

Introduction and Aim of work

Lake Qarun is saline lake. It lies at the lowest part of the Fayoum Depression; which is located in the Western Desert about 85 km. South West to Cairo, between 30° 24' and 30° 49' E Longitude, and 29° 29' and 29° 34' N Latitude (Fig. 1).

It covers an area of about 54,000 Faddans (21,600 Hectares). The average depth is about 4.2 m., while its maximum depth is about 9.0 m., (Abd-Ellah, 1999). The average water level of the lake ranges between 44.3 m., and 44.8 m., below sea level. Lake Qarun doesn't receive direct Nile water; its main water source is agriculture drainage water that loaded with raw sewage, fertilizers and pesticides. Water discharge to the lake through two main drains, namely, El-Wadi Drain in the middle part and El-Bats Drain in the eastern side. In addition, there is some other minor drain discharges at the southern shores.

Drainage water and evaporation mainly affect the water salinity. Since the lake is located in hyperarid area, it is suffering from a continuous increase in salinity. The earliest record of the average salinity was 11.6 ‰ in 1920 and progressively increased to 44.0 ‰ in the western area during the summer season (Abd-Ellah, 1999).

The average pH value of the lake water was about 8.2. The dissolved oxygen reaches to 5.76 mg. O_2/L . in winter and 4.7 mg. O_2/L . in summer (Sabae, 1993).

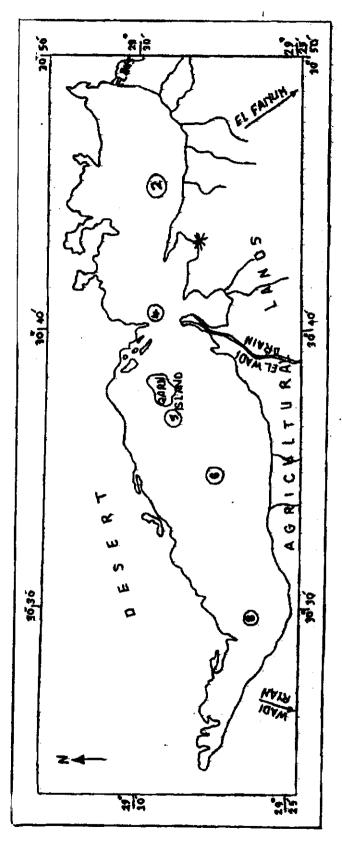


Fig. (1): Map of Lake Qarun
(*) Shakshouk Research Station

There are four common species of mullet in Lake Qarun: Mugil cephalus L.; liza ramada Risso; Liza aurata Risso and Liza saliens Risso (Kirollus, 1977). El-Zarka (1963) reported that the salinity increase of Lake Qarun directly affected the freshwater fishes, which were of Nile origin. To compensate for the loss of freshwater fishes, marine fishes including solea and mullet species were transplanted annually to Lake Qarun. The first lot of mullet fry was planted in 1928. El-Zarka (1968) showed that Liza saliens only of mullet species was acclimatized and spawning successfully in Lake Qarun. Mullet species in Lake Qarun like females of many commercially important fishes fail to complete ovarian ripenning and do not undergo final oocyte maturation, and ovulation or spawning when reared in captivity (Mousa, 1994 and Farouk, 1995).

The development of aquaculture activities depends on two main axes, the availability of fish fry and artificial feed. The present fry collection stations from nature can not satisfy the increasing demand for the juvenile of *Liza ramada*. Consequently, it is necessary to develop and establish practical techniques for artificial propagation of mullet in order to substitute the fry collection from wild stocks. Although mullets are very important for aquaculture, their mass propagation is still restricted to a few species, mainly *Mugil cephalus* (Mousa 1999).

The present study aims to investigate the important aspects of the reproductive biology, physiology and induced spawning of *Liza ramada* in Lake Qarun. These include:

(a) Study of sexual maturity of gonads at breeding season, gonado-somatic index (GSI) and egg diameter.

- (b) Examination of the histological characters of ovaries and testes to give background about the seasonal changes, which occur during reproductive cycle of *Liza ramada* to give us information about character breeding.
- (c) Determination of the level of sex steroid hormone levels in the plasma during maturation stage in both male and female fish to clarify the changes, which occur during the reproductive cycle.
- (d) Induced spawning using Human Chorionic Gonadotropin (HCG) to determine the optimum dose and best environmental conditions (photoperiod, temperature and salinity) required for artificial propagation of *Liza ramada* in Lake Qarun.

Finally, study the distribution of Mullet ova and fry species in Lake Qarun, and their feeding behaviour.

Literature Review

Many important parameters should be studied to know the reproduction mode of a fish species to give a basis for fish aquaculture and fishery management.

In the present work, the parameters studied for *Liza ramada* are: maturity stages, gonado-somatic index (GSI), egg diameters, Histology of gonads, effects of some environmental parameter on gonads maturation and sex steroid hormone and induced spawning of *Liza ramada*. Moreover we studied the feeding behaviour of Mullet fry and survey of eggs and larvae of Mullet species in Lake Qarun.

A- Reproductive biology:

The reproductive biology of other species were studied by many authors: Zaki et al (1986) for Clarias gariepinus; Zaki and Hamza (1986) for Solea solea; Zaki and El-Gharabawy (1991a) for Mugil capito; Vassilopoulou and Papaconstantinou (1992) for Pagrus pagrus; Moharram (1993) for Siganus rivulatus; Zaki et al (1994) for Mugil seheli; Abdo (1996) for Dicentrarchus labrax; El-Gharabawy (1996) for Lithognathus mormyrus; Pajuelo et al (1997) for Mullus surmuletus; Cruz and Hawkins (1998) for Pollicipes; Wagdie et al (1998) for two species Pagellus erythrinus and Pagellus acarne; Zaki et al (1998) for Sparus aurata and Graaf et al. (1999) for Oreochromis niloticus.

Assem (2000) for Caranx crysos; Hotos et al (2000) for Liza aurata.

McAdam et al. (1999) investigated the reproductive seasonality of *Puntius wanenfeldti* from the Perak River, Malaysia, over 19-month period. They reported that female greater than 160 g had mature or rematuring ovaries and males of all sizes had mature testes throughout the study period.

Hay et al. (1987); Ware and Tanasichuk (1989); Gillis et al. (1990) studied the gonadosomatic indices in relation to maturation for assessment as approximation of the whole population.

Hay et al. (1987) and Gillis et al. (1990) studied the gonadosomatic indices with maturation for assessment as approximation of the whole population. Ashour et al. (1990 a,b,c) studied the seasonal reproductive cycle, gonadosomatic index and maturation of Mormynus kannume, Chrysichthys auratus and Schilbe mystus.

Laleye et al. (1995) studied the condition factor and the gonadosomatic index of two species of *Chrysichthys* in Nockoue Lake and Porto-Novo Lagoon in Benin. They reported that the condition factor increased progressively from September to February then decreased from March to August.

Zaki et al. (1994) showed that in Mugil seheli the gonadosomatic index increased progressively towards the spawning seasons. They reported that both females and males reached the peak value in November, the spawning period continued from November to February. They also reported that the highest value of

GSI for females was much higher than that of males.

Graaf et al (1999) studied the reproductive biology of Nile tilapia (*Oreochronis niloticus* L.) under tropical conditions in Congo. They concluded that oocyte development is a better indicator for the determination of size at first maturation than gonadosomatic index.

The analysis of ova diameter in the ovary provides evidence to the spawning habits and duration of spawning. According to Hickling and Rutenberg (1936), the frequency polygons of the ova diameters are steep and well separated from each other in fish having a sharply from each other. In fish having a sharply demareated spawning period, where as those of a fish having an extended spawning period are characterized by a series of low peaked polygones.

Khalile (1985) and Ghabrial (1990) studies the frequency distribution of ova diameters for *Clarias garipinus*, *Oreachromis aureus* and *O. niloticus* and they reported that there were so sharp separations between the general egg stock and the ripe eggs and the immature ones.

Ashour et al (1990 a,b,c) studied the seasonal variations in the size of the eggs in the ovaries of Mormyerus kannume, Chrysichthys auratus and Schilbe mystus from the River Nile at Beni Suef area. They found that the eggs increased very slowly in size during the resting and preparatory stages, and in prespawning and spawning stages, a progressive increase in size of eggs was noticed to take place in a short time. That is indicating a long spawning season.

Ashour et al (1990 a) studied the wide seasonal variations in the size of the egg diameter *Mormyerus kannume*; *Chrysichthys auratus* and *Schilbe mystus*, and the percentage ratio between ovary length and body of the abdominal cavity length.

All authors who studied the sexual cycle of female fish, which spawn several times in the life cycle, confirmed the permanent presence of small oocytes at different stages of development. The frequency of these oocytes is always considerably greater than that of the ripening oocytes and it consists of not less than three groups of oocytes (Al-Zahaby et al, 1983; El-Agamy, 1986 and Zaki et al, 1995).

The reproductive biology of Mugil species were studied by many authors Silva and Desilva (1981) for Mugil cephalus; Alvarez-Lajonchere (1982) for Mugil liza, Mugil cureme, Mugil hospes and Mugil trichodon; Mohamed (1982) for Mugil seheli and Mugil capito in Lake Timsah; Valter (1983) in Mullet; Naama et al, (1986) for Liza abu; Zaki and El-Gharabawy (1991a) for Mugil capito; Modrusan et al. (1991) for grey mullets; and Zaki et al. (1994) for Mugil seheli.

Vassilopoulou and Papaconstantineu (1992) studied the reproductive biology for *Pagrus pagrus*; Moharram (1993) for *Siganus rivulatus*; Abdo (1996) for *Dicentrarchus labrax*; and El-Gharabawy (1996) for *Lithognathus limormyrus*, to determine the breeding season and its character as important factor.

Zaki and El-Gharabawy (1991a) work on the sexual maturity, length at first sexual maturity, gonadosomatic index and the analysis of egg diameters to throw light on the reproduction cycle of *Mugil capito*. They observed that, *Mugil capito* has a prolonged fractional breeding season.

Zaki and El-Gharabawy (1991b) examined the ovaries of *Mugil capito* to give a picture of the reproductive cycle of this species. They divided oocyte maturation into five periods. Oogenic development in *Mugil capito* was found asynchronous.

Histology structure and seasonal changes of gonads:

- The gonads:

Accurate knowledge of the gonadal cycles and their functional mechanisms in fishes is of essential value for the successful management of either natural fisheries or fish farming. Therefore, the histological structure and seasonal variations of the teleostean gonads in general have attracted the attention of many investigators.

Nevertheless, in spite of the extensive important of the mullet, as one of the most economic fish, yet it is somewhat surprising that so limited information, concerning its reproduction, other than spawning time is available. For instance, little attention has been paid to the dynamics of oocyte development and ovarian recrudescence in natural or captivated striped mullet populations. In a more precise manner, the information available on gonad maturation in *Liza ramada* synoname *Mugil capito* reared in different water is sparse and sporadic.

However, Stenger (1959) presented a publication concerning ovary and testes maturation processes as well as germ cell development in variously sized mullet collected from coastal waters of northeast Florida, a marine habitat.

Abraham (1963) studied the seasonal ovarian cycle of *Mugil* cephalus in certain freshwater ponds and in Lake Tiberias in Israel.

Later, Kuo et al (1974a) provided a description of oogenesis as well as the development stages of the oocytes in *Mugil cephalus* collected from Hawaii waters, a marine habitat.

Shireman (1975) postulated that gonadal atresia had occurred in both male and female mullet shortly after they had matured in freshwater habitats; in Lake Palourde and Maringouin Bayou in southern Louisiana.

Greeley et al (1988) described oocyte growth and development in *Mugil cephalus* during seasonal ovarian recrudescence in coastal waters of northeast Florida, a marine habitat.

From another point of view, some researchers were concerned about the problem pertaining induction and promotion of maturation outside the natural spawning season and the culture conditions which have to be adjusted to stimulate the environmental cues that initiate maturation. Such as photoperiod, temperature and /or the combination of these two conditions being the most important and frequently implicated factors in such cases. In this respect, Kuo et al (1974b) demonstrated that the shortened photoperiod (6 L/18D) initiates vitellogenesis in *Mugil cephalus* and

a lower temperature (21 °C) ensures its completion. They also marked that vitellogenesis could be initiated by injecting the fish with pregnant mare's serum gonadotropin (PMSG) at the dose level of 1 I.U./g body weight three times per week. Nonetheless, the same researchers have marked that when either photoperiod or temperature was taken into consideration alone, did not always trigger the gonadal maturation process. Also, manipulating of these factors is not possible in all locations. Thus, alternative methods, such as hormone-therapies, need to be created to overcome the physiological constraints to gonadal recrudescence.

In the same area, Kulikova (1985) was able to stimulate the vitellogenesis of *Neogobius melanostomus* with injections of human chorionic gonadotropin (CG) at total dosages of 25-50 I.U./g body weight. Lee et al. (1987) followed the effectiveness of implanting analogues of lutenizing hormone-releasing hormone (LHRH-a) cholesterol pellets and 17α -methyltestosterone (17α –MT) capsules for enhancing maturation in grey mullet, *M. cephalus*. Also, chronic administration of lutenizing hormone-releasing hormone analogue (LHRH-a) + testosterone was noticed by Tamaru et al. (1991) to result in acceleration of egg growth in *M. cephalus* females in saline water.

A variety of hormonal treatments, inducing final maturation and changeover *M. cephalus* female with vitelline oocytes (tertiary yolk stage) to spawning condition. In this respect, Shehadeh and Ellis (1970) were able to stimulate the final maturation and spawning of *M. cephalus* females by injecting them with a

suspension of one salmon pituitary and 25 I.U. of Synahorine (containing HCG).

However, high doses of hormones were found to be required for the changeover of female mullet *M. cephalus* with vitelline oocytes (tertiary yolk stage) to spawning condition, comprising 500,000-80,000 I.U. human chorionic gonadotropin (HCG)/ kg body weight (Kuo et al., 1973), 28-48 mg of fresh mullet pituitaries and 10,000-80,000 I.U. human chorionic gonadotropin (HCG)/ kg body weight with different application methods (Kulikova and Gnatchenko, 1987), and 20 mg carp pituitary homogenate/ kg of fish, followed by 200 mg lutenizing hormone-releasing hormone analogue / kg of fish (Lee et al., 1988 and Suzuki et al., 1991).

The morphology, histology and cyclical changes in the gonads have been studied in many teleosts comprising *Barbus tor* (Rai, 1965); *Sebastodes paucispinis* (Moser, 1967); *Chrysichthys auratus* (Ashour et al., 1990 b); *Schizothorax richardsonii* (Bisht, 1974 and Bisht and Joshi, 1975); *Fundulus grandis* (Greeley et al., 1988); and leaping grey mullet, gray mullet and Pacific mullet (Moiseyeva et al., 1991).

However, the histochimestry of vitellogenesis has only been investigated in a few teleosts such as *Syngnathus fuscus* and *Fundulus hetercoclitus* (Anderson, 1968); and *Carassius auratus* (Khoo, 1979).

In the present time, a great amount of data about the seasonal changes of the sexual glands in bony fish has accumulated.

Ramos (1983) studied the histological oogenesis in the Solea (Solea solea), and described six stages of oocyte development. He concluded that the development rhythm of the ovary was a synchronus.

Zaki et al, (1986) studied the histological changes in the ovary of *clarias saripinus*. They divided the course of development into five periods.

Mousa (1994) studied the oogenesis, spermatogenesis and histochemistry of the gonads in *Mugil cephalus*.

Spermatogenesis process has also been studied by many authors. This process involves a proliferation of spermatogonia through repeated mitotic divisions and growth to form primary spermatocytes, which then undergo reduction divisions to form secondary spermatocytes, that divide to produce spermatids which then metamorphose to motile and potentiality functional gametes, the spermatozoa (Hoar 1983)

A histological study was carried out to follow gonadal changes in captivity white bream during the second and third years of life by Micle et al (1987). They stated that all but one individual matured as a male. The spawning was found to occur in winter and the environmental factors were likely to have influenced the reproductive activity of the captive fish.

Hourigan et al (1991) investigated the ultrastructure of testes of 2 male phenotype of the protogynous fish, *Thalassoma duperrey*.

Flores and Burns (1993) studied the ultrastructure of the early spermatogonia in mature testes of the platyfish, *Xiphophorus* maculatus, then compared to that of oogonia in mature ovaries of *X. maculatus* and the related *X. nigrensis*.

Gwo et al (1993) studied ultrastructure of the spermatozoon of the teleost fish *Acanthopagrus schlegeli* (Perciformes, Sparidae). Pecio and Rafinski (1994) studied the structure of the testes, spermatozoa and spermatozeugmata of *Mimagoniates barberi* Regan, 1907 (*Teleostei, Characidae*), and internally fertilizing, oviparous fish.

Yao et al (1995) illustrated the ultrastructure of sperm and eggs of the ocean pout (*Macrozoarces americanus* L.), an internally fertilizing marine teleost, was examined by scanning and transmission electron microscopy.

Reygadas and Escorcia (1998) studied the histology of the testes of chard *Chirostoma jordani*, and ultrastructure of gamete cells through fotonic and electron microscopy.

B- Sex steroid hormones:

The fluxes in plasma sex steroids that accompany changes in teleost reproductive activity have been extensively investigated. Most studies focused on changes during the annual reproductive cycle e.g. Fitzpatrick et al (1986) for coho salmon; Tamaru et al (1991) for striped mullet.

Seasonal changes of the sex steroids in mature female and male carp (*Cyprinus carpio* L.) and ovarian tissue were estimated by Galas and Bieniarz (1989).

Testosterone hormone has been identified and measured in mature females of a variety of several teleost; Atlantic species salmon (Ozon, 1972); plaice *Pleuronectes platessa* (Wingfield and Grimm, 1977), and Cod, *Gadus morhua* (Sangolang and Freeman, 1977).

Seasonal cycle of plasma estrogens have been found to correlate with ovarian development and vitelloggenesis in brown bullhead *Ictalrus nebulosus* (Rosenblum et al., 1987), gulf -killfish *Fundulus grandis* (Greely et al., 1988); *Mugil cephalus*; (Mousa, 1994) and *Mugil seheli* (El-Gharabawy et al., 1994).

Malison et al (1994) investigated the serum levels of estradiol-17 β , testosterone, 17 α , 20 β -dihydroxy-4-pregnen-3-one and 11-ketotestosterone in wild freshwater *Strizostedion vitreum* captured from upper mid-western lake and rivers throughout the year.

Assem (1995) studied the monthly distribution of plasma levels of testosterone, progesterone and estradiol in *Solea vulgaris* and *Solea aegyptiaca* in relation to the gonadosomatic indices. The study showed a positive correlation between GSI and plasma levels of estradiol and testosterone in female with maximum values attained in the spawning season. For male, a paid increase was reported in plasma testosterone in the prespawning and spawning periods.

Chang et al (1995) investigated the plasma levels of 17α -hydroxyprogesterone in grey mullet, *Mugil cephalus*, during the period of sex differentiation and the annual cycle.

Abdallah (1996) studied the levels of testosterone, progesterone and estradiol in the plasma of *Diplodus vulgaris*.

Abdo (1996) studied the levels of plasma testosterone, progesterone and estradiol in sea bass *Dicentrarchus labrax* during the annual reproductive cycle in the Egyptian Mediterranean water.

Joss et al. (1996) estimated the serum concentration of testosterone from a population of wild lungfish over 6-7 years of sampling. They found that male lungfish have high circulating levels of testosterone (similar to 50 ng/ml) which varied seasonally and should be correlated with spermatogenesis as judged by testis histology.

El-Boray (1997) measured the plasma levels of testosterone, and progesterone in *Rhabdo sargus haffara* in captivity in two different fish farms in Suez Bay in relation to maturity stages. He gave a picture for the physiology of steroid hormones during the reproductive cycle in two different environments.

Lokman and Young (1998) studied the plasma steroid profiles in wild New Zealand freshwater eels (Anguilla dieffenbachii and Anguilla australis) before and after the onset of the natural spawning migration.

Kestemonte et al. (1999) studied the relationships between sexual maturity, steroid hormone levels and migrations of female roach *Rutilus rutilus*. They measured the levels of plasma testosterone, 17β - estradiol and 17α , 20β -dihydroxy-4-pregnen-3-one in three groups of fish during different periods of migration in the river Meuse (Belgium).

C- Induced spawning:

The development of aquaculture activities increases the demand for mullet fry as a source of seed. The natural mullet fry showed a severe drop due to the increasing pollution problems and over-fishing. Therefore, the induced spawning of mullet species is a must to cover the needs of aquaculture projects.

Abraham et al. (1967) stated that the spawning of *Liza* ramada was always achieved after transfer to seawater and injection with pituitary homogenate or human chorionic gonadotropin.

Yashouv (1969) published first report on induced spawning of *Mugil cephalus* reared in captivity in freshwater ponds. Ling (1970) succeeded to induce the spawning of *Mugil cephalus* by using mullet pituitary homogenate combined with Synahorin.

Kuo et al. (1973) induced Mugil cephalus female by two times injection with 60 I.U. HCG/g. body weight. Shehadeh et al. (1973) reported the induction of testicular maturation in the striped mullet, Mugil cephalus L. This was accomplished by injecting 17 α -Methyl Testosterone (17 α -MT) on alternative days over 30 day-period.

Kuo et al. (1974a) indicated standard practices to success the induced spawning of Mugil cephalus under controlled conditions. They reported that hypophysation of females begins when the mean egg diameter is larger than 650 μm. The dose of gonadotropin

required to induce spawning of Mugil cephalus varied from 12 to 21 μg . /g. body weight.

Liao (1975) summarized the work done in Taiwan between 1963 and 1973 on the propagation of *Mugil cephalus*. The total dosage was 2.5 – 6 pituitary glands, 10- 60 RU Synahorin, and 0 - 300 mg. vitamin E.

Kuo et al. (1972) reported that Mugil cephalus spawned in captivity by administration of partially purified Salmon Gonadotropin (SG) with potency of 1 mg. that equivalent to 2150 I.U. HCG Human Chorionic Gonadotropin.

Sebastian & Nair (1975) stated that *Mugil macrolepis* has been success fully induced to spawn by administration of pituitary of the same species at 26 to 29 °C and salinity 29 to 31 ‰.

Radhakrishnan et al. (1976) induced *Mugil parsia* to breed with a single low dose of mullet pituitary at the rate of 5 mg./kg. body weight of the female.

Chaudhuri et al. (1977) pointed out that the doses of hormones that can be given to fish varied according to the condition of the fish in artificial propagation of *Mugil cephalus*.

James et al. (1983) reported that the effective dosage of Human Chorionic Gonadotropin was 340,000 I.U./kg. body weight of *liza marcolopis*.

Weber and Lee (1985) Lee and Weber (1986) reported successful induction of testicular maturation of Mugil cephalus

with the use of 17α - Methyl Testosterone (17α -MT) incorporated in the feed.

Bok and Jongbloed (1987) reported the induced spawning of southern female (*Liza richardsoni*) by a series of injection with homogenized *Cyprinus carpio* pituitaries and Human Chorionic Gonadotropin to stimulate the final maturation of the egg.

Lee et al. (1988) estimated the cost and effectiveness of CPH /LHRH-a and HCG/LHRH-a treatments on the induced spawning of *Mugil cephalus*. They reported that CPH/ LHRH-a treatment is the most reliable and cost effective method, but the cost of HCG/LHRH-a is high and the response was poor.

Lee and Tamaru (1988) reported that maturation of *Mugil cephalus* male could be successfully induced throughout the year by using 17α-Methyl Testosterone (MT) administered orally; injected or implanted.

Alvarez-Lajonchere et al. (1988) conducted induce spawning and larval rearing experiment of *Mugil liza* at Tunas. They reported that the best results were obtained with each of the following treatments: mullet pituitary homogenate; HCG combined with mullet pituitary homogenate; HCG alone (53100 I.U./kg); and HCG with carp pituitary homogenate.

Shafik (1990) conducted some physiological studies on *Mugil cephalus* and *Liza ramada* of Lake Qarun with special emphasis on the fisheries of the lake. He succeeded to induce *Mugil*

cephalus in Philippines by injection with acetone dried mullet pituitary (10-50 mg./kg.) and / or Human Chorionic Gonadotropin (53-250 I.U./kg.) as well as vitamin E (50-300 mg./fish).

El-Gerisy (1993) failed to induce spawning of *Liza ramada* after injection with 4500 I.U.HCG/kg. body weight under controlled the environmental parameters (temperature, 17.5 °C, S ‰, 25).

Mousa (1999) indicated that effective in inducing final oocyte maturation and ovulation in *Liza ramada* by using pregnyl (HCG) as a priming injection at a dose of 18,000 IU/kg body weight followed by resolving injection of 30,000 IU HCG in combination with 200 µm LHRHa/kg body weight. He stated that the average GSI and diameter of ovarian oocyte increased gradually during induction of final oocyte maturation.

Photoperiod, temperature and salinity are the most environmental factors required for regulation of teleost reproduction, especially in gonadal activity. The environmental factors affecting on reproduction of mullet fish are not necessary for reproduction of other teleost fish.

Hines and Yashouv (1971) studied the importance of salinity on the spermatozoa of *Liza ramada*. They reported that the period of activity of mullet spermatozoa suspended in seawater was similar to that of sperm suspended in osmalar equivalent dextrose solution or artificially prepared seawater. Sperm activity was longest in solutions of pH and osmolarity closely approaching that of normal seawater.

Kuo et al. (1974 b) demonstrated the importance of photoperiod for gonadal activity in the grey mullet, *Mugil cephalus*. They concluded that photoperiod plays a dominant role in stimulating oocyte growth and the temperature regulates the vitellogenesis towards functional maturity.

Nash and Koningsberger (1981) reported that natural spawning of striped mullet could occur in lower salinities. They found that adult and juvenile *Mugil cephalus* are euryhaline.

Zheng (1987) found that the Chinese mullet, *Mugil soiuy* has been successfully bred by administration of hormones at temperature 15 to 16 °C.

Lee et al. (1992) studied the effect of salinity on the induction, spawning and fertilization in the striped mullet, *Mugil cephalus*. They reported that variations in salinity do not pose a barrier for induction of final maturation and spawning in this species. However, they recommended 100 % seawater for use during the spawning- phase of the hatchery production of striped mullet.

Zaki et al. (1993) studied the spermatogenesis process and production of sperms in *Liza ramada*. They reported that the reproduction of this species in Lake Edku at 30- 34 ‰ salinity occurs in January. Males, which are in freshwater attained sexual maturity and sperms, can be obtained by hormonal injection for artificial fertilization.

El-Greisy (1993) studied the influence of photoperiod, temperature and salinity on reproduction of *Liza ramada* during the period of natural breeding season. She reported that long photoperiod with high temperature and continuous illumination (24 hr. L.) or continuous darkness (24 hr. D.) inhibited the gonadal maturation of *Liza ramada*. She observed that at 25 ‰, the oocytes were developed.

In most teleost, there are two biologically important steroid hormones for oocyte growth and maturation. These hormones were identified 17α -estradiol and 17α - 20β -dihydroxy progesterone during these two processes. Also, Testosterone is important hormone and called spermatogenesis hormone. Many investigators were paid attention to the important of the steroid hormones during oogenesis and spermatogenesis of mullet and identified the concentrations of them during these processes.

Suzuki et al. (1991) examined the changes of ovarian steroid metabolism in-vitro in the grey mullet, while undergoing induced final maturation and spawning with CPH and LHRH-a.

Tamaru et al. (1991) investigated the steroid profiles during maturation and induced spawning of the striped mullet, *Mugil cephalus*. They found that during hormonally induced spawning, mullet exhibit an initial increase in serum testosterone and estradiol compared to saline injected controls.

Zaki et al. (1996) investigated the influence of exogenous hormone treatment on the growth and maturation of the oocyte of *Mugil cephalus* in freshwater ponds. They found that testosterone

and estradiol -17α increased gradually during the vitellogenic stages. They reported that the high levels of estradiol- 17α increased the synthesis and secretion of vitellogenin, a precursor of yolk proteins, thus causing oocyte growth in *Mugil cephalus* female.

D- Food and feeding fry:

The food and feeding of mullet post larvae were investigated by many authors.

Naguib (1961) stated a brief description of the nature of the ingested food of fishes in the Lake Qarun.

Ferrari and Chieregato (1981) analyzed the stomach content of fish fry of five species (*Sparus aurata* L., *Dicentrarchus labrax* L., *Liza ramada* Risso, *Liza aurata* Risso, and *Liza saliens* Risso) which are most commonly caught in Ghana. They reported that the change in feeding habits during growth was related to size variations for each species.

Egusa (1950) pointed out that *Mugil cephalus* starts feeding on benthic amphipods and harpacticoid copepods on reaching a body length of 2.15 to 3.95 cm. Thomson (1966) gave information on the food and feeding habits of mullets post-larvae. He found that in addition to zooplankton, *Mugil cephalus* also takes benthic amphipods and copepods.

Liao (1969) concluded that in newly hatched larvae of mullet, the mouth formation is completed on the third or fourth day and then active feeding begin. Also, he mentioned that oyster larvae as well as rotifers were taken on the fifth day after hatching.

Odum' (1970) indicated that mullet post- larvae are carnivorous and feed on mosquito larvae, copepods and other zooplankton until they reach to standard length of about 30 mm.

Kuo et al. (1972) reported that laboratory reared larvae of grey mullet, *Mugil cephalus* feed at the beginning on wild zooplankton and Artemia naupli: on the fifth day after hatching, when the yolk sac was completely absorbed. This type of feeding continued until the post-larvae reached to about 18 mm., in length (42 days after hatching) and began to feed on benthic diatoms.

Zismann et al. (1975) found that copepods were the most important food item in the gut contents of mullets taken in the neuston. They indicated that these fish are selective in their feeding in the natural environment.

King (1986 and 1988) pointed out that Liza grandisquamis fed actively at night and reduced its feeding activity during the day. He indicated that Liza grandisquamis primarily fed on detritus and secondary on mud, sand grains, diatoms, blue-green and green algae, while higher plant tissues, micro crustaceans and free living nematodes were of incidental importance. He studied also the primary diets of Liza grandisquamis and reported variations in food habit related to fish length, months and season.

Eskinazi et al. (1986) recorded 39 diatom species in the stomach content of Mugil curema, Mugil incilis and Mugil liza. Osorio (1988a&b) found benthic diatoms in the stomach contents of Mugil curema, Mugil incilis and Mugil liza. The mean particle size

was 163 nm. in Mugil curema; 299 nm. in Mugil incilis and 401 nm. in Mugil liza.

Torricelli et al. (1988) investigated the daily feeding rhythms of 5 species of mullet fry (*Liza ramada*, *Liza aurata*, *Liza saliens*, *Mugtl cephalus* and *Chelon labrosus*) by analyzing their stomach fill during 24 hr. cycles. They reported that feeding activity occurred mainly during day- time.

Eda et al. (1990) determined the onset of feeding Mugil cephalus larvae and temporal changes in their food selectivity. They found that all unfed larvae were died 192 hr. after hatching. Larvae fed with enriched artemia had significantly high growth (p < 0.05) compared with those non-enriched with artemia or rotifer.

Pisaevskaya and Akscnova (1991) studied the feeding spectrum of larvae and fry of Mugil cephalus, Liza saliens and Liza auratus in Black Sea. They found that the indices of food similarity for fry 7.06 – 12.5 mm. long, amounted to 52.5 for the Mugil cephalus and Liza saliens and 40.4 for Liza saliens and Mugil auratus. The highest index 65.3 was recorded for Mugil cephalus and Mugil auratus fry.

E-Distribution of Mullet ova and fry species in Lake Qarun:

In Lake Qarun, the most important fish species belonging to family mugilidae are *Mugil cephalus*; *Liza ramada* and. *Liza saliens*. Egyptian investigators carried out intensive studies on biology, fisheries and reproduction of these species. Wimpenny (1936) described the ova and larvae of mullet in Lake Qarun.

El-Zarka (1968) showed that *Liza saliens* prefers areas affected by drainage water and hence comparatively low chlorosity but high productivity. It is apparent from the distribution of catch that this species was not recorded at the stations that lie in the eastern side of the lake.

El-Zarka and El-Sedafy (1970) and El-Sedafy (1971) investigated some biological aspects of *Liza saliens* of Lake Qarun. They reported that *Liza saliens* spawn in the lake at the minimum temperature of 20 °C and optimum of 30 °C.

Kirollus (1977) reported that *Liza saliens* was acclimatized in Lake Qarun and spawned there. Other species i.e. *Mugil cephalus* and *Liza ramada* have to be transplanted annually from the Mediterranean Sea in order to maintain their stock in the lake.