*J. Appl. Environ. Biol. Sci.*, 7(1)1-10, 2017
© 2017, TextRoad Publication
ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

# First Experimental Induced Breeding of the Largemouth Bass *Micropterus salmoides* Lacépède, 1802 (Centrarchidae) in Algeria

**Djamel Eddine ZOUAKH & Abderrafik MEDDOUR**

Aquaculture & Pathology Research laboratory, *AQUAPATH*, Annaba University, Algeria

*Received: September 1, 2016*
*Accepted: November 20, 2016*

## ABSTRACT

In North Africa, this experimental work represents the first artificial induced spawning of *Micropterus salmoides* on artificial gravel nests. During February 2012, gillnet fishes were collected from 3 dams located in the west of Algeria. 24 adults including 10 males and 14 females were selected, and transferred into two under cover concrete rectangular raceways (R1 and R2) supplied with suitable water quality. Males and females were kept separated, and supplied with *ad libitum* natural food. The experiments started at 14°C water temperature, and were carried out on 3 batches of fishes. In R1, the batch B1 consisted of 3 males and 5 females. In R2, the batch B2 included 6 males and 8 females, and B3 of a couple of fishes. 52 days later, when the water temperature reached 23°C, the fishes began to exhibit courtship behaviours. As a control group, fishes of B1 were not given any hormonal treatment. Fishes of B2 were given a single injection of 4500 IU of HCG/Kg of body weight. The couple of fishes in B3 were given a single injection of a solution of 4500 IU of HCG/Kg of body weight mixed with the extract of 1g of pituitary gland of *Cyprinus carpio*. A $1m^2$ artificial spawning gravel nest was immersed at each corner of the raceways. No spawning occurred in B1 despite courtship behaviour. For B2, spawning occurred on the bottom of R2 and on one artificial nest (average 2000 eggs/$m^2$). B3 showed better spawning (average 3500 eggs/$m^2$). The artificial nests were transferred into nursery raceways under laboratory conditions. The global rate of hatching was 80%. Monitoring of the fry growth was carried out until the 24$^{th}$ day post-hatching.

**KEYWORDS:** *Micropterus salmoides*; Human Chorionic Gonadotrophin; Pituitary gland extract; Artificial spawning; Artificial nest; Algeria.

## 1. INTRODUCTION

*Micropterus salmoides* is an indigenous species to the United States [1,2]. In fact, there are two recognized subspecies of largemouth bass, the northern largemouth bass *Micropterus salmoides salmoides* native to the Midwestern United State, and the Florida largemouth bass *M. salmoides floridanus* LeSueur [3,4]. Several worldwide introductions have expanded the distribution of *M.salmoides* to freshwater bodies in Africa, Europe, South America and Asia [4,5,6]. It is considered as an alien invasive predator [7] and has a large food spectrum including invertebrates, amphibians and mainly fish.

During 1985, started in Algeria a national program of aquaculture with the introduction, in the northern freshwater ecosystems, of fingerlings of *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Sander lucioperca* and the largemouth bass *Micropterus salmoides* imported from Hungary [8,9]. Since that period of restocking, the unique records of successful attempts of artificial controlled spawning were made on *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis* and *S. lucioperca* [10,11,12,13]. In the north-west of Africa, no work has been done on *M.salmoides* ([13,14], that reproduces naturally in the local freshwater ecosystems. The target of this experimental work was to master the technical aspects of an artificial spawning induction by an intramuscular injection of Hormones and to follow up the growth of the larval and fingerling stages.

## 2. MATERIAL AND METHODS

### *Samplings*

During February 2012, 24 wild adults *Micropterus salmoides*, including 10 males (Average weight 1,200 kg ; Mean Total Length (TL) = 34,1cm) and 14 females (Average weight 1,500 kg ; Mean TL = 42,5 cm), were selected from various gillnet captures in 3 dams in the western Algerian area (**Fig.1**), with 4 specimens from Beni-Bahdel Dam (Tlemcen district), 16 specimens from Bou-Hanifia Dam (Mascara district), and 4 specimens from Sidi-M'hamed-Ben-Ali Dam (Sidi-Belabbes district).

***Corresponding Authors:** Djamel Eddine ZOUAKH, Abderrafik MEDDOUR, Aquaculture & Pathology Research laboratory, *AQUAPATH*, Annaba University, Algeria. Email:dzouakh@gmail.com & rafikmeddour@yahoo.ca

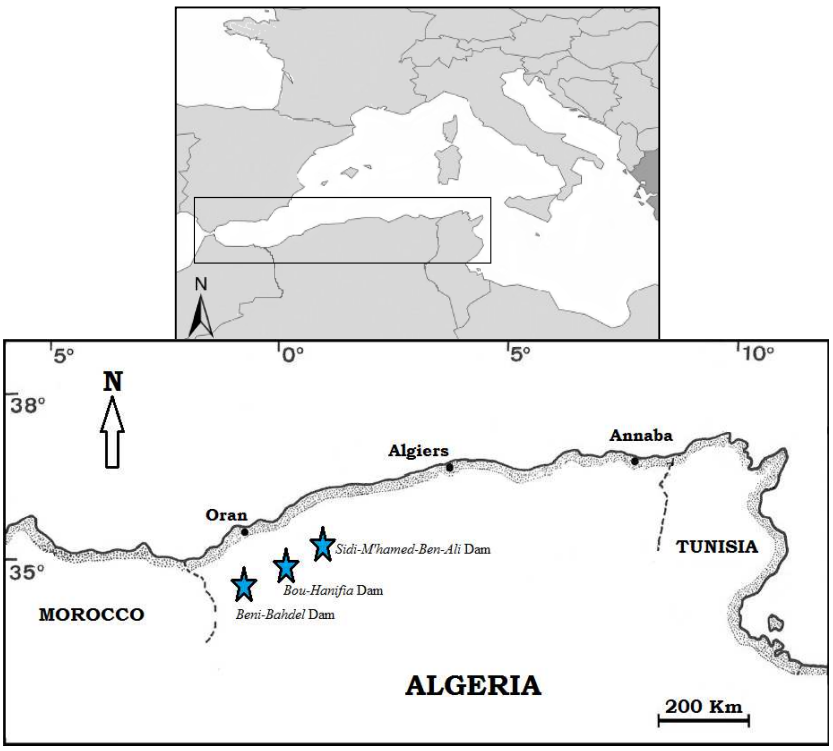


**Figure 1**: Sampling sites of *Micropterus salmoides*.

Immediately after capture, fishes were submitted to a prophylactic bath in a solution of 1ppm Methylene blue during 5 minutes. In order to avoid acute toxicity, the fishes were anesthetized in a induction bath of Phenoxyethanol (1ml/10L) during 5 to 10 minutes or in a 80 ppm bath of clove oil and ethanol [15,16,17,18]. The individuals were measured, weighted, and tagged on the dorsal fin in order to recognize and control each individual during the experimental protocols. Fishes were then transferred to an experimental aquaculture station in fresh oxygenated water (Mean Temperature 12°C) within appropriate tanks for fish transportation.

***Acclimation***

During 52 days (08$^{th}$ February to 30$^{th}$ March 2012), males and females were held in two separate under cover concrete raceways R1 and R2 (7.20 x 3.80 x 1.30 m) supplied with optimal water quality. The water supply was sufficient to insure a daily renewal of the entire volume of the raceways. The water temperature and dissolved oxygen were daily controlled. Initially, the experiment started with a mean water temperature of 14°C.

Although that the recommended stocking ratio is of 3 males to 2 females [4], and regarding to the limited number of the captures, 3 batches were randomly separated. In R1, the first batch B1, as a control group, included 3 males and 5 females. In R2, the batch B2 consisted of 6 males and 8 females, and the batch B3 consisted of a couple. In both raceways, males and females were kept separated by a wire mesh device. During the entire experiments, feeding was *ad libutm* and the fishes were supplied with fingerlings of *Luciobarbus setivimensis*, *Liza ramada*, *Alburnus alburnus*, *Cyprinus carpio*, *Gambusia affinis affinis* and *Oreochromis niloticus* collected from the local natural reservoirs.

***Protocols for inducing the artificial spawning***

In R1, as a control group B1, the fishes were not given any hormonal treatment but were kept in similar conditions for water quality and food supply as in R2. Fishes in R2 were carefully recovered one by one from the raceway, and anesthetized as described before. According to their weight [19], the fishes of B2 were given a single hormonal injection of 4500 IU of HCG/Kg of body weight. The fishes of B3 were given a single injection of a solution of 4500 IU of HCG/Kg of body weight mixed with the extract

of 1g of pituitary gland of *C.carpio*. Immediately after full recovery of the fishes from the anaesthesia, the separating devices were removed from R1 and R2 in order to enable direct contact between the fishes. However in R2, the batches B2 and B3 remained separated by the wire device.

*M.salmoides* is known to spawn in areas of shallow water [20]. With a surface area of 1m², an artificial nest was immersed at the each corner of the raceways at a depth of 35 to 45 cm. The nests were made with rectangular plastic crates and filled with small gravel. Previously to immersion, the crates and the gravel were disinfected in a solution of 1% Methylene blue, and then rinsed thoroughly with water.

## 3. RESULTS

At the end of Match, when the water temperature reached 23°C, the fishes began to exhibit constant courtship behaviour (i.e. nipping, nudging, inverted swimming etc.) [3,20]. The males remained close to the nests. The sexual dimorphism in *M.salmoides* is still debatable. Regarding to the size of mature specimens, females are larger than males [1,20,21]. The sexual dimorphism can also be reflected by differences in color [3]. The males from B1, B2 and B3 submitted to smooth abdominal stripping released soft milt. The females showed a rounded abdomen (**Fig.2A**). Indeed, individuals greater than 35 cm in TL can be sexed by looking at the scaleless area surrounding and immediately adjacent to the urogenital opening. In the male, this area is nearly circular in shape while in the female it is elliptical or pear-shaped [4] with a reddish genital opening (**Fig.2B**).

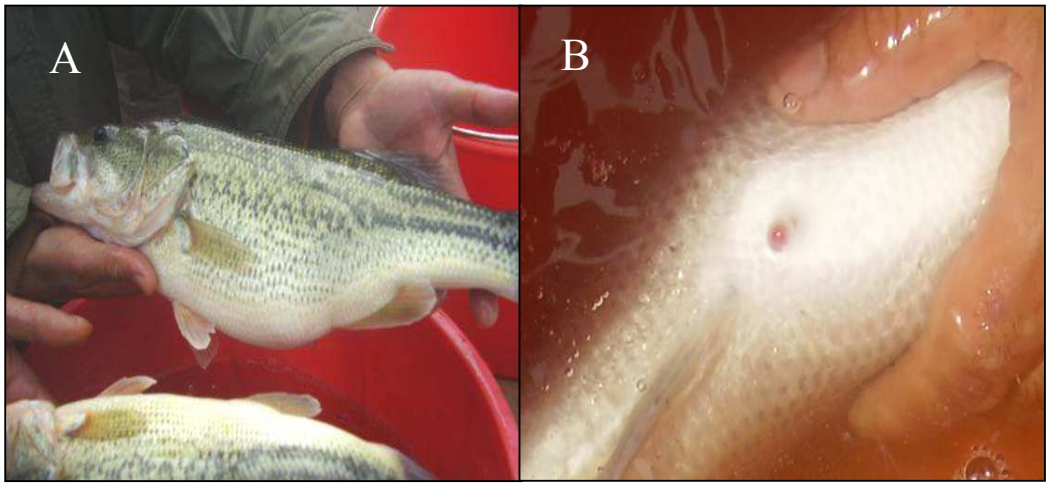


**Figure 2**: Mature female *M. salmoides* with round abdomen (**A**) and reddish genital opening (**B**).

***Spawning***

No spawning occurred in R1 despite the courtship behaviour of the males. In R2, 24 hours following the hormonal injection, amongst the 4 immersed artificial nests only 2 were covered with eggs. The first one was from B2 treated with HCG (average 2000 eggs/$m^2$), and the second one from B3 injected with HCG + Pituitary extract (average 3500 eggs/$m^2$). For a mean weight of 1.5 kg of a female *M.salmoides*, the mean spawning was 3700 eggs/kg of fish. The two empty nests from B2 were removed as the females spawned on the concrete bottom of R2.

***Hatching and larval care***

In R2, the eggs covering the concrete bottom were closely guarded by the males. The artificial nests covered with eggs were transferred into two nursery raceways for better monitoring of the subsequent developing stages under laboratory conditions. With 1 mm in diameter, the eggs were yellow to orange. The incubation period lasted 3 days at 22°C mean water temperature. The hatching from the artificial nests reached a global rate of 80%. Concerning the spawning on the concrete bottom in R2, the hatching rate was lower (17%) owing to the development of *Saprolegnia*. To monitor the fry growth, 92 individuals were transferred into 2 aquariums (75 x 45 x 40 cm). The remaining larvae were transferred into small stocking ponds.

The feeding of the larval stages was *ad libitum* and started from the 4th Day-Post-Hatching (DPH). The diet consisted of phytoplankton, egg yolk, then progressively with live *Artemia* and small larval aquatic insects. Starting from the 6th DPH, in order to insure a good growth with a suitable conversion rate [22], the larvae were reared at a low density (01 larva per Litre), optimal water conditions (24 °C Mean temperature; 12 mg/l dissolved oxygen), and were fed with abundant supply of *Daphnia sp*. Under laboratory conditions, the post-hatching results are as follows (**Tab.1**; **Fig.3**).

**Table 1**: Monitoring of the larval stages of *M. salmoides* reared under laboratory conditions.

| Day Post Hatching | Mean Total Length | Visible characteristics | Supplied Food |
|---|---|---|---|
| 1st | 5 mm | Hatching of transparent larva; Mouth not opened; Swim bladder not visible; Abdominal cavity filled with yolk sac that gradually decreases in volume until the 3rd DPH. | ----- |
| 3rd | 6 mm | Well developed eyes; Important decrease in volume of yolk sac; appearance of a primitive digestive tract. | ----- |
| 4th | 6 mm | Mouth opened; Disappearance of yolk sac; Primitive intestine present; Eyes very active; Hunting preys behaviour. | Phytoplankton + egg yolk |
| 7th | 7 mm | Mouth visible; Digestive tract very apparent; Pigmented eyes. | |
| 11th | 9 mm | Black spots at the head and the dorsal area; Dorsal and caudal fins present; Food visible at the level of the digestive tract. | Cladocera + *Artemia sp.* + larvae of aquatic insects + artificial food |
| 17th | 12 mm | Mouth well developed with prominent lower jaw; Lateral line visible; Pectoral fins visible. | |
| 21st | 19 mm | All fins well formed; accentuated pigmentation at the back and lateral sides. | |
| 24th | 45 mm | Fishes bearing intersected caudal fin; anal fin and dorsal fin with a well developed flexible part and spiny part less developed; Ventral fin hardly distinguished; pectoral fins; Lateral line marked with black spots from the caudal fin to the posterior area of the eye; dorsal side of the fish with less accentuated pigmentation; Lower jaw quite visible; Genital areas not visible. | Small shellfish + fingerlings |

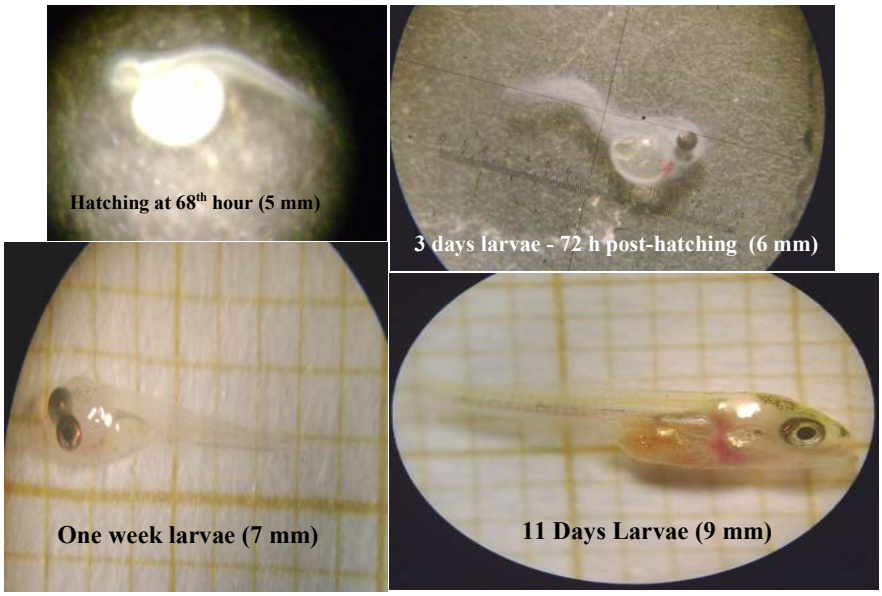


**Figure 3**: Length growth of fry *Micropterus salmoides*.

During the fry rearing, cases of mortality were observed owing to growing cannibalism (**Fig.4**). As a preventive measure, artificial fish food, with high level of proteins (45%), was supplied until the fishes refused it. Small fingerlings of wild fishes were then supplied from the 24th to the 45th day.

**Figure 4**: *Micropterus salmoides* larval cannibalism.

During the larval stage, the TL growth displayed a gradual increase until the 17th day, and then remarkably rose up from the 21st day till the 45th day (**Fig.5**) where fingerlings reached 45 mm (**Fig.6**).

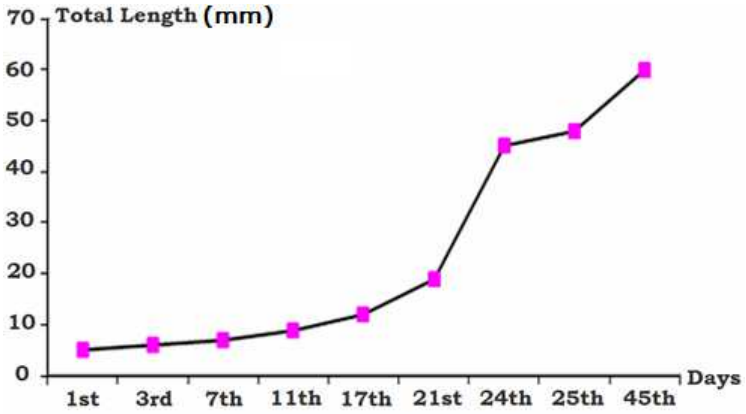


**Figure 5**: Total length growth of *M.salmoides* under laboratory conditions (N = 30; Mean Temp. 24 °C; 12 mg/l dissolved oxygen).

**Figure 6**: *Micropterus salmoides* 24th DPH (45 mm).

## 4. DISCUSSION

***Artificial spawning***

Hypophysation is the way that gives the most positive results for inducing artificial spawning. The injection of hormones, or extracts of pituitary gland, stimulates the process of final oocytes maturation and provokes the ovulation. Artificial spawning of marine and freshwater fishes, through intramuscular injections of gonadotropin and/or hypophyseal extracts, is well documented [10,11,12,13,19,23, 24,25,26,27,28,29,30,31,32,33,34].

Hypophysation by the intra-peritoneal way can also be practised by injecting, through the abdominal wall, an appropriate volume of hormones in order to induce the maturation of oocytes and artificial spawning. Regarding previous intra-peritoneal experiments [11,12], if the injection is not made extremely carefully, the needle can provoke the perforation of the intestinal tube enabling the diffusion of the intestinal content into the abdominal cavity, and the mixing of the intestinal content with the injected volume of hormones. The intra-peritoneal injection can also induce the loss of the injected hormone into the intestinal tube. Such events had compromised the success of artificial spawning and even the death of fishes as it was observed with the silver carp *Hypophthalmychthis molitrix* and *Sander lucioperca* [10,11]. On *Sander lucioperca* and *Clarias gariepinus,* the use of pituitary extracts associated with mammal Gonado Stimulating Hormones (GSH), HCG, and LH-RH are practical to induce artificial spawning, and to provide eggs of good quality [29,35,36]. Fresh or preserved pituitary glands from mature fish of the same species (homoplastic) or from other related species (heteroplastic), and the HCG have been successfully used in most species [24,29]. The HCG stimulates directly the gamete maturation in the gonads [26,37]. It has been used to induce artificial spawning of *M.salmoides* [3,4,37,38,39].

Rottmann et al.[40] indicate that the external environmental factors (photoperiod, water temperature, nutrition, and spawning grounds) may vary considerably among species. This fact is related to the endocrine affinity defining fishes, depending on their original climatic and geographical distribution, as being warm or clod species according respectively to their physiological demand for living and reproducing in warm or cold water temperature. According to Spengler [3] and Lam [41], these external factors have a major impact on the process of maturation of oocytes (to stage 4), ovulation, and spawning. Indeed, Spengler [3] indicated that the water temperature is one of the main external factors in the reproduction of *M.salmoides*, and that in females, the maturation of oocytes is mostly induced by the increase of temperature but not photoperiod. Stuber et al. [42] reported that the natural reproduction of *M.salmoides* occurs with the rapid rise of water temperature above 15.5°C whereas Lorenzoni et al.[1] indicated that the reproduction of this fish occurs when the water temperature is close to 20°C or above. In captivity conditions, manipulation of the environmental factors such as water temperature, photoperiod and spawning substrate is crucial during the steps of artificial reproduction of fishes. According to Harvey and Hoar [24], in the warm climates, once can consider that a high water temperature and a long photoperiod are the primary factors of an accelerated gonadal maturation.

In cold countries such as Canada, *M.salmoides* males can reach sexual maturity by ages three to four, and females at four to five [43]. In Italy, *M.salmoides* mature individuals are able to initiate their reproductive period in late winter and early spring, and the sexual maturity is reached at age 2 years (22cm) for males, and 3 years (30 cm) for females [1]. In warmer temperate climate such as in Algeria, females *M. salmoides* can possibly mature much faster but this has to be confirmed by relevant investigation on the seasonal gonad development. Because of the climatic conditions, the spawning season of *M.salmoides* occurs during April and May in the USA [37] and in Italy [1]. In Algeria, the warm temperate climate conditions are favourable for an earlier artificial spawning of *M.salmoides* as the water temperature in ponds usually reaches 20°C to 25°C during the day starting from the beginning of March. However, during the night the air temperature can drop to 15°C or less, and would compromise any expectations of artificial spawning in open air with no cover conditions [10,11,12,13].

The fish behaviour can also boost the spawning steps [20,40]. It is possible to observe the fishes spawning when mature females are in the presence of other active females in spawning grounds, or when females are in presence of active females who already had received a hormonal treatment [12,13,36]. This previous element has not been considered in this work in order to fulfil the control group concept with B1. Despite the courtship display of the males, females of B1 did not spawn, probably because they did not reach the final steps of the maturation of the oocytes (stage 4), prior to the ovulation stage (i.e. spawning). In R2, for a mean weight of 1.5 kg of a female *M.salmoides*, the estimated mean spawning (3700 eggs/kg of fish) is within the range of the natural spawning (5000 to 15000 eggs) reported in the literature [44].

***Hatching, larval care and development***

Hatching occurred 70 hours at 22°C whereas Hill and Cichar [45] indicated it at about 45.5 hr post-fertilization at 22.2°C. With the increase in age and body size, the voracious young *M. salmoides* changes its diet, with juveniles normally feeding on small crustaceans, before switching to insects and then finally to fish prey as adults [2]. If *M.salmoides* is reported to begin piscivorous feeding at approximately 100 mm TL [46], it is a fish-eater when reaching 5 cm in total length (present study). According to Brown et al. [43], in Lake Washington (USA), the feeding and diet of young *M. salmoides* included fishes when fry reached 61-80 mm. Other authors [45,43] indicated that if *M.salmoides* swallow prey whole, the ratio between gape and prey size is critical in determining when the fish become piscivorous. In the consulted literature, the growth of fry is not available and the available data concerned individuals > 40 mm or over [21,45,46,47, 48,49]. During the larval breeding of the present study, the recorded mortalities were mainly due to predation. The cannibalistic feeding is a predominant feature in *M.salmoides* [6].

## 4. Conclusion

Despite the fact that this investigation was carried out on a limited number of individuals, this first experimental controlled reproduction of *M.salmoides* in Algeria was successfully carried out through the use of hormonal induction with HCG, and HCG mixed with pituitary extract. It is evident that the use of HCG alone to induce an artificial spawning of *M.salmoides* does not remain reliable whereas successful results are reported in the literature for Cyprinids, *Sander lucioperca* and *Clarias gariepinus*. This work confirms the successful use of artificial gravel nests that led to a high rate of hatching. The low density rearing of the larvae and the fingerlings, under a high level of dissolved oxygen and a sufficient natural food supply, led to satisfactory growth performances of the fry. Further experiments of induced reproduction on a larger number of *M.salmoides* would enable to refine the protocols of artificial spawning of *M.samoides* in order to insure valuable restocking of the various dams, lakes and water reservoirs of the country.

***Acknowledgments***: The authors would like to thank the anonymous referees for helpful suggestions and comments. The work was supported by the Algerian Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (MESRS). Projet CNEPRU Pisciculture continentale d'eau douce et d'eau saumâtre *PISCES,* Code: D00L03EP160320150001. The authors declare that they have no conflicts of interest.

## REFERENCES

1. Lorenzoni, M., A.J.M. Dör, R. Erra, G. Giovinazzo, M. Mearelli and S. Selvi, 2002. Growth and reproduction of largemouth bass (*Micropterus salmoides* Lacépède,1802) in lake Trasimeno (Umbria, Italy). Fisheries research, 56: 89-95.
2. Magoro, M.L., 2014. Predation by alien largemouth bass, *Micropterus salmoides* lacepéde, 1802 (Centrarchidae: Perciformes), on indigenous marine fish species in the Kowie system, South Africa. Msc Thesis, South African Institute for Aquatic Biodiversity, Grahamstown.
3. Spengler, D.E., 2010. Natural Reproductive Cycle of Northern Largemouth Bass in the Upper Midwest, with applications to off-season spawning. Thesis of Master of Science, South Dakota State University, USA, 77p.
4. Heidinger, R.C. 1976. Synopsis of biological data on the largemouth bass *Micropterus salmoides* (Lacepede, 1802). FAO, Fish.Synop., 115: 85p.
5. Jackson, D.A. 2002. Ecological effects of *Micropterus* introductions: the dark side of black bass. American Fisheries Society Symposium, 31: 221-232.
6. Magoro, M.L., A.K. Whitfield and L. Carassou, 2015. Predation by introduced largemouth bass *Micropterus salmoides* on indigenous marine fish species in the lower Kowie River, South Africa. African Journal of Aquatic Science, 40: 81-88.

7. Murray, T.S., L. Mandla, M.L. Magoro, A.K. Whitfield and P.D. Cowley, 2015. Movement behaviour of alien largemouth bass *Micropterus salmoides* in the estuarine headwater region of the Kowie River, South Africa. African Zoology: 1-9.

8. Meddour, A. and K. Meddour-Bouderda, 1999. Bilan d'une pisciculture extensive et parasites des poissons de la lagune Mellah et du lac Oubeira (Parc National El Kala). In the Proceedings of J'NESMA-99, Journées Internationales d'études sur les Sciences Marines, Commandement des Forces Navales, Tamentsfouste-GET, 29-31 Mai 99, Alger, Atelier B, pp: 657-670.

9. Meddour, A. and K. Meddour-Bouderda, 2001. Biodiversity and fish culture development within the National Park of El Kala, Algeria. In the proceedings of the International Workshop on Marine Biodiversity in Muslim Countries, Algiers, 22-24 October 2001, INOC-MPRH-IDB, INOC, Turkey, Workshop Report N° 07, pp: 42-51.

10. Meddour, A., A. Rouabah, K. Meddour-Bouderda, N. Loucif, A. Remili et Y. Khatal, 2005. Expérimentations sur la reproduction artificielle de *Sander lucioperca* et *Hypophthalmichthys molitrix*. Sciences & Technologie C, 23: 63-71.

11. Meddour, A. et A. Rouabah, 2005. Expérimentations sur la reproduction artificielle d'espèces d'intérêt piscicole. In the Proseedings of the 1er Séminaire International de Biologie et Physiopathologie de la Reproduction. Université El Hadj Lakhdar Batna, pp:1-35.

12. Rouabah, A. et A. Meddour, 2006. Perspectives de développement de la pisciculture en Algérie par induction hormonale. In the Proceedings of the Congrès Vétérinaire Maghrébin, Société Algérienne de Médecine Vétérinaire, 14-15 Avril, Hammamet, Tunisia, pp: 21-35.

13. Meddour, A., 2009. Pisciculture et Biodiversité de la Parasitofaune des Poissons dans le Nord-Est de l'Algérie. Thèse de Doctorat ès Sciences, Option Sciences Vétérinaires, Institut des Sciences Vétérinaires, Centre Universitaire de Tarf, Algérie.

14. FAO, 1991. Workshop on deversification of aquaculture production. MEDRAP II, RAB/89/005-RER/87/009, Field document 91/4, Edited by MEDRAP II Regional Center Tunis, Tunisia, 142p.

15. Anderson, W.G., McKinley, R.S. and Colavecchia, M. 1997. The use of clove oil as an anesthetic for rainbow trout and its effects on swimming performance. North American Journal of Fisheries Management 17: 301-307.

16. Peake, S., 1998. Sodium Bicarbonate and Clove Oil as Potential Anesthetics for Nonsalmonid Fishes. North American Journal of Fisheries Management, 18(4):919-924.

17. Velišek, J., Z. Svobodova and V. Piaačkova, 2005. Effects of Clove Oil Anaesthesia on Rainbow Trout (Oncorhynchus mykiss). ACTA VET. BRNO, 74: 139-146.

18. Felix, N., U. Bala-Murugan and K. Rajaram, 2013. Efficacy of phenoxyethanol and clove oil as anaesthetics in marine finfish cobia, *Rachycentron canadum*. International Journal of Fisheries and Aquatic Studies 2013, 1 (1): 46-49.

19. Tamas, H.G, L. Horváth and T. Istvan, 1982. Reproduction and production of larvae. Szarvas Institute internal report, Hungary, 18p [Translated from Hungarian].

20. Cooke, S.J., R.S. McKinley and D.P. Philipp 2001. Physical activity and behavior of a centrarchid fish, *Micropterus salmoides* (Lacépède), during spawning. Ecology of Freshwater Fish, 10: 227-237.

21. Alesio, G. 1984. Le black-bass, *Micropterus salmoides* (Lacep.), dans les eaux italiennes. Un antagoniste du brochet ?. Bull. Fr. Piscic., 292: 1-17.

22. Melotti, P., A. Roncarati, A. Dees and R. Vicenzi, 2005. Largemouth bass (*Micropterus salmoides* Lacépède): Results of farming trials. Ital. J. Anim. Sci., 4(2): 589-590.

23. Billard, R. ; Breton, B. ; Postier, A. ; Jalabert, B. & Weil, C. (1978) - Endocrine control of the teleost reproductive cycle, its relation to external factors : Salmonids and Cyprinids model. In: Comparative endocrinology (eds P.J. Gaillard and R.H. Boer) pp 34-48, Elsevier, Holland Biomedical Press, Amsterdam.

24. Harvey, B.J. and W.S. Hoar, 1980. La reproduction provoquée chez les poissons: Théorie et pratiques. IDRC, TS-21, Ottawa, Ontario: 48p.

25. Marcel, J. et J. Lecomte, 1980. Les techniques de production de poissons phytophages en Chine. In : La pisciculture en étang, (ed R. Billard) pp : 287-302, INRA, Paris.

26. Lam, T. J. 1985. Induced spawning in fish. In: Reproduction and Culture of Milk fish. (eds C.S. Lee and I.C. Liao) pp 14-56, Oceanic Institute, Hawai and Tungkang Marine Laboratory, Taiwan.

27. Lin, H.R., G.V.D. Kaak, J.Y. Liang, G. Peng, G.Y. LI, L.Z. Lu, X.J. Zhou, M.L. Chang and R.E. Peter, 1986. The effects of LHRH-analogue and drugs which block the effects of dopamine on gonadotropin section and ovulation in fish cultured in China. In: Aquaculture of Cyprinids. (eds R. Billard et J. Marcel) pp 139-149, INRA, Paris.

28. Huet, M., 1986. Textbook of fish culture. Breeding and cultivation of fish. Second Edition, Fishing News Books Ltd, Farnham, Surrey, England: 439p.

29. Marte, C.L, 1989. Hormone-induced spawning of cultured tropical finfishes. In : The Actes de Colloque Advances in tropical aquaculture, Tahiti, AQUACOP, IFREMER, pp : 1-9.

30. FAO, 1990. Selected aspects of warm water fish culture. A compilation based on lectures presented at a series of FAO/AGFUND International Training Courses in Aquaculture hosted by Hungary in 1987 and 1988. Edited by Coche, A. and Edwards, D. Food and Agriculture Organisation of The United Nations, Rome, GCP/INT/435/AGF: 181p.

31. Loir, M., and R. Billard, 1990. Hormonal control of gamete production in male teleost fish. *International Symposium on Comparative Endocrinology*, Malaga, Spain, pp: 1-10.

32. De Graaf, G and H. Janssen, 1996. Artificial reproduction and pond rearing of the African catfish *Clarias gariepinus* in sub-Saharan Africa. A handbook. FAO Fisheries Technical Paper, N° 362, Rome, FAO: 73p.

33. Weil, C., Fostier, A. and R. Billard, 1986. Induced spawning (ovulation and spermation). In Carp and related species in aquaculture of Cyprinids. (eds R. Billard, et J. Marcel), INRA, Paris: 119-137.

34. Woynarovich, E. and L. Horváth 1981. La reproduction artificielle des poissons en eau chaude : Manuel de vulgarisation, FAO, *Doc. Tech. Pêche*, 201: 191p.

35. Zakes, Z. and K. Demska-Zakes, 2009. Controlled reproduction of pikeperch *Sander lucioperca* (L.): a review. Arch. Pol. Fish., 17: 153-170.

36. Rouabah, A., 2016. Reproduction du sandre *Sander lucioperca* (L.) et de *Clarias gariepinus*. Thèse de Doctorat es Sciences Vétérinaires, Département des Sciences Vétérinaires, Université Saad Dahleb Blida.

37. Porter, M.D., 1997. Oocyte Maturation During Hormone-Induced Spawning in Largemouth Bass, *Micropterus salmoides*. Journal of Applied Aquaculture, 7(1):19-27.

38. Wilbur, R.L., and F. Langford, 1975. Use of human chorionic gonadotropin (HCG) to promote gametic production in male and female largemouth bass. Southeastern Association of Game Fish Commissioners 28:242-250.

39. Grizzle, J.M., D. Xu and W.A. Rogers, 1995. Efficacy of Human Chorionic Gonadotropin for spawning striped bass and white bass. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies, 49: 88-96.

40. Rottmann, R.W., J.V. Shireman and F.A. Chapman, 1991. Hormonal Control of Reproduction in Fish for induced Spawning. Southern Regional Aquaculture Center, United States, Department of Agriculture. Publication No. 424, 4p.

41. Lam, T. J. 1983. Environmental influences on gonadal activity in fish. In: Fish physiology, volume 9B, (eds W.S. Hoar, D.J. Randall & E.M. Donaldson) pp 81-154, Academic Press, New York.

42. Stuber, R.J., G. Geghart and O.E. Maughan, 1982. Habitat suitability index models: Largemouth bass. U.S. Dept Int. Fish Wild. Serv. FWS/OBS-82/10.16. 32p.

43. Brown, T.G., Runciman, B., Pollard, S., and A.D.A. Grant, 2009. Biological synopsis of largemouth bass (*Micropterus salmoides*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2884: v + 27p.

44. Schlumberger, O., 2002. Mémento de pisciculture d'étang. 4eme Edition, Tech & Doc Edition, Paris, 238p.

45. Hill, J.E., and C.E. Cichra, 2005. Biological Synopsis of Five Selected Florida Centrarchid Fishes with an Emphasis on the Effects of Water Level Fluctuations. Special Publication SJ2005-SP3. Water Supply Management Division St. Johns River Water Management District, Palatka, Florida: 136p.

46. Modde, T. and C.C. Stone, 1980. Growth and biomass of largemouth bass (*Micropterus salmoides*) in a western South Dakota pond. PROC. S. O. ACAD. SCI., 59: 138-146.

47. Alessio, G. 1981. Ricerche sul persico truta *Micropterus salmoides* nel bacino medio-superiore del F.Po. Natura, 72: 197-220.

48. Rodriguez-Sánchez, V., L. Encina, A. Rodríguez-Ruiz and R. Sánchez-Carmona, 2009. Largemouth bass, *Micropterus salmoides*, growth and reproduction in Primera de Palos' lake (Huelva, Spain). Folia Zool., 58(4): 436-446.

49. Smith, M.A., M.A. Pegg and K.S. Irons, 2007. Analysis of Fish Age Structure and Growth in the Illinois River. U.S. Geological Survey, Upper Midwest Environment Science Center, La Crosse, Wisconsin, June 2007. LTRMP Technical Report 2007-T002: 55p.