Age determination and feeding habits of *Nemipterus japonicus* (Bloch, 1791) in the Northern Oman Sea

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Abstract

Age determination and feeding habits of the Japanese threadfin bream, *Nemipterus japonicus*, was carried out in the northern Oman Sea (Chabahar area), based on 212 specimens collected between September 2009 and May 2010. The minimum and maximum fork length and body weight were measured as 145, 258 mm and 55.31, 288.12 g. The relationship between Body Weight (BW) and Fork Length (FL) for all individuals was estimated as $BW= 0.0001 \times FL^{2.83}$ (r^2 = 0.9425, n =212). The Vacuity Index (VI) was 55.2% that shows *N. japonicus* is a moderate feeder. The maximum and minimum Gastro-Somatic Index for males was in autumn and winter seasons; and for females were in summer and spring. The Food Preference Indices were estimated as: crustacean (63.2%) as main food; fishes (38.9%) and molluscs (36.8%) as minor food. Age determination was done by otolith sectioning. A total of 135 sagitta were sectioned. The maximum age was 5^+ years old for a female with FL = 256 mm and the youngest one was 1^+ year old for a female with FL =145 mm. Based on obtained results there is a significant relationship between feeding and age namely with increase of age, the feeding rate is decreased without any changes in type of feeding and food contents.

Keywords: *Nemipterus japonicus*, Feeding, Age, Otolith, Oman Sea

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Introduction

The family Nemipteridae is represented by *Nemipterus japonicus* in the trawler catches off Oman Sea. The catch ratio of *N. japonicus* has been increased within last decade and is considered as one of the main commercial species (Valinassab et al., 2006). However, there is practically no information available regarding the biology of this species in the Oman Sea. *N. japonicus* is a demersal species and widespread in the Red Sea and eastern shores of Africa to the Philippines and Japan (Russell, 1993). It occurs in depths of 5-80 m (Russell, 1990). This species is important economically and is trawled in commercial quantities in the South China Sea (Eggleston, 1972; Lee, 1974; Weber and Jothy, 1977) as well as in the Andaman Sea (Senta and Tan, 1975), Western Bay of Bengal (Krishnamoorthi, 1971) and Persian Gulf and Oman Sea (Valinassab et al., 2006). The *N. japonicus* has been studied on the population dynamics (Vivekanandan and James, 1986; Zacharia, 1998; Rajkumar et al., 2003), reproductive biology (Krishnamoorthi, 1971; Eggleston, 1972; Murty, 1984; Bakhsh, 1994; Rajkumar et al., 2003; Manojkumar, 2004; Kerdegari et al., 2009), food habits and feeding (Bakhsh 1994; Manojkumar, 2004), length-weight relationship (Murty, 1984; Bakhsh, 1994; Zacharia, 1998; Rajkumar et al., 2003; Manojkumar, 2004) and morphology (Russell, 1990). The objectives of this investigation were to provide information on the feeding biology and age of this species in the study area. The results obtained can be used for stock assessment and fishery management.

Materials and methods

The samples of *N. japonicus* collected seasonally during the period from September 2009 to May 2010. A total of 212 specimens (150 females and 62 males) were caught by bottom trawlers with mesh size of 80 mm in cod end. Sampling sites were restricted to depths of 10-100 m in the northern Oman Sea, Chabahar area (Figure 1). Length measurements of specimens were taken to the nearest 1 mm and body and stomach weights were measured to the nearest 0.01 g.

The relationship between Body Weight (BW) and Fork Length (FL) was described:

$$BW = a \times FL^b$$

Where: BW = Body Weight, FL = Fork Length, a = Intercept and b = Slope (Biswas, 1993).

In a fish, growing isometrically (increasing in all dimensions at the same rate) and doubles in length, its weight will increase in volume; that is, by 8 (or 2^3) times. In above-mentioned formula where b is close to 3 (isometric growth) and a is a constant determined empirically. For investigation the difference, the test of t-pauly was employed (Pauly, 1984). The sex of the fishes was determined by macroscopic examination of gonads.

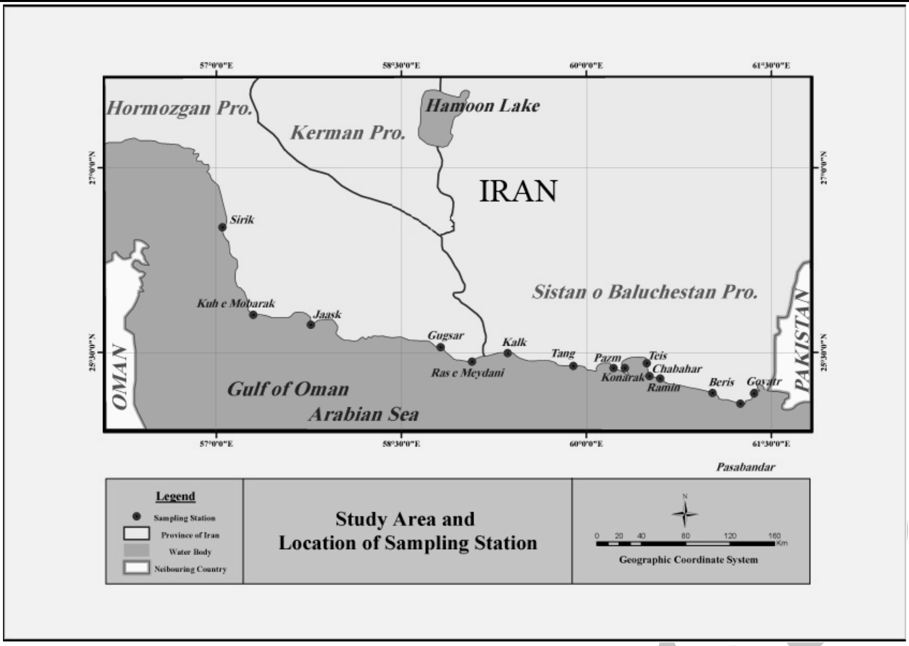

Figure 1: Study area restricted to the northern Oman Sea (Iranian waters)

Observation of feeding

During the study period, the stomach contents of 212 fishes were voided and preserved in 70% alcohol. The percentage occurrence method was used in which the number of stomachs containing a particular food group was expressed as a percentage of the total number of stomachs examined. Food items were identified up to each level wherever possible by various references (Fauchald, 1977; Smith and Heemstra, 1986; Wolfgag, 1986; Carmelo, 1996; Carpenter et al., 1997). The different food indices were calculated consist of:

The Vacuity Index (VI) calculated as follows:

VI (%) = Number of empty stomachs / Number of total stomachs × 100 (Biswas, 1993). Index intended to be interpreted according to the following conditions:

If $0 \leq VI < 20$, aquatic is edacious.

If $20 \leq VI < 40$, aquatic is relatively edacious.

If $40 \leq VI < 60$, aquatic is moderately fed.

If $60 \leq VI < 80$, aquatic is relatively low fed.

If $80 \leq VI < 100$, aquatic is low fed (Biswas, 1993).

The Gastro-Somatic Index calculated as follows:

GSI (%) =[Stomach weight (g) / Body weight (g)] × 100 (Biswas, 1993).

Mann – Whitney and Kruskal- Wallis tests at 5% probability level were used to test the homogeneity of GSI among sexes and seasons, respectively (Pelosi and Sandifer, 2003).

The Food Preference Index (FP) calculated as follows:

FP (%) = [Number of stomachs which contain a specific prey / Number of stomachs which contain food] × 100 (Biswas, 1993).

According to this formula if FP < 10, eaten prey is considered to be negligible in the diet.

If 10 ≤ FP < 50, eaten food is considered as minor food and if FP≥ 50, eaten food is considered as main food of fish (Biswas, 1993).

All tests were undertaken using SPSS version 17.0.

Age determination

Sagitta otoliths were removed from the fish, rinsed in distilled water to remove any tissue, and then dried with a paper towel. Otoliths were stored dry in gelatin capsules, which were placed for further sectioning under hard microcutter. Otoliths were embedded in polyester resin and cut with a microcutter and polished using a grinder in order to make cross sections crossing the focus, leaving a thin slice of approximately 0.4 mm thick. The number of ring marks (outer edge of opaque zone) on sectioned sagitta was counted by two readers using microscope with transmitted light under a black background at 20X magnification. Otoliths difficult to read were taken out; then, if there was an agreement between both readers, the resulting counts of the ring marks were adopted (Granada et al., 2004).

Results

Length-Weight Relationship

The length and weight frequency distributions indicated that males were in the range of 147-256 mm FL at body weights of 62.73-285.22 g and females were 145-258 mm FL at body weights of 55.31-288.12 g. Relationship between FL and BW were estimated as:

$BW= 0.0001\times FL^{2.83}$ ($r^2 = 0.9425$, n = 212) for both sexes combined (Figure 2).

The t-pauly test shows that the cubic law hold good for this species (P > 0.05).

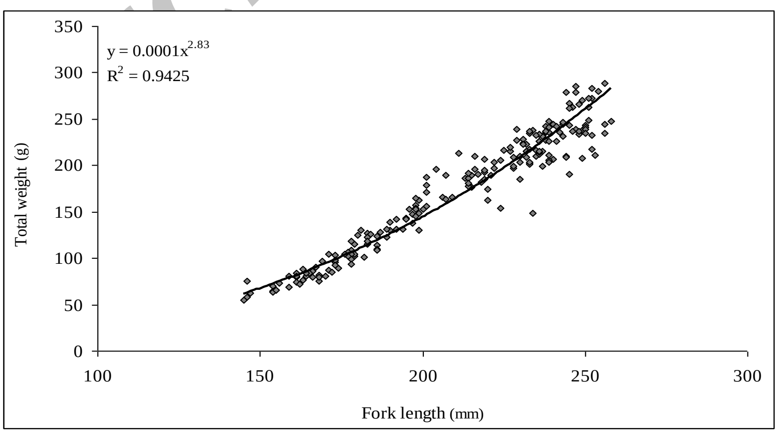

Figure 2: Relationship between Body Weight (BW) and Fork Length (FL) of *N. japonicus* (sexes combined)

Feeding

Investigation of stomachs of 212 *N. japonicus* fishes showed that 51 stomachs were full (24.1%), 44 semi-full (20.7%) and 117 of stomachs were empty (55.2%) (Fig. 3)

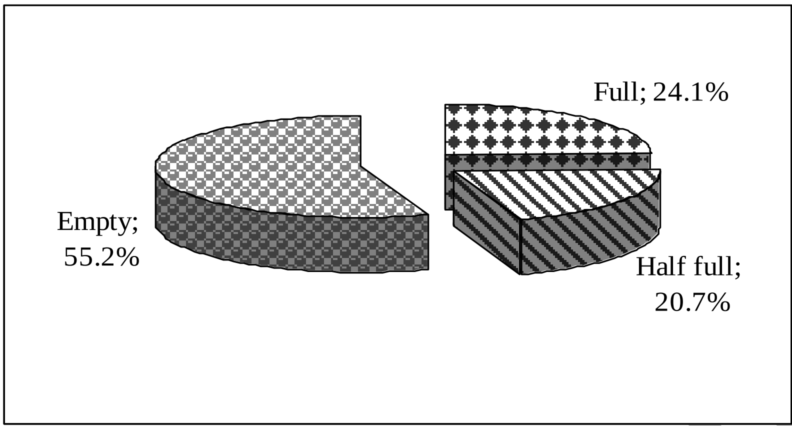

Figure 3: Frequency of *N. japonicus*'s full, semi-full and empty stomachs in the northern Oman Sea

The Vacuity Index for both sexes over a year gets 55.2%. Comparison of VI index in males and females in four seasons shows that the index is lower in males than females and possibly males than females are more greedy (Figure 4). The number of specimens were 52, 50, 60 and 50 for spring, summer, autumn and winter, respectively.

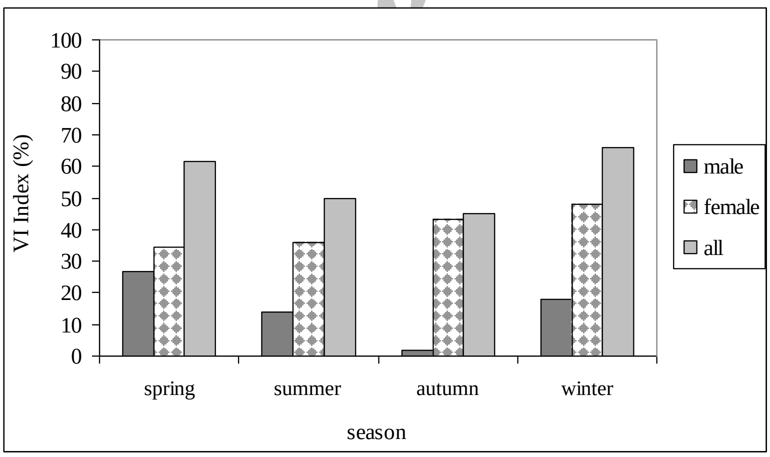

Figure 4: Comparison of VI index in male and female *N. japonicus* in four seasons in the northern Oman Sea

Seasonal changes in GSI index on separation of the sexes is shown in Figure 5. For comparison of GSI index in the two sexes, the Mann-Whitney test was used of which there wasn't observed any significant difference between sexes ($P>0.05$). For comparison of GSI index between the different seasons used of Kruskal-Wallis test and a significant difference between seasons was observed ($P<0.05$).

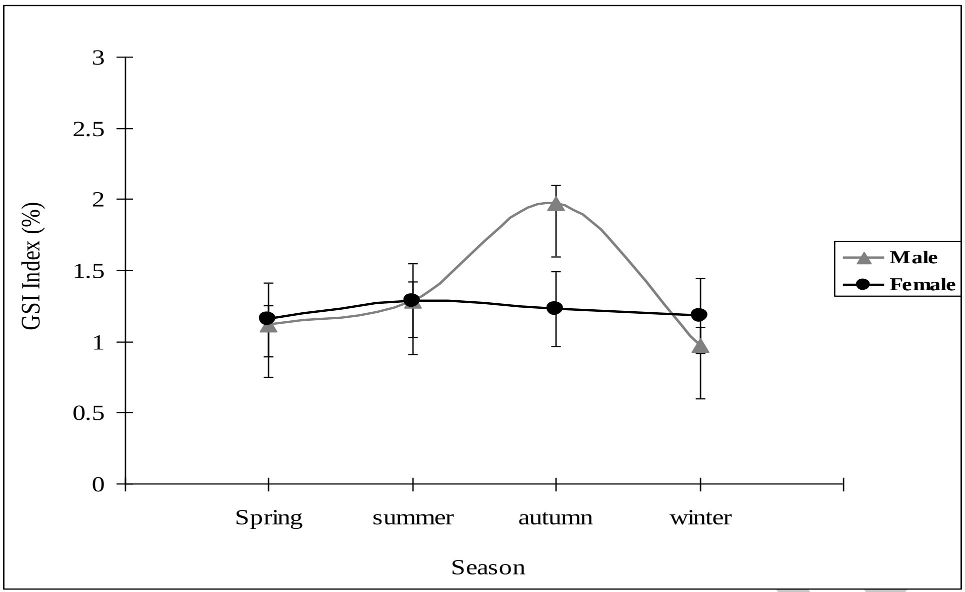

Figure 5: Changes of GSI index in male and female *N. japonicus* in the Northern Oman Sea

The FP index for animal food items is shown in Table l. According to Table 1, crustacean (63.2%) as main food; fishes (38.9%) and molluscs (36.8%) as minor food; polychaets (8.4%), sipuncula (7.4%), foraminifera (6.3%), phytoplanktons (4.2%), sea weeds (2.1%) and nemertean worms (1.1%) as incidental food were identified.

Table 1: Food Preference (FP) indices for different types of the Consumed food by *N. japonicus* in the north Oman Sea (%)

Animal food items		Animal food items	
Crustacean	63.2	*Saurida tumbil*	
Crabs	28.4	Carangidae	2.1
Pinnoteridae		Sillaginidae	1.1
Leocosidae		*Sillago sihama*	
Portunidae		Bregmacerotidae	1.1
Shrimp	20	*Bregmaceros* sp.	
Penaeidae		Molluscs	36.8
Penaeus sp.		Bivalvia	11.6
Amphipoda	11.6	Cephalopoda	10.5
Ampelicidae		Loliginidae	
Squilla mantis	7.4	Sepiidae	
Cumacea	5.3	Gastropoda	5.3
Copepoda	2.1	Naticidae	
Isopoda	1.1	*Neverita* sp.	
Flabellifera		Opistobranchia	
Lobster	1.1	Marginellidae	
Palinuridae		*Granulina* sp.	
Panulirus sp.		Scaphopoda	2.1
Fish	38.9	Dentaliidae	
Nemipteridae	6.3	Nematoda	25.3
Nemipterus japonicus		Polychaete	8.4
Muraenesocidae	6.3	Aphroditidae	
fish Juvenile	5.3	Glyceridae	
Fish egg	4.2	Pectrinariidae	
Mullidae	3.2	Sipuncula	7.4
Upeneus sp.		Foraminifera	6.3
Synodontidae	2.1	Nemertia	1.1

Comparison of food frequency in *N. japonicus*'s stomach contents in different seasons indicated that crustacean frequencies were higher than other items(fish and molluscs) in three seasons, while its frequency in spring was equal with fish (40%). The highest frequency in winter was related to molluscs (100%), while in the other three seasons have the lowest frequency than of fishes and crustaceans. Also in winter, the lowest frequency is related to fishes (52.9%) (Fig. 6).

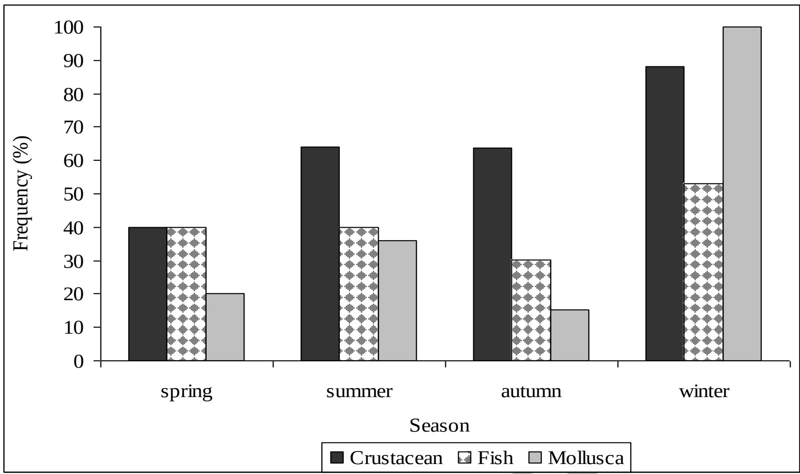

Figure 6: Comparison of food frequency in the *N. japonicus*'s stomach in different seasons in the north Oman Sea

Age

A total 135 otoliths were sectioned, of which 112 pieces were reliably used for age determination. Growth increments were defined as structures that comprise an opaque zone and a translucent zone. The maximum age was found 5^+ years old for a female fish with FL = 256 mm and the youngest one was1^+ year old for a female specimen with FL =145 mm. Some cross sections of otoliths in different ages are shown in Figure 7.

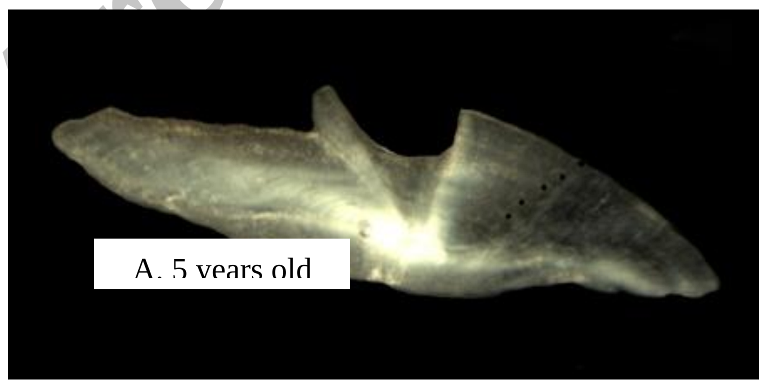

Figure 7: Images of cross sections of *N. japonicus*'s otoliths (Zoom: 20X)

The age distribution of *N. japonicus* fish on both sexes indicate that most abundant age groups belongs to age groups of 3-4 years old and the least one was determined for age groups of 1-2 years old (Figure 8).

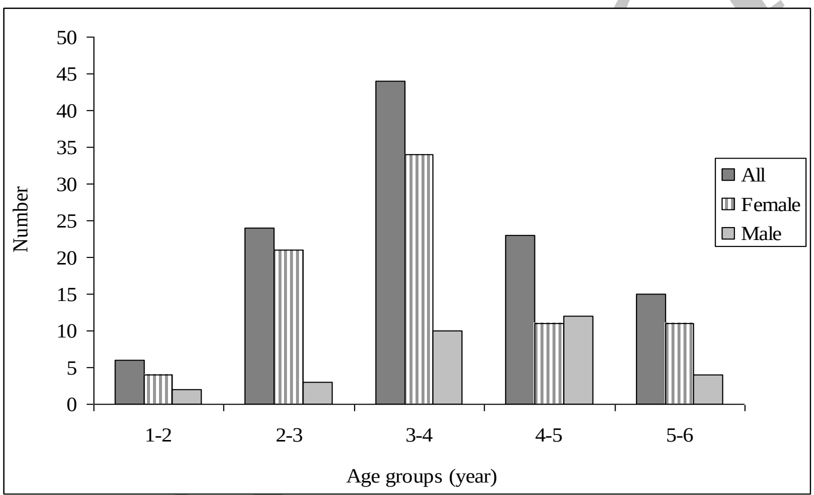

Figure 8: Age frequency of *N. japonicus* on separation of the sexes in the northern Oman Sea.

Relationship between feeding and age

Investigation of *N. japonicus* diet in different age groups showed that crustaceans in age groups of 2-3, 3-4 and 5-6 years, and fishes in age groups of 1-2 and 4-5 years, the major nutritional groups in the diet of this fish are (Figure 9).

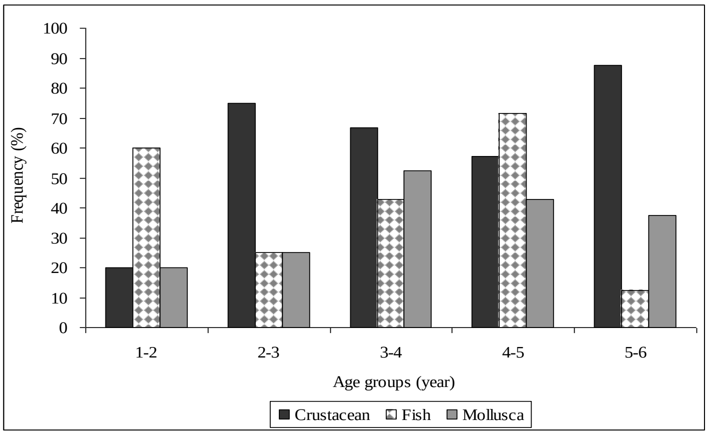

Figure 9: Comparison of food frequency identified in the *N. japonicus*'s stomach in different age groups in the northern Oman Sea

Comparison of the mean stomach contents in different age groups shows that the highest feeding rate done in younger fishes (age groups of 1-2 years) and lowest feeding rate in the oldest fishes (age groups of 5-6 years); it can be concluded that the older individuals have enjoyed of less feeding rate than the younger ones (Figure 10).

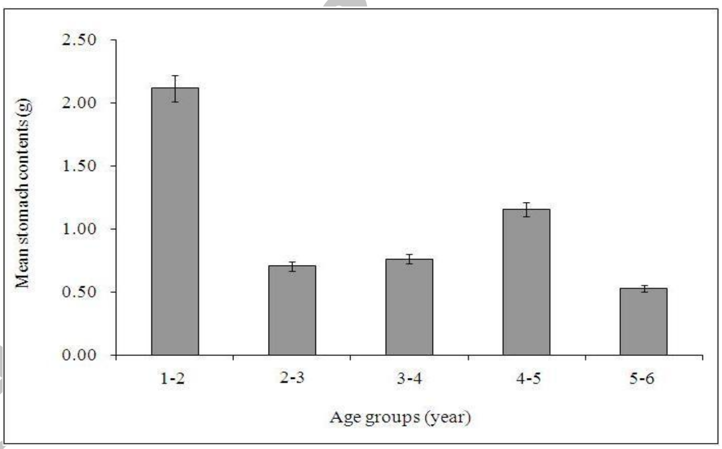

Figure 10: Changes of mean stomach contents of *N. japonicus* in different age groups in the northern Oman Sea

Discussion

The length-weight relationship is an important factor in the biological studies and stock assessments of fishes (Abdurahiman et al., 2004). This relationship is helpful for estimating the weight of a fish of a given length in which can be used in studies of gonad development, rate of feeding, metamorphosis, maturity and condition (Le Cren, 1951). Murty (1984) estimated values of slope for males (2.43) and females (2.95) from Kakinda in Indian waters. Bakhsh (1994) found it 2.42 for males and 2.76 for females from the Jizan Region of Red Sea. Mathews and Samuel (1989) found that this value was 2.97 for Kuwait waters whereas Vivekanandan and James (1986) estimated it 2.94 for Madras waters in India. In addition, this value was 2.66 for Karnataka region in India (Zacharia, 1998). Manojkumar (2004) reported it 2.99 from Veraval waters, Gujarat, India. In the present study, slope (b) obtained for both sexes combined (2.83) that indicate this species has symmetrical or isometric growth. The test of t-pauly also didn't show significant difference between calculated b and 3 in level of 95% ($P > 0.05$). The mean Vacuity Index get equivalent with 55.2% (Figure 3) that shows this aquatic is placed in group of fishes with moderate feeding that with the results obtained from researches conducted in the Gujarat region of India (VI= 52.43%) matches (Manojkumar, 2004). The high numbers of empty stomachs may be due to samples being caught before feeding, method of catch, the lack of favorite food items of fish in a range of specific time or due to come into stress when caught and also bring up the food eaten that existence of semi-digested food in the fishes' mouth will be confirmed this reason. Comparison of Vacuity Index in males and females in four seasons, indicate that the nutritional status of males to females was more favorite (Figure 4), as in males, 50% of stomachs were empty, 24.2% full and 25.8% semi-full and this proportion in females were 57.3%, 24% and 18.7%, respectively. This is probably related to the most activity of males in hunting of organisms, because this study was done on male and female fishes that they were in various stages of sexual maturity, and existence of eggs in the female fish's ovary naturally leads to reducing the activity and mobility that will follow weakly feeding in fish. Also Krishnamoorthi (1971) and Raje (2002) obtained similar results on more feeding in males than females of this species. Investigation of GSI index showed that male fish in autumn and female fish in summer had the highest feeding rate (Figure 5). However, in this study the results of Kruskal-Wallis and Mann-Whitney tests showed that differences in feeding rate was significant between seasons, but between the two sexes wasn't significant. Studies of Krishnamoorthi (1971) and Raje (2002) in Indian waters also showed that *N. japonicus* in the summer months had the highest feeding rate. Since the growth of fish is affected by factors such as quality and quantity of food, absorption of food and water temperature, therefore water temperature affects on metabolic rate and energy consumption (Shepherd and Bromage, 1990) and in warm months increases feeding intensity with increasing of organisms activity. Therefore, water temperature can be justified increasing of feeding rate in *N. japonicus* in warm months of year. Investigation of *N. japonicus*'s stomach contents in different regions showed that feeding diversity in the aquatic is high and by different types of aquatic animals feed. In this study, determination of Food Preference (FP) indices for different food items showed that crustaceans with 63.2% are as main food and fishes (38.9%) and molluscs (36.8%) are as minor food (Table 1). Studies of Kuthalingam (1965), George et al. (1968), Krishnamoorthi (1971), Eggleston (1972), Vinci (1982), Euzen (1987) and Bakhsh (1994) also showed that crustaceans and fishes are as main food in this fish that with the findings of this study is quite consistent. In this study, comparison of food frequency in the *N. japonicus*'s stomach contents in different seasons showed that most of the feeding in spring done of crustaceans and fishes, in summer and autumn of crustaceans and in winter of molluscs (Figure 6). Among crustaceans, crabs had highest frequency in these fishes' stomach and during time of sampling observed with oscillations and their highest frequency was in winter. Also, other crustaceans such as shrimp, *Squilla mantis* and Amphipoda observed in stomach contents with their highest frequencies for seasons of autumn and winter, respectively. Existence of a wide range of crustaceans in the *N. japonicus*' stomach in the present study, also conforms findings of other researchers (Kuthalingam, 1965; Krishnamoorthi, 1971; Gopal and Vivekanandan, 1991; Bakhsh, 1994; Raje, 2002; Manojkumar, 2004). Presence or absence of any prey (including crustaceans) seems to depend on its frequency in environment and prey hunting isn't selective. Of identified molluscs, bivalves (11.6%) and among identified fishes, Nemipteridae (6.3%) and eel (Muraenesocidae) (6.3%) had maximum frequency.

The bivalves had the highest frequency in winter and Nemipteridae and eel (Muraenesocidae) had the highest frequency in spring and winter, respectively. In the case of *N. japonicus* diet in different seasons, significant differences didn't observe and food items available in each season for the fish were with no major differences and this fish in all four seasons has fed of the three groups of crustaceans, molluscs and fishes as main food groups and only difference was observed in feeding rate. The identified molluscs in this study were included of: families Sepiidae and Loliginidae of cephalopoda (10.5%), genuses *Neverita* and *Granulina* and subclass Opistobranchia of class Gastropoda (5.3%), family Dentaliidae of class Scaphopoda (2.1%) and class Bivalvia (11.6%). In other studies unlike the present study, molluscs comprised small percentage of *N. japonicus*'s stomach contents (Krishnamoorthi, 1971;

Gopal and Vivekanandan, 1991; Raje, 2002; Manojkumar, 2004). The identified osteichthyes in this study were including of *N. japonicus*, eel, *Upeneus* sp., *Saurida tumbil*, Carangidae, *Sillago sihama* and *Bregmaceros* of family Bregmacerotidae. In other studies, also a wide range of types of fishes in the *N. japonicus*'s stomach have been identified (Vinci, 1982; Euzen, 1987; Bakhsh, 1994; Raje, 2002; Manojkumar, 2004).

Comparison of results of this study with other researches shows that there is a significant difference in identified fish species in several areas, that this could be due to the differences in studied waters and species that live in any area. As a conclusion, presence of a food content in the diet, in addition to availability features, and its selection as food (Wootton, 1995), also depends on the seasonal fluctuations,physical and chemical factors of sea water (Cavetiviere , 1987). Nikolsky (1963) revealed that reason of the difference in frequency of food types in the stomach is related to its frequency in the environment. Some food items such as polychaets (8.4%), sipuncula (7.4%), foraminifera (6.3%), phytoplanktons (4.2%), sea weeds (2.1%) and nemertia (1.1%) (Table 1), had occupied part of the *N. japonicus*'s stomach in the present study, probably are as incidental food and doesn't seem to be preferential swallowed. Their presence could be conclusion of their availability in region of life of *N. japonicus*, but surely this species is a highly carnivore. Also, the nematode worms observed in four seasons of sampling, but despite the high percentage (25.3%) (Table 1), it can't be considered as food, because nematodes was sometimes observed outside of stomach and on the fish's digestive tract and with regard to their safety seems to be parasites of *N. japonicus*. Ghaem Maghami et al. (2008), in addition to nematode parasite, have reported existence of *Serrasentis sagittifer* parasite in *N. japonicus*'s digestive system from the waters of Persian Gulf (Bushehr).

Age determination is one of the important parameters that used in fisheries science for determination of the growth and development. The otolith is as one of the most suitable options for age determination of tropical and subtropical marine fishes (Hilborn and Walters, 1992; Green et al., 2009). The age determination of several species of fishes in south waters of Iran using of otolith cutting has been done to these species including of *Pampus argenteus* (Abu-Hakima, 1984), *Pomadasys kaakan* (Al-Husaini et al., 2001), *Acanthopagrus bifasciatus* and *Argyrops spinifer* (Grandcourt et al., 2004). In this study, maximum and minimum age was estimated 5^+ years old and 1^+ year old, respectively. Studies of Granada et al. (2004) showed that species of *Nemipterus* genus can't survive more than 10 years and females are with the lower longevity than males that confirms the results of this study.

Investigation of fish diet in different age groups showed that the fish fed mainly of crustaceans, but molluscs and fishes also were fed with variable frequency percentages (Figure 9). Evaluation of feeding rate with calculation of mean stomach contents in each age groups showed that most older fishes (age groups of 5-6 years) enjoyed of lower feeding rate than younger people (Figure 10), but didn't have the limited food variety comparing to younger individuals. In addition to factors affecting the feeding rate (season, water temperature, distribution patterns and density of alimentary organisms), age also is as an important factor in feeding rate of fish, because with increasing of age, level of energy and metabolism rate was reduced. Therefore, organism need feed less and reducing of feeding rate in the olds seems to be normal.

Acknowledgements

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