Fecundity of mosquitofish, *Gambusia affinis* (Baird & Girard) as a function of female size in fish from two lakes in Libya

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Fecundity of mosquitofish, Gambusia affinis *(Baird & Girard) as a function of female size in fish from two lakes in Libya.–* The relationships between length and weight of the female *Gambusia affinis* and location with the fecundity (eggs and eyed embryos) were analysed. The weight of fish was the most accurate predictor of fecundity: the heavier the female, the larger was their fecundity. The brood fish from BuDezera produce double the number of eyed embryos per 0.01g weight increase, compared to brood fish from Ain Ziana. In general, fish from BuDezera had fecundity higher than fish of the same weight group from Ain Ziana lake. Fish length was also positively correlated with fecundity, but not as closely as weight.

Key words: Fecundity, *Gambusia affinis*, Libya.

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Introduction

The origin of *Gambusia affinis* is the Mississipi Valley, U.S.A. From there it has been progressively introduced to many countries such as Spain, eastern European countries, Italy and North Africa as a mean of malaria control (GERBERICK & GENTILE, 1956; GERBERICK & LAIRD, 1966; BAY, 1967). There is no date for introduction of this species in Libya, it could have been introduced by the Italians during 1929 (AL-HASSAN & AL-HASANI, 1988). However, in spite of the species widespread use, little is known about its reproductive potential. It is necessary to have more detailed information concerning the reproduction of this species and the factors which influence its fecundity so that its use in mosquito control can be understood and optimized. The studies of KRUMHOLZ (1948), BROWN (1966), WU et al. (1974) and NA'AMA & AL-HASSAN (1988) are the most detailed studies of the fecundity of *G. affinis*. KRUMHOLZ (1948) determined the relationship between the fecundity and the length of the females. BROWN (1966) and WU et al. (1974) also take into consideration time of year in which fish were collected, site of collection, length and weight of fish on their relationship with fecundity. Recently, NA'AMA & AL-HASSAN (1988) reported on the relationship between the fecundity and both the length and weight of the females from Iraq and Egypt.

The aim of the present study is to determine and compare the relationship between fecundity and length and weight of the females in two inland water bodies in Libya.

Materials and methods

Fish specimens were collected from two inland lakes, namely Ain Ziana and BuDezera situated north east of Benghazi city, Libya (fig. 1). Two-hundred and thirty-seven fish were collected from Ain Ziana, while one hundred and thirty-one fish were collected from BuDezera by hand net during the period April 1995-July 1995. The fish were preserved in 10% formalin immediately after capture. The total length (TL) and weight of each female fish was measured to the nearest 0.01 mm and 0.01 g respectively. After dissection, the number of eggs and eyed

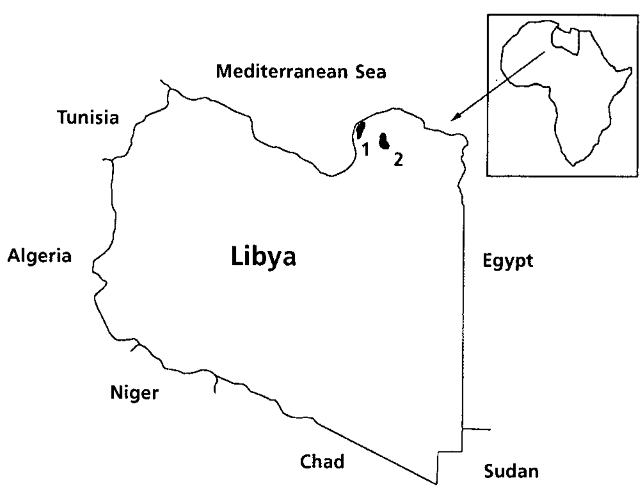

Fig. 1. Map showing sampling localities of *Gambusia affinis* in Lybia: 1. Lake Ain Ziana; 2. Lake BuDezera.

Mapa mostrando las localidades de muestreo de Gambusia affinis *en Libia: 1. Lago Ain Ziana; 2. Lago BuDezera* embryos (larvae) were counted under a dissecting microscope. Eggs larger than 0.5 mm in diameter were counted according to the method of TURNER (1937) and WU et al. (1974). The fish were assigned to 3 mm length classes and to 0.2 g weight classes.

Results

Eyed embryo (larvae)-length size relationship

Table 1 shows the relationship between the number of eyed embryos and the length of the female fish. The regression lines for eyed embryo against length are shown in figure 2. The average number of eyed embryos was observed to increase by 0.554 and 1.307 for Ain Ziana and BuDezera respectively with each 1 mm. The values of *r* are much higher in BuDezera, as shown in table 5.

Eyed embryo (larvae)–weight relationship

The relationship between the number of eyed embryos and weight of females from the two localities are shown in table 2. The regression lines of the relation are shown in figure 3. The number of eyed embryos appeared to increase by 8.8291 and 16.333 for each 0.01 g increase in body weight for fish from Ain Ziana and BuDezera lakes respectively. The values for *r*, as shown in table 5, are higher in BuDezera than Ain Ziana.

Egg-length size relationship

Egg numbers observed in females of different lengths in the collection from the two localities are given in table 3. The calculated regression lines for this relationship are shown in figure 4. The average egg numbers increase by 0.392 and 0.601 with each 1 mm for Ain Ziana and BuDezera respectively. The values of *r*, as shown in table 5, are higher in Ain Ziana than BuDezera.

Egg–weight relationship

The relationship between the number of eggs and length of females from the two lakes is shown in table 4. The regression lines of this relationship are shown in figure 5.

The number of eggs increases by 6.387 and 9.246 for each 1 mm for Ain Ziana and BuDezera respectively. The values of *r*, as shown in table 5 are nearly equal in both lakes.

Discussion

Reproductive output is considered one the most important factors in the maintenance of a population. However, there are many factors which can potentially influence the productivity of fish, including age, length, weight, genotype of the breeding stock, the number of fish per unit area and the time of the year the fish are collected. When population studies of *G. affinis* are considered, these factors have been examined by many authors (e.g. TURNER 1937; KRUMHOLZ, 1948; BROWN, 1966; BAGENAL, 1957, 1967, 1971; WU et al., 1974; MILTON & ARTHINGTON, 1983).

Among the fish specimens described here, both the largest (53 mm) and the smallest reproductive female (28 mm) were recorded from Ain Ziana Lake. Fishes of 30 to 47 mm collected from both lakes contained eyed embryos (larvae). The highest fecundity found in this study consisted of 30 eyed embryos and 18 eggs from a fish of 53 mm TL and 1.9 g collected from Ain Ziana Lake.

Age at first maturity is closely related to the maximum age attained by the fish, thus fish living longer have an older age when they mature (CUSHING, 1968). The present results are in agreement with Cushing's statement. The largest female was 53 mm long and females attained sexual maturity at a minimum length of 28 mm (see table 1). On the other hand, these results differ from those of KRUMHOLZ (1948), BROWN (1966) and WU et al. (1974) in that the maximum length attained by fish is smaller and fish reached sexual maturity at smaller sizes consistent with the results of NA'AMA & AL-HASSAN (1989).

In Lake Ain Ziana, the correlation coefficient (table 5) for weight versus number of eggs and number of eyed embryos is greater than for length versus embryo, while in BuDezera Lake they are equal. This indicates that weight of the female is not accurate for predicting the fecundity of this fish, which is consistent with the findings of WU et al. (1974) and NA'AMA & AL-HASSAN (1988).

Table 1. Average, range and standard deviation of number of eyed embryos from female *Gambusia affinis* at two lakes in relation to female body length: TL. Total length (mm); N. Number of fishes; A. Average; R. Range; SD. Standard deviation.

Media, variación y desviación estándar de embriones con ojos de la hembra de Gambusia affinis *en los dos lagos, en relación a la longitud corporal de la hembra: TL. Longitud total (mm), N. Número de peces; A. Media; R. Variación; SD. Desviación estándar.*

	Ain Ziana				BuDezera			
TL	N	A	R	SD	N	A	R	SD
27-29	10	7	0	±0.00	14	0	0	±0.00
30–32	23	13.66	13-15	±1.15	22	17.33	1-13	±6.03
33–35	27	11.14	9-17	±3.67	35	11.71	1-19	±5.41
36–38	35	16.13	9-25	±4.17	23	17.24	9-19	±3.07
39–41	53	19.38	16-25	±2.75	15	19.75	17-19	±0.96
42–44	38	19.12	16-27	±3.64	-	-	-	-
45–47	27	22.14	13-27	±4.77	12	27.00	27	±0.00
48–50	10	21.10	0	±0.00	-	-	-	-
51–53	18	19.30	0	-	-	-	-	-

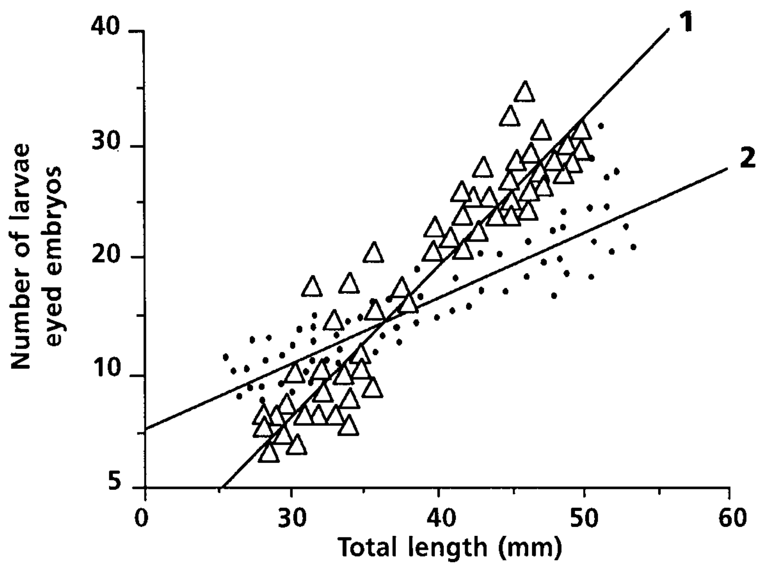

Fig. 2. The relationship between eyed embryo and female length of *Gambusia affinis* in collections from BuDezera (1) and Ain Ziana (2).

Relación entre embriones con ojos y longitud de la hembra de Gambusia affinis *en muestras de BuDezera (1) y Ain Ziana (2).*

Table 2. Average, range, and standard deviation of number of eyed embryos from female *Gambusia affinis* at two lakes in relation to female body weight: TW. Total weight (g); N. Number of fishes; A. Average; R. Range; SD. Standard deviation.

Media, variación y desviación estándar del número de embriones con ojos de la hembra de Gambusia affinis *en los dos lagos, en relación al peso corporal de la hembra: TW. Peso total (g); N. Número de peces; A. Media; R. Variación; SD. Desviación estándar.*

	Ain Ziana				Budezera			
TW	N	A	R	SD	N	A	R	SD
0.2–0.4	14	17	5-25	±5.39	3	7	1-13	±8.48
0.5–0.7	24	21	11-21	±2.59	26	14.35	9-19	±0.59
0.8–1.0	8	20.57	16-27	±4.00	3	15.66	11-19	±4.16
1.1–1.3	7	18	13-26	±4.70	-	-	-	-
1.4–1.6	2	27	9-27	±12.73	1	27.00	-	-
1.7–1.9	1	-	-	-	-	-	-	-

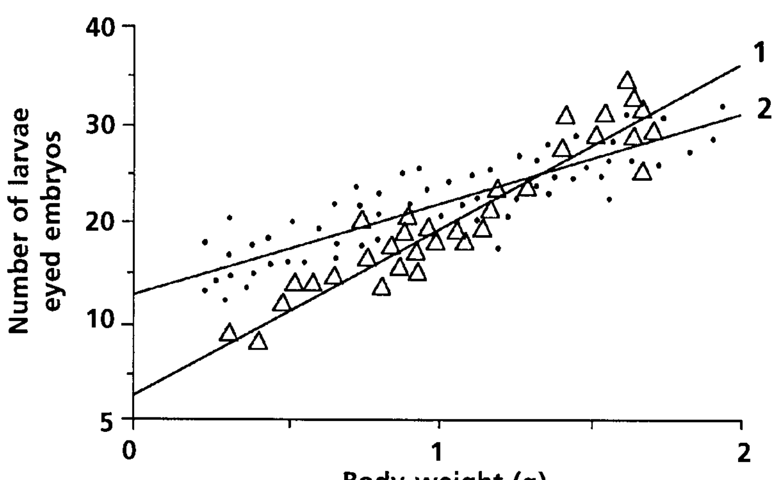

Fig. 3. The relationship between number of eyed embryos and female weight of *Gambusia affinis* in collections from BuDezera (1) and Ain Ziana (2).

Relación entre el número de embriones con ojos y el peso corporal de la hembra de Gambusia affinis *en muestras de BuDezera (1) y Ain Ziana (2).*

Table 3. Average, range and standard deviation of number of eggs from female *Gambusia affinis* at two lakes in relation to female body length: TL. Total length (mm); N. Number of fishes; A. Average; R. Range; SD. Standard deviation.

Media, variación y desviación estándar del número de huevos de la hembra de Gambusia affinis *en los dos lagos, en relación a la longitud corporal de la hembra: TL. longitud total (mm); N. Número de peces; A. Media; R. Variación; SD. Desviación estándar.*

	Ain Ziana				BuDezera			
TL	N	A	R	SD	N	A	R	SD
27-29	-	-	-	-	3	3.66	2-6	±2.08
30-32	-	-	-	-	16	8.81	2-16	±4.39
33-35	3	7.66	6-9	±2.22	14	9.14	1-17	±5.63
36-38	-	-	-	-	15	8.66	1-23	±0.57
39-41	-	-	-	-	3	10.30	1-25	±11.40
42-44	-	-	-	-	-	-	-	-
45-47	2	13	11-15	±1.23	1	18	-	-
48-50	-	-	-	-	-	-	-	-
51-53	1	18	-	-	-	-	-	-

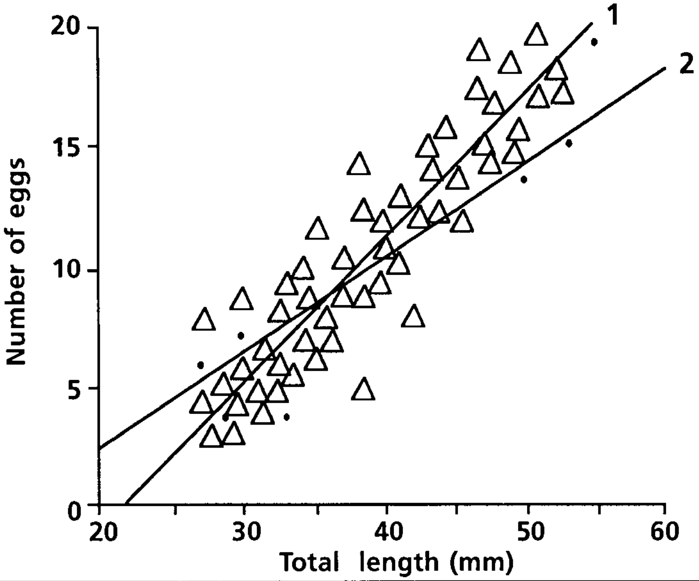

Fig. 4. The relationship between number of eggs and female length of *Gambusia affinis* in collections from BuDezera (1) and Ain Ziana (2).

Relación entre el número de huevos y la longitud de la hembra de Gambusia affinis *en muestras de BuDereza (1) y Ain Ziana (2).*

Table 4. Average, range and standard deviation of number of eggs from female *Gambusia affinis* at two lakes in relation to female body weight: TW. Total weight (g); N. Number of fishes; A. Average; R. Range; SD. Standard deviation.

Media, variación y desviación estándar de huevos de la hembra de Gambusia affinis *en los dos lagos, en relación al peso corporal de la hembra: TW. Peso total (g); N. Número de peces; A. Media; R. Variación; SD. Desviación estándar.*

	Ain Ziana				BuDezera			
TW	N	A	R	SD	N	A	R	SD
0.2-0.4	2	7.5	6-9	±2.12	23	9.17	2-17	±4.43
0.5-0.7	8	8.0	-	-	26	8.07	1-23	±6.60
0.8-1.0	1	11.0	-	-	2	13.00	1-25	±16.97
1.1-1.3	1	11.0	-	-	-	-	-	-
1.4-1.6	1	16.5	-	-	-	-	-	-
1.7-1.9	-	-	-	-	-	-	-	-

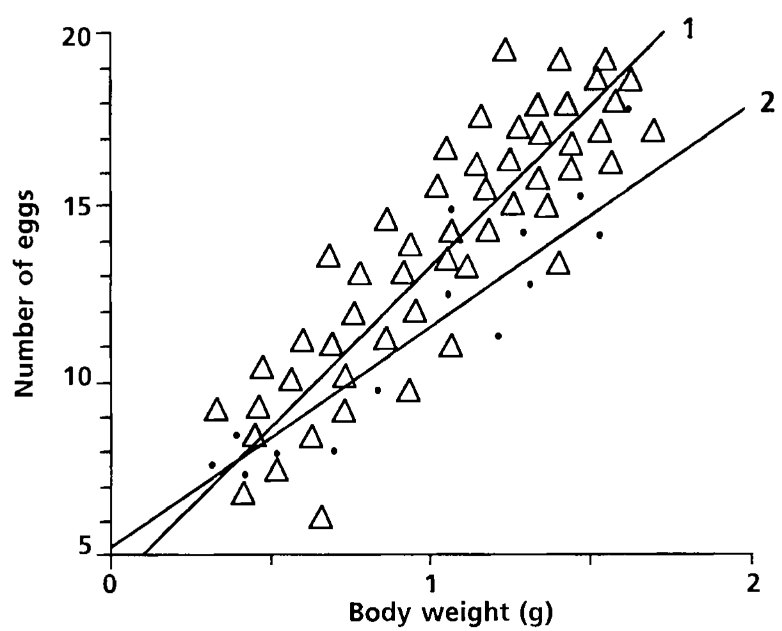

Fig. 5. The relationship between number of eggs and female weight of *Gambusia affinis* in collections from BuDezera (1) and Ain Ziana (2).

Relación entre el número de huevos y el peso de la hembra de Gambusia affinis *en muestras de BuDezera (1) y Ain Ziana (2).*

Table 5. Eyed embryo x length (Em x L), eyed embryo x weight (Em x W), number of eggs x length (Eg x L) and number of eggs x weight (Eg x W) relationships in *Gambusia affinis* from two lakes: S. Significance.

Relaciones de Gambusia affinis *de los dos lagos: embriones con ojo x longitud (Em x L), embriones con ojo x peso (Em x W), número de huevos x longitud (Eg x L) y número de huevos x peso (Eg x W). S. Nivel de significación.*

Site	Relationship	*a*	*b*	*r*	S
Ain Ziana	Em x L	-5.860	0.554	0.654	$P = 0.05$
	Em x W	12.776	8.829	0.784	$P = 0.05$
	Eg x L	-5.509	0.392	0.993	$P = 0.05$
	Eg x W	5.133	6.387	0.803	$P = 0.05$
BuDezera	Em x L	-33.474	1.307	0.998	$P = 0.05$
	Em x W	2.818	16.330	0.986	$P = 0.05$
	Eg x L	13.041	0.601	0.702	$P = 0.05$
	Eg x W	3.930	9.246	0.856	$P = 0.05$

From tables 1 and 3, it is clear that fishes from BuDezera Lake have both larger numbers of eyed embryos and number of eggs than fishes of equivalent size from Ain Ziana Lake. The difference in the results obtained for the two lakes could be attributed to either genetic or environmental factors. The effect of genotype on the relationship of length and weight with both eggs and number of eyed embryos were observed in several fish species (KRUMHOLZ, 1948; WU et al., 1974). Such a relationships appeared to have genetic basis (PURDOM, 1974; HAYNES & CASHNER, 1995). On the other hand, the relationship between the growth rate of the fish and its fecundity is quite evident and well documented in the literature (for references see WOOTTON, 1990). Growth rate in fish is usually influenced by a wide range of environmental factors. Among these are temperature, salinity, competition and food availability. Temperature has a pervasive controlling effect on the rate of growth of fishes (WOOTTON, 1990) which in turn affects the fecundity of the fish. Several authors have reported the effect of this factor on the reproduction of fishes. MEDLEN (1951) found that the reproduction could be stimulated in *G. affinis* at temperatures above 15.5°C. VLAMING (1972) concluded that temperature appeared to be extremely important in regulating cypriniform reproduction cycles.

BuDezera is a landlocked lake, with a water temperature higher than that found in Ain Ziana Lake, which is connected to the Mediterranean sea. Water temperature in BuDezera ranged between 19.1-27.0°C while that of Ain Ziana ranged between 16.1–24.0°C (EL-TOUMI et al., pers. comm.). Such differences in water temperature regimes will represent a general trend that could continue year after year unless a profound change affects the topography of the two lakes.

The growth rate, and in turn, the reproduction cycles of the fish, could be hampered by the adverse change in salinity. Although *G. affinis* is tolerant of brackish water, its natural habitat in the Mississippi drainage is freshwater. The energy costs of osmotic regulation in brackish water will mean that less energy can be allocated to growth (BRETT, 1979). Salinity acts as a masking factor for growth. Such an effect should show up as a decrease in the growth efficiency at a given ration (WOOTTON, 1990). This effect occurs in different ways. LEONARDOS

& SINIS (1998) and MORITA & TAKASHIMA (1998) reported that increased salinity had an adverse effect on the number and size of eggs in *Aphanius fasciatus* and *Salvelinus leucomaenis* respectively. On the other hand, WARDOYO (1991) discussed the effect of salinity on the reproductive performance of *Tilapia nilotica*. His work suggested that the increase in the salinity could reduce reproductive performance. In the case of the two lakes in question, Lake Ain Ziana experiences higher salinity than Lake BuDezera due to its connection with the Mediterranean Sea. Water salinity in the former lake ranges between 10.49-18.99‰ while in Lake BuDezera it ranges between 6.5-9.5‰ (EL-TOUMI et al., pers. comm.). The great difference in water salinity explains clearly how salinity affect the fecundity of *G. affinis* in Lake Ain Ziana.

Food availability and competion factors can act together on *G. affinis* in both lakes under consideration. In Lake BuDezera, the total number of fish species is only three (carp, *Cyprinus carpio;* mullet, *Mugil cephalus;* mosquitofish, *G. affinis*) (personal observation), while in Lake Ain Ziana the number rises to 14 which includes mostly marine fish (AL-HASSAN & EL-SILINI, 1999). In less competition atmosphere and with more abundant food, *G. affinis* in Lake BuDezera seems to grow better than those in Lake Ain Ziana which in turn affects their fecundity. Other authors have also observed similar effects of salinity on fecundity (MILTON & ARTHINGTON, 1983; MOYLE & CECH, 1996).

Resumen

Fecundidad de la gambusia, Gambusia affinis *(Baird & Girard) en función del tamaño de la hembra en peces de dos lagos de Libia*

Se analiza la relación entre longitud y peso de la hembra *Gambusia affinis* y localización con la fecundidad (huevos y embriones con ojos) (figs. 1-5). El peso del pez fue el mejor parámetro para predecir su fecundidad: a mayor peso de las hembras, mayor fue su fecundidad. El pez de cría de BuDezera produce doble número de embriones con ojos por cada 0,01 g de incremento de peso, en comparación con el pez de cría de Ain Ziana (tablas 1-5). En general, peces de BuDezera tienen una fecundidad mayor que peces del mismo grupo, respecto al peso, del lago Ain Ziana. La longitud tambien está correlacionada positivamente con la fecundidad, pero no tanto como el peso.

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