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State of Blue Crab *Callinectes Sapidus* in the Lagoon of Orikum in Albania

Ermira Milori*, Stela Ruci, Eliana Ibrahimi and Sajmir Beqiraj

Department of Biology, Faculty of Natural Sciences, University of Tirana, Bulevardi Zogu i Pare, 25/1, 1001 Tirana, Albania

ABSTRACT

Callinectes sapidus Rathbun, 1896, or as it is otherwise called blue crab, is an invasive species, which was reported for the first time to the Mediterranean Sea in 1949. It has been spread and adapted well to almost the entire Mediterranean and during the recent years even along the coast of the Adriatic Sea. Today it is considered as one of the worst invasive marine species in this region, with an impact on both biodiversity and socio-economic aspects.

After a preliminary study on the distribution of blue crab in the Albanian coast, the aim of this study is to provide data on the presence and abundance of this species and to evaluate the population structure by measuring biometric parameters in the lagoon of Orikum. Blue crab observations and collections are conducted almost every month during the period 2012, 2014 and 2015 in the Orikum lagoon. Based on standard method of biometric parameters, measurements of weight, height and width of individuals collected during the study period in the Orikum lagoon were performed. During the study period questionnaires were distributed to local fishermen to collect information on the presence of the blue crab, asses its condition and its possible impact on other populations in the Orikum lagoon.

***Corresponding author**

Ermira Milori, Department of Biology, Faculty of Natural Sciences, University of Tirana, Bulevardi Zogu i Pare, 25/1, 1001 Tirana, Albania.
E-mail: ermiramilori@gmail.com

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Introducton

The blue crab *Callinectes sapidus* Rathbun 1896, has been reported as a highly aggressive species and is included among the 100 'worst' invasive species in the Mediterranean, with an impact on biodiversity and socio-economics aspects [1]. The invasive marine species are considered one of the principal causes of biodiversity changes in the Mediterranean by potentially modifying the marine ecosystems. This is a serious problem referring the increase of introduction, as well as the impact they have on the environment, economy, and human health [2]. Introduction of the invasive species is a general phenomenon and extends to all Mediterranean areas [2]. Therefore, invasive species are considered "important species" and should be monitored in all the areas [3].

The first reporting of this species in Albanian coast, is in Patoku lagoon in 2009 [4]. This paper is focused on the presence, abondance and characteristics of blue crab populations in the Orikumi lagoon. Based on personal communications with the local fishermen of Orikumi lagoon, the blue crab appeared in the Orikum area for the first time in 2003. The presence of the blue crab *Callinectes sapidus* has been largely recorded in the Lagoon of Orikum, especially during the period June and July.

Material and Methods

The Orikum lagoon is situated in the south-western area of the district of Vlora, with central geographical coordinates 40° 19' N latitude; 19° 25' E longitude. The lagoon originated from a coastal depression, it is located mainly on the alluvial deposits of the Dukati River and is separated by the sea by a littoral ridge. It has an area of 1,500 ha. Its maximum depth goes up to 3.5 m while the average depth is 2.5 m [5]. The lagoon is connected to the sea through two canals, one of them is artificially opened. This canal is in the eastern part of the lagoon, almost adjacent to the Pashaliman Military Base checkpoint. The canal is short (Dajlan canal) and has a very low water flow. The chemical composition of lagoon waters varies according to the amount of water in the lagoon and according to the different seasons and different periods of tidal waves in the sea. Also, due to the flowing of fresh water to the lagoon from the waters of the Dukat area, the salinity of the water in different parts presents great variations, ranging from 15% to 27 % psu [6].

Figure 1: Map of Orikum Lagoon

Figure 2: Map of Albania, showing the position of Orikum Lagoon

Experimental method

Blue crabs were collected as by-catch from gillnets and fyke nets of local fishermen. In central part of the lagoon, the collection was done from gillnets of 24 mm mesh size and a linear length of 300 m, while in the other parts of the lagoon, in front of the communication channel with the sea, the collection was done from fyke nets of 8 mm mesh size and a linear length of 10-15 m. Also, a small number of individuals were collected directly on the ``dajlan`` (a compact reed fence, that is used to close the communication of the lagoon with the sea).

The classification of the blue crab based on the carapace width (CW)

It has been evaluated the report between males and females (sex ratio) (M: F) and biometric measurements have been carried out. Carapace width (CW) and height have been measured, to evaluate crabs' age after Hines et. al and their maturity after Cadman and Weinstein [7,8].

Based on the classification system of Harding, the blue crabs individuals were classified by their maturity, as juveniles, carapace width (CW < 120 mm) and adults with carapace width (CW > 120 mm) [9].

The individuals were classified by size based on carapace width (CW), in small individuals (CW <80mm), medium individuals (CW 80-120 mm), and large individuals (CW> 120m) according to Cadman & Weinstein [8].

Blue crab individuals were classified by age, based on carapace width in up to 1 year, capace width (CW <100 mm), individuals between 1 and 2 years old, carapace width(CW 100-170 mm), and individuals over 2 years, carapace width (CW> 170 mm), according to Hines et al., 1990.

All collected crabs were weighed and Spearman correlation was also evaluated to see the correlation between weight, width, and height. In addition to direct observation and sampling, questionnaires were also distributed to fishermen in the area to gather information on the presence of the blue crab, its potential impact on other populations and the overall socio-economic impact on the fisheries community in the Orikum area.

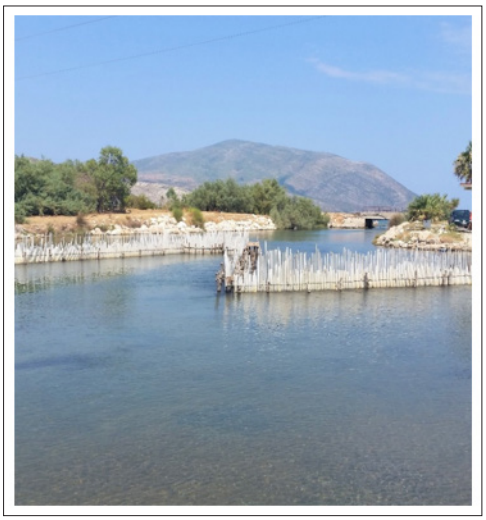


Figure 3: View from western part of Orikum Lagoon

Figure 4: Weighting crabs for parametric correlation analyses

Statistical analyses

Data preprocessing and analysis were performed in IBM SPSS Statistics version 26.0 (IBM Corp. Released, 2019). The data is given as mean ± standard deviation unless otherwise stated. The exploration of the data is done through frequency tables and descriptive statistics. The outliers in the data are assessed by inspection of boxplots. The data for all continuous variables for each level of the factors were checked for normal distribution by Shapiro-Wilk's test ($p>0.05$). The Spearman correlation is used to see if there was a correlation between parameters not normally distributed. The results are considered significant for $p<0.05$.

Results and Discussion

The abundance of the blue crab during the periods of sampling in lagoon of Orikum was quite high compared with the other publication on the presence of this species in the Adriatic Sea like in Beqiraj & Kashta, Beqiraj et al., Florio et al., Kirincic & Stevcic, Onofri et al., [4,10-13]. The highest presence of the individuals of blue crab in the lagoon of Orikum was recorded in the central part of the lagoon and the lowest presence of individuals was recorded in front of the channel of communication of the lagoon with the sea. Juvenil individuals have been reported in June, July, and August and the ovigerous females in June, July – September. Some of the reasons for the stability and high presence of blue crab in the lagoon of Orikum can be related to the richness of benthic invertebrates that are food for the crab, as well as the density of underwater meadows with macro vegetation (Zostera noltii, Rupia cirrhosa) suitable habitat for sheltering.

Table 1: Number of males and females of the blue crab collected in Orikum Lagoon

2012	**Sex**	**Total**
	Female	32
	Male	36
	Total	**68**
2014	Female	16
	Male	5
	Total	**21**
2015	Female	38
	Male	43
	Total	**81**

According to the table 1, the report between males and females (sex ratio) F:M is almost 1:1 because 86 individuals out of the total of 170 individuals collected in the lagoon of Orikum were females and 84 individuals were males.

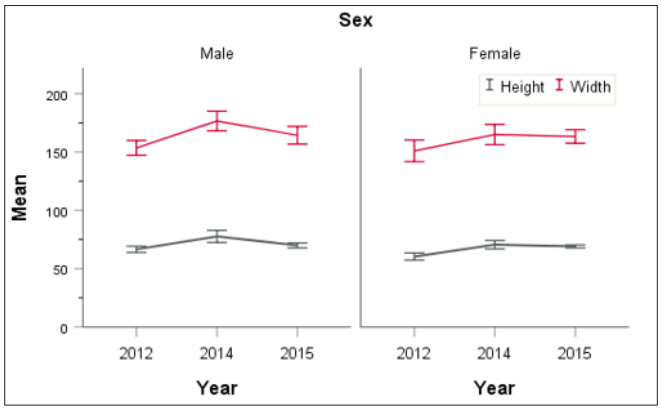
(a) (b)

Figure 5: Juveniles blue crab *Callinectes sapidus* from Orikum Lagoon: a) male ventral view; b) female ventral view

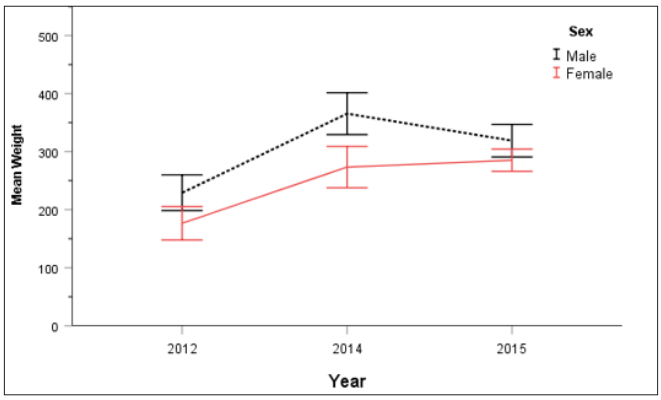
The statistical data preprocessing and analysis shown a low standard deviation to the two biometric parameters width and height for the male and female individuals and a high standard deviation to weight for males and females of the blue crab recorded from the Orikum lagoon, as we can see to the table 2 here below. Such a high standard deviation of weight is not expected, if we refer to a similar analysis, as published in Florio et al., for the lagoons of Lesina and Varano, in the southwestern Adriatic [11]. The high value of the standard weight deviation in the Orikumi lagoon may be related to the fact that many of the individuals analyzed had accidentally broken (from stagnation in fishing nets) one of the moving appendices. The weight of male blue crabs is higher compared to the weight of females.

Table 2: Descriptive statistics by year and sex

Year	Sex		N	Minimum	Maximum	Mean	Std. Deviation
2012	Male	Height	36	53	89	66.58	7.944
		Width	36	115	182	153.56	18.666
		Weight	36	83	398	229.11	91.163
	Female	Height	32	41	76	60.38	8.412
		Width	32	90	193	151.00	25.610
		Weight	32	40	365	176.50	80.061
2014	Male	Height	5	71	82	77.60	4.159
		Width	5	169	184	176.60	6.804
		Weight	5	325	403	365.40	28.988
	Female	Height	16	52	79	70.56	6.762
		Width	16	116	182	165.06	16.316
		Weight	16	121	380	273.31	66.958
2015	Male	Height	43	52	82	69.93	6.926
		Width	43	76	183	164.40	24.760
		Weight	43	104	433	318.84	91.278
	Female	Height	38	61	80	69.08	3.851
		Width	38	82	179	163.32	17.555
		Weight	38	122	372	285.08	57.981

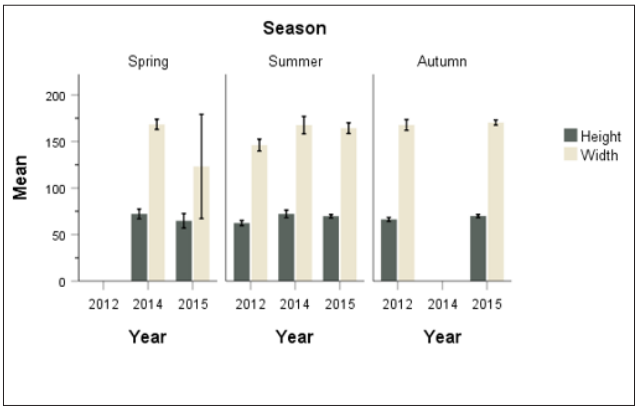


(a)



(b)

Figure 6: Mean of biometric parameters (a) and (b) for males and females across years



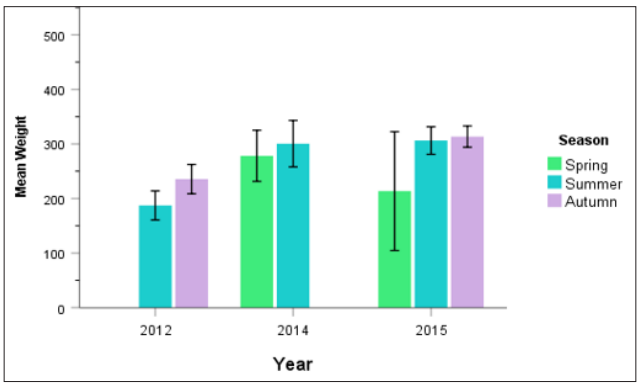


Figure 7: Mean of biometric parameters by seasons across years

The data for height, width and weight for all subgroups were not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$). A Kruskall Wallis test was run to determine if there were differences in height, width, and weight between four years of study. Based on the visual inspection, it was estimated that the data distribution was similar in all years of the study.

For males

Medians of height for all years were statistically different, X2 (2) = 10.88, p=0.004. Multiple comparisons showed significant differences among years 2012 and 2015 only (p<0.05), figure 6(a) and figure 8. Median of width for all years were statistically different, X2 (2) = 16.045, p <0.0001. Multiple comparisons showed not significant differences only between years 2014 and 2015 (p>0.05), all the other pairs were statistically different, figure 6(a) and figure 8.

Median of weight for all years were statistically different, X2 (2) = 18.62, p <0.0001. Multiple comparisons showed not significant differences only between years 2014 - 2015 (p>0.05), all the other pairs were statistically different (p<0.05), figure 6(b).

For females

Median of height for all years were statistically different, X2 (2) = 30.51, p <0.0001. Multiple comparisons showed significant differences for all pairs, except for 2014-2015, figure 6(a). Median of width for all years were statistically different, X2 (2) = 8.63, p=0.013. Multiple comparisons showed no significant differences between year 2014 and 2015 (p>0.05), all the other pairs were statistically different, figure 6(a).

Median of weight for all years were statistically different, X2 (2) = 30.93, p <0.0001. Multiple comparisons showed significant differences between all pairs except for years 2014-2015 (p>0.05), figure 6(b). The comperative data for height, width and weight by seasons across the years, showed not significant differences except the spring of 2012 and the autumn of 2014, figure 7.

Table 3: Correlations matrix between parameters

Year				Height	Width	Weight
2012	Spearman's rho	Height	Correlation Coefficient		.862**	.908**
			Sig. (2-tailed)		.000	.000
			N	68	68	68
		Width	Correlation Coefficient	.862**		.824**
			Sig. (2-tailed)	.000		.000
			N	68	68	68
		Weight	Correlation Coefficient	.908**	.824**	
			Sig. (2-tailed)	.000	.000	
			N	68	68	68
2014	Spearman's rho	Height	Correlation Coefficient		.516*	.593**
			Sig. (2-tailed)		.017	.005
			N	21	21	21
		Width	Correlation Coefficient	.516*		.743**
			Sig. (2-tailed)	.017		.000
			N	21	21	21
		Weight	Correlation Coefficient	.593**	.743**	
			Sig. (2-tailed)	.005	.000	
			N	21	21	21
2015	Spearman's rho	Height	Correlation Coefficient		.701**	.707**
			Sig. (2-tailed)		.000	.000
			N	81	81	81
		Width	Correlation Coefficient	.701**		.823**
			Sig. (2-tailed)	.000		.000
			N	81	81	81
		Weight	Correlation Coefficient	.707**	.823**	
			Sig. (2-tailed)	.000	.000	
			N	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

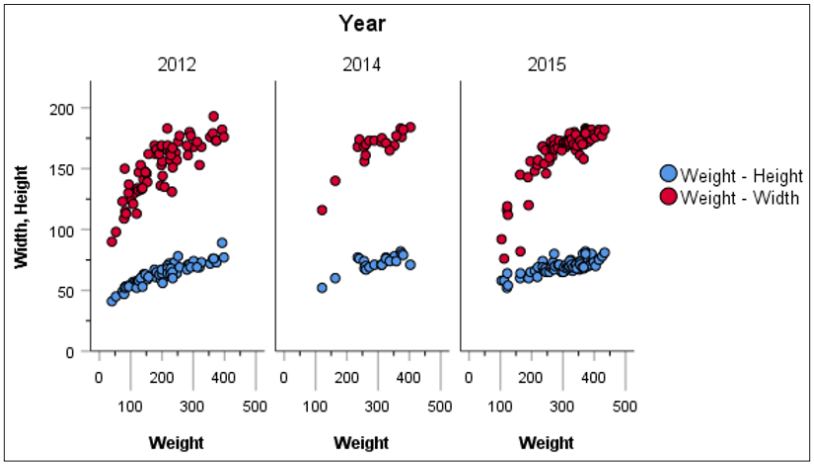


Figure 8: Correlation between parameters for each year

As it is shown to the Table 3 and Figure 8, here above the evaluation of Spearman correlation shows a moderate correlation in the 2014 and a strong correlation ($p<0.05$) between weight, width and height for the blue crab individuals collected in the other years of this study.

Most of the individuals found in Orikumi Lagoon could be considered as matured, according to the classification system of Cadman and Weinstein, which reports that maturity is reached at carapace width (CW) of 120-170mm [8]. Based on the classification system of Harding, the blue crabs individuals were classified as juveniles, carapace width (CW < 120 mm) and adults with carapace width (CW > 120 mm) [9].

Table 4: Classification of individuals into juveniles and adults according to the Harding system [9].

2012	**Sex**	**Juveniles** (CW<120 mm)	**Adults** (CW>120 mm)	**Total**
	Female	5	27	32
	Male	1	35	36
	Total	**6**	**62**	**68**
2014	Female	1	15	16
	Male	0	5	5
	Total	**1**	**20**	**21**
2015	Female	1	37	38
	Male	4	39	43
	Total	**5**	**76**	**81**

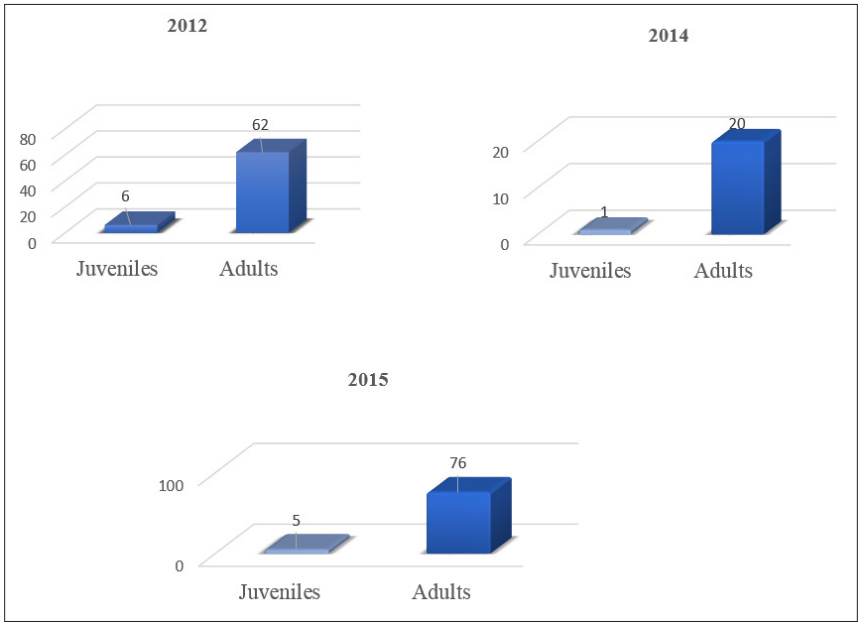


Figure 9: Ratio between juvenile and adult individuals of the blue crab in Orikum Lagoon collected in 2012, 2014, 2015.

From the analyzed data as it is shown in the figure 9 and the table 4, we can evaluate a different ratio of juveniles and adults over the three years of study. The highest number of juvenile individuals has been reported in the 2012 and the highest number of mature individuals has been reported in the 2015. 158 individuals out of the total of 170 individuals belonged to ``matured`` category.

The individuals were classified based on carapace width (CW), in small individuals (CW <80mm), medium individuals (CW 80-120 mm), and large individuals (CW> 120m) according to Cadman & Weinstein [8].

Table 5: Classification of individuals by size [8].

2012	**Sex**	**Small individuals** (CW<80m)	**Average individuals** (CW 80-120mm)	**Large individuals** (CW>120mm)	**Total**
	Female	0	5	27	32
	Male	0	1	35	36
	Total	**0**	**6**	**62**	**68**
2014	Female	0	1	15	16
	Male	0	0	5	5
	Total	**0**	**1**	**20**	**21**
2015	Female	0	1	37	38
	Male	1	3	39	43
	Total	**1**	**4**	**76**	**81**

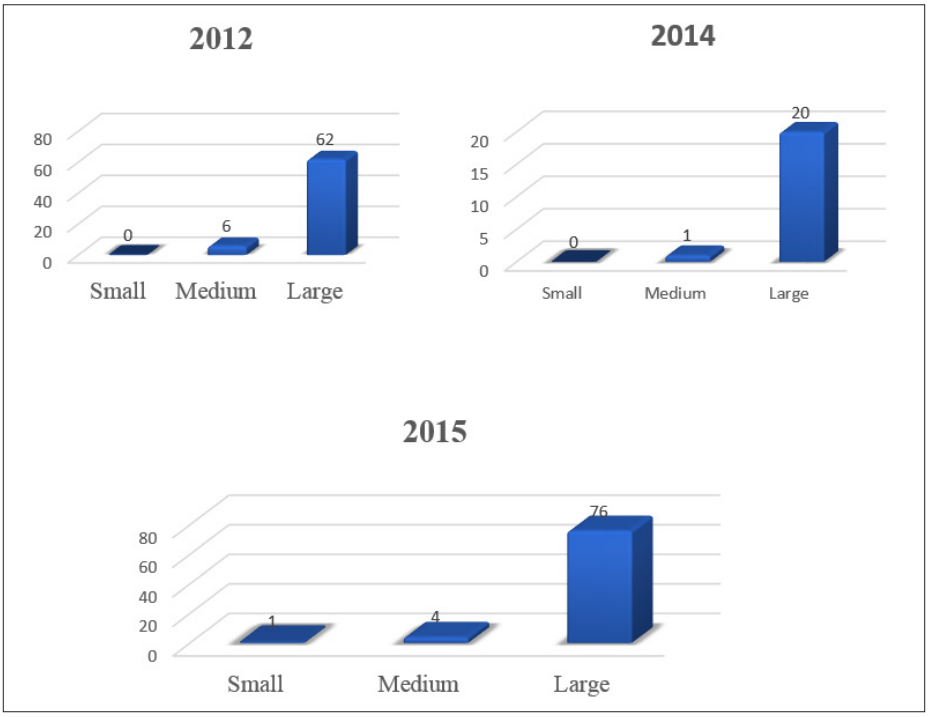


Figure 10: The ratio of individuals according to the size, small, medium and large for each year, 2012, 2014, 2015.

According to the table 5 and the figure 10 the large individuals of the blue crab predominated significantly over three years of study in the Orikum lagoon. The high number of large individuals is another indicator for the stability of the blue crab in the lagoon of Orikum. Blue crab individuals were classified based on carapace width in up to 1 year (CW <100 mm), individuals between 1 and 2 years old (CW 100-170 mm), and individuals over 2 years (CW> 170 mm), according to Hines et al., [7].

Table 6: Classification of individuals by age [9].

	Sex	Up to 1 year (CW < 100 mm)	Between 1 and 2 year (CW 100 - 170 mm)	Over 2 year (CW > 170 mm)	Total
2012	Female	1	27	5	32
	Male	0	27	8	36
	Total	**1**	**54**	**13**	**68**
2014	Female	0	8	8	16
	Male	0	1	4	5
	Total	**0**	**9**	**12**	**21**
2015	Female	1	23	14	38
	Male	2	16	25	43
	Total	**3**	**39**	**39**	**81**

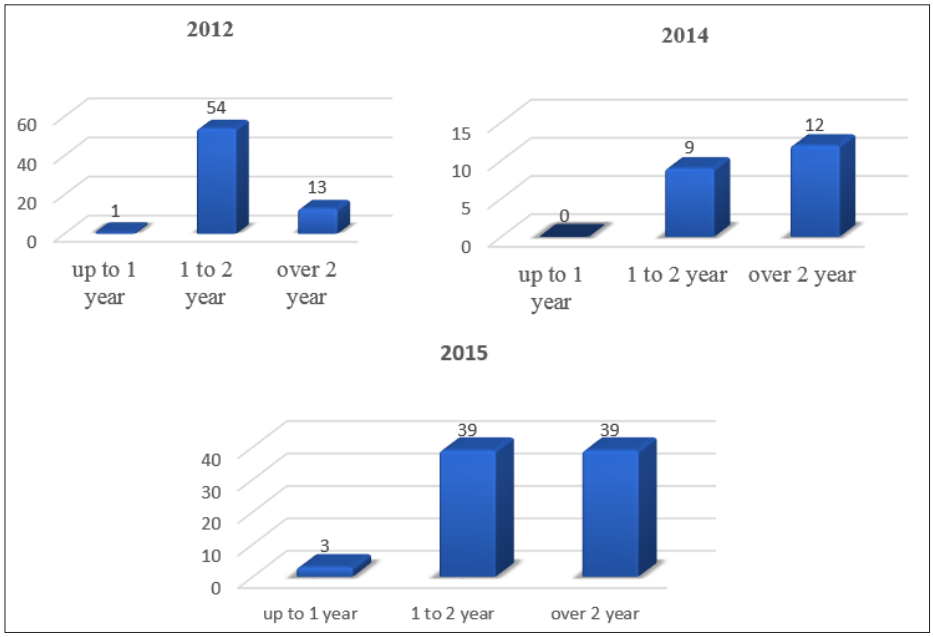


Figure 11: Ratio between individuals up to 1 year, 1-2 years and over 2 years of the blue crab in Orikum Lagoon collected in 2010, 2014, 2015.

As it is shown in the table 6 and in the figure 11, individuals of the blue crab 1 to 2 year predominate in the 2012, the individuals over 2 year predominate in the 2014 and in the 2015 we can evaluate an equal number of individuals of 1 to 2 year and over 2 year. The number of individuals up to 1 year is higher in 2015, another indicator for the stability of the blue crab in the lagoon of Orikum.

In a general consideration, referring to the questionnaires distributed to the local fishermen, they confirmed that the blue crab is very common in the lagoon of Orikum. The first seeing of the blue crab in this lagoon has been reported at the end of 1980 and until 2011 it has become a common species in the lagoon of Orikum. The blue crab is collected for commercial purpose by the local fishermen especially in the May-August period when the presence of the blue crab in the lagoon is very high. Local fishermen consider the blue crab as an aggressive species and a potential risk during its collection.

Conclusions

According to the data analyzed and to the questionnaires distributed to the local fishermen, blue crab *Callinectes sapidus* can be considered as a common species in the Orikum lagoon with relatively high abundance and density. Some of the reasons for the stability and high presence of blue crab in the lagoon of Orikum can be related to the richness of benthic invertebrates that are food for the crab, as well as the density of underwater meadows with macro vegetation (Zostera noltii, Rupia cirrhosa) suitable habitat for sheltering. The bio-ecology of the blue crab population in Orikumi lagoon has also been affected by the regime of entrances and exits of the blue crab to the lagoon conditioned by humans with the change of opening and closing of the wooden fences (locally named “dajlan”). The structural characteristics of the population changes across the years because the blue crab is regulary traded by the fishermen in the Orikumi lagoon.

The report between females and males (sex ratio) is almost 1:1. The highest presence of blue crab in the Orikum lagoon is from June to August, with the highest presence of juveniles in June, July, and September and with ovigerous females from June to September. The correlation between three parameters, height, weight, and width, is moderate in 2014 and quite strong in 2012 and 2015. The continues presence of juvenile individuals,

ovigerous females, large and over 2-year individuals in high abundance led to the consideration that the blue crab is established in the lagoon of Orikum.

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