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GONADAL DEVELOPMENT AND SPAWNING OF *Barbus sharpei*, *Barbus luteus* AND *Mugil hishni* IN FRESH AND SALTWATER LAKES OF IRAQ

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A B S T R A C T. The annual cycle of gonadal development and fecundity of *Barbus sharpei* (buni), *Barbus luteus* (himri) and *Mugil hishni* (hishni) in the freshwater lakes Tharthar and Habbaniya (salinity 0.2–1.8‰) and the saltwater Lake Razzaza (salinity 12–13‰) were investigated. In fish from the saltwater of Razzaza the annual cycle of ovarian development was accelerated by two months in comparison with fish living in freshwater. High percentage of mature oocytes was found in the ovaries of buni, twice during February and April and in himri between March and June. The fecundity of buni and hishni was significantly lower in saltwater than in freshwater. Since the species investigated had similar condition coefficients, feeding spectra, digestive tract filling coefficients and growth rates in both salt and freshwater, it is suggested that the changes in the sexual cycle were due to the increased salinity of the aquatic environment.

Key words: GONADAL DEVELOPMENT, FECUNDITY, WATER SALINITY, *Barbus luteus*, *Barbus sharpei*, *Mugil hishni*

INTRODUCTION

The patterns of gonadal development and reproduction of several species of fish were similar in fresh water of Tharthar and Habbaniya reservoirs (Epler et al. 1996). The effects of water salinity in Razzaza (12–13‰) on gonad maturation were not described in the above mentioned paper.

The effects of environmental factors such as temperature (Bray 1971, Epler, Bieniarz 1973, Wilkońska, Żuromska 1977, Epler, Bieniarz 1979, Kokurewicz 1979, Horoszewicz et al. 1981, Epler et al. 1981, Horoszewicz 1983) or daylength (Fenwick 1970, Goryczko 1972) on gonadal development and spawning is well established, but there is little data how these processes are affected by salinity. In the sea bass, *Dicentrarchus labrax* (Stequert 1972), oocyte maturation and ovulation will not occur in fresh water, although spermination may take place in salinities as low as 1–2‰ (Roblin 1980). Increa-

sed conductivity induces gonadal regression in the South American gymnotoid fish *Eigenmannia verescens* (Kirschbaum 1979). Similarly, in the neon tetra, *Paracheirodon innesi* a slight increase in salinity (5‰) inhibits gonadal development, which may be attributed to an increased ambient calcium level (Lam 1983). These species breed during the rainy seasons, and gonadal regression occurs during the dry period when water conductivity would be expected to increase. High salinity does not, however, cause gonadal regression in *Gillichthys mirabilis*, although wild fish undergo gonadal regression when the salinity is increasing in their estuarine habitat (De Vlaming 1971).

During other ichthyological investigations in Iraq, the possibility arose to examine the effects of salinity by comparing the gonadal development and spawning of buni (*Barbus sharpei*), himri (*Barbus luteus*) and hishni (*Mugil hishni*) in fresh water in Tharthar and Habbaniya resorvoir (salinity of 1.2–1.8‰) with those in the salt water Razzaza reservoir (salinity of 12–13‰).

MATERIALS AND METHODS

Habbaniya is a natural lake, connected with Euphrates River. Tharthar and Razzaza were created by inundation of desert depressions. Tharthar is irrigated by waters of the River Tigris via the artificial Samara canal, and Razzaza is irrigated once a year during the spring flood of the River Euphrates via Habbaniya Lake and the Mujarah canal. Depending on the level of the spring floodwaters Razzaza takes from several days to several weeks to fill, and during the remainder of the year the water level in the lake falls as a result of intense evaporation. Table 1 shows the characteristics of the three lakes used in these investigations.

MATERIALS

During the 12 month period of the experiment, 457 spawners were examined in Razzaza lake (buni: 53 females and 54 males, himri: 82 females and 83 males, and hishni: 95 females and 90 males), and 539 spawners in Tharthar and Habbaniya lakes (buni: 80 females and 75 females, himri: 86 females and 93 males, and hishni: 120 females and 95 males). The proportion of these species in the total fish fauna of the lakes investigated is given in Table 2 (data based on the results of the yearly catch).

TABLE 1

Environmental description of Tharthar, Habbaniya and Razzaza lakes

	Tharthar	Habbaniya	Razzaza
Area (km^2)	2068	415	1432
Average depth (m)	30	9	12
Salinity (‰)	1.2–1.8	0.2–0.7	12–13
Annual temperature range (°C)	10.4–30.1	11.0–30.4	10.2–30.4
Water level range (m)	1.2–4.9	1.1–1.4	1.2–6.4
„Hard vegetation"	Phragmites sp.	Phragmites sp.	Phragmites sp.
„Soft vegetation"	Polygonum sp.	Polygonum sp.	Polygonum sp.

TABLE 2

The proportions (as a percentage) of catch of buni, himri and hishni in Tharthar, Habbaniya and Razzaza lakes

Species	Tharthar	Habbaniya	Razzaza
Buni	1.7	2.2	1.5
Himri	11.6	6.1	7.2
Hishni	35.6	72.0	42.5

METHODS

The growth rate (from direct measurements), age (from scales), condition coefficent (c.c.), digestive tract filling coefficient (d.t.f.c.), feeding spectrum, gonadosomatic index (GSI) and fecundity were determined using routine ichthyobiological methods. Samples of gonads were fixed in Bouin's solution for histological analysis and stained with hematoxylin and eosin to determine the percentage of oocytes in maturity stages according to Sakun and Bucka (1968) and of oocytes during resorption (Table 3). The mean diameter of oocytes at different stages of maturity was obtained by direct microscopic measurements of 100 cells. The sum of the number in each oocyte category from 20 histological sections multiplied by their mean diameter was considered as a hundred percent. This sum served for calculation of the area ocupied by oocytes in maturity stages II–IV.

TABLE 3

The state of oocyte maturity (according to Sakun & Bucka 1968)

Description	Stage of maturity	Mean diameter (mm)	
		hishni	other species
Big yolk oocytes	IV	0.40	0.60
Oocytes during vitellogenesis	III–IV	0.31	0.48
Oocytes at the beginning of vitellogenesis; full vacuolisation	III	0.23	0.30
Oocytes after protoplasmatic growth, one layer of vacuoles	II–III	0.15	0.22
Oocytes during protoplasmatic growth	II	0.10	0.16
Resorbing oocytes	Resorption	0.37	0.54

TABLE 4

Total body length (L.c.) of buni, himri and hishni from Tharthar/Habbaniya and Razzaza lakes (in cm)

Age	Buni		Himri		Hishni	
	Tharthar/Habbaniya	Razzaza	Tharthar/Habbaniya	Razzaza	Tharthar/Habbaniya	Razzaza
1+	15.5	12.0	13.5	12.9	14.5	10.8
2+	17.2	15.7	15.6	15.9	16.7	15.1
3+	32.0	31.6	19.0	18.3	17.7	16.6
4+	33.8	36.8	24.7	22.8	18.9	17.0
5+	38.4	38.8	29.2	26.0	-	-
6+	41.0	42.0	-	-	-	-

RESULTS

There were no significant differences in growth rate (Table 4), condition coefficient or digestive tract filling coefficient (Table 5) between fish from Razzaza, Habbaniya and Tharthar lakes. The composition of natural feed, as determined by stomach content of the fish, was also similar in all three lakes (Table 6): with plants predominating in buni and himri and detritus in hishni. Fish from Tharthar had significantly higher fecundity than those from Razzaza (Table 7).

TABLE 5

Digestive tract filling coefficient (d.f.c.c.) and condition coefficient (c.c) of investigated species

Month	Buni				Hishni				Himri			
	Tharthar/Habbaniya		Razzaza		Tharthar/Habbaniya		Razzaza		Tharthar/Habbaniya		Razzaza	
	c.c.	d.t.f.c.	c.c.	d.t.f.c.	c.c.	d.t.f.c.	c.c.	d.t.f.c.	c.c.	d.t.f.c.	c.c.	d.t.f.c.
III	1.19	3.18	1.17	1.96	1.61	1.58	0.99	5.98	1.27	5.28	1.52	5.37
V	1.21	0.77	1.12	0.24	1.09	1.82	1.26	0.35	1.35	1.74	1.39	0.18
VII	1.25	0.95	1.35	0.14	1.14	0.25	0.98	1.22	1.28	1.41	1.97	0.46
IX	1.21	0.61	1.35	1.41	1.08	1.85	1.00	2.22	1.24	2.99	1.51	1.24
XI	1.13	2.75	1.21	1.35	1.02	5.92	1.15	2.01	1.29	3.85	1.48	0.23
I	0.95	3.25	1.27	1.00	0.98	7.59	1.11	4.08	1.20	8.94	1.45	6.12

TABLE 6

The main components of natural food of investigated fish species from Tharthar, Habbaniya and Razzaza lakes (the percent of food)

	Buni		Himri		Hishni	
	Tharthar/Habbaniya	Razzaza	Tharthar/Habbaniya	Razzaza	Tharthar/Habbaniya	Razzaza
Plants	100	95.7	69.3	64.9	3.6	0.9
Oligochaeta	-	-	-	0.3	-	-
Tendipedidae	-	0.2	-	16.7	-	-
Mollusca	-	3.5	-	-	-	-
Pisces	-	-	5.6	5.2	-	-
Detritus	-	0.6	25.0	12.0	83.7	84.4
Mineral parts	-	-	0.1	1.5	12.7	14.7

TABLE 7

Relative fecundity of buni and hishni from Tharthar/Habbaniya and Razzaza lakes

Buni			Hishni		
Age	Tharthar/Habbaniya	Razzaza	Age	Tharthar/Habbaniya	Razzaza
4+	19075	11987	1+	0720854	378415
5+	28471	11205	2+	756118	369237
6+	27502	10021	3+	562022	359873

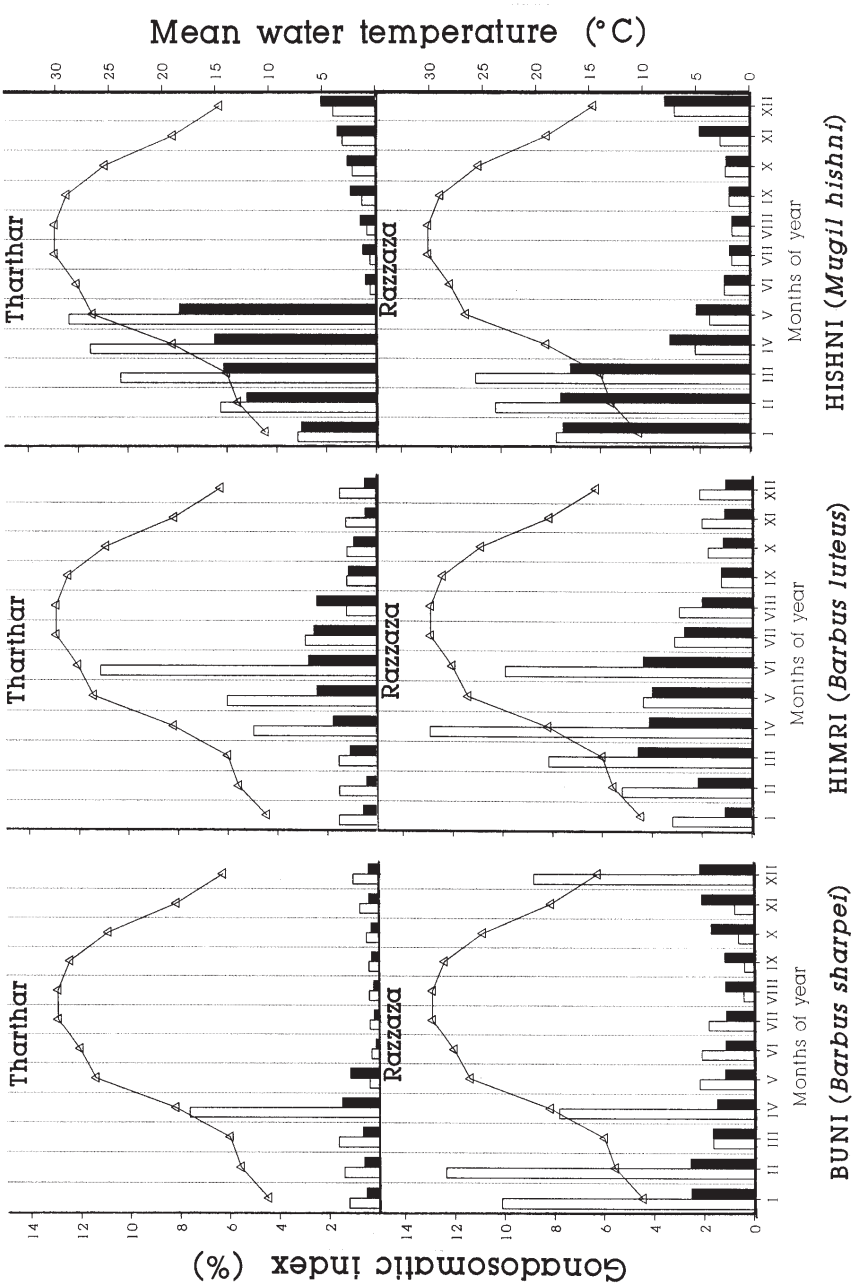


Fig. 1. Annual cycle of gonadosomatic index (GSI) in males (black bars) and females (empty bars) of investigated fish species. Line (-Δ-) represents mean monthly water temperature.

GONADOSOMATIC INDEX (Fig. 1)

The highest values of GSI in female and male of buni from Tharthar were observed in April (7.62 and 1.48) and the lowest in May and June (0.3 and 0.13). In Razzaza lake the highest values were found in February (12.35 and 2.55) and in females in April (7.82). The lowest GSIs were observed in July and September (0.4 and 1.12).

In female and male himri from Tharthar the GSI was highest in June (11.11 and 2.75) and lowest in October (1.19 and 0.92). In Razzaza the highest GSI values were in April for males (12.92 and 4.12) and in June for females (9.90). GSI was lowest in September (1.23 in both sexes).

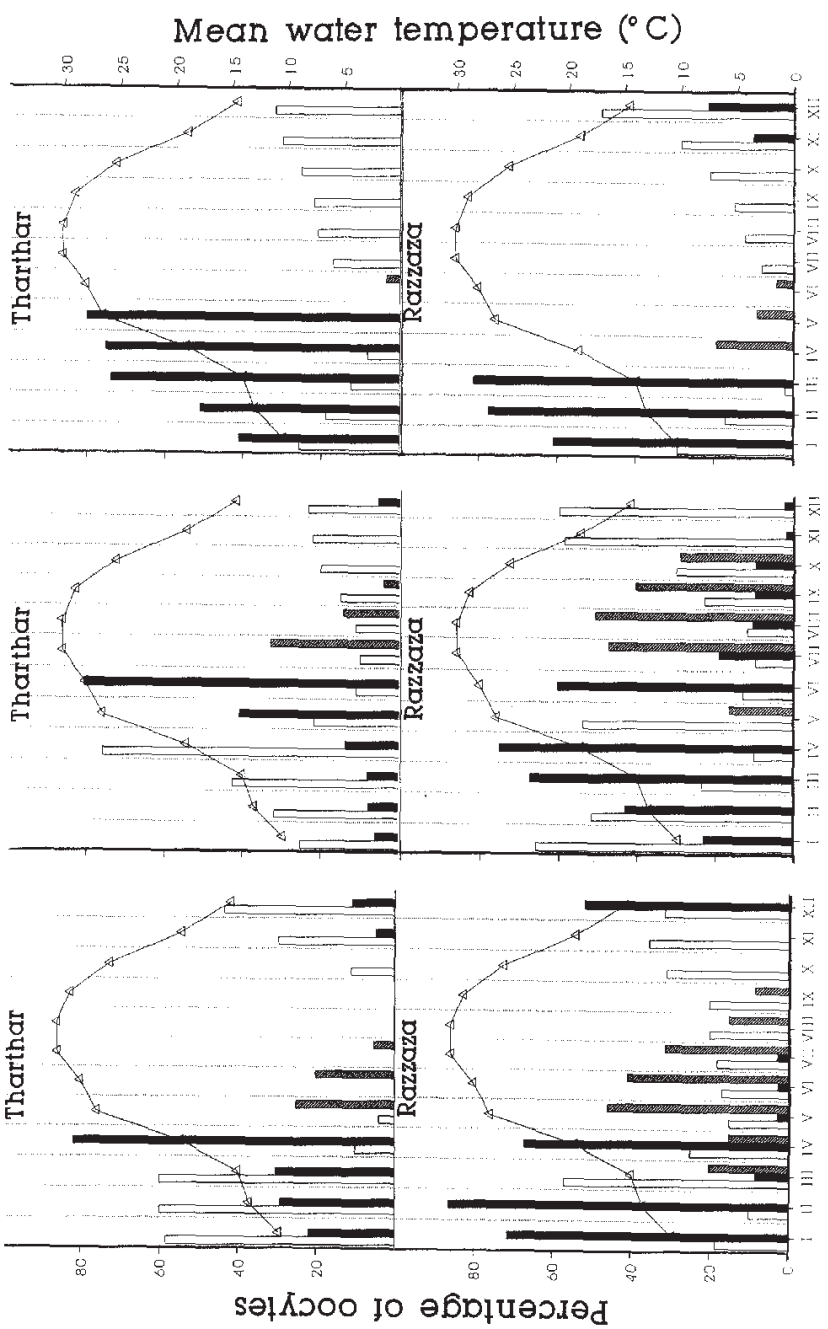
In female and male hishni from Tharthar the GSI was highest in May (12.33 and 7.9), and lowest in June (0.21 and 0.40). In Razzaza the GSI was highest in March (11.02 and 7.20) and lowest in August (0.6 and 0.68).

GONADAL HISTOLOGY (Fig. 2)

In buni from Tharthar stage III–IV oocytes of maturity were found in October (the beginning of vitellogenesis) and stage IV oocytes appeared for the first time in November. The highest percentage of mature (stage IV) oocytes (82.1) was present in April. Resorbing oocytes were observed in May (25%), June (20%) and July (5.3%). No stage III or IV oocytes were found between May and September. In buni from Razzaza Lake stage III–IV oocytes were present (from 18 to 57%) during the whole year. The highest percentage of mature oocytes were found in February (86%) and in April (67.3%). Resorbing oocytes were observed from March to September, but their numbers were highest in May, June and July (31–46%).

In himri from Tharthar, stage III–IV oocytes were present all year around (from 11 to 75%). Stage IV oocytes were found in December (5.4%), but the percentage was highest in June (80.5%). Resorbing oocytes were present in July (33%) and August (14.3%). In himri from Razzaza, stage III–IV oocytes were found from July (10%) to January (65%), and while mature oocytes were present all year their highest percentage was observed in April (75.1) and June (60.3). Resorbing oocytes were observed from July (47%) to October (29%).

Mature oocytes were observed in hishni from Tharthar from January (41%) to May (80%). In June there were resorbing oocytes (3.5%) and oocytes at the earlier stages of maturity. Stage III–IV were present from July to April. In hishni from Razzaza



. Fig. 2. Annual cycle of ovarian development in investigated fish species. III–IV (empty bars), IV (black bars) - stages of ovarian maturity. R - resorbing oocytes (stripped bars).

mature oocytes were present from November (10.3%) to March (81.6%) and stage III–IV oocytes from July to February. Resorbing oocytes were present from April (19%) to June (4.3%).

Testes of all investigated males were in the Vth stage of maturity. Spermatozoa were present in seminal tubules. Changes in numbers of spermatozoa and the weight of gonads were observed through the annual cycle: the lowest values were found in summer and the highest at the time of spawning.

DISCUSSION

There were no significant differences in the biological parameters of fish populations of *Barbus sharpei*, *Barbus luteus* and *Mugil hishni* taken from fresh- and saltwater lakes. The natural food of the fish from the two environments was almost identical, especially if the dominant components were considered. It can thus be assumed that differences in the annual cycle of gonadal development and fecundity of these species are caused by salinity of the aquatic environment. Both GSI (Fig. 1) and stage of ovarian maturity (Fig. 2) differ statistically significantly for all species between the two salinities. In salt water the acceleration of gonad development is evident in comparison with the fish living all year in fresh water. Histological analysis of gonads shows that buni in Tharthar lake is ready to spawn in April, while in Razzaza it spawns in February and by March an increase in the percentage of maturing oocytes (stage III–IV) is again observed. The presence of resorbing oocytes in the same months indicates that some oocytes have already ovulated and been released and by April fish are ready for the next spawning. A similar situation was observed in himri, which spawns in fresh water in June/July. This acceleration of ovarian maturation and spawning in saltwater fish was also found in hishni where the appearance of mature oocytes and their maximum numbers were observed two months earlier in Razzaza than in Tharthar and Habbaniya. This species, however, spawns only once a year in salt water. It is possible that during spawning, fertilization of eggs takes place not only in fresh, but also in salt water, since in hishni, but not buni and himri, the motility of spermatozoa was observed after adding water from Razzaza lake to the sperm. In such a situation ovulated eggs of buni and himri are not fertilized during the first „spawning readiness" and these species will have to undertake another trial to spawn successfully. The specimens caught in April and May, before freshwater irrigation of

Razzaza, have maturing and resorbing oocytes. It is possible that in place of ovulated and released eggs a new generation of oocytes grow and they mature and are ready for ovulation at the same time as fish living in fresh water. The moment of the second „spawning readiness" falls within the period of significant decrease in salinity of Razzaza, at least in the gulf connected with the irrigation canal from Habbaniya. It is very probable that in the presence of aquatic vegetation, effective spawning of both the fish living throughout the year in Razzaza and those which have come to this lake at the time of irrigation takes place. However the spawng may run with disturbances because a high percentage of resorbing oocytes were found in buni in May - July (40–30%), in himri in July - August (50–30%). This high percentage of resorbed oocytes shows that not all females had spawned. However spawning must take place in Razzaza since there was high proportion of the investigated species in the annual net catch (Table 2).

For the three fish species investigated, increased water salinity did not inhibit gonad development like in *Eigenmannia verescens* (Kirschbaum 1979) or fish in which reproduction depends on the rainy season (Lam 1983). In these species, increased water salinity modified only the annual cycle of gonad development and the time of spawning.

The relative fecundity of the species from Tharthar/Habbaniya is higher than in *Barbus barbus* from the temperate zones, and confirms the results of Astrauskas (1971) who demonstrated that fish fecundity was higher in warm waters than in temperate regions. Relative fecundity of buni and hishni living in the salt water of Razzaza is significantly lower (Table 7) than that of the same species in fresh water. Since there were no differences in growth, condition, feed and feeding it is suggested that salinity of the water is responsible for the difference in fecundity of buni and hishni.

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STRESZCZENIE

ROZWÓJ GONAD I TARŁO *Barbus sharpei, Barbus luteus* i *Mugil hishni* W SŁODKICH I SŁONYCH WODACH IRAKU

Badano roczny cykl rozwoju gonad i płodność *Barbus sharpei* (buni), *Barbus luteus* (himri) i *Mugil hishni* (hishni) w słodkich jeziorach Tharthar i Habbaniya, gdzie zasolenie wynosi 0,2–1,8‰ i w słonym jeziorze Razzaza o zasoleniu 12–13‰. Stwierdzono, że u ryb z jeziora Razzaza roczny cykl rozwoju jajnika został przyspieszony o dwa miesiące w porównaniu z rybami tego gatunku żyjącymi w słodkiej wodzie. Obecność wysokiego procentu dojrzałych oocytów stwierdzono w jajnikach buni dwukrotnie: w lutym i w kwietniu, a w jajnikach hishni w marcu i czerwcu. Płodność buni i hishni była istotnie niższa w słonej niż w słodkiej wodzie. Ponieważ współczynnik kondycji, współczynnik wypełnienia przewodu pokarmowego i tempo wzrostu badane u ryb przebywających w słodkiej i w słonej wodzie były podobne, można sądzić, iż zmiany w cyklu płciowym spowodowane były zwiększonym zasoleniem środowiska wodnego.

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