Libyan Journal of Ecological & Environmental Sciences and Technology
(LJEEST)

LJEEST
ISSN: 2710-5237
www.srcest.org.ly/jou

http://aif-doi.org/LJEEST/050208

Feeding Habits of Non-Indigenous Fishes *Siganus luridus*, *Siganus rivulatus* and Native Fish *Sarpa salpa* in Western Coast of Libya

*Samia Al-Rzagy, Entesar Abomies And *Esmail Shakman*

ARTICLE INFO

Vol. 5 No. 2 December 2023

***Pages* (55- 64)**

Article history:
Revised form 19 October 2023
Accepted 21 Novamber 2023

Article history:
Zoology department -Tripoli University – Libya
Botany department - Tripoli University – Libya
* Corresponding author, Zoology department -Tripoli University – Libya, Tel. 00218922761703 – E. mail: shugmanism@yahoo.com

Authors affiliation
itaklic
Font & size
email@mail.com

Keywords:
Herbivorous, Competition, food, Niche, Libya

ABSTRACT

A total of 570 herbivorous fishes (*Sarpa salpa*, *Siganus luridus* and *Siganus rivulatus*) were collected from the western coast of Libya during the period from May 2013 to June 2014. Samples were taken directly from fishermen then transferred to the laboratory in Marine Biology Research Center, in order to take different measurements such as; total length and total weight for each fish. Livers and stomachs have been taken and weighed. The results showed that in the herbivores fishes, *S. luridus* was more abundant, shows more ability to occupating the niche, and compete the other herbivores fishes. Moreover, this study showed that the seagrass and algae are important diet for both species; also there is no high competition between these species in this area of the south Mediterranean. This study tried to fill the gap of knowledge and document some important biological aspects on both species in Libyan waters.

السلوك الغذائي للأسماك غير الاصلية *Siganus luridus* و *Siganus rivulatus*
والأسماك الاصلية *Sarpa salpa* في الشاطي الغربي لليبيا

سامية الرزاقى، انتصار ابوميس، واسماعيل الشقمان

تم جمع 570 من الأسماك العاشبة *Sarpa salpa* و *Siganus luridus*و *Siganus rivulatus* من الشاطي الغربي الليبي خلال الفترة من مايو 2013 إلى يونيو 2014. وتم أخذ العينات مباشرة من الصيادين ثم نقلت إلى المختبر بمركز بحوث الأحياء البحرية، وذلك لأخذ القياسات المختلفة مثل؛ الطول الكلي والوزن الكلي لكل سمكة. تم أخذ الكبد والمعدة ووزنها. بينت النتائج أن السمكة العاشبة *S. luridus* كان أكثر وفرة، ويظهر قدرة أكبر على احتلال المكان المناسب، ومنافسة الاسماك العاشبة الأخرى. علاوة على ذلك، أظهرت هذه الدراسة أن الأعشاب البحرية والطحالب تعتبر غذاءً مهمًا لكلا النوعين؛ كما لا توجد منافسة عالية بين هذه الأنواع في هذه المنطقة من جنوب البحر الأبيض المتوسط. حاولت هذه الدراسة سد الفجوة المعرفية وتوثيق بعض الجوانب البيولوجية المهمة لكلا النوعين في المياه الليبية.

INTRODUCTION

After the opening of the Suez Canal in 1869, the diversity in the Mediterranean has been changed because a lot of non-indigenous marine species have penetrated the Mediterranean, and most of these species have distributed along the north and south coasts, this migration called the Lessepsian migration (Por, 1978), these species are increased and some of them have been established well (Golani, 2002, 2010; Golani et al., 2015; Bariche, 2012). *S. rivulatus* and *S. luridus* belong to Siganidae which is a small family of herbivores, widely spread in the Indian Ocean and Western Pacific (Woodland, 1983). These fishes have invaded the

Mediterranean from the Red Sea through the Suez Canal; these two species were recorded for first time in Libyan coast in 1970. (Stirn, 1970), and they have become a commercial species in the south Mediterranean (Shakman and Kinzelbach, 2007b; Shakman *et al*., 2009). The alien marine species are one of the most reasons impacting the biodiversity in the Mediterranean (Galil, 2007; Coll *et al*., 2010), which represent about 5% of native marine species in the Mediterranean (Zenetos *et al.*, 2012). Both Non-indigenous fishes S. rivulatus and S. luridus compete with native fish S. salpa, where it has declined in abounndce and in some cases may replace, because it feeds on the same algae and seaweed (Sala *et al*., 2011). In recent years, there has been considerable interest in studying the impact of these species on local flora and fauna in the Mediterranean (Bariche *et al*., 2004; Azzurro *et al*., 2007; Galil, 2007; Golani, 2010). As well as in the Eastern Mediterranean (George, 1972; Hussein, 1986; Yeldan and Avsar, 2000; Saad and Sabour, 2001; Bariche *et al*., 2003). Several studies emphasised that these species compete with local species, including *S. salpa*, on space and various food resources (Bariche *et al*., 2012). Feeding habits of S. luridus and S. rivulatus in the Red Sea have been studied by (Lundberg, 1980; Lundberg et al., 2004). In the Mediterranean, different studies of feeding habits have been conducted for S. salpa in Italian coast (Criscoli *et al*., 2006), and in the southern France (Havelange *et al*., 1997). Moreover, different studies have been conducted on *S. luridus* and *S. rivulatus* in the mediterranean (Hamza *et al*., 2000; Shakman *et al*., 2009, Sala *et al*., 2011). Due to the lack of information on these species in the Mediterranean, therefore, this study addressed the feeding habits of non-indigenous fishes (*S. rivulatus* and *S. luridus*), and native fish *Sarpa salpa* as well as the species composition with herbivorous fish.

MATERIALS AND METHODS

A total of 570 non indigenous fishes (*S. luridus*, *S. rivultus*) and native fish *Sarpa salpa* were collected monthly from the western coast of Libya during the period from May 2013 to June 2014. They were caught from the same habitat (rocky and sandy covered by seaweeds) by using Trammel net. The fish were transported in an Ice box to the Laboratory at the Marine Biology Research Center. All fish were sortied, numbered and measured (total weight, total length, standard length and head length), after that the fishes were sectioned in order to taken weights of stomach, liver and conads. To investigate the feeding habits, each stomach was placed after weighting to the nearest gram in a glass tube containing formalin at a concentration of 5%. The fish data from which the stomach was taken, the fish number and the date of preparation were written and stored. The stomach was taken out of the formalin, then opened with the dissecting scissors, and the food was discharged. The size of the stomach was given from 0 to 4, giving zero to the empty stomach and the number one given to the filled stomach 25% completely filled with 100%. The food content is discharged into a petri dish with drops of pure water to ensure separation of the contents by using a special needle under the binocular microscope with different magnification forces, corresponding to the size of the prey components according to Hyslop, 1980 (Shakman et al., 2009). The preyes were sorted into groups according to the taxonomic class, then, each group was weighed separately. The size of each group was determined in the food content compared to the rest of the prey in the same stomach. The prey is 100 per cent according to Cachia et al., 1991, 1996) The total number of undigested preyes is low compared with the digested, weighed and then placed in 70% alcohol flasks, to be stored and classified to the nearest taxonomic category, using Cachia et al. 1996 and De Haas and Knorr, 1979); the data have been analysed by using different questions in Excel.

RESULTS

Abundance of herbivorous fishes

For herbivores fish, S. luridus was more abundant than other fishes S. salpa and S. rivulatus (Fig. 1).

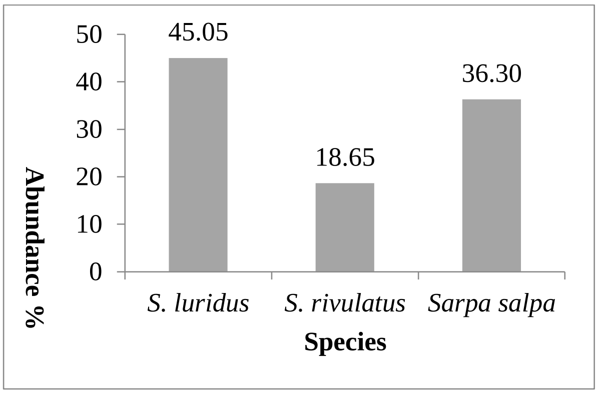

Fig. 2. Relative abundance of herbivorous fishes along the western coast of Libya

1. **Length frequency**

Total length of S. salpa has ranged from 14.0 cm to 33.9 cm., and the results showed that the most frequent lengths of this fish were 20.0 - 20.9 cm. and S. luridus length ranged between 14.0 cm and 24.9 cm., and the most frequent lengths of this fish were 21.0 - 21.9 cm. The length of S. rivulatus was between 17.0 and 28.9 cm and the most frequent length was 19.0 to 19.9 cm (Fig. 2).

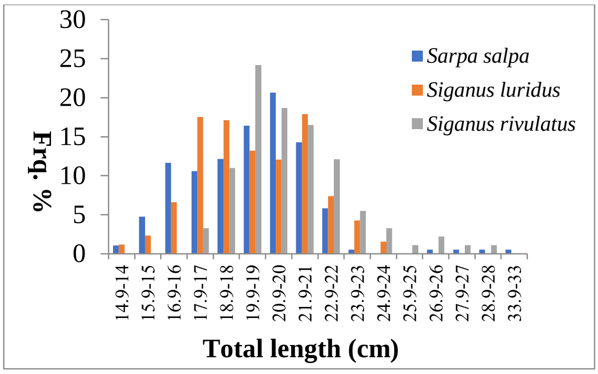

Fig 2. Length frequency of Herbivores fishes along the western coast of Libya

2. Food and feeding habits

- *Sarpa salpa*

The favoured food for *S. salpa* was varies from season to season. In the spring, the IRI% of *Ulva sp*. represents the highest percentage 36%, followed by 24% *Posidonia oceanica*, Cladophora 22% and *Gelidium sp*. by 11% (Fig. 3).

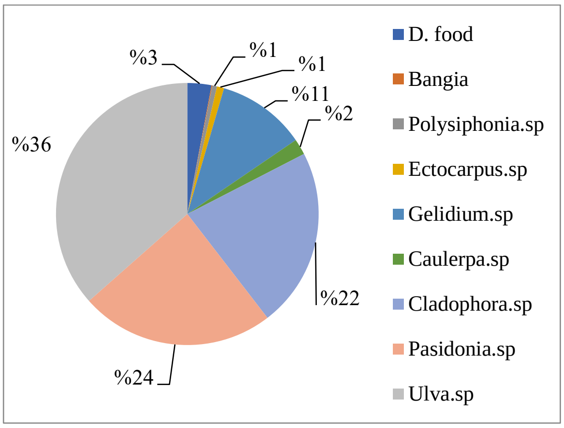

Fig. 3. IRI% of S. salpa in the western coast of Libya (Spring season)

In the summer, the main food of *Sarpa salpa* was *Pasidonia oceanica* (42%), *Gelidium sp* (28%), *Ectocarpus sp* (10%), *Ulva sp* (7%), *Caulerpa sp* (7%) and *Sphasilaria sp* (0.31%) (Fig. 4).

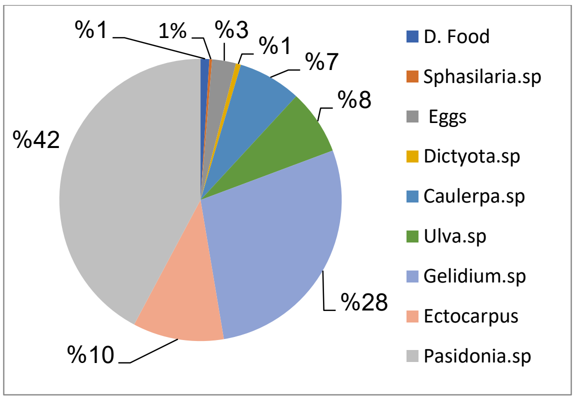

Fig. 4. IRI% of S. salpa in the western coast of Libya (Summer season)

In the fall season, the main food was *Gelidium sp*, at a rate of 49.42%, followed by *Pasidonia oceanica*, at a rate of 36.48%, *Cladophora sp*, at a rate of 6.23%, and *Caulerpa sp.*, at a rate of 4.0%. The digested food was 3.2%, the algae of *Sphasilaria sp* and *Dictyota sp* was a similar percentage of 0.27%, and the algae of *Polysiphonia sp* was 0.14% (Fig. 5).

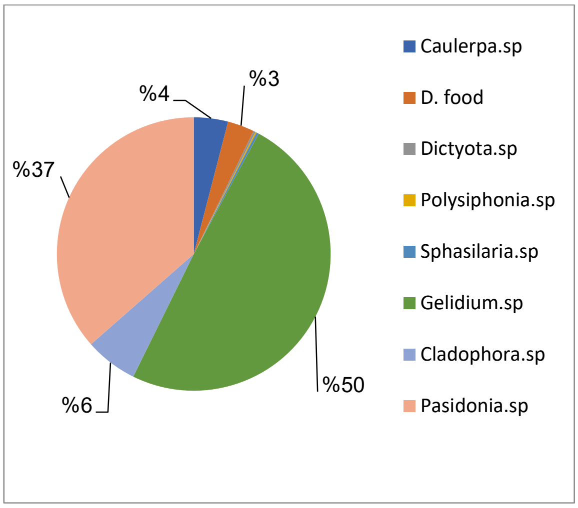

Fig. 5. IRI% of S. salpa fish in the western coast of Libya (autumn).

In winter, the highest percentage of food was *Pasidonia oceanica*, at 38.18%, as the main food, followed by *Gelidium sp*, at a rate of 17.4%, Ulva sp, at a rate of 16.86%, *Cladophora sp*, at a rate of 9.95%, then digested food, at a rate of 7.25%, *Sphasilaria sp*, at a rate of 3.41%, and *Enteromorpha sp*, at a rate of 3.12%. %, *Caulerpa sp*, 2.36%, *Polysiphonia sp*, 1.22%, and *Dictyoptris sp*, 0.13%; Egg sacs were 0.1% (Fig. 6).

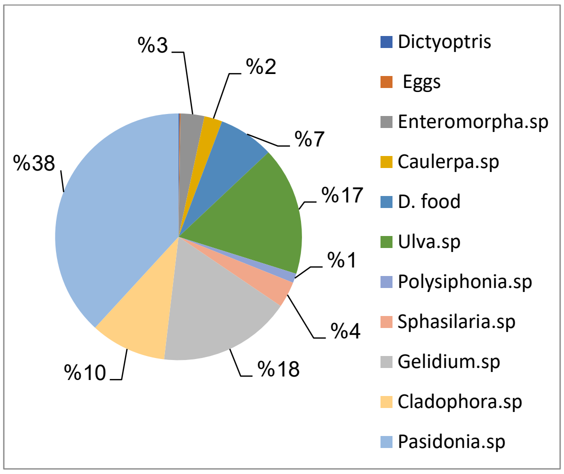

Fig. 6. IRI% of S. salpa fish in the western coast of Libya (winter season).

- ***Siganus luridus***

The main food of *S. luridus* during the spring are *Pasidonia oceanica* and *Caulerpa* sp (39.9% and 19.2%, respectively), the algae *Cladophora* sp was 13.0% and the algae *Gelidium* sp was 8.5%. *Dictyoptris* sp algae had a percentage of 8.2% and *Ulva* sp had a percentage of 4.9%, while digested food had a percentage of 3.5%, and *Sphasilaria* sp algae had a percentage of 1.2%; And egg sacs, 0.8%, *Flibellia* sp, 0.5%, and *Dictyota* sp, 0.2% (Fig. 7).

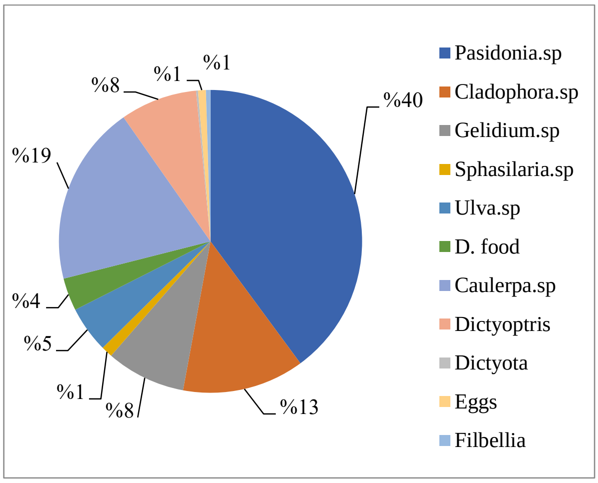

Fig. 7. IRI% of S. luridus fish in the western coast of Libya (spring).

The main food of *S. luridus* during summer season was *Dictyoptris sp* algae at a rate of 17.4%, followed by *Caulerpa sp* algae at a rate of 9.1%, and as for digested food, it was at a rate of 5.2%, *Ulva sp* algae at a rate of 4.4%, *Gelidium sp* algae at a rate of 4.2%, and *Cladophora sp* at a rate of 3.9%. %, Sphasilaria sp. by 1.6%, egg sacs by 1.3%, and *Dictyota sp*. by 0.3% (Fig. 9).

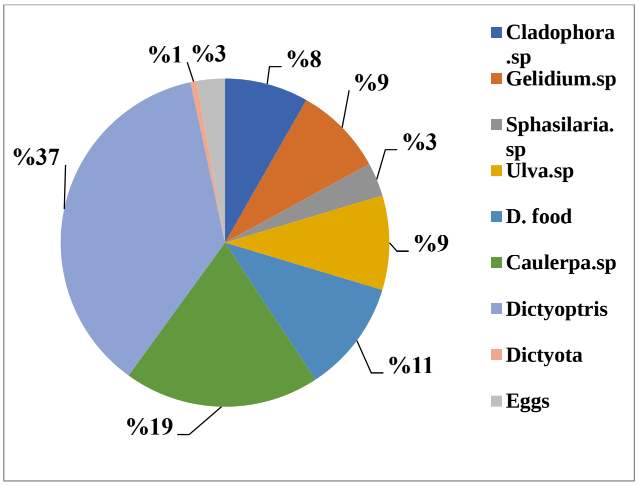

Fig. 8. IRI% of S. *luridus* fish in the western coast of Libya (summer season).

The main food for *S. luridus* in the fall season included *Pasidonia sp* at a rate of 33.8%, followed by *Gelidium sp* and *Caulerpa sp* at a rate of 18.0% and 17.0%, respectively, and *Ulva sp* at a rate of 11.6%, and the digested food was at a rate of 6.3% and *Dictyoptris sp* algae at a rate of 4.6%. % and *Flibellia sp* at 3.6%, which is a similar percentage with *Sphasilaria sp* at 3.5%, *Cladophora sp* moss had a rate of 1.3%, and egg sacs had a rate of 0.2% (Fig. 9).

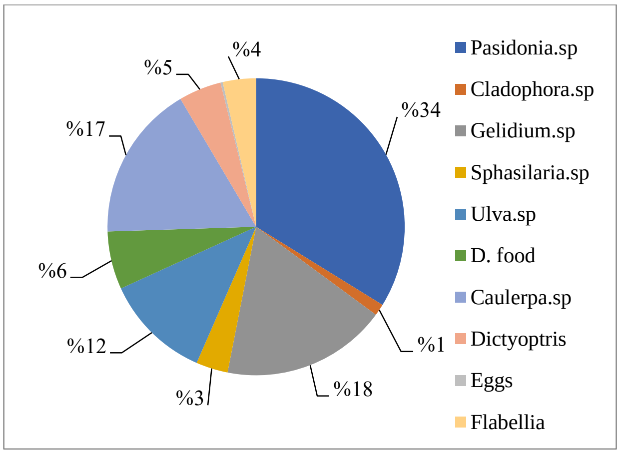

Fig. 9. IRI% of S. *luridus* in the western coast of Libya (autumn).

In winter, the main food of *S. luridus* was the *Pasidonia* sp., at a rate of 41.4%, and *Dictyoptris* sp., at a rate of 14.1%. It was followed by *Gelidium*.sp moss, at a rate of 11%, and the digested food was at the same rate, i.e., 11%. The algae *Dictyota* sp represented 9%, the algae *Caulerpa* sp represented 6%, *Ulva* sp represented 5.3%, and *Sphasilaria* sp represented 1.7%, with similar percentages for *Cladophora* sp 0.4% and Porphra 0.4%. The *Flibellia* sp moss was 0.3%, as in (Fig. 10).

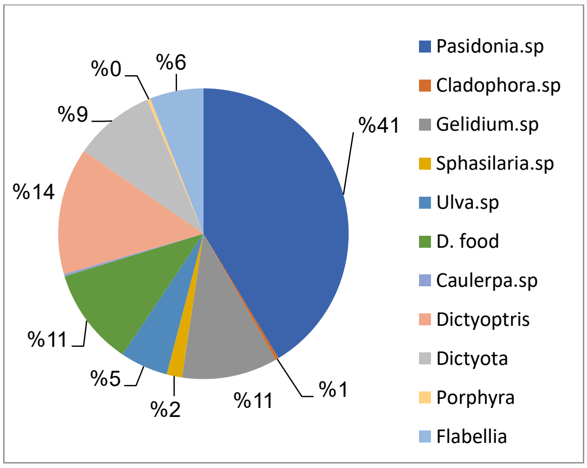

Fig. 10. IRI% of S. *luridus* fish in the western coast of Libya (winter season).

- ***Siganus rivulatus***

The relative importance index (IRI%) showed that the main food for *S. rivulatus* in the spring is *Gelidium sp* algae at a rate of 23.0%, followed by *Pasidonia oceanica* and *Cladophora* sp at a rate of 19.5% and 19.4%, respectively, and at a rate of 16.8%, so the food was on *Ulva. sp* The algae *Caulerpa sp* was 6.4%, *Ectocarpus sp* was 2.7%, *Sphasilaria sp* was 1.8%, *Enteromorpha sp* was 1.5%, *Dictyoptris sp* was 1.0% and *Polysiphonia sp* was 0.4%, and the digested food was 5.6% (Fig. 11).

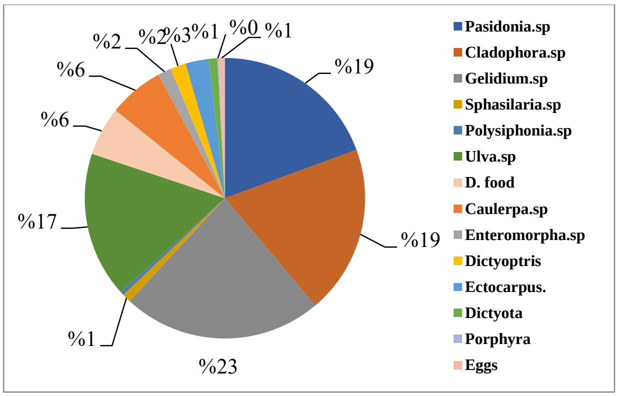

Fig. 11. IRI% of *S. rivulatus* in the western coast of Libya (spring).

The results showed that the main and preferred food for *S. rivulatus* in the fall season was *Gelidium sp.*, at a rate of 46%, followed by *Pasidonia sp*., at a rate of 28%, and *Cladophora sp*., and *Caulerpa sp*., at a rate of 4% and 5%, respectively, and *Enteromorpha sp.*, at a rate of 1%, and *Sphasilaria sp*. as well, at a rate of 1%. Digested food represented by 15% (Fig. 12).

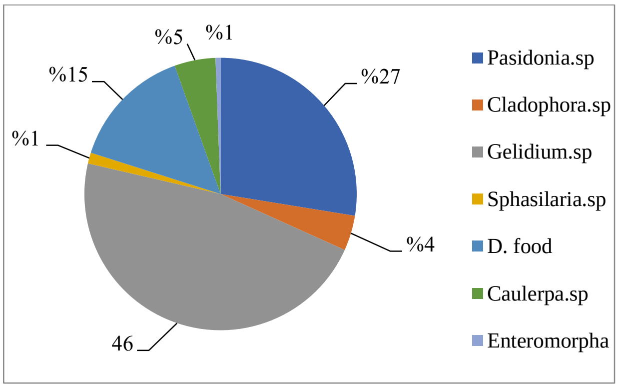

Fig. 12. IRI% of *S. rivulatus* in the western coast of Libya (autumn).

The main food for *S. rivulatus* in the winter, *Gelidium sp* moss accounted for 30%, and *Pasidonia sp* moss made up 28% of the food, followed by *Flibellia.sp* with 17%, *Dictyoptris sp* with 4%, *Cladophora sp* with 3%, and *Sphasilaria* sp with 3%, and the digested food was 15% (Fig. 13).

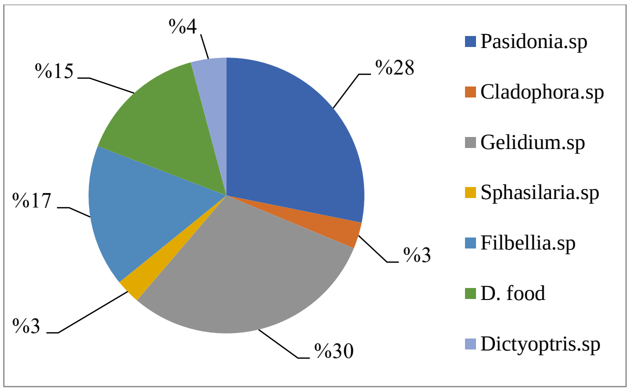

Fig. 13. IRI% of *S. rivulatus* in the western coast of Libya (winter season).

The main food for *S. rivulatus* in the summer is *Gelidium sp.*, with a percentage of about 30.0%, followed by the *Pasidonia oceanica*, with a percentage of 28.2%, *Flibellia sp.*, with a percentage of 16.7%, *Dictyoptris sp.*, with a percentage of 4.2%, and *Cladophora sp.*, with a percentage of 3.1%, and with a percentage of 2.9%, the food was *Sphasilaria sp*. As for the digested food, it was 15.0% (Fig. 14).

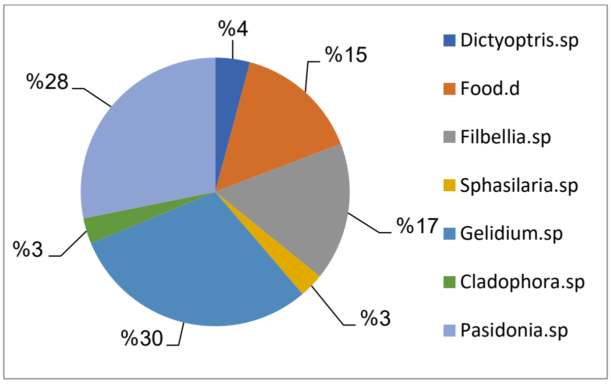

Fig. 14. IRI% of *S. rivulatus* in the western coast of Libya (summer season).

DISCUSSION

Alien fishes are still spreading throughout the Mediterranean Sea, and this spread varies according to the species as well as the time of its entry into the Mediterranean Sea; However, this has led to a change in the biodiversity of fish in the Mediterranean Sea, and this is considered one of the effects caused by this migration. Some of these species have become permanent catches and are of economic importance. There is a difference in the spread of local and invasive fish species along the Libyan coast. There was an increase in fish diversity in the eastern region of the Mediterranean compared to the central region and the western region of the Libyan Mediterranean (Shakman and Kinzelbach, 2007a). The percentage of invasive fish species relative to native fish species decreases from east to west along the Libyan coast, and this may reflect that there is a relationship between the early arrival of invasive species and their increased abundance (Shakman, 2008). The Mediterranean Sea includes only two herbivores: the species (Scaridae) *S. cretense* and (Sparidae) *S. salpa* (Bauchot and Hureau, 1986; Quignard and Pras, 1986). In addition to the presence of two invasive herbivorous fish coming from the Red Sea via the Suez Canal, they are the species *S. luridus* and *S. rivulatus*. The most abundant herbivorous fish during this study was the red sea fish, *S. luridus,* followed by the shellfish, *S. salpa,* and *S. rivulatus*. This may be due to the ability of these invasive species to occupy habitats, their speed of spreading, as well as their ability to compete with native species. These results are consistent with the study conducted in the eastern Mediterranean in coastal Lebanon (Bariche *et al.,* 2004).The same study indicates that endemic species such as *S. salpa* have declined significantly in the last seventy years. This study also indicated that there are some clear examples of the impact of newly settled species on local fauna, which is one of the most abundant species in the rest of the Mediterranean, and this may be due to its competition with *Siganus sp*. (Bariche *et al.*, 2004). In this study, there was a difference in the main food from one season to another. In the spring and fall, algae were the main food and seaweed was the secondary food. The results varied in the summer and winter seasons, as the main food was seaweed, and algae was the secondary food. Seasonal differences lead to variation in food preferences and affect the rate of its diversification; due to the lack of food in the winter, this species was forced to roam in search of food. Therefore, this season was characterized by a diversity of nutrition, and algae and seaweed appeared as part of the nutritional content recorded. Researchers conducted in the same area are agreed with him, including the following: (Steele *et al*., 2014; Harmelin- Vivien *et al*., 1995; Francour, 1997; Guidetti, 2000; Verlaque, 1990; Havelange *et al.,* 1997; Prado *et al*., 2007). In the Adriatic Sea, it was found that seaweed is the main food on which these fish rely on (Skoko *et al*., 2004). The Shalaba fish differed in nutrition and feeding behavior from other species of the Diplodus family, as most of them feed on crustaceans, molluscs, algae, and worms (1997) (Pallaro *et al*., 2006; Sala and Ballesteros, 1997). Nutritional indicators were variable according to the seasons of the year for this species of fish. The nutritional status factor was high during the spring and low during the winter, while the liver condition factor was high during the summer, which is considered a breeding season for this species. These results differ with several studies conducted in the eastern part of Libya. Because this study analyzed the results monthly or as a result of the physiological state of this species (Shakman *et al*., 2009). This study showed that the seaweed Pasidonia oceanica was dominant in the stomach contents, with a very small representation of the brown algae *Dictyota sp*. during the spring. In summer, the brown algae *Dictyoptris sp*. was dominant, followed by the green algae Caulerpa with a small representation of the algae *Dictyota sp*., as was observed. In fall season, seaweeds dominated, followed by the green algae *Caulerpa sp*. and the red algae *Gelidium sp*., with a very small representation of the green algae *Cladophora sp*. In winter, the predominant stomach contents were seaweeds, followed by brown algae *Dictyoptris sp*, with a lesser representation of algae species *Cladophora sp*, *Caulerpa sp*, and *Prophyra sp*. During the study year, it was observed that seaweeds dominated as the main food, followed by brown algae *Dictyoptris sp*. The result obtained can be explained by the fact that the high index of relative importance of seaweeds and brown algae is not an indication of the black potato fish's preference for them, but rather the reason is due to its targeting of a wide range of seaweeds and algae (Lundberg and Golani, 1995). This result was similar to what was found in the Red Sea (Lundberg and Golani, 1995), where *S. luridus* fish is mainly consume brown algae such as Lobophora variegata, and species of *Sargassum spp.* (Lundberg and Lipkin, 1979). In the Gulf of Aqaba, brown algae were the preferred (major) food (Lundberg and Lipkin, 1979; Lundberg and Golani, 1995), but they also consume a wide range of algae and seaweeds. This study was similar to what was found on the eastern coast of Libya (Shakman *et al*., 2009), where brown algae was mainly consumed, and it was the source of food in the fall, but it was observed that its consumption shifted to red algae in the winter. This same transformation from brown algae to red algae and green algae has been observed in Greek waters in the fall and winter seasons and is due to the frequent consumption of brown algae (Stergiou, 1988). This may be due to the specialized digestive tract to digest coarse brown algae and the increased ability to Benefit from it (Lundberg and Golani, 1995). The change in nutritional indicators is not significant during the seasons of the year, because these species do not rely on food even during the breeding season (Shakman, 2008). These results are also similar to a study conducted in the eastern part of Libya (Shakman *et al*., 2009). This species prefers an environment rich in meadows of Pasidonia, so parts of it are present in the gastric content, and they form part of the volume of the main food. The food in the gastric content reflects the presence of seaweeds in the first place, the most important of which is *Pasidonia oceanica*, followed by the red algae *Gelidium sp*. As for the presence of egg sacs It refers to occasional feeding, which was also present in the stomach content of Red Sea fish (Lundberg and Lipkin, 1979, Lundberg and Golani, 1995), and molluscs and polychaete worms were among the stomach content in the southern Mediterranean fish of the eastern Libyan coast (Shakman *et al*., 2009). It can be confirmed from the results of this study that algae of the species *Cladophora sp*., *Gelidium sp*., and the seaweed *Pasidonia oceanica* were found to be dominant in stomach contents in the spring season, as this season is characterized by the highest nutritional diversity of marine algae. The explanation for this is due to the suitability of the environmental conditions that enjoy the abundance and diversity of food in this season. In the fall, red algae *Gelidium sp.* and seaweeds dominated, with a very small presence of algae of the species *Enteromorpha.sp*, *Sphasilaria sp.*, *Caulerpa sp.* In the summer, red algae *Gelidium sp*. and seaweeds were dominant, with a very small representation of algae species *Dictyoptris sp.*, *Sphasilaria sp.*, and *Cladophora sp*. As for the winter season, the red algae *Gelidium sp.* and sedgeweeds were dominant, with less representation of the algae species *Cladophora sp.*, *Sphasilaria sp.*, and *Dictyoptris sp*. This result was similar to what was found in the southern Mediterranean (Shakman *et al*., 2009). It was noted that seaweed consumption is important in all seasons and did not change significantly over the year. In this study, red algae contributed to more than half of the fish's diet. *S. rivulatus* This matches exactly with a study in the Red Sea Lundberg and Lipkin, 1979). In the Eastern Mediterranean, green algae contributed more than 60% of the diet during the spring, and brown algae contributed 89% during the fall (Lundberg *et al*., 2004). In the study of Shakman *et al* (2009) in Libyan waters, the consumption of green algae was more evident in the spring and summer, and brown algae in the fall, and the source of food consumed in the winter was red algae. Although the available data on the Red Sea are not extensive and still few information on seasonal study, they indicate that fish feed on a wide range of green algae and red algae species.

In general, the nutritional diversity of white sigands individuals was highest during spring, and lowest during other seasons, with similar nutritional content consumed in summer and winter as it consisted of *Gelidum sp.* and seaweed. This gives the impression that white potato fish have a high feeding activity throughout the year, and the results of this study are consistent with studies conducted in Libyan waters, and it was found that this species of fish has a high feeding density even during the breeding and egg-laying season (Shakman *et al*., 2009). It is also consistent with a study conducted in the eastern Mediterranean in Syrian waters, where it was observed that it feeds all the time without interruption, even during reproduction (Sabour and Lakkis, 2007). Another study showed a decrease in feeding activity during the breeding and egg-laying season (Khumar and Siddiui, 1989), which is a trend not observed in this study. It can be said that these fish offer different mechanisms to avoid competition when food resources are scarce (Hutchinson, 1965). The exposure of herbivorous species to competition is less in the Mediterranean region compared to the Red Sea region (Bariche *et al.*, 2004, Shakman and Kinzelbach, 2007a), and therefore the radical changes to the diet are not significant as long as the food resources are similar in their original habitat in terms of distribution and abundance, and these species are similar in some types of food available in this part of the Mediterranean Table 3.

Table 3. Similarity in food items of herbivorous fishes in the western coast of Libya (Φ = Present)

Food items	*Sarpa salpa*	*Siganus luridus*	*Siganus rivulats*
Ulva spp	Φ	Φ	Φ
Cladophora sp	Φ	Φ	Φ
Gelidium sp	Φ	Φ	Φ
Enteromorpha	Φ	X	Φ
Ectocarpus sp	Φ	X	Φ
Sphacelaria spp	Φ	Φ	Φ
Posidonia oceanica	Φ	Φ	Φ
Caulerpa racemose	Φ	Φ	Φ
Polysiphonia spp	Φ	X	Φ
Bangia sp	Φ	X	X
Eggs	Φ	Φ	Φ
Dictyota spp	Φ	Φ	Φ
Dictyoptris spp	Φ	Φ	Φ
Flibellia sp	X	Φ	Φ
Porphyra sp	X	Φ	Φ

Conclusion

It is concluded that both alien fishes are able to utilize a wide range of food sources, and can switch between food groups, according to preference and abundance in the seasons. Seaweeds were an important food source in most seasons, in addition to a wide range of algae that played an important role in the diet. The differences between invasive species in their food tastes in the new environment have not changed much, and it appears that changes in the nutritional index between seasons are not significant.

REFERNCES

Azzurro E., Carnevali O., Bariche M., Andaloro F. (2007). Reproductive features of the non-native Siganus luridus (Teleostei, Siganidae) during early colonization at Linosa Island (Sicily Strait, Mediterranean Sea). Journal of Applied Ichthyology 23: 640–645.

Bariche M., Vivien M. H., Quignard J. P. (2003) Reproductive cycles and spawning periods of two Lessepsian Siganid fishes on the Lebanese coast. Journal of Fish Biology 62: 129-142.

Bariche M,. Letourneur Y., Vivien M. H (2004). Temporal fluctuations and settlement patterns of native and Lessepsian herbivorous fishes on the Lebanese coast (eastern Mediterranean). Environmental Biology of Fishes 70: 81- 90

Bariche M. (2012). Field identification guide to the living marine resources of the Eastern and Southern Mediterranean. FAO Species Identification Guide for Fishery Purposes. Rome, FAO, 610.

Bauchot M L., Hureau J. C. (1986) Sparidae. In fishes of the north-eastern Atlantic and the Mediterranean (ed. P. J. P. Whitehead et al.), pp. 883-907. Paris: UNESCO.

Bauchot M L. and Hureau, J.C. (1990) Sparidae. In: Quero, J.C., Hureau, J.C., Karrer, C., Post, A. & Saldanha, L. (Eds.), Check-list of the Fishes of the Eastern Tropical Atlantic, Clofeta II, UNESCO, Paris, 790–812.

Cachia C., Mifsud C. and Sammut P.M. (1991). The Marine Shalled Mollusca of the Maltese Islands (Part I Arhaeoga strpoda) Grima Printing,Malta.108.

Cachia C., Mifsud C. and Sammut, P.M. (1996). The Marine Mollusca of the Maltese Islands (Part II Neotaenioglossa) Backhuys, Publishers ,Leiden. 288.

Coll M, Piroddi C, Kaschner K, Ben Rais Lasram F, Steenbeek J, Aguzzi J, Ballesteros E, Nike Bianchi C, Corbera J, Dailianis T, Danovaro R, Estrada M, Froglia C, Galil BS, Gasol JM, Gertwagen R, Gil J, Guilhaumon F, Kesner-Reyes K, Kitsos M -S, Koukouras A, Lampadariou N, Laxamana E, López-Fé de la Cuadra CM, Lotze HK, Martin D, Mouillot D, Oro D, Raicevich S, Rius-Barile J, Saiz-Salinas JI, San Vicente C, Somot S, Templado J, Turon X, Vafidis D, Villanueva R and Voultsiadou E (2010) The biodiversity of the Mediterranean Sea: estimates, patterns and threats. PLoS ONE 5(8): doi:10.1371.

Criscoli A., Colloca F., Carpentieri P., Belluscio A. and Ardizzone G.(2006). Observations on the reproductive cycly, age and growth of salema , *Sarpa salpa* (Sparidae) along the western central coast of Italy. CSI.MAR., 70 (1) : 131- 138.

De Hass W .and Knorr F.(1979).The young specialist looks at marine life.1stedn..Burke Publishing Company Limited.LONDON.356.

with an adjacent small artificial reef. J. Exp. Mar. Biol. Ecol. (97): 269-285.

Francour P. (1997). Fish assemblages of Posidonia oceanica beds at Port Cros (France, NW Mediterranean) - assessment of composition and long-term fluctuations by visual census. P.S.Z.N.I.: Mar. Ecol., (18): 157-173.

Galil B., (2007). Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. Marine Pollution Bulletin (55), 314–322.

George C. J. (1972) Notes on the breeding and movements of the Rabbitfish, *Siganus rivulatus* (Forsskål 1775) and *S. luridus* Rüppell, in the coastal waters of Lebanon. Annali Del Museo Civico Di Storia Naturale de Genova (9): 32-44.

Golani D. (2002). Lessepsian fish migration - Characterization and impact on the Eastern Mediterranean. In: Bayram Öztürk and Nuri Basusta (eds). Workshop on Lessepsian migration, 20-21 July 2002 Gökceada- Turkey 1-9.

Golani D. (2010). Colonization of the Mediterranean by Red Sea fishes via the Suez Canal—Lessepsian migration. In: Golani D, Appelbaum-Golani B (eds) Fish invasions of the mediterranean sea: Change and reneval. Pensoft Publishers, Sofia, 145–188.

Golani D ; Fricks R; and Appelbaum B.(2015). First record of the Indian anchovy Stolephorus indicus (van Hasselt, 1823) (Clupeiformes: Engraulidae) in the Mediterranean Sea . BioInvasions Records (2015), Issue 4: 293–297.

Guidetti P. (2000). Differences among fish assemblages associated with nearshore Posidonia oceanica seagrass beds, rocky-algal reefs and unvegetated sand habitats in the Adriatic Sea. Estuar. Coast Shelf. Sci., 50: 515-529.

Hamza A K, Mohamed N I, El-Serafy, (2000). Food and feeding habits of Siganus rivulatus and Siganus luridus from the coastal Mediterranean water of Alexandria. Polish archives of hydrobiology, 47: 205-212.

Harmelin-Vivien M L., Harmelin J G. and Leboulleux V. (1995). Microhabitat requirements for settlement of juvenile sparid fishes on Mediterranean rocky shores. Hydrobiologia, 301: 309-320.

Havelange S., Lepoint G. Dauby P. and Bouquegneau J M. (1997). Feeding of the sparid fish *Sarpa salpa* in a seagrass ecosystem – diet and carbon flux. *P.S.Z.N.I.: Mar. Ecol*., 18: 289-297.

Hussein K. A. (1986) Timing of spawning and fecundity of Mediterranean *Siganus rivulatus* (Forsk.) Bulletin of the Institute of Oceanography and Fisheries (ARE) 12: 175-186.

Hutchinson G.E. (1965). The ecological theatre and evolutionary play. Yale University Press, New Haven, Connecticut, USA.

Hyslop E J.(1980).Stomach contents analysis –areview of methods and their application. Fish .Biol .17:411 – 429.

Khumar F, Siddiqui M S, (1989). Food and feeding habitis of the carp Labeo calbasu (Hamilton, 1822) in north Indian waters. Acta ichthyologica et piscatoria, 19: 33-48.

La Mesa M., La Mesa G. and Micalizzi M.(2005).Age and growth of madeira scorpion fish,(Scorpaena maderensis Valenciennes,1833).in the central Mediterranean.Fis.Res. 74:265-272.

Lundberg B, (1980). Selectivity of food algae by herbivorous fish *Siganus rivulatus* in the marine vegetation at Mikhmoret (the Mediterranean coast of Israel). Ph.D. Thesis, University of Jerusalem.

Lundberg B, Lipkin Y, (1979). Natural food of the herbivorous rabbitfish (Siganus spp.) in Northern Red Sea. Botanica marina, 22: 173-181.

Lundberg B, Golani D, (1993). Algal diet of Siganus luridus, a Lessepsian migrant, as adapted to algal resources at the Mediterranean coast of Israel. A preliminary study. Israel journal of zoology, 39: 69.

Lundberg B, Golani D, (1995). Diet adaptation of Lessepsian migrant rabbitfishes, Siganus luridus and S. rivulatus, to the algal resources of the Mediterranean coast of Israel. Marine ecology P.S.Z.N.I., 16: 73-89.

Lundberg B, Ogorek R, Galil BS, Goren M, (2004). Dietary choices of Siganid fish at Shiqmona reef. *Israel journal of zoology*, 50: 39-53.

Por F.D. (1978) Lessepsian migration. The influx of Red sea Biota into the Mediterranean by way of The suez canal. Berlin: springer verlag 228.

Prado P., Tomas, F., Alcoverro, T. & Romero, J. (2007). Extensive direct measurements of Posi-donia oceanica defoliation con□rm the importance of herbivory in temperate seagrass meadows. Marine Ecology Progress Series 340, 63– 71.

Quignard J. P., Pras A. (1986) Scaridae. In: fishes of the northern-eastern Atlantic and the Mediterranean, (ed. P. J. P. Whitehead *et al*.). 943-944. UNESCO, Paris.

Saad A.,and Sabour W. (2001). Données préliminaires sur la reproduction de *Siganus rivulatus* (Forsskål, 1777, Pisés, Siganidae), dans les eaux côtières de Syrie. Rapport, du 36 Congres de la Commission Internationale Pour l'exploration Scientifique de la Mer Méditerranée 36 : 319.

Sabour W And Lakkis S. (2007). diet and feeding habits of *siganus rivulatus* and *S. luridus* two red sea migrats in the syrian coastalwates (eastern mediterranean).

Sala E. and Ballesteros, E.(1997).Portioning of space and food recourses by three fish of Genus Diplodus in Mediterranean Rocky infernalittotial ecosystem. Marine ecology, 152,(1-3).237-238.

Sala E, Kizilkaya Z, Yildirim D, Ballesteros E .(2011). Alien marine fishes deplete algal biomass in the eastern Mediterranean. PLoS ONE 6(2): e17356, http://dx.doi.org/ 10.1371/journal.pone.0017356.

Shakman E. A., Kinzelbach R. (2007a) Commercial fishery and fish species composition in coastal waters of Libya. Rostocker Meereskundliche Beiträge 18: 65-80.

Shakman E. A., Kinzelbach R. (2007b) First record of the Sweeper fish *Pempheris vanicolensis* Cuvier, 1821 in the eastern part of the Libyan coast. Rostocker Meereskundliche Beiträge 18: 65-80.

Shakman E .(2008). Lessepsian migrat fish species of the coastal water of Libya : status , Biology , Ecology PhD thesis.

Shakman E. Boedeker C. Bariche M . and Kinzelbach R .(2009). Food and feeding habits of the Lessepsian migrants *Siganus luridus* Rüppell, 1828 and *Siganus rivulatus* Forsska°l, 1775 (Teleostei: Siganidae) in the southern Mediterranean (Libyan coast).journal of Biological Research-Thessaloniki 12: 115 – 124.

Skoko S M., Kraljevic M., Dulcic J., and Pallaoro A.(2004), Growth of juvenile *salema, sarpa salpa(Sparidae*), in the Kornatic Archipelago, eastern Adriatic sea. SCI. MAR., 68 (3): 411-417.

Steele L , Darnell K M., Cebrián J. and Sanchez–Lizaso J L. (2014). *Sarpa salpa* herbivory on shallow reaches of *Posidonia oceanica* beds . Animal Biodiversity and Conservation 37.1 .

Stergiou K. I. (1988) Feeding habits of the Lessepsian migrant *Siganus luridus* in the eastern Mediterranean, its new environment. Journal of Fish Biology 33 (4): 531-543.

Stirn J. (1970) Some note on western trends of Lessepsian migration. Journées Ichthyologiques, Rome, 30 nov- 1dec. 187-190, CIESM, Monaco.

Verlaque M. (1990). Relationships between *Sarpa salpa* (L.) (Teleostei, Sparidae), other browser fishes, and the Mediterranean algal phytobenthos.

Woodland D J. (1983) Zoogeography of the Siganidae (Pisces): an interpretation of distribution and richness patterns. Bulletin of Marine Science 33: 713-717.

Yeldan H., Avsar D. (2000) A Preliminary study on the Reproduction of the Rabbitfish (*Siganus rivulatus* (Forsskål, 1775)) in the northeastern Mediterranean. Turkish Journal of Zoology 24: 173 -182.

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, García Raso JE, Çinar ME, Almogi Labin A, Ates AS, Azzuro E, Ballesteros E, Bianchi CN, Bilecenoglu M, Gambi MC, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle V, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci- Papadopoulou MA, Ramos Esplá A, Salas C, San Martín G, Sfriso A, Streftaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union’s Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterranean Marine Science (13): 328–352.