Journal of Biological Research **3**: 87–93, 2005
J. Biol. Res. is available online at http://www.jbr.gr

Spawning period and sexual maturity of the fishes *Scardinius erythrophthalmus* Linnaeus, 1758 and *Rutilus rubilio* Bonaparte, 1837 in the reservoir of Sidi-Salem (NW Tunisia)

IMED DJEMALI[1*], AMOR EL ABED[1] and OTHMAN JARBOUI[2]

[1] *National Institute of Sciences and Technologies of the Sea, 28 rue du 2 Mars 1934, Salammbô, 2025 Tunis, Tunisia*
[2] *National Institute of Sciences and Technologies of the Sea, Sfax, 3018 Sfax, Tunisia*

Received: 29 December 2004 Accepted after revision: 30 May 2005

Overall 1447 specimens of *Rutilus rubilio* and *Scardinius erythrophthalmus* were collected in the reserve of Sidi-Salem dam (NW Tunisia) for the determination of the spawning period based on the monthly variations of the gonadosomatic index, hepatosomatic index and the condition factor (K). Samples were collected from January to December 2001. The results showed that the spawning period of *R. rubilio* ranges from March to April, whereas that of *S. erythrophthalmus* from April to September. The size (total length) at first sexual maturity (L_{50}), was assessed based on the logistic function and was 7.8 ± 0.23 cm (females) and 8.5 ± 0.43 cm (males) for *R. rubilio* and 7.9 ± 0.49 cm (females) and 8.5 ± 0.19 cm (males) for *S. erythrophthalmus*, respectively.

Key words: *Rutilus rubilio, Scardinius erythrophthalmus*, reserve of Sidi-Salem, Tunisia, spawning period, sexual maturity.

INTRODUCTION

Rutilus rubilio Bonaparte, 1837 and *Scardinius erythrophthalmus* Linnaeus, 1758 were introduced to the Tunisian reserve of Sidi-Salem dam (Fig. 1) in the nineties in order to be used as forage fish for other carnivorous species, notably for the pikeperch *Stizostedion lucioperca* (M'hetli, 2001). The population dynamics of these two species strongly influence the state of the pikeperch stock which is most targeted by the fishermen. *Rutilus rubilio* and *Scardinius erythrophthalmus* are therefore equally consumed by the local population in comparison with the population of the big cities. Studies on the reproduction of *R. rubilio* are rare (Daoulas, 1981; Crivelli, 1996) considering that this is a species of southern Europe found mainly in Italy, Greece and Croatia (Garcia-Berthou, 1999). It has no important commercial value. In fact, most studies have been carried out on the roach *R. rutilus*, because of its importance in the trophic balance of the freshwater reserve, its angling and especially in its large geographic distribution over Europe (Peczalska, 1968; Goldspink, 1979; Easton & Dolben, 1980; Worthington *et al*., 1982; Vollestad & L'Abée-Lund, 1987). This is equally valid for *S. erythrophthalmus*. No biological data are available for these two species in Tunisia.

* Corresponding author: tel.: +216 71 730548, fax: +216 71 732622, e-mail: imed.djemali@instm.rnrt.tn

MATERIALS AND METHODS

The study on the sexuality and reproduction of *R. rubilio* and *S. erythrophthalmus* was performed on a total of 1447 individuals during the year 2001 (668 *R. rubilio* and 779 *S. erythrophthalmus*). Samples were caught by fishermen, using nets (Degiorgi, 1994) with horizontal and vertical tablecloth and mesh sizes varying from 10 to 120 mm.

The following measurements were made for both species:

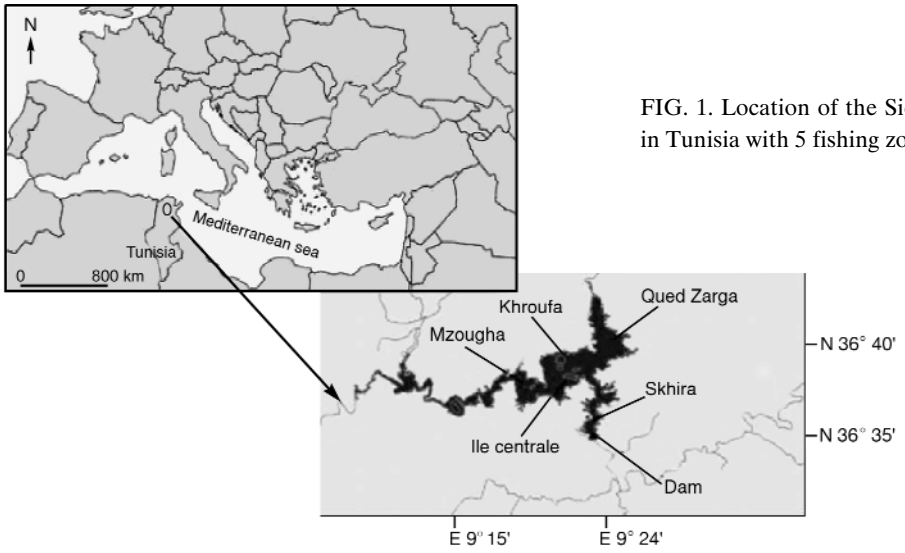

FIG. 1. Location of the Sidi-Salem reservoir in Tunisia with 5 fishing zones.

- Total length (L_T) in cm
- Total weight (W_t) in gr
- Net weight (W_e) in gr
- Liver weight (W_f) in gr
- Gonad weight (W_g) in gr

To every evisceration of the fish in the laboratory, all gonads were carefully observed for sex determination. The spawning period of these two cyprinids was identified based on the monthly variations of the gonadosomatic index (RGS), the hepatosomatic index (RHS) and the condition factor (K) (Ouannes-Ghorbel *et al*., 2002):

$$RGS = \frac{Wg}{We} \times 100$$

$$RHS = \frac{Wf}{We} \times 100$$

$$K = \frac{We}{L_T^3} \times 100$$

Length at first sexual maturity

The size of the first sexual maturity is defined as the size at which 50% (L_{50}) of the fishes are mature (Dia *et al*., 2000). This definition is also used here. However, all fishes caught were mature which obliged us to fish by a hand net during the reproduction period of the two species (between March and July). This net allowed us to capture fishes with a length between 3 and 9 cm (L_T).

L_{50} was estimated using the logistic function (King, 1995) and the FSAS (Saila *et al*., 1988):

$$P = \frac{1}{1+\exp\left[-(b+aL_T)\right]}$$

In the above equation, P is the proportion of the mature fishes, L_T the total length and a, b are constants.

In order to verify the fit of this equation, a chi-square test was performed:

$$\chi^2 = \sum_{i=1}^{n} \frac{(M_i - nP_i)^2}{nP_i}$$

M_i: observed number of matures fishes
nP_i: calculated number of matures fishes

RESULTS AND DISCUSSION

Spawning period

The temporal evolution of RGS for *R. rubilio* is shown in Fig. 2. RGS exhibited a maximum for both sexes in March indicating that spawning takes place between March and April.

The sexual cycle of *S. erythrophthalmus* (males and females) in the reserve of the Sidi-Salem dam comprise the following phases:

- Phase 1: Maturation of the gonads from January to April.
- Phase 2: Spawning period between April and September.
- Phase 3: Sexual resting from September to December.

In Sidi-Salem, *S. erythrophthalmus* shows a wide spread of spawning time. It lasts six months, in contrast to *R. rubilio* in which spawning lasts two months.

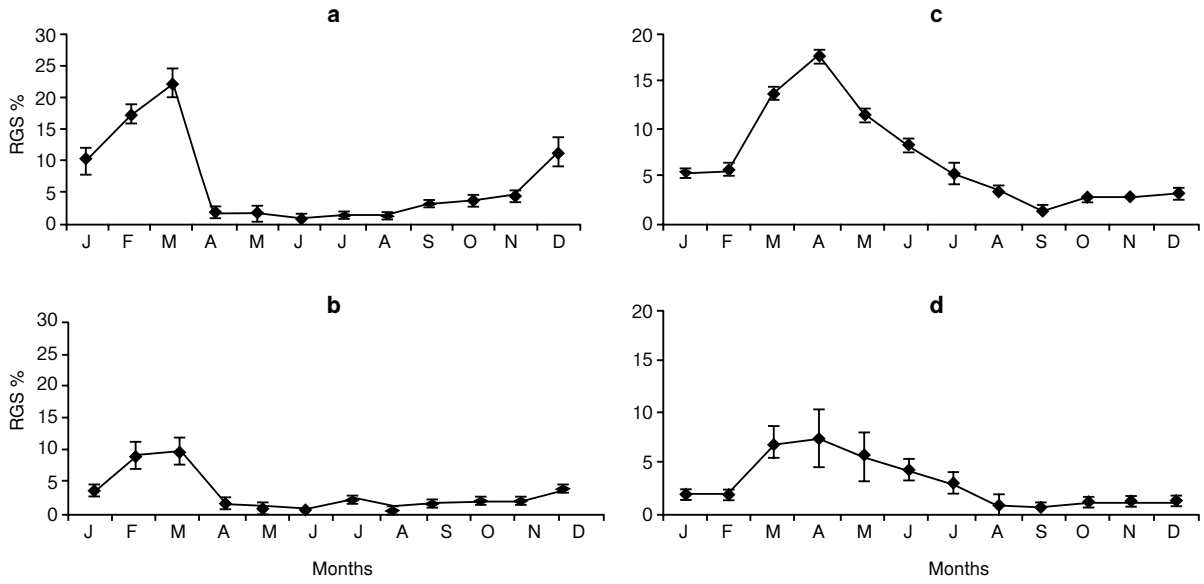

FIG. 2. Monthly variation of gonadosomatic index for *Rutilus rubilio* (a) female, (b) male and *Scardinius erythrophthalmus* (c) female and (d) male (bars show standard errors).

The period of spawning of the Sidi-Salem *R. rubilio* ranges from March to April and it seems to correspond to a weak gap, during the reproduction period of most *Rutilus* species (Table 1). Therefore, most species spawn near this period but because they are located at different latitudes, it is reasonable to assume that spawning is not induced by a certain temperature (Vollestad & L'Abée-Lund, 1987). Also, a progressive increase in temperature induces spawning of *R. rubilio* in Sidi-Salem more significantly than the photoperiod, as suggested by Vollestad & L'Abée-Lund (1987) on *R. arcasii*. On the other hand, under a certain temperature, spawning does not begin. This temperature-limit of spawning changes with the areas where the fish is found. In Norway, it is 6°C (Vollestad & L'Abée-Lund, 1987), but it can vary from 10 to 17°C (Peczalska, 1968; Goldspink, 1979; Easton & Dolben, 1980). *Rutilus rubilio* has therefore the tendency to adapt in the latitudes where it is found.

Rutilus rubilio in Sidi-Salem spawn earlier when compared with other species in Europe (Table 1). The main factors affecting spawning in freshwater ecosystems are temperature (Rincon & Lobon-Cervia, 1989) and photoperiod (Mann *et al*., 1984). Photoperiod and temperature are apparently higher in North Africa compared with higher latitudes. Chemical pollution may also affect the spawning period. In fact, a study by Wu *et al*. (2003) has shown that hormonal changes with retarded gonadal development and spawning in both males and females of *Cyprinus carpio* are caused by the increase of certain chemicals

TABLE 1. Spawning period of *Rutilus* species in different areas of the world

Author	Species	Country	Period of spawning (months)
			J F M A M J J A S O N D
Rincon & Lobon-Cervia, 1989	*Rutilus arcasii*	Spain (Moros Lake)	
Rincon & Lobon-Cervia, 1989	*Rutilus arcasii*	Spain (Uceros Lake)	
Crivelli, 1996	*Rutilus rubilio*	Italy	
Daoulas, 1981	*Rutilus rubilio*	Greece	
Spratte & Hartman, 1997	*Rutilus rutilus*	Germany	
Maitland & Campbell, 1992	*Rutilus rutilus*	England	
Billard, 1997	*Rutilus rutilus*	France	
Vostradovsky, 1973	*Rutilus rutilus*	Czechoslovakia	
This study	*Rutilus rubilio*	Tunisia	

TABLE 2. Spawning period of *Scardinius erythrophthalmus* in different areas of the world

Author	Country	Period of spawning (months)											
		J	F	M	A	M	J	J	A	S	O	N	D
Vostradovsky, 1973	Czechoslovakia												
Spratte & Hartman, 1997	Germany												
Billard, 1997	France												
Maitland & Campbell, 1992	England												
Koli, 1990	Finland												
This study	Tunisia												

in the aquatic environment. From Table 1 it becomes apparent that *R. rubilio* spawns from March to April in Tunisia and two months later, from May to June, in Greece and Italy.

In all European regions, spawning of *S. erythrophthalmus* lasts three months, except for England where it lasts two months, from May to June (Table 2). The spawning period of the Tunisian *S. erythrophthalmus* constitutes therefore a particularity because it lasts six months, from April to September. Bruslé & Quignard (2001) have asserted that spawning takes place in warm waters (18 to 27°C). In fact, *S. erythrophthalmus* begins to spawn from April when water temperature is 15°C (Mouelhi, 2000), slightly lower than the minimal temperature signalled. The previously quoted remarks concerning the other susceptible factors that influence the period of spawning for *R. rubilio*, are also valid for *S. erythrophthalmus*.

In the seventies, it was considered that the chart of the gonadosomatic index translated the various stages of the sexual cycle of fishes (Lahaye, 1979). Recent studies have shown that, this was valid only for fishes with single spawning, like *R. rubilio* (Djemali, 2005) or *R. rutilus* (Rinchard & Kestemont, 2003). On the other hand, and for the fishes with multiple spawning like *S. erythrophthalmus* (Gerdeaux & Billard, 1985), a maturation study on oocytes is necessary. In fact, the gonads can reach a certain maturity without any spawning. In this case, a histological study will make it possible to confirm or cancel this result in parallel with the following-up of the gonadosomatic index.

The reproduction of the fishes is a physiological phenomenon that necessitates the mobilization of large amounts of energy. This energy is, following the cases, drawn at the levels of the muscle or the liv-

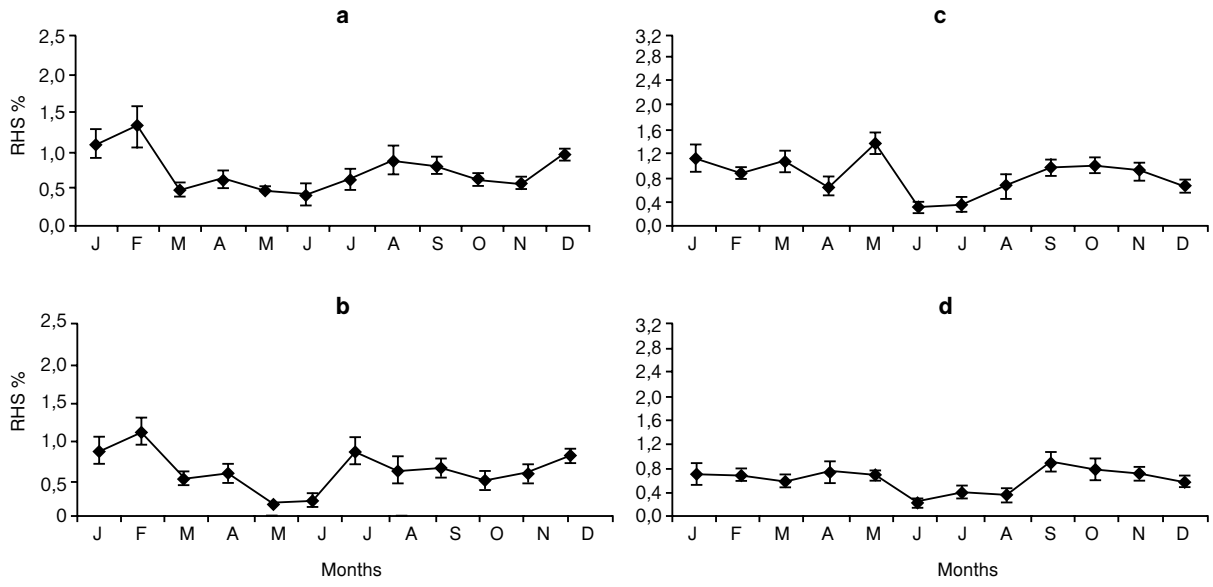

FIG. 3. Monthly variation of hepatosomatic index of *Rutilus rubilio* (a) female, (b) male and *Scardinius erythrophthalmus* (c) female and (d) male (bars show standard errors).

er (Ekanem *et al.*, 2004). By calculating the RHS and the condition factor (K), we are able to know in which organs lipid reserves are stocked for reproduction (Chakroun-Marzouk & Ktari, 2003; Rinchard & Kestemont, 2003). In both studied species of the Sidi-Salem reservoir, we did not observe any significant variation of K during the period of spawning, while the hepatosomatic index fell during this period in *R. rubilio* as well as in *S. erythrophthalmus* (Figs 3 and 4) for both sexes. The two fishes take their energy from the liver.

These two indices are not correlated with each

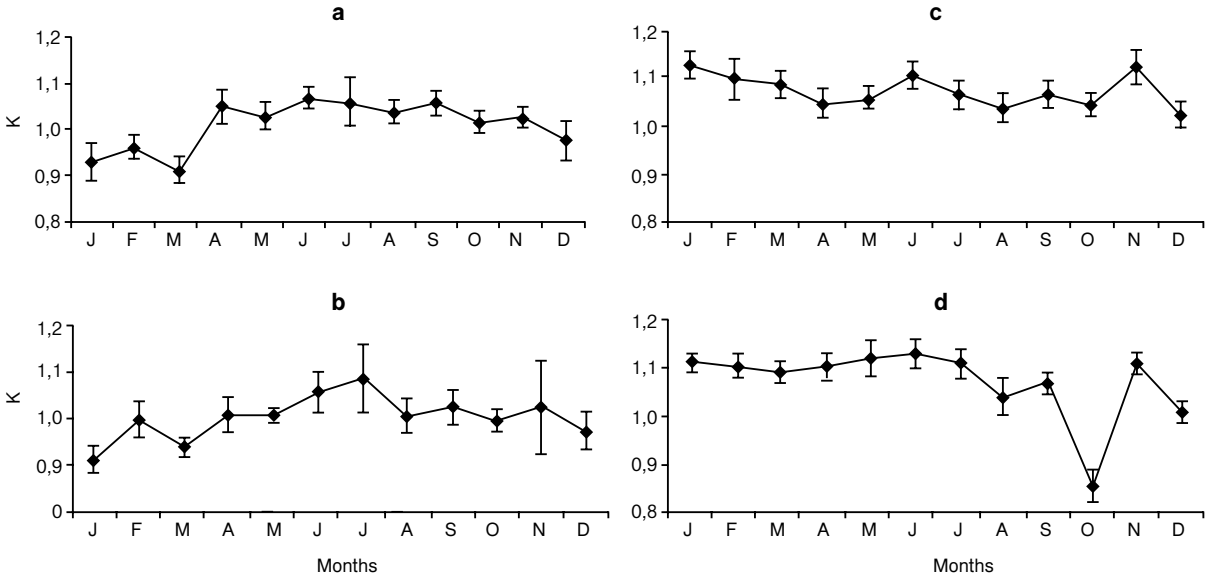

FIG. 4. Monthly variation of condition factor of *Rutilus rubilio* (a) female, (b) male and *Scardinius erythrophthalmus* (c) female and (d) male (bars show standard errors).

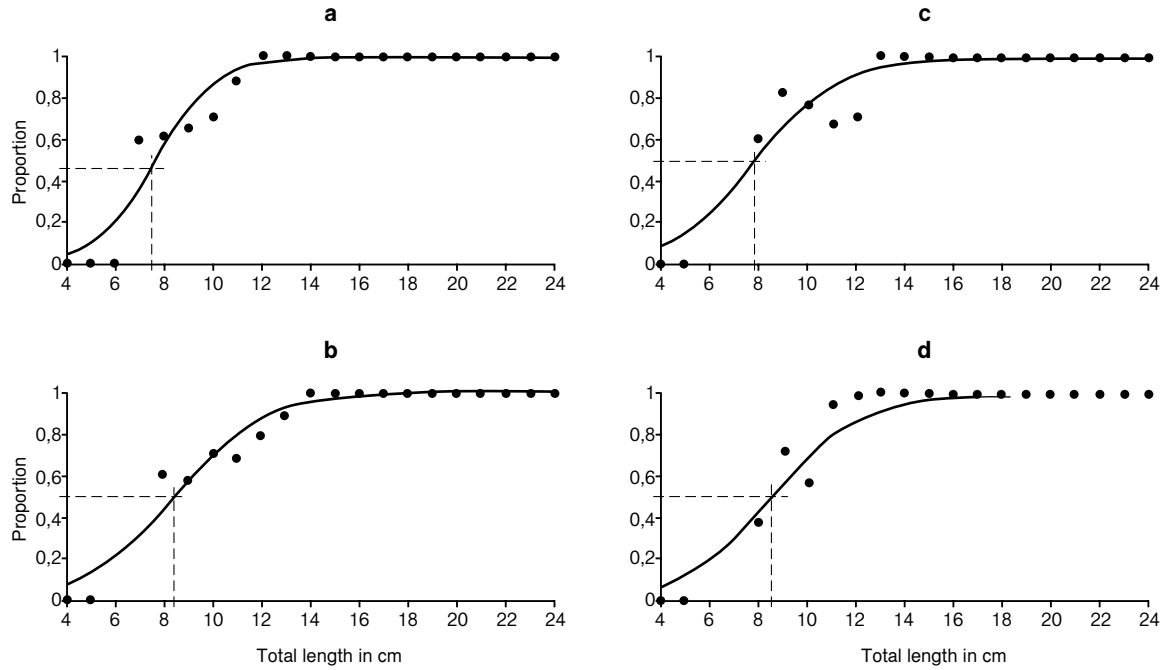

FIG. 5. Length at 50% maturity (L_{50}) based on the logistic function for *Rutilus rubilio* (a) female ($R^2 = 0.97$), (b) male ($R^2 = 0.98$) and *Scardinius erythrophthalmus* (c) female ($R^2 = 0.96$) and (d) male ($R^2 = 0.98$) in the reservoir of the Sidi-Salem dam.

other, while the gonadosomatic index is slightly correlated with the hepatosomatic index. Nevertheless, there is a delay of one month between these two indices.

Size at first sexual maturity

The size of *R. rubilio* at first sexual maturity for females and males (Fig. 5a, b) was 7.8 ± 0.23 cm and 8.5 ± 0.43 cm L_T ($\chi^2_{observed} < \chi^2_{theoretical}$), respectively. When we retrieved these sizes from the growth curves according to the model of Von Bertalanffy (Djemali, 2005), we noticed that these lengths corresponded to an age of one year for both sexes.

The size of *S. erythrophthalmus* at first sexual maturity for females and males (Fig. 5c, d) was 7.89 ± 0.49 cm and 8.53 ± 0.19 cm L_T ($\chi^2_{observed} < \chi^2_{theoretical}$) respectively, which corresponded to an age of one year. In fact, according to the study by Djemali (2005), the model of Von Bertalanffy for *S. erythrophthalmus* and *R. rubilio* in the reservoir of Sidi-Salem was, for both sexes, L_t (mm) = 315.1 ± 13.3(1-e$^{(-0.379\ (t-0.377))}$) and L_t (mm) = 322.4 ± 13.0(1-e$^{(-0.383\ (t-0.088))}$), respectively.

The size of *R. rutilus* at first sexual maturity in southern England was 9.2 and 13.0 cm for males and females, respectively (Mann, 1973; He & Stewart, 2001). The size at sexual maturity for the Tunisian *R. rubilio* was lower than that of the English species.

According to our results, it could be assumed that most species of the European genus *Rutilus* spawn one or two months earlier than the Tunisian species *R. rubilio*. *Scardinius erythrophthalmus* begins to spawn in April with a spread period of six months. A histological study on oocytes would confirm these results concerning *S. erythrophthalmus*. The total sizes at first sexual maturity (TL_{50}) of *S. erythrophthalmus* and *R. rubilio* in the Tunisian reservoir of Sidi-Salem, are attained in one year.

REFERENCES

Billard R, 1997. *Les poissons d'eau douce des rivières de France. Identification, inventaire et répartition des 83 espèces*. Delachaux & Niestlé, Lausanne.

Bruslé J, Quignard JP, 2001. *Biologie des poissons d'eau douce européens*. Tec & Doc, Lavoisier, Paris.

Chakroun-Marzouk N, Ktari MH, 2003. The Brown Meagre from Tunisian coasts, *Sciaena umbra* (Sciaenidae): sexual cycle, age and growth. *Cybium*, 27: 211-225.

Crivelli AJ, 1996. *The freshwater fish endemic to the Mediterranean region. An action plan for their conservation*. Station Biologique Tour du Valat Arles, France.

Daoulas C, 1981. Contribution to the biology of *Rutilus rubilio* (Bonaparte 1837) (Pisces, Cyprinidae) in Lake Trichonis (Greece). Doctorate Thesis, Aristotle University of Thessaloniki, Thessaloniki, Greece.

Degiorgi F, 1994. Etude de l'organisation spatiale de l'ichtyofaune lacustre. Prospection multisaisonière de 6 plans d'eau de l'est de la France à l'aide de filets verticaux. Ph. D. Thesis, Université de Franche-Comté, Besançon, France.

Dia M, Jarboui O, Kone Y, Bouain A, 2000. Note préliminaire sur la période de ponte et la maturité sexuelle du pagre à points bleus *Pagrus caeruleostictus* capturé au large de Nouakchott (Mauritanie). *Oebalia*, 26: 3-14.

Djemali I, 2005. Evaluation de la biomasse piscicole dans les plans d'eau douce tunisiens: Approches analytique et acoustique. Thèse de doctorat en sciences agronomiques, Institut National Agronomique de Tunisie.

Easton KW, Dolben IP, 1980. The induced spawning and subsequent survival and growth of roach (*Rutilus rutilus*). *Fisheries management*, 11: 59-66.

Ekanem SB, Achima MJ, Ekere MM, 2004. Studies on some reproductive aspects of *Pseudotolithus elongatus* in the Cross River estuary, Nigeria. *Scientia marina*, 68: 265-271.

Garcia-Berthou E, 1999. Spatial heterogeneity in roach (*Rutilus rutilus*) diet among contrasting basins within a lake. *Archives of hydrobiology*, 146: 239-256.

Gerdeaux D, Billard R, 1985. *Gestion piscicole des lacs et des retenues artificielles*. INRA, Paris.

Goldspink CR, 1979. The population density, growth rate and production of roach *Rutilus rutilus* in Tjeukemeer, the Netherlands. *Journal of fish biology*, 15: 473-498.

He JX, Stewart DJ, 2001. Age and size at first reproduction of fishes: predictive models based on growth trajectories. *Ecology*, 82:784-792.

King M, 1995. *Fisheries biology: Assessment and management*. Fishing New Books, Osney Mead Oxford, UK.

Koli L, 1990. *Fishes of Finland*. Werner Söderström Osakeyhtiö, Helsinki.

Lahaye J, 1979. Les cycles sexuels chez les poisons marins. *Océanis*, 6: 637-654.

Maitland PS, Campbell RN, 1992. *Freshwater fishes of the British Isles*. Harper Collins Publishers, London.

Mann RH, 1973. Observation on the age, growth, reproduction and food of the roach *Rutilus rutilus* (L.) in two rivers in southern England. *Journal of fish biology*, 5: 707-736.

Mann RH, Mills CA, Crisp DT, 1984. Geographical variation in the life-history tactics of some species of freshwater fish. In: Potts GW, Wootton RJ, eds. *Fish*

reproduction: Strategies and Tactics. Academic Press, London: 171-186.

M'hetli M, 2001. Le sandre *Stizostedion lucioperca* (Linnaeus, 1758) téléostéen. Percidae. Allochtone: étude biologique et essai d'optimisation des critères d'élevage. Thèse de doctorat en sciences biologiques, Université de Tunis.

Mouelhi S, 2000. Etude écologique de la retenue de Sidi-Salem: Aspect physico-chimiques des eaux et dynamique des peuplements zooplanctoniques. Thèse de doctorat en sciences biologiques, Université de Tunis II.

Ouannes-Ghorbel A, Bradai MN, Bouain A, 2002. Spawning period and sexual maturity of *Symphodus (Crenilabrus) tinca* (Labridae) in Sfax coasts (Tunisia). *Cybium*, 26: 89-92.

Peczalska A, 1968. Development and reproduction of roach *Rutilus rutilus* in the *Szczecin Firth. Polish archives of hydrobiology*, 15: 103-120.

Rinchard J, Kestemont P, 2003. Liver changes related to oocytes growth in roach, a single spawner fish, and in bleak and white bream, two multiple spawner fish. *International review of hydrobiology*, 88: 68-76.

Rincon PA, Lobon-Cervia J, 1989. Reproductive and growth strategies of the red roach, *Rutilus arcasii* (Steindachner, 1866), in two contrasting tributaries of the River Duero, Spain. *Journal of fish biology*, 34: 687-705.

Saila SB, Recksiek CW, Prager MH, Chen X, 1988. Basic fishery science programs. A compendium of microcomputer programs and manual of operation. *Development of aquacuture and fisheries sciences*, 18: 231.

Spratte S, Hartmann U, 1997. *Fischartenkataster: Süßwasserfische und Neunaugen in Schleswig-Holstein*. Ministerium für ländliche Räume, Landwirtschaft, Ernährung und Tourismus, Kiel, Germany.

Vollestad LA, L'Abée-Lund JH, 1987. Reproductive biology of stream-spawning roach, *Rutilus rutilus*. *Environmental biology of fishes*, 18: 219-227.

Vostradovsky J, 1973. *Freshwater fishes*. The Hamlyn Publishing Group Limited, London.

Worthington AD, Macfarlane NAA, Easton KW, 1982. Controlled reproduction in the roach (*Rutilus rutilus*). In: Richter CJJ, Goos HJH, eds. *Reproductive physiology of fish*. Proceedings of an international workshop: 220-223.

Wu RSS, Zhou BS, Randall DJ, Woo NYS, Lam PKS, 2003. Aquatic hypoxia is an endocrine disruptor and impairs fish reproduction. *Environmental science and technology*, 37: 1137-1141.