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Diet of Two Deep-Water Sharks, *Deania calcea* (Lowe, 1839) and *Deania profundorum* (Smith and Radcliffe, 1912), in the North Atlantic of Morocco

Mohammed Nafia*[1], Ahmed El Achi[1, 2], Khalid Manchih[2], Abderrahim Ouaach[3], Mohamed Moncef[1]

[1]Team of Environmental Study and Analysis Laboratory, Faculty of Sciences, Chouaib Doukkali University, El Jadida, Morocco
[2]National Institute of Fisheries Research (INRH), Morocco
[3]Biological Engineering, Agrifood and Aquaculture Laboratory, Polydisciplinary Faculty of Larache, Abdelmalek Essaadi University, Tetouan, Morocco
***Corresponding Author:** nafia122@gmail.com

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ABSTRACT

Squaliform sharks are relatively vulnerable bycatch in many deep-water fisheries. The diets of two deep-water sharks, *Deania calcea* and *Deania profundorum*, on the continental slope and continental shelf (200–1100 m) of the Moroccan coasts (North-East Atlantic) were subjected to an examination of the stomach content using monthly samples collected between February 2018 and March 2021. For investigation, 683 *Deania calcea* individuals were collected, ranging in size from 55 to 116cm, with 423 females and 267 males. While, 161 *Deania profundorum* individuals were sampled, with 117 females and 44 males ranging in size from 49 to 100cm. It was observed that, the diet of both *Deania calcea* and *Deania profundorum* consisted of four essential prey groups; cephalopods, bony fish, crustaceans and annelids. The main prey species of the two deep-sea sharks studied were the bony fish, cephalopods and crustaceans. This study would provide comprehensive information for the conservation of the species under study and managing a good exploitation.

INTRODUCTION

Studying the nutritional ecology of marine predators and getting reliable information on diets of deep-sea shark species is critical to understand their ecological roles in marine ecosystems. Currently, the International Council for the Exploration of the Ocean **(ICES)** defines deep-sea fisheries as fisheries deeper than 400m **(Clarke *et al*., 2003)**, while the Food and Agriculture Organization of the United Nations (FAO) defines deep-sea fisheries as fisheries deeper than 400m **(Clarke *et al*., 2003)**. Fisheries in deeper waters are defined as waters that occur beyond and below continental shelf break **(FAO, 2011)**.

Fishing can affect deep-sea shark populations in two ways. First, being caught in nets as bycatch can lead to fishing mortality, while escaping nets can lead to behavioral disturbances and subsequent natural mortality **(Rayer, 2004)**. Second, by altering habitats and resources, fisheries can affect population productivity or natural mortality. Many chondrichthyans occupy an important ecological niche as top predators in the marine environment. Feeding trends of fish species are crucial in classical ecological theory, mainly in the identification of structure and the stability of food chain **(Post *et al*., 2000)**, the evaluation of the functional responses of prey and predators **(Dörner & Wagner, 2003)** in addition to the identification of food competition **(Bacheler *et al*., 2004)**. The key role of diet studies for fisheries biology and ecology is important for fisheries management, and it was only discovered in 1998 with the use of trophic level to predict the effects of fishing on the balance of marine food chain **(Pauly *et al*., 1998)**. Deep-sea sharks are abundant and distributed on the Moroccan coasts, where they form a bycatch in trawl fisheries and a catch of longline fisheries **(Institut National des Recherches Halieutiques [INRH], 2020)**. The trawler ships consider these group of sharks as a bycatch, but the long-liner ships target them for the commercial value of their livers. Squaliforms are abundant; they represent 42%. All of them are commonly caught in deep waters (400 - 1500m). However, a little is known about the behavior of deep-water shark's populations on continental slope and continental shelf of Morocco (North-East Atlantic). To date, the diet of deep-water sharks of the Moroccan coasts is unknown. In order to provide more reliable information for the good conservation of two squaliform species, *D. calcea* and *D. profundorum*, this work aimed to study their diet in the North Moroccan Atlantic, using the stomach content analyses (SCA) and offering a description of each stomach content in order to determine the dietary composition as well as preferential, occasional and accidental preys.

MATERIALS AND METHODS

1. Sampling

A total of 851 specimens of deep-water sharks, representing 690 of *D. calcea* and 161 of *D. profundorum* and belonging to the Centrophoridae family were collected for the current study. Samples were collected from the commercial fishing landing of long-line vessels from February 2018 to December 2020 for *D. profundorum*, and until March 2021 for *D. calcea*. Long-line vessels fleet were used to operate in continental slope and continental shelf waters exceeding 200 to 1100m of depth around the coasts of Morocco (North East of Atlantic). Samples taken after surveys were collected using a fishing master on board of 11 long-liners operating in the area between 20° 55N and 34° 45N. The sample unit consists of a standardized plastic case (56x37x16 cm). For each sample batch, sharks were identified by species, and their sex were determined, total weight, gutted weight and liver weight (nearest 1 g), total length (TL) (nearest 1 cm) and maturity stages were recorded. All stomachs were removed and immediately fixed individually in a 70% ethanol solution in order to analyze all the contents of each one monthly during all sampling period. In laboratory, all stomach contents were analyzed, and food items were separated and identified to the lowest possible taxonomic level. The percentage of each prey was estimated. Fish baits used to attract bottom sharks to the hook were excluded from the analyses. All preys were identified to the most precise taxonomic level possible, and they were counted and weighed to nearest 0.1g. A small prey was observed under a binocular microscope, following various identification works **(Domingo & Jaume, 1998; Richardson *et al.*, 2013)**. Preys in an advanced state of digestion were recognized by their undigested remains, such as the fish scale, otoliths, bones and appendages. In addition, empty stomachs were counted during the identification process. Several indices were used in the analysis of stomach contents. The following indices were used to quantify the importance of different preys in the diet of these two deep-water sharks. Stomachs with everted or obvious regurgitated contents were not taken, and they were not included in statistics.

2. Stomach content analysis

Stomach content analysis performed follow the fullness rating scale from 0 to 3, where 0 is empty and 3 is completely full **(Pethybridge *et al.*, 2011)**. Before dissection, each stomach was weighed (nearest 0.1 g) and then everted. Contents were discarded upon dissection. They were sieved and recorded, and prey items were identified as much as possible. Taxonomic resolution was achieved where possible with the aid of identification key **(Keable & Bruce, 1997)** and local reference collections **(Domingo *et al.*, 1998)**. After identification, prey items were classified in groups and families.

Vacuity index (Vi)

The vacuity index ($Vi_{\%}$) represents the percentage of the number of empty stomachs (Nes) compared to the total number of stomachs examined (Tns) **(Hureau, 1970; Geistdörfer, 1975)**. This coefficient, inversely proportional to the power supply intensity, is calculated according to the following equation:

$$\boxed{Vi_{\%} = (Nes / Tns) \times 100}$$

Frequency of occurrence (Fo)

The frequency of occurrence ($Fo_{\%}$) represents the percentage of the number of stomachs containing at least one identified individual prey (Nsi), compared to the total number of non-empty stomachs (Nsp). Therefore, Fo is calculated by the following equation **(Hureau, 1970; Labourg *et al.*,1973)**:

$$\boxed{Fo = (Nsi / Nsp) \times 100}$$

This frequency of occurrence expresses the importance of a given prey in relation to the number of stomachs examined and makes it possible to know the dietary differences of the species studied according to the following scale: Fo>50% was qualified as preferential prey; 10%<Fo<50% was qualified as secondary prey; Fo<10% was identified as occasional prey.

Total fullness index (TFI)

The total stomach fullness index (TFI) is calculated for each individual stomach containing at least one prey **(Bowering & Lilly, 1992)**. This index, used to assess stomach filling from a quantitative point of view, was modified by **Bozzano *et al*. (1997)**, as follows:

$$\boxed{TFI = Wsc \times 10^4 / TW_i}$$

Where, Wsc is the weight of stomach contents, and TWi is the total weight of the individual.

Index of relative importance (IRI)

The ratio for each prey group in the diet is expressed in terms of three parameters; percentage of frequency of occurrence (Fo); percentage of abundance in number (N), and percentage of abundance by weight (P) **(Hyslop, 1980)**. According to **Bozzano *et al*. (1997)**, a modification of the version of IRI described by **Pinkas *et al*. (1971)** was used. Hence, the following equation is used to determine the index of relative importance (IRI); where, IRI>50% stands for preferential prey; 10%<IRI<50% for secondary prey; 1%<IRI<10% for a complementary prey, and IRI<1% represents an accidental prey.

$$\boxed{IRI = Fo \times (N + P)}$$

3. Statistical analysis

To calculate the degree of similarity of food preferences in different seasons as well as between different size groups of the both of species, we used the Agglomerative Hierarchical Clustering (AHC) with the Primer 6 software, using the Jump Minimum as an aggregation method and Euclidean distance for distance measurement. This method is the most used for this type of analysis. The dendrograms obtained give us the composition of the different classes and seasons, as well as the order in which they were formed. It also tells us, on the horizontal axis, what was the value of the index between the two classes that were aggregated during a given stage or both seasons. The analysis of variance (ANOVA Two way) was used to test the variability of the different indices according to size classes and seasons.

RESULTS

Stomachs' contents examinations showed that they composed four cases; empty stomach, content with identified undigested prey at the genus and family taxonomic level and unidentified content in two forms; unidentified biotic materiel (UBM) and unidentified abiotic materiel (UAM). In total, 11 prey's taxa (including 4 teleost, 4 cephalopods, 1 crustacean and 2 polychaetae) were identified for this two sharks *D. calcea* and D. *profundorum*. Contents analysis confirms that all of them are exclusively carnivorous diet. Some preys were recognized by their components, such as otoliths, scales and vertebras for Teleostei; antennas, shells and appendages for crustaceans, whereas cephalopods group was spotted by the remains of beaks, mantles suckers and tentacles. Based on identification keys **(Reiss *et al.*, 2009; Marceniuk *et al.*, 2017; Luna *et al.*, 2021)**, Table (1) shows the list of preys' items identified based on stomach content analysis. Identification of all preys ingested, identified abiotic materiel (IAM) and unidentified abiotic materiel are displayed in Table (1). *D. calcea* was the numerous species sampled with 690 specimens, while *D. profundorum* was the least common species sampled, with an average of only 161 specimens collected per sampling period since in landed catches, the *D. calcea* is more abundant than *D. profundorum*.

According to this study, the diet of *D. calcea* was composed of 3 cephalopods, 1 crustacean, 4 teleostei and 2 annelidae. The *D. profundorum* diet was composed of 4 cephalopods, 1 crustacean, 4 teleosts and 2 annelids.

Both species, *D. calcea* and *D. profundorum*, have a vacuity index (Vi) equal to 46% and 29%, respectively. This indicates that, 317 specimens of *D. calcea* and 47 specimens of *D. profundorum* have an empty stomach. *Deania calcea* presents a different mode of fullness of stomachs, with 12% full, 20% medium full and 22% containing about one third of the capacity of the stomach. We recorded for this species a diversity of preys per stomach varied from 1 to 6, except those containing more than three preys not exceeding 11 stomachs in total (Table 2).

The fullness of *D. profundorum* stomach examined was just 6% full, 39% medium full, and only 26% containing one third of the capacity of the stomach. For this species, a diversity of preys per stomach varied from 1 to 2, with only one stomach containing 5 preys (Table 2).

In general, for the two species, stomachs were rarely full. A diversity of preys was recorded per stomach, varying from 1 to 6. About half of the stomata examined contained a single prey. On the other hand, less than 1% of the samples presented 3 to 6 preys per stomach for the two species (Table 2). A large proportion of the prey remained unidentified; these preys were predominantly well-digested remains of fish (bones and scales). The teleost fish prey included pieces of flesh, suggesting either the prey was scavenged, or a live prey was attacked but not entirely ingested.

Table 1. Diet composition of *D. calcea* and *D. profundorum*, in terms of the major prey taxa and identifiable dietary categories

Species	Prey group	Prey family	Prey identification possible
Deania calcea	**Cephalopodae**		*Loligo vulgaris*
			Sepia sp.
			Sepiola sp.
			Unidentified
	Crustacae		*Paraepinaeus longirostris*
			Unidentified
	Teleostei	**Scombridae (bait)**	*Scomber* sp.
		Myctophidae	Unidentified
		Trichiuridae	*Aphanopus carbo*
			Lepidopus caudatus
			Unidentified Teleosts
			Otoliths unidentified
	Annelidae	**Nematodes**	Unidentified
		Cestodes	Unidentified
	UBM	**UBM**	Unidentified Biotic Material
Deania profundorum		**Cephalopodae**	*Loligo vulgaris*
			Octopodae
			Sepia sp.
			Sepiola sp.
			Unidentified
		Crustacae	*Paraepinaeus longirostris*
			Unidentified
		Annelida	Cestodes
			Nematodes
		Teleostei	*Aphanopus carbo*
			Lepidopus caudatus
			Myctophidae
			Otoliths unidentified
			Scomber sp.
			Unidentified
			Unidentified Teleosts
	UBM	**UBM**	Unidentified Biotec Materiel

UBM: Unidentified Biotic Material.

Table 2. Percentage of stomachs by qualitative stomach fullness with the number and diversity of preys

		D. calcea	*D. profundorum*
Stomach fullness	**% Empty stomach (0)**	46	29
	% 1/3 Full	22	26
	% 2/3 Full	20	39
	% 3/3 Full	12	6
Prey diversity	**Empty or Digested fluid**	317	47
	1 Identified Prey (IP)	322	94
	2 (IP)	33	19
	3 (IP)	8	0
	4 (IP)	1	0
	5 (IP)	1	1
	6 (IP)	1	0
Stomachs rejected (regurgitated)		**7**	**0**

IP: identified prey.

The prey of *D. calcea* was basically composed of fish, among which teleost were dominant with FO reaching 56.01%, followed by demersal and pelagic species (Table 3). The other groups of preys formed a mixture of cephalopods species (*Loligo vulgaris*, *Sepiola* sp. and *Sepia* sp.), crustacean (*Paraepinaeus longirostris*), whereas the annelids were attached to the inside stomachs, which favors the hypothesis claiming the parasitic character.

The prey of *D. profundorum* was preferentially composed of fish; teleosts were dominant with frequency of occurrence (FO) reaching 75.44%, followed by demersal and pelagic species (Table 3). Similar to *D. calcea* diet, the other prey groups were a mixture of cephalopods species (*Loligo vulgaris*, *Octopus vulgaris* and *Sepia officinalis*), crustaceans (*Paraepinaeus longirostris)* and annelids.

The seasonal evolution of the vacuity index (Vi) of the two squaliform species shows that there is a variation between all of them. The Vi of both sexes of *D. Calcea* was almost approximate from autumn 2018 to autumn 2020, varying between 20% and 70%, except for spring 2020, where a variation was detected starting from spring 2020 to spring 2021 (Fig. 1). On the other hand, the seasonal evolution of the Vi of *D. profundorum* shows that there is a variation between females and males observable throughout the study period (February 2018 to December 2020).

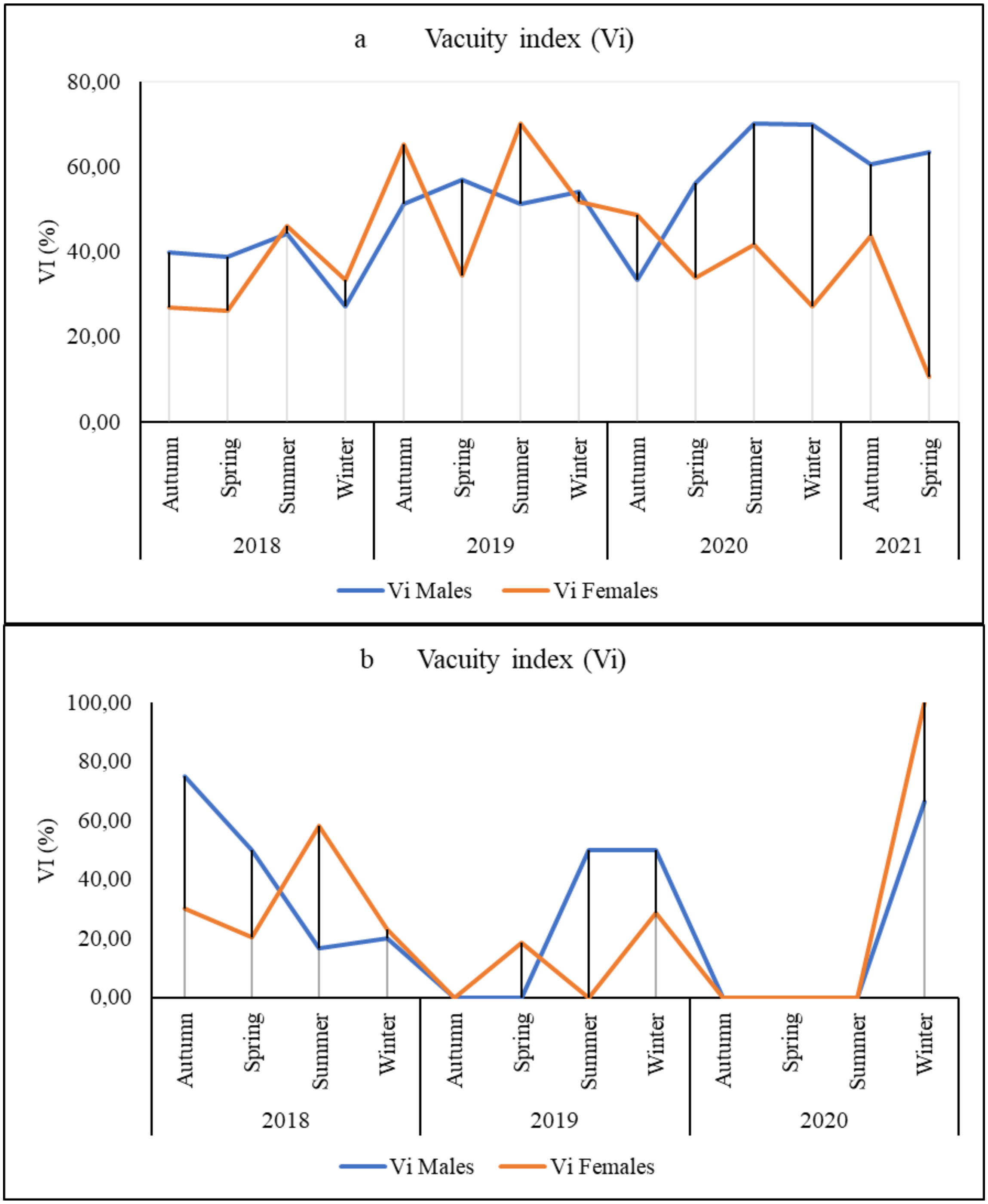

Fig. 1. Evolution of the vacuity index (Vi) of males and females of (a) *D. calcea* and (b) *D. profundorum*

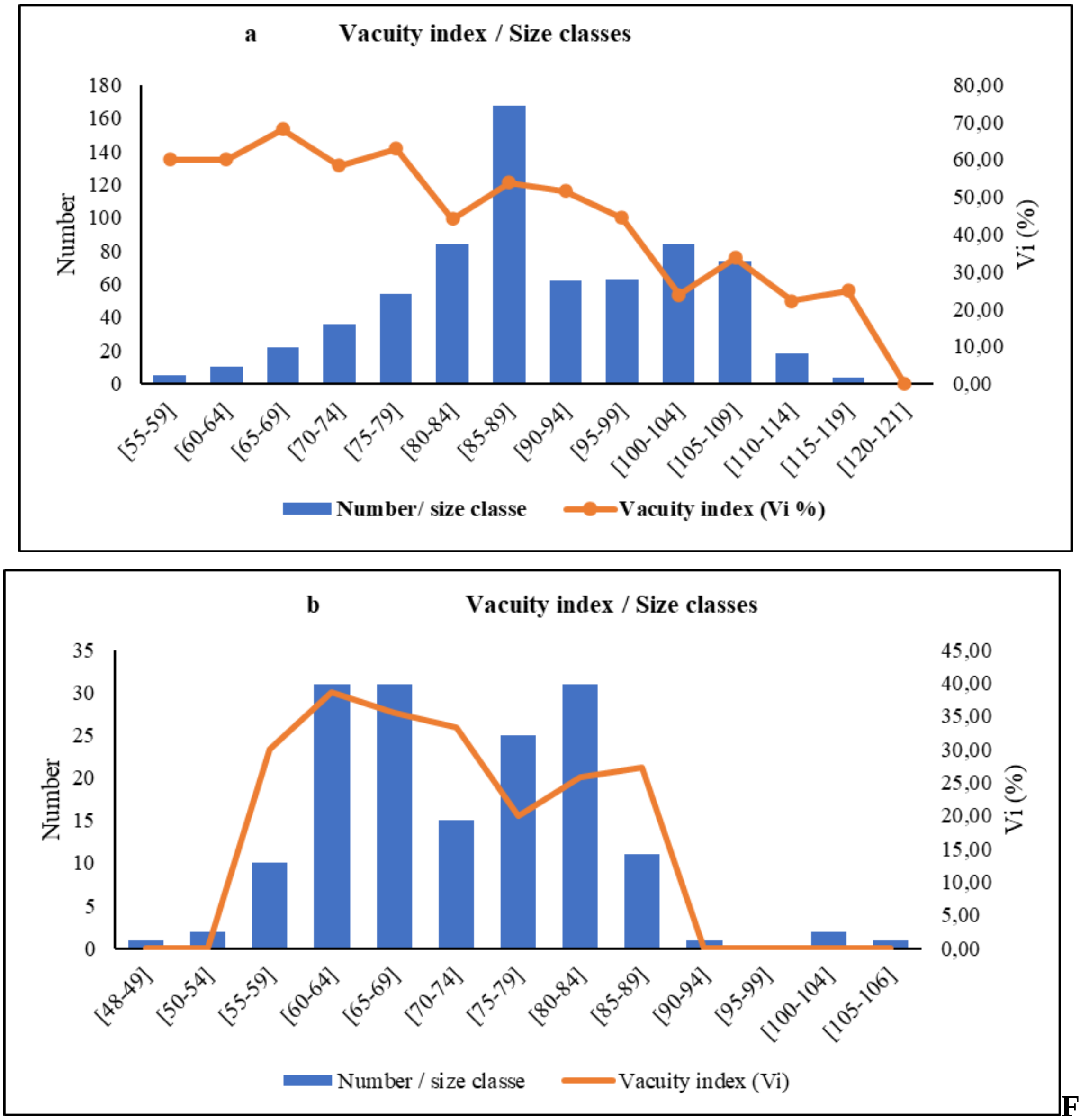

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Fig. 2. Evolution of vacuity index per size classes of (a) *D. calcea* and (b) *D. profundorum*

The vacuity index (Vi) of the two deep-water sharks changes with species, seasons and years. For the two squaliforms, the vacuity index (Vi) changes with sexes. As a result, no correlation was detected of Vi and both sexes for the two species, *D. calcea* and *D. profundorum* (Fig. 1). The Vi is influenced by the season, the depth or the marine environment for the two species studied. We concluded that, during the 2018-2021, sampling period, the Vi did not have the same rate of variation for the species under study (Fig. 1).

The Vi of *Deania calcea* is more than 40% for small size classes [85-89]. For the size group [105-109] of *D. calcea*, the Vi starts to decrease with the increase of the size classes. For *D. profundorum*, all size classes between [55-59] and [85-89] have a Vi between 20% and 40%, but the smaller and larger sizes have lower Vi that does not exceed 5%. *D. calcea* size classes less than [95-99] have a Vi more than 40%, whereas beyond these sizes the Vi is less than 40%, and it decreases as the size increases, reaching zero for [120-121]. For *D. profundorum* with size classes less than [50-54] and more than [90-94], it has zero Vi, but sizes between [55-59] and [85-89] have a Vi that varies from 30% to 40% (Fig. 2).

Table 3. Frequency of occurrence (Fo) of the diet composition of *D. calcea* and *D. profundorum*

Species	Group	Nei	Nep	Fo (%)	Classification prey
Deania calcea	Cephalopodae	100	366	**27,32**	**Secondary**
	Crustaceae	17		**4,64**	**Occasional**
	Teleostei	205		**56,01**	**Preferential**
	Annelida	48		**13,11**	**Secondary**
Deania profondorum	Cephalopodae	26	114	**22,81**	**Secondary**
	Crustaceae	5		**4,39**	**Occasional**
	Teleostei	86		**75,44**	**Preferential**
	Annelida	18		**15,79**	**Secondary**

Nei: number of stomachs containing individual prey, Nep: number of non- empty stomachs

The results of the frequency of occurrence calculated for these two deep-water sharks of the family Centrophoridae show that the teleostei group have a large Fo exceeding 56% for *D. calcea* and 75% for *D. profundorum*. As a result, this group is classified as preferential prey for the two species. Cephalopods group have 27.32% and 22.81% for this species, respectively, which allows it to be classified as secondary prey for them. The crustacean group and the annelids group were qualified as occasional prey for all species (Table 3).

The analysis of the diet of these two deep water sharks based on the calculation of the frequency of occurrence (Fo) shows that, *D. calcea* has a diet composed preferentially of Teleostei, as main meal, followed by cephalopods and annelids, and occasionally crustaceans. For *D. profundorum*, the (Fo) shows that this species has almost the same diet as *D. calcea* (Table 3). Based on this analysis of Fo, it can be deduced that, these two studied species prefer to feed on teleostei group. Opportunistically, in the absence of preferential preys, they research for their diet as a secondary or occasionally prey. In this study, both species eating other groups as a secondary or occasional prey include cephalopods, crustaceans and annelids (Table 3).

Table 4: Index of relative importance (IRI) of the diet composition of *D. calcea* and D. *profundorum* (Centrophoridae)

Species	Group	Fo (%)	N	P (kg)	IRI (%)	Classification prey
Deania calcea	Cephalopodae	27,32	110,00	2,2	**30,66**	**Secondary**
	Crustaceae	4,64	29,00	0,388	**1,37**	**Accidental**
	Teleostei	56,01	351,00	3	**198,28**	**Preferential**
	Annelida	13,11	188,00	0,015	**24,66**	**Secondary**
Deania profondorum	Cephalopodae	22,81	30,00	0,237	**6.90**	**Complementary**
	Crustaceae	4,39	11,00	34,1	**1,98**	**Accidental**
	Teleostei	75,44	140,00	638,55	**587,33**	**Preferential**
	Annelida	15,79	67,00	4,52	**11,29**	**Secondary**

The index of relative importance (IRI) calculated for the two species show that the Teleostei group had a large IRI exceeding 198% for *D. calcea* and 587% for *D. profundorum*. As a result, this group was classified as preferential prey for the two species. Cephalopods group recorded an IRI less than 50%, which allowed it to be classified as secondary prey for *D. calcea,* but it was classified as complementary prey for *D. profundorum*, with IRI equals to 6.90%. The crustacean’s group was classified as accidental prey for the two species. The annelids group was qualified as secondary prey for *D. calcea* and *D. profundorum*, with 24.66% and 11.29, respectively.

The analysis of Index of relative importance (IRI) shows that *D. calcea* diet was composed preferentially of Teleostei, followed by cephalopods and accidentally crustaceans. For *D. profundorum*, the IRI analysis shows that this species prefers also Teleostei as a principal prey, they eat secondarily annelids, cephalopods as a complementary prey and accidentally crustaceans (Table 4). Given this IRI analysis, it was observed that, these two studied species prefer to feed on Teleostei group, while in the absence of this group in their search for prey, they eat secondarily or occasionally the other groups such as cephalopods, crustaceans and annelids (Table 4).

The Total Fullness Index (TFI) calculated for this two squaliform species shows that *D. calcea* presents a TFI ratio from 56 to 70, 1.22 for annelids (Table 5). While *D. profundorum* has a TFI ratio from 45 to 53, concerning the three groups, Teleostei, cephalopods and crustaceans, and just 1.36 for annelids group (Table 5). As a result of the TFI analysis, crustaceans and cephalopods have the highest ratio even when they are classified by the other indices (Fo and IRI. The crustacean’s group recorded the highest TFI ratio (70.83) in the diet of *D. calcea*. For *D. profundorum*, the three groups, cephalopods, crustaceans and Teleostei, have a close TFI ranging from 45 to 53 (Table 5).

Table 5. Total stomach Fullness Index of diet composition of *D. calcea* and *D. profundorum*

Species	**Group**	**Wsc (g)**	**Twi (g)**	**TFI**
D. calcea	Cephalopodae	2202,21	344158	**63,99**
	Crustaceae	388	54782,2	**70,83**
	Teleostei	2997,48	530438	**56,51**
	Annelida	15,06	123210,5	**1,22**
D. profondorum	Cephalopodae	236,86	45921,5	**51,58**
	Crustaceae	34,1	7533,7	**45,26**
	Teleostei	638,55	120079,6	**53,18**
	Annelida	4,52	33184,5	**1,36**

Wsc: weight stomach contants (g), Twi: Total body weightc(g), TFI; Total fulness index

The stomach content of the *D. calcea* is characterized by a diversified composition according to the size classes of said species, we recorded that the sizes less than [60-64] have food composed only of nematodes and small-sized fish. from sizes [65-69], we found that this species began to diversify their diet by adding fish of different sizes, cephalopods and unidentified biotic material (UBM). From sizes between [90-94] and [105-109], we recorded the appearance of traces of the crustacean's group in their stomach contents. In addition, the crustacean's group was absent in sizes from 110-114 and more. The fish were present almost for all size classes, with a different percentage varying from 22% to 77% (Fig. 3).

The stomach content of the *D. profundorum* is characterized by a diversified composition according to the size classes of the species under study. It was observed that, the size classes [49-49] and [105-109] had food composed only of nematodes. For sizes [100-104], their stomach contents were composed of cephalopods and nematodes. From sizes between [50-54] and [90-94], we recorded the appearance of traces of the crustaceans, cephalopods and fish in high percentage. Additionally, the unidentified biotic material (UBM) was present just for sizes 75-79. The fish were present for size classes between [50-54] and [90-94], with a different percentage varying from 60% to 100% (Fig. 4).

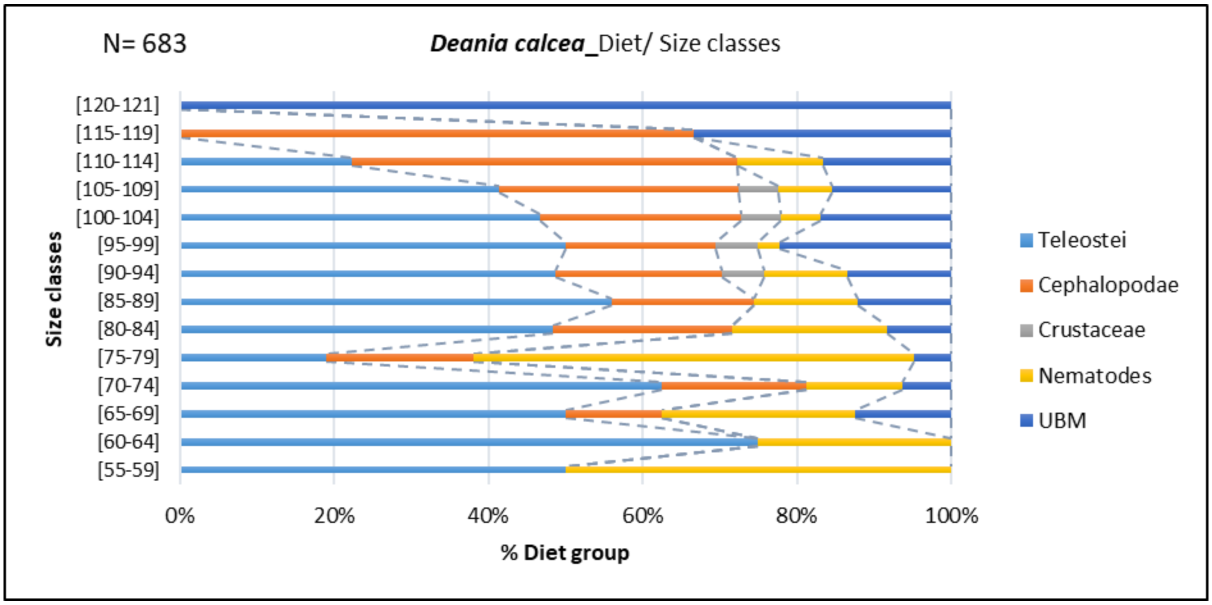

Fig. 3. Diet composition per size classes of *D. calcea*

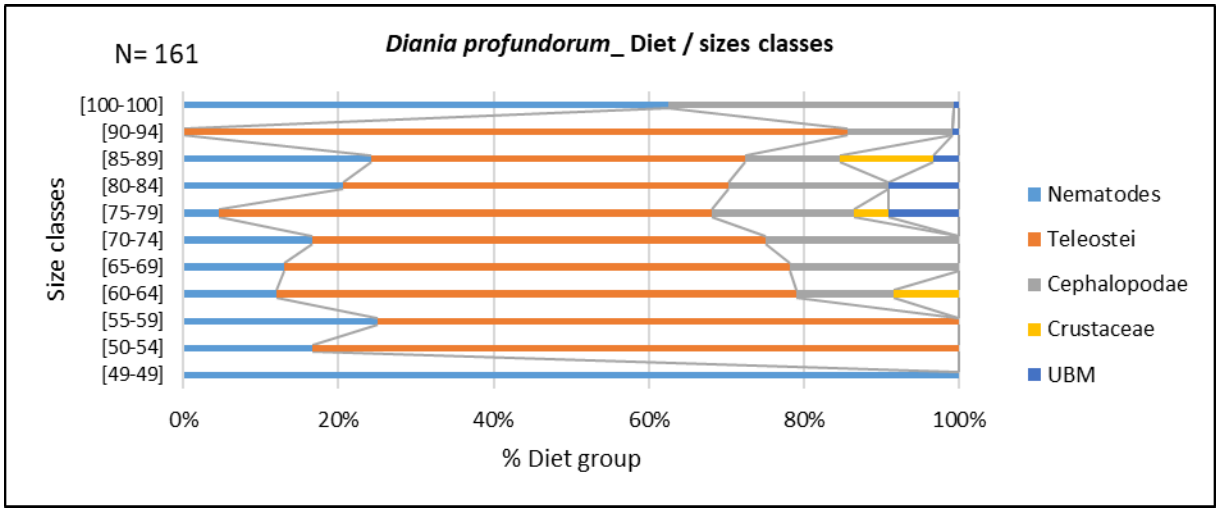

Fig. 4. Diet composition per size classes of *D. profundorum*

The estimation of the degree of similarity of food preferences between the different size groups of *D. calcea* using hierarchical agglomerative clustering (HAC) shows that, the population of this species can be divided into three groups, with a similarity degree of 40%. The first group size ate cephalopods; the second one had a diet composed of teleost (Myctophidae) and nematodes, while the 3rd group had a diet composed of teleost (Myctophidae), cephalopods, crustaceans and nematodes.

The first group was made up of individuals belonging to the 115-121cm size range. The second group was composed of individuals of sizes between 55 & 64cm. The third group was composed of individuals with sizes between 65 &114cm (Fig. 5).

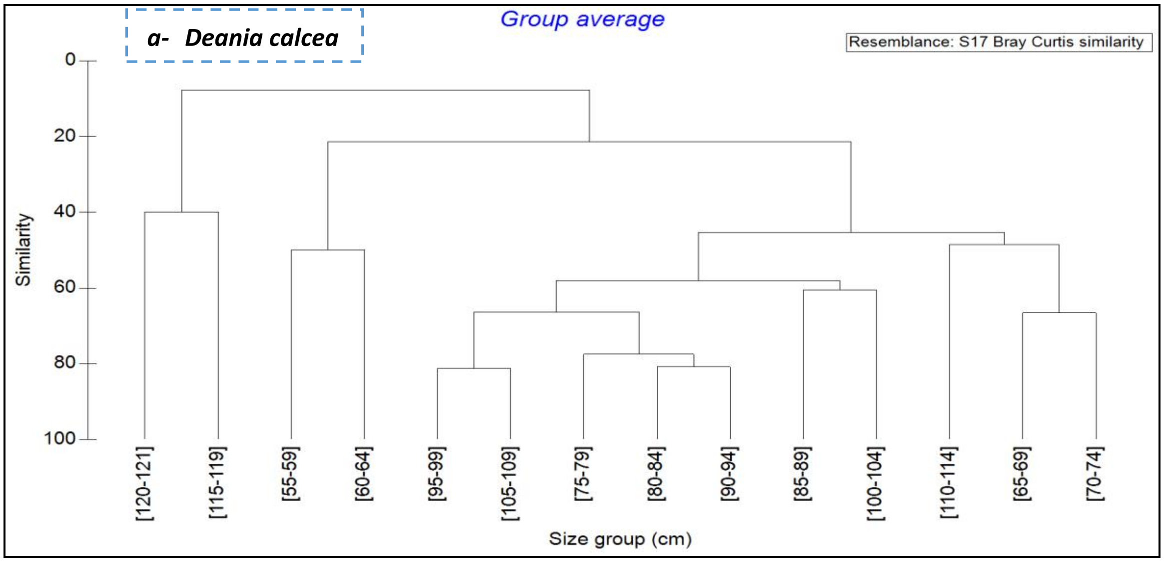

Fig. 5. Dendrogram showing the food similarity of size classes of *Deania calcea*

The estimation of the degree of similarity of food preferences between the different size groups of *Deania profundorum* using HAC shows that the population of this species can be divided into two groups, with a degree of similarity of 55%: The first group size fed principally on teleost cephalopods and annelids, the second group had a diet composed of teleost, cephalopods, crustaceans and nematodes.

The first group was made up of individuals belonging to the 48-49 and 90-100cm in terms of total length (TL). The second group of specimens had sizes (TL) between 50 to 89cm. (Fig. 6).

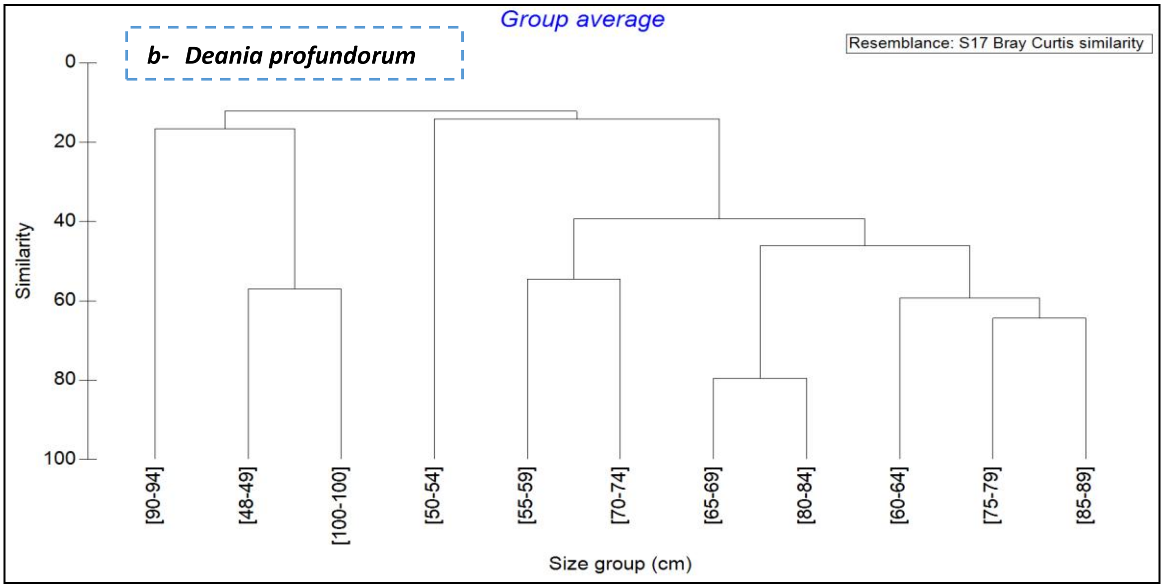

Fig. 6. Dendrogram showing the food similarity of size classes of *D. profundorum*

DISCUSSION

The feeding preferences of fish species are important in classic ecological theory, mainly in the identification of food competition, the structure and stability of the food chain and the evaluation of functional responses of prey and predators **(Post *et al*., 2000; Bacheler *et al*., 2004)**. Whether a sample is considered large enough to adequately describe diet depends on the level of taxonomic detail to which the prey species are identified, and the statistic used to measure diet breadth, which may be the number of preys or prey diversity. Although as few as 15–30 non-empty stomach samples may be considered adequate to describe prey diversity for some shark species **(Alonso *et al*., 2002; Lucifora *et al*., 2006)**, we do consider the sample sizes achieved in this study to be indicative of prey and feeding behavior. The two deep-water sharks, *Deania calcea* and *Deania profundorum*, were found to have eaten primarily Teleostei belonging to 13 families in total. *D. calcea* consumes also cephalopods and annelids as a second prey, and accidentally the crustaceans. *D. profundorum* consumes cephalopods as a complementary prey, annelids as a secondary prey and crustaceans as an accidental prey. Some species' heads were the only pieces found in content stomach, and some flesh were found in this content; these occurrences may indicate some incomplete ingestion, or perhaps scavenging. Jack mackerel heads and tails were found in the stomachs of *D. calcea* and *D. profundorum* and were almost certainly scavenged discards from commercial fishing vessels. In 366 *D. calcea*, we found predominantly benthic teleost prey, dominated by Myctophidae and Trichiuridae. Secondly, we found cephalopods, crustaceans and nematodes as complementary, secondary or accidental preys. **Ebert *et al*. (1992)** found that Myctophids, particularly *Diaphus ostenfeldi*, formed clearly the dominant prey group in the diet of *D. calcia;* cephalopods were of a secondary importance and crustaceans of minor importance. We found predominantly benthic teleost (Myctophidae) and cephalopods preys dominated by *Sepia* sp. and *Sepiola* sp. Nematodes were of secondary importance. **Ebert *et al*. (1992)** found that, in the West Coast of southern Africa, the diet of *D. calcea* was composed particularly of myctophids, which were clearly the dominant prey group, Cephalopods were of secondary importance, and crustaceans of minor importance. In the North-east Atlantic, this species apparently eats unidentified teleost, gadoids, myctophids and squid **(Mauchline & Gordon, 1983)**. In New Zeeland, the diet of *D. calcea* was characterized by teleost fish and natant decapods. Myctophids were the most frequent and numerous of the identifiable fish prey. However, in terms of prey weight, myctophids were relatively unimportant, and other prey categories of larger fish were more important, particularly merlucciids and macrourids, as well as various squids **(Dunn *et al*., 2013)**. In North-east Atlantic Ocean, **Preciado *et al*. (2009)** found that *D. calcea* fed on larger pelagic prey (cephalopods and fish such as *M. poutassou* and unidentified Alepocephalidae. This finding supports earlier studies that reported *D. calcea* consuming a small number of larger prey **(Mauchline & Gordon, 1986; Yano, 1991)**.

In 114 non- empty stomach of *D. profundorum*, we found teleost as a preferential prey, cephalopods and annelids were a secondary prey, and crustaceans were of minor importance. **Ebert *et al*., (1992)** found that, the most abundant item in the diet was myctophids, followed by unidentified teleost. Unidentified cephalopods and *Diaphus* sp. were also important. Myctophid followed by that of other teleost, cephalopods and *Diaphus* sp. were also important preys. No crustaceans were found in the study of **Ebert *et al*. (1992)**. Elsewhere, these species have been reported to feed on teleost fish, squid and crustaceans **(Bass *et al*., 1976, Compagno, 1984)**. According to these results, *D. calcea* and *D. profundorum* have almost the same feeding habits, whether in terms of diet composition or in terms of the order of prey group preference. We also concluded that, these two species of the Centrophoridae family have a group feeding mode justified by the existence of parts of a single prey shared by several stomachs belonging to a single sample.

CONCLUSION

The examination and analysis of stomach contents of the two deep water sharks, *D. calcea* and *D. profundorum*, reveal their highly diverse diet compositions, which means that the two species are opportunists. It is essentially composed of Teleost (Myctophidae, Trichiuridae, Merluciidae, Phycidae and Scombridae), Cephalopods (Octopodae and Ommastrephidae) Crustaceae (Penaeidae, Aristeidae and Nephropidae) and Annelids (Nematodes and Cestodes). The size of prey and the size of individuals have an influence on their diet composition. These results are of great importance for making a good decision by ensuring good fisheries governance for a sustainable management, economically profitable and socially equitable exploitation.

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