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Diet Composition and Feeding Strategy of *Butis koilomatodon* Inhabiting the Estuarine Regions in the Mekong Delta, Vietnam

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Key words
***Butis koilomatodon*, Estuarine areas, Feeding activity, Food composition, Predator, mud-sleeper**

ABSTRACT

Understanding the fish's food and feeding habits is essential in aquaculture and research on invasive species. *Butis koilomatodon* is one of the potential candidates for aquaculture in the Mekong Delta because it can survive in a wide range of water temperature (26–36 °C) and salinity (3.8-37.25%), but data on this fish species' food and feeding habit are still fragmented and deficient. Consequently, this research aims at supplying necessary data related to diet compositions and feeding activity of *Butis koilomatodon* collected in six estuarine areas of Mekong delta from April 2019 to March 2020. A total number of 1,227 specimens of *Butis koilomatodon* (891 males and 336 females) were analyzed diet composition and feeding strategy based on the kinds of food they consumed. The results show that four main food categories were shrimps, small fish, Polychaeta, and detritus, of which the highest frequency of prey is shrimp while the lowest one is Polychaeta. The gender and fish size do not affect this species' dietary constituent; however, the changes in seasons and sampling sites impact on the diet composition of these species. The shrimps, small fish, and detritus contribute to regulating the food composition of *Butis koilomatodon* between two seasons and among the six sampling sites. In combination with the modified Costello graphic, all fish specimens' gut fullness suggested that *Butis koilomatodon* is a predator with high feeding intensity. The findings can supply the fundamental knowledge about the nutrient biology of *Butis koilomatodon* and be useful for artificial cultivating this fish.

INTRODUCTION

The mud-sleeper *Butis koilomatodon* (Bleeker, 1849) (Perciformes: Butidae) is considered an indigenous species in the Indo- Pacific estuaries. Both Miller *et al.* (1989) and Contente *et al.* (2016) show that this species can live in a wide of water temperature (26–36 °C) and salinity (3.8–37.0%). The mud sleeper has a limited capacity for long-distance swimming and an inactive lifestyle with a carnivorous diet consisting of native fishes and crustaceans (Contente *et al*., 2016). *Butis koilomatodon* is considered an invasive species that can strive with local goby species in nutrition and natural surroundings (Macieira *et al*., 2012). *Butis* genus has a high economic value (Nguyen, 2005) is often found in the estuarine areas of the Mekong Delta (Dinh, 2011; Tran *et al*., 2013; Dinh *et al*., 2018a, 2020b; Nguyen *et al*., 2020; Tran *et al*., 2020, 2021c).

In order to understand the basics of fish activities in a specific aquatic system, the species' food and foraging habits need to be analyzed (Brodeur and Pearcy, 1992; Wootton, 1996; Blaber, 2000). This information is a useful measure to select the type of fishes that are more beneficial for aquaculture (Azadi *et al*., 2009; Manon and Hossain, 2013). The diet composition changes depending on fish sizes, seasons, and habitats (Aarnio and Bonsdor, 1993; Carman *et al*., 2006; Brush *et al*., 2012). The change is majorly due to the fish's foraging behavior and the

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availability of food (Dinh *et al*., 2017b). In the Mekong Delta, this goby faces the risks of habitat destruction, loss of species (Vedra and Ocampo, 2014), and overfishing (Trinh and Tran, 2012; Diep *et al*., 2014; Dinh *et al*., 2020a). So far, morphometric characteristics, habitat conditions, growth pattern and reproductive biology have been studied and published (Yokoo *et al*., 2006; Bonfim *et al*., 2017; Lam and Dinh, 2020, 2021; Dinh *et al*., 2021; Lam *et al*., 2021); conversely, there is inadequate knowledge on the diet and the feeding ecology. Hence, our study aimed to understand the diet and feeding ecology of *B. koilomatodon* based on the differences of sexes, sizes, seasons, and habitats in the Mekong Delta's estuarine regions. This information would be the reference for further studies and help assess fish and population conservation.

MATERIALS AND METHODS

Study sites

The fish sample collection took place from April 2019 to March 2020 in six sites along with the coastal areas, including Duyen Hai (Tra Vinh province), Cu Lao Dung and Tran De (Soc Trang province), Hoa Binh and Dong Hai (Bac Lieu province), and Dam Doi (Ca Mau province) (Fig. 1). *Avicennia marna* (Forssk.) Vierh. and *Sonneratia caseolaris* (L.) A. Engl. were two types of dominant vegetation. These estuaries had predominantly semidiurnal tides, and the tidal flat was tremendous. The diverse marine ecosystem, such as estuaries, is a habit of valuable seafood species and a place where fishing activities occur regularly (Tran *et al*., 2008). The sampling areas climate was tropical monsoon with a dry season lasting for five months from January to May

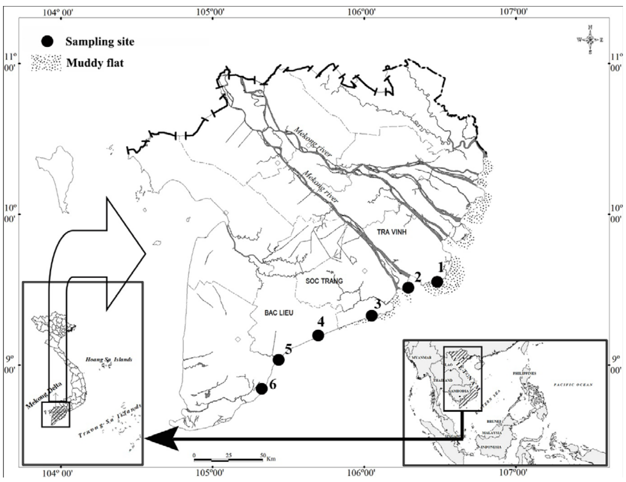

Fig. 1. The sampling map in the Mekong Delta (•: Sampling area; 1: Duyen Hai, Tra Vinh, 2: Cu Lao Dung, Soc Trang, 3: Tran De, Soc Trang, 4: Hoa Binh, Bac Lieu, 5: Dong Hai, Bac Lieu, and 6: Dam Doi, Ca Mau).

(very little rainfall) and the remaining seven months in the wet season (a monthly rainfall about 400 mm). The average annual temperature is about 27°C (Le *et al*., 2006).

Fish collection

The fish sample collection was taken every month from April 2019 to March 2020 by bottom gill nets. The net length was 5m, the mesh size in the cod-end was 1.0 cm, and in the mouth was 2.5 cm. When the tide was at the highest level, gill nets were set up near the mangrove's edge. When the tide receded after 2-3 h, fishes were collected and classified using the external description of Tran *et al*. (2013). To distinguish *B. koilomatodon* from its congeners, the immature fish samples were classified according to the definition of Yokoo *et al*. (2006) and basing on the length at first mature of fish. Specimens were preserved in formalin buffer solution 5% before transporting to the laboratory. The fish sexes were differentiated based on urogenital papilla, e.g., the genital papilla was round in females but triangle in males (Dinh *et al*., 2020c). The fish genders were determined again by observing the gonads after dissection.

Diet composition analysis

The specimens of *B. koilomatodon* (891 males and 336 females) were examined to quantify the diet composition and feeding intensity (Table I). In the laboratory, *B. koilomatodon* was measured total length (nearest 0.1 cm) and weight (nearest 0.01 g). The digestive tracts were separated and weighed (nearest 0.0001 g) content of prey items (afterward dissected to take food). Prey items were enumerated and categorized according to the lowest practical taxon. The equation $\% O_i = 100 \times O_i/N$ (where O_i is the number of fish consuming prey i and N is the total number of fish examined) was used to quantify the existence of the type of prey in the fish stomach (Hynes, 1950) and the gravimetric method ($\%W_i = 100 \times W_i/W_{total}$, where, W_i is weight of prey i, W_{total} is the total weight of all prey individuals) (Hyslop, 1980). The combined analysis of prey occurrence and weight was used to quantify diet composition, known as biovolume, preponderance index, or point of prey. Biovolume was calculated as $\%V_i = (100 \times O_i \times Wi)/\Sigma(O_i \times W_i)$, where V_i, O_i and W_i are the percentage of biovolume, occurrence and weight of prey *i*, respectively. The impact of sexes, fish sizes, seasons, and sites on the biovolume value of food was also quantified (Natarajan and Jhingran, 1961; Hyslop, 1980).

Feeding strategy analysis

The graphical method of Costello (1990) was used to graph the relationship between the percentage of biovolume and the frequent appearance of prey. The role of prey and feeding strategy were determined based on this graph. Accordingly, the graph was divided into four areas (quarters). Next to the upper right quarter, the items were the principal prey components. The prey items were essential but had a low number located near the top left quarter. Conversely, next to the low left corner, the prey items were the least important and the less essential prey item with a more significant number was closer to the low right corner.

Data analysis

The combination of PRIMER v.6.1.11 (Clarke and Gorley, 2006) and PERMANOVA+ v.1.0.1 add-on package (Anderson *et al*., 2008) was used to analyze the biovolume of all food items. The above analysis was then used to compare diet composition according to sex, size, season, and site variables (Baeck *et al*., 2013). In case of any differences in the above groups' diet composition, non-parametric tests were used to confirm what types of prey caused the variation (Dinh *et al*., 2017b). The Mann-Whitney U was used to quantify which food item caused mainly the intraspecific variation of food composition related to genders and seasons, whereas Kruskal-Wallis H was used to test which prey caused a spatial change of food composition.

Fish size was divided into two groups (immature and mature) based on the length at first mature of fish in each sampling site (length at first mature of males and females were 7.0 and 4.8 cm in Duyen Hai; 8.6 and 6.7 cm in Cu Lao Dung; 6.93 and 5.5 cm in Tran De; 5.09 and 5.4 cm in Hoa Binh; 5.1 and 5.5 cm in Dong Hai; and 5.3 and 4.9 cm in Dam Doi; Dinh *et al*., 2021). All of these above tests were considered the statistical significance when the *p*-value was less than 0.05.

RESULTS

General diet composition of B. koilomatodon

Table I shows the number of males and females obtained from six sampling sites. Among them, 760 individuals (557 males and 203 females) possessed gut with food accounting for 61.94%, whereas 467 fishes had empty stomachs accounting for 38.06%. Gut content analysis indicated that shrimp, small fish, Polychaeta, and detritus were essential food items. Moreover, there were two rare kinds of food detected in some samples. The first food item was snail (aquatic species) seen in one male individual in August in Hoa Binh, Bac Lieu. The second food item of exceptional food was small crabs found in four males (three in the dry season and one in the wet season) in Tran De, Soc Trang, and one female in the dry season in Hoa Binh, Bac Lieu. The shrimp and small fish occurred in the highest relative frequency of 79.68% and 26.25%, respectively, while detritus and Polychaeta showed the lowest occurrence at 12.14% and 1.85%, respectively. Referring to the prey weight ratio, the shrimp continuously accounts for the largest percentage (72.07%). The small fish weight also made up the second position with 24.32%, and the smallest ratio was Polychaeta (1.43%). The rest weight percent was detritus (2.17%). Regarding the biovolume, the goby ingested predominantly shrimp (89.62%), followed by small fish (9.93%). The remaining 0.5% consisted of Polychaeta and detritus.

Table I. Number of *Butis koilomatodon* collected from six studied sites.

Sampling time	Duyen Hai, Tra Vinh				Cu Lao Dung, Soc Trang				Tran De, Soc Trang				Hoa Binh, Bac Lieu				Dong Hai, Bac Lieu				Dam Doi, Ca Mau			
	Total fish		Number of fish with empty stomach		Total fish		Number of fish with empty stomach		Total fish		Number of fish with empty stomach		Total fish		Number of fish with empty stomach		Total fish		Number of fish with empty stomach		Total fish		Number of fish with empty stomach	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Apr-19	6	2	1	0	3	1	2	1	12	3	7	2	7	25	2	3	17	4	4	2	21	6	10	3
May-19	10	1	8	0	10	2	3	2	8	0	5	0	22	9	14	6	12	11	2	3	19	9	4	3
Jun-19	8	5	3	4	6	4	0	1	8	0	2	0	25	5	5	2	14	3	10	2	15	14	4	4
Jul-19	8	0	1	0	3	1	1	0	9	3	1	1	24	6	15	2	19	0	12	0	16	4	2	2
Aug-19	7	5	1	0	6	1	3	0	9	1	1	1	24	6	10	5	12	8	6	5	11	10	5	6
Sep-19	9	1	0	0	5	4	3	1	9	3	2	1	24	6	8	4	11	5	5	2	14	0	3	0
Oct-19	12	0	1	0	5	1	2	1	7	6	2	6	21	7	10	4	14	4	10	1	19	2	8	1
Nov-19	8	2	2	0	3	1	1	0	15	0	3	0	21	9	6	7	16	1	13	0	7	9	0	3
Dec-19	9	3	0	1	1	4	1	1	7	2	2	0	23	8	13	2	1	13	0	7	11	13	1	4
Jan-20	19	5	5	0	3	2	1	1	4	1	1	0	28	2	23	1	15	2	3	0	15	15	0	1
Feb-20	9	11	1	1	5	1	1	1	2	1	0	0	16	7	13	5	14	4	4	2	20	10	6	2
Mar-20	26	4	12	3	12	2	3	1	3	1	1	1	20	6	13	4	13	3	5	3	24	6	2	1
Sum	131	39	35	9	62	24	21	10	93	21	27	12	255	96	132	45	158	58	74	27	192	98	45	30

M, males and F, females.

Table II. Percentage of the frequency of occurrence, weight, and biovolume of food items of *Butis koilomatodon* according to gender and fish size.

Category	Gender/ Fish size	Food items				PERM ANOVA	
		Shrimp	Small fish	Polychaeta	Detritus	Pseudo F	p
Occurrence	Male	78.82	26.75	1.62	13.46	1.934	0.152
	Female	82.09	24.88	2.49	8.46		
Weight	Male	71.16	25.03	1.74	2.07		
	Female	75.18	21.92	0.39	2.51		
Biovolume	Male	89.25	10.31	0.05	0.39		
	Female	90.83	8.7	0.01	0.46		
Occurrence	Immature	79.2	20.8	3.1	12.83	0.579	0.48
	Mature	79.96	28.46	1.31	11.8		
Weight	Immature	13.31	3.90	0.87	0.69		
	Mature	44.68	15.57	0.27	1.05		
Biovolume	Immature	90.44	8.71	0.14	0.71		
	Mature	89.43	10.24	0.01	0.32		

Table III. Percentage of the frequency of occurrence, weight, and biovolume of food items of *Butis koilomatodon* according to two seasons and six studied sites.

Category	Gender/ Fish size	Food items				PERMANOVA	
		Shrimp	Small fish	Polychaeta	Detritus	Pseudo-F	p
Occurrence	Dry season	76.76	30.02	3.15	14.53	3.014	0.048
	Wet season	83.29	21.61	0.29	9.22		
Weight	Dry season	70.89	24.24	2.14	2.73		
	Wet season	74.33	24.24	0.22	1.2		
Biovolume	Dry season	89.38	10.03	0.06	0.52		
	Wet season	90.12	9.65	0.01	0.22		
Mann-Whitney U test	U	5.03	0.218	0.62	2.144		
	p	0.000	0.827	0.535	0.032		
Occurrence	DHTV	88.1	22.22	1.59	7	4.439	0.001
	CLDST	61.82	23.64	10.91	20		
	TDST	72	24	0	14.67		
	VHBL	71.84	25.86	2.87	20.69		
	DHBL	80.87	29.57	0.87	5.22		
	DDCM	87.91	28.37	0	9.77		
Weight	DHTV	77.16	21.27	1.01	0.56		
	CLDST	54.49	28.19	14.21	3.11		
	TDST	70.4	26.25	0	3.35		
	VHBL	69.74	26.36	0.66	3.24		
	DHBL	66.57	31.52	1.53	0.38		
	DDCM	74.72	22.25	0	3.03		
Biovolume	DHTV	91.58	8.29	0.03	0.1		
	CLDST	84.42	14.34	0.51	0.73		
	TDST	88.52	10.84	0	0.64		
	VHBL	88.39	10.97	0.02	0.62		
	DHBL	86.44	13.44	0.05	0.08		
	DDCM	90.58	8.86	0	0.56		
Kruskal Wallis H test	χ^2	83.22	29.80	5.08	36.32		
	p	0.00	0.00	0.166	0.00		

Note: DHTV: Duyen Hai, Tra Vinh; CLDST: Cu Lao Dung, Soc Trang; TDST: Tran De, Soc Trang; HBBL: Hoa Binh, Bac Lieu; DHBL: Dong Hai, Bac Lieu; DDCM: Dam Doi, Ca Mau.

Diet composition in males and females of different sizes, seasons, and study sites

The occurrence, weight, and biovolume of food items in different sexes, sizes, seasons, and sampling sites of *B. koilomatodon* were analyzed (Tables II and III). Despite being different in all of the above parameters, the principal prey was still shrimp, followed by small fish, detritus, and Polychaeta. Table III showed that the diet constituent of *B. koilomatodon* changed remarkably between dry and wet seasons (PERMANOVA, Pseudo-F = 3.014, $p = 0.048$) and six sampling sites (Pseudo-F = 4.439, $p = 0.001$). Contrary, this diet composition was independent upon genders and fish sizes (Pseudo-F_{Gender} = 1.934, Pseudo-$F_{Fishsize}$ = 0.579, $p > 0.05$, Table II). In addition, it was impacted by the interaction between seasons and sites (Pseudo-F = 4.164, $p = 0.001$), but not for other interactions like genders x fish sizes, seasons x fish sizes and sites x fish sizes (Pseudo-$F_{Gender \times Fishsize}$ = 0.258, Pseudo-$F_{Season \times Fishsize}$ = 0.322, Pseudo-$F_{Gender \times Fishsize}$ = 1.011, $p > 0.05$).

The Mann-Whitney U test analysis revealed that shrimp (Mann-Whitney U, U= 5.030, $p<0.01$) and detritus (U= 2.144, $p= 0.032$) were the main reasons for the variation of diet composition in *Butis koilomaton* between dry and wet seasons. Inversely, small fish and polychaeta did not affect *B. koilomatodon* diet between the two seasons. Three prey items, including shrimp, small fish, and detritus, contributed to the regulation of the changes of their diet composition (Kruskal Wallis H, $\chi^2_{shrimp} = 83.220$, $\chi^2_{Fish} = 29.80$, $\chi^2_{Detritus} = 36.320$, $p<0.01$) among different regions.

Feeding strategy

Figure 2, the Costello graphic, illustrates the feeding strategy of *B. koilomatodon* according to seasons and sampling sites. These two factors significantly influenced the frequency of food appearance. This graph proved that *B. koilomatodon* was carnivorous, consuming chiefly shrimp, followed by small fish, detritus, and Polychaeta, respectively. The Costello graphics of *B. koilomatodon* according to gender and fish sizes also showed a similar feeding strategy.

DISCUSSION

The Mekong Delta is well known for the dense system of rivers and canals, a favorable condition for growth, and aquatic fauna and flora (Tran *et al*., 2008). Six sampling sites belong to the Mekong Delta's estuarine regions, which supplied habitats for hundreds of brackish and saltwater taxa such as shrimp, crabs, oysters, and snails, turtles, snakes, and mollusks (Vu *et al*., 2015). Due to the abundant and diverse food source, the estuary is an ideal habitat for the fish assemblages, including *B. koilomatodon*, and key important factor determining fish species' adaption and survival is feeding strategy (Chaudhuri *et al*., 2014). Food composition of *B. koilomatodon* in this study comprised shrimp, small fish, Polychaeta, and detritus, in which the shrimp was the most priority prey with the highest occurrence, weight, and biovolume. The same prey composition is found in other localities along the Brazilian coast, where *B. koilomatodon* preyed on several species of crustaceans and small native fishes (Macieira *et al*., 2012). Similarly, in Brazil, *B. koilomatodon* in the mangrove forest is a mysterious predatory fish, which ravens for crustaceans and mini size fish (Corrêa and Uieda, 2007), while in the Amazon coastal zone, mollusk (13.33%) and crustacean (53.33%) are detected in the gastrointestinal tract of *B. koilomatodon* specimens (Soares *et al*., 2012). Clearly, the food composition of *B. koilomatodon* depended on the availability of the food in the environment. In our research, the number of fishes with full stomachs was greater than fishes with empty stomachs, indicating that the species was an active feeder.

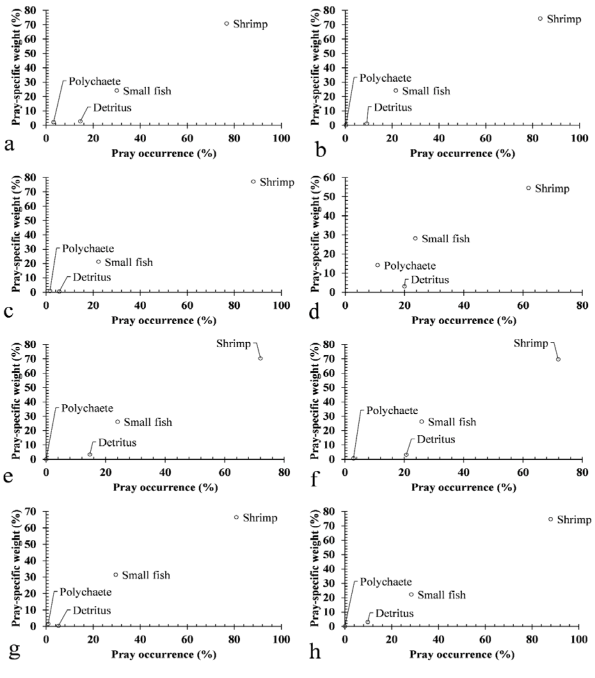

Fig. 2. The modified Costello graphics represent feeding strategy based on plotting the relationship between the percentage of weight and frequency of occurrence of food items for *Butis koilomatodon* in two seasons; a: dry season, n=413; b: wet season, n=347) and at six sites; c: Duyen Hai, Tra Vinh, n=126; d: Cu Lao Dung, Soc Trang, n=55; e: Tran De, Soc Trang, n=75; f: Hoa Binh, Bac Lieu, n=174; g: Dong Hai, Bac Lieu, n=115; h: Dam Doi, Ca Mau, n=215).

According to Amundsen *et al*. (1996), the prey in the highest right corner symbolizes the differentiation of the carnivorous population. Shrimp was found in this position meant that shrimp was the most priority prey of *B. koilomatodon* population in this study's scope. For *Butis butis* collected from mudflats of Indian Sundarban estuaries, prey items consist of decapods crabs, decapods shrimps and juvenile fishes found to be common amongst the major portions of the stomach (Chaudhuri *et al*., 2012). For the *Eleotris vittata* (Dumèril, 1861) in the lower Cross River of Nigeria, the dominant food items are crustaceans (*Callinectes* sp. and *Macrobrachium* sp.) (74.40%) while the lowest are macrophytes (2.63%), pisces (unidentified fish), mollusks (*Tympanotonus fuscatus* and *Pomecia palludosa*) and nematodes having index of food dominance of 18.88%, 7.29% and 4.42%, respectively. The rests are macrophytes (plant roots, seeds and leaves). The round goby *Neogobius melanostomus* in the Trent River, Ontario ingestes benthos, zooplankton, amphipods, chironomids, and dreissenids (the most heavily consumed) (Ekpo *et al*., 2015a).

According to Parker (1992), female size depends on fecundity while the male size is affected by male-male combat, which could drive male size beyond that of females. In this study, *B. koilomatodon* male did not change prey items than female fishes, although males were larger than females. Research about the effect of gender on the diet of goby species inhabiting in the mangrove ecosystem has different outcomes. For instance, Ravi (2013) indicates that the gut contents of *B. boddarti* male from Pichavaram mangroves, southeast coast of India, was different from females. As for *P. barbarus* male (Linnaeus, 1766) from the Imo estuary, Nigeria consumes more cyanobacteria, *Coscinodiscus* spp. and *Sesarma* spp., than females (Udo, 2002a). Furthermore, fish's hunting activity and feeding process can change by the difference in fish's body shape. The mature fish with a complete caudal fin increases propulsion efficiency more than immature fish for hunting (Behzadi *et al*., 2018). The diet composition of immature (group 1) and mature (group 2) of *B. koilomatodon*'s individuals were similar. *B. koilomatodon* is a carnivore with moderate body size and a sedentary lifestyle (Contente *et al*., 2016), so the modification in body structure did not drive the variation clearly in feeding strategy. The reverse result shows that round goby's diet composition in the lake's nearshore region in Ontario varied by fish size. The river mid-sized (70-85 mm) round gobies ate mostly zebra mussels and for the laboratory, the small gobies (55-69 mm) consumed few mussels, while larger gobies (85-103 mm) ingested more (Johnson *et al*., 2008). Besides, *B. boddarti* adult living in Pichavaram mangroves, southeast coast of India, reduces the consumption in diatoms and increases in nematodes and polychaetes compared to juveniles (Ravi, 2013). The goby *P. barbarus* living in the mangroves of Imo River estuary, Nigeria (Udo, 2002b) and Rumuolumeni Creek, Niger Delta, Nigeria (Bob-Manuel, 2011) had diet composition depended on fish size. In the mangrove estuary of the Urauchi River on Iriomote Island, Southern Japan, the favorite prey of *P. argentilineatus* mature was *Uca* spp., while polychaetes were predominated prey in the diet of immature fish (Nanjo *et al*., 2008). Briefly, the feeding behavior and the favorite prey (shrimp) of *B. koilomatodon* were not affected by both gender and fish size.

There was a difference in the diet of *B. koilomaton* between the dry and the wet season. Shrimps and detritus were the leading causes of this change. In the wet season, the rainfall is higher and more concentrated than the dry season, which caused changes in detritus input (Nedeco, 1993). Detritus, along with suspended sediment or other particulate materials, supplies abundant food resources (Stoner, 2004) for this mud sleeper dwelling in the mud bottom. Thus, wet season has been considered the main feeding and growing period for nearly all species in the tropics' seasonal flood plain rivers (Chukwu and Kuton, 2001). Furthermore, the density and distribution of prey items in *B. koilomatodon* food constituent might vary with the water salinity difference between wet and dry seasons. Similarly, the main dietary component of small round gobies in the St. Clair River, Michigan changed from ephemeropterans in the summer to trichopterans in the fall (French III and Jude, 2001). For *B. dussumieri* (Valenciennes, 1837) collected from the Ulhas River estuary in northwestern India, fish eggs are predominant prey, while they are replaced with nematodes pre-monsoon stage postmonsoon (Mutsaddi and Bal, 1969). Rathod and Patil (2009) show that diatoms are the main food item for *B. dussumieri* during the pre-monsoon periods and shifted to nematodes as an alternate food item in post-monsoon. In the New Calabar River mangroves, the significant increase of unidentified crabs, annelids, nematodes and *Penaeus* sp. in the gut content of *P. barbarus* is the main reason for the seasonal change of its diet composition (Chukwu and Deekae, 2013). Crustaceans, followed by Pisces and mollusks occurs in guts of all bigmouth sleeper, *Eleotris vittata* (Dumèril, 1861) (Pisces: Eleotridae) in the lower Cross River, Nigeria during sampling months. However, Pisces and mollusks do not occur in the guts of the fish in June and September (Ekpo *et al*., 2015b). The present outcomes revealed that different sampling sites also regulated the diet of mud sleeper goby with different sample sizes. Amongst six sampling sites, Dam Doi has a tidal flat consisted inter-tidal flat and sub-tidal flat, which are favorable conditions for the aquatic development

(Van Lap and Oanh, 2012), while Cu Lao Dung is an islet with three typical ecosystem: Mangroves, coastal mudflat and estuarine (Chau and Minh, 2013). Thus, the differences in prey density and composition could be due to sampling sites. For example, the round goby *Neogobius melanostomus* occupying the downstream and upstream areas consumes dreissenids more in the central area of the Trent River, Ontario (Raby *et al*., 2010). Another example, *P. serperaster* in Malaysia mainly ingested diatoms (Khaironizam and Norma-Rashid, 2000) whereas detritus is the primary prey of it in the Mekong Delta (Dinh *et al*., 2017b). For *P. argentilineatus* in Zanzibar, their diet includes amphipods and copepods as the main preys while in mainland Tanzania are polychaetes (Kruitwagen *et al*., 2007). The stomach content of *B. boddarti* in Pichavaram mangroves, southeast coast of India is fish eggs and nematodes (Ravi, 2013). Contrary, these items are not detected in the guts of this species in the Mekong Delta, Vietnam (Dinh, 2015).

Based on the modified Costello graphic, *B. koilomatodon* was classified as carnivorore with high feeding intensity, and it adjusted the diet composition to adapt to different environmental conditions. In aquatic food webs, the crucial trait was body size because the consumers were mostly larger than their prey (Kortsch *et al*., 2019). It is evident that this mud sleeper goby consumed shrimp, small fish, Polychaeta, and detritus whose body sizes were smaller than it. However, *B. koilomatodon* with small body size was also the target food for other larger predators in the estuarine ecosystem. Hence, this species was classified both as carnivorous and prey. The same result is found in the round goby *Neogobius melanostomus* considered as predator, but it is the prey for zander (*Sander lucioperca*), the main predator in European brackish waters (Hempel *et al*., 2016). Further examples, *Periophthalmus barbarus* (Udo, 2002a, b; Chukwu and Deekae, 2013), *Periophthalmus argentilineatus* (Kruitwagen *et al*., 2007), *Periophthalmodon schlosseri* (Zulkifli *et al*., 2012; Tran *et al*., 2019), *Boleophthalmus boddarti* (Ravi, 2013; Dinh, 2015) and *Parapocryptes. serperaster* (Dinh *et al*., 2017b), *Eleotris melanosoma* (Dinh *et al*., 2017a), *Glossogobius aureus* (Nguyen and Tran, 2018), *Periophthalmodon septemradiatus* (Dinh, 2018; Dinh *et al*., 2018b, 2020c), *Glossgoboius sparsipapillus* (Tran *et al*., 2021a, b), *Glossogobius giuris* (Phan *et al*., 2021) are classified both as a carnivorous and a prey.

CONCLUSIONS

Overall, the food items of *Butis koilomaton* is a cancerous fish with a wide range of food composition, so it infers that to be invertivore-piscivore with a high feeding intensity. The four components in the diet were shrimps, small fish, Polychaeta and detritus. Amongst the preys, shrimp is the predominant, followed by small fish and others. The diet composition depends on seasons, sampling sites, and the interactions between them. Yet, the diet is independent on gender and fish size. Further investigations into the impact of water quality on food sources and this fish's role in the natural food chain should be carried out in the study areas. The findings are useful to procure suitable diets for the artificial cultivation of the species for future fish population conservation.

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Statement of conflict of interest

The authors have declared no conflict of interests.

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