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MORPHOMETRY OF SOUTHERN BLUE WHITING *MICROMESISTIUS AUSTRALIS* (NORMAN, 1937) – FROM THE REGION OF BURDWOOD BANK

MORFOMETRIA BŁĘKITKA POŁUDNIOWEGO – *MICROMESISTIUS AUSTRALIS* (NORMAN, 1937) – Z REJONU ŁAWICY BURDWOOD

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Morphometric characteristic of southern blue whiting is presented. It embraces 31 measurable and 9 meristic features. Studies were made on 119 fishes (44 females and 75 males) caught near the Burdwood Bank in the period March – April, 1981. The results were taken advantage of in discusing the homogeneity of southern blue whiting stocks inhibiting various waters of the south hemisphere. Problems of sexual dimorphism in this species have also been discussed.

INTRODUCTION

Situation of the shelf fishing grounds as well as increasing depletion of the traditionally exploited fish stocks resulted in the need of finding out new fish resources that could substitute the fish species caught so far. It appeared that blue whiting resources do constitute such a reserve. Stocks of this fish have hardly been exploited till now.

In 1983 Polish catches of southern blue whiting amounted to 281.3 thousand tons, in this 258 thousand tons were caught in the shelf of Argentina (Yearbook of Fishery Statistics, 1983).

Resources of this fish have been estimated at 1–2 milion tons (Lopez and Belisio, Moisiejew and Gullard, cit. after Żukowski and Liwoch 1977).

Meat of blue whiting (Liwoch 1978a) is considered as highly valuable, typical of Gadide fishes. On the other hand high infestation of this fish with parasites, reaching 100%, constitutes considerable drawback (Grabda 1978). Some authors (Nodzyński and Żukowski 1972) stated that blue whiting should not be permitted for human consumption, and can only be used to produce fish meal. Notwithstanding this, it should be noted that parasites of southern blue whiting (*Protozoa* Kudoa sp.) are not harmful for humans but only lower the fish meat quality.

Literature on southern blue whiting is scarce. The data on the biometric features of this species are almost non-existent. So far, most papers dealt with the exploitation of southern blue whiting. Only Śpak (1975), Śust (1971, 1978), Liwoch (1978, 1979), Żukowski and Liwoch (1977), and Kijek (1981) discussed some aspects of the biology of this fish.

An attempt has been made in the present paper to explain the homogeneity of the southern blue whiting stocks inhabiting different waters of the south hemisphere. Problems related to the sexual dimorphism in this fish have also been discussed.

MATHERIAL AND METHODS

Matherials consisted of 119 specimens of southern blue whiting (*Micromesistius australis*), 44 females and 75 males. The fishes were caught in the region of Burdwood Bank (Fig. 1) in March-April 1981.

Biometric features were studied – 31 measurements were made and 11 meristic features were determined for each fish. In doing this, advantage was taken of the scheme prepared by Michin for *Gadidae* fishes, as given in the paper Prawdin (1966) with an apropriate modification (Fig. 2).

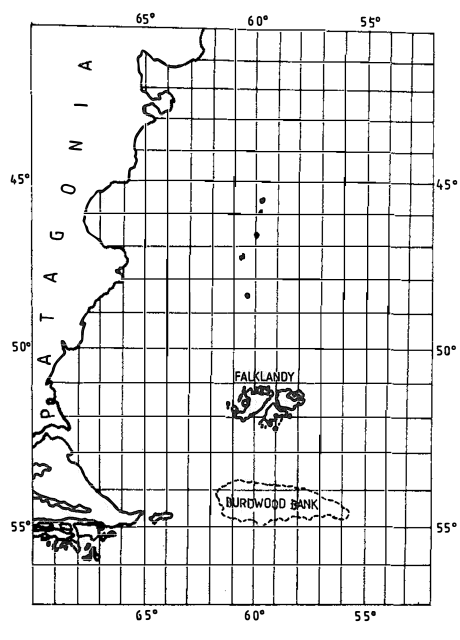

Fig. 1. Sampling stations – Burdwood Bank

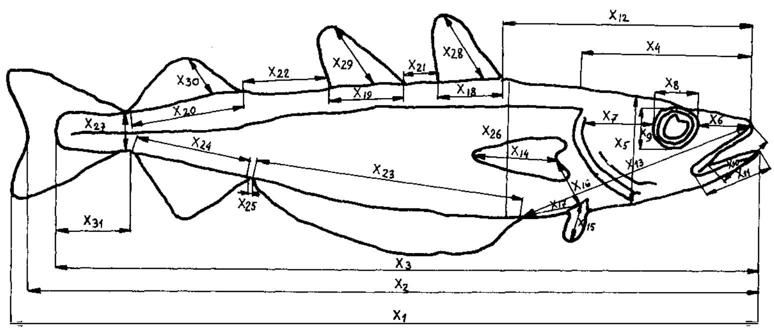

Fig. 2. Scheme of the measurement of biometric features

x_1 – total body length
x_2 – caudal length
x_3 – body length
x_4 – head length
x_5 – head height
x_6 – preorbital length
x_7 – postorbital length
x_8 – horizontal eye diameter
x_9 – vertical eye diameter
x_{10} – length of upper jaw
x_{11} – length of lower jaw
x_{12} – antedorsal length
x_{13} – preanal length
x_{14} – length of pectoral fin
x_{15} – length of ventral fin
x_{16} – distance between ventral and pectoral fin
x_{17} – distance between ventral and anal fin
x_{18} – length of the base of first dorsal fin
x_{19} – length of the base of second dorsal fin
x_{20} – length of the base of third dorsal fin
x_{21} – distance between first and second dorsal fin
x_{22} – distance between second and third dorsal fin
x_{23} – length of the base of first anal fin
x_{24} – length of the base of the second anal fin
x_{25} – distance between anal fins
x_{26} – maximal body height
x_{27} – minimal body height
x_{28} – height of the first dorsal fin
x_{29} – height of the second dorsal fin
x_{30} – height of the third dorsal fin
x_{31} – length of the caudal part

Data given in the same paper by Prawdin were used to calculate percentage of the length of particular fish body parts in total body length.

The fishes were divided into females and males (sex was determined during dissection).

The results were treated statistically. Standard deviation, coefficient of variability, and standard error were calculated. Ruszczyc (1981) stated that coefficients of variability were significant only when their value reached 8–10%. Biometric features for which the coefficient of variability was below 8% were considered as of low plasticity, those with variability coefficient of 8–15% as modertely plastic, and those with coefficient over 15% as highly plastic.

In order to verify the null hypothesis on the lack of differences between average values for males and females, test C (Cochran-Cox) was used after Oktaba (1980).

In all cases when the samples differed as to their number ($n_1 \neq n_2$), i.e. for comparisons between males and females, but showed normal distribution and different variance (S_1^2 S_2^2), the following equation (test C) was used to verify the null hypothesis:

$$C^\circ = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{Z_1 + Z_2}}$$

where:

$$Z_1 = \frac{n_1 S_1^2}{n_1(n_1-1)} \qquad Z_2 = \frac{n_2 S_2^2}{n_2(n_2-1)}$$

S_1^2, S_2^2 – variance,

n_1, n_2 – number of observations,

$\bar{y}_1, \bar{y}_2$ – arithmetical mean.

Numerators of the two last fractions represented the sums of squared deviations from the average for the first and the second sample respectively. At the assumed error risk of 5%, the critical value is calculated from the equation:

$$C_{0.05} = \frac{Z_1 t_1 + Z_2 t_2}{Z_1 + Z_2}$$

where:

t_1 – critical value of $t_{0.05}$ from the Student's t tables at n-1 degrees of freedom

t_2 – critical value from the Student's t tables at $n_2 - 1$ degrees of freedom.

Values C° and $C_{0.05}$ are compared to find out whether the difference between the averages is a significant one. If $C^\circ > C_{0.05}$ the difference is significant.

Correlation coefficient was also calculated (linear correlation between two features) for the whole material, and for the females and males separately.

The correlation coefficient was calculated using the equation:

$$r = \frac{\Sigma (X-\bar{x})(Y-\bar{y})}{\sqrt{\Sigma (X-\bar{x})^2 (Y-\bar{y})^2}}$$

(Ruszczyc 1981)

This can be presented as:

$$r = \frac{n\Sigma xy - \Sigma ix \, \Sigma iy}{\sqrt{[n\Sigma x^2 - |\Sigma x|^2][n\Sigma y^2 - |\Sigma y|^2]}}$$

where:

n	–	number of observations
Σ xy	–	sum of the product of the two consecutive variables
Σ x	–	sum of the values of the first variable
Σ y	–	sum of the values of the socond variable
$\Sigma\ x^2$	–	sum of the squares for the first variable
$\Sigma\ y^2$	–	sum of the squares for the second variable.

Correlation was calculated for the fish age and length. Square of the correlation coefficient expressed in % gave the coefficient of the determination r^2 (Oktaba 1980). This coefficient reflects the percentage effect of the independent variable on the dependent one. (In this case the effect of age on the fish length).

Fish age was determined from the otoliths on the basis of annual rings. The materials embraced southern blue wihiting 7 to 15 years of age, divided into 8 age groups.

RESULTS

Length structure.

The sample consisted of 119 fishes (37% males, 63% females, Fig. 3). The fish length ranged from 43 cm to 58.5 cm. The fishes were grouped using 2 cm intervals. Two length groups were most numerous: 49–51 cm and 51–53 cm. These groups were represented by 63.9% of all specimens. Length group 43–45 cm was represented by only 0.833% specimens, group 45–47 cm by 1.667%, and group 57–59 cm by 2.5%.

Length of the females ranged from 43 cm to 58.5 cm, 51–53 cm group being the most numerous (25.2%), and groups 43–45 cm and 45–47 cm the least numerous ones (2.3% of the specimens in each group).

Length of the males ranged from 45 cm to 57 cm. Two consecutive length groups were most numerous: 49–51 cm and 51–53 cm. These two groups embraced 73.8% of all males. Length class 45–47 cm was the least numerous (1.3%).

Analysis of the measurable features.

Measurable features have been expressed in relative units i.e. as the indices of body proportions in relation to the fish length. Overal data are given in Table 1.

The following features were classified as of low plasticity (i.e. those for which the coefficient of variability did not exceed 8%): total length, caudal length, body length, head length, horizontal eye diameter, length of lower jaw, precaudal length, length of ventral fin, base length of the first anal fin, height of the first dorsal fin. These 11 features constituted 35.5% of all measurable features under study. Features of medium plasticity (coefficient of variability 8–15%) were as follows: head height, preorbital length (*longitudo praeorbitale*), postorbital length (*longitudo postorbitale*), vertical eye diameter, length of upper jaw, anterdorsal length, distance between pectoral and ventral fin, distance between ventral and dorsal fin, base length of the first, second and third anal fin,

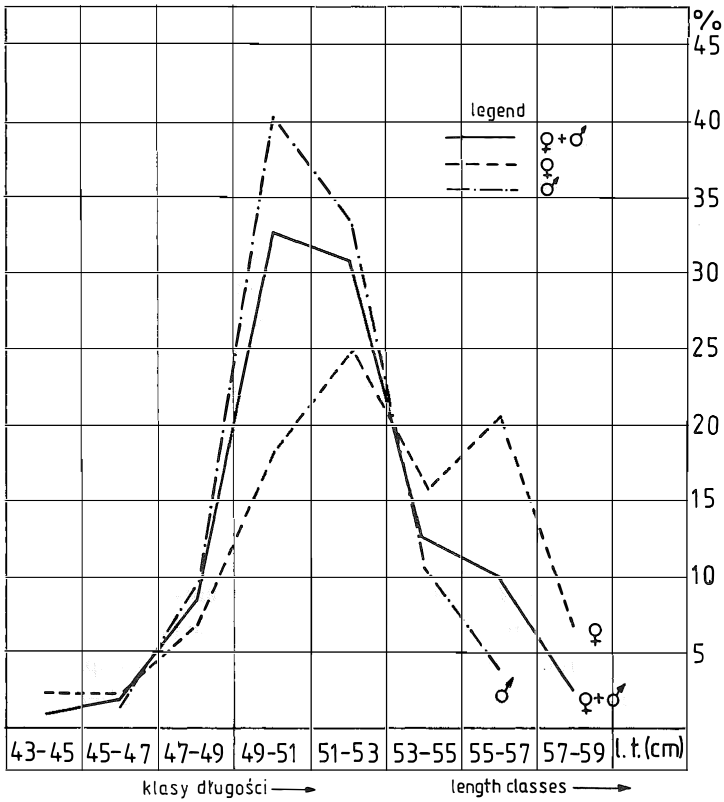

Fig. 3. Length composition of the fishes under study

the largest body height (*altitudo corporis maxima*), the smallest body height (*altitudo corporis minima*), height of the second and third dorsal fin, length of the caudal part (*longitudo peduncli caudae*), base length of the second anal fin, distance between the first and the second and the third dorsal fin. These features of medium plasticity (19 features) represented 61.30% of all measurable indices. Only one feature was very plastic. This was the distance between the first and the second anal fin (variability coefficient over 15%).

Features characterized by low variability (variability coefficient below 8%) can be considered as relatively stable. They are fairly useful in distinguishing the features characteristic for males and females.

In case of females (Table 2) the features of low plasticity were as follows: total length, caudal length, body length, head length, vertical eye diameter, length of lower jaw, preanal length, length of pectoral fin, length of ventral fin, base length of the second anal fin. These 10 features represent 32.3% of all measurable features.

The second group, embracing features of medium plasticity (coefficient of variation 8–15%), was represented by: head height, preorbital length, postorbital length,

Table 1

Indices of body proportions in relations to body length, in % for the whole material (n = 119)

No	Linear values	Range (cm)	M (cm)	Range (cm)	M (%)	±m (%)	±S (cm)	V (%)
1	Total length (l.t)	43.0–58.5	51.40	108.3–111.7	109.55	0.23	2.54	4.94
2	Caudal length (l. caud.)	40.5–56.0	49.03	103.7–105.2	104.50	0.23	2.53	5.16
3	Body length (l.c.)	38.5–54.0	46.92	100	100.00	0.23	2.51	5.35
4	Head length	8.9–14.5	10.47	23.12–26.85	22.31	0.08	0.82	7.83
5	Head height	5.1– 8.1	6.57	13.25–15.00	14.00	0.05	0.58	8.83
6	Prorbital length	2.7–4.2	3.37	7.01–7.78	7.18	0.03	0.30	8.90
7	Postorbital length	2.7–6.7	4.76	7.01–12.41	10.14	0.05	0.54	11.34
8	Horizontal eye diameter	2.2–3.2	2.75	5.71– 5.93	5.86	0.02	0.21	7.64
9	Vertical eye diameter	2.2–4.3	2.65	5.71– 7.96	5.65	0.02	0.26	9.81
10	Length of upper jaw	2.5–4.3	3.18	6.49– 7.96	6.78	0.03	0.35	11.00
11	Length of lower jaw	3.6–5.6	4.21	9.35–10.37	8.97	0.03	0.29	6.89
12	Preanal length	12.1–17.8	14.34	31.43–32.96	30.56	0.10	1.07	7.46
13	Antedorsal length	12.9–18.5	15.17	33.51–34.26	32.33	0.11	1.23	8.11
14	Length of pectoral fin (P)	5.6–8.0	6.82	14.55–14.81	14.53	0.03	0.29	4.25
15	Length of ventral fin (V)	4.4–5.7	4.84	10.56–11.43	10.32	0.02	0.25	5.17
16	P – V distance	2.2–3.8	3.15	5.71– 7.04	6.71	0.03	0.34	10.79
17	V – A distance	3.8–8.2	5.62	9.87–15.19	11.98	0.07	0.78	13.88
18	Length of D1 base	2.6–4.8	3.56	6.75– 8.89	7.59	0.03	0.36	10.11
19	Length of D2 base	3.4–5.9	4.29	8.83–10.93	9.14	0.05	0.51	11.89
20	Length of D3 base	6.0–9.4	6.65	15.58–17.41	14.17	0.06	0.69	11.38
21	D1 – D2 distance	2.7–4.6	3.55	7.01– 8.52	7.57	0.03	0.37	10.42
22	D2 – D3 distance	4.8–7.9	6.75	12.47–14.63	14.39	0.06	0.61	9.04
23	Length of Al base	13.7–20.7	17.51	35.58–38.33	37.32	0.11	1.19	6.80
24	Length of A2 base	6.9–10.2	8.16	17.92–18.89	17.39	0.06	0.68	8.33
25	Al – A2 distance	0.7–2.3	1.27	1.82– 4.26	2.71	0.03	0.32	25.20
26	Maximal body height	5.8–9.5	7.42	15.06–17.59	15.81	0.07	0.79	10.65
27	Minimal body height	1.2–2.4	1.89	3.12– 4.44	4.03	0.02	0.19	10.05
28	Height of D1 fin	4.2–6.5	5.51	10.91–12.04	11.74	0.04	0.44	7.99
29	Height of D2 fin	3.5–6.4	5.13	9.09–11.85	10.93	0.04	0.47	9.16
30	Height of D3 fin	2.6–5.6	3.97	6.75–10.37	8.46	0.05	0.56	14.11
31	Lenght of caudal part	3.2–5.5	4.23	8.31–10.19	9.02	0.04	0.41	9.70

Table 2

Indicies of body proportions in relation to body length.
in % for the females (n = 44)

No	Linear values	Range (cm)	M (cm)	Range (%)	M (%)	$^{+}$-m (cm)	$^{+}$-S (cm)	V (%)
1	Total length (l.t.)	43.5–58.5	52.23	108.3–113.0	109,54	0.49	3.23	6.18
2	Caudal length (l. caud.)	40.5–56.0	50.08	103.7–105.2	105.03	0.48	3.21	6.41
3	Body length (l.c.)	38.5–54.0	47.68	100	100.00	0.48	3.18	6.67
4	Head length	8.9–12.8	10.71	23.11–23.70	22.46	0.12	0.82	7.66
5	Head height	5.1–8.1	6.68	13.25–15.00	14.01	0.10	0.63	9.43
6	Preorbital length	2.9–4.2	3.48	7.53– 7.78	7.30	0.05	0.33	9.48
7	Postorbital length	4.0–6.3	4.93	10.39–11.67	10.34	0.08	0.51	11.36
8	Horizontal eye diameter	2.3–3.2	2.80	5.93– 5.97	5.87	0.03	0.23	8.21
9	Vertical eye diameter	2.2–3.1	2.65	5.71– 5.74	5.56	0.03	0.21	7.92
10	Length of upper jaw	2.5–4.3	3.25	6.49– 7.96	6.82	0.06	0.39	12.00
11	Length of lower jaw	3.6–4.8	4.29	8.89– 9.35	9.00	0.05	0.31	7.23
12	Preanal length	12.1–17.8	15.47	31.43–32.96	32.45	0.19	1.29	8.34
13	Antedorsal length	13.2–18.5	15.88	34.26–34.29	33.31	0.19	1.26	7.93
14	Length of pectoral fin (P)	5.6–7.9	6.83	14.55–14.63	14.32	0.05	0.34	5.00
15	Length of ventral fin (V)	4.5–5.7	4.91	10.56–11.69	10.30	0.05	0.33	6.72
16	P – V distance	2.3–3.7	3.17	5.97– 6.85	6.65	0.06	0.38	11.99
17	V – A distance	4.2–8.2	5.96	10.91–15.19	12.50	0.12	0.78	13.09
18	Length of D1 base	2.9–4.7	3.69	7.53– 8.70	7.74	0.06	0.39	10.57
19	Length of D2 base	3.6–5.9	4.41	9.35–10.95	9.25	0.08	0.52	11.79
20	Length of D3 base	6.2–9.1	7.63	16.10–16.85	16.00	0.11	0.73	9.57
21	D1 – D2 distance	2.8–4.6	3.73	7.27– 8.52	7.82	0.06	0.38	10.19
22	D2 – D3 distance	5.3–7.9	6.68	13.77–14.63	14.01	0.10	0.65	9.73
23	Length of A1 base	13.7–20.7	17.68	35.58–38.33	37.06	0.21	1.42	8.03
24	Length of A2 base	6.9–9.8	8.60	17.92–18.15	18.04	0.10	0.68	7.91
25	A1 – A2 distance	0.7–2.3	1.22	1.82–4.26	2.56	0.05	0.36	29.51
26	Maximal body height	5.8–9.5	7.63	15.06–17.59	16.00	0.13	0.85	11.14
27	Minimal body height	1.2–2.4	1.91	3.12– 4.44	4.01	0.03	0.22	11.52
28	Height of D1 fin	4.2–6.5	5.41	10.91–12.04	11.39	0.08	0.50	9.24
29	Height of D2 fin	3.5–6.4	5.10	9.09–11.85	10.70	0.08	0.53	10.39
30	Height of D3 fin	2.6–5.6	3.89	6.75–10.37	8.16	0.10	0.64	16.45
31	Length of caudal part	3.6–5.5	4.39	9.35–10.19	9.21	0.06	0.43	9.79

horizontal eye diameter, length of upper jaw, antedorsal length, distance between pectoral and ventral fin, base length of the first secon and third dorsal fin, distance between the first and second, and between the second and third dorsal fin, base length of the first anal fin, the largest and the smallest body height, length of the first and second dorsal fin, and length of the caudal part. These are 19 features representing 61.3% of all measurable features. Two features (6.5%) were very plastic: distance between the first and second anal fin, and height of the third dorsal fin.

In case of males (Table 3) the following features appeared to be of low plasticity (variation coefficient up to 8%): total length, caudal length, body length, head length, preorbital length, horizontal eye diameter, length of lower jaw, antedorsal length, preanal length, length of pectoral fin, length of ventral fin, base length of the first anal fin, height of the first dorsal fin. These are 13 features (41.9% of all measurable features).

Medium-plastic features in males were as follows: head height, postorbital length, vertical eye diameter, length of upper jaw, distance between pectoral and ventral fin, distance between ventral and anal fin, base length of the first, second and third dorsal fin, distance between the first and second, and between the second and third dorsal fin, base length of the second anal fin, the largest and the smallest body height, length of the second and third dorsal fin, length of the caudal part. These are 17 features (54.8% of all measurable features). Only one feature appeared to be very plastic: distance between the first and second anal fin.

Features of low plasticity (variation coefficient below 8%), common for both males and females, were as follows: total length (average length bigger for females), caudal length (bigger for females), body length (as before), head length (as before), length of lower jaw (as before), preanal length (as before), length of pectoral fin (average bigger for males). These are 7 features, i.e. 22.3% of all measurable ones. They can be used to determine the sex dimorphism.

In order to establish whether the differences between the average values for males and females were significant, the Cochran-Cox test was used.

Measurable features with significant values of the variation coefficient (i.e. pointing to sex dimorphism) were: preorbital length, length of ventral fin, preanal length, height of the third dorsal fin. However, they did repeat only in two age-groups (from among the 8 distinguished ones). Hence, we can only speak of a slight sexual dimorphism with respect to the above given measurable features.

Correlation and determination coefficients were also calculated for total fish length and age. Correlation coefficient between total length and fish age amounted to 0.645 for the whole material. With n-2 degrees of freedom, this coefficient is significant at probability level of 5% as well as 1% (tables of the significance of correlation coefficients, Ruszczyc 1981).

Correlation between total length and age of the females was expressed by the coefficient of 0.768. It was also statistically significant.

In case of females the respective coefficient of correlation amounted to 0.425. Also this coefficient proved to be statistically significant.

Table 3

Indices of body proportions in relation to body length,
in % for the males (n = 75)

No	Linear values	Range (cm)	M (cm)	Range (%)	M (%)	±m (cm)	±S (cm)	V (%)
1	Total length (l.t.)	45.5–55.5	50.91	107.8–111.0	109.53	0.22	1.87	3.67
2	Caudal length (l. caud.)	44.0–54.0	48.43	104.9–107.3	104.20	0.22	1.90	3.92
3	Body length (l.c.)	41.0–51.5	46.48	100	100.00	0.22	1.88	4.04
4	Head length	9.0–14.5	10.33	21.95–28.16	22.22	0.99	0.82	7.93
5	Head height	5.5–8.0	6.52	13.41–15.53	14.03	0.06	0.54	8.28
6	Preorbital length	2.7–4.0	3.28	6.59–7.77	7.06	0.03	0.26	7.92
7	Postorbital length	2.7–6.7	4.66	6.59–13.01	10.03	0.06	0.50	10.73
8	Horizontal eye diameter	2.2–3.2	2.69	5.37–6.21	5.79	0.02	0.20	7.43
9	Vertical eye diameter	2.2–4.3	2.62	5.37–8.35	5.64	0.03	0.29	11.07
10	Length of upper jaw	2.5–4.3	3.14	6.10–8.35	6.76	0.04	0.32	10.19
11	Length of lower jaw	3.7–5.6	4.17	9.02–10.87	8.97	0.03	0.27	6.47
12	Preanal length	12.8–16.9	13.68	31.22–32.82	29.43	0.10	0.84	6.14
13	Antedorsal length	12.9–17.3	14.87	31.46–33.59	31.99	0.12	1.04	6.89
14	Length of pectoral fin (P)	6.5–8.0	6.87	15.85–15.33	14.78	0.03	0.26	3.78
15	Length of ventral fin (V)	4.4–5.6	4.81	10.73–10.87	10.35	0.02	0.18	3.74
16	P – V distance	2.2–3.8	3.14	5.37–7.38	6.76	0.04	0.32	10.19
17	V – A distance	3.8–6.8	5.43	9.27–13.20	11.68	0.08	0.70	12.89
18	Length of D1 base	2.6–4.8	3.47	6.34–9.32	7.47	0.04	0.35	10.09
19	Length of D2 base	3.4–5.9	4.22	8.29–11.46	9.08	0.06	0.49	11.61
20	Length of D3 base	6.0–9.4	7.67	14.36–18.25	16.50	0.08	0.67	8.73
21	D1 – D2 distance	2.7–4.5	3.45	6.59–7.38	7.42	0.04	0.37	10.72
22	D2 – D3 distance	4.8–7.8	6.79	11.71–15.15	14.61	0.07	0.58	8.54
23	Length of A1 base	14.3–19.5	17.41	34.88–37.86	37.46	0.12	1.02	5.86
24	Length of A2 base	7.0–10.2	7.90	17.07–19.81	17.00	0.08	0.66	8.35
25	A1 – A2 distance	0.7–2.2	1.30	1.71–4.27	2.80	0.03	0.28	21.54
26	Maximal body height	5.8–8.8	7.30	14.15–17.09	15.71	0.08	0.73	10.00
27	Minimal body height	1.5–2.4	1.89	3.66–4.66	4.07	0.02	0.17	8.99
28	Height of D1 fin	4.3–6.2	5.57	10.49–12.04	11.98	0.05	0.39	7.00
29	Height of D2 fin	3.7–5.9	5.15	9.02–11.46	11.08	0.05	0.44	8.54
30	Height of D3 fin	2.0–5.0	4.01	7.32–9.71	8.63	0.06	0.50	12.47
31	Length of caudal part	3.2–5.3	4.13	7.80–10.29	8.89	0.05	0.39	9.44

Table 4

Number of rays in the fins of southern blue whiting – whole material
(n = 119)

Type of fin		Number of rays	M	±m	±S	V (%)
Dorsal fin	(D1)	11–14	12.27	0.10	0.69	5.32
Dorsal fin	(D2)	10–15	12.84	0.16	1.09	8.49
Dorsal fin	(D3)	21–26	23.64	0.12	1.25	5.29
Anal fin	(A1)	30–39	34.98	0.19	1.93	5.52
Anal fin	(A2)	21–28	25.14	0.24	1.59	6.32
Pectoral fin	(P)	18–24	20.18	0.20	1.30	6.44
Caudal fin	(C)	33–46	42.00	0.43	2.83	6.74

Table 5

Number of rays in the fins of southern blue whiting – females
(n = 44)

Type of fin		Number of rays	M	±m	±S	V (%)
Dorsal fin	(D1)	11–14	12.09	0.09	0.76	6.29
Dorsal fin	(D2)	10–17	12.81	0.20	1.74	13.58
Dorsal fin	(D3)	20–26	23.46	0.16	1.37	5.84
Anal fin	(A1)	30–39	35.01	0.22	1.90	5.43
Anal fin	(A2)	21–30	24.95	0.19	1.62	6.49
Pectoral fin	(P)	16–24	20.30	0.16	1.40	6.90
Caudal fin	(C)	32–48	42.22	0.29	2.50	5.92

Table 6

Number of rays in the fins of southern blue whiting – males
(n = 75)

Type of fin		Number of rays	M	±m	±S	V (%)
Dorsal fin	(D1)	11–14	12.16	0.07	0.74	6.09
Dorsal fin	(D2)	10–17	12.82	0.14	1.51	11.78
Dorsal fin	(D3)	20–26	23.53	0.12	1.33	5.65
Anal fin	(A1)	30–39	35.00	0.18	1.81	5.46
Anal fin	(A2)	21–30	25.02	0.15	1.61	6.43
Pectoral fin	(P)	16–24	20.25	0.13	1.37	6.77
Caudal fin	(C)	32–48	42.14	0.24	2.63	6.24

Coefficient of determination for the whole material was 41.60% (i.e. age determined the fish length in 41.60%, whereas it was in 58.40% determined by other factors). This coefficient amounted to 58.98% for the fish females, and to 18.06% for the males.

Analysis of the meristic features (calculable).

Number of rays in the first dorsal fin varied from 11 to 14 (Tab. 4). Most of the fishes had 12 rays, both as regards females (Tab. 5) and males (Tab. 6).

Number of rays in the second dorsal fin ranged from 10 to 17, mostly 12. Males usually had 12 and females 13 rays in this fin.

Number of rays in the third dorsal fin ranged from 20 to 26. Fishes with 23 or 24 rays predominated. Females usually had 23 rays and males 24.

Number of rays in the three dorsal fins was always higher for females than for males.

Number of rays in the first anal fin ranged from 30 to 39,35 being the most frequent value, both with respect to fish males and females.

The second anal fin had 21 to 30 rays, but fishes with 25 rays predominated (24 rays for females and 25 for males). Average number of rays in the first anal fin was higher in males, and in the second anal fin – in females.

Number of rays in the pectoral fins ranged from 16 to 24. Fishes with 21 rays predominated. Females usually had 20 rays in this fin, and males had 21, so average number was higher for males.

Number of rays in the caudal fin was from 32 to 48, 42 rays being most frequent. Females usually had 42 and males 43 rays in this fin, so the average number was again higher for males.

Ventral fin of the fishes had always 6 rays.

Number of rays in the suboperculum membrane was also constant and amounted to 7.

Number of gill rakers ranged from 33 to 48 (33–46 in females, 36–48 in males, Tab. 7). It was not possible to state whether number of the gill rakers was related to the fish sex.

Table 7

Number of vertebrae and of gill rakers in southern blue whiting

Specification	Number of vertebrae	M	$\pm$m	$\pm$S	V (%)	Number of gill rakers
All fishes	53–56	54.85	0.07	0.76	1.39	33–48
Females	53–56	54.66	0.12	0.79	1.45	33–46
Males	53–56	54.96	0.08	0.72	1.32	36–48

M – arithmetical mean
m – average error of the mean
S – standard deviation
V – coefficient of variation

Number of vertebrae ranged from 53 to 56 (Tab. 7). Fishes with 55 vertebrae predominated (both males and females), but the average number amounted to 54.66 for females and to 54.96 for males. This feature was of low plasticity in both sexes.

The analyses revealed that the meristic features were generally more plastic in the fish females than in males.

DISCUSSION

Biometric features of southern blue whiting have been characterized by Śust (1971, 1978), Śpak (1975), Liwoch (1978, 1979), Żukowski and Liwoch (1977). Data presented in these papers can be used as a comparative material in discussing my results.

The fish sample under study (119 specimens) was predominated by males which represented 63% of the materials. This confirms the results obtained by Liwoch (1978, 1979) who stated that males usually represented 55 to 76% of the fish stock. However, older fishes were predominated by females, this being also in agreement with the results of Liwoch. Hence, females tend to live longer than males.

Total length of southern blue whiting from the region of Burdwood Bank varied from 43 to 58,5 cm (most specimens were 49–53 cm long). Żukowski and Liwoch (1977) stated that length of this fish from the region of Falkland Islands ranged from 18 to 61 cm (most fishes being 42 to 48 cm in length). On the other hand, Śubnikow et al. (cit. after Żukowski and Liwoch 1977) found that near Patagonia this fish was 37 to 60 cm in length (modal values 44–52 cm). According to this author, southern blue whiting attained 44–58 cm in the Sea of Scotia. Also Śust (1971) stated that fishes in the region of Falkland Islands and Burdwood Bank were smaller than in the Sea of Scotia, this being probably caused by the food availability in the regions with more intensive water mixing as well as by different sample size.

Comparison of my results with those given by Śust (1971) revealed considerable differences as to the measurable features. Fishes analysed by Śust originated from the region of Falkland Islands and Patagonia and from south Orkneys.

Śust (1971) underlined considerable variability of the measurable features, pointing to significant differences even between the samples obtained in one region but in different years. As regards specimens from different regions, this author found that from among 23 features as many as 17 differed significally. Still, he stated that there was no satisfactory proof on the genetic heterogeneity of blue whiting populations.

Contrary to this, Śpak (1975) suggested that populations of this species may differ.

My results suggest that the measurable features are characterized by high plasticity. They did not confirm Śpak's (1975) conclusion that the coefficient of variability decreased for some features along with the fish length. No such trend was noted. The same author stated that the sex dimoprhism in southern blue whiting (Compbell's Shallow region) was reflected in higher average values of 4 measurable features in the fish males (the highest body height, length of ventral and pectoral fins, eye diameter). My studies confirmed this statement for one feature only, i.e. length of the pectoral fin.

Analysis of the meristic features revealed that they were less plastic that the measurable ones. The same was found by Śust (1971). However, even these features differed considerably in the specimens from various regions. Considerable differences were noted even in these features which Śpak (1975) had classified as stable (number of rays in the dorsal fins, number of vertebrae). Comparison of my results with those of Śust (1971) revealed that only the average number of vertebrae was fairly similar.

Śust (1978) gave the range of variations of particular meristic features in the two subspecies of southern blue whiting: *Micromesistius australis australis* and *Micromesistius australis pallidus*. These data as well as the results of my studies revealed that the number of rays in the first dorsal fin (i.e. range of variation) was constant in all cases. Number of rays in the second dorsal fin and number of gill rakers in *M. australis pallidus* was similar as in my material, whereas as regards the third dorsal fin my results were similar to those obtained by Śust for *M. australis australis*. The latter was also true of the two anal fins and the number of vertebrae. Hence, most features were characteristic of *M. australis australis*, although not all and the numerical values were only roughly similar (with the exception of the number of rays in the first dorsal fin).

Śpak (1975) confirmed the differences as to the meristic features of the fishes from different regions. The same was found by Lopez and Bellisio (cit. after Żukowski and Liwoch 1977). These authors consider the differences to be significant and suggested that blue whiting may form different stocks contrary to the opinions expressed Śubnikow et al. (cit. after Żukowski and Liwoch 1977).

The results of my studies suggest that particular features, especially the measurable ones, are characterized by considerable variability. This variability is observed in the fishes from the same region as well as from different regions.

CONCLUSIONS

1. Southern blue whiting is characterized by considerable variability of the measurable and meristic features.
2. Statistically significant differences between males and females (determined with Cochran-Cox test) were found only in a few age groups. Consequently, it may be stated that sex dimorphism is weakly pronounced in this fish, this being true of the meristic and measurable features.
3. Correlation between fish age and length was confirmed for all specimens as well as separately for males and females. Coefficient of variability was significant in all three cases.
4. Coefficient of determination was much higher for the females.
5. Number of rays in the ventral fin was constant, being 6 for both sexes.
6. Number of rays in the gill membrane was constant, being 7 for both sexes.

7. Range of variations in the number of rays in particular fins of southern blue whiting from the region of Burdwood Bank was as follows:
   a) first dorsal fin 11–14
   b) second dorsal fin 10–17
   c) third dorsal fin 20–26
   d) pectoral fin 16–24
   e) first anal fin 20–39
   f) second anal fin 21–30
   g) caudal fin 32–48
8. Number of gill rakers ranged from 33 to 48, and number of vertebrae from 53 to 56.
9. Measurable features in the fish under study were characterized by considerable variability, while meristic features were relatively stable.
10. The results on biometric features of southern blue whiting were within the range characteristic of the two fish subspecies defined by Śust.

REFERENCES

Grabda J., 1978: Studies on parasitic infestation of blue whiting (Micromesistius sp. sp.) with respect to the fish utilization for consumption. Acta Ichthyologica et Piscatoria. VIII-1:29–40.

Kijek R., 1981: Age and growth rate of southern blue whiting, Micromesistius australis Norman, caught in 1980 from the Patagonia-Falkland Shelf. (M.Sc. degree). Zakład Biologii, AR Szczecin.

Liwoch M., 1978: Charakterystyka biologiczna błękitka południowego w rejonie Szelfu Patagońskiego w latach 1977–1978. Badania biologiczno-rybackie i ocena zasobów ryb Antarktyki. [Biological characteristics of southern blue whiting in the Patagonia shelf in 1977–1978. Biological and fishery research with estimate of the fish resources in Antarctica]. MIR, Gdynia. 27–75.

Liwoch M., 1979a: Charakterystyka , biologia i połowy błękitka. [Biology and catches of blue whiting]. Technika i Gospodarka Morska 9, 12: 722–724.

Liwoch M., 1979b: Charakterystyka biologiczna błękitka południowego w rejonie Szelfu Patagońskiego w roku 1979. Badania biologiczno-rybackie i ocena zasobów wód Antarktyki w sezonie 1978/1979. [Biological characteristics of southern blue whiting in the Patagonia shelf in 1979. Biological and fishery research with an estimate of the fish resources in Antarctica in 1978-79]. MIR, Gdynia. 112–122.

Nodzyński J., Żukowski C., 1972: Biologiczna i technologiczna charakterystyka błękitka. [Biology and technological character of blue whiting]. Studia i Materiały, MIR Seria D, Gdynia. p.p. 43.

Oktaba W., 1980: Metody statystyki matematycznej w doświadczalnictwie. [Statistical methods in experimental research]. PWN, Warszawa.

Oktaba W., 1980: Elementy statystyki matematycznej i metodyka doświadczalnictwa. [Elements of statistics and experimental methods]. PWN, Warszawa.

Prawdin I., 1966: Rukovodstwo po izućenju ryb. (in Russian). Piśćevaja promyślennost:. Moskwa.

Ruszczyc Z., 1981: Metodyka doświadczeń zootechnicznych. [Methods of zootechnical experimentation]. Państwowe Wydawnictwo Rolnicze i Leśne. Warszawa.

Śpak B.M., 1975: Morfometrićeska charakteristika južnoj putassy w rejonie Nowozelandskowo płata s zameśćenjami o djagnoze roda Micromesistius. Voprosy Ichtiologii, 15, 2, Moskva: 195–202. (in Russian)

Śust K.B., 1971: O strukture populacji južnoj putassy w jugo – zapadnoj Atlantiku. TRUDY WNIRO, 86. (in Russian)

Śust K.B., 1978: O rasprostranienii i biologii predstawitelej roda Micromesistius (Gem Gadidae). Voprosy Ichtiologii. 18. Moskva: 541–543. (in Russian)

Żukowski C., Litwoch M., 1977: Biologia i zasoby ryb szelfu argentyńskiego. [Biology and fish resources of the Argentina Shelf]. MIR, seria B. Studia i materiały, Gdynia.

Statystyczny Rocznik Rybacki. Yearbook of fishery Statistics. 1983, 56.

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MORFOMETRIA BŁĘKITKA POŁUDNIOWEGO – *MICROMESISTIUS AUSTRALIS* (NORMAN, 1937) Z REJONU ŁAWICY BURWOOD

STRESZCZENIE

Zawarta w niniejszej pracy charakterystyka morfometryczna dotyczy błękitka południowego *Micromesistius australis* (Norman, 1937) złowionego w rejonie Ławicy Burdwood w miesiącach marzec – kwiecień 1981 roku. Badania objęły 31 cech wymierzalnych oraz 11 cech merystycznych. Wykazały one duży zakres wahań współczynnika zmienności dla obu grup cech. Cechy merystyczne błękitka południowego z Ławicy Burwood można opisać następująco: D_1(11–14), D_2(10–17), D_3(20–26), A_1(30–39), A_2(21–30), V(6), P(16–24), C(32–48), kręgi (53–56), wyrostki filtracyjne (33–48), promienie podskrzelowe (7).

Badania autorki potwierdziły udowodnioną już korelację pomiędzy długością a wiekiem ryby – zarówno dla materiału w całości, jak i oddzielenie dla samic i samców.

Zastosowany test istotności Cochrana-Coxa, mający wykazać różnice istotne pomiędzy średnimi dla samic i samców, nie potwierdził istnienia tychże.

Na podstawie wartości współczynnika zmienności i porównania ich z wynikami innych badaczy, stwierdzono tylko jedną cechę wymierzalną charakterystyczną dla danej płci – większą długość płetwy piersiowej u samców. Dymorfizm płciowy u tego gatunku należy uznać więc za słabo zaznaczony.

W zbadanym materiale błękitka południowego z Ławicy Burdwood stwierdzono cechy charakterystyczne zarówno dla podgatunku *M. australis pallidus* jaki *M. australis australis* (z przewagą dla tego drugiego). Nie można więc wyodrębnić żadnego z dwóch podgatunków na podstawie badań błękitka w niniejszej pracy.

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