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BIOMETRIC ANALYSIS ON THE FRESHWATER CRAYFISH (ASTACUS LEPTODACTYLUS ESCH. 1823) WHICH IS PRODUCED IN TURKEY - RELATIONSHIP BETWEEN THE MAJOR BODY COMPONENTS AND MEAT YIELD*

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Summary: *In this research the biometric analysis has been carried out on the major body components and meat yield of crayfish (Astacus leptodactylus Esch.* 1823*) which is an important fishery product in Turkey.*

A total of 753 *crayfish (*409 *female,* 344 *male) were collected from the different lakes of Anatolia, where the crayfish populations were exploited.*

Statistical relationships between the body components and meat yield of Astacus leptodactylus Esch. 1823 *were represented and compared with the other crayfish species and lobster.*

Özet: *Türkiye'de üretilen tatlı su istakozu (Astacus leptodactylus Esch.* 1823*) üzerinde ürün özelliği bakımından biyometrik incelemeler.*

Bu araştırmada, Türkiye'nin su ürünleri ekonomisinde önemli yeri olan tatlı su istakozunun (Astacus leptodactylus Esch. 1823) *gövde ve verim (yenebilen kısım, kas) özellikleri üzerinde biyometrik analizler yapılmıştır.*

İstakozlar başta Eğridir gölü olmak üzere, çeşitli göllerden (Apolyont, Manyas, İznik, Eber, Akşehir, Terkos gölleri ve Miliç çayı) toplanmıştır.

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Dişi ve erkek istakozların gövde ile verim özelliklerine ilişkin verilerle bu özellikler arasındaki ilişkiler istatistiki olarak incelenmiştir.

Elde edilen sonuçların, istakozların beslenme, büyüme, erginlik durumları ile av yasaklarına ilişkin boy uzunluğunun saptanmasında yararlı olabileceği üzerinde tartışılmış ve diğer istakoz türleri ile karşılaştırmaları yapılmıştır.

Introduction.

Freshwater crayfish is an important fishery product in Turkey. Crayfish is in demand in other European countries especially in France, Sweden, Germany and Italy.

According to recent estimates, the annual catch of the crayfish Astacus leptodactylus in Turkey is 1275 tons (1975). The minimum legal size for capture of crayfish is 10 cm. and trapping season is very long (from July to the beginning of the May of next year).

Overfishing, long trapping season, pollution etc. have an adverse effect on the crayfish growth, size and maturity. The total production has declined from year to year.

On the other hand, no information is available on the biology and population dynamics of this species in Turkey. Studies of crayfish biology frequently require biometric analysis (9, 11). The statistical analysis of the measurement is useful in determining relative condition, growth, size, sexual maturity and permit comparison of data from different localities (16). For this reasons, these circumstances have prompted us to reserach into the biometric analysis of Astacus leptodactylus in Turkey aimed at a coutribution to the present decline in production.

Materials and Methods.

Most of the samples used in this study were trapped from the Eğridir lake in May, July and October in 1976. Some of them were collected from different lakes such as Apolyont, Manyas, İznik, Eber, Akşehir and the Miliç brook between in July and October in 1975.

A total of 753 crayfish were examined in this study. Immediately after removal from the traps, the crayfishes were transported to the laboratory, weighed and measured.

Four lengths were selected for the study: Body length, carapace length, propodus length, abdominal width (Fig. 1).

After the measuring and weighing, the crayfish were immersed in boiling water for 5 minutes, then the muscle of tail and chelae were carrefully removed and weighed. The pleopod eggs and the number of eggs in ovaries were counted.

Statistical analysis:

The calculation of the values for the arithmetic means, standart deviations and standart estimates followed the procedures outlined by Kendir (12).

The regression of body length on the body weight was estimated by the formula;

$$y = a + bx^2 + cx^3$$ (7, 12).

The significance of the differences between the mean values were tested (t-test) (12).

The analysis of variance were made to compare the differences between the lake groups and also sex groups in respects of body weights and body lengths of the crayfish. The least significant differences ($LSD_{0.05}$ $LSD_{0.01}$) were estimated for the lake groups (13).

$$LSD_{0.05} = t_{0.25} \sqrt{\frac{25^2P}{n_o}} \qquad LSD_{0.01} = t_{0.005} \sqrt{\frac{25\,SP}{n_o}}$$

Phenotypic correlation coeffecients and regression equations between the traits were calculated according to Snedecor and Cochran (17).

The condition factors of crayfish were calculated from the following equation $K = \frac{100.\ W}{L^3}$ which is given by Farmer (10).

Results and Discussion:

The results of the descriptive analysis are summarized in the Tables and Figures.

The regression equations and associated statistics describing body length-body weight relationships of Astacus leptodactylus were represented in the Table 1,2 and Fig. 2.

The males of Astacus leptodactylus were heavier than females ($P<0.01$). This disparity between the sexes was due to the havier males chelipeds.

Correlation coefficients were apparent that, the two variables were positive and highly correlated for each sexes.

The mean body lengths for males and females did not differ significantly ($P>0.05$).

Many authors (1, 2, 3, 10, 14) have provided body length-body weight relationships for the different species of crayfish in different countries.

Abrahamsson (4) informed that the differences in the body proportion of males and females of crayfish were reflected in their body length-body weight relations. This weight disparity can be attributed to the greater rate of cheliped development in the males.

The similar findings were found in Finland by Lindqvist and Louekari (14). They gave an excellent example of body length-body weight relationships for Astacus astacus. They also observed that the longer crayfish were relatively heavier than females. The weight differences between the sexes were due to the heavier male chelipeds.

Some authors (6, 10, 14, 15) have obtained body length-carapace length (Cephalothrax length) and body weight-carapace length relationships.

Andersen (6) plotted carapace length against body length and obtained an arithmetic relationship with Nephrops norvegicus. But he did not calculate the regression values for these estimates.

We obtained statistical relationships between these variables for Astacus leptodactylus. The mean carapace length for males and females were 48.03 + 0.528 mm., 45.82 + 0.402 respectively. The values for males were high as compared with the females ($P<0.001$) (Table 1,2).

Statistical analysis showed that a positive correlation occured between the body length and carapace length. In both sexes when the carapace length has increased the body length has increased too (Fig. 3).

The regression coefficients of body length-carapace length for both sexes were not significantly different ($P>0.05$). But on the contrary the regression coefficient of body weight-carapace length equation were significantly different ($P<0.01$). The increas of body weight especially in the larger size males were higher than females as depending on the carapace length (Fig. 4).

Some investigators (10, 14) have presented carapace length-propodus length (cheliped finger) relationship for different species. They have found that the propodus length of male crayfish were higher than the females. Our results showed similar findings with Astacus leptodactylus (Fig. 5).

Lindqvist and Louekari (14) have given a detailed description about the width of the third (widest) abdominal segment of Astacus astacus. They have found that the width of the third abdominal segment was 20.7 + 0.28 mm. (n=83) in males and 24.5 + 0.23 mm. (n=98) in females. The abdomen was 18 % wider in the females than the males ($P<0.001$).

Farmer (10) informed that there were distinct differences between the abdominal width of the males and females of Nephrops norvegicus. The difference between both sexes reflects the increased width of the abdomen in females for carrying eggs (4, 10, 14).

In our study, available data on the relationship between abdominal width and carapace length are given in Table 1,2., Fig. 6.

The mean abdominal width (third) was 42.72 + 0.487 mm. for females. The abdomen was 16 % wider in the females than in the males. These estimated values were higher than the values of Astacus.

We have recorded also a positive correlation between the carapace length and the abdominal width for both sexes. The increasing rate was always higher for females than males.

The great part of edible meat (muscle) of crayfish was obtained from the tail.

Some authors (8, 14, 18) have investigated relationships between body components and meat yield.

Lindqvist and Louekari (14) informed that the weight of the tail muscle has about the same both sexes for Astacus astacus. But the weight of the cheliped muscles were higher in the males than in the females.

We have recorded similar results with Astacus leptodactylus (Fig. 7). We have estimated also a positive correlation between the cheliped muscles and body lengths in both sexes the body length has increased while the cheliped muscles has increased. The increasing rate was relatively higher for males than females (Table 1, 2., Fig. 8).

Generally the minimum legal size for capture of crayfish is 100 mm. in the lakes of Turkey. Therefore in our study, comparisons were made between the samples with 100 mm. or the longer body length and the others. Males, longer than 100 mm., relatively had more cheliped muscles than females. These differences were significant ($P< 0.001$) Fig. 8). For this reason from the standpoint of meat production, the present minimum legal size 100 mm for catching crayfish in our lakes seems justified as far as the males are concerned; the meat production in males increases sharply above this size. But here we observed the fact that the longer females also produce more eggs.

According to Lindqvist and Louekari (14), in Astacus astacus females the production of total meat is indipendent of body weight, whereas larger males produce relatively more meat, this difference is nearly all due to the relatively larger cheliped size in the males. They have also calculated the mean relative muscle weight for all the males was 18.1 + 0.27 % and for all the females was 17.1 + 0.18 %.

In our study, the total muscle weight of the males and females was found almost the same for Astacus leptodactylus. But the total muscle weight of the males larger than 100 mm. had heavier muscle weight than the females. This difference was due to the increasing cheliped muscle, but it was not statisticaly significant ($P>0.05$) (Table 1, 2., Fig. 9). The mean relative muscle weight was 23.29 + 0.530 % for the females and 21.83 + 0.598 % for the males. These values were higher than values of Astacus astacus.

Stewart *et al.* (18) inform that changes in total muscle weight were not confined to disproportinate changes in any one of the major body components. According to them, the relative muscle weight of lobsters (Homorus americanus) was between 19.9 % and 23 % of their body weight The another study about the proportion of the meat in an introduced specie, Orconectes limosus Raf., in Poland by Dabrowski *et al.*(8) informed that the average meat yield of the classes of 7.10 cm. was 24.07 % for the females and 24.30 % for the males. According to them if the crayfish weight increases, the percantage of the meat yield also increases.

Estimates of the fecundity of different species of crayfish such as Astacus astacus L., Pasifastacus leniusculus Dana, Orconectes limosus Raf., and Nephrops norvegicus L. have been carried out by some authors (1, 2, 4, 5, 10, 14, 19).

Abrahammson (4) was obtained a positive correlation between body length and number of pleopod eggs in both Astacus and Pacifastacus. We observed similar results with Astacus leptodactylus (Fig. 10).

According to Lindqvist and Louekari (14), the mean number of ovarian eggs was 248 + 68 (n=68), and the regression equation was y=6.41 × - 363.8. In our study, the mean number of pleopod eggs was 183.06 + 9.047, the mean ovarian egg number was 210.08 + 7.24 ($P<0.02$). Here we must consider the fact that this difference is due to the length of incubation period and not all eggs attach to the pleopods during egg-laying (4, 10).

In our study, when the state of nutrition (condition factor) of crayfish was investigated in the lake Eğridir, it was found that the males generally showed a better state of nutrition than the females. There was also a distinct change in the state of nutrition throughout the year, the change is higher in both males and females in the autum than in spring. A similar situation was found in the lobster, N. norvegicus (10).

In our study the variance analysis made on the samples, taken from different lakes has shown significant differences between the sexes for the body length ($P<0.01$). But there was no difference between the sexes in the same lake. There were significant differences in respect of body weight between the both sexes and this difference have changed from lake to lake (Table 3). The reason of the weight differences between the crayfish out the different lakes was not clear, therefore overfishing, pollution, irrigation may be cantributory factors. We do not know the influence of temperature, food supply, population density on population stability.

Abrahamsson (5) informed that the Astacus population in River Aleån was unexploited and therefore contained high population of large individuals.

Some authors (1, 2, 3, 4, 5, 14, 19) indicated that the temperarature, food supply and population density were the most important environmental factors and these influences the growth rate.

Increasing importance of the freshwater crayfish (Astacus leptodactylus Esch. 1823) in respects of the fishing industry and the possibilities of exports have induced us to this study.

Table 1. Arithmetic means for different length-weight measurements of Astacus leptodactylus from Eğridir lake. October, 1976

Parameters	Male		Female		
	n	$\bar{x} \pm S\bar{x}$	n	$\bar{x} \pm S\bar{x}$	
Body length (mm.)	82	101.06 ± 1.221	90	101.17 ± 0.980	0.070⁻
Carapace length (mm.)	82	48.03 ± 0.528	90	45.82 ± 0.401	3.368⁺⁺
Propodus length (mm.)	82	38.36 ± 1.003	90	29.80 ± 0.575	8.07⁺⁺
Abdominal width (mm.)	82	36.71 ± 0.321	90	42.72 ± 0.487	10.084⁺⁺
Bodt weight (g.)	82	29.57 ± 1.348	90	24.95 ± 0.784	3.039⁺
Cheliped muscle weight (g.)	82	2.22 ± 0.164	90	1.42 ± 0.125	4.413⁺⁺
Tail muscle weight (g.)	82	4.25 ± 0.198	90	4.41 ± 0.185	0.590⁻
Total muscle weight (g.)	82	6.47 ± 0.312	90	5.84 ± 0.258	1.564⁻
Relative muscle weight (%)	82	21.82 ± 0.598	90	23.29 ± 0.530	1.806⁻

—: ($P>0.05$); + : ($P<0.01$); ++: ($P<0.001$)

Table 2. Regression values and correlation coefficients between the different parameters of Astacus leptodactylus from Eğridir lake. October, 1976

Parameters	Sex	n	Correlation		Regression	t-test(x)
			r ± S_r	a	b ± S_b	
Body length-Carapace length (mm.)	Male	82	0.915 ± 0.018	− 0.463	2.114 ± 0.010	20.326^{++}
	Female	90	0.939 ± 0.013	− 3.846	2.292 ± 0.089	25.752^{++}
Body weight-Carapace length (mm.)	Male	82	0.891 ± 0.023	−79.710	2.275 ± 0.128	17.773^{++}
	Female	90	0.864 ± 0.027	−52.397	1.688 ± 0.104	16.230^{++}
Propodus length (mm.)-Carapace length (mm.)	Male	37		−70.611	2.211 ± 0.218	10.116^{++}
	Male	45	0.833 ± 0.034	−21.042	1.227 ± 0.223	5.497^{++}
	Female	90	0.801 ± 0.038	−11.394	0.898 ± 0.071	12.559^{++}
Abdominal width (mm.)-Carapace length (mm.)	Male	82	0.858 ± 0.029	4.509	0.663 ± 0.044	14.955^{++}
	Female	90	0.888 ± 0.022	− 6.674	1.078 ± 0.059	18.180^{++}
Tail muscle weight (g.)-Body length (mm.)	Male	82	0.873 ± 0.026	−10.301	0.144 ± 0.099	15.950^{++}
	Female	90	0.803 ± 0.038	−10.862	0.151 ± 0.011	12.592^{++}
Cheliped muscle weight (g.) -Body length (mm.)	Male	52		−11.440	0.133 ± 0.014	9.500^{++}
	Male	30	0.753 ± 0.048	− 5.349	0.073 ± 0.024	3.041^{++}
	Female	90	0.803 ± 0.038	− 4.440	0.058 ± 0.006	8.787^{++}
Total muscle weight (g.)-Body length (mm.)	Male	52		−25.841	0.341 ± 0.023	13.652^{++}
	Male	30	0.963 ± 0.008	− 7.680	0.133 ± 0.042	3.166^{++}
	Female	90	0.794 ± 0.039	−15.302	0.209 ± 0.017	12.294^{++}

(x) : The difference of the regression value from the null

+: ($P<0.002$): ++: ($P<0.001$)

Table 3. Arithmetic means for length and weight measuresment of Astacus leptodactylus from different lakes.

Area and Date	Male			Female		
	Body length (mm.)		Body weight (g.)	Body length (mm.)		Body weight (g.)
	n	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	n	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$
Akşehir lake July, 1975	23	102.82 ± 3.847	32.95 ± 6.101	40	111.15 ± 2.980	35.52 ± 3.229
Apolyont lake August, 1975	49	110.00 ± 1.610	35.42 ± 1.710	36	106.94 ± 1.839	29.05 ± 1.90
Eber lake July, 1975	18	101.38 ± 2.909	21.94 ± 3.312	11	101.36 ± 4.106	21.36 ± 4.268
Eğridir lake October, 1976	82	101.06 ± 1.221	29.57 ± 1.348	90	101.17 ± 0.980	24.95 ± 0.784
İznik lake August, 1975	52	103.07 ± 1.259	32.88 ± 1.500	45	103.33 ± 1.522	28.6 ± 1.259
Manyas lake August, 1975	41	115.45 ± 2.617	47.68 ± 3.509	50	114.5 ± 1.431	38.46 ± 1.378
Miliç brook July, 1975	18	98.61 ± 1.705	26.11 ± 1.586	20	102.25 ± 1.729	29.05 ± 1.499
Terkos lake August, 1976	18	96.66 ± 3.024	26.33 ± 2.067	17	98.23 ± 3.481	22.17 ± 2.137
Least significant different:	LSDo.05 = 3.76,		LSDo.01 = 9.879	LSDo.05 = 3.65		LSDo.01 = 4.799

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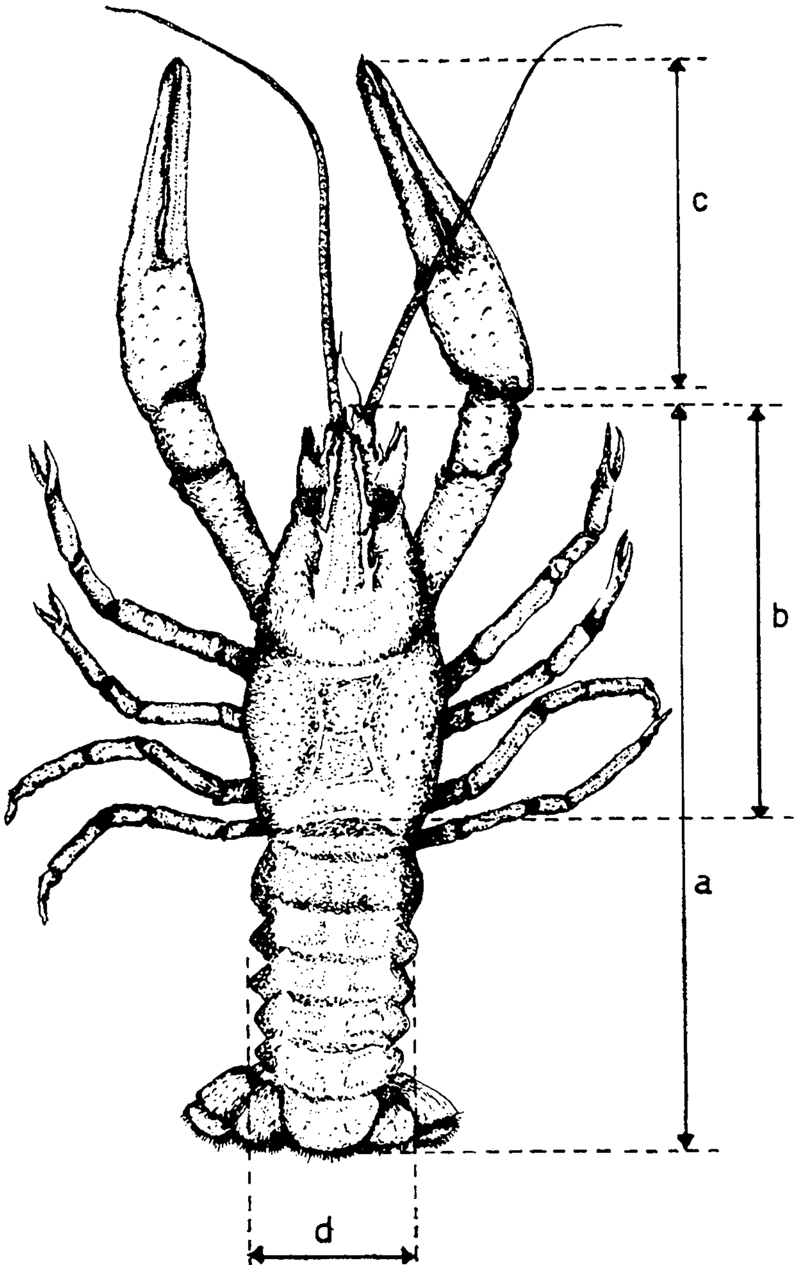

Fig. 1. Certain size parameters in crayfish a) total length; b) carapace length; c) propodus length (chela); d) abdominal width.

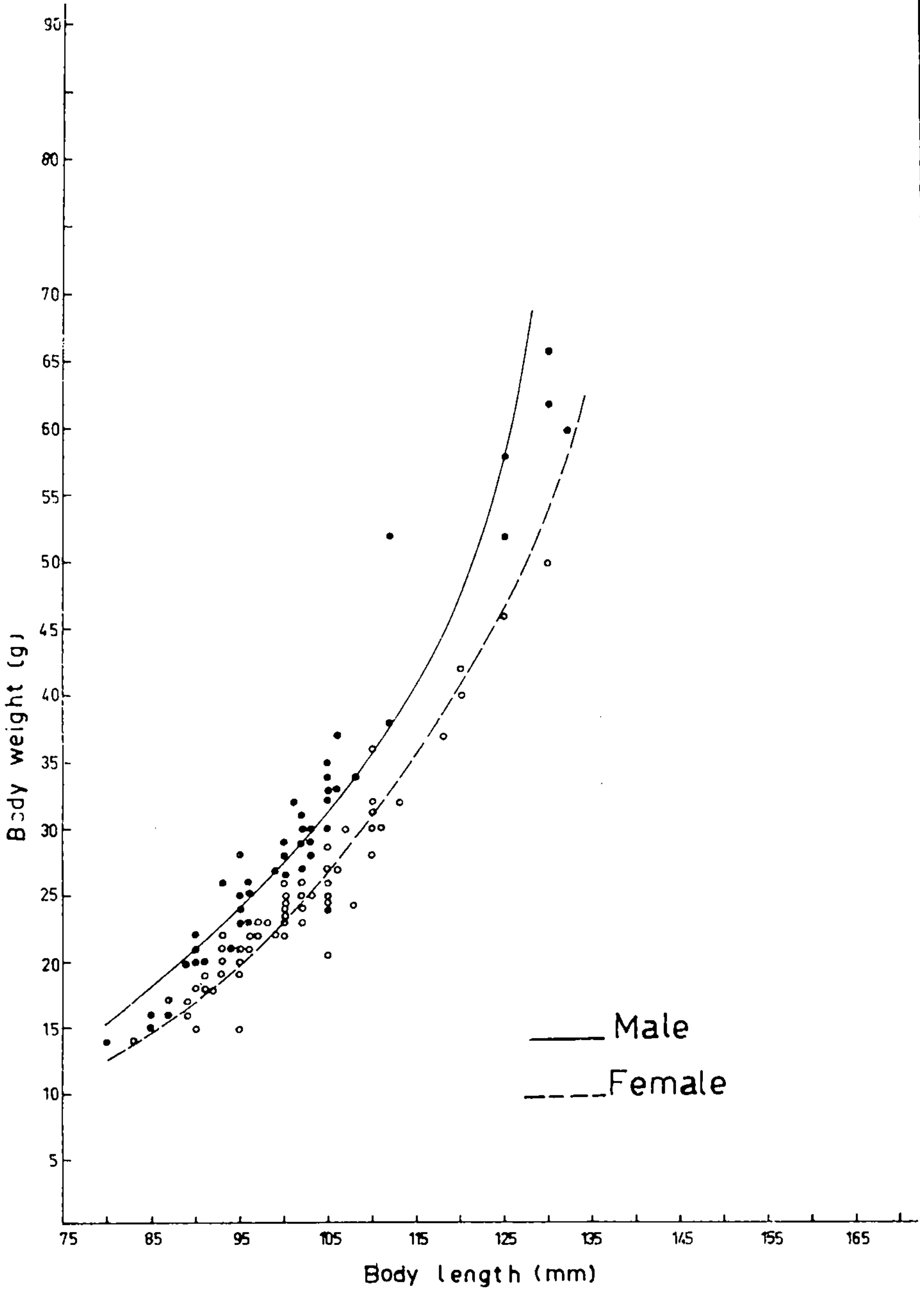

Fig. 2. The body length-body weight relation in the present crayfish sample from Eğridir lake.

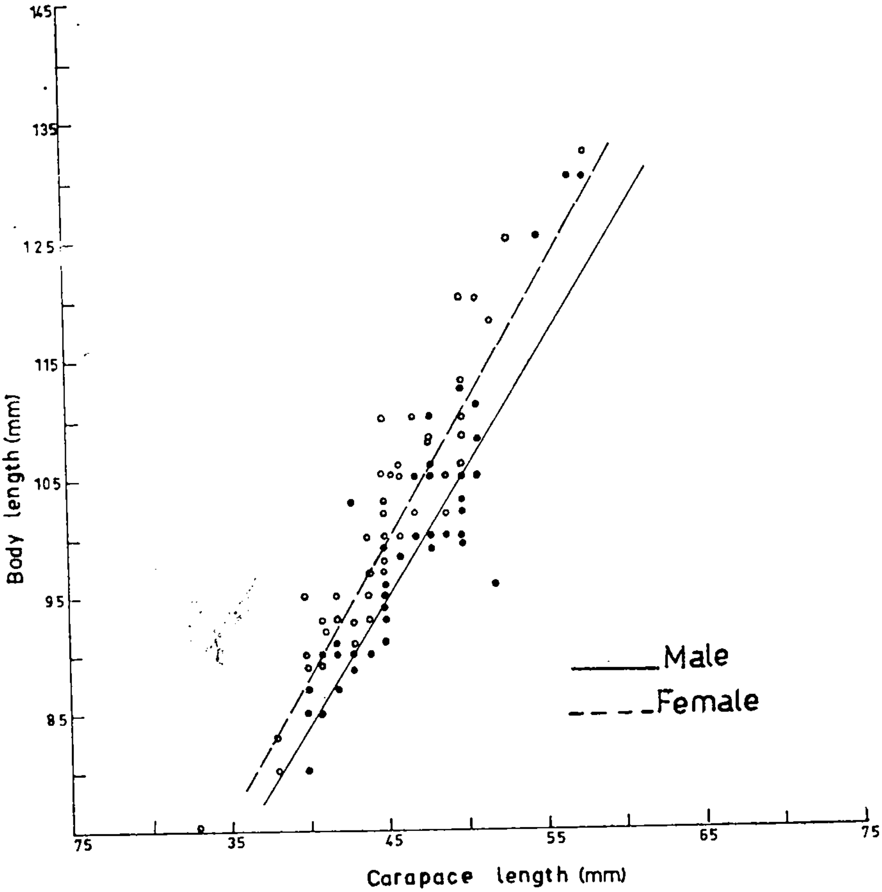

Fig. 3. The relation between carapace length and body length.

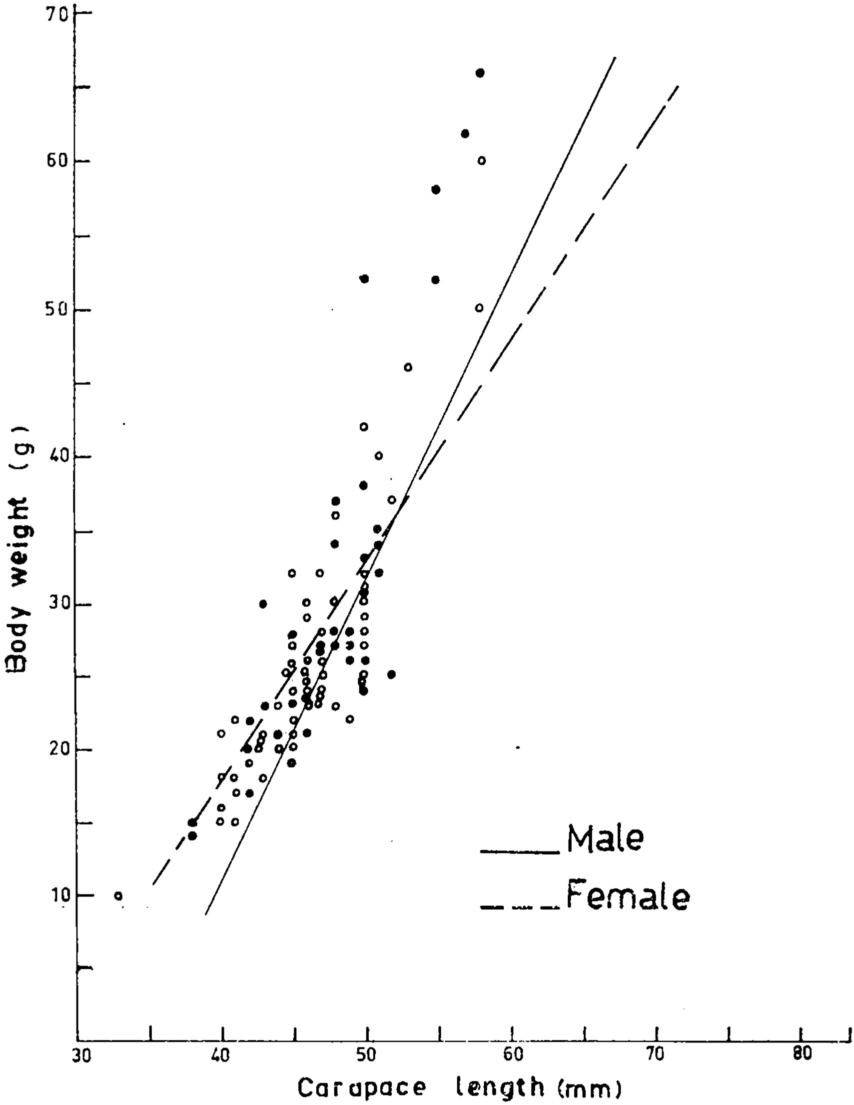

Fig. 4. The relation between body weight and carapace length.

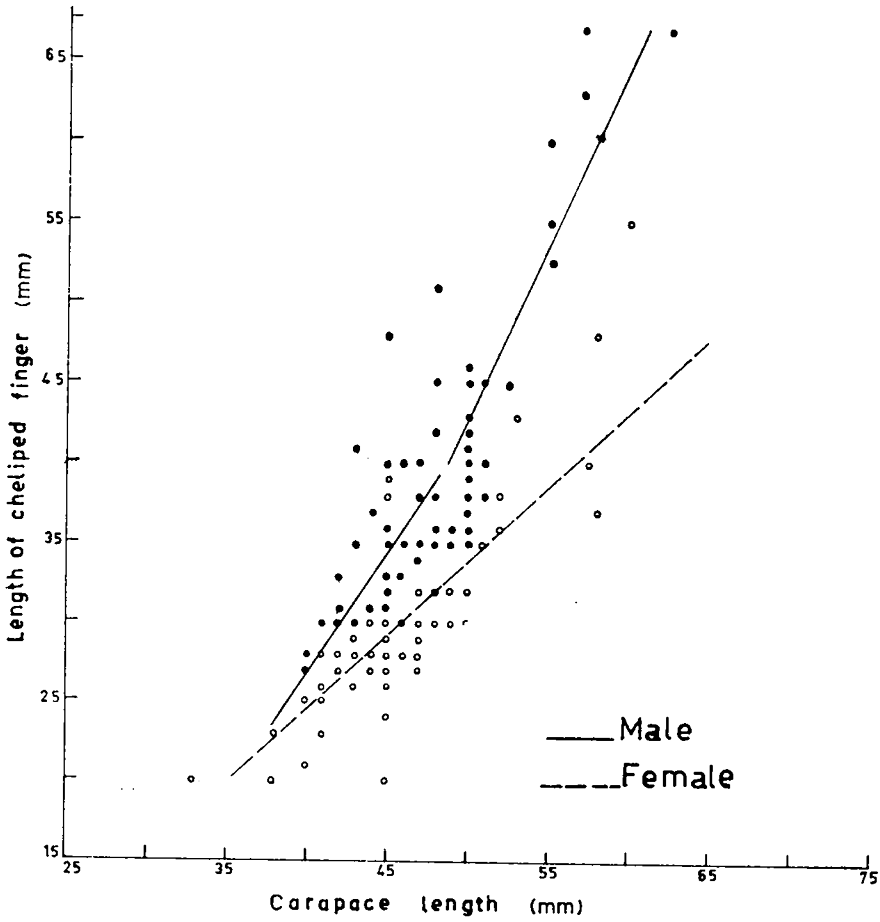

Fig. 5. The relation between carapace length and propodus length (chela).

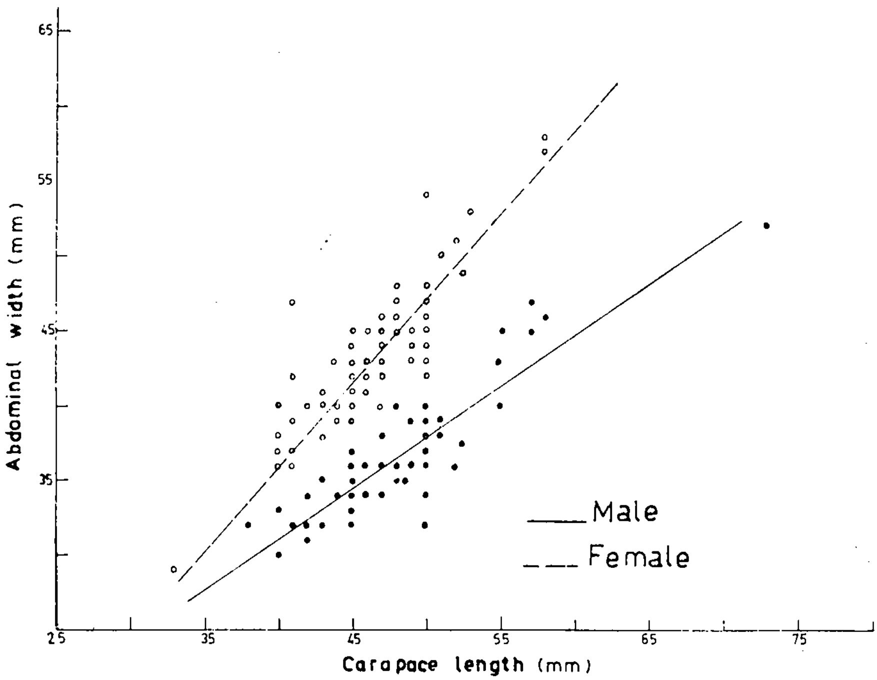

Fig. 6. The relation between carapace length and abdominal width.

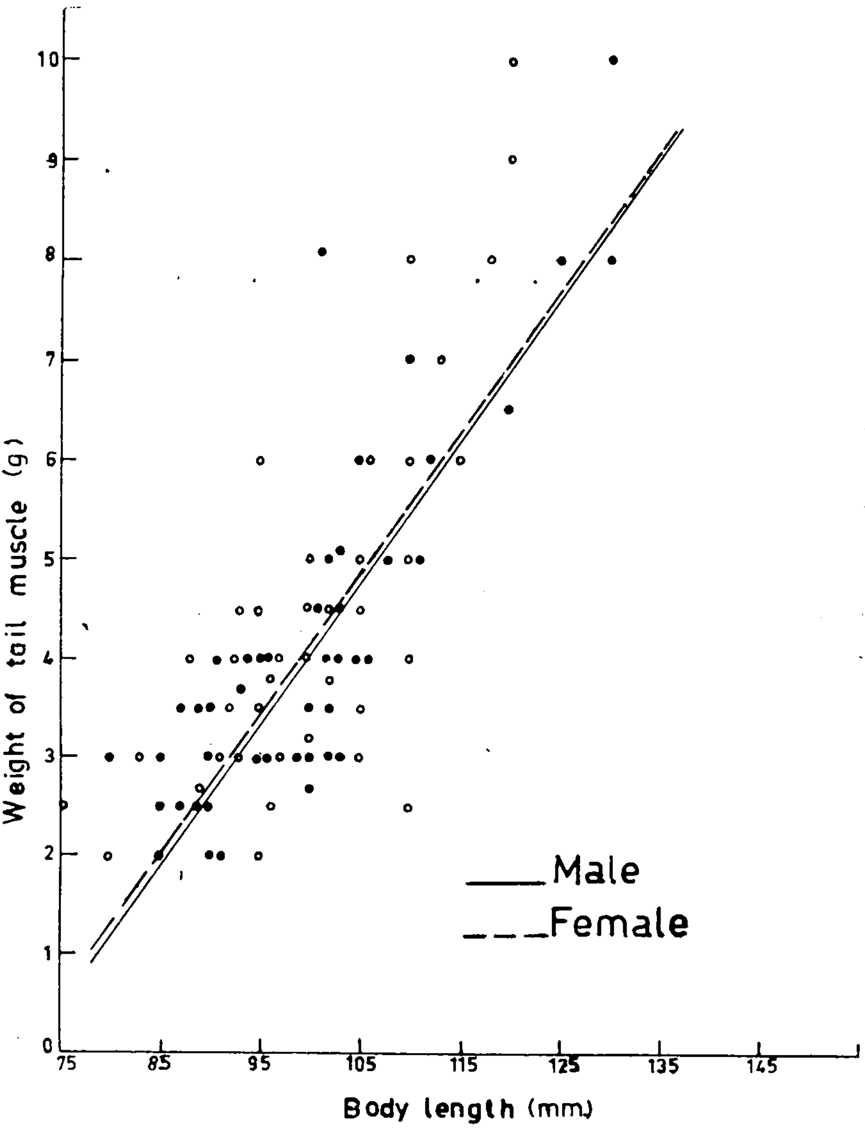

Fig. 7. The relation between body length and tail muscle weight.

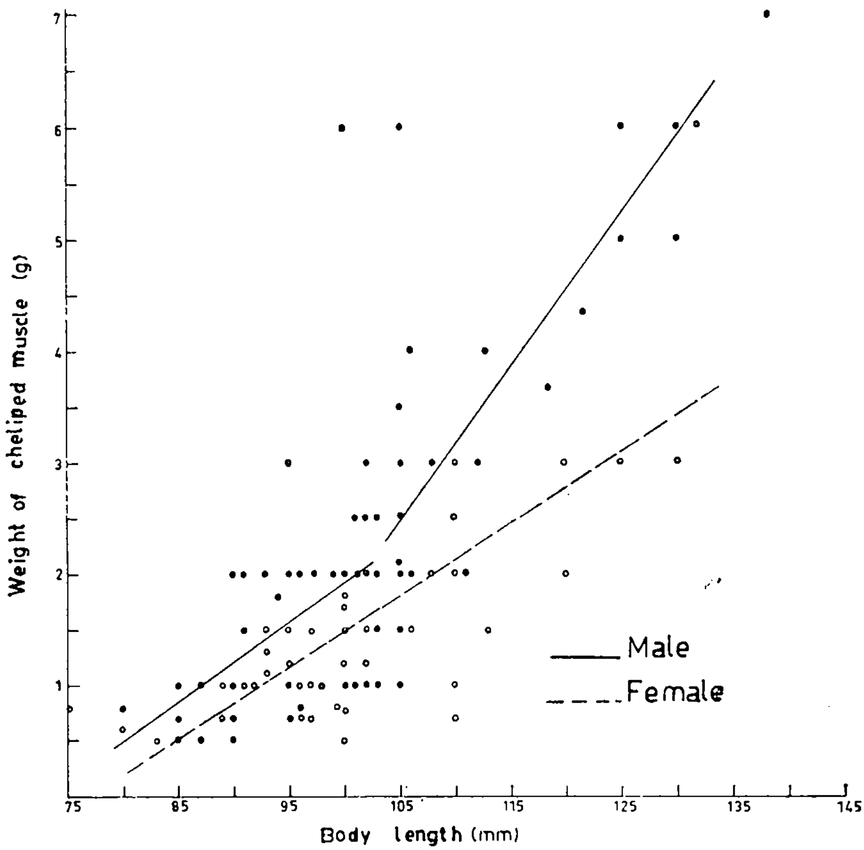

Fig. 8. The relation between body length and cheliped muscle weight (propodite, carpopodite, meropodite muscles were combined).

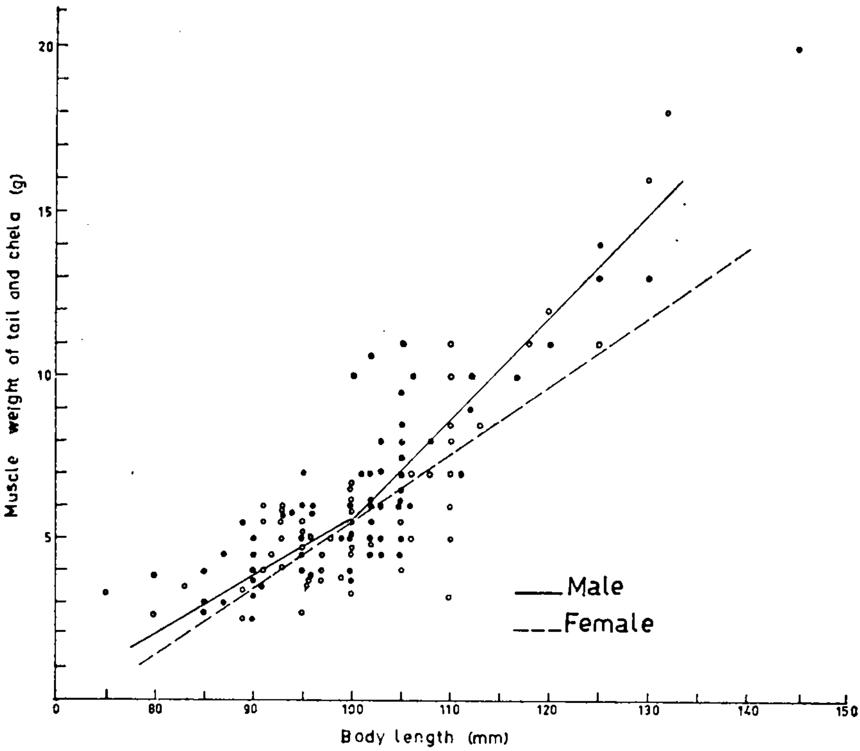

Fig. 9 The relation between body length and total muscle weight (muscle weight of tail and chela).

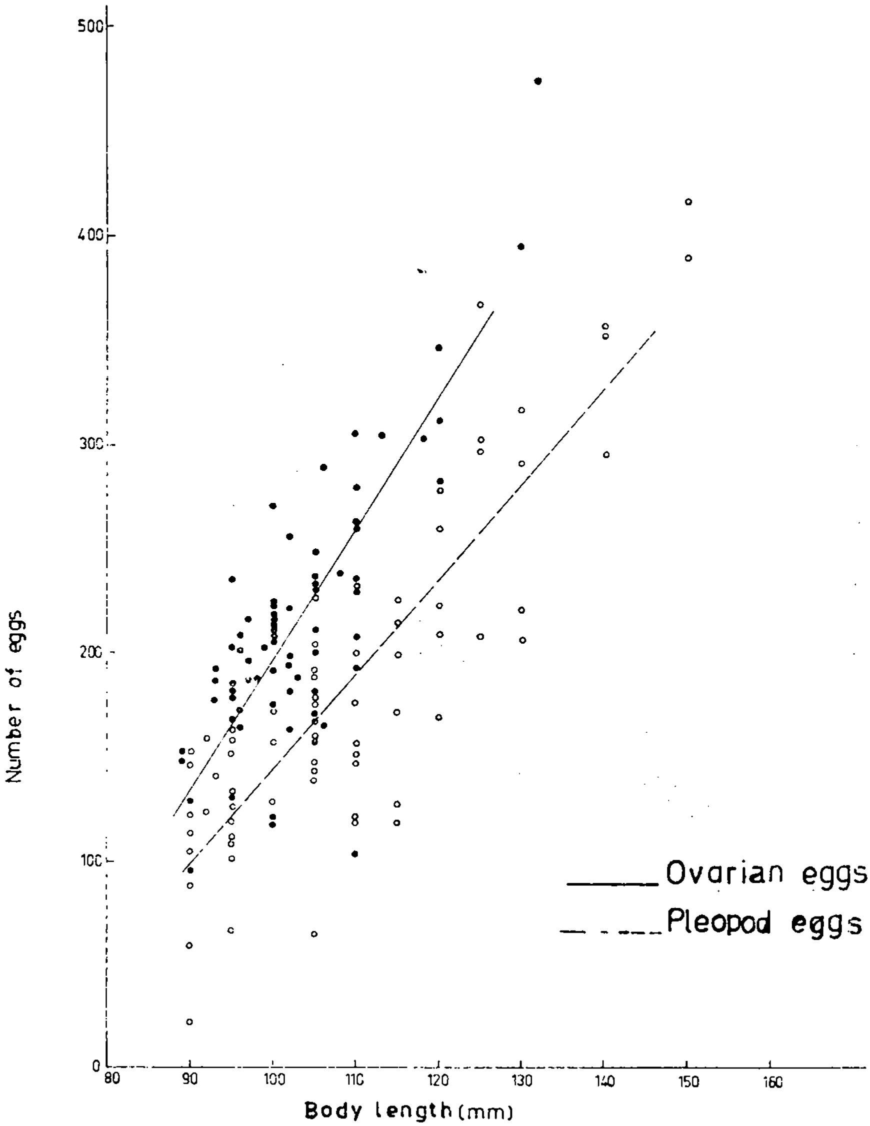

Fig. 10. Estimates of the fecundity of females of different size from Eğridir lake.