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SOME ASPECTS OF THE BIOLOGY OF THE ANADROMOUS POPULATION OF WHITEFISH (*COREGONUS LAVARETUS LAVARETUS*) FROM LAKE ŁEBSKO (NORTHERN POLAND)

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ABSTRACT. The age structure and growth rate of a native population of whitefish, *Coregonus lavaretus lavaretus* L., were analyzed on the basis of 66 specimens. The fishes were caught in autumn-winter 2000-2001 in Łebsko Lake. Fecundity estimates were calculated from a sample of 43 female ovaries. The age of the studied whitefish ranged from 2+ to 9+. Specimens aged 2+ predominated. In the first year of life the whitefish reached a body length (*longitudo corporis* – l.c.) of 12.2 (± 2.9) cm and a weight of 255 (± 150.1) g. In subsequent years these figures were as follows: second year – 30.8 (± 5.9) cm and 775 (± 287.9) g; fifth year – 27.3 (± 4.7) cm and 2581 (± 315.8) g; ninth year – 53.9 cm and 3878 (± 124.2) g. Average fecundity ranged from 46.8 (± 6.3) to 154.4 (± 13.4) thousands eggs in segregated size classes.

Key words: WHITEFISH (*COREGONUS LAVARETUS*), AGE, GROWTH, FECUNDITY, ŁEBSKO LAKE

INTRODUCTION

Coregonids inhabit clear, cool waters (Todd and Łuczyński 1992) and are popular food fishes in several northern and eastern European countries. Seven species are commonly distinguished in Europe, three of which occur in Poland – vendace *Coregonus albula* (L.), whitefish *Coregonus lavaretus* (L.), and peled *Coregonus peled* Gmel. They are typical freshwater species, although they can inhabit brackish water systems. Reproduction takes place in the autumn-winter period, frequently under ice cover (Szczerbowski 1995). The whitefish is economically one of the most important and significant fish species in the inland fisheries of Poland and is the most commonly stocked species (Mickiewicz and Wołos 1999). This species can be divided into several ecological forms that differ biologically. Different whitefish forms behave in many respects as

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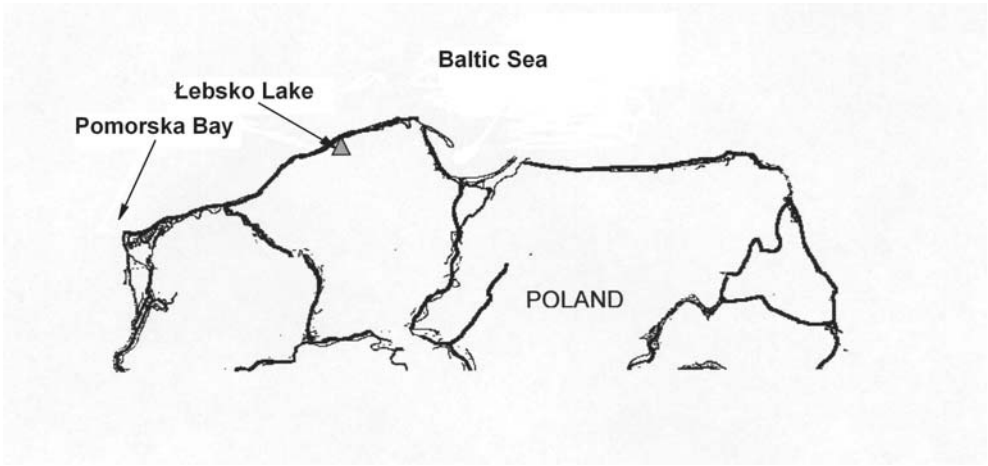

Fig. 1. Location of the occurence of native, andronomous populations of whitefish in Poland.

species or subspecies (Himberg and Lehtonen 1995). Only two native populations of whitefish are known to reproduce naturally in Polish water reservoirs - Pomorska Bay and Lake Łebsko (Heese et al. 1999) (Fig. 1). Thienemann (1922, 1935) and Kulmatycki (1924) described the Lake Łebsko whitefish population. At present, this native population is included in a species restoration project. Heese et al. (1999) identified the morphological characteristics of the species on the basis of 40 specimens, but no data were provided regarding the biological characteristics this native fish.

The aim of the current study was to determine the age structure and the growth rate of the Lake Łebsko breeding stock and the fecundity of its whitefish females.

MATERIALS AND METHODS

The fish used to study age and growth rate were collected using a set of gill nets with a mesh bar length ranging from 50 to 90 mm. The fish were netted by fishermen from Łeba in autumn and winter (November, December 2000 and January 2001). A total of 66 specimens were netted (Table 1).

These fish were measured (*longitudo corporis* – l.c.) to the nearest 0.1 mm and weighed to the nearest 1 g. Next, scales were collected from the area above the lateral line between the dorsal and adipose fins. Scale age was verified by the parallel analysis of hard dorsal fin rays (marginalia) (Fig. 2).

TABLE 1

Characteristics of material collected in Łebsko Lake in 2000-2001

Sex	Number of fish	Range of body length (cm)	Average body length (± SD) (cm)	Range of body weight (g)	Average body weight (± SD) (g)
Female	43	36.5 – 59.4	44.4 (5.9)	1020 – 4655	1939 (924.4)
Male	23	36.2 – 48.1	40.8 (7.8)	870 – 2035	1121 (113.1)
Total	66	36.2 – 59.4	42.4 (5.3)	870 – 4655	1578 (834.0)

SD – standard deviation

After cleaning the remains of muscle tissue from the marginalia, they were cut into five μm slices using an IZOMET-BUEHLER circular saw. These slices were placed on microscope slides, fixed with resin and examined under a light microscope. Back calculations from the scales were done based on the square function according to Heese (1992). The growth rate of body length (l.c.) and weight was calculated using the Bertalanffy formula (Szypuła 1995). Absolute fecundity was estimated gravimetrically with the method applied and verified by Brylińska and Bryliński (1972). Each gonad was weighed to the nearest 1 mg. Then 1 – 2 g samples were collected from the posterior, middle, and anterior parts of the gonad. The samples were fixed with 2% buffered formaldehyde and after a few days the eggs in each sample were counted. The results were averaged, which allowed absolute fecundity to be estimated. Relations between fecundity and several characteristics (body length,

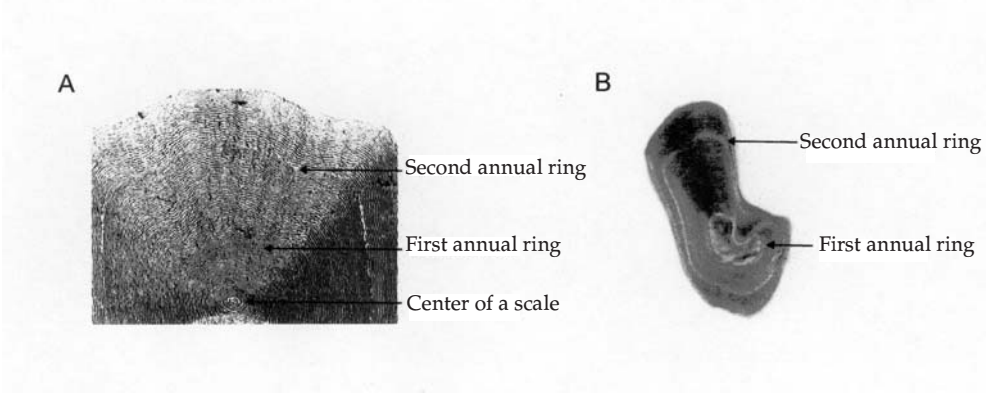

Fig. 2. Structure of a scale (A) and the marginalium (B) of whitefish aged 2+, body length – 36.5 cm, body weight – 1020 g.

weight and age) were examined using correlation analysis. Using the distribution of the correlation coefficient, corresponding critical values were determined for n – 2 freedom degrees and the determination coefficients were calculated.

RESULTS

AGE AND GROWTH RATE

The whitefish collected for estimates of age and growth rate were aged between 2+ to 9+; however, there were no 8+ females in the survey catch. A total of 66 individuals were collected, among them 43 females (65.2%) and 23 males (34.8%). Specimens aged 2+ predominated over 3+ and 5+ fish (Fig. 3). In the first year of life whitefish reached a length of 15.7 cm (l.c.), in the second year 24.3 cm and then 31.3, 37.0, 41.8, 45.6, 48.7, 51.3 and 53.4 cm in subsequent years (Fig. 4). The following values of body growth parameters were calculated based on the Bertalanffy formula: L_∞ = 62.89 cm, K = 0.20029, t_o = -0.43479, W_∞ = 4732.7. The growth rate of body weight was calculated using the relationship: log W = 0.8115 + 1.5921 log L.

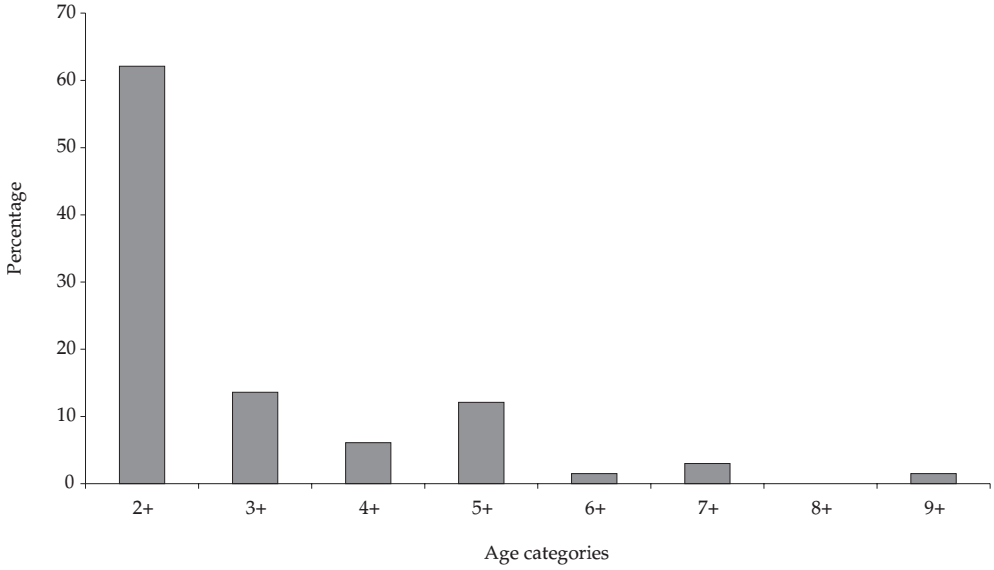

Fig. 3. Quantitative share of different age categories in the whitefish caught in Łebsko Lake.

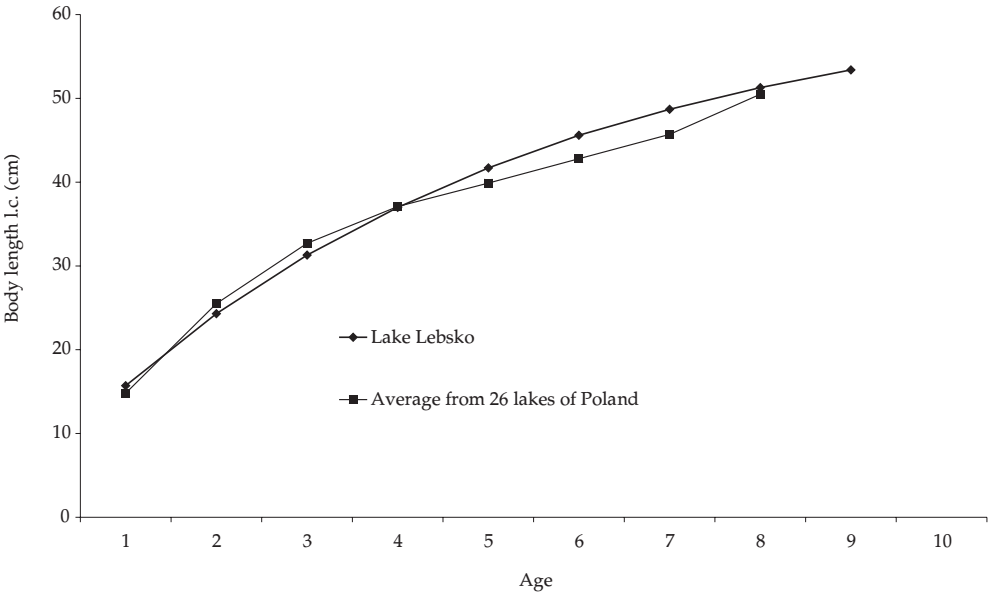

Fig. 4. Growth rate of body length of whitefish from Łebsko Lake.

FECUNDITY OF FEMALES

The ovaries of all the analyzed females were of normal shape and no gross or microscopic pathological changes were observed. The eggs of the studied specimens were yellow-orange in color and were not differentiated in size. The individual fecundity of the whitefish inhabiting Lake Łebsko ranged from 40.4 to 169.8 thousand eggs in a body length range from 36.5 to 59.4 cm and body weight range from 1020 to 4655 g. The average individual fecundity of Łebsko whitefish females ranged from 46.8 (± 6.3) to 169.8 (± 7.3) thousand eggs in segregated size classes. In the smallest size class (below 40.0 cm body length) it was 46.8 thousand eggs against approximately 154 thousand eggs in the biggest size class (over 55.1 cm). Among the youngest females (aged 2+), the average fecundity was 52.6 (± 9.9) thousand eggs, while in the oldest fish group (aged 9+) it was close to 170 (± 7.3) thousand eggs. Detailed data for each size class are presented in Table 2. Correlation analysis showed that the relationships between the fecundity of whitefish females from Lake Łebsko and chosen biomeristic parameters and between fecundity and the age of the fish were statistically significant in all the examined samples (Fig. 5).

TABLE 2

Individual fecundity of whitefish from Łebsko Lake
(in segregated size classes and age categories)(thousands of eggs)

Size classes (cm)	Age								Average fecundity (± SD) in size classes
	2+	3+	4+	5+	6+	7+	8+	9+	
> 40.0	47.1	44.7	-	-	-	-	-	-	46.8 (± 6.3)
40.1 – 45.0	55.9	72.5	-	-	-	-	-	-	57.9 (± 11.5)
45.1 – 50.0	-	73.6	77.4	125.1	-	-	-	-	108.5 (± 27.3)
50.1 – 55.0	-	-	-	127.2	107.3	137.6	-	-	125.4 (± 11.9)
< 55.1	-	-	-	146.2	-	147.0	-	169.8	154.4 (± 13.4)
Average fecundity (± SD) in age categories	52.6 (± 9.9)	65.8 (± 15.8)	77.4 (± 5.6)	128.5 (± 11.3)	107.3 (± 8.2)	142.3 (± 8.3)	-	169.8 (± 7.3)	

SD – standard deviation

DISCUSSION

Previously conducted research on Polish whitefish indicated that the breeding stock included fish aged from three to ten years and that the most abundant group was comprised of four-year olds. Szczerbowski (1969) estimated that four-year old fishes represented 56.7% of the breeding stock in Lake Maróz and 63.7% in Lake Gołdapiwo. The results obtained for whitefish from Lake Łebsko differ from the data presented above. The most abundant group was comprised of three-year old fishes that were spawning for the first time. The percentage share of individual generations in the breeding stock can be related to more or less successful fry recruitment, catches, and fry stocking. This last factor should be excluded in the case of whitefish from Lake Łebsko because whitefish fry were not stocked in the years preceding the research.

The analysis of the growth of body length and weight is a complex problem due to the diversity of the species and the influence of environmental conditions, especially the availability of suitable food. Some researchers believe that densely rakered (DR) whitefish mature faster than sparsely rakered whitefish (SR). This is confirmed by results obtained by Szczerbowski (1995), who analyzed the growth of whitefish from Lake Wdzydze. The densely rakered whitefish reached a body length of 30.9 cm in the third year of life compared to a length of 26.6 cm reached by sparsely rakered whitefish. In the sixth year of life the difference in body length was 9.7 cm. The author observed greater differences when he compared the two forms from Lake Zagadania. In the fifth year of life the DR whitefish were 14 cm longer than the SR whitefish. Based on five different whitefish populations, Szczerbowski (1981) suggested five

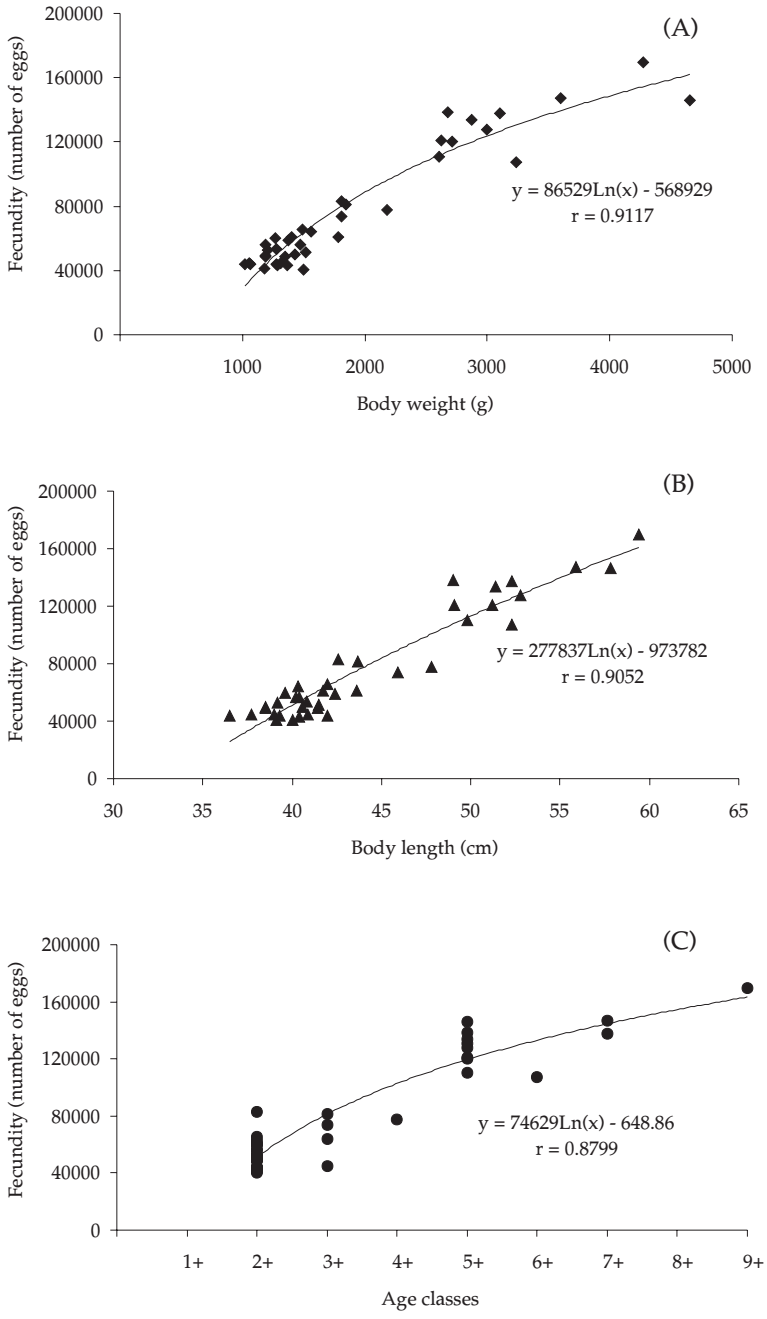

Fig. 5. Logarithmic dependence between fecundity and body weight (A), body length (B), and age (C) of whitefish from Łebsko Lake.

classes of growth rapidity. The lower limit of very quick growth was 17.3 cm in the first year of life, and 28.7 and 35.4 cm in the second and third years, respectively. The whitefish from Lake Łebsko attained a greater size each year. They were 1.9 cm longer in the first year and 2.1, 3.4, and 4.5 cm longer in the second, third and fourth years, respectively. Similar tendencies were observed with reference to weight. The lower limits of very quick growth were exceeded by about 97 g in the first year and by as much as 2270 g in the seventh year. The very quick growth rate in body length and weight of the whitefish from Lake Łebsko is probably related to the abundance of food in the lake and the Baltic Sea.

The comparison of results of research concerning whitefish fecundity revealed that values calculated for whitefish from Lake Łebsko are higher than the individual fecundity of *Coregonus lavaretus generosus* Peters from Pomorska Bay (Pęczalska 1962). According Pęczalska (1962), the absolute fecundity of females weighing from 1000 to 1250 g and from 2251 to 2500 g was between 22972 to 59522 eggs and 65850 to 90270 eggs, respectively. However, Falkowski (1991) reported that the absolute fecundity of females weighing from 530 to 1260 g was from 7800 to 82600 eggs, and relative fecundity was from 16200 to 72200 eggs.

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REFERENCES

Brylińska M., Bryliński E. 1972 – Methods of estimation the fecundity of fish (*Abramis brama* L.) – Rocz. Nauk Rol. 94: 7-40.

Falkowski S. 1991 – Fecundity of whitefish (*Coregonus lavaretus* L.) in Polish lake populations – Ph.D. Thesis, IRS Olsztyn. 86 pp. (in Polish).

Heese T. 1992 – Optimizing fish growth rate estimation using the back-calculation method – WSI Koszalin. 155 pp. (in Polish).

Heese T., Lampart-Kałużnicka M., Arciszewski M., Modzelewski T. 1999 – Anadromous whitefish (*Coregonus lavaretus f. lavaretus*) from Łebsko Lake – In: Proc. XVII Meeting of PTZool., 20-23 September 1999, Słupsk (in Polish).

Himberg M., Lehtonen H. 1995 – Systematics and nomenclature of coregonid fishes, particularly in Northwest Europe – Arch. Hydrobiol. Spec. Issues Advanc. Limnol. 46: 39-47.

Kulmatycki W. 1924 – Appendix to the knowledge of whitefish in Poland – Rybak Polski 8: 313-352 (in Polish).

Mickiewicz M., Wołos A. 1999 – Characteristics of lake stocking done by users in 1998 – In: Inland Fisheries, 4th Conference of fishery lake users in Dadaj, IRS Olsztyn: 23-32 (in Polish).

Pęczalska A. 1962 – Research on the whitefish (*Coregonus lavaretus* L.) from Pomorska Bay and Szczeciński Peninsula in 1956-1958 – Prace MIR 11A: 287-320 (in Polish).

Szczerbowski J.A. 1969 – The growth of whitefish (*Coregonus lavaretus* L.) introduced to different lake types – Rocz. Nauk Rol. 90: 671-687.
Szczerbowski J.A. 1981 – Criteria for estimating the rate of growth in fish – Rocz. Nauk Rol. 99: 123-136.
Szczerbowski J.A. 1995 – Inland fisheries in Poland– IRS Olsztyn. 569 pp.
Szypuła J. 1995 – Exercises in fish biology – AR Szczecin. 49 pp. (in Polish).
Thienemann A. 1922 – Weitere Untersuchungen an Coregonen – Arch. Hydrobiol. 13: 414- 469.
Thienemann A. 1935 – Der Schnäpel (*Coregonus lavaretus balticus*) in Vorpommern – Sonderdruck aus Dohrniana 14: 85-91.
Todd T.N., Łuczyński M. (eds) 1992 – Biology and management of Coregonid fishes – Pol. Arch. Hydrobiol. 39: 247-894.

STRESZCZENIE

WYBRANE ELEMENTY BIOLOGII ANADROMICZNEJ POPULACJI SIEI (*COREGONUS LAVARETUS LAVARETUS*) Z JEZIORA ŁEBSKO (PŁN. POLSKA)

Przeanalizowano wybrane elementy biologii autochtonicznej, anadromicznej formy siei (*Coregonus lavaretus lavaretus*) zasiedlającej jezioro Łebsko. Jest to jedna z dwóch znanych obecnie autochtonicznych populacji rozradzających się naturalnie, eksploatowanych gospodarczo. Jest to też populacja objęta aktualnie programem restytucji. W badaniach wykorzystano 66 osobników (43 samice i 23 samce) pozyskanych za pomocą wontonów w okresie jesienno-zimowym 2000/2001 roku.

Przedmiotem analiz była struktura wiekowa populacji, tempo wzrostu oraz płodność osobnicza samic siei. Wiek badanych ryb wahał się od 2+ to 9+, wśród których dominowały osobniki najmłodsze (2+). W pierwszym roku życia sieja z jeziora Łebsko osiągała średnią długość ciała 12,2 (± 2,9) cm i średnią masę 255 (± 150,1) g, w drugim roku 27,3 (± 4,7) cm i 775 (± 287,9) g, w piątym roku życia 42,1 (± 4,9) cm i 2581 (± 315,8) g, a w dziewiątym średnią długość 53.9 cm i średnią masę 3878 (± 124,2) g. Średnia płodność absolutna samic siei wahała się od 46,8 (± 6,3) do 154,4 (± 13,4) tysięcy jaj w wyodrębnionych klasach wielkościowych i wiekowych.