 cm (95.17%), followed by fish ≤9.9 cm (89.01%) and fish 9.9–11.9 cm (85.83%). This research has provided important scientific data that serve as a foundation for future studies aimed at conserving fish species in general, and goby species in particular in the Thi Nai Lagoon ecosystem.

Keywords: Tropical sand goby, *Acentrogobius caninus*, feeding habits, natural diet, nutritional characteristics.

1. INTRODUCTION

Thi Nai is one of the most important lagoon ecosystems in the South Central region of Vietnam, characterized by high biodiversity and playing a crucial role in providing abundant aquatic resources for local communities. The fish species composition in this ecosystem is highly diverse, with 95 species recorded in 2020, belonging to 81 genera, 55 families, and 16 orders [1]. Among them, eight species belong to goby families, such as tank goby (*Glossogobius giuris*), crazy fish (*Butis butis*), and tropical sand goby (*Acentrogobius caninus*). Although these goby species are relatively small in size, they are favored as food by local residents. Consequently, they are under strong pressure from fishing activities.

Moreover, these species are also affected by aquaculture activities around the lagoon. According to our field observations, local people often apply piscicides before starting aquaculture cycles, leading to a severe decline in many goby species, including the tropical sand goby, with catches decreasing markedly. Therefore, in order to contribute to the conservation and sustainable development of goby resources, especially the tropical sand goby, studies ranging from basic to applied research are urgently needed. However, to date, very few studies have been conducted on this species in the Thi Nai Lagoon. In particular, no in-depth research on the nutritional characteristics and feeding habits of the tropical sand goby has been carried out in this area. Meanwhile, knowledge of natural food composition and feeding habits will provide insights into fish biology and trophic interactions among species within the fish community [2].

In addition, the composition of food items may vary with fish size in some goby species. For example, large *Neogobius melanostomus* primarily feed on dreissenid mollusks, whereas smaller individuals mainly consume chironomids [3]. Although the diet composition of fish is species-specific, it can still change depending on food availability in the environment or morphological characteristics of the fish [4]. This study also aims to investigate variations in diet and feeding habits of the tropical sand goby in relation to fish sizes that has not previously been examined in the Thi Nai Lagoon ecosystem. The results will provide a deeper understanding of dietary flexibility of the tropical sand goby.

2. MATERIALS AND METHODS

2.1. Fish sample collection and processing

A total of 590 tropical sand goby individuals were collected from fishermen operating in coastal areas of Thi Nai Lagoon, Gia Lai Province, from July to

November 2025 for this study. Of these, 280 individuals were collected during the dry season (July–August 2025) and 310 individuals during the rainy season (September–November 2025). The specimens were preserved on ice in foam boxes and transported to the Animal Science Laboratory, Quy Nhon University, for analysis. Fish samples were analyzed on the same day or fixed in 5% formalin for later examination.

Fish species identification followed Dinh et al. [5]. Fish size classes were determined based on quartiles of total length distribution [6]. Accordingly, individuals were categorized into three size groups: ≤9.9 cm, 9.9–11.9 cm, and >11.9 cm.

2.2. Analysis of feeding habits and natural diet

In the laboratory, all 590 fish specimens were measured for total length (TL) using a ruler with 1 mm precision and weighed for body mass (W) using an electronic balance with 0.01 g precision. Fish were then dissected to remove the digestive tract, and gut length (Lg) was measured to calculate the relative gut length (RLG). RLG was used to predict feeding habits: herbivorous species (RLG > 3), carnivorous species (RLG < 1), or omnivorous species (RLG = 1–3) [7], [8].

$$RLG=Lg/TL$$

A total of 204 fish specimens containing food in their digestive tracts were analyzed to determine natural diet composition, including 96 samples from the dry season and 108 samples from the rainy season. A Leica S9i stereomicroscope was used for gut content dissection and food item identification. Food items were classified into different groups such as fish, snails, shrimp, etc., based on FAO references [9] - [12].

Feeding indices were calculated following Hyslop and Cortés [13],[14].

- Frequency of occurrence of food item i

$Oi\%$= (Number of stomachs containing food item i /Total number of stomachs analyzed) ×100

- Numerical percentage of food item i

$Ni\%$=(Total number of food item i/Total number of all food items)×100

- Weight percentage of food item i

$Wi\%$=(Total weight of food item i/Total weight of all food items)×100

- Relative Importance of food item i

$IRIi=Oi\%\times(Ni\%+Wi\%)$

- Percentage of Relative Importance

$IRIi\%=IRIi/\sum IRIi\times100$

2.3. Data analysis

Data were processed and calculated using Microsoft Excel 2016 and SPSS 20.0. A t-test was used to examine whether RLG values differed significantly from 1. One-way ANOVA was applied to test differences in RLG values among size groups within each season.

3. RESULTS AND DISCUSSION

3.1. Feeding habits

The feeding habits of the tropical sand goby during the dry and rainy seasons were assessed using the relative gut length (RLG) index, with the results presented in Table 1. The RLG values of the tropical sand goby ranged from 0.73 to 0.87 in the dry season, while those in the rainy season ranged from 0.75 to 0.89. All values were lower than 1, and t-test results indicated that the RLG values of all size groups in both seasons were significantly different from 1. Therefore, the tropical sand goby can be identified as a carnivorous species [7],[8].

Table 1. Relative length of gut (RLG) of the tropical sand goby during the dry and rainy seasons

Seasons	Size classes	Total length (TL)	Intestine length (Lg)	RLG	t-test results
Dry season (n=280)	≤9.9 cm (n=90)	9.39 ± 0.60	8.15 ± 1.42	0.87 ± 0.15[a]	t=-8.078; p<0.001
	9.9-11.9 cm (n=166)	10.84 ± 0.53	7.98 ± 2.08	0.74 ± 018[b]	t=-18.528; p<0.001
	>11.9 cm (n=24)	12.72 ± 0.71	9.34 ± 1.89	0.73 ± 0.14[b]	t=-9.535; p<0.001
Rainy season (n=310)	≤9.9 cm (n=98)	9.26 ± 0.69	8.23 ±1.56	0.89 ± 0.17[a]	t=-6.197; p<0.001
	9.9-11.9 cm (n=175)	10.90 ± 0.51	8.54 ± 1.30	0.78 ± 0.12[b]	t=-24.325; p<0.001
	>11.9 cm (n=37)	12.96 ± 1.00	9.68 ± 1.48	0.75 ± 0.13[b]	t=-11.504; p<0.001

Note: *Within the same season, different letters indicate statistically significant differences.*

Many studies have used the RLG index to predict feeding habits of lost of fish species, of which, many gobies have been reported to exhibit RLG values lower than 1 and and suggested a carnivorous feeding strategy. For example, *Glossogobius giuris* shows RLG values ranging from 0.68–0.72 [15], 0.38–0.43 [16], and 0.45–0.78 [17], *Butis koilomatodon* exhibits RLG values from 0.52 to 0.63 [18], and *Glossogobius sparsipapillus* ranges from 0.18 to 0.83 [19]. In contrast, a small

number of goby species display RLG values between 1 and 3, showing omnivorous feeding, such as the goby *Aulopareia unicolor* with RLG values ranging from 1.05 to 1.10 [20] and *Parapocryptes serperaster* (family Gobiidae), which has an RLG value of 1.57 [21]. Overall, the RLG index indicates that most goby species are carnivorous, although a few species exhibit omnivorous feeding habits with a preference toward animal prey.

In addition, RLG values in this study varied among size groups in both seasons, with lower RLG values observed in the two larger size groups. Similar results were reported by Ly for *Glossogobius giuris* and *Aulopareia unicolor* [20]. The change in this RLG is likely to be an adaptation to the natural food sources they use. Nevertheless, the RLG provides preliminary insights into the feeding habits of fish and is not completely reliable for reflecting the trophic level of some goby species in the tropical Indo-Pacific area [22]. Therefore, detailed analyses of their natural diet are required to accurately characterize fish feeding habits.

3.2. Diet changes among different fish size groups

To clarify the feeding habits of the tropical sand goby, we examined their natural diet and assessed whether there were differences in food composition among size groups. The results of gut content analysis for different size groups during the dry and rainy seasons are presented in Tables 4 and Table 5.

During the dry season (Table 4), fish in the ≤9.9 cm and ≥11.9 cm size groups consumed three types of prey, namely shrimp, snails, and fish, whereas individuals in the 9.9–11.9 cm group consumed up to five prey categories (shrimp, snails, fish, squid, and unidentified food items). Overall, snails were the most important food item for all three size groups. However, the contribution of snails to the IRI decreased progressively from smaller to larger size groups: 88.29% in the ≤9.9 cm group, 69.92% in the 9.9–11.9 cm group, and 65.07% in the ≥11.9 cm group. Conversely, the contribution of fish prey to the diet increased with fish size, from 0.35% IRI in the ≤9.9 cm group to 4.97% in the 9.9–11.9 cm group and 26.52% in the ≥11.9 cm group. Meanwhile, the IRI percentage of shrimp was highest in the 9.9–11.9 cm size group.

Table 4. Natural diet of fish groups during the dry season

Size groups of fish	Food	Frequency of occurrence (%)	Percentage by number (%)	Percentage by weight (%)	Percentage of IRI (%)
≤9.9 cm (n=28)	Shrimps	35.71	22.73	13.81	11.36
	Snails	64.29	72.73	85.07	88.29
	Fish	7.14	4.54	1.12	0.35
9.9-11.9 cm (n=50)	Shrimps	32.00	23.19	33.09	25.10
	Snails	44.00	60.87	53.13	69.92
	Fish	12.00	15.94	13.79	4.97
	Squids	2.00	1.45	1.56	0.08
	Unidentified	12.00	8.70	5.97	2.45
≥11.9 cm (n=18)	Shrimps	16.67	8.33	34.87	8.41
	Snails	50.00	66.67	44.74	65.07
	Fish	50.00	25.00	20.39	26.52

During the rainy season (Table 5), dietary habits of the fish still varied among size groups. The two smaller size groups consumed shrimp, snails, and fish, whereas the largest size group fed on shrimp, fish, and crabs. Among all food items, shrimp was the most important prey in all three size groups; however, its contribution to the Index of Relative Importance (IRI) was highest in fish ≥11.9 cm (95.17%), followed by fish ≤9.9 cm (89.01%), and lowest in fish group of 9.9–11.9 cm (85.83%). The remaining food items contributed only marginally to the overall IRI of the fish, except for snails in the 9.9–11.9 cm size group, which accounted for 11.83% of the IRI.

Table 4. Natural diet of fish groups during the rainy season

Size groups of fish	Food	Frequency of occurrence (%)	Percentage by number (%)	Percentage by weight (%)	Percentage of IRI (%)
≤9.9 cm (n=30)	Shrimps	66.67	51.28	80.52	89.01
	Snails	11.33	33.33	8.60	5.66

	Fish	20.00	15.38	10.88	5.32
9.9 – 11.9 cm (n=55)	Shrimps	67.27	58.73	76.06	85.83
	Snails	27.27	30.16	15.67	11.83
	Fish	12.73	11.11	8.27	2.33
≥11.9 cm (n=23)	Shrimps	73.91	73.91	81.40	95.17
	Fish	13.04	13.04	10.28	2.52
	Crabs	13.04	13.04	8.32	2.31

The present study demonstrates that the natural diet spectrum of fish varies quite distinctly among different size groups. Similar findings have been reported in many other studies. Brush et al. showed that round goby (*Neogobius melanostomus*) individuals larger than 80 mm exhibited a higher IRI percentage of dreissenid prey and a lower IRI percentage of non-shelled invertebrates (particularly chironomids) compared with smaller individuals (≤80 mm) [3]. Size-related dietary shifts have also been documented in the goby *Pomatoschistus minutus*, which primarily feeds on copepods at smaller size classes but consumes oligochaetes, fish, bivalves, and shrimp at bigger sizes [23]. Or shrimps are only consumed by the largest size group of *Pomatoschistus microps* [23]. Similarly, dietary changes throughout the life cycle have been reported in other fish species, such as tiger sharks *Galeocerdo cuvier* [24], the snapper *Lutjanus fulvus* [25], or *L. argentimaculatus* [4]. During the life history, carnivorous fish species often alter their feeding habits [26]. These changes may be influenced by differential habitat use among size groups, that can be related to the availability of prey in each habitat [27]. When natural food resources in a habitat change, prey selection by fish may also shift accordingly. In addition, morphological and anatomical changes are important factors contributing to dietary variation in fish [28], [29]. Moreover, ontogenetic dietary shifts may help fish optimize energy accumulation for growth and reduce predation risk [30], [31]. Therefore, the observed changes in the natural diet spectrum of the tropical sand goby across size groups in this study may be associated with morphological traits, habitat use, or the availability of natural food resources in their habitats.

4. CONCLUSIONS

The relative gut length (RGL) index of the fish ranged from 0.73 to 0.87 during the dry season and from 0.75 to 0.89 during the rainy season, with the lower values observed in two large size groups. These values reflect a carnivorous feeding strategy in the fish.

Natural food items found in the digestive tract included snails, shrimp, fish, crabs, squid, and unidentified food. Dietary composition varied among size groups: during the dry season, the IRI contribution of snails gradually decreased from smaller to larger size groups (88.29% in fish ≤9.9 cm, 69.92% in fish 9.9–11.9 cm, and 65.07% in fish ≥11.9 cm); during the rainy season, the IRI contribution of shrimp was highest in fish ≥11.9 cm (95.17%), followed by fish ≤9.9 cm (89.01%) and lowest in fish 9.9–11.9 cm (85.83%).

In conclusion, this study elucidates the feeding habits and natural food composition of the tropical sand goby. Notably, it reveals clear ontogenetic dietary shifts associated with growth in this species in Thi Nai Lagoon. These findings provide important baseline scientific data for future studies aimed at the conservation of this fish species as well as other fish in the Thi Nai Lagoon ecosystem.

References

[1] V. V. Chi and N. T. P. Hien, "The fish species composition diversity in Thi Nai lagoon, Binh Dinh Province", *Quy Nhon University Journal of Science*, vol. 14, no. 1, pp. 87–94, 2020.

[2] S. J. M. Blaber, *Tropical Estuarine Fishes: Ecology, Exploitation and Conservation*. Oxford, UK: Blackwell Science, 2000.

[3] J. M. Brush, A. T. Fisk, N. E. Hussey, and T. B. Johnson, "Spatial and seasonal variability in the diet of round goby (*Neogobius melanostomus*): Stable isotopes indicate that stomach contents overestimate the importance of dreissenids," *Can. J. Fish. Aquat. Sci.*, vol. 69, pp. 573–586, 2012.

[4] V. V. Chi and J. D. True, "Feeding ecology of juvenile mangrove red snapper *Lutjanus*

argentimaculatus (Forsskål, 1775) in central Vietnam," *Malayan Nat. J.*, vol. 70, no. 1, pp. 33–45, 2018.

[5] T. D. Dinh, K. Sato, N. T. Phuong, H. P. Hung, T. X. Loi, M. V. Hieu, and K. Utsugi, *Taxonomic Descriptions of Fishes of the Mekong Delta, Vietnam*. Can Tho, Vietnam: Can Tho Univ. Publishing House, 2013.

[6] N. Wolf, S. R. Webster, J. M. Welker, and B. P. Harris, "Assessing the relationship between diet and size-at-age in Pacific halibut (*Hippoglossus stenolepis*) using $\delta^{13}C$ and $\delta^{15}N$ analysis," *Can. J. Fish. Aquat. Sci.*, vol. 76, pp. 1–10, 2019.

[7] G. V. Nikolsky, *Ecology of Fishes*. London, UK: Academic Press, 1963.

[8] C. Geevarghese, "Morphology of the alimentary tract in relation to diet among gobioid fishes," *J. Nat. Hist.*, vol. 17, pp. 731–741, 2007.

[9] K. E. Carpenter and V. H. Niem, Eds., *FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific, Vol. 1*. Rome, Italy: FAO, 1998.

[10] K. E. Carpenter and V. H. Niem, Eds., *FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific, Vol. 2*. Rome, Italy: FAO, 1998.

[11] K. E. Carpenter and V. H. Niem, Eds., *FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific, Vol. 4*. Rome, Italy: FAO, 1999.

[12] K. E. Carpenter and V. H. Niem, Eds., *FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific, Vol. 5*. Rome, Italy: FAO, 2001.

[13] E. Cortés, "A critical review of methods of studying fish feeding based on analysis of stomach contents: Application to elasmobranch fishes," *Can. J. Fish. Aquat. Sci.*, vol. 54, pp. 726–738, 1997.

[14] E. J. Hyslop, "Stomach contents analysis—A review of methods and their application," *J. Fish Biol.*, vol. 17, pp. 411–429, 1980.

[15] V. V. Chi, D. T. X. Tru, and V. Dieu, "Feeding biology of broadhead sleeper (*Eleotris melanosoma*) and tank goby (*Glossogobius giuris*) distributed in Thi Nai lagoon, Binh Dinh Province," vol. 18, no. 11.1, pp. 48–51, 2020.

[16] P. H. Gieo, D. M. Quang, N. T. Truong, N. S. Tran, and T. H. D. Nguyen, "Factors affecting relative gut length and fullness index of *Glossogobius giuris* living along Hau River, Vietnam," *AACL Bioflux*, vol. 14, no. 5, pp. 2708–2717, 2021.

[17] S. Gogoi, S. Deb, and S. P. Biswas, "Length–weight relationship and feeding habit of *Glossogobius giuris* and *Nandus nandus* from Sessa River, India," *Asian J. Biol. Life Sci.*, vol. 11, no. 3, pp. 719–723, 2022.

[18] N. T. N. Y, L. T. H. Tran, and D. M. Quang, "Feeding habits and predation intensity of the high-backed goby *Butis koilomatodon*," *TNU J. Sci. Technol.*, vol. 225, no. 8, pp. 358–365, 2020.

[19] T. T. Canh, N. H. D. Ton, N. T. T. Hien, and D. M. Quang, "Gastrointestinal tract morphology and Clark index of *Glossogobius sparsipapillus*," *Vietnam J. Agric. Sci.*, vol. 19, no. 4, pp. 535–543, 2021.

[20] V. T. M. Ly, "Study on biological characteristics of several goby fish species in the lower Tam Quan River," M.S. thesis, Quy Nhon Univ., Vietnam, 2022.

[21] D. M. Quang, G. Q. Jian, S. Dittmann, and T. D. Dinh, "Seasonal variation of food and feeding in burrowing goby *Parapocryptes serperaster*," *Ichthyol. Res.*, vol. 64, pp. 179–189, 2017.

[22] C. Pogoreutz and H. Ahnelt, "Gut morphology and relative gut length do not reliably reflect trophic level in gobiids," *J. Appl. Ichthyol.*, vol. 30, pp. 408–410, 2014.

[23] J. P. Salgado, H. N. Cabral, and M. J. Costa, "Feeding ecology of *Pomatoschistus minutus* and *Pomatoschistus microps*," *Scientia Marina*, vol. 68, pp. 425–434, 2004.

[24] C. G. Lowe, B. M. Wetherbee, G. L. Crow, and A. L. Tester, "Ontogenetic dietary shifts of the tiger shark *Galeocerdo cuvier*," *Environ. Biol. Fishes*, vol. 47, pp. 203–211, 1996.

[25] Y. Nakamura *et al*., "Evidence of ontogenetic migration from mangroves to coral reefs by *Lutjanus fulvus*," *Mar. Ecol. Prog. Ser.*, vol. 355, pp. 257–266, 2008.

[26] A. F. Johnson, M. Valls, J. Moranta, S. R. Jenkins, J. G. Hiddink, and H. Hinz, "Effect of prey abundance and size on the distribution of demersal fishes," *Can. J. Fish. Aquat. Sci.*, vol. 69, pp. 191–200, 2012.

[27] D. R. Barton, R. A. Johnson, L. Campbell, J. Petruniak, and M. Patterson, "Effects of round gobies on dreissenid mussels," *J. Great Lakes Res.*, vol. 31, no. 2, pp. 252–261, 2005.

[28] V. Lukoschek and M. I. McCormick, "Ontogeny of diet changes in *Parupeneus barberinus*," *Mar. Biol.*, vol. 138, pp. 1099–1113, 2001.

[29] R. J. Schmitt and S. J. Holbrook, “Ontogeny of prey selection by *Embiotoca jacksoni*,” *Mar. Ecol. Prog. Ser.*, vol. 18, pp. 225–239, 1984.

[30] J. A. Brown, “The adaptive significance of behavioural ontogeny in centrarchid fishes,” *Environ. Biol. Fishes*, vol. 13, pp. 25–34, 1985.

[31] G. D. Grossman, “Ecological aspects of ontogenetic shift in prey size utilisation in bay goby,” *Oecologia*, vol. 47, pp. 233–238, 1980.

Tập tính ăn và sự thay đổi thức ăn tự nhiên của cá bống tro (*Acentrogobius caninus*) ở đầm Thị Nại, tỉnh Gia Lai

TÓM TẮT

Nghiên cứu này được thực hiện nhằm xác định thức ăn tự nhiên và sự thay đổi về tập tính ăn của cá bống tro (*Acentrogobius caninus*) ở đầm Thị Nại, tỉnh Gia Lai. Tổng cộng 590 cá thể được thu gom để phân tích, trong đó 280 cá thể được thu trong mùa khô và 310 cá thể được thu trong mùa mưa. Chiều dài ruột tương đối của cá (RLG) ở mùa khô dao động từ 0,73 đến 0,87 trong khi đó ở mùa mưa là từ 0,75 đến 0,89, thể hiện tính ăn động vật của cá. Chỉ số này có xu hướng giảm dần khi cá lớn lên. Thức ăn tự nhiên của cá thể hiện đây loài ăn động vật, với các nhóm mồi như cá, tôm, ốc, cua, mực và thức ăn không xác định. Thức ăn tự nhiên của cá bống tro thay đổi khá rõ theo các nhóm kích thước. Ốc là thức ăn quan trọng nhất ở mùa khô, nhưng sự đóng góp trong khẩu phần giảm dần từ nhóm cá nhỏ đến nhóm cá lớn (88,29% ở nhóm cá ≤9,9 cm, 69,92% ở nhóm cá 9,9–11,9 cm, và 65,07% ở nhóm cá ≥11,9 cm); Tôm đóng vai trò quan trọng trong mùa mưa và cũng có sự thay đổi giữa ba nhóm kích cỡ cá, với IRI cao nhất ở nhóm cá ≥11,9 cm (95,17%), tiếp đến là cá ≤9,9 cm (89,01%) và thấp nhất ở cá từ 9,9–11,9 cm (85,83%). Kết quả nghiên cứu này đã cung cấp những dữ liệu khoa học quan trọng, làm cơ sở cho các nghiên cứu trong tương lai nhằm bảo tồn các loài cá nói chung và cá bống nói riêng trong hệ sinh thái đầm Thị Nại.

Từ khóa: Cá bống tro, *Acentrogobius caninus*, tập tính ăn, thức ăn tự nhiên, đặc điểm dinh dưỡng