A C T A I C H T H Y O L O G I C A E T P I S C A T O R I A

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Fish systematic

MORPHOLOGICAL CHARACTERISTICS OF SOUTH BALTIC LUMPFISH, *CYCLOPTERUS LUMPUS* L., 1758

CHARAKTERYSTYKA MORFOLOGICZNA TASZY, *CYCLOPTERUS LUMPUS* L., 1758 POŁUDNIOWEGO BAŁTYKU

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Morphological characteristic of lumpfish caught in the spring of 1995 in coastal waters of the Southern Baltic Sea near Unieście and Chłopy have been outlined in this paper. In total 140 fish were used for measurements. The analysis of countable features of fish revealed that the number of fin rays was as follows: D_2 10–11; A 9–11; P 18–24. Also tubercles arranged in three rows situated on body sides were counted. Characteristics of 19 morphometric features have been set out; 17 features were described with indices expressed as percentage of the standard length. Sexual dimorphism refers to the head and fin dimensions.

INTRODUCTION

Lumpfish, *Cyclopterus lumpus* has no economic significance, therefore, it has never been a frequent object of research and consequently very few works on this subject have been published (Draganik 1996). Lumpfish occurs both in the European waters and on the other side of the Atlantic, near the US, Canada, and Greenland coasts (Kuczyński and Heese 2000). The fish belongs to the family Cyclopteridae, which comprises 21 genera and 177 species (Nelson 1984). It is present in the whole area of the Baltic Sea from the depth of 20 to 250 m whereas in the North Sea even down to 400 m (Andriâšev 1954; Pethon 1989). Lumpfish begins to appear in larger numbers in the coastal waters zone from February to May, most frequently in April (Heese 1998). This is associated with the commencement of reproduction, which takes place in earlier spring in the shallow water zone (Terofal and Militz 1996). At that time sexually mature specimens seek for a stony bottom overgrown with rock weed and kelps (Andriâšev 1954). Females spawn in several portions and then the males take care for the eggs both during the incubation period and after hatching (Wiktor 1962), when lumpfish larva has 6–7 mm in length (Virbickas 1986; Muus 1991). During the first year of their life the youngsters stay in coastal waters until they reach 50 mm in length (Andriâšev 1954). The adults migrate to deeper waters after the reproduction period (Wheeler 1983). They feed on crustaceans, polychaetes, ctenophores, gobiid fishes (Muus 1991), as well as on pelagic feed composed, among other things, of other fish eggs or flatfishes larvae (Garrod and Harding 1981). Winter is the period of the most intense predation of lumpfish (Krzykawski et al. 1990). In the Baltic Sea they usually reach the length of 30 cm; sometimes much bigger individuals are caught—they probably get into the Baltic from the North Sea (Kuczyński and Heese 1998).

The objective of this work is to present lumpfish morphology, its morphometric and meristic features and to evaluate their sexual dimorphism.

MATERIAL AND METHODS

The material for the present work was collected in April an May 1995 in the central of part of the Southern Baltic Sea (Chłopy and Unieście). A total of 140 fish, including 53 males and 87 females, were examined. The average total length (*TL*) of the fish in the sample studied was 170.6 mm (SD ±14.44). The biggest individual featured total length of 244 mm. The average weight of the fishes was 192.5 g (SD ±46.94). The analysis of meristic features covered the number of rays in the second dorsal, anal, and pectoral fins and the number of tubercles arranged in six rows: two ventral, two lateral and two dorsal (Fig. 1).

A total of 19 morphometric features of the body were examined, following the diagram proposed by Holčik et al. (1989). The values of 17 features were expressed as indices calculated as percentage of the overall body length. The mean value (M), standard error of mean (m), standard deviation (SD), coefficient of variation (CV) were calculated for all the variables. A statistical analysis through application of "StatSoft" software was carried out for the morphometric features expressed with indices searching for any features that would show statistically significant differences between the females and males using t-Student or Kolmogorov-Smirnov tests. Also correlation between the body length and the real values of the measured features and between the body length and the indexed feature values was also considered. The analysis for the normal distribution features was carried out based on Pearson linear correlation coefficient. For those features that do not fit to normal distribution, the Spearman ranks correlation coefficient was applied.

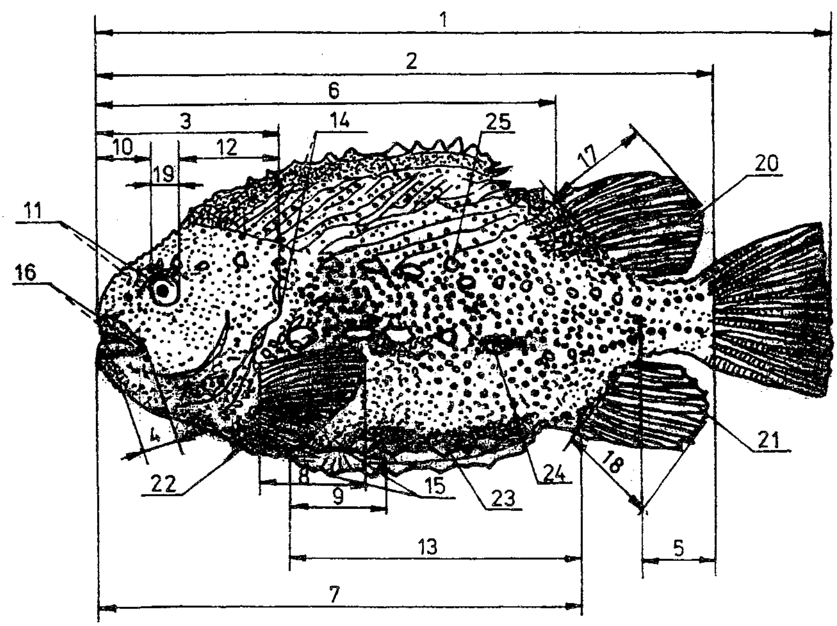

Fig. 1. Diagram of morphometric features of lumpfish (*Cyclopterus lumpus*)

(Appendix to Fig. 1)

1. Total length – *Longitudo totalis*
2. Standard length – *Longitudo corporis*
3. Head length – *Longitudo capitis*
4. Length of upper jaw – *Longitudo ossis maxillae*
5. Caudal length – *Longitudo pedunculi caudalis*
6. Predorsal length – *Longitudo praedorsale*
7. Preanal distance – *Longitudo praeanalis*
8. Pectoral fin length – *Longitudo pinnae* P
9. Sucker length – *Longitudo acetabuli*
10. Preocular distance – *Spatium preorbitale*
11. Interorbital distance – *Spatium interorbitale*
12. Postocular distance – *Spatium postorbitale*
13. V–A distance – *Spatium* V–A
14. Head width – *Latitudo capitis*
15. Sucker width – *Latitudo acetabuli*
16. Width of snout – *Latitudo rostrum*
17. Depth of IID – *Altitudo pinnae* D_2
18. Depth of anal fin – *Altitudo pinnae* A
19. Horizontal diameter of eye – *Diameter oculi horizontalis*
20. Number rays of dorsal fin IID – *Numerus radiorum pinnae* D_2
21. Number rays of anal fin – *Numerus radiorum pinnae* A
22. Number rays of pectoral fin – *Numerus radiorum pinnae* P
23. Number of tubercles in ventral row (I) – *Numerus tubercula osseorum in ordine ventrali* (I)
24. Number of tubercles in lateral row (II) – *Numerus tubercula osseorum in ordine laterali* (II)
25. Number of tubercles in dorsal row (III) – *Numerus tubercula osseorum in ordine dorsali* (III)

RESULTS

Body shape and colour description

Lumpfish body is of a lump shape, featuring pentagonal cross-section and fairly short, small head. The first dorsal fin is covered with a skin fold. The second dorsal fin is located at the back of the body. The anal fin is of similar size as the second dorsal fin. Pelvic fins have ventral location and are transformed into a sucker. The pectoral fins are fairly narrow at their base and situated fairly low (below the main axis of the body). The body is covered with variable size tubercles arranged in three rows on each side of the body with smaller and irregularly located tubercles between the rows. Lumpfish body is dark-grey in colour with green-blue tint, lighter coloured belly, sometimes almost white. During the spawning season a brick-red colour appears on bellies and parts of pectoral fins of males. Young individuals are green-yellow in colour and have black spots.

Description of meristic features

The following formula vas developed based on the analysis of the number of rays in the second dorsal, pectoral, and anal fins (Tab. 1):

$$D_2\ 10–11,\ A\ 9–11,\ P\ 18–24$$

Table 1

Statistical characteristic of the number of rays in the second dorsal fin (D_2), and anal fin (A) and in pectoral fins (P) (n = 140)

Fin	Range	M ±m	SD	CV
D_2	10–11	10.56 ±0.04	0.50	4.72
A	9–11	10.16 ±0.04	0.49	4.81
P	18–24	20.39 ±0.08	0.92	4.50

Table 2

Statistical characteristic of the number of tubercles (small and big) arranged in three rows: ventral, lateral, and dorsal (n = 140)

Tubercles		Range	M ±m	SD	CV
Ventral	big	3–6	4.75 ±0.05	0.64	13.39
	small	0–8	3.99 ±0.15	1.79	44.71
Lateral	big	3–8	5.04 ±0.05	0.55	10.87
	small	4–12	7.82 ±0.16	1.93	24.69
Dorsal	big	5–12	8.19 ±0.13	1.55	18.91
	small	6–12	11.04 ±0.17	2.04	18.49

Particular features showed fairly low coefficient of variability, which proves high stability of the features within the sample studied. The number of tubercles (Tab. 2) showed, however, high coefficients of variability, which proves low stability of those features. No correlation was found between the fish body length or sex and the number of the tubercles.

Description of morphometric features

In the first part of the analysis an assumption was made about the existence of sex-related features. A total of 87 females and 53 males identified based on their gonads were examined. The analysis of differences significance for mean values of given features fitting the normal distribution, with equal variances, was carried out through t-Student test (Tab. 3). For the remaining features, without normal distribution, the Kolmogorov-Smirnov test for two independent samples was applied (Tab. 4).

Table 3

Evaluation of significance of differences between the mean female feature values (n = 87) and male mean feature values (n = 53) fitting to normal distribution (t – test-t value; p – test probability)

Feature	M		SD		CV		t	p
	female	male	female	male	female	male		
Longitudo capitis	**30.63**	**33.02**	**2.44**	**2.11**	**7.96**	**6.46**	**-5.93**	**$2\cdot10^{-8}$**
Latitudo rostrum	**15.90**	**17.56**	**1.67**	**1.93**	**10.49**	**11.20**	**-5.38**	**$3\cdot10^{-7}$**
Spatium postorbitale	**15.68**	**16.70**	**1.30**	**1.49**	**8.28**	**9.06**	**-4.26**	**$3\cdot10^{-5}$**
Spatium interorbitale	**17.38**	**18.60**	**1.57**	**2.00**	**9.03**	**10.96**	**-4.02**	**$9\cdot10^{-5}$**
Longitudo ossis maxillae	**10.32**	**11.68**	**1.23**	**1.13**	**11.93**	**9.82**	**-6.51**	**$1\cdot10^{-9}$**
Altitudo pinnae A	20.93	21.30	2.10	1.80	10.06	8.52	-1.06	$2\cdot10^{-1}$
Latitudo capitis	25.33	26.50	2.71	2.80	10.69	10.69	-2.44	$1\cdot10^{-2}$
Diameter oculi horizontalis	7.59	7.91	1.05	1.24	13.90	15.89	-1.62	$1\cdot10^{-1}$
Spatium preorbitale	11.96	12.51	1.45	1.50	12.14	11.96	-2.15	$3\cdot10^{-2}$

Table 4

Evaluation of significance of differences between mean female feature values (n = 87) and male mean feature values (n = 53) not fitting to normal distribution (level of significance calculated for test values)

Feature	M		SD		CV		p
	female	male	female	male	female	male	
Longitudo praeanalis	**74.82**	**70.91**	**5.67**	**3.82**	**7.58**	**5.43**	**$1\cdot10^{-3}$**
Longitudo acetabuli	**16.86**	**19.28**	**1.57**	**2.57**	**9.29**	**13.42**	**$1\cdot10^{-3}$**
Latitudo acetabuli	**13.63**	**16.10**	**1.28**	**2.30**	**9.43**	**14.52**	**$1\cdot10^{-3}$**
Longitudo pinnae P	**20.17**	**21.01**	**1.84**	**1.29**	**9.13**	**6.27**	**$1\cdot10^{-2}$**
Spatium V-A	57.15	54.89	6.16	3.57	10.78	6.60	$1\cdot10^{-1}$
Longitudo pedunculi caudalis	13.66	14.16	1.81	2.13	13.23	15.01	$1\cdot10^{-1}$
Altituda pinnae D_2	20.18	21.00	3.07	2.18	15.20	10.56	$1\cdot10^{-1}$
Longitudo praedorsale	73.87	71.18	6.75	5.47	9.14	7.83	$2\cdot10^{-2}$

The t-Student analysis determined five of the nine features where the differences was statistically significant at the level of 0.01, whereas in the Kolmogorov-Smirnov test carried out at the same level of significance only four out of eight tested variables shoved statistically significant difference assuming equality of mean values of female and male features. The features related to the sexual dimorphism pertain mostly to the head and sucker dimensions. Following the determination of the sex-related features a comprehensive analysis of plastic features for 50 females and 50 males taken at random was carried out (Tab. 5).

Table 5

Lumpfish (*Cyclopterus lumpus*) of Southern Baltic measurable features characteristic carri edout for 50 females and 50 males

Feature	Range	M ± m	SD	CV
Longitudo totalis (mm)	139–199	164.92±1.66	11.73	5.70
Longitudo corporis (mm)	120–181	136.64±1.57	11.13	6.72
Longitudo corporis = 100%				
Longitudo capitis	28.95–37.02	32.99 ±0.30	2.11	8.36
Longitudo ossis maxillae	8.30–13.98	11.62 ±0.15	1.07	11.62
Longitudo praeanalis	59.01–81.92	71.00 ±0.52	3.66	5.35
Longitudo praedorsale	58.90–100.00	71.24 ±0.76	5.37	6.60
Longitudo acetabuli	14.71–25.51	19.26 ±0.36	2.54	13.93
Longitudo pedunculi caudalis	10.06–22.86	14.22 ±0.30	2.14	14.27
Longitudo pinnae P	18.36–24.17	20.97 ±0.18	1.29	8.09
Latitudo rostrum	13.50–22.10	17.61 ±0.27	1.91	11.43
Latitudo capitis	21.94–36.35	26.52 ±0.39	2.75	10.66
Latitudo acetabuli	11.42–24.13	16.11 ±0.32	2.23	15.08
Altitudo pinnae A	16.52–24.92	21.25 ±0.26	1.81	9.25
Altituda pinnae D_2	16.85–26.30	20.99 ±0.31	2.22	10.46
Spatium preorbitale	9.35–16.32	12.56 ±0.21	1.47	11.96
Spatium interorbitale	14.84–24.37	18.66 ±0.28	1.97	10.20
Spatium postorbitale	13.43–22.48	16.67 ±0.21	1.49	8.78
Spatium V-A	48.01–67.12	54.89 ±0.51	3.58	6.86
Diameter oculi horizontalis	5.38–10.53	7.85 ±0.17	1.22	14.87

Correlation between the body length ant the absolute and indexed values of the features

Analysis of the relation between absolute values of the individual features studied revealed the highest correlation between: body length and preanal distance (r = 0.826) and body length and predorsal length (r = 0.770). A fairly high correlation was also noted for such pairs of features as: body length and V–A distance, body length and head length, body length and depth of anal fin as well as the body and pectoral fin lengths. For the indices, the highest correlation coefficient was determined for the body length and postocular distance (r = –0.522), whereas the remaining features were weakly correlated (Tab. 6).

Table 6

Analysis of regression (y = a + bx) and correlation (r) between the standard length (SL) and morphometric features tested (r^2, determination coefficient; p, probability value; 1, relation between standard length (mm) and individual features in absolute values (mm); 2, relation between standard length and individual features expressed as an index (%)

Realationship		r	r^2	p	a	b
Longitudo corporis (x),	1	0.608	0.370	$1 \cdot 10^{-14}$	17.783	0.188
Longitudo capitis (y)	2	-0.463	0.214	$1 \cdot 10^{-8}$	44.647	-0.093
Longitudo corporis (x),	1	0.373 *	0.139	$6 \cdot 10^{-6}$	17.867	0.130
Latitudo capitis (y)	2	-0.424	0.180	$1 \cdot 10^{-7}$	38.722	-0.092
Longitudo corporis (x),	1	0.377	0.142	$4 \cdot 10^{-6}$	12.137	0.078
Latitudo rostrum (y)	2	- 0.411	0.169	$4 \cdot 10^{-7}$	25.268	-0.062
Longitudo corporis (x),	1	0.306 *	0.093	$2 \cdot 10^{-4}$	3.612	0.051
Diameter oculi horizontalis (y)	2	-0.237 *	0.056	$4 \cdot 10^{-3}$	10.355	-0.019
Longitudo corporis (x),	1	0.407	0.166	$6 \cdot 10^{-7}$	7.292	0.069
Spatium preorbitale (y)	2	-0.309	0.096	$1 \cdot 10^{-4}$	17.203	-0.036
Longitudo corporis (x),	1	0.408 *	0.166	$1 \cdot 10^{-6}$	10.410	0.062
Spatium postorbitale (y)	2	-0.522 *	0.273	$3 \cdot 10^{-11}$	23.818	-0.055
Longitudo corporis (x),	1	0.426	0.182	$1 \cdot 10^{-7}$	13.305	0.083
Spatium interorbitale (y)	2	-0.457	0.209	$1 \cdot 10^{-8}$	27.035	-0.065
Longitudo corporis (x),	1	0.342	0.117	$3 \cdot 10^{-5}$	8.249	0.049
Longitudo ossis maxillae (y)	2	-0.410	0.168	$4 \cdot 10^{-7}$	16.942	-0.043
Longitudo corporis (x),	1	0.770 *	0.593	$9 \cdot 10^{-29}$	5.648	0.686
Longitudu praedorsale (y)	2	-0.104 *	0.001	$2 \cdot 10^{-1}$	79.861	-0.050
Longitudo corporis (x)	1	0.826 *	0.682	$1 \cdot 10^{-25}$	4.157	0.703
Longitudo praeanalis (y)	2	-0.150 *	0.022	$7 \cdot 10^{-2}$	76.361	-0.021
Longitudo corporis (x),	1	0.646 *	0.417	$6 \cdot 10^{-18}$	11.749	0.478
Distantia V-A (y)	2	-0.252 *	0.063	$2 \cdot 10^{-3}$	65.983	-0.068
Longitudo corporis (x),	1	0.416	0.173	$3 \cdot 10^{-7}$	5.683	0.098
Longitudo pedunculi caudae (y)	2	-0.088 *	0.008	$3 \cdot 10^{-1}$	17.548	-0.026
Longitudo corporis (x),	1	0.423 *	0.179	$2 \cdot 10^{-7}$	6.791	0.158
Altitudo pinnae D_2 (y)	2	-0.227 *	0.005	$6 \cdot 10^{-3}$	22.596	-0.015
Longitudo corporis (x),	1	0.593	0.352	$1 \cdot 10^{-14}$	6.988	0.161
Altitudo pinnae A (y)	2	-0.229	0.053	$6 \cdot 10^{-3}$	26.076	-0.035
Longitudo corporis (x),	1	0.518 *	0.268	$5 \cdot 10^{-11}$	7.836	0.149
Longitudo pinnae P (y)	2	-0.319	0.102	$1 \cdot 10^{-4}$	26.437	-0.042
Longitudo corporis (x),	1	0.218 *	0.047	$9 \cdot 10^{-3}$	14.703	0.073
Longitudo acetabuli (y)	2	-0.469 *	0.220	$4 \cdot 10^{-3}$	28.443	-0.075
Longitudo corporis (x),	1	0.149 *	0.022	$7 \cdot 10^{-2}$	13.503	0.049
Latitudo acetabuli (y)	2	-0.493 *	0.243	$5 \cdot 10^{-10}$	24.158	-0.068

* the Spearman ranks correlation coefficient

High correlation coefficient calculated based on the absolute values were usually associated with low coefficients for the indexed values for the same features. The latter were always negative. Taken this into consideration one can assume high diagnostic value of the indexed features, which are related to dimensions along the body axis. This refers in particular to the predorsal, preanal (Figs. 2, 3.), then the V–A distance, caudal length, and D_2 and A fin dimensions. The diagnostic value of the measurements related to the body width is of lesser significance and probably dependent on the fish and environmental conditions.

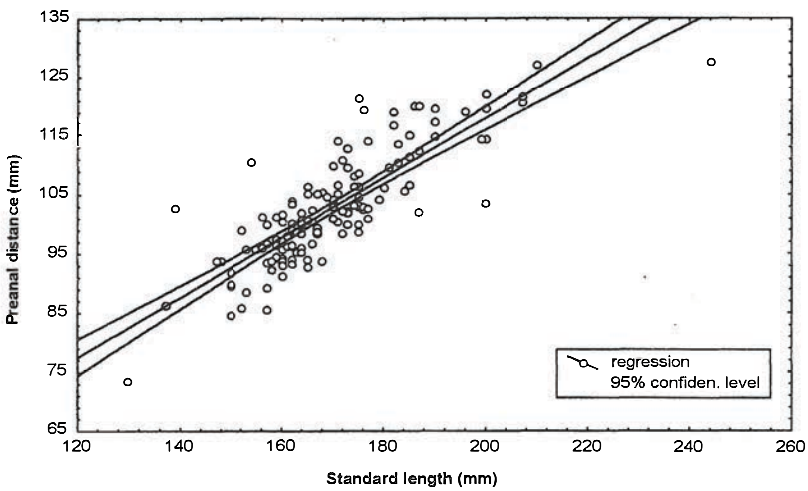

Fig. 2. Relation between lumpfish standard length and preanal distance in absolute values

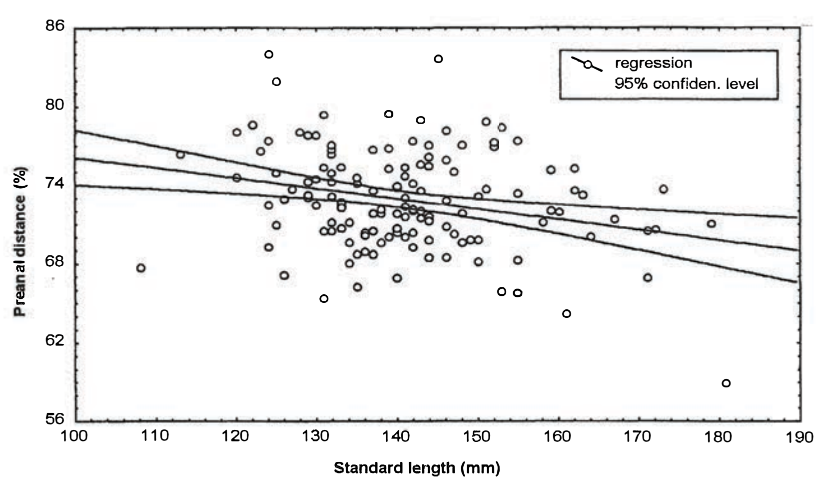

Fig. 3. Relation between lumpfish standard length and preanal distance (indexed)

DISCUSSION

Acquisition of suitable samples for morphological or biological studies is fairly difficult and this is associated with the lumpfish biology and its migration habits. To spawn lumpfish migrates from deep waters to the shallow ones. The specimens used for the present study were collected by a net at the depth of 10–20 m in spring during the spawning season. Description of spawning and the methods of parental care exercised over the progeny can be found in numerous publications like those by Wiktor (1962), Blacker (1983), Wheeler (1983) or Virbickas (1986). It appears from those works that until late summer months lumpfish occur in fairly shallow waters. After that period the adult individuals occurring in the Southern Baltic disappear from coastal areas until the winter months.

This problem was dealt with in the sixties by Bagge (1964) who had formulated three suppositions concerning periodical disappearance of lumpfish from shallow waters. The most probable of those suppositions shows that lumpfish live in pelagic waters for a part of the year and this was confirmed by works on the alimentary tract contents (Garrod and Harding 1981), as well as in papers describing distribution of lumpfish in the Norwegian Sea (Holst 1993). Some remarks concerning pelagic occurrence of lumpfish can also be found in a paper of Hognestad and Vader (1979) or Muus (1991) It is evident from the discussion provided by the above authors that the biology of lumpfish is still poorly known. The morphological description given in the present paper has been carried out in such extent for the Baltic population for the first time.

The presently determined number of fin rays was compared with the data of the others authors. In the second dorsal fin we found 10–11 rays. Very similar numbers were reported by Andriâšev (1954) and Virbickas (1986) whereas Saemundsson (1932), Wiktor (1962) or Terofal and Militz (1996) assumed that the first ray of D_2 is a sort of spine and considered it as a hard ray whereas the other rays are soft (I–10). We found 9 to 11 rays in the anal fin whereas Wiktor (1962) and Virbickas (1986) recorded the range of 10–11. Saemundsson (1932) as well as Terofal and Militz (1996) considered the first ray of the anal fin a hard ray, proposing the following formula for that fin: I 9–10 or I-10. In the present work the highest variability was recorded for the pectoral fin, where the number of rays varied from 18 to 24. The literature specifies the ray number range for the latter fins as 20–21 (Saemundsson 1932; Andriâšev 1954; Wiktor 1962).

Six rows of tubercles are present on both sides of the lumpfish body; three for each side (ventral, lateral and, dorsal). Andriâšev (1954) and Terofal and Militz (1996) mentioned the seventh single row of tubercles located along the mid-dorsal line. The observed high variability of that feature indicates lack of stability in the number of the tubercles. Significant effect of environmental conditions, like temperature or salinity, on the development of that particular feature during the egg incubation and early days of development can be anticipated.

The statistical analysis has confirmed the occurrence of sex-related features. In nine out of 17 measurable features differences between the males and females were found to be statistically significant. In the past only the body dimensions were believed to show differences between sexes (females are bigger than males; Andriâšev 1954; Muus 1991; Terofal and Militz 1996). Such phenomenon has not been confirmed for the Southern Baltic lumpfish. The males studied had stronger heads, jaws, and bigger suckers (both in length and width). However, those features are not sufficient to determine sex of an individual without anatomic examination.

CONCLUSIONS

1. The following formulas has been established based on the analysis of meristic features: D_2 10–11, A 9–11, P 18–24.
2. Statistical differences between females and males were found in 9 out of 17 indexed measurable features.
3. The highest values of correlation coefficients were observed for the relations between the body length (mm) and the preanal distance (mm) $r = 0.826$ and between the body length (mm) and the predorsal length (mm) $r = 0.770$.
4. The measurements parallel to the long axis of the body expressed as percentage of the body length, were proved to have high diagnostic value.
5. The males in the population studied reached higher mean values of the features related to the sex dimorphism than the females, however, without anatomic examination the sex cannot be determined explicity.

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CHARAKTERYSTYKA MORFOLOGICZNA TASZY, *CYCLOPTERUS LUMPUS* L.,1758 POŁUDNIOWEGO BAŁTYKU

STRESZCZENIE

Tasza jest rybą żyjącą w Atlantyku, występującą również w stosunkowo mało wysolonych wodach Morza Bałtyckiego. W pracy przedstawiono zagadnienia związane z morfologią tego gatunku. Ryby do badań pozyskano z łowisk w okolicach Unieścia i Chłopów, w lutym 1995 roku. Analiza cech policzalnych dotyczyła liczby promieni w płetwach (piersiowych, drugiej grzbietowej i odbytowej), oraz liczby guzków kostnych znajdujących się w 3 rzędach na każdym boku ciała. Dla płetw ustalono następującą formułę: D_2 10–11, A 9–11, P 18–24. Liczba guzków kostnych charakteryzowała się wysokimi współczynnikami zmienności, co świadczy o dużej plastyczności tej cechy w badanej populacji. Analiza cech wymierzalnych dotyczyła 19 zmiennych, z których 17 zostało opisane za pomocą indeksów, wyrażonych w % długości ciała. Spośród 17 przebadanych zmiennych indeksowanych, aż u dziewięciu średnie wartości cech samic i samców okazały się statystycznie istotne. Samce posiadały masywniejszą głowę, mocniejsze szczęki i większe przyssawki niż samice, jednak na podstawie wyglądu głowy i przyssawki nie zawsze można było jednoznacznie ustalić płci. Badając siłę związku korelacji pomiędzy długością ciała a cechami wymierzalnymi, stwierdzono dużą wartość diagnostyczną cech indeksowanych, prowadzonych dla pomiarów wzdłuż osi ciała ryby. Najwyższe współczynniki korelacji zanotowano dla zależności długości ciała (mm) a odległości przedodbytowej (mm) (r = 0,826), oraz dla długości ciała (mm) a odległości przedgrzbietowej (mm) (r = 0,770).

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