BIOLOGICAL MONITORING (BIOLOGICAL SAMPLES COLLECTION) OF THE LANDED RAPANA CATCH BY THE BULGARIAN FISHING FLEET

SCIENTIFIC REPORT FOR 3RD AND 4TH QUARTER OF 2018

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This study is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA-Burgas/Д-46/14.05.2017 and is focused on the scientific assessment of the quantity and biological parameters of rapana from the landed catch by the Bulgarian fishing fleet in 2018.

This research was conducted with the financial support from the European Commission in accordance with Regulation №199/2008 of the Council and Decision 2010/93/EC of the Commission, allocated to support member states for the development of a common framework for collection, management and use of data in the fisheries' sector and to support the scientific consultations about the overall policy in the fisheries' field.

This research is indicative for the 3rd and 4th quarter of 2018 and presents the dynamics of the biological parameters of rapana from the landed catch at Rezovo, Varna, Shabla and Byala, based on the biometric measurements and analysis of 800 individual species.

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Biological Monitoring (Biological Samples Collection) of the Landed Rapana Catch by the Bulgarian Fishing Fleet for 3rd and 4th quarter 2018

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1. INTRODUCTION

This report is based on the biometric analysis of 800 individuals *R. venosa* and summarizes data about the third and fourth quarter of 2018.

The analysis presents the dynamics of the biological characteristics of *R. venosa* - landings, linear-weight structure, linear-weight ratio and sex structure by data from landings at Krapets, Kavarna, Balchik, Varna and Tsarevo for the period 07.2018 - 4.11.2018.

1.1 DATA COLLECTED

The current study allowed the collection of several types of data:

1. Data about the fishing vessels' activity

- Fish expedition data
- Departure port
- Arrival port
- Fishing vessel name
- Vessel type
- Vessel length (m)

2. Used fishing gear

- Depth scale of the fishing activities (up to 35 m depth)

3. Main biological data

- Total weight of the target species, landed at a port
- Number of collected individuals in the biological sample
- Total weight of the sample (Total weight – shell weight (TW, g))
- Shell length (Shell length, SL, mm),
- Shell width (Wd, mm)
- Aperture shell length (Aperture length, AL, mm).

4. Additional biological data

- Total weight without shell (Body weight – shell weight, BW,g)
- Ratio between genders, gender maturity of collected individuals and gonadosomatic index index (when applicable);
- Ratio between gender maturity and shell length, gender to shell length ration and gender to to total weight ratio;

The final results are presented in the form of tables and maps with data about:

- Landings of the target species at ports
- Biological parameters of rapana – size, weight, linear-weight ratios, gender structure from the samples;

2. MATERIAL AND METHODOLOGY

2.1 SAMPLING SCHEME

The collection of the biological samples (based on 800 individuals) was carried out by taking samples from landings from different ports along the northern and southern territorial waters of Black Sea. The main task is to assess the differences between the population parameters in the main fishing areas.

The main ports for sample collection for the 3rd quarter of 2018 are – Kavarna and Balchik, fishing was done by beam trawls by fishing vessels "Viking"and "Elekta". The research for the 4th quarter of 2018 covered ports Krapets, Varna and Tsarevo, while the rapana fishing was carried out bu using scuba diving technique and beam trawl. The research was done for 8 days for the period 01.07 – 30.11.2018 and the information is summarized below in Table 1.

Table 1.

Ports and vessels, where biological samples were taken from rapana landings

Date	Fishing vessel	No of fishing vessel	Technical specifications	Departure	Arrival	Fishning method
Third quarter 2018						
12.07.2018	Viking	ВН 8406	Length - 14.52 m; Weight - 30.06 GT; Power 132.39 kW	Kavarna	Kavarna	Beam trawl
27.07.2018	Elekta	ВН 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
28.07.2018	Elekta	ВН 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
01.09.2018	Elekta	ВН 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
Fourth quarter 2018						
03.10.2018	ШБ 6026	ШБ 6026	Length - 6.5 m; Weight - 1.82 GT; Power 58.84 kW	Krapets	Krapets	Scuba diving
04.10.2018	ЦР 591	ЦР 591	Length - 8.9 m; Weight - 3.56 GT; Power 55.16 kW	Tsarevo	Tsarevo	Scuba diving
19.10.2018	ЦР 591	ЦР 591	Length - 8.9 m; Weight - 3.56 GT; Power 55.16 kW	Tsarevo	Tsarevo	Scuba diving
07.11.2018	РК №4	РК №4	Length - 12.58 m; Weight - 24.46 GT; Power 220.59 kW	Varna	Varna	Beam trawl

The technical specifications of the beam trawls are as following; maximum length of beam 10 m, a maximum height of the opening 500mm; rail size: minimum 200 mm wide, minimum 500 mm long, number of chains up to 5, a diameter of chain blocks 10 mm, minimum size of the mesh 40 mm.

2.2 Sample analysis

Random samples of *R. venosa* were taken at the landings by ports in the northern and southern territorial waters. The main task is to assess the development of the species during the active fishing season.

2.3 Laboratory analysis

The size, weight and sex classes of *R.venosa* are analyzed by using an analysis technique for the weight, size (shell length) and sex structures of the researched individuals from different landings (at least 800 individuals) for the 3rd and 4th quarter of 2018.

- For each individual, the following biometric parameters are measured – total weight of the individual (total weight - weight with shell, TW, g), body weight of the individual (body weight – weight w/o shell, BW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm);
- The ratio between the different biometric parameters is calculated in relation to each of the parameters;
- The sex maturity is analyzed, as well as the ratio between the sexes, GSI (if applicable);
- The ratio between the sex and the length is calculated and the ratio between the sex to the total weight of the individuals.

2.4 Methodology for analysis

The morphometric relationships between the biological parameters – total weight (TW), body weight (BW), shell length (SL), shell width (Wd), aperture length (AL) – are analyzed by alometric models. The derived results are processed by using the least squares method and the following equations:

$$Log\ W = Log\ a + b * LogL$$

Where, W – weight; L – size; a, b – constants.

Natural logarithm (ln) is used as a second way of calculating the parameters *a,b* of the *L-W* ratio:

$TW(g) = a.SL(mm)^b$, followed by anti-logarithm so a $= ln\ q$ and $q = exp^a$.

XLSTAT software is used to make the linear-weight histograms of the samples from the landed catch, as well as for the data processing. The statistical data about the different classes, presented in the histograms, include – lower and upper limits of the classes, frequency, relative frequency and density.

The accuracy of the program for sample collection is based on the following documents:

- " Report of the Workshop on Sampling and Calculation Methodology for Fisheries Data" (WKSCMFD) (ICES 2004);
- Report SGPIDS (ICES, 2011a),
- Report of the Study Group on Practical Implementation of Discard Samples (SGPIDS).

3. RESULTS

3.1. BIOMETRIC MEASUREMENTS

3.1.1 LENGTH AND WEIGHT STRUCTURE OF LANDINGS

3.1.1.1 PORT KAVARNA, 12.07.2018

The sample consists of 100 individuals rapana, with a total weight of 4.058 kg, from a total of 1628 kg rapanas at Kavarna Port, fished by "Viking" vessel with a beam trawl.

The summarized statistical data about the biometric measurements is presented in Table 2. The average weight of the measured individuals reaches 40.58 g ± 14.90 SD, at an average length - 61.15 mm ± 7.05 SD, shell width - 46.17 mm ± 5.77 SD and aperture length 42.4 ± 5.6 SD.

Table 2

Summarized statistic about the measured biological parameters - total weight (TW - weight with shell, TW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) for Kavarna Port, 12.07.2018.

	TW,g	SL, mm	Wd, mm	AL, mm
Mean	40.58	61.15	46.17	42.4
Standard Error	1.49	0.71	0.58	0.6
Median	38.25	60.00	45.50	41.5
Mode	29.00	60.00	48.00	38.0
Standard Deviation	14.90	7.05	5.77	5.6
Sample Variance	223.32	49.72	33.29	31.7
Kurtosis	1.86	0.19	-0.38	-0.6
Skewness	1.07	0.32	0.26	0.2
Range	86.00	37.00	28.00	27.0
Minimum	13.00	45.00	33.00	29.0
Maximum	99.00	82.00	61.00	56.0
Sum	4034.00	6102.00	4609.00	4239.0
Count	100.00	100.00	100.00	100.0
Confidence Level(95.0%)	2.97	1.40	1.14	1.1

The most common size classes are - 57 - 62 mm (28 % from measured individuals), as well as size class - 66 - 70 mm (19 %) (Fig. 1.1, Table 3.1).

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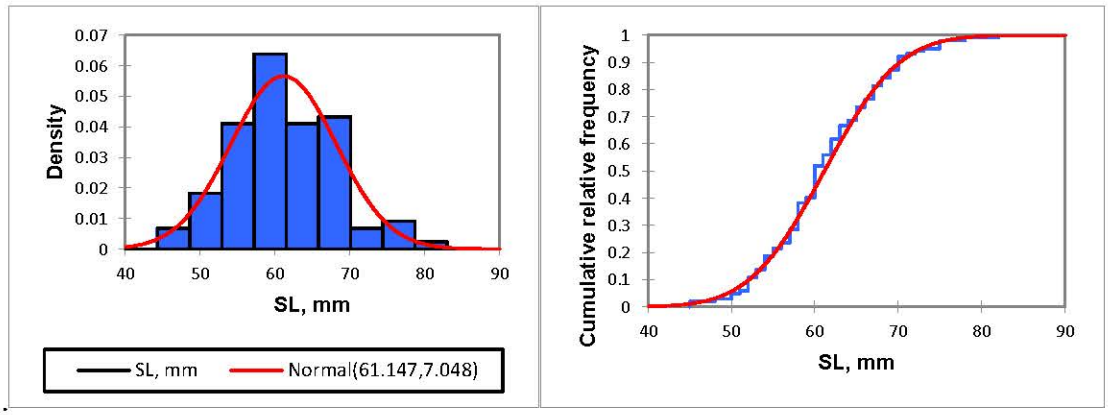

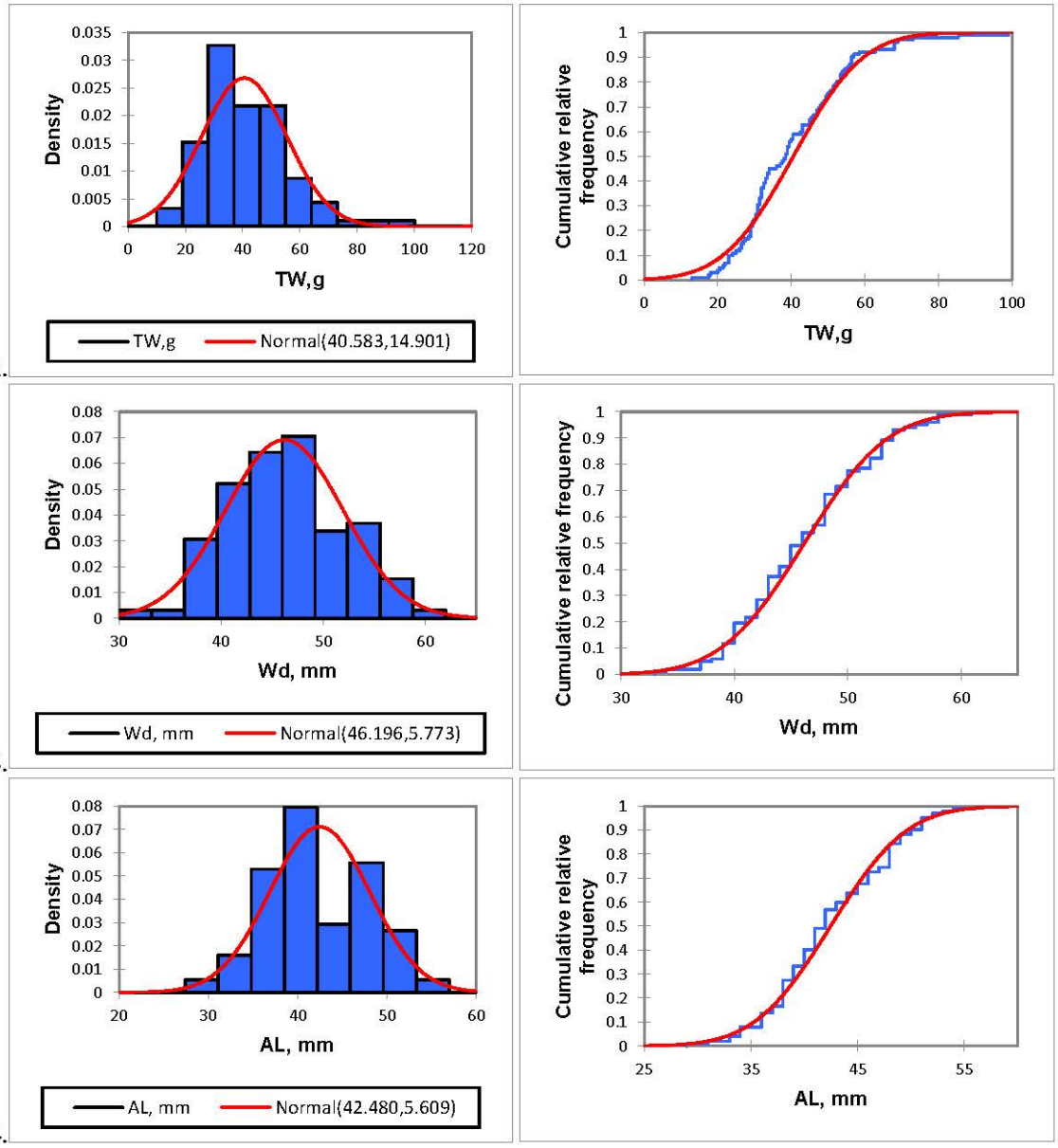

Fig. 1. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from Kavarna, 12.07.2018

In regard to the weight structure (TW, g), the following classes are predominant: 28 - 37 g (30 % from all measured individuals), 37 - 46 g и 46 - 55 g *20 % from the total number of the measured individuals (Fig. 1.2, Table 3.2).

Table 3

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) rapana classes in the sample from Kavarna/12.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
44	49	3	0.029	0.007

49	53	8	0.078	0.018
53	57	18	0.176	0.041
57	62	28	0.275	0.064
62	66	18	0.176	0.041
66	70	19	0.186	0.043
70	74	3	0.029	0.007
74	79	4	0.039	0.009
79	83	1	0.010	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	19	3	10	19
19	28	14	19	28
28	37	30	28	37
37	46	20	37	46
46	55	20	46	55
55	64	8	55	64
64	73	4	64	73
73	82	1	73	82
82	91	1	82	91
91	100	1	91	100

In regard to the parameter - shell width (Wd, mm), most common are the following classes: 46 - 49 mm -23 % and 43 - 46 mm -21 % (Fig. 1.3).

Based on the aperture length (AL, mm), the predominant classes are 39 - 42 mm (30 %) and 46 - 50 mm (21 %, Fig. 1.4).

The following percentage ratios have been derived - width (Wd, mm)/ length (SL, mm) of the shells, aperture length (SL, mm)/total length (Wd, mm) of the shell and aperture length (AL, mm)/width (Wd, mm) of the shell.

The mean ratio - width (Wd, mm)/length (SL, mm) is 75.55 % ± 3.69 SD, while the AL/SL (%) is 69.41 % ± 3.43 SD, and the ratio between AL/Wd (%) gives a value of - 91.94 % ± 3.63 SD (Table 4).

Table 4

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the individuals from Kavarna, 12.07.2018

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	75.55	69.41	91.94
Standard Error	0.37	0.34	0.36
Median	75.42	69.73	92.31
Mode	75.00	66.67	92.31
Standard Deviation	3.69	3.43	3.62
Sample Variance	13.65	11.79	13.12
Kurtosis	2.11	0.59	0.48
Skewness	-0.66	-0.17	-0.01
Range	22.29	19.31	22.05

Minimum	61.54	60.00	82.50
Maximum	83.82	79.31	104.55
Sum	7706.32	7079.68	9377.75
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.73	0.67	0.71

The following linear-weight relationships have been derived:

1) Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.2966*log SL (mm) + 1.3147, (R^2=0.87, p<0.001, Fig..2.1).
2) Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.3338*log Wd (mm) + 1.1337, (R^2=0.93, p<0.001, Fig..2.2)
3) Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3493*log Al (mm) + 1.0724, (R^2=0.90, p<0.001, Fig..2.3).

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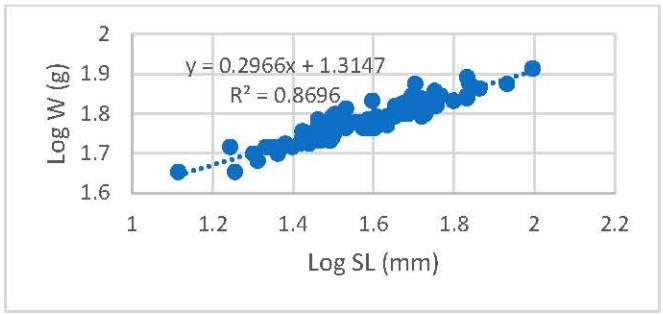

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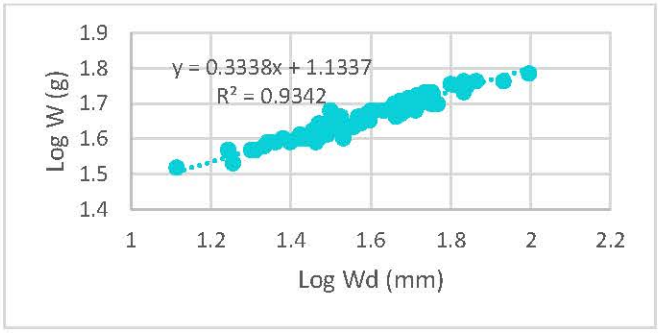

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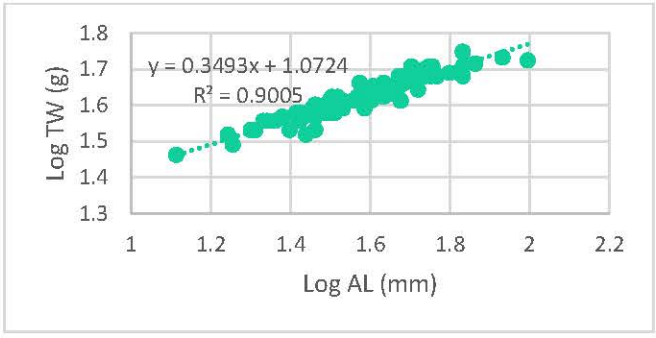

Fig. 2. Linear-weight ratio (Log 10) for the measured individuals rapana, Kavarna, 12.07.2018

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ with natural logarithm and value of the correlation coefficient R^2 are presented in Table 5.

Table 5

Parameters *a, b* of L-W relationship, given by the equation: $TW(g) = a.SL(mm)^b$ and value of R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.000225
b	2.9318
R^2	0.87

3.1.1.2 BALCHIK PORT, 27.07.2018

The sample of 100 individuals rapana is with a total weight of 4.1815 kg, from a total of 1820 kg rapanas at port Balchik Port, fished by "Elekta" vessel with beam trawl.

The average weight of the measured individuals reaches 41.82 g ± 13.57 SD, at an average length - 61.62 mm ± 6.32 SD, shell width - 46.76 mm ± 5.18 SD and aperture length 42.36 ± 4.46 SD (Table 6).

Table 6

Summarized statistics about the measured biological parameters – total weight (TW - weight with shell, TW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), at Balchik Port, 27.07.2018

	TW, g	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	41.82	61.62	46.76	42.36
Standard Error (SE)	1.36	0.63	0.52	0.45
Median	38.00	60.00	46.00	42.00
Mode	33.50	58.00	44.00	41.00
Standard Deviation (SD)	13.57	6.32	5.18	4.46
Sample Variance	184.21	40.00	26.87	19.93
Kurtosis	3.67	2.13	2.20	1.24
Skewness	1.61	1.14	1.09	0.86
Range	78.50	39.00	31.00	25.00
Minimum	22.50	48.00	37.00	33.00
Maximum	101.00	87.00	68.00	58.00
Sum	4181.50	6162.00	4676.00	4236.00
Count	100.00	100.00	100.00	100.00

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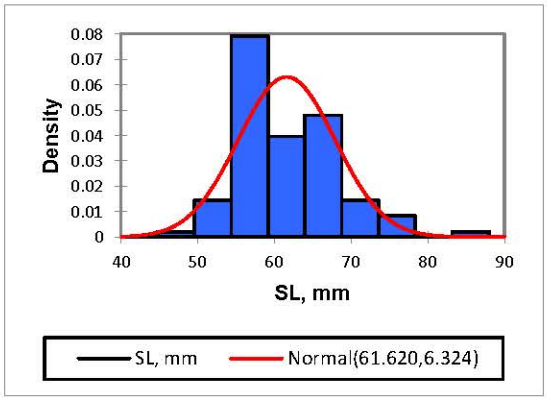

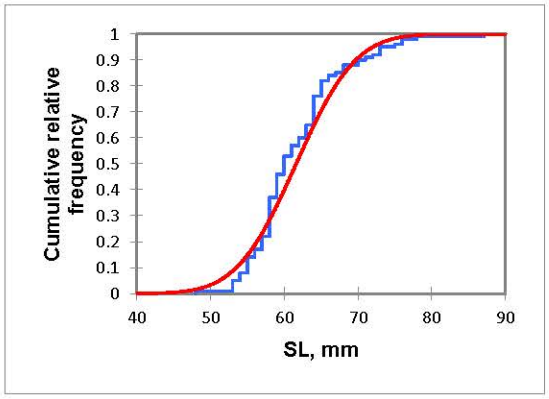

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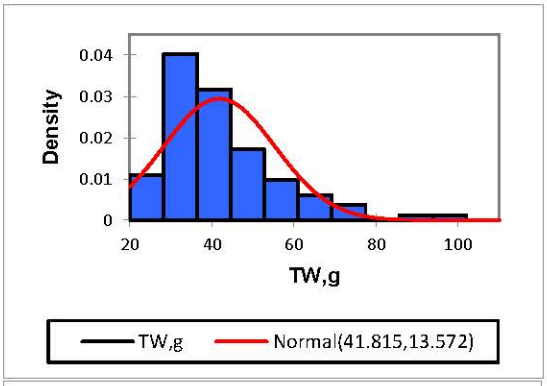

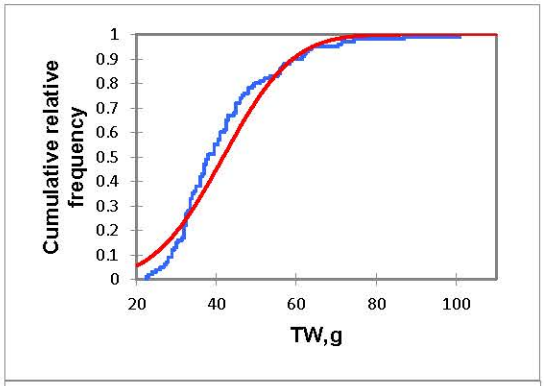

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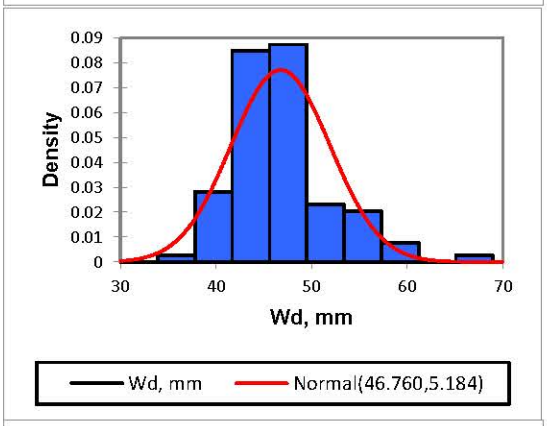

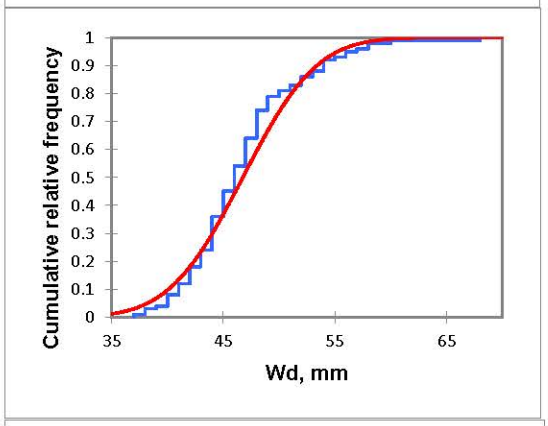

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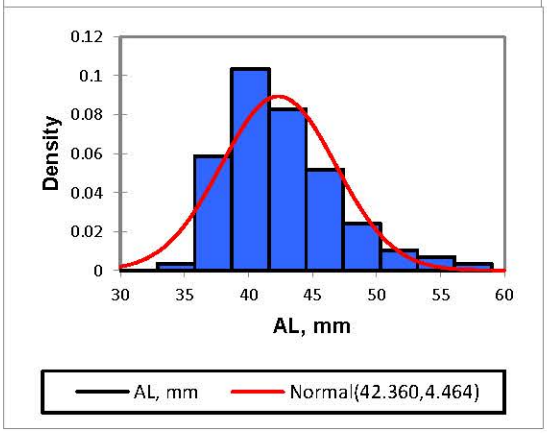


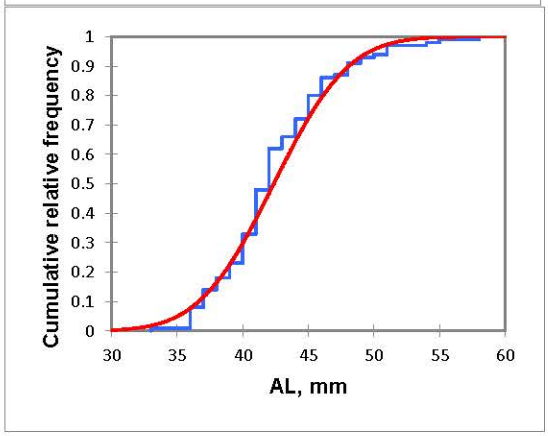


Fig. 3. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from Balchik/27.07.2018

The most common size classes are - 54 - 59 mm -38 % and 64 - 69 mm - 23 % (Fig. 3.1, Table 7.1).

For the weight classes, the following classes are predominant - 28 - 36 g (33 % from all measured individuals), followed by 36 - 45 g, 26 % (Fig. 3.2, Table 7.2).

Table 7

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) rapana classes in the sample from Balchik/27.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
40	45	0	0.000	0.000
45	50	1	0.010	0.002
50	54	7	0.070	0.015
54	59	38	0.380	0.079
59	64	19	0.190	0.040
64	69	23	0.230	0.048
69	74	7	0.070	0.015
74	78	4	0.040	0.008
78	83	0	0.000	0.000
83	88	1	0.010	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
20	28	9	0.090	0.011
28	36	33	0.330	0.040
36	45	26	0.260	0.032
45	53	14	0.140	0.017
53	61	8	0.080	0.010
61	69	5	0.050	0.006
69	77	3	0.030	0.004
77	86	0	0.000	0.000
86	94	1	0.010	0.001
94	102	1	0.010	0.001

The following percentage ratios have been derived - width (Wd, mm)/length (SL, mm) of the shells, aperture length (SL, mm)/total length (Wd, mm) of the shell and aperture length (AL, mm)/width (Wd, mm) of the shell (Table 8).

Table 8

Percentage ratios between shell width and length, aperture length/total shell length and aperture length/total width (Balchik/27.07.2018).

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	75.87	68.76	90.68
Standard Error	0.27	0.25	0.28
Median	75.47	68.80	90.91
Mode	75.86	66.67	91.11
Standard Deviation	2.67	2.48	2.84
Sample Variance	7.14	6.16	8.05
Kurtosis	0.47	1.42	1.82
Skewness	0.53	-0.16	-0.39

Range	13.96	15.95	19.15
Minimum	69.86	60.32	80.85
Maximum	83.82	76.27	100.00
Sum	7586.75	6876.43	9067.80
Count	100.00	100.00	100.00

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.3133*log SL (mm) + 1.2856, (R^2=0.85, p<0.001, Fig..4.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.3521*log Wd (mm) + 1.1033, (R^2=0.92, p<0.001, Fig..4.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3266*log Al (mm) + 1.1015, (R^2=0.86, p<0.001, Fig..4.3).

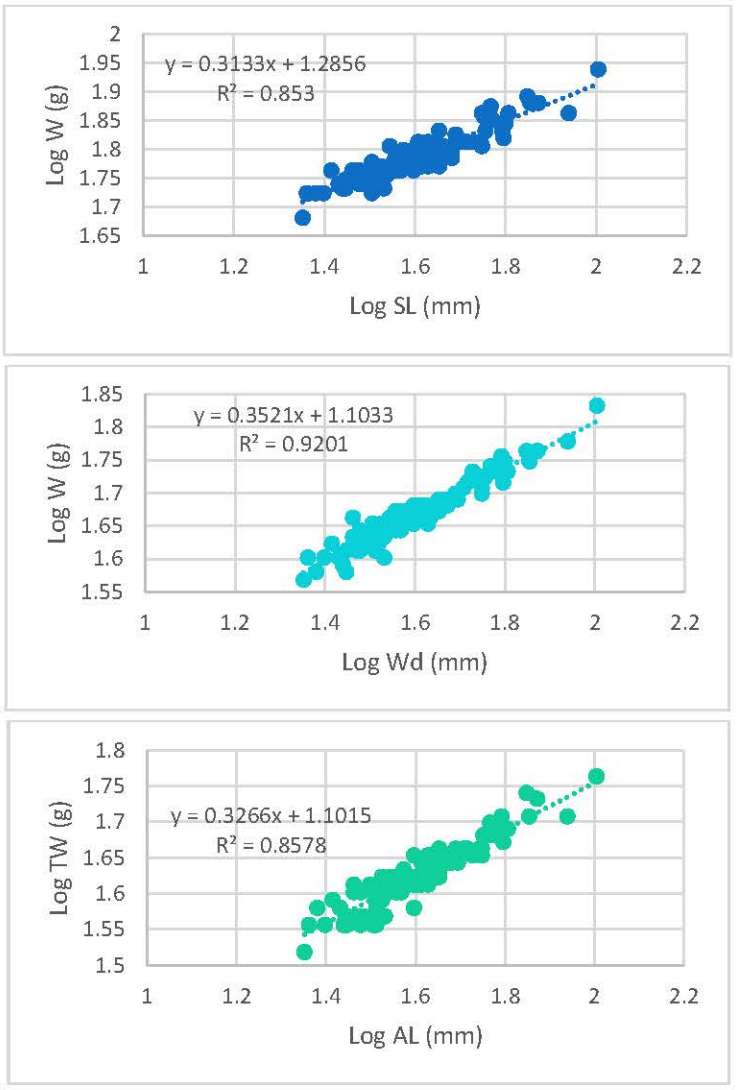


Fig. 4. Linear-weight ratio (Log 10) for the measured individuals rapana, Balchik, 27.07.2018

Parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ and value of correlation coefficient R^2, presented in Table 9.

Table 9

Parameters *a, b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ and value of R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.000544
b	2.72215
R^2	0.85

3.1.1.3 BALCHIK PORT, 28.07.2018

The sample with 100 individuals rapana is with a total weight of 5.2625 kg, from a total of 2070 kg rapanas from Balchik Port from the fishing vessel "Elekta" with beam trawl technique.

The average weight of the measured individuals is 52.63 g ± 18.82 SD, at an average length – 67.14 mm ± 7.73 SD, shell width – 51.53 mm ± 7.05 SD and aperture length 46.54 ± 6.60 SD (Table 10).

Table 10

Summarized statistics about the measured biological parameters – total weight (TW - weight with shell, TW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Balchik Port, 28.07.2018

	TW, g	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	52.63	67.14	51.53	46.54
Standard Error	1.88	0.77	0.71	0.66
Median	51.00	67.00	51.00	47.00
Mode	54.50	68.00	53.00	47.00
Standard Deviation	18.82	7.73	7.05	6.60
Sample Variance	354.13	59.80	49.71	43.50
Kurtosis	1.92	0.22	-0.17	-0.37
Skewness	1.13	0.56	0.42	0.38
Range	101.00	38.00	33.00	30.00
Minimum	22.00	52.00	37.00	32.00
Maximum	123.00	90.00	70.00	62.00
Sum	5262.50	6714.00	5153.00	4654.00
Count	100.00	100.00	100.00	100.00
Confidence Level(95.0%)	3.73	1.53	1.40	1.31

The most common classes in the sample are – size class 66 - 71 SL mm (23 % from the measured individuals), as well as size class - 62 - 66 mm (18 %, Fig. 5.1, Table 11.1).

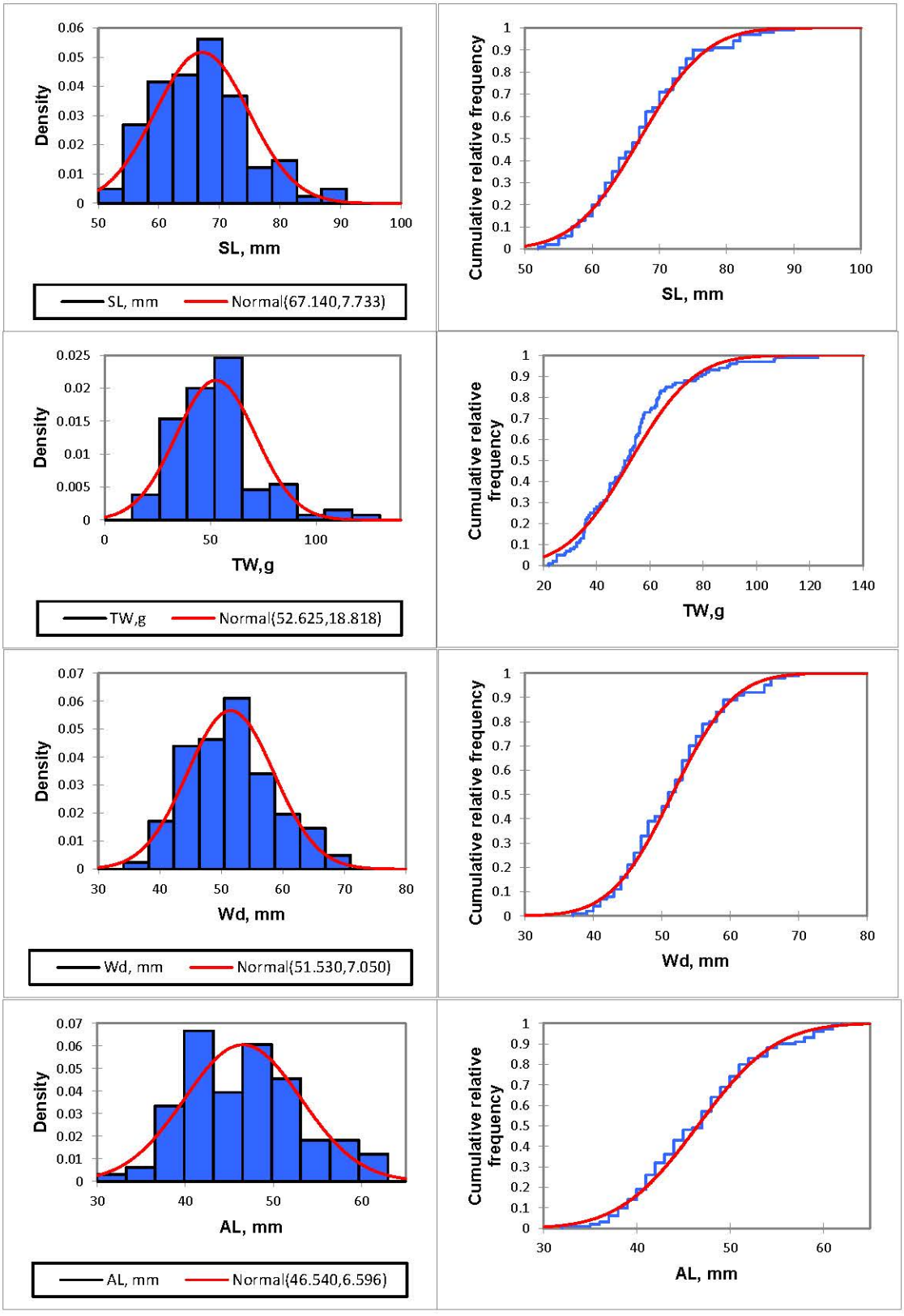


Fig. 5. Distribution of the measured parameters by classes: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) and cumulative distribution by classes in the sample from Balchik, 28/07/2018

In regard to the weight structure (TW, g), the predominant weight classes are: 52 - 65 g (32 % from all measured individuals) and 39 - 52 g (26 % from the total number of measured individuals (Fig. 5.2, Table 11.2).

In regard to the shell width (Wd, mm), the most common classes are 51 - 55 mm (25 % from the measured individuals) and 46 - 51 mm (19 %, Fig. 5.3).

Based on the parameter aperture length (AL, mm), the predominant classes are 40 - 43 mm (22 %) and 47 - 50 mm (20 %, Fig. 5.4).

Table 11

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) classes of the rapana in the sample from Balchik Port, 28.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	54	2	0.020	0.005
54	58	11	0.110	0.027
58	62	17	0.170	0.041
62	66	18	0.180	0.044
66	71	23	0.230	0.056
71	75	15	0.150	0.037
75	79	5	0.050	0.012
79	83	6	0.060	0.015
83	87	1	0.010	0.002
87	91	2	0.020	0.005

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
13	26	5	0.050	0.004
26	39	20	0.200	0.015
39	52	26	0.260	0.020
52	65	32	0.320	0.025
65	78	6	0.060	0.005
78	91	7	0.070	0.005
91	104	1	0.010	0.001
104	117	2	0.020	0.002
117	130	1	0.010	0.001

The mean ratio - width (Wd, mm)/length (SL, mm) is 76.62 % ± 3.53 SD, AL/SL (%) and is about 69.19 % ± 3.85 SD, while the ratio of AL/Wd (%) is 90.34% ± 3.83 SD (Table 12).

Table 12

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and AL/Wd (%) of the individuals from Balchik Port, 28.07.2018

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	76.62	69.19	90.34
Standard Error	0.35	0.38	0.38

Median	76.15	69.41	91.09
Mode	75.00	66.13	88.89
Standard Deviation	3.53	3.85	3.83
Sample Variance	12.45	14.81	14.70
Kurtosis	1.47	3.24	9.29
Skewness	0.59	-0.77	-2.35
Range	21.27	26.15	25.86
Minimum	69.35	52.05	70.37
Maximum	90.63	78.21	96.23
Sum	7662.08	6919.11	9034.00
Count	100.00	100.00	100.00
Confidence Level(95.0%)	0.70	0.76	0.76

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.3094*log SL (mm) + 1.2996, (R^2=0.89, p<0.001, Fig..6.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.3723*log Wd (mm) + 0.768, (R^2=0.90, p<0.001, Fig. 6.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.4277*log Al (mm) + 0.9002, (R^2=0.52, p<0.001, Fig..6.3).

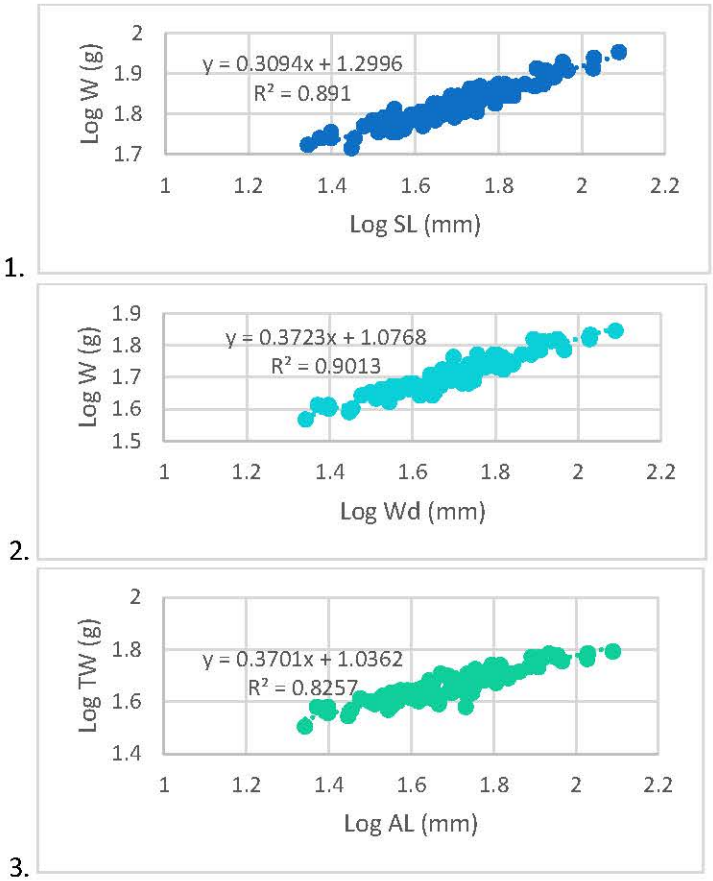


Fig. 6. Linear-weight ratio (Log 10) for the measured individuals rapana, Balchik, 28.07.2018

The parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ and value of R^2, presented in Table 13.

Table 13

Paramters *a, b* of L-W ratio: $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.00028
b	2.87975
R^2	0.89097

3.1.1.4 Balchik Port, 01.09.2018

The sample of 100 individuals rapana e with a total weight of 4.363 kg, from a total of 2060 kg rapans at the Balchik Port, fished by fishing vessel „Elekta", equipped with beam trawl.

The average weight of the measured individuals is 43.63 g ± 18.53 SD, at an average length - 63.13 mm ± 9.19 SD, shell width - 47.55 mm ± 7.67 SD and aperture length 43.57 ± 7.20 SD (Table 14).

Table 14

Summarized statistics about the measured biological parameters – total weight (TW - weight with shell, TW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), from Balchik Port, 01.09.2018

	TW,g	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	43.63	63.13	47.55	43.57
Standard Error	1.83	0.91	0.76	0.71
Median	39.00	62.00	47.00	43.00
Mode	48.00	61.00	49.00	43.00
Standard Deviation	18.53	9.19	7.67	7.20
Sample Variance	343.25	84.43	58.86	51.84
Kurtosis	0.35	0.00	-0.29	-0.21
Skewness	0.83	0.47	0.44	0.45
Range	83.50	46.00	36.00	34.00
Minimum	14.50	44.00	32.00	29.00
Maximum	98.00	90.00	68.00	63.00
Sum	4493.50	6502.00	4898.00	4488.00
Count	103.00	103.00	103.00	103.00
Confidence Level(95.0%)	3.62	1.80	1.50	1.41

The most common size classes in the sample are - 55 - 60, mm and 60 - 66 mm SL (*22 % from all measured individuals), as well as size class - 66 - 71 mm (16 %) (Fig. 7.1, Table 15.1). 92 % of all the measured individuals are up to 76 mm in length.

In regard to the weight structure (TW, g), the following classes are predominant: 37 - 46 g (23 % from all measured individuals), 19 - 28 g (18 %) and 28 - 37 g (17 % from the total number of measured individuals (Fig. 7.2, Table 15.2), 94 % from all measured individuals are up to 72 g in weight.

In regard to the shell width (Wd, mm), most common are the following classes: 42 - 46 mm and 46 - 50 mm (*22 %), followed by class - 38 – 42 mm (15 % (Fig. 7.3).

Looking at the aperture length of the individuals (AL, mm), the predominant classes are - 46 mm (28 %) and 38 - 42 mm (21 % (Fig. 7.4).

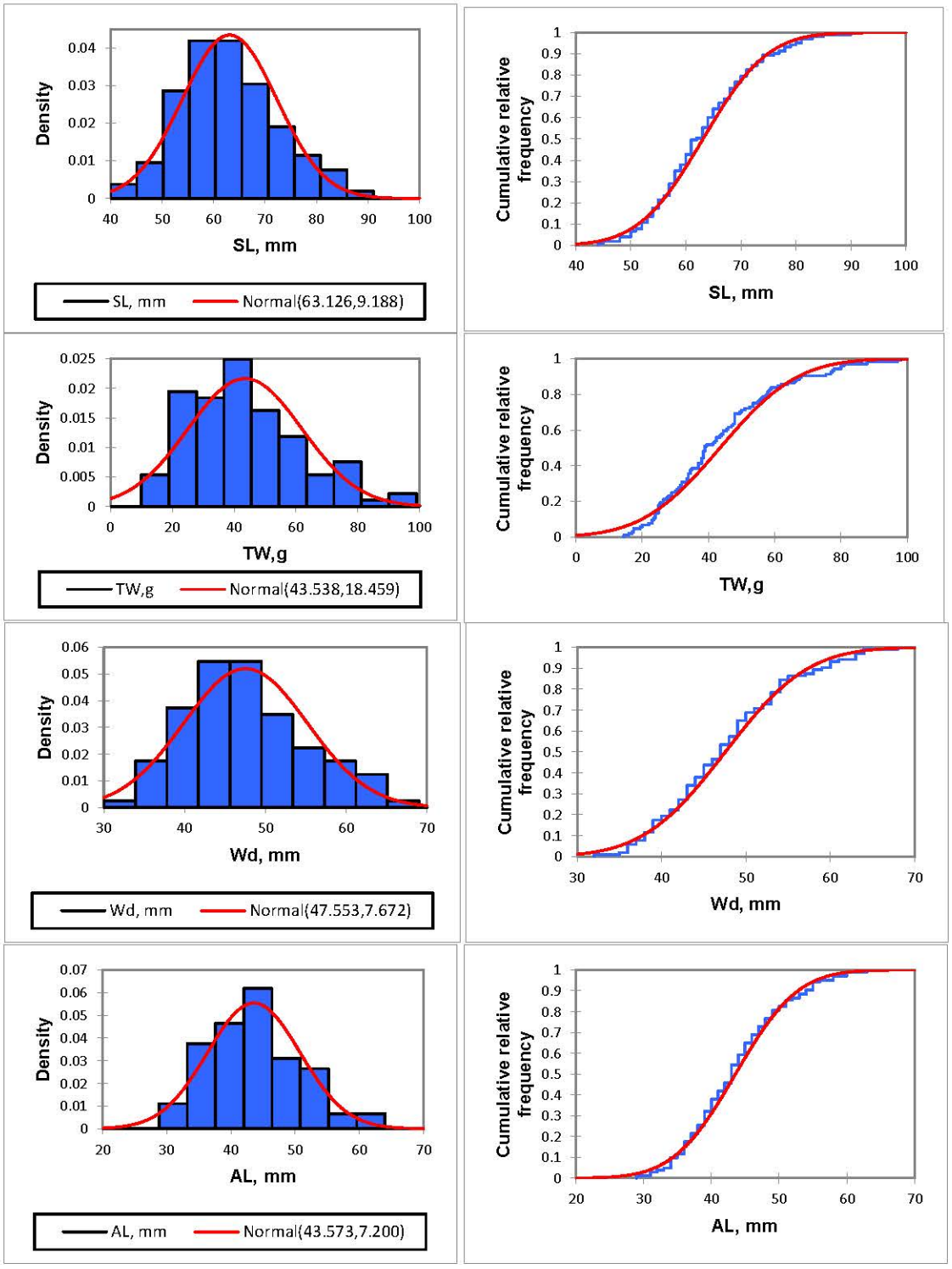


Fig. 7. Distribution of the measured parameters по класове: shell length (SL, mm, 1), обща маса (TW, g, 2), ширина на черупка (Wd, mm, 3), дължина на отвора (AL, mm, 4) and cumulative distribution by class в пробата от Balchik, 01/09/2018

Table 15

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) classes of the rapana in the sample from Balchik Port 01.09.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
40	45	2	0.019	0.004
45	50	5	0.049	0.010
50	55	15	0.146	0.029
55	60	22	0.214	0.042
60	66	22	0.214	0.042
66	71	16	0.155	0.030
71	76	10	0.097	0.019
76	81	6	0.058	0.011
81	86	4	0.039	0.008
86	91	1	0.010	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	19	5	0.048	0.005
19	28	18	0.173	0.019
28	37	17	0.163	0.018
37	46	23	0.221	0.025
46	55	15	0.144	0.016
55	63	11	0.106	0.012
63	72	5	0.048	0.005
72	81	7	0.067	0.008
81	90	1	0.010	0.001
90	99	2	0.019	0.002

The mean ration - width (Wd, mm)/length (SL, mm) reaches 75.25 % ± 4.02 SD, while AL/SL (%) is 68.91 % ± 3.65 SD, for the ratio AL/Wd (%) the derived value is 91.61% ± 2.49 SD (Table 16).

Table 16

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the individuals from Balchik 01.09.2018

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	75.25	68.91	91.61
Standard Error	0.40	0.36	0.25
Median	74.65	68.52	91.89
Mode	75.00	66.67	91.49
Standard Deviation	4.02	3.65	2.49
Sample Variance	16.13	13.35	6.22
Kurtosis	9.08	5.16	1.99
Skewness	1.60	0.76	-1.03

Range	34.09	30.00	14.35
Minimum	63.64	56.36	81.48
Maximum	97.73	86.36	95.83
Sum	7751.16	7097.96	9435.36
Count	103.00	103.00	103.00
Confidence Level(95.0%)	0.78	0.71	0.49

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.3026*log SL (mm) + 1.3112, (R^2=0.81, p<0.001, Fig..8.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.36*log Wd (mm) + 1.0952, (R^2=0.93, p<0.001, Fig..8.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3625*log Al (mm) + 1.053, (R^2=0.89, p<0.001, Fig..8.3).

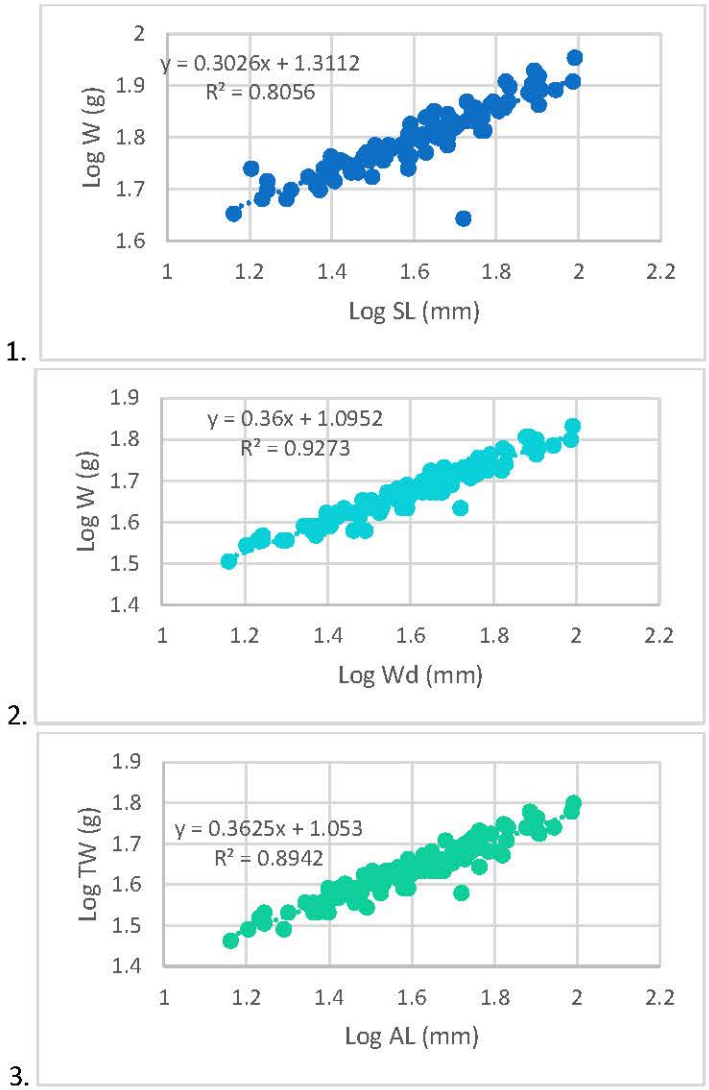


Fig. 8. Linear-weight ratio (Log 10) for the measured individuals rapana, Balchik, 01.09.2018

The parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ and value of R^2, presented in Table 17.

Table 17

Parameters *a, b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.00066
b	2.6624
R^2	0.81

3.1.1.5 SUMMARIZED DATA FOR THE 3RD QUARTER OF 2018

During the third quarter of 2018, the landings from the four observed ports vary between 1628 - 2070 kg/day, fished by vessels with lengths between 14.5 -16.5 m, equipped with beam trawls (Table 18). The average landing from vessels with length of 16.5m is 1983 kg per fishing day.

Table 18

Summarized data about the landings by days and ports done by different types of vessels and different fishing techniques for the third quarter of 2018

Date	Landing port	Fishing vessel length (m)	Landed quantity (kg) from the fishing vessel	Weight (kg) of the sample with 100 individuals *R. venosa*	Fishing tecchnique
12.07.2018	Kavarna	14.52 m	1628	4.058	Beam trawl
27.07.2018	Balchik	16.5 m	1820	4.182	Beam trawl
28.07.2018	Balchiik	16.5 m	2070	5.263	Beam trawl
01.09.2018	Balchik	16.5 m	2060	4.353	Beam trawl

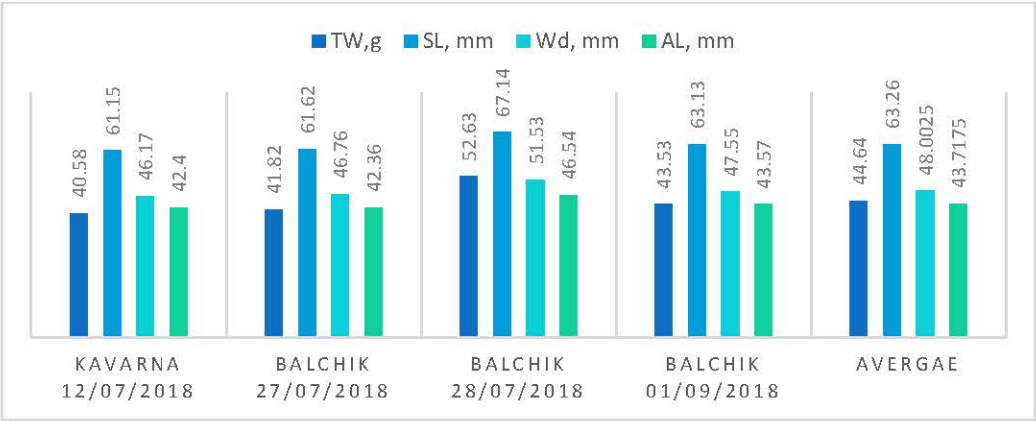
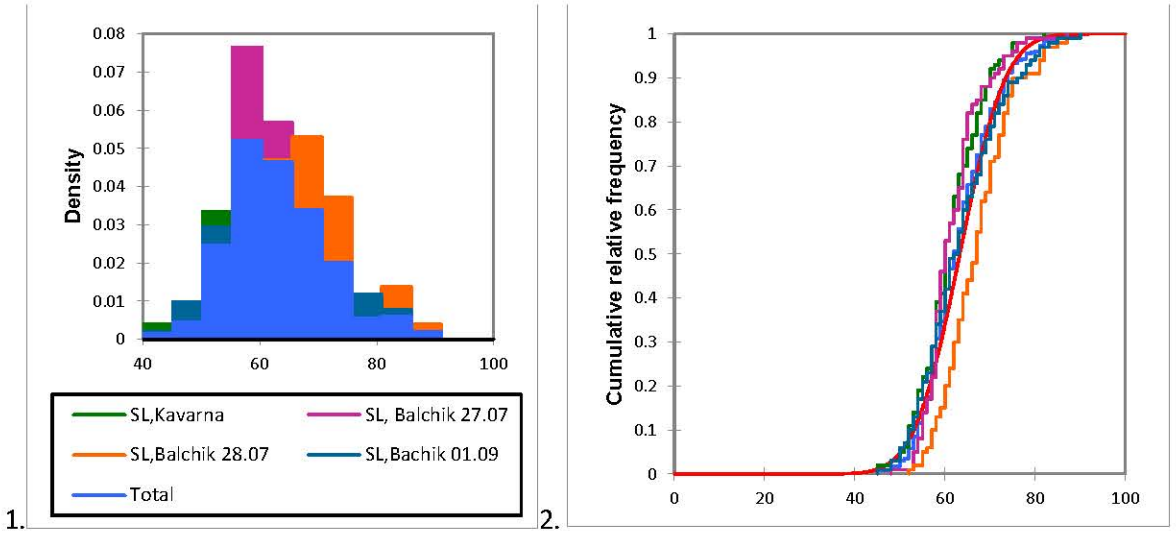


Fig. 9. Distribution of the mean values for the biological parameters of *R. venosa* – total weight (TW, g), shell length (SL, mm), shell width (Wd, mm) and aperture length (AL, mm) by landing ports for the third quarter of 2018

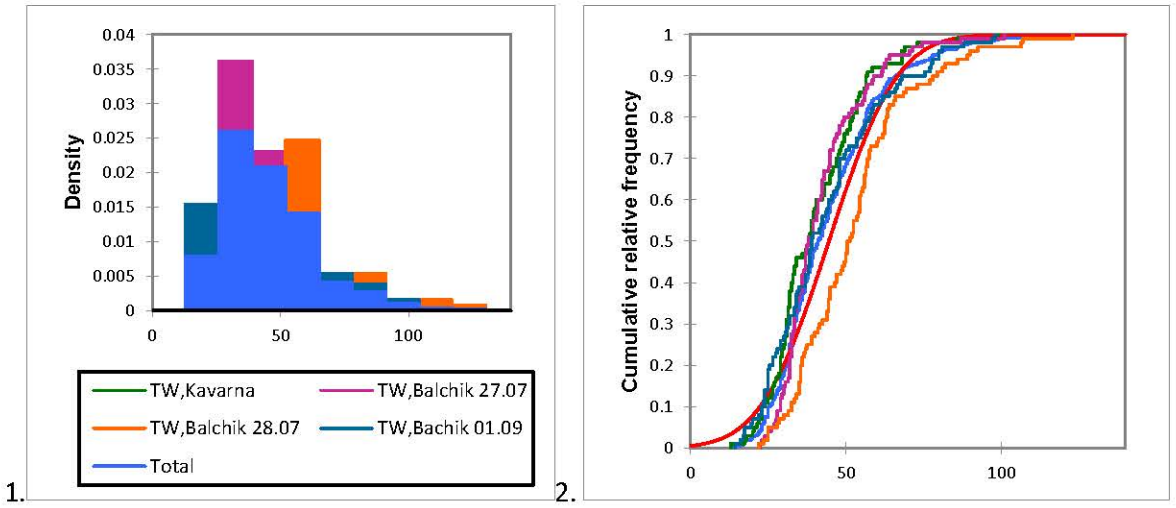
In regard to the biological parameters of the measured individuals *R. venosa* by ports, the average maximum size at Balchik Port is - 67.14 mm SL abd weight - 52.63 g TW from the landed individuals (Fig. 9).

The average weight of R.venosa harvested by beam trawl for the third quarter is 44.61 g TW ± 17.29 SD, while the minimum and maximum values are in the range 13 - 123 g TW (Fig. 10). The average *R.venosa* is 63.28 mm SL ± 7.96 SD, while the minimum and maximum sizes between44 - 90 mm SL (Fig. 11).



1. 2.

Fig. 10. Distribution of the classes by shell size (SL, mm, 1), and cumulative distribution by class (2) for the third quarter of 2018



1. 2.

Fig. 11. Distribution of the classes by individuals' weight (TW, g, 1) and cumulative distribution by class (2) for the third quarter of 2018

During the third quarter of 2018, most common are the size classes - 55 - 60 mm (27 % from all measured individuals), as well as size class - 60 - 66 mm (24 %) (Fig. 10.1, Table 19.1), while 93 % of the individuals are with a size smaller than < 76 mm and just 7% are bigger than > 76 mm (Fig. 10.2, Table 19.1).

In regard to the weight structure (TW, g), the following classes are predominant: 26 - 39 g (34 % from all measured individuals), 39 - 52 g - 27 % from the total number of measured individuals (Fig. 11.1, Table 19.2). During the third quarter of 2018, 89 % of the measured individuals have weight < 65 g, while 2% are > 91 g (Fig. 11.2).

Table 19

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) classes of rapana, in total for the 3rd quarter 2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
40	45	3	0.008	0.001
45	50	9	0.023	0.004
50	55	50	0.125	0.025
55	60	106	0.265	0.052
60	66	95	0.238	0.047
66	71	69	0.173	0.034
71	76	41	0.103	0.020
76	81	11	0.028	0.005
81	86	12	0.030	0.006
86	91	4	0.010	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
13	26	41	0.103	0.008
26	39	135	0.338	0.026
39	52	108	0.270	0.021
52	65	73	0.183	0.014
65	78	21	0.053	0.004
78	91	14	0.035	0.003
91	104	5	0.013	0.001
104	117	2	0.005	0.000
117	130	1	0.003	0.000

The comparison analysis of the parameters *a* and *b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ show a negative allometric growth of *R. venosa* in all samples with a coefficient b ≠ 3 (t-test, p=0.05). The average value of the coefficient *b* is 2.79, however varies in the range 2.66 - 2.94, with the lowest value of 2.66 for Balchik Port on 1/09/2018 and maximum of 2.93 at Kavarna Port, beginning of July 2018 (Fig. 12). The overall conclusion is that the increase in the parameter *a* results in the decrease of the parameter *b*.

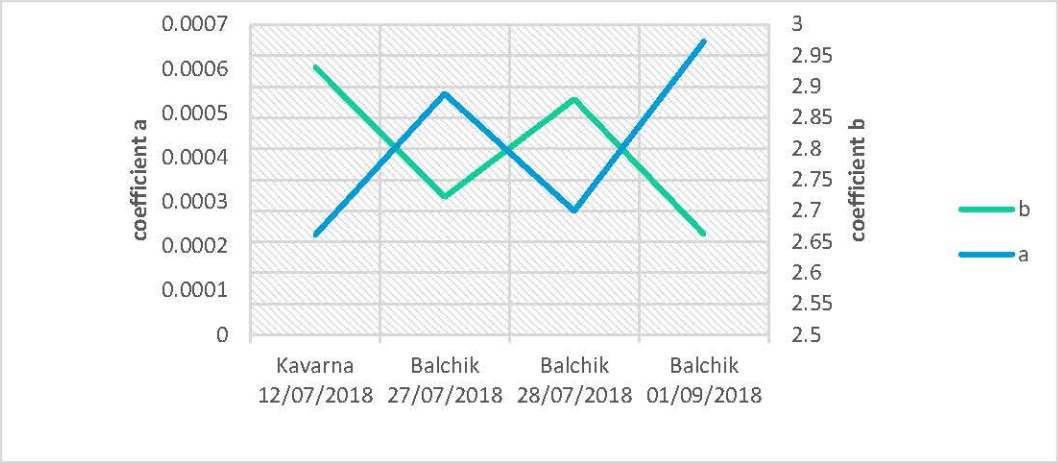


Fig. 12. Parameters *a, b* of the linear-weight ratios for the samples from different ports for the third quarter of 2018

Percentage ratios of the width to length of the shells (Wd/SL, %) of *R. venosa*, aperture length to the total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the third quarter 2018 presented on Fig. 13.

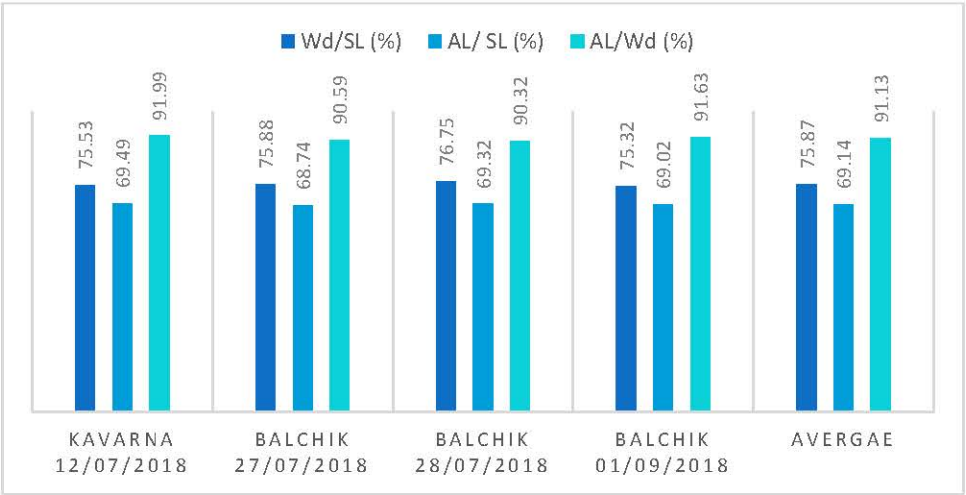


Fig. 13. Percentage ratios between shell width and length (Wd/SL, %) of *R. venosa*, aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the 3rd quarter of 2018

The average ratio of Wd/SL for the third quarter of 2018 reaches 75.87 %, with the lowest share in the sample from Balchik from 01/09/2018 – 75.32 %, while the highest share is in the sample from 28/09/2018 – 76.75% (Fig..13). Accordingly, the ratio AL/SL reaches an average of 69.14 %, lowest in the sample from 01/09/2018 – 69.02 %, highest – 69.49 % in the sample from Kavarna. In regard to the ratio AL/Wd (%), the average ratio for the third quarter of 2018 is 91.13 %, with minimum values in the sample from Balchik Balchik 28/09/2018 r – 90.32 % and maximum – in the sample from Kavarna - 91.99 %.

3.1.1.6 KRAPETS PORT, 03.10.2018

The sample of 100 individuals rapana has a total weight 9.545 kg, from a total of 985 kg landed at Krapets Port by the fishing vessel ШБ 6026, using scuba diving technique.

The average weight of the measured individuals reaches 95.45 g ± 18.05 SD, at an average length - 81.19 mm ± 5.26 SD, shell width - 64.09 mm ± 4.21 SD and aperture length 59.21 ± 3.95 SD (Table 20). The weight without shell is 44.23 g ± 9.01 SD and comprises 45.63 % ± 4.67 SD of the total weight, varying between 37.2 % and 56.2 % from the total weight of the body.

Table 20

Summarized statistic about the measured biological parameters - total weight (TW - weight with shell, TW, g), weight w/o shell (BW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) for Krapets Port, 03.10.2018

	TW,g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	95.45	44.23	45.63	81.19	64.23	59.21
Standard Error	1.80	1.27	0.67	0.53	0.42	0.40
Median	94.00	42.25	44.63	81.00	64.00	59.00
Mode	82.50	36.50	44.24	79.00	65.00	58.00
Standard Deviation	18.05	9.01	4.67	5.26	4.21	3.95
Sample Variance	325.74	81.22	21.85	27.63	17.73	15.62
Kurtosis	2.11	0.43	-0.08	0.74	1.17	1.62
Skewness	1.15	0.74	0.50	0.34	0.71	0.70
Range	100.50	41.50	19.02	32.00	25.00	24.00
Minimum	67.50	29.00	37.20	66.00	55.00	50.00
Maximum	168.00	70.50	56.22	98.00	80.00	74.00
Sum	9545.00	2211.50	2235.77	8119.00	6423.00	5921.00
Count	100.00	50.00	49.00	100.00	100.00	100.00
Confidence Level(95.0%)	3.58	2.56	1.34	1.04	0.84	0.78

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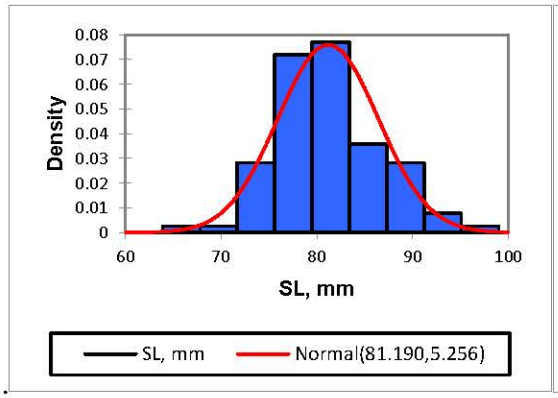
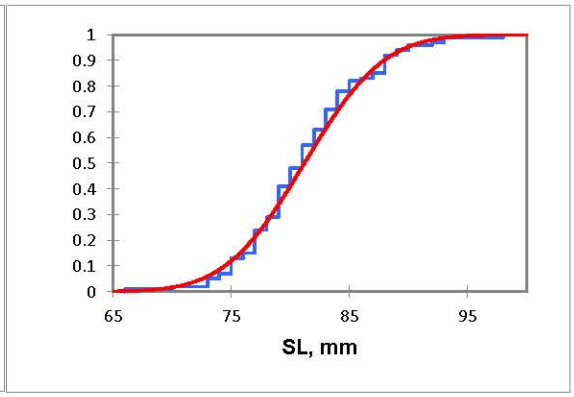




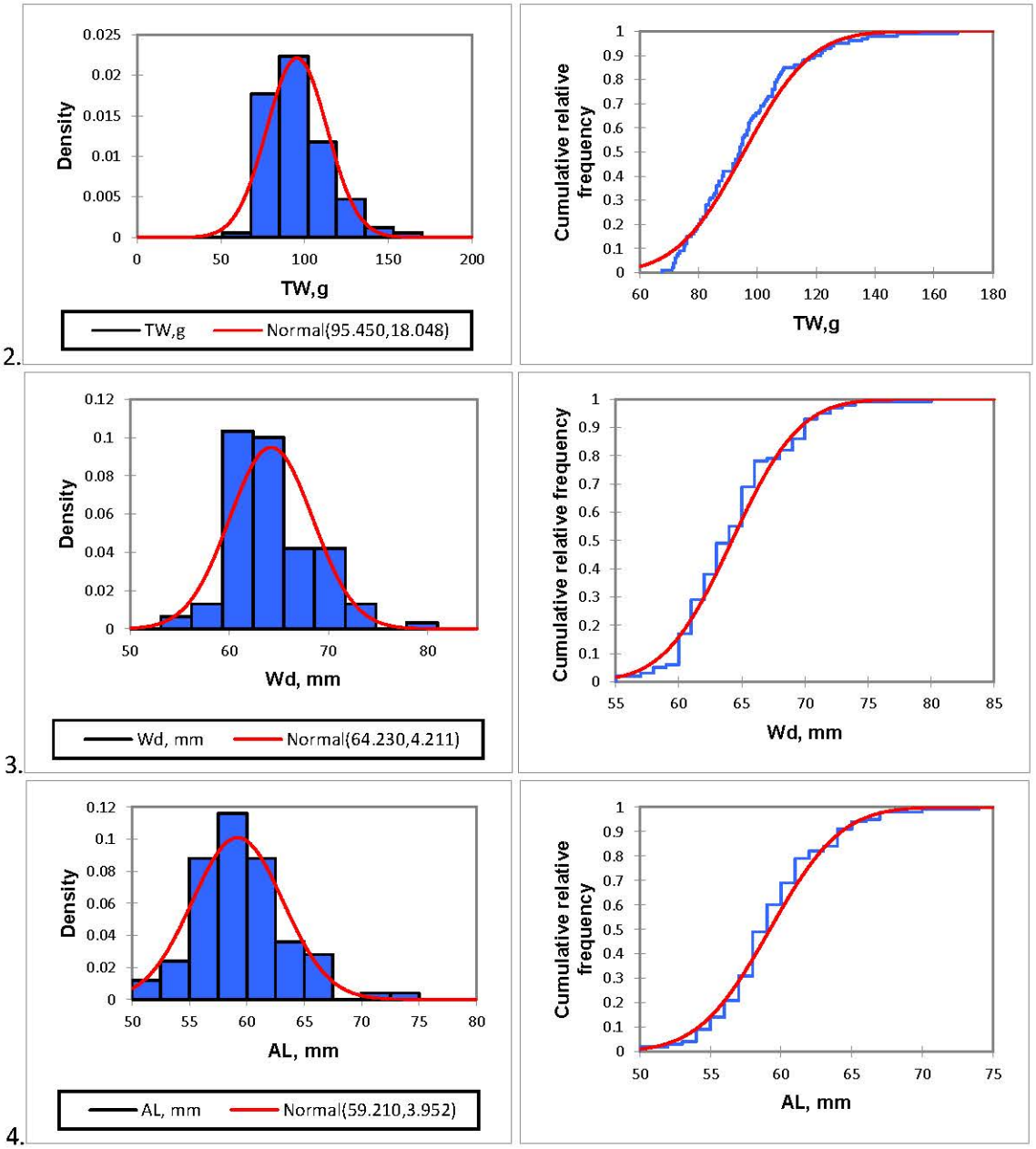


Fig. 14. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from Krapets, 03.10.2018

Most common are the size classes 80 - 83 mm (30 % from the measured individuals), as well as the size class - 76 - 80 mm (28 %) (Fig. 14.1, Table 21.1).

In regard to the weight structure (TW, g), the following classes are predominant: 85 - 102 g (38 % from all measured individuals), 68 - 85 g (30 %) и 102 -119 g -20 % from the total number of the measured individuals (Fig. 14.2, Table 21.2).

Table 21

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) classes of rapana in the sample from Krapets, 03.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
64	68	1	0.010	0.003
68	72	1	0.010	0.003
72	76	11	0.110	0.028
76	80	28	0.280	0.072
80	83	30	0.300	0.077
83	87	14	0.140	0.036
87	91	11	0.110	0.028
91	95	3	0.030	0.008
95	99	1	0.010	0.003

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
51	68	1	0.010	0.001
68	85	30	0.300	0.018
85	102	38	0.380	0.022
102	119	20	0.200	0.012
119	136	8	0.080	0.005
136	153	2	0.020	0.001
153	170	1	0.010	0.001

In regard to the parameter - shell width (Wd, mm), most common are the following classes: 59 - 62 mm - 32 % and 62 - 66 mm -31 % (Fig. 14.3).

Based on the parameter aperture length (AL, mm), the predominant classes are 58 - 60 mm (29 %) and 55 - 58 mm, as well as 60 - 63 mm (*22 %, Fig. 14.4).

The mean ratio - width (Wd, mm)/length (SL, mm) is 75.55 % ± 3.69 SD, while AL/SL (%) is 69.41 % ± 3.43 SD, however the ratio of AL/Wd (%) has an average value of - 91.94% ± 3.63 SD (Table 22).

Table 22

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the measured individuals from Krapets, 03.10.2018

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	79.20	72.99	92.21
Standard Error	0.37	0.31	0.24
Median	79.50	73.08	92.25
Mode	79.75	72.73	93.85
Standard Deviation	3.70	3.10	2.44
Sample Variance	13.66	9.59	5.93
Kurtosis	0.01	-0.03	4.10
Skewness	-0.21	-0.30	-1.28

Range	19.77	15.82	15.94
Minimum	68.18	63.64	80.88
Maximum	87.95	79.45	96.83
Sum	7919.54	7298.62	9220.97
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.73	0.61	0.48

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.2445*log SL (mm) + 1.4269, (R^2=0.50, p<0.001, Fig..15.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.2947*log Wd (mm) + 1.2256, (R^2=0.68, p<0.001, Fig..15.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3063*log Al (mm) + 1.1677, (R^2=0.73, p<0.001, Fig..15.3).

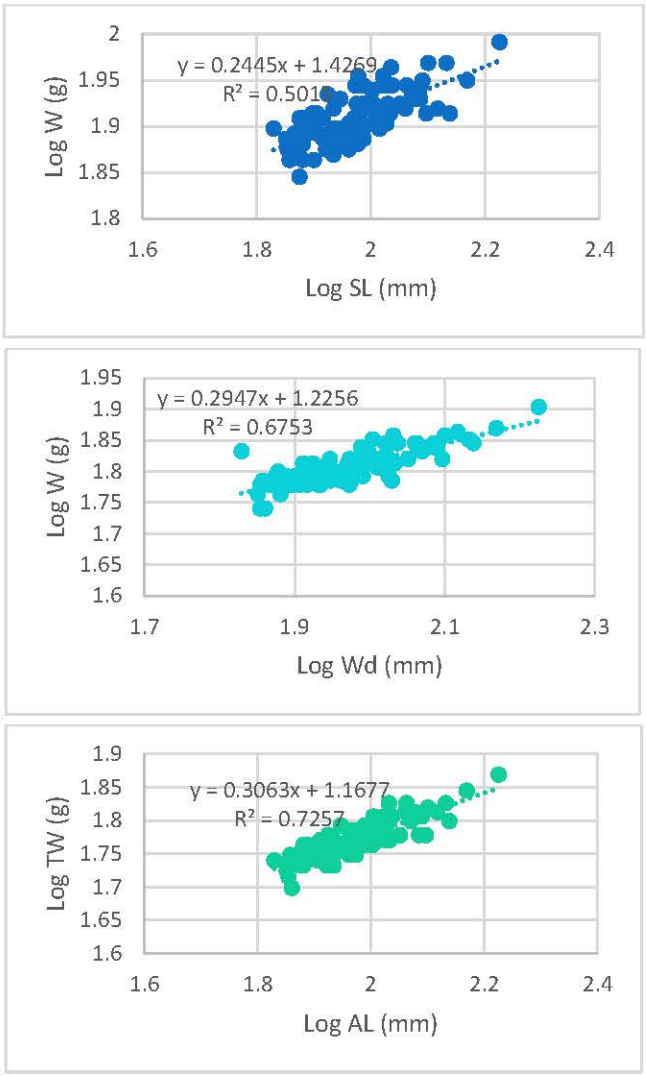


Fig. 15. Linear-weight ratio (Log 10) for the measured individuals rapana, Krapets, 03.10.2018

Parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ by natural logarithm and value of the correlation coefficient R2, presented in Table 23.

Table 23

Parameters *a, b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ and value of R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.01663
b	1.9658
R^2	0.50

3.1.1.7 TSAREVO PORT, 04.10.2018

The sample consists of 100 individuals rapana, with a total weight of 8.3656 kg, from a total of 600 kg rapanas at Tsarevo Port. The catch had been carried out by the fishing vessel ЦР 591, using scuba diving technique.

The average weight of the measured individuals reaches 83.56 g ± 14.95 SD, at an average length - 75.06 mm ± 4.34 SD, shell width - 60.13 mm ± 3.66 SD and aperture length 54.19 ± 3.57 SD. The weight without shell is 31.27 g ± 5.65 SD, which is about 38.17 % ± 4.42 SD of the total weight, varying between 26.2 and 49.4% from the meat weight (Table 24).

Table 24

Summarized statistic about the measured biological parameters - total weight (TW - weight with shell, TW, g), weight w/o shell (BW, g), % BW from TW, shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Tsarevo Port, 4.10.2018

	TW,g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	83.56	31.27	38.17	75.06	60.13	54.19
Standard Error	1.50	0.80	0.62	0.44	0.37	0.36
Median	81.50	31.25	38.74	74.00	60.00	54.00
Mode	75.00	35.50	40.00	74.00	60.00	55.00
Standard Deviation	14.95	5.65	4.42	4.34	3.66	3.57
Sample Variance	223.36	31.94	19.50	18.87	13.40	12.75
Kurtosis	4.22	-0.09	0.49	1.14	1.82	3.19
Skewness	1.56	0.52	-0.10	0.84	0.83	1.08
Range	91.00	24.00	23.23	23.00	20.00	22.00
Minimum	55.50	21.50	26.13	66.00	54.00	48.00
Maximum	146.50	45.50	49.36	89.00	74.00	70.00
Sum	8272.00	1563.50	1908.48	7431.00	5953.00	5365.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level(95.0%)	2.98	1.61	1.26	0.87	0.73	0.71

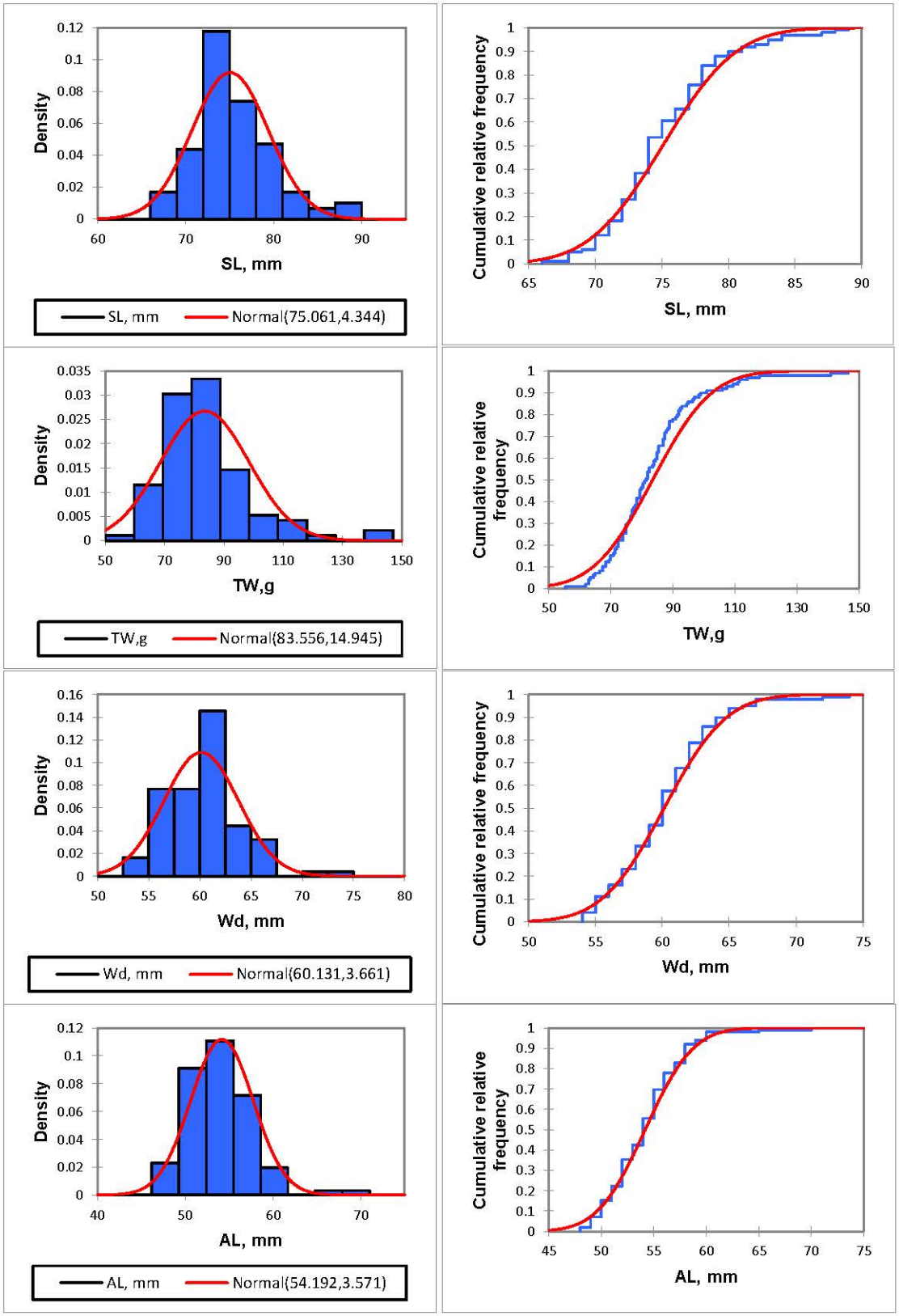


Fig. 16. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from, 04.10.2018

Most common are the size classes 72 - 75 mm (35 % from the measured individuals), as well as class - 75 - 78 mm (22 %) (Fig. 16.1, Table 25.1).

In regard to the weight structure (TW, g), the following classes are predominant: 79 - 89 g (32 % from all measured individuals), 68 - 79 g - 29 % from the total number of the measured individuals (Fig. 16.2, Table 25.2).

Table 25

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) rapana classes in the sample from Tsarevo/04.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
66	69	5	0.051	0.017
69	72	13	0.131	0.044
72	75	35	0.354	0.118
75	78	22	0.222	0.074
78	81	14	0.141	0.047
81	84	5	0.051	0.017
84	87	2	0.020	0.007
87	90	3	0.030	0.010

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	60	1	0.010	0.001
60	69	11	0.111	0.011
69	79	29	0.293	0.030
79	89	32	0.323	0.033
89	99	14	0.141	0.015
99	108	5	0.051	0.005
108	118	4	0.040	0.004
118	128	1	0.010	0.001
128	137	0	0.000	0.000
137	147	2	0.020	0.002

In regard to the parameter - shell width (Wd, mm), most common are the following classes: 60 - 63 mm -36 % (Fig. 16.3).

Based on the parameter aperture length (AL, mm), the predominant classes are 52 - 56 mm (34 %) and 49 - 52 mm (28 %, Fig. 16.4).

The following percentage ratios have been derived - width (Wd, mm)/ length (SL, mm) of the shells, aperture length (SL, mm)/total length (Wd, mm) of the shell and aperture length (AL, mm)/width (Wd, mm) of the shell.

The mean ratio - width (Wd, mm)/length (SL, mm) is 75.55 % ± 3.69 SD, while AL/SL (%) is 69.41 % ± 3.43 SD, and regarding the ratio of AL/Wd (%), the derived results is - 91.94% ± 3.63 SD (Table 26).

Table 26

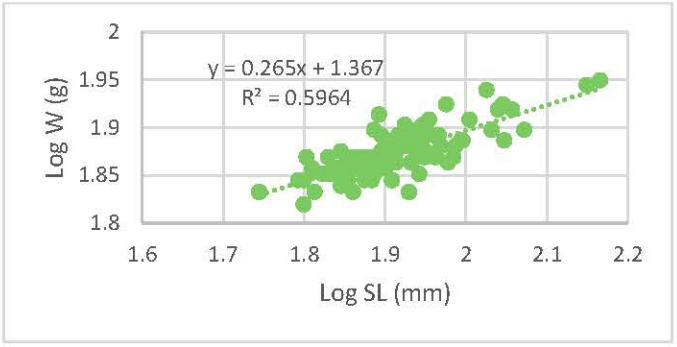
Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the individuals from Tsarevo, 04.10.2018

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	80.16	72.21	90.12
Standard Error	0.31	0.27	0.21
Median	80.28	72.50	90.00
Mode	81.82	72.97	90.00
Standard Deviation	3.11	2.68	2.12
Sample Variance	9.69	7.20	4.49
Kurtosis	0.25	0.13	0.34
Skewness	0.16	-0.12	0.09
Range	16.54	14.03	11.92
Minimum	73.17	65.38	84.75
Maximum	89.71	79.41	96.67
Sum	7935.47	7149.21	8922.05
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.62	0.54	0.42

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.265*log SL (mm) + 1.367, (R^2=0.60, p<0.001, Fig..17.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.2993*log Wd (mm) + 1.205, (R^2=0.69, p<0.001, Fig..17.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3095*log Al (mm) + 1.14, (R^2=0.64, p<0.001, Fig..17.3).

1.



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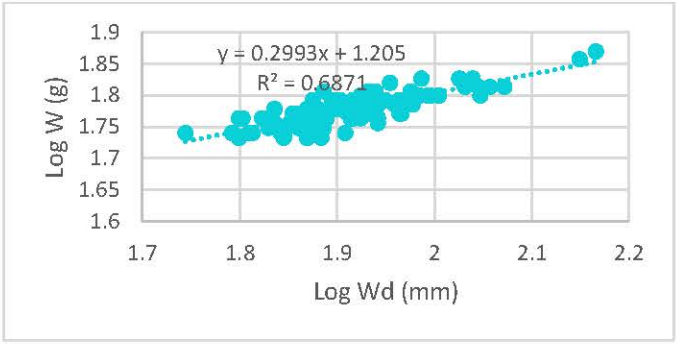


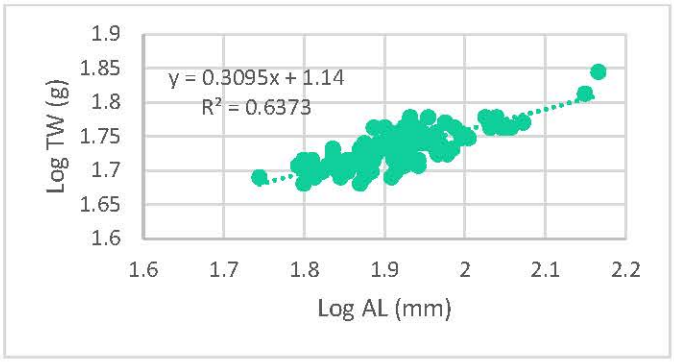
3. 

Fig. 17. Linear-weight ratio (Log 10) for the measured individuals rapana, Tsarevo, 04.10.2018

The parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ by using natural logarithm and value of the correlation coefficient R^2 are presented in Table 27.

Table 27

Parameters *a, b* of L-W ratio: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $W(g) = a.L(mm)^b$	
a	0.00497
b	2.2507
R^2	0.60

3.1.1.8 Tsarevo port, 19.10.2018

The sample consists of 100 individuals rapana, with a total weight of 5.401 kg, from a total of 280 kg landing at Tsarevo Port. The catch had been carried out by fishing vessels ЦР 591 using scuba diving technique.

The average weight of the measured individuals reaches 54.01 g ± 10.93 SD, at an average length - 61.17 mm ± 4.73 SD, shell width - 50.82 mm ± 4.03 SD and aperture length 45.65 ± 3.88 SD. The weight without shell is 19.6 g ± 3.1 SD, which is about 37.09 % ± 4.12 SD from the total weight, varying between 28.07 and 47.96 % from the meat weight (Table 28).

Table 28

Summarized statistic about the measured biological parameters - total weight (TW - weight with shell, TW, g), weight w/o shell (BW, g), % BW от TW, shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) at Tsarevo Port, 19.10.2018

	TW,g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	54.01	19.6	37.09	64.17	50.82	45.85
Standard Error	1.04	0.4	0.58	0.47	0.40	0.39
Median	55.00	19.8	36.94	64.00	51.00	46.00
Mode	55.50	21.0	36.94	67.00	53.00	47.00
Standard Deviation	10.43	3.1	4.12	4.73	4.03	3.88
Sample Variance	108.79	9.5	16.99	22.36	16.21	15.06

Kurtosis	6.48	0.1	0.26	6.45	5.34	5.79
Skewness	0.53	-0.4	0.18	-0.69	-0.36	-0.52
Range	89.00	15.0	19.89	40.00	34.00	33.00
Minimum	16.50	11.0	28.07	42.00	33.00	29.00
Maximum	105.50	26.0	47.96	82.00	67.00	62.00
Sum	5401.00	977.5	1854.37	6417.00	5082.00	4585.00
Count	100.00	50.0	50.00	100.00	100.00	100.00
Confidence Level(95.0%)	2.07	0.9	1.17	0.94	0.80	0.77

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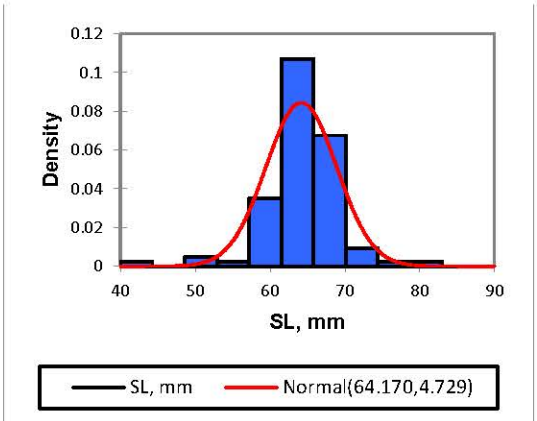

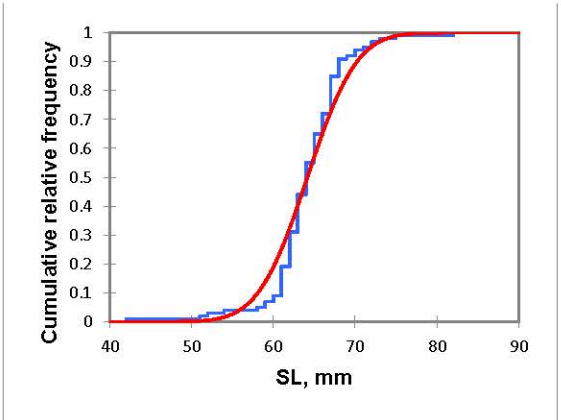

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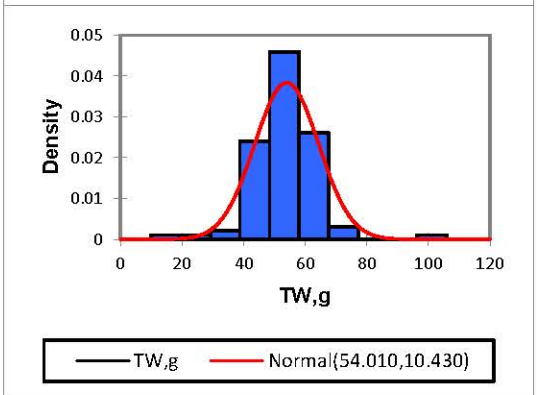

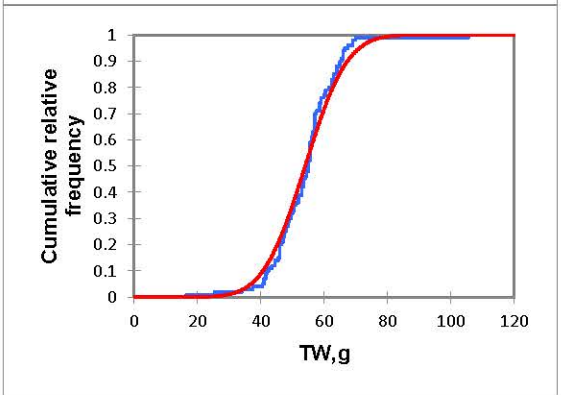

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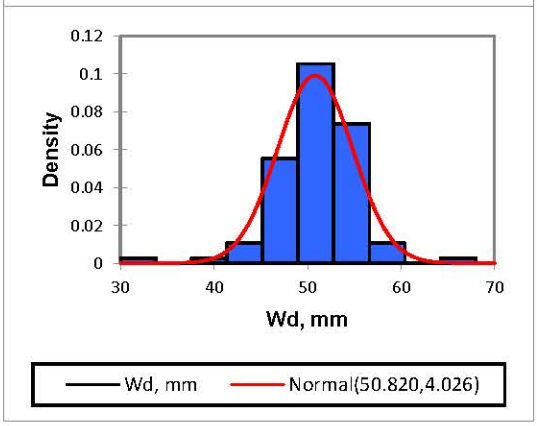

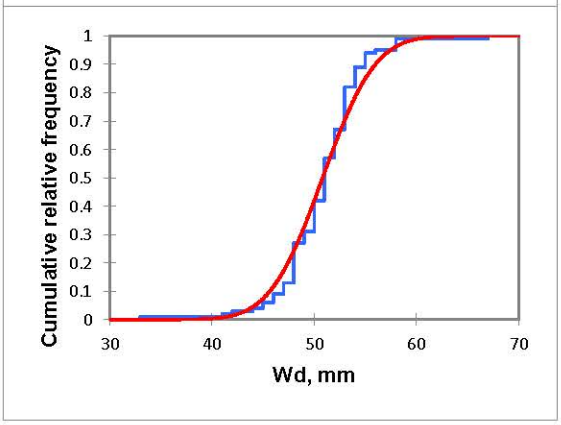

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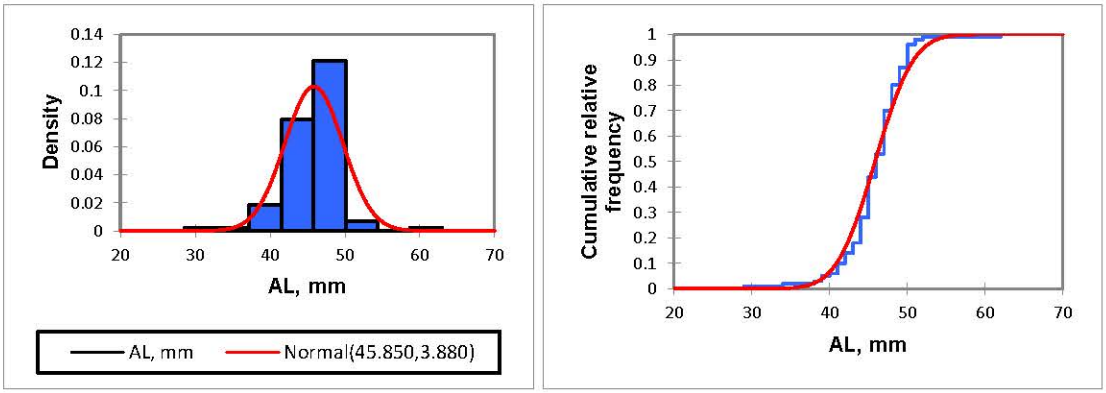

Fig. 18. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from Tsarevo, 19.10.2018

The most common size classes for these individuals are - 62 - 66 mm (46 % from the measured individuals), as well as size class - 66 - 70 mm (29 %) (Fig. 18.1, Table 29.1).

In regard to the weight structure (TW, g), the following classes are predominant: 48 - 58 g (44 % from all measured individuals), 58 - 68 g - 25 % from the total number of the measured individuals (Fig. 18.2, Table 29.2).

Table 29

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) rapana classes in the sample from Tsarevo Port/19.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
40	44	1	0.010	0.002
44	49	0	0.000	0.000
49	53	2	0.020	0.005
53	57	1	0.010	0.002
57	62	15	0.150	0.035
62	66	46	0.460	0.107
66	70	29	0.290	0.067
70	74	4	0.040	0.009
74	79	1	0.010	0.002
79	83	1	0.010	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	20	1	0.010	0.001
20	29	1	0.010	0.001
29	39	2	0.020	0.002
39	48	23	0.230	0.024
48	58	44	0.440	0.046
58	68	25	0.250	0.026
68	77	3	0.030	0.003

77	87	0	0.000	0.000
87	96	0	0.000	0.000
96	106	1	0.010	0.001

In regard to the parameter - shell width (Wd, mm), most common classes in the sample are: 49 - 53 mm - 40 % and 53 - 57 mm -28 % (Fig. 18.3).

Based on the aperture length parameter (AL, mm), the dominant classes are 46 - 50 mm (52 %) and 42 - 46 mm (34 %, Fig. 18.4).

The mean ratio - width (Wd, mm)/length (SL, mm) is 79.23 % ± 3.22 SD, while AL/SL (%) is 71.45 % ± 3.07 SD, and in regard to the ratio AL/Wd (%), the derived result is – 90.21% ± 2.62 SD (Table 30).

Table 30

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the individuals from Tsarevo, 19.10.2018

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	79.23	71.45	90.21
Standard Error	0.32	0.31	0.26
Median	79.10	71.43	90.38
Mode	82.26	74.63	90.38
Standard Deviation	3.22	3.07	2.62
Sample Variance	10.35	9.43	6.86
Kurtosis	-0.25	-0.36	0.96
Skewness	0.13	0.15	-0.76
Range	14.87	15.75	13.39
Minimum	72.22	63.93	80.95
Maximum	87.10	79.69	94.34
Sum	7922.90	7145.09	9021.22
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.64	0.61	0.52

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.304*log SL (mm) + 1.2821, (R^2=0.70, p<0.001, Fig..19.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.3457*log Wd (mm) + 1.1088, (R^2=0.81, p<0.001, Fig..19.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3538*log Al (mm) + 1.0499, (R^2=0.72, p<0.001, Fig..19.3).

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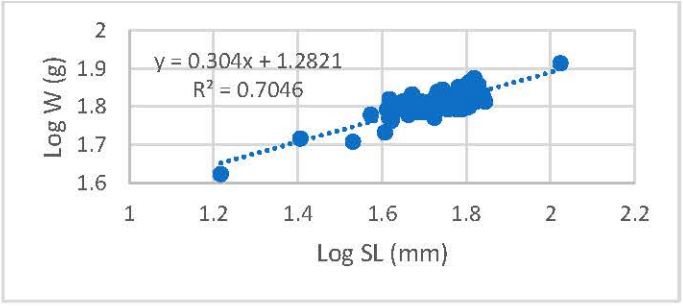

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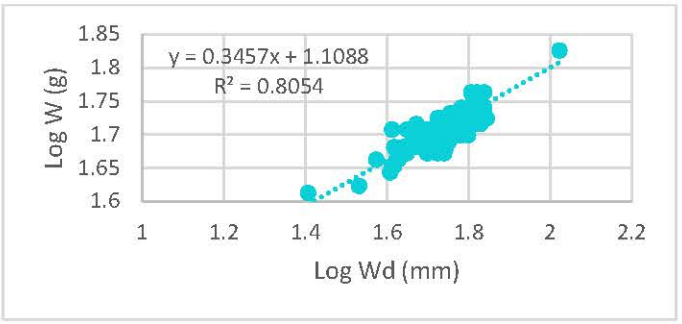

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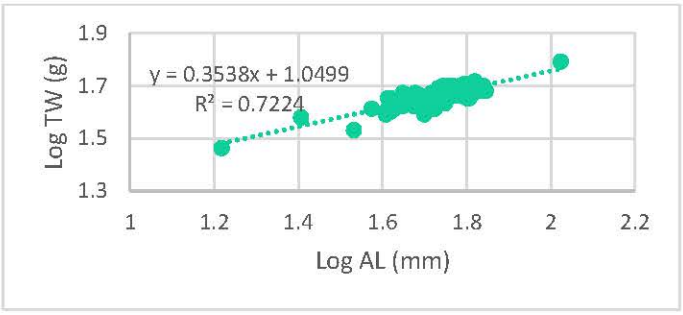

Fig. 19. Linear-weight ratio (Log 10) for the measured individuals rapana, Царево, 19.10.2018

Parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ by using natural logarithm and value of the correlation coefficient R^2 are presented in Table 31.

Table 31

Parameters *a, b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.0034
b	2.3177
R^2	0.70

3.1.1.9 VARNA PORT, 04.11.2018

The sample consists of 100 individuals rapana, with a total weight of 4.1065 kg, from a total of 5380 kg landing for 2 days at Varna Port, fishing vessel РК №4, equipped with beam-trawl.

The average weight of the measured individuals reaches 41.07 g ± 14.77 SD, at an average length - 62.99 mm ± 6.57 SD, shell width - 47.97 mm ± 6.13 SD and aperture length 44.09 ± 5.7 SD. The weight without shell is 17.12 g ± 5.68 SD is 42.52 % ± 4.78 SD from the weight with shell, varying between 31.9 % and 55 % from the meat weight (Table 32).

Table 32

Summarized statistic about the measured biological parameters - total weight (TW - weight with shell, TW, g), weight w/o shell (BW, g), % BW from TW, shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) for Varna Port, 4.11.2018

	TW,g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm

Mean	41.07	17.12	42.52	62.99	47.97	44.09
Standard Error	1.48	0.80	0.68	0.66	0.61	0.57
Median	38.25	17.00	42.52	62.50	48.00	44.00
Mode	28.50	23.00	44.44	60.00	50.00	40.00
Standard Deviation	14.77	5.68	4.78	6.57	6.13	5.70
Sample Variance	218.11	32.22	22.85	43.20	37.54	32.49
Kurtosis	0.80	0.41	0.32	-0.35	0.18	-0.08
Skewness	0.80	0.43	0.17	0.34	0.31	0.23
Range	72.00	28.00	23.10	31.00	32.00	26.00
Minimum	14.50	6.00	31.90	50.00	35.00	33.00
Maximum	86.50	34.00	55.00	81.00	67.00	59.00
Sum	4106.50	856.00	2126.01	6299.00	4797.00	4409.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level(95.0%)	2.93	1.61	1.36	1.30	1.22	1.13

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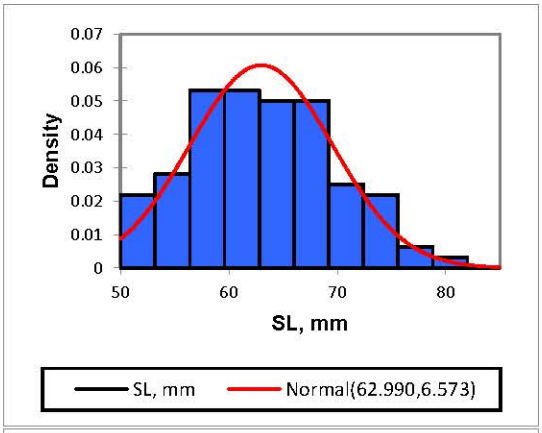

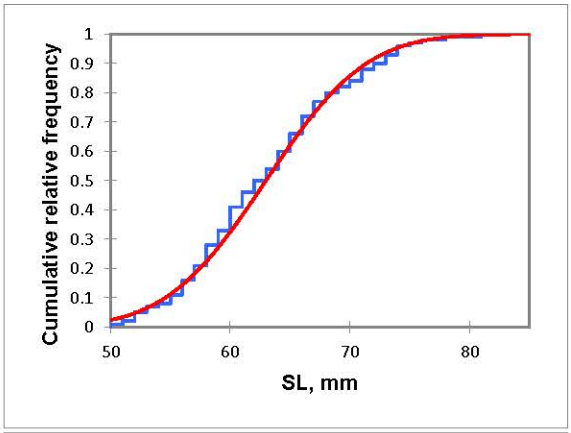

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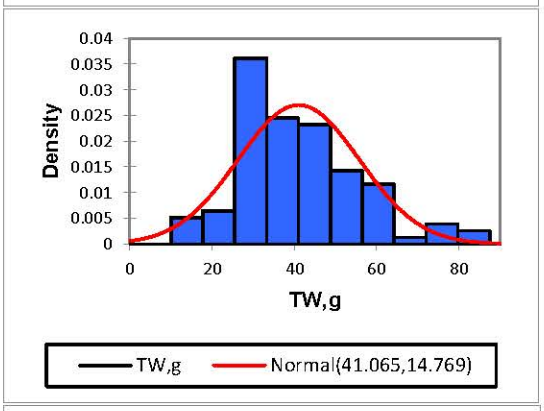

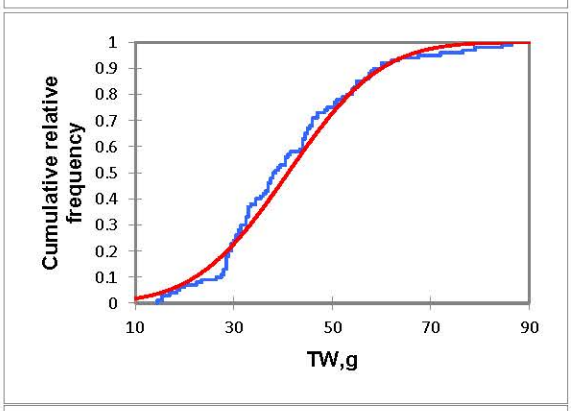

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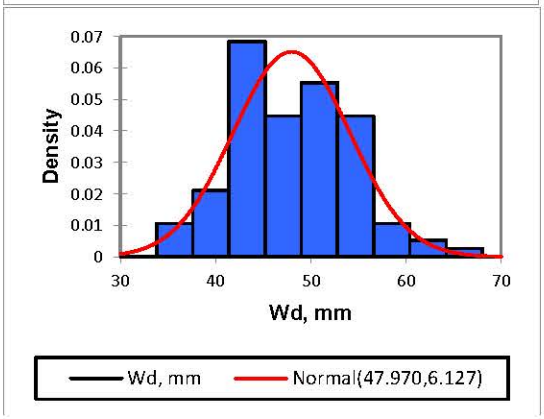

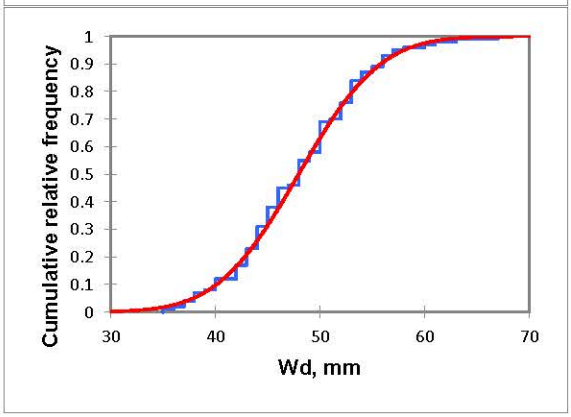

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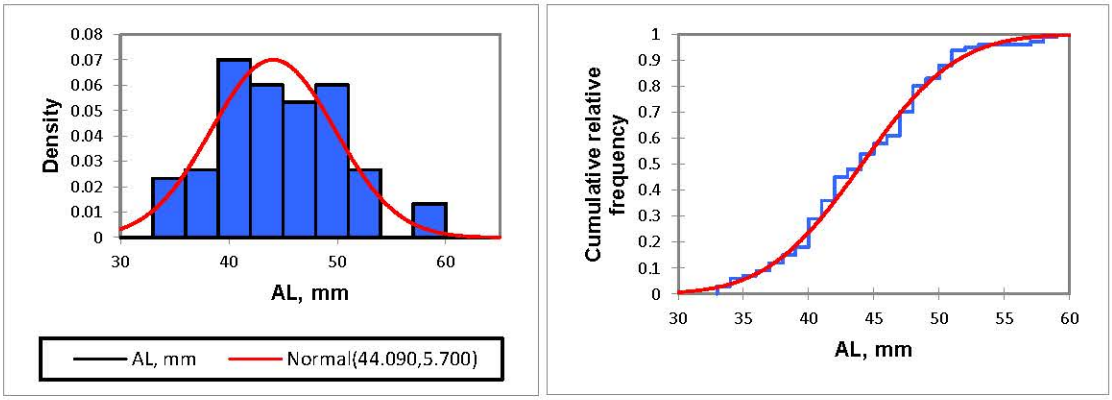


Fig. 20. Distribution of the measured parameters: shell length (SL, mm, 1), total weight (TW, g, 2), shell width (Wd, mm, 3), aperture length (AL, mm, 4) by classes and cumulative distribution by class in the sample from Varna, 04.11.2018

The most common individuals are from size class - 56 - 60 mm and 60 - 63 mm (*17 % from the measured individuals), as well as size classes – 63 - 66 mm and 66-69 mm (*16 %) (Fig. 20.1, Table 33.1).

In regard to the weight structure (TW, g), the following classes are predominant: 26 - 33 g (28 % from all measured individuals), 33 - 41g - 19 % from the total number of the measured individuals (Fig. 20.2, Table 33.2).

Table 33

Statistical data about the distribution of the size (mm, 1) and weight (g, 2) rapana classes in the sample from Varna/04.11.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	53	7	0.070	0.022
53	56	9	0.090	0.028
56	60	17	0.170	0.053
60	63	17	0.170	0.053
63	66	16	0.160	0.050
66	69	16	0.160	0.050
69	72	8	0.080	0.025
72	76	7	0.070	0.022
76	79	2	0.020	0.006
79	82	1	0.010	0.003

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	18	4	0.040	0.005
18	26	5	0.050	0.006
26	33	28	0.280	0.036
33	41	19	0.190	0.025
41	49	18	0.180	0.023

49	57	11	0.110	0.014
57	64	9	0.090	0.012
64	72	1	0.010	0.001
72	80	3	0.030	0.004
80	88	2	0.020	0.003

In regard to the parameter - shell width (Wd, mm), most common are the following classes: 41 - 45 mm -26 % and 49 - 53 mm -21 % (Fig. 20.3).

Based on the parameter aperture length (AL, mm), the dominant classes are 39 - 42 mm (21 %) and 42 - 45 mm (18 %, Fig. 20.4).

The mean ratio - width (Wd, mm)/length (SL, mm) is 76.06 % ± 4.15 SD, while for the AL/SL (%) it is 69.88 % ± 3.64 SD, and the ratio AL/Wd (%) is calculated at 91.91% ± 2.12 SD (Table 34).

Table 34

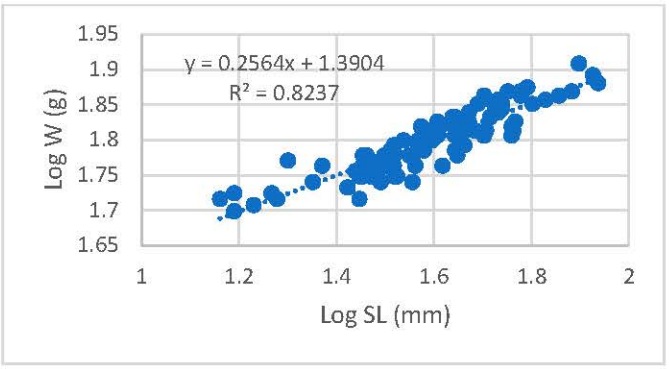
Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the individuals from Varna, 04.11.2018

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	76.06	69.88	91.91
Standard Error	0.42	0.36	0.21
Median	75.44	69.85	92.00
Mode	75.00	66.67	94.00
Standard Deviation	4.15	3.64	2.12
Sample Variance	17.23	13.22	4.51
Kurtosis	3.89	1.44	-0.28
Skewness	1.11	0.53	-0.24
Range	27.30	21.26	9.64
Minimum	66.04	62.07	86.36
Maximum	93.33	83.33	96.00
Sum	7605.65	6988.04	9191.37
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.82	0.72	0.42

The following linear-weight relationships have been derived:

1. Between weight (TW, g) and linear size (SL, mm): LogTW (g) = 0.2564*log SL (mm) + 1.3904, (R^2=0.82, p<0.001, Fig..21.1).
2. Between weight (TW, g) and shell width (Wd, mm): LogTW (g) = 0.3172*log Wd (mm) + 1.1745, (R^2=0.83, p<0.001, Fig..21.2)
3. Between weight (TW, g) and aperture length (AL, mm): Log TW (g) = 0.3236*log Al (mm) + 1.277, (R^2=0.84, p<0.001, Fig..21.3).

1.



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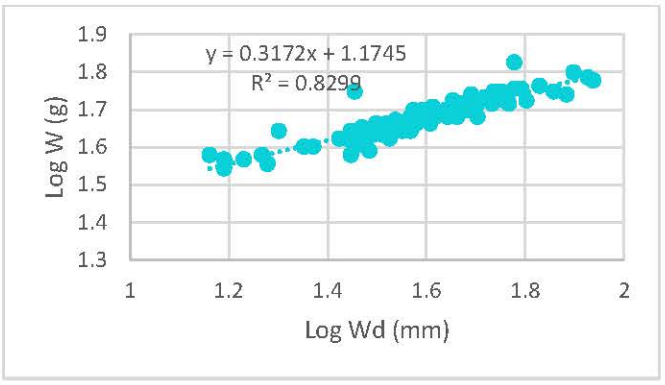

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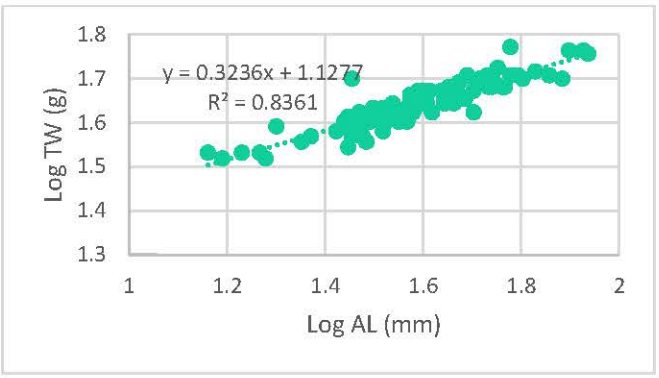


Fig. 21. Linear-weight ratio (Log 10) for the measured individuals rapana, Varna, 04.11.2018

Parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ by using natural logarithm and value of the correlation coefficient R^2 presented in Table 35.

Table 35

Parameters *a, b* of the L-W ratio, given by the equation: $TW(g) = a.SL(mm)^b$ and value of R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.0000651
b	3.21231
R^2	0.82

3.1.1.10 SUMMARIZED DATA ABOUT THE 4TH QUARTER OF 2018

In the fourth quarter of 2018, based on the fishing technique, the landings at the four observed ports varied between 280-2690 kg / day and the highest values were recorded for beam trawl. When using Scuba diving for catching, landings vary between 280 - 985 kg / day, with the most significant quantities at the port of Carpets in early October and the lowest - in mid October in the port of Tsarevo

Table 36

Summarized data about the landings by days and technique for all ports and fishing vessels for the 4th quarter of 2018.

Date	Landing port	Fishing vessel length (m)	Landed quantity (kg) from fishing vessel	Weight of the sample with 100 ind *R. venosa* (kg)	Fishing technique/gear
03.10.2018r.	Krapets	6.5 m	985	9.545	Scuba diving
04.10.2018r.	Tsarevo	8.9 m	600	8.356	Scuba diving
19.10.2018r.	Tsarevo	8.9 m	280	5.401	Scuba diving
07.11.2018r.	Varna	12.58 m	5380 kgs rapana fop 2 days or 2690 (kg/day)	4.107	Beam trawl

The average weight of *R.venosa*, caught by scuba diving, is 77.65 g TW ± 22.88 SD. The minimum and maximum weights are in the range of 16.5 – 168 g TW. The average sized *R.venosa* is estimated to be 73.47 mm SL ± 8.52 SD, while the minimum and maximum sizes are 42 and 98 mm respectively. The average size in the northern part of the Black Sea is with 15,4% bigger than the one in the southern part. (Fig. 22 и 23).

During the 4th quarter of 2018, the landings from beam-trawls showed an average weight of *R.venosa* - 41.07 g TW ± 14.77 SD, the minimum and maximum values to be - 14.5 - 86.5 g TW. The average size of *R.venosa* is 62.99 mm SL ± 6.57 SD, which is 15.4 % shorter than the one measured from the scuva diving fishing. The minimum and maximum sizes are in the range of 50 - 81 mm SL.

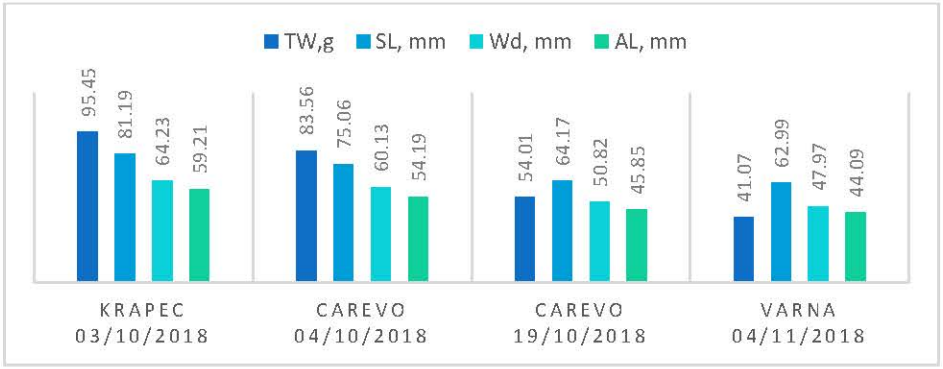


Fig. 22. Distribution of the mean values for the biological parameters of *R. venosa* – total weight (TW, g), shell length (SL, mm), shell width (Wd, mm) and aperture length (AL, mm) by ports for the 4th quarter of 2018

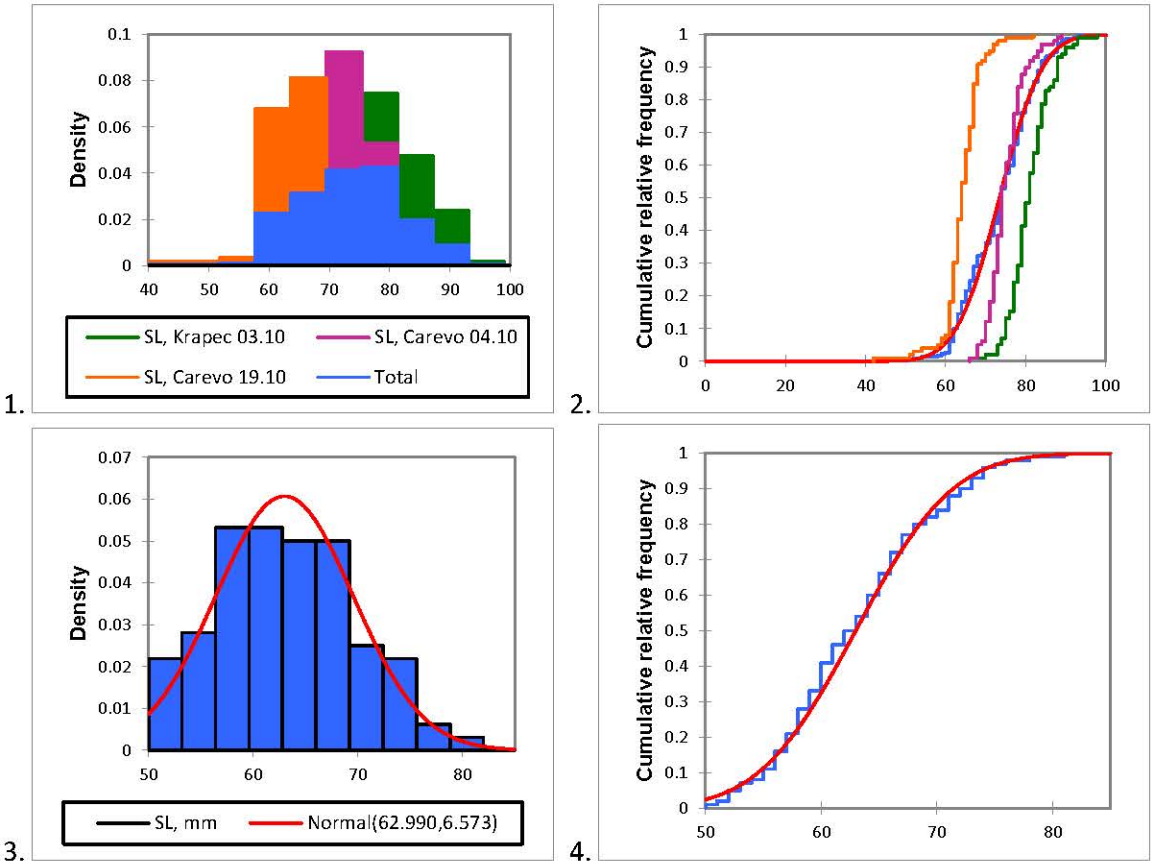


Fig. 23. Distribution of the classes by shell size (SL, mm) for different types of fishing: (1) Scuba diving and (3) beam trawl; cumulative distribution by classes for the two types of fishing (2, 4) for the 4th quarter of 2018

For the fishing with scuba diving, the most common individuals are within group - 75 - 81 mm and 70 - 75 mm (25 - 24 % from all measured individuals) (Fig. 23.1). For 94 % of the measured individuals, the average size is less than < 87 mm (Fig. 23.2). For the beam trawl fishing, most individuals refer to size groups - 56 - 63 mm (34 % from all measured individuals) (Fig. 23.3 and 23.4).

During the fourth quarter of 2018, with scuba diving, the dominant classes of the weight structure are 68 - 85 g (27 %) and 51 - 68 g (24 % from the total number of the measured individuals) (Fig. 24.1). 86% of the measured individuals are with a weight of < 102 g, while just 4% are bigger than > 119 g (Fig. 24.2). In regard to beam trawl, the weight class 26 - 33 g (28 % from all measured individuals) and 33 - 41 g - 19 % from the total number of the measured individuals (Fig. 24.3 и 24.4).

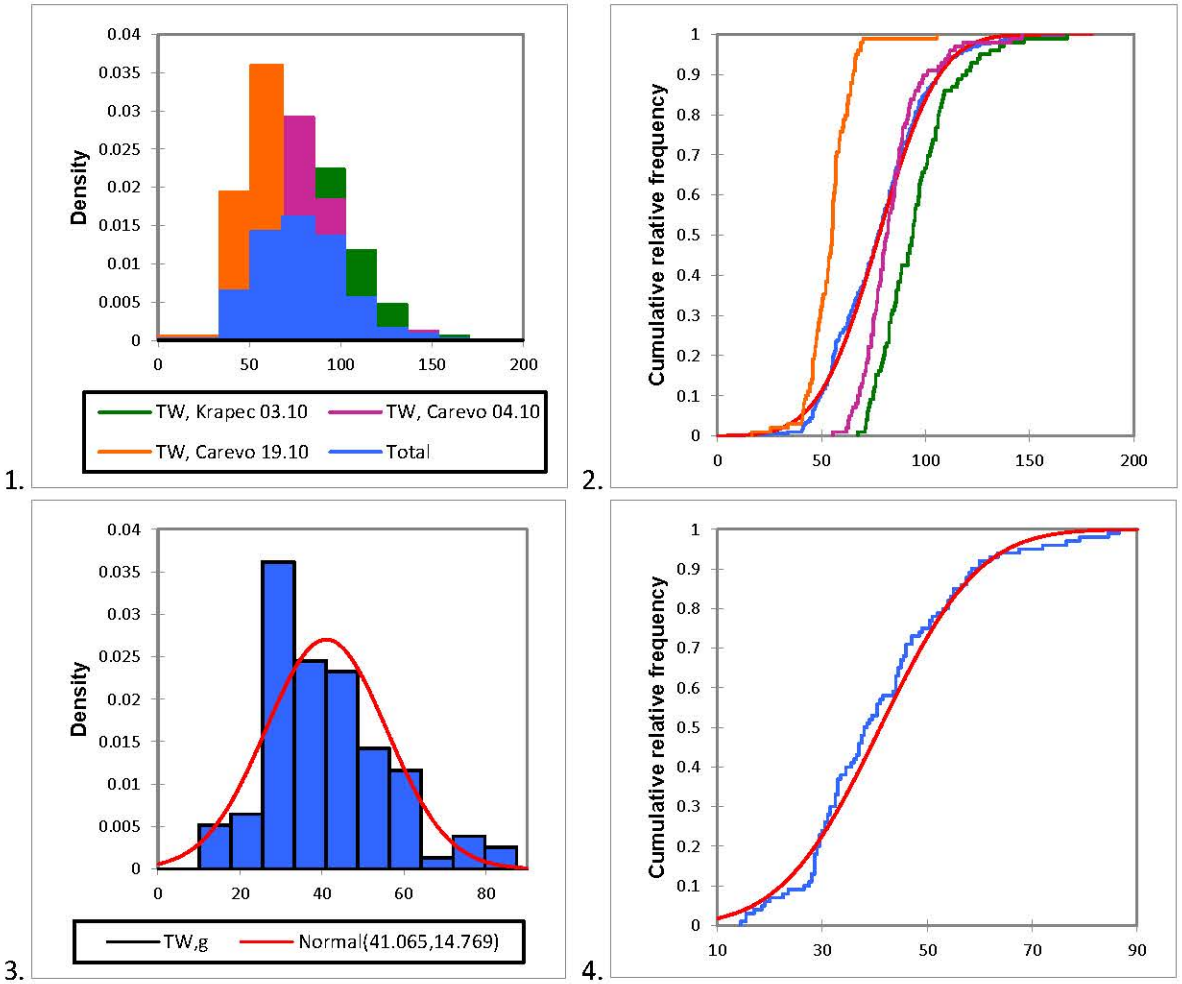


Fig. 24. Distribution of *R.venosa* by classes according to weight (TW, g) for different types of fishing: - (1) Scuba diving and (3) beam trawl and cumulative distribution by class for both fishing types (2, 4) for the fourth quarter of 2018

The comparison analysis of the parameters *a* and *b* of the L-W ratio from type: $TW(g) = a.SL(mm)^b$ shows allometric growth of *R. venosa* with a coefficient $b \neq 3$ (t-test, p=0.05) and significant differences in the (Fig. 25).

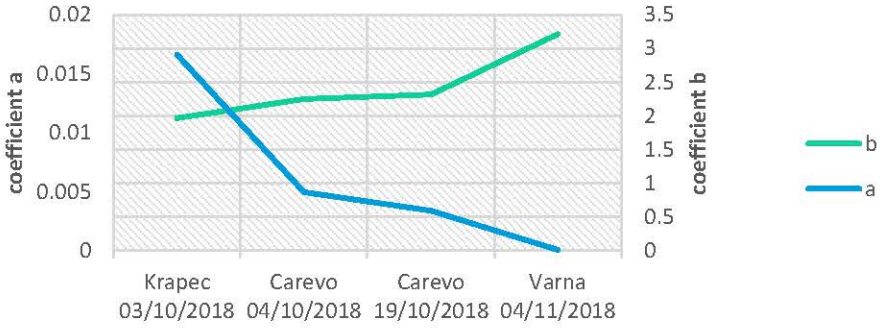


Fig. 25. Parametrs *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$, for the different landing ports for the 4t[h] quarter of 2018.

Percentage ratios of the width to length of the shells (Wd/SL, %) на *R. venosa*, aperture length to the total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the 4th qurter of 2018 are presented on Fig. 26.

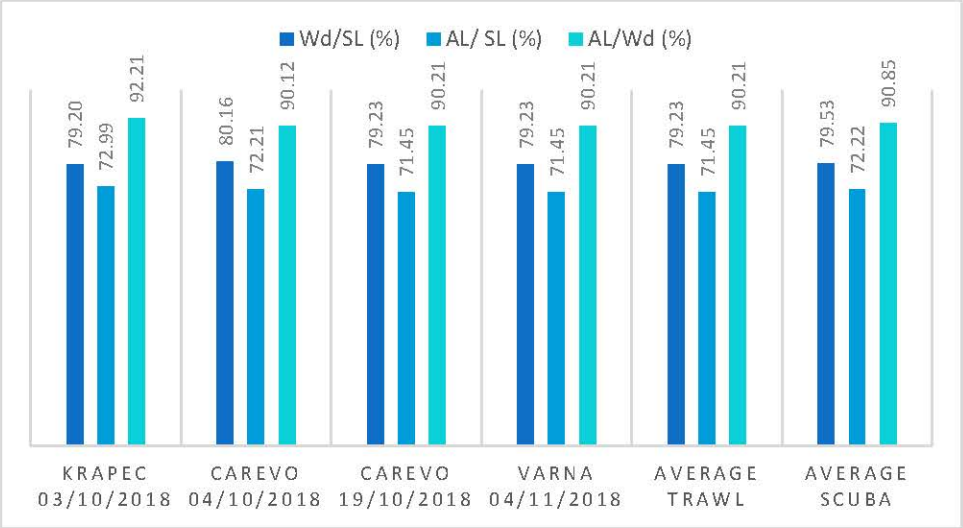


Fig. 26. Percentage ratios between shell width and length (Wd/SL, %) на *R. venosa*, aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the fourth quarter of 2018

Data is consistent and some conslusions were derived: Wd/SL is 79.53 % and is with 0.38 % bigger than the one from beam trawl. Accordingly the AL/SL ratio is 72.22% and reveals a difference of 1.07 % compared to the ones, caught by beam trawl. As for the AL/Wd, the mean value for scuba diving method is 90.85 %, which is 0.7 % higher than the mean value for the beam trawl method.

3.1.2 Sex structure

3.1.2.1 Port Kavarna, 12.07.2018

The sex ratio in the analyzed sample is 44 % ♀ to 56 % ♂ or 1 : 1.27. The average size for the female individuals is (SL, mm) 58.23 mm ± 54.78 SD, while for the males it is about 0.39 % bigger (Table 37).

Table 37

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Kavarna Port, 12.07.2018

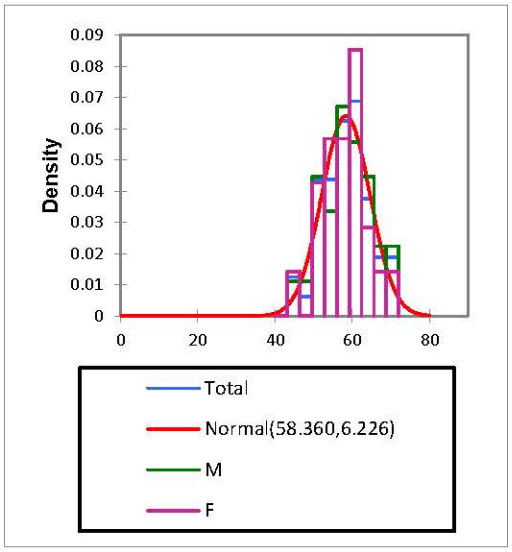
	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	58.23	58.46	33.68	34.59
Standard Error	1.25	1.25	2.01	2.12
Median	58.00	58.00	32.00	33.25
Mode	58.00	60.00	32.00	51.50
Standard Deviation	5.87	6.60	9.45	11.22
Sample Variance	34.47	43.52	89.27	125.91

Kurtosis	0.49	-0.71	0.79	-1.09
Skewness	-0.05	-0.05	0.83	-0.10
Range	26.00	25.00	38.50	38.50
Minimum	45.00	45.00	18.00	13.00
Maximum	71.00	70.00	56.50	51.50
Sum	1281.00	1637.00	741.00	968.50
Confidence Level(95.0%)	2.60	2.56	4.19	4.35

The female individuals are mostly within size classes 59 - 63 mm - 27 %, 53 -56 mm and 56 -59 mm *18 % (Fig. 27, Table 38.2).

The dominant size classes for the male individuals is 56 - 59 mm - 21 %, followed by size class 59 - 62 mm - 18 % (Fig. 27, Table 38.1).

1.



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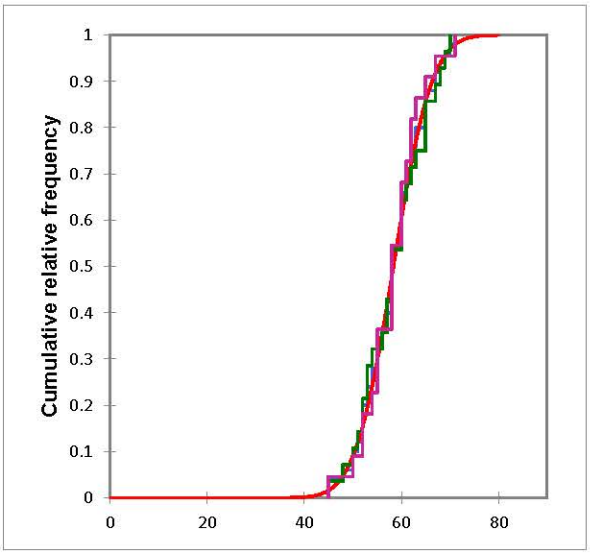


Fig. 27. Distribution of the size classes by gender (1) based on shell length (SL, mm) and cumulative distribution of the size classes by gender (2) in the sample from Kavarna, 12.07.2018

Table 38

Statistical data about the distribution of the size (mm) classes of rapana by gender (1, male; 2, female) in the sample from Kavarna Port, 12.07.2018

1

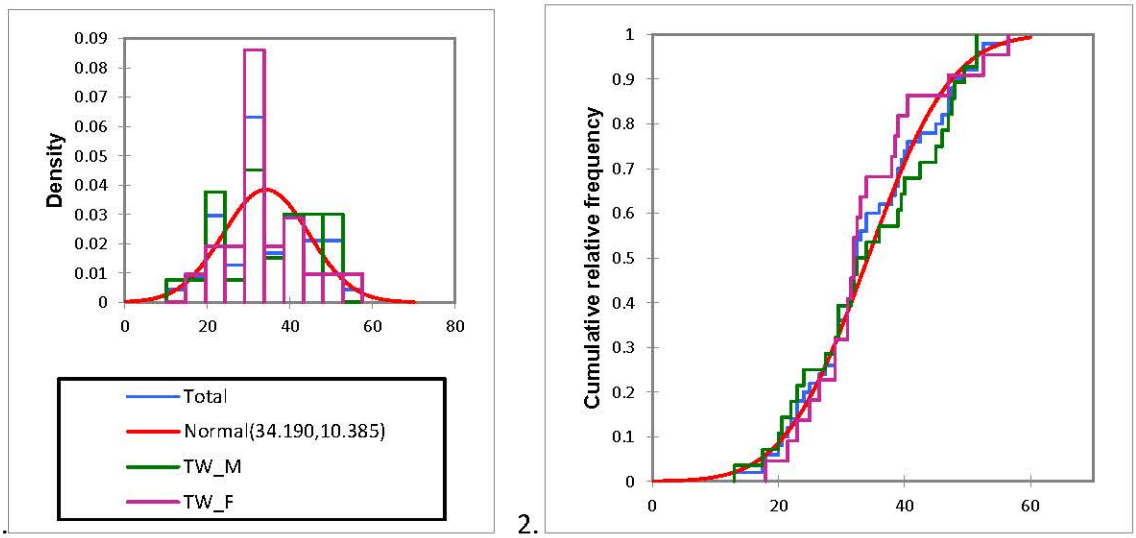
Lower bound	Upper bound	Frequency	Relative frequency	Density
43	46	1	0.036	0.011
46	50	1	0.036	0.011
50	53	4	0.143	0.045
53	56	3	0.107	0.033
56	59	6	0.214	0.067
59	62	5	0.179	0.056
62	66	4	0.143	0.045
66	69	2	0.071	0.022
69	72	2	0.071	0.022

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
43	46	1	0.045	0.014
46	50	0	0.000	0.000
50	53	3	0.136	0.043
53	56	4	0.182	0.057
56	59	4	0.182	0.057
59	62	6	0.273	0.085
62	66	2	0.091	0.028
66	69	1	0.045	0.014
69	72	1	0.045	0.014

The average weight for the male individuals is (TW, g) 34.59 g ± 11.22 SD, while the average weight for the female individuals is with 2.7 % lower (Table 37).

The following weight classes are predominant in the male individuals 29 - 34 g - 21% and 20 - 24 g - 18 %, followed by weight classes 39 - 42 g, 43 - 48 g, 48 - 53 g *14 % (Fig. 28, Table 39). As for the female individuals, the most common weight classes are 29 - 34 g - 41% and 39 - 43 g *14 % (Fig. 28, Table 39).



1. 2.

Fig. 28. Distribution of the weight classes by gender (1) based on weight (TW, g) and cumulative distribution of the weight classes by gender (2) in the sample from Kavarna, 12.07.2018

Table 39

Statistical data about the distribution of the weight (g) classes of rapana by gender (1, male; 2, female) in the sample from Kavarna Port/12.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	15	1	0.036	0.008
15	20	1	0.036	0.008
20	24	5	0.179	0.038

24	29	1	0.036	0.008
29	34	6	0.214	0.045
34	39	2	0.071	0.015
39	43	4	0.143	0.030
43	48	4	0.143	0.030
48	53	4	0.143	0.030
53	58	0	0.000	0.000

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
15	20	1	0.045	0.010
20	24	2	0.091	0.019
24	29	2	0.091	0.019
29	34	9	0.409	0.086
34	39	2	0.091	0.019
39	43	3	0.136	0.029
43	48	1	0.045	0.010
48	53	1	0.045	0.010
53	58	1	0.045	0.010

3.1.2.2 Port Balchik, 27.07.2018

A representative sample of the sample has an established presence of imposex individuals and the sex ratio is 70.15% ♂: 26.87% ♀: 2.99% imposex or 2.65: 1: 0.11. In terms of the shell length (SL, mm), in females the average size was 58.39 mm ± 3.52 SD, and in males the average size was 6.7% larger. In the case of the individuals, the average size of the shell is 3.6% larger than the female specimens (Table 40).

Table 40

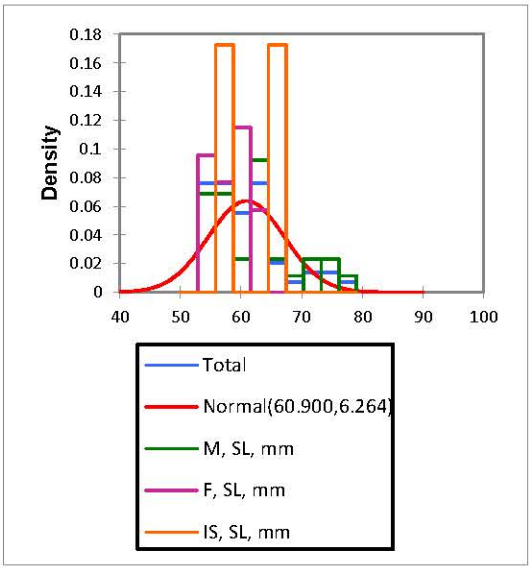
Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Balchik Port, 27.07.2018

	SL, mm			TW, g		
	Females	Males	Imposex	Females	Males	Imposex
Mean	58.39	62.43	60.50	34.36	44.83	36.25
Standard Error	0.83	1.31	4.50	1.48	2.89	4.25
Median	58.50	62.00	60.50	35.25	40.00	36.25
Mode	58.00	58.00		37.00	33.50	
Standard Deviation	3.52	7.16	6.36	6.27	15.81	6.01
Sample Variance	12.37	51.29	40.50	39.26	249.82	36.13
Kurtosis	-0.93	-0.30		-1.03	0.50	
Skewness	0.01	0.75		-0.15	1.11	
Range	11.00	25.00	9.00	21.00	64.00	8.50
Minimum	53.00	53.00	56.00	24.00	23.00	32.00
Maximum	64.00	78.00	65.00	45.00	87.00	40.50
Sum	1051.00	1873.00	121.00	618.50	1345.00	72.50
Confidence Level (95.0%)	1.75	2.67	57.18	3.12	5.90	54.00

The predominant size classes for the male individuals are three - 62 - 65 mm, 27 %, as well as size classes - 53-56 mm and 56-59 mm – forming around *20 % from all the size classes (Fig. 29, Table 41.1).

There is a similar picture with the female individuals, most are in the size classes - 59 - 62 mm - 33 % and 53-56 mm, 28 % from all the size classes (Fig. 29, Table 41.2).

1.



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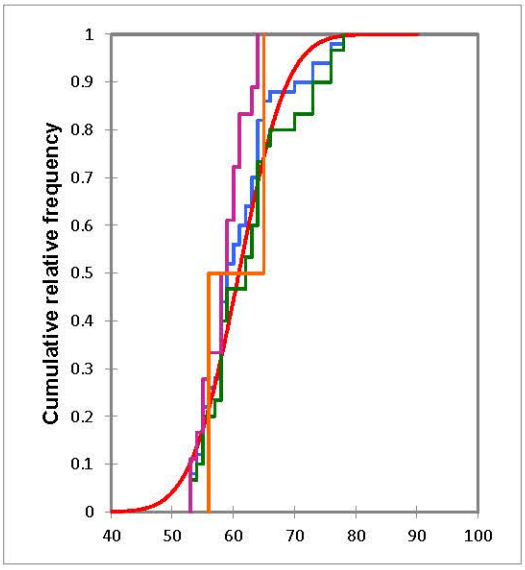


Fig. 29. Distribution by sex and size classes (1) based on shell length (SL, cm) and cumulative distribution of the size classes by sex (2) in the sample from Balchik, 27.07.2018

Table 41

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Balchik Port/27.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
53	56	6	0.200	0.069
56	59	6	0.200	0.069
59	62	2	0.067	0.023
62	65	8	0.267	0.092
65	67	2	0.067	0.023
67	70	1	0.033	0.011
70	73	2	0.067	0.023
73	76	2	0.067	0.023
76	79	1	0.033	0.011

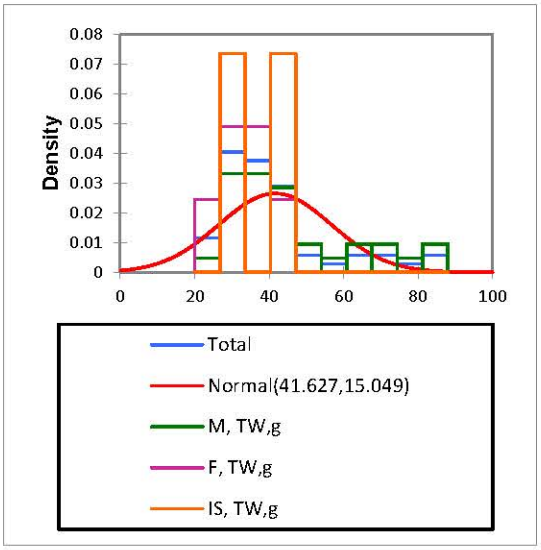
2

Lower bound	Upper bound	Frequency	Relative frequency	Density
53	56	5	0.278	0.096
56	59	4	0.222	0.077
59	62	6	0.333	0.115
62	65	3	0.167	0.057

65	67	0	0.000	0.000
67	70	0	0.000	0.000
70	73	0	0.000	0.000
73	76	0	0.000	0.000
76	79	0	0.000	0.000

In regard to the body weight (TW, g), the average weight for the male individuals is 46.19 g ± 17.29 SD, the average weight for the female individuals is with 29 % lower (Table 40).

1.



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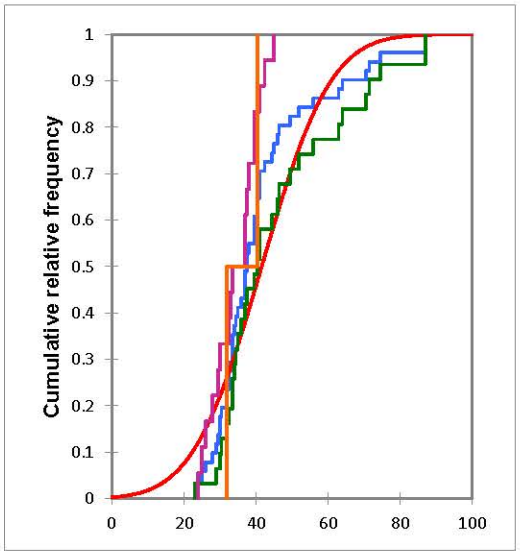


Fig. 30. Distribution of the size classes by gender (1) based on the total weight (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Balchik, 27.07.2018

Table 42

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Balchik Port, 27.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
20	27	1	0.032	0.005
27	34	7	0.226	0.033
34	40	7	0.226	0.033
40	47	6	0.194	0.028
47	54	2	0.065	0.009
54	61	1	0.032	0.005
61	68	2	0.065	0.009
68	74	2	0.065	0.009
74	81	1	0.032	0.005
81	88	2	0.065	0.009

2

Lower bound	Upper bound	Frequency	Relative frequency	Density

20	27	3	0.167	0.025
27	34	6	0.333	0.049
34	40	6	0.333	0.049
40	47	3	0.167	0.025
47	54	0	0.000	0.000
54	61	0	0.000	0.000
61	68	0	0.000	0.000
68	74	0	0.000	0.000
74	81	0	0.000	0.000
81	88	0	0.000	0.000

3.1.2.3 PORT BALCHIK, 28.07.2018

In this sample were found imposex individuals and the gender ratio in the representative sample was 48% ♀: 46% ♂: 6% imposex or - 1: 1.04: 0.13. In terms of the shell size (SL, mm) in females the average size is 65.92 mm ± 8.28 SD, and in males the averages size is 5.4% larger. In the case of imposex individuals, the average shell size is the smallest and is 3% smaller than that of the female specimens (Table 44).

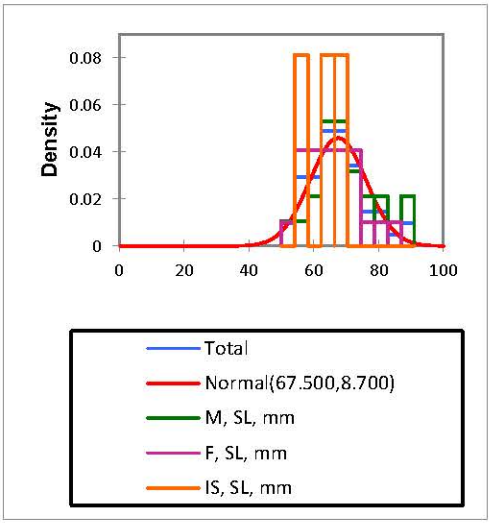
Table 44

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by gender in the sample from Balchik Port, 28.07.2018

	SL, mm			TW, g		
	Females	Males	Imposex	Females	Males	Imposex
Mean	65.92	69.61	64.00	49.83	60.89	44.17
Standard Error	1.69	1.92	3.46	4.01	4.73	5.83
Median	65.00	68.00	64.00	48.50	54.50	42.50
Mode	73.00	68.00		44.50	50.50	
Standard Deviation	8.28	9.20	6.00	19.66	22.67	10.10
Sample Variance	68.51	84.61	36.00	386.60	513.77	102.08
Kurtosis	0.07	0.10		2.04	1.80	
Skewness	0.53	0.54	0.00	1.17	1.17	0.72
Range	33.00	37.00	12.00	81.50	101.00	20.00
Minimum	52.00	53.00	58.00	25.00	22.00	35.00
Maximum	85.00	90.00	70.00	106.50	123.00	55.00
Sum	1582.00	1601.00	192.00	1196.00	1400.50	132.50
Confidence Level (95.0%)	3.50	3.98	14.90	8.30	9.80	25.10

In regard to the male individuals, the predominant size classes are 62 - 66 mm and 66 - 71 mm - *22 % (Fig. 31, Table 45.1). Accordingly, for the female individuals the most abundant size classes are 54 - 75 mm and both comprise 17 % (Fig.. 31, Table 45.2). The size classes in the imposex forms are equally represented. (Fig.. 31).

1.



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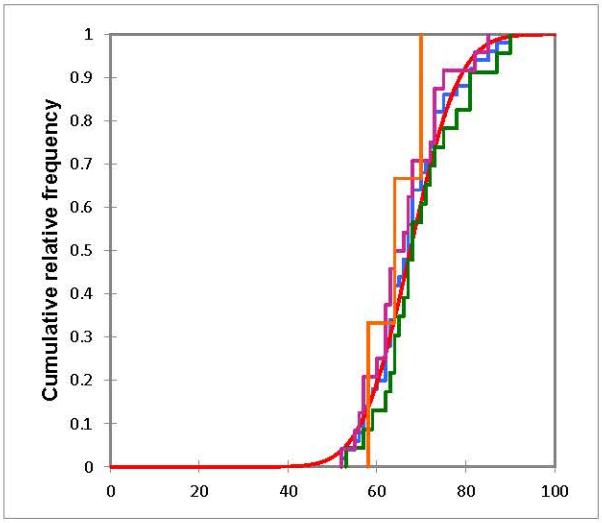


Fig. 31. Distribution of the size classes by gender (1) based on shell length (SL, cm) and cumulative distribution of the size classes by sex (2) in the sample from Balchik, 28.07.2018

Table 45

Statistical data about the distribution of the size (mm) classes of rapana by gender (1, male; 2, female) in the sample from Balchik Port, 28.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	54	1	0.043	0.011
54	58	1	0.043	0.011
58	62	2	0.087	0.021
62	66	5	0.217	0.053
66	71	5	0.217	0.053
71	75	3	0.130	0.032
75	79	2	0.087	0.021
79	83	2	0.087	0.021
83	87	0	0.000	0.000
87	91	2	0.087	0.021

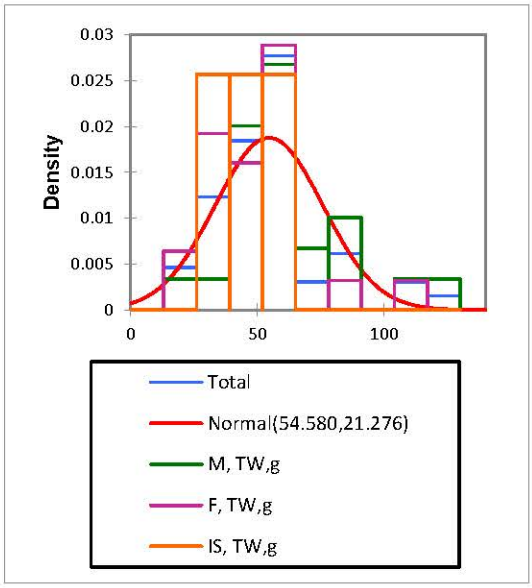
2

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	54	1	0.042	0.010
54	58	4	0.167	0.041
58	62	4	0.167	0.041
62	66	4	0.167	0.041
66	71	4	0.167	0.041
71	75	4	0.167	0.041
75	79	1	0.042	0.010
79	83	1	0.042	0.010
83	87	1	0.042	0.010
87	91	0	0.000	0.000

In regard to the body weight (TW, g), the average weight for the male individuals is 60.89 g ± 22.67 SD, the average weight for the females is 20 % lower, while for the imposex forms it is c 32 % lower (Table 44).

The following weight classes are predominant in the male individuals 52 - 65 g - 35 %, as well as classes - 39 - 52 g - 26% and 78 - 91 g - 13 % (Fig. 32, Table 46). The predominant weight classes for the female individuals are 52 - 65 g - 38 % and 26 - 39 g - 25 % (Fig. 32, Table 46.2). As for the imposex forms, the weight classes range from 26 g to 76 g and are evenly distributed (Fig. 32).

1.



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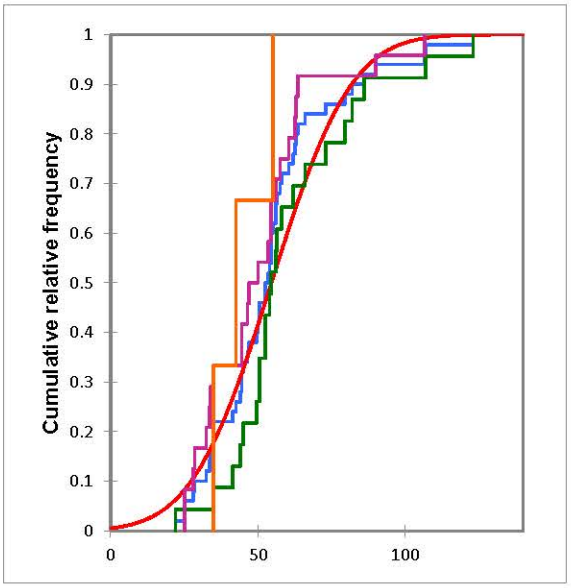

Fig. 32. Distribution by sex and weight classes (TW, g) (1) and cumulative distribution of the weight classes by sex (2) in the sample from Balchik, 28.07.2018

Table 46

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Balchik Port, 28.07.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
13	26	1	0.043	0.003
26	39	1	0.043	0.003
39	52	6	0.261	0.020
52	65	8	0.348	0.027
65	78	2	0.087	0.007
78	91	3	0.130	0.010
91	104	0	0.000	0.000
104	117	1	0.043	0.003
117	130	1	0.043	0.003

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
13	26	2	0.083	0.006

26	39	6	0.250	0.019
39	52	5	0.208	0.016
52	65	9	0.375	0.029
65	78	0	0.000	0.000
78	91	1	0.042	0.003
91	104	0	0.000	0.000
104	117	1	0.042	0.003
117	130	0	0.000	0.000

3.1.2.4 PORT BALCHIK, 01.09.2018

The sex ratio in the analyzed sample is 40 % ♀ : 44 % ♂ : 16 % imposex or 1 : 1.1 : 0.4.

In regard to the shell (SL, mm), the average size of the female individuals is 61.15 mm ± 7.77 SD, while the male's average size is 3 % bigger. For the imosex forms the percentage difference for ♀ is 3.2 %, in favor of the imposex individuals (Table 47).

Table 47

Summarized statistics of the biological parameters - shell length (SL, mm) and weight of the body (TW, g) by sex in the sample from Balchik Port, 01.09.2018

	SL, mm			TW, g		
	Females	Males	Imposex	Females	Males	Imposex
Mean	61.15	62.95	63.13	38.05	42.77	39.25
Standard Error	1.74	1.81	2.45	3.05	3.76	4.25
Median	60.00	63.00	62.00	33.75	39.25	37.75
Mode	60.00	52.00	57.00	33.50	25.00	
Standard Deviation	7.77	8.48	6.92	13.62	17.65	12.03
Sample Variance	60.34	71.85	47.84	185.55	311.37	144.64
Kurtosis	3.92	-0.49	-1.31	2.79	0.45	-1.59
Skewness	1.44	0.42	0.42	1.49	0.74	0.18
Range	37.00	29.00	19.00	58.50	70.50	31.50
Minimum	48.00	52.00	55.00	19.50	17.50	24.00
Maximum	85.00	81.00	74.00	78.00	88.00	55.50
Sum	1223.00	1385.00	505.00	761.00	941.00	314.00
Confidence Level (95.0%)	3.64	3.76		6.38	7.82	10.05

The most common size class for the male individuals is 63 - 68 mm - 27 % (Fig. 33, Table 48. 1), while for the females the predominant size class is- 54 - 58 mm (30 %), as well as 58 - 63 mm - 25 % (Fig. 33, Table 48.2). The biggest size class for the imposex forms is 54 - 58 mm - 38 % (Fig.33).

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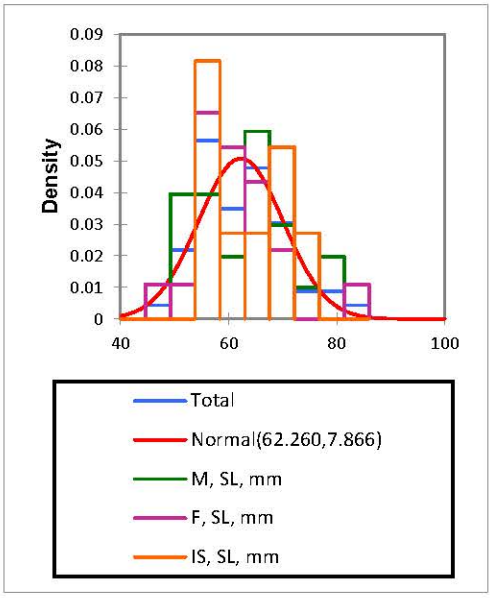

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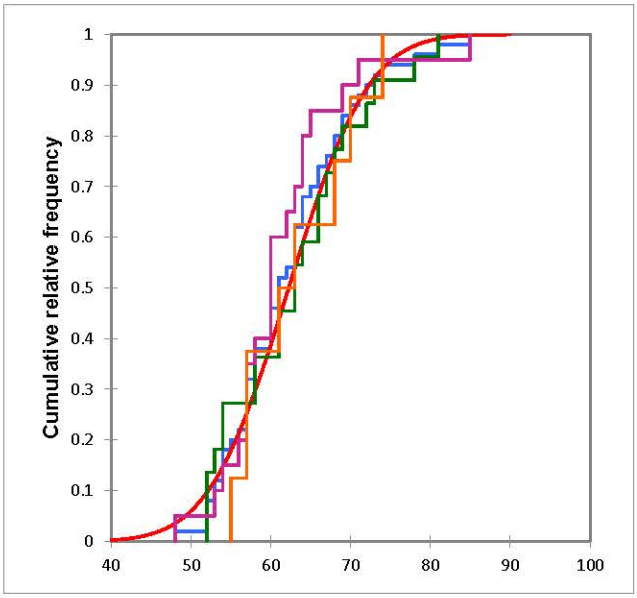

Fig. 33. Distribution by sex and size classes (1) based on shell length (SL, cm) and cumulative distribution of the size classes by sex (2) in the sample from, 01.09.2018

Table 48

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Balchik Port, 01.09.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
49	54	4	0.182	0.040
54	58	4	0.182	0.040
58	63	2	0.091	0.020
63	68	6	0.273	0.059
68	72	3	0.136	0.030
72	77	1	0.045	0.010
77	81	2	0.091	0.020

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
45	49	1	0.050	0.011
49	54	1	0.050	0.011
54	58	6	0.300	0.065
58	63	5	0.250	0.054
63	68	4	0.200	0.043
68	72	2	0.100	0.022
72	77	0	0.000	0.000
77	81	0	0.000	0.000
81	86	1	0.050	0.011

In regard to the body weight (TW, g), the average weight for the male individuals is 42.77 g ± 17.65 SD, the average weight for the female individuals is with 14 % lower, while for the imposex forms it is 9 % lower than ♂ (Table 47, Fig. 34).

The following weight classes are predominant in the male individuals 18 - 26 g and 34 - 42 g - *23 % (Fig. 34, Table 49.1). As for the female individuals, the predominant classes are 26 - 34 g (33 %) and 34 - 42 g *24 % (Fig. 34, Table 49.2). The imposex forms are distributed in different weight classes - 26 - 34 g, 34 - 42 g and 50 - 57 g *25 % (Fig. 34).

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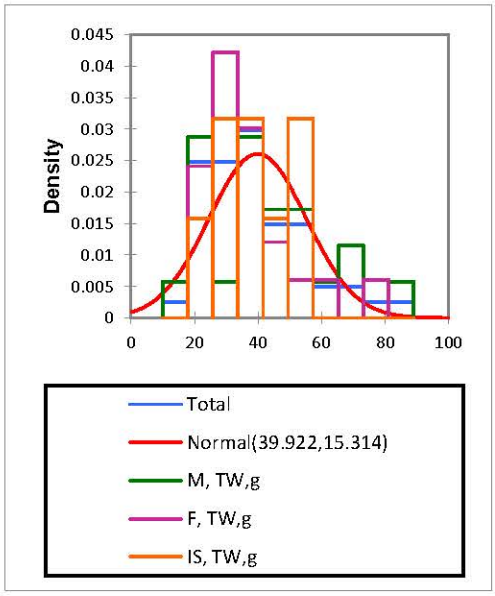

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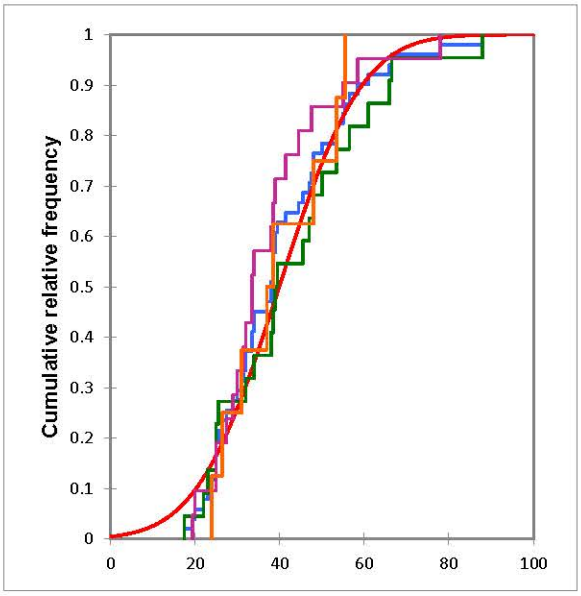

Fig. 34. Distribution by sex (1) based on the total weight (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Balchik, 01.09.2018

Table 49

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Balchik Port, 01.09.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	18	1	0.045	0.006
18	26	5	0.227	0.029
26	34	1	0.045	0.006
34	42	5	0.227	0.029
42	50	3	0.136	0.017
50	57	3	0.136	0.017
57	65	1	0.045	0.006
65	73	2	0.091	0.012
73	81	0	0.000	0.000
81	89	1	0.045	0.006

2

Lower bound	Upper bound	Frequency	Relative frequency	Density

18	26	4	0.190	0.024
26	34	7	0.333	0.042
34	42	5	0.238	0.030
42	50	2	0.095	0.012
50	57	1	0.048	0.006
57	65	1	0.048	0.006
65	73	0	0.000	0.000
73	81	1	0.048	0.006

3.1.2.5 SUMMARY OF THE SEX STRUCTURE IN THE 3RD QUARTER OF 2018

The average percentage ratios for all the researched areas are as follows: ♀ : ♂ : IS forms - 39.72 % ♀: 54.04 % ♂ : 6.25 % IS (Fig. 35). The highest share of imposex individuals was observed at Balchik – around 6.25 % from all the individuals. It's worth mentioning that there were none inposex individuals in the landings from Kavarna.

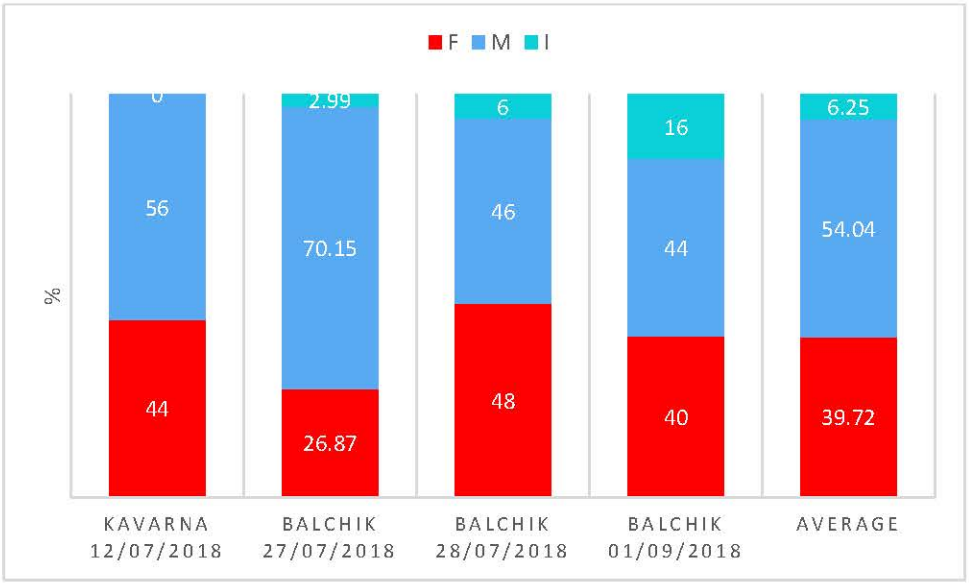

Fig. 35. Summarized data about the sex structure of *R. venosa* by ports for the 3rd quarter of 2018

The data about the landings for the third quarter show a maximum of 36% of imposex forms compared to the female individuals, which is an increase of 48% in the maximum quantity of imposex forms, again compared to the ♀ individuals, observed for the second quarter of 2018.

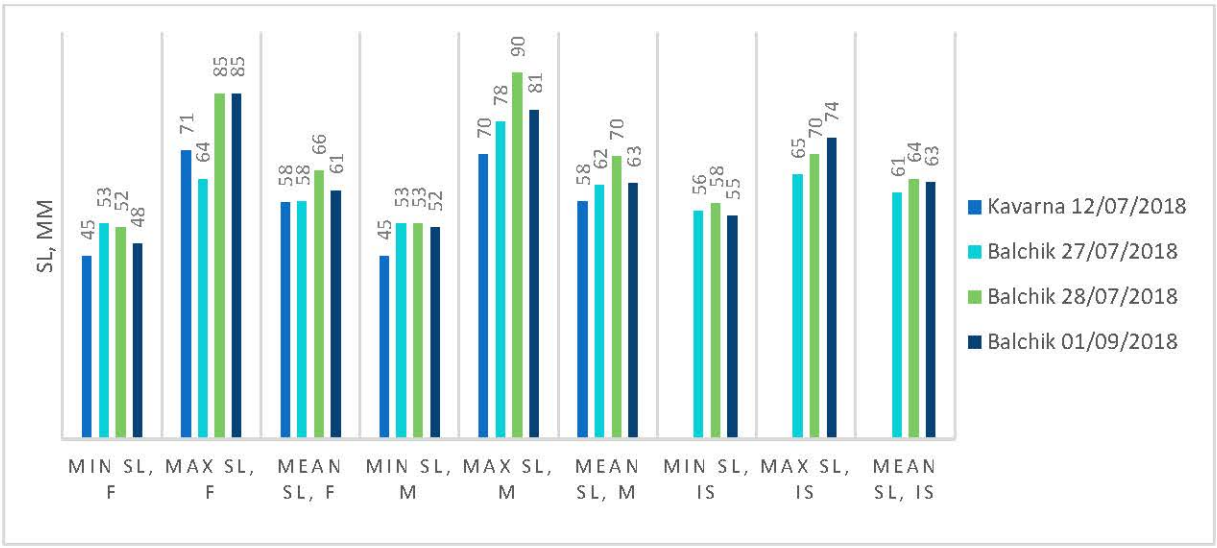

Fig. 36. Summarized data about the minimum, maximum and average size (SL, mm) by sex *R. venosa* (M, F, IS) and by ports for the third quarter of 2018

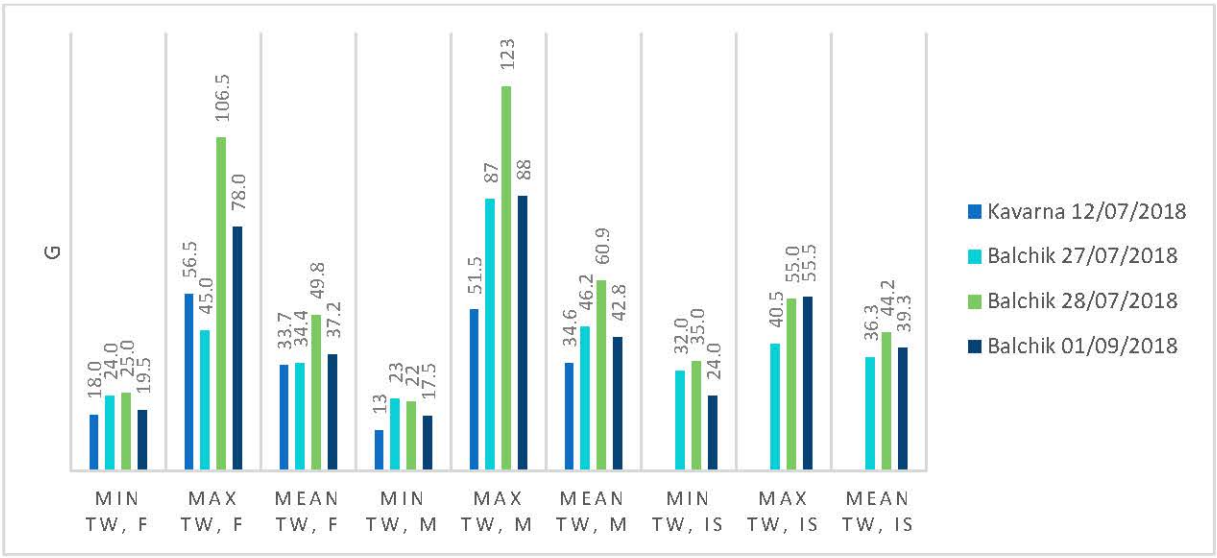

Fig. 37. Summarized data about the minimum, maximum and average weight (TW, mm) by sex *R. venosa* (M, F, IS) and by ports for the third quarter of 2018

During the third quarter of 2018, the biggest sizes of the male individuals were 63.4 mm on average, followed by IS forms – 62.5 mm, while the female individuals were around 60.9 mm (Fig. 36). The biggest individuals were observed in Balchik (28.07.2018), while the smalles were observed at Kavrna but in the beginning of the monitoring period (Fig. 36).

The average weight of the male individuals reaches 46.11 g, while for the females it is 38.77 g, and the imposex forms - 39.89 g (Fig. 37). The biggest individuals in size were observed in Balchik (28.07.2018), however it is worth mentioning that also the smallest in size were observed at the beginning of July (Fig. 37).

3.1.2.6 Port Krapets, 03.10.2018

The sex ratio in the analyzed sample is 68% ♂ to 32 % ♀ or 2.43 : 1. In regard to the shell size (SL, mm), the females have an average size of 81.5 mm ± 5.56 SD, while for the males it is with 1,5% larger (Table 50).

Table 50

Summarized statistics of the biological parameters - shell length (SL, mm) and body weight (TW, g) by sex in the sample from Krapets, 03.10.2018

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	81.50	82.74	97.84	97.35
Standard Error	1.39	0.96	6.43	3.08
Median	80.00	84.00	93.25	95.00
Mode	79.00	88.00		95.00
Standard Deviation	5.56	5.59	25.71	17.98
Sample Variance	30.93	31.29	661.12	323.17
Kurtosis	4.82	-0.64	2.63	0.71
Skewness	1.76	-0.37	1.49	0.83
Range	25.00	23.00	100.50	76.50
Minimum	73.00	70.00	67.50	71.00
Maximum	98.00	93.00	168.00	147.50
Sum	1304.00	2813.00	1565.50	3310.00
Confidence Level(95.0%)	2.96	1.95	13.70	6.27

The size classes for the female individuals are 79 - 82 mm - 44 %, as well as 82 - 85 mm - 25 % (Fig. 38, Table 51.2).

The most common size class for the male individuals is 87 - 90 mm - 26 %, followed by size class 79 - 82 mm - 18 % (Fig. 38, Table 51.2).

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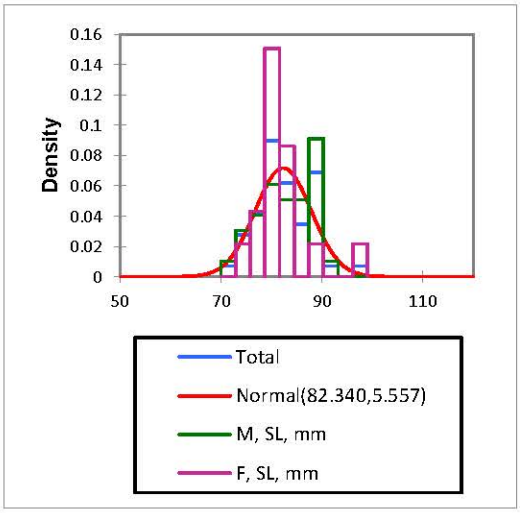

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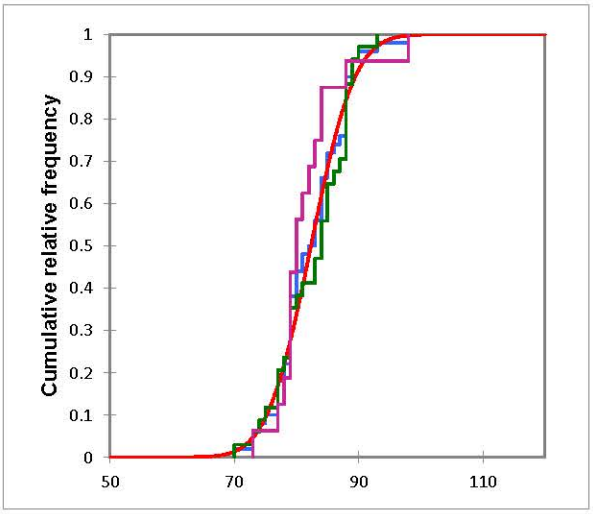


Fig. 38. Distribution of the size classes by gender (1) based on shell length (SL, mm) and cumulative distribution of the size classes by sex (2) in the sample from, 03.10.2018

Table 51

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Krapets, 03.10.2018

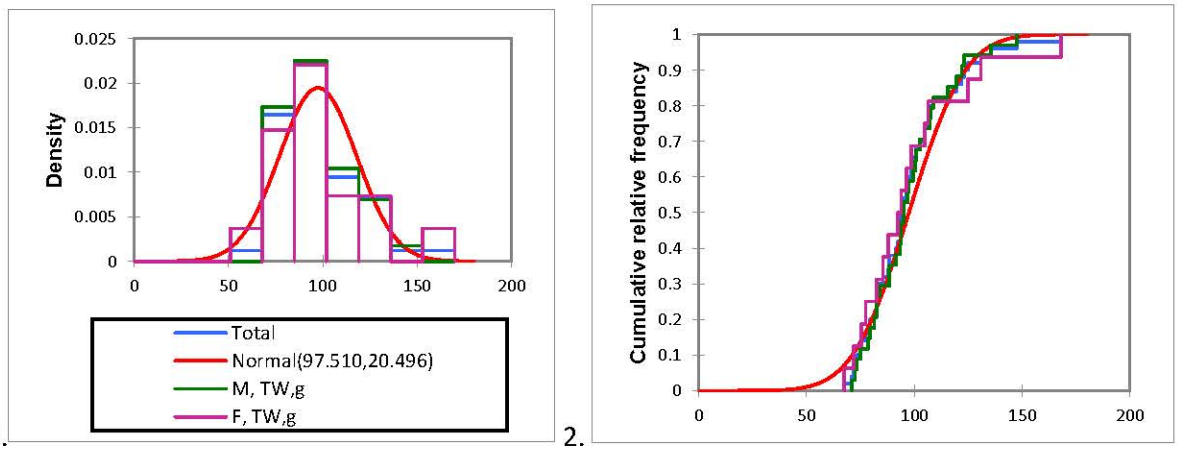
1

Lower bound	Upper bound	Frequency	Relative frequency	Density
70	73	1	0.029	0.010
73	76	3	0.088	0.030
76	79	4	0.118	0.041
79	82	6	0.176	0.061
82	85	5	0.147	0.051
85	87	5	0.147	0.051
87	90	9	0.265	0.091
90	93	1	0.029	0.010

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
73	76	1	0.063	0.022
76	79	2	0.125	0.043
79	82	7	0.438	0.151
82	85	4	0.250	0.086
85	87	0	0.000	0.000
87	90	1	0.063	0.022
90	93	0	0.000	0.000
93	96	0	0.000	0.000
96	99	1	0.063	0.022

In regard to the body weight (TW, g), the average weight for the male individuals is 97.35 g ± 17.98 SD, the average weight for the female individuals is with 0.5 % higher, however the size of the male individuals is 1.5 % bigger (Table 50). Two weight classes are dominant for both sexes - 85 - 102 g (38 %) and 68 - 85 g - 25 - 29% (Fig. 39, Table 52).



1. 2.

Fig. 39. Distribution by sex classes (1) based on the total weigh (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Krapets, 03.10.2018

Table 52

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Krapets, 03.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
68	85	10	0.294	0.017
85	102	13	0.382	0.022
102	119	6	0.176	0.010
119	136	4	0.118	0.007
136	153	1	0.029	0.002

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
51	68	1	0.063	0.004
68	85	4	0.250	0.015
85	102	6	0.375	0.022
102	119	2	0.125	0.007
119	136	2	0.125	0.007
136	153	0	0.000	0.000
153	170	1	0.063	0.004

3.1.2.7 Port Tsarevo, 04.10.2018

The sex ratio in the analyzed sample is 92 % ♂ to 8 % ♀ or 12 : 1. In regard to the shell size (SL, mm), the female individuals have an average size of 76.75 mm ± 7.14 SD, while the average size for the male individuals is 2.3 % smaller (Table 53).

Table 53

Summarized statistics of the biological parameters - shell length (SL, mm) and body weight (TW, g) by sex in the sample from Tsarevo Port, 04.10.2018

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	76.75	75.00	86.13	81.79
Standard Error	3.57	0.60	6.70	1.90
Median	74.50	74.00	80.75	79.75
Mode		74.00		75.00
Standard Deviation	7.14	4.07	13.41	12.88
Sample Variance	50.92	16.58	179.73	165.77
Kurtosis	2.35	-0.41	3.55	0.55
Skewness	1.53	0.41	1.86	0.70
Range	16.00	16.00	29.00	58.50
Minimum	71.00	68.00	77.00	55.50
Maximum	87.00	84.00	106.00	114.00
Sum	307.00	3450.00	344.50	3762.50
Confidence Level(95.0%)	11.35	1.21	21.33	3.82

There is a balance between size classes 68 mm to 77 mm for the female individuals - 25 % (Fig. 40, Table 54.2).

The predominant classes for the male individuals are 71 - 74 mm and 74 - 77 mm - 24 % (Fig. 40, Table 54.1).

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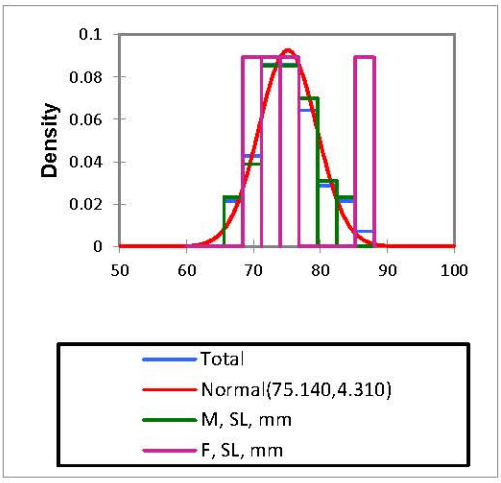

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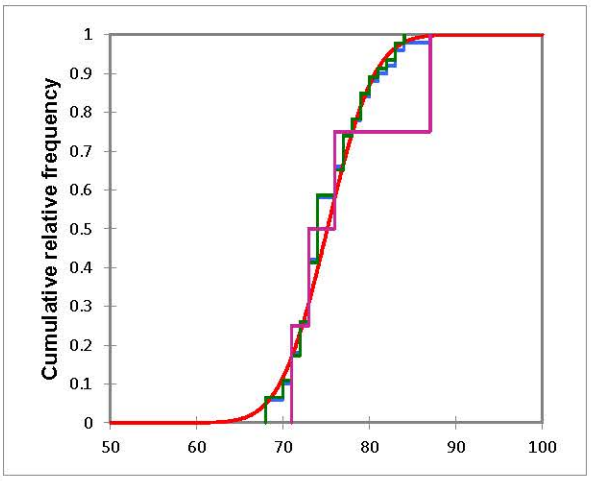


Fig. 40. Distribution of the size classes by gender (1) based on shell length (SL, mm) and cumulative distribution of the size classes by sex (2) in the sample from Tsarevo, 04.10.2018

Table 54

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Tsarevo, 04.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
66	68	3	0.065	0.023
68	71	5	0.109	0.039
71	74	11	0.239	0.085
74	77	11	0.239	0.085
77	80	9	0.196	0.070
80	82	4	0.087	0.031
82	85	3	0.065	0.023

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
68	71	1	0.250	0.089
71	74	1	0.250	0.089
74	77	1	0.250	0.089
77	80	0	0.000	0.000
80	82	0	0.000	0.000
82	85	0	0.000	0.000
85	88	1	0.250	0.089

In regard to the body weight (TW, g), the average weight for the male individuals is 81.79 g ± 12.88 SD, a the average weight for the female individuals is with 5.2 % bigger (Table 53).

The predominant weight classes for the male individuals are 76 - 83 g - 28% and 83 - 89 g - 22 % (Fig. 41.1, Table 55.1). There is a clear trend for the weight class of the female individuals - 76 - 83 g - 75 % (Fig. 41.2, Table 55.2).

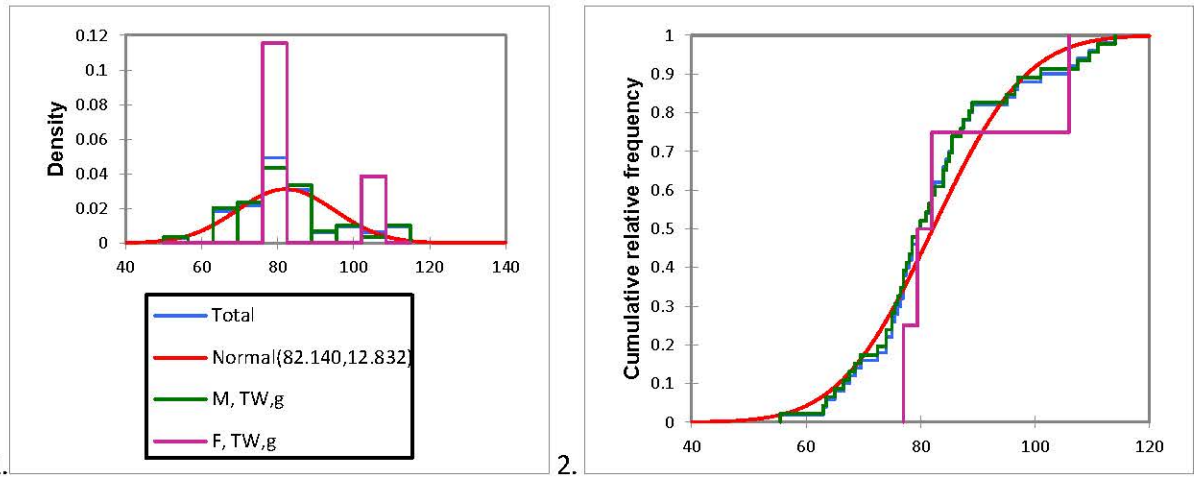


Fig. 41. Distribution by class and sex (1) based on the total weight (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Tsarevo, 04.10.2018

Table 55

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Tsarevo, 04.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	57	1	0.022	0.003
57	63	0	0.000	0.000
63	70	6	0.130	0.020
70	76	7	0.152	0.023
76	83	13	0.283	0.043
83	89	10	0.217	0.033
89	96	2	0.043	0.007
96	102	3	0.065	0.010
102	109	1	0.022	0.003
109	115	3	0.065	0.010

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
76	83	3	0.750	0.115
83	89	0	0.000	0.000
89	96	0	0.000	0.000
96	102	0	0.000	0.000
102	109	1	0.250	0.038

3.1.2.8 Tsarevo Port, 19.10.2018 г

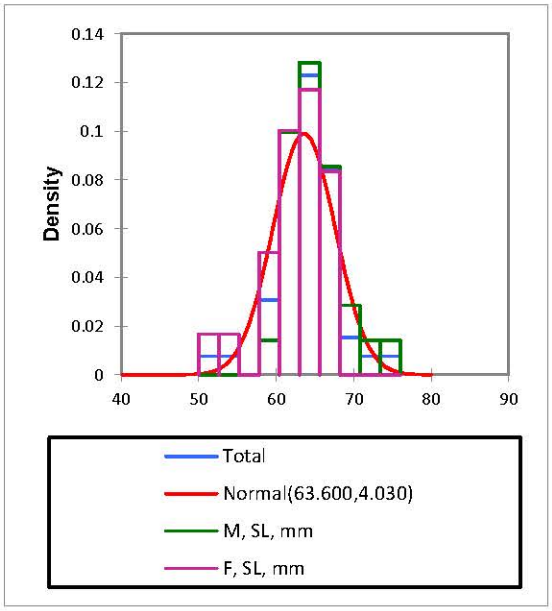
The sex ratio in the analyzed sample is 54 % ♂ to 46 % ♀ or1.17 : 1. In regard to the shell (SL, mm), the average size of the female individuals is 62.09 mm ± 3.91 SD, while for the male individuals it 4.41 % bigger (Table 56).

Table 56

Summarized statistics of the biological parameters - shell length (SL, mm) and body weight (TW, g) by sex in the sample from Tsarevo, 19.10.2018

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	62.09	64.89	52.22	53.63
Standard Error	0.81	0.72	2.03	1.29
Median	63.00	64.00	53.00	55.00
Mode	61.00	61.00	57.00	55.50
Standard Deviation	3.91	3.73	9.72	6.70
Sample Variance	15.26	13.95	94.41	44.95
Kurtosis	2.05	1.02	-0.88	-0.57
Skewness	-1.32	1.10	-0.06	-0.06
Range	16.00	15.00	35.00	25.00
Minimum	51.00	60.00	34.00	41.00
Maximum	67.00	75.00	69.00	66.00
Sum	1428.00	1752.00	1201.00	1448.00
Confidence Level(95.0%)	1.69	1.48	4.20	2.65

Two size classes are predominant for both sexes - 63 - 66 mm, forming 30-33 %, as well as 60 - 63 mm - *26 % from all classes (Fig. 42, Table 57).



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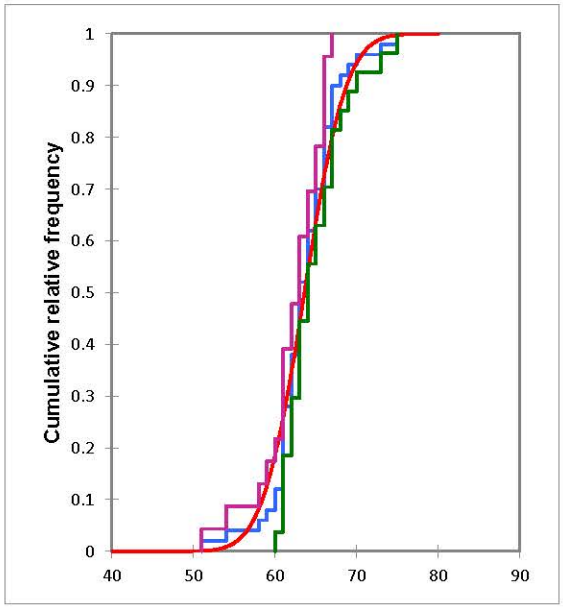

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Fig. 42. Distribution of the size classes by sex (1) based on shell length (SL, mm) and cumulative distribution of the size classes by sex (2) in the sample from Tsarevo, 19.10.2018

Table 57

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Tsarevo, 19.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
58	60	1	0.037	0.014
60	63	7	0.259	0.100
63	66	9	0.333	0.128
66	68	6	0.222	0.085
68	71	2	0.074	0.028
71	73	1	0.037	0.014
73	76	1	0.037	0.014

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	53	1	0.043	0.017
53	55	1	0.043	0.017
55	58	0	0.000	0.000
58	60	3	0.130	0.050
60	63	6	0.261	0.100
63	66	7	0.304	0.117
66	68	5	0.217	0.084

In regard to the body weight (TW, g), the average weight for the male individuals is 53.63 g ± 6.71 SD, a the average weight for the female individuals is with 2.67 % lower (Table 19).

The dominant weight class for both sexes is 54-58 g, forming between 27-37 % from all weight classes (Fig. 43, Table 58).

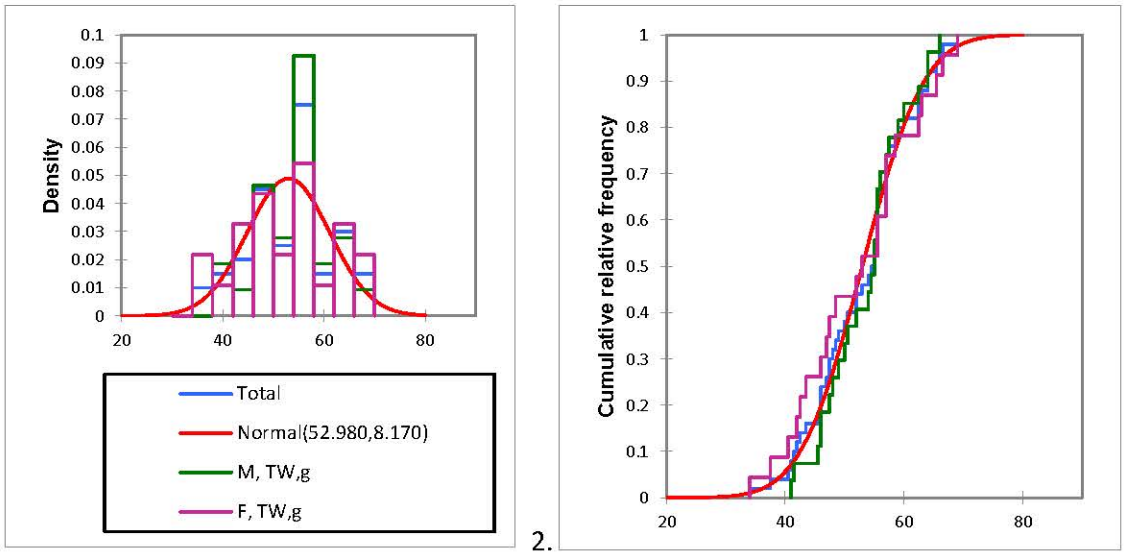

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Fig. 43. Distribution by class and sex (1) based on the total weight (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Tsarevo, 19.10.2018

Table 58

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Tsarevo, 19.10.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
38	42	2	0.074	0.019
42	46	1	0.037	0.009
46	50	5	0.185	0.046
50	54	3	0.111	0.028
54	58	10	0.370	0.093
58	62	2	0.074	0.019
62	66	3	0.111	0.028
66	70	1	0.037	0.009

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
34	38	2	0.087	0.022
38	42	1	0.043	0.011
42	46	3	0.130	0.033
46	50	4	0.174	0.043
50	54	2	0.087	0.022
54	58	5	0.217	0.054
58	62	1	0.043	0.011
62	66	3	0.130	0.033
66	70	2	0.087	0.022

3.1.2.9 Port Varna, 04.11.2018

The sex ratio in the analyzed sample is 50 % ♀ to 50 % ♂. The average size (SL, mm) for the female individuals is 63.76 mm ± 6.81 SD, while for the male individuals it about 2.5 % smaller (Table 59).

Table 59

Summarized statistics of the biological parameters - shell length (SL, mm) and weight (TW, g) by sex in the sample from Varna, 04.11.2018

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	63.76	62.20	43.38	38.04
Standard Error	1.36	1.15	3.00	2.59
Median	64.00	61.00	43.50	36.50
Mode	66.00	60.00	54.00	45.00
Standard Deviation	6.81	5.76	15.02	12.96
Sample Variance	46.36	33.17	225.63	168.00
Kurtosis	-0.81	-0.24	1.79	0.02
Skewness	-0.17	0.52	0.50	0.65

Range	26.00	22.00	71.00	53.00
Minimum	50.00	52.00	15.50	14.50
Maximum	76.00	74.00	86.50	67.50
Sum	1594.00	1555.00	1084.50	951.00
Confidence Level(95.0%)	2.81	2.4	6.20	5.35

The predominant size class for the female individuals is 64 - 66 mm - 20 % (Fig. 44, Table 60.2), while the most common size class for the male individuals is - 58 - 61 mm - 24 %, followed by size class 64 -66 mm - 20 % (Fig. 44, Table 60.1).

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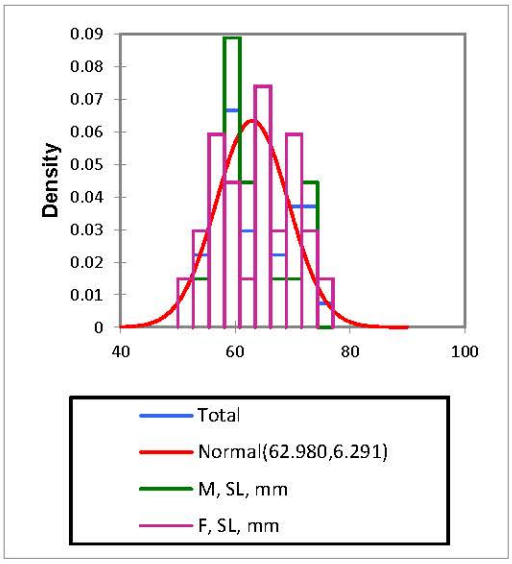

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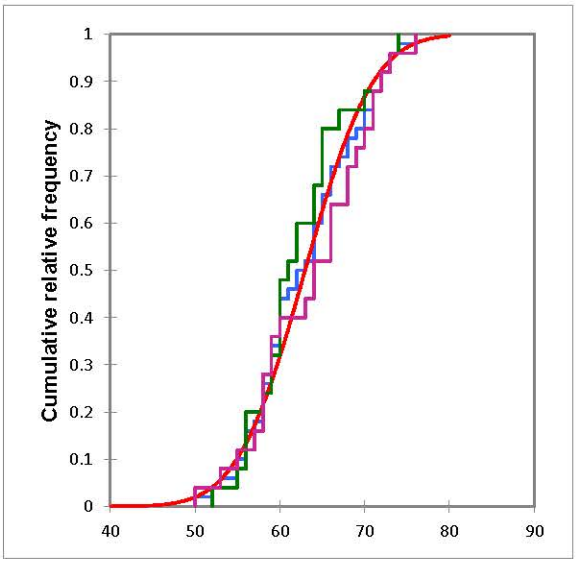

Fig. 44. Distribution of the size classes by gender (1) based on shell length (SL, cm) and cumulative distribution of the size classes by sex (2) in the sample from Varna, 04.11.2018

Table 60

Statistical data about the distribution of the size (mm) classes of rapana by sex (1, male; 2, female) in the sample from Varna, 04.11.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	53	1	0.040	0.015
53	55	1	0.040	0.015
55	58	4	0.160	0.059
58	61	6	0.240	0.089
61	64	3	0.120	0.044
64	66	5	0.200	0.074
66	69	1	0.040	0.015
69	72	1	0.040	0.015
72	74	3	0.120	0.044

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
50	53	1	0.040	0.015
53	55	2	0.080	0.030
55	58	4	0.160	0.059
58	61	3	0.120	0.044
61	64	1	0.040	0.015
64	66	5	0.200	0.074
66	69	2	0.080	0.030
69	72	4	0.160	0.059
72	74	2	0.080	0.030
74	77	1	0.040	0.015

In regard to the body weight (TW, g), the average weight for the male individuals is 38.04 g ± 12.96 SD, while for the female individuals is with 13.11 % bigger (Table 59).

The predominant size classes for the male individuals are 26 - 33 g - 40% and 33 - 41 g - 24 % (Fig. 45, Table 61.1). As for the female individuals, the predominant size classes are 49 - 57 g - 32% and 26 - 33 g - 20 % (Fig. 45, Table 61.2).

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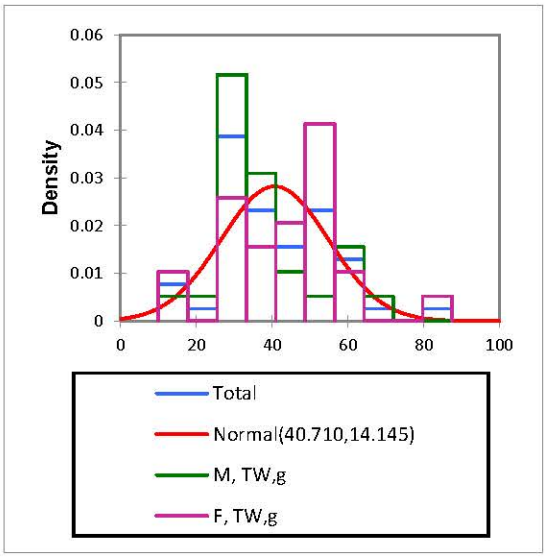

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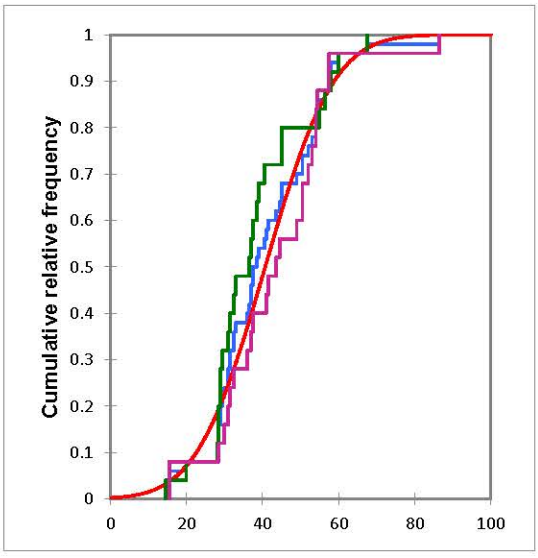

Fig. 45. Distribution by sex classes (1) based on body weight (TW, g) and cumulative distribution of the weight classes by sex (2) in the sample from Varna, 04.11.2018

Table 61

Statistical data about the distribution of the weight (g) classes of rapana by sex (1, male; 2, female) in the sample from Varna, 04.11.2018

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	18	1	0.040	0.005
18	26	1	0.040	0.005

26	33	10	0.400	0.052
33	41	6	0.240	0.031
41	49	2	0.080	0.010
49	57	1	0.040	0.005
57	64	3	0.120	0.015
64	72	1	0.040	0.005

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
10	18	2	0.080	0.010
18	26	0	0.000	0.000
26	33	5	0.200	0.026
33	41	3	0.120	0.015
41	49	4	0.160	0.021
49	57	8	0.320	0.041
57	64	2	0.080	0.010
64	72	0	0.000	0.000
72	80	0	0.000	0.000
80	88	1	0.040	0.005

3.1.2.10 Gonadosomatic Index for the 4TH quarter of 2018

The summarized statistics data about the dynamics of the gonadosomatic index (GSI) for the 4th quarter of 2018 are presented in Table 62. The average values for the index from scuba diving reaches 17.413 ± 3.56 SD, while the highest values of the GSI were observed in the sample from Tsarevo, 04.10.2018 - 18.30 ± 3.55 SD (Table 62).

Table 62

Summarized statistics of GSI by ports for the 4th quarter of 2018

	Krapets 03.10.2018	Tsarevo 04.10.2018г.	Kavarna 19.10.2018г	Varna 04.11.2018г
Mean	16.15	18.30	17.78	12.17
Standard Error	0.40	0.50	0.55	0.63
Median	16.11	18.54	18.27	13.33
Mode	16.67	20.00	16.67	11.11
Standard Deviation	2.85	3.55	3.91	4.48
Sample Variance	8.12	12.63	15.31	20.03
Kurtosis	1.20	4.72	0.78	2.32
Skewness	-0.09	-1.21	-0.78	-1.49
Range	14.64	21.91	17.14	18.52
Minimum	8.51	3.85	6.67	0.00
Maximum	23.15	25.76	23.81	18.52
Sum	807.69	915.08	889.17	608.53
Count	50.00	50.00	50.00	50.00
Confidence Level(95.0%)	0.81	1.01	1.11	1.27

3.1.2.11 SUMMARY OF THE GENDER STRUCTURE FOR THE 4TH QUARTER OF 2018

There have been no imposex forms for the fourth quarter of 2018. The percentage ratio of males to females from beam trawl fishing is 50 % ♀: 52 % ♂ (Fig. 46), while in the case of scuba diving the percentage ratio is quite different because of the selective technique, and the males are predominant with a percentage share - 71.33 % from the total number of observed individuals (Fig. 46).

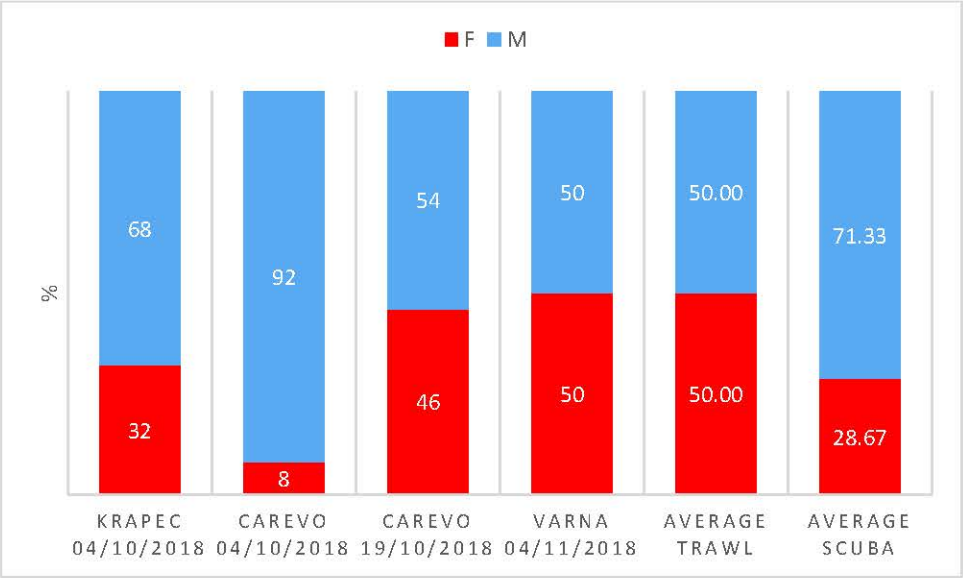

Fig. 46. Summarized data about the sex structure of *R. venosa* by ports for the 4th quarter of 2018

The average sizes of the individuals, based on the sex structure, in the samples depend on the method of fishing, for example while using Scuba diving, individuals of both sexes have an average of 15.8% larger average sizes than those caught by beam trawl. Scuba diving catches were used to collect data from Krapets and Tsarevo, and larger mean sizes were found in samples from the northern territorial waters (Fig. 47). By sex, the differences in average linear sizes for Scuba diving are negligible and reach an average of 1.08% and up to 2.5% when catching bait-trawl. In the case of catching a beam trawl in front of Varna on 4.11.2018, the average size of the male individuals reached 62.2 mm, while in the females- 63.8 mm, while in Scuba diving - the average ♂ sizes reached 74.2 mm, and on ♀ - 73.4 mm (Fig. 47).

The dynamics of the weights by sex between the different fishing areas is more significant than that of the sizes. When using scuba diving, the average weight of the males reached 77.6 g, in females it is 78.7 g, and in all ports with this type of landings, the weight of the female individuals is higher than the average male weight by 1.04%. When using beam-trawl, the mean weight of males was 38 g and that is 13.3% lower than that of female individuals - 43.4 g (Fig. 48).

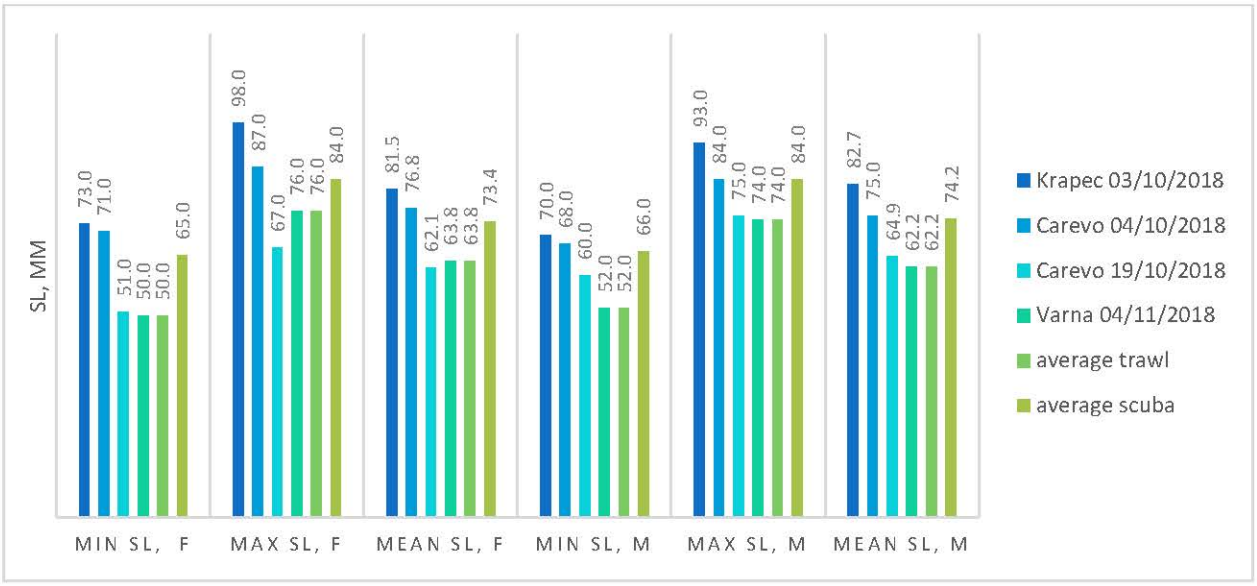

Fig. 47. Summarized data about the minimum, maximum and average size (SL, mm) by sex *R. venosa* (M, F) and by ports for the fourth quarter of 2018

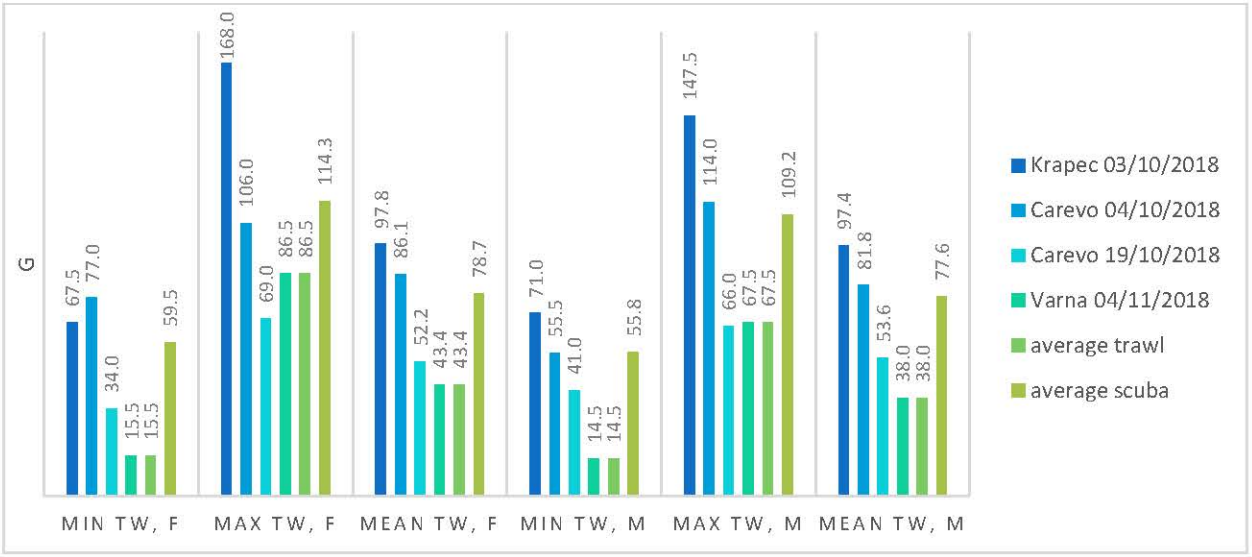

Fig. 48. Summarized data about the minimum, maximum and average weigths (TW, g) by sex of *R. venosa* (M, F, IS) and by ports for 4th quarter of 2018

The most significant individual's average weights were observed in the northern territorial waters – Krapets, with scuba diving fishing.

4. CONCLUSIONS

- The analysis on the rapana landings for the 3rd and 4th quarter of 2018 is based on 800 individuals, collected at five different ports - Kavarna, Balchik, Krapets, Tsarevo and Varna.
- During the 3rd quarter of 2018, the landings from different fishing vessels with lengths 14.5 - 16.5 m, equipped with beam trawls vary between 1628 - 2070 kg/day. The average landings of rapana for the ships with length 16.5 m are 1983 kg per fishing day. The landings for the 4th quarter of 2018 were collected from beam trawling and scuba diving and vary between 280 - 2690 kg/day depending on the fishing method, with biggest landings from beam trawls. The landing from scuba diving resulted between 280 - 985 kg/day.
- The average size of *R.venosa* individuals caught by beam trawl for the 3rd quarter of 2018 is 63.26 mm SL ± 7.96 SD, while the minimum and maximum individual sizes are 44 and 90 mm respectively. There is a slight increase in the size during 4th quarter of 2018, with an average size of 62.99 mm SL ± 6.57 SD, and the minimum and maximum individual's sizes - 50 - 81 mm SL. The average size of rapana using scuba diving for the 4th quarter of 2018 is 73.47 mm SL ± 8.52 SD and this is 15.4 % bigger compared to the one onserved in the beam-trawl landings. The minimum and the maximum sizes vary in the range 42 - 98 mm SL.
- During the 3rd quarter of 2018, the average weight of *R.venosa* reached 44.61 g TW ± 5.51 SD, while the minimum and maximum individual weights were 13 and 123 g TW. The average weight of *R.venosa,* caught in the 4th quarter 2018 by beam-trawl, is 41.07 g TW ± 14.77 SD, and the minimum and maximum values for the size are - 14.5 - 86.5 g TW. In the case of scuba diving, the average weight of the species is 77.65 g TW ± 22.88 SD, while the minimum and maximum sizes vary in the range 16.5 – 168 g TW. The difference between the average sizes of *R. venosa* for both fishing methods is about 61.6 % for the 4th quarter of 2018.
- The maximal average sizes for the 3rd quarter of 2018 were observed in Balchik (July .2018) - 67.14 mm SL, as well as weight - 52.63 g TW. The average sizes for the 4th quarter, collected by scuba diving are with 15.4% bigger because of the scuba diving technique.
- During the third quarter of 2018, 93 % from the measured individuals R. venosa have and average size < 76 mm, the predominant size classes 55 - 60 mm (27 %) и 60 - 66 mm (24 % from the measured individuals). The landings from the beam-trawl fishing for the fourth quarter of 2018 show that 94 % from the measured individuals are with sizes < 87 mm, while the most populated size classs is 56 - 63 mm (34 % from the measured individuals). For the fishing with scuba diving, the most common size classes are - 75 - 81 mm and 70 - 75 mm (25 - 24 % from the measured individuals)
- In regard to the weight structure (TW, g), the results for the third quarter 2018 show that the predominant weight classes are 26 - 39 g (34 %) and 39 - 52 g - 27 % from the total number of the measured individuals. During this period 89 % from the measured individuals are with a weight < 65 g, while 2% are heavier than > 91 g. The landing in the fourth quarter of 2018, 94 % of the size of the individuals weighed <65 g, in proportions dominated by classes 26 - 33 g - 28% and 33 - 41 g - 19%. For scuba diving, in the fourth quarter of 2018, 86 % of the measured individuals weighing <102 g and dominant classes: 68-85 g (27%) and 51-68 g (24%).
- The mean share of the ratio Wd/SL for the third quarter of 2018 r reached 75.87 %, AL/SL = 69.14 %, while the mean AL/Wd = 91.13 %. In the fourth quarter of 2018, the average Wd / SL = 79.53%, for specimens fished by diving, was 0.38% higher than the ones with the beam trawl. The ratio of AL/SL = 72.22% and shows a difference of 1.07% of the ratio between the

parameters from the beats trawl collection. In the AL /Wd ratio, the mean value for scuba diving was 90.85% and again showed a slight difference of 0.7% compared to the beam-trawl technique.

- During the third quarter of 2018, a negative alometric growth of *R. venosa* for all the samples was estimated, at a coefficient b ≠ 3 (t-test, p=0.05) and an average value of the coefficient b = 2.79. As for the fourth quarter of 2018, the parameter b < 3 for the samples from Krapets and Tsarevo, which is a sign of a negative alometric growth. The analysis of the sample from Varna (November 2018) showed the opposite trend, the parameter b > 3, which is a positive alometric growth for *R. venosa* individuals.
- In the third quarter of 2018, on average for all observed landing sites, the percentages of: ♂: IS forms are 39.72% ♀: 54.04% ♂: 6.25% imposex (IS). The most imposex individuals were observed at Balchik - an average of 6.25% of all specimens. In the fourth quarter of 2018, no imposex forms were found. On average, it can be concluded that for this period, the percentage ratio between the two sexes is 50 ♀: 50% ♂. For rapana collected by diving technique, due to the fact that the catch method itself is highly selective, the proportion between sexes is disturbed.
- During the third quarter of 2018, the average size of the male individuals, caught by beam trawl fishing, is 63.4 mm, followed by the IS forms – 62.5 mm, while the smallest size was observed in the female individuals – 60.9 mm. The biggest sizes for all the sexes was observed in Balchik (July.2018), while the smallest sizes were observed in Kavarna. The fourth quarter revealed slightly different data because of the scuba diving technique – on average 15.8% bigger in size for both sexes compared to the beam trawl. The average size for the male individuals was 62.2 mm, while for the female individuals - 63.8 mm. In regard to the scuba diving fishing, the average size of the females was 74.2 mm, while males - 73.4 mm.
- The highest GSI values for the last quarter of 2018 were observed in the sample from Tsarevo, 04.10.2018 - 18.30 ± 3.55 SD, while the average GSI reached 17.413 ± 3.56 SD observed in the scuba diving landings and 12.77 ± 4.48 SD – landings from beam-trawl.

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