Induced Spawning and Larval Rearing of Climbing Perch, *Anabas testudineus* under Controlled Conditions of Raipur (Chhattisgarh)

C. S. Chaturvedi[*1], Rashmi Ambulkar[2], R. K. Singh[3], Rehana Abidi[4] and A. K. Pandey[5]

[1&2]ICAR - Central Institute of Fisheries Education, Versova, Mumbai - 400 061

[3]Research Wing, State Fisheries Department, Raipur - 492 001

[4]&[5]ICAR - National Bureau of Fish Genetic Resources, Canal Ring Road, Lucknow - 226 002

***Email:** chaturvedi@cife.edu.in

Introduction

Anabas testudineus, commonly known as "Koi/Kawai" or "climbing perch" is found in both fresh- and brackish water as well as estuaries of Pakistan, India, Nepal, Bangladesh, Sri Lanka, southern China, Myanmar, Thailand, Singapore, Indonesia, Malaysia, Laos, Vietnam, Brunei and the Philippines (Talwar and Jhingran, 1991; Chonder, 1999; Jayaram, 2010; Pal and Chaudhry, 2010). It fetches high price in the markets of India and south-east Asian countries. This species possesses accessory respiratory organs (Olson *et al.*, 1986; Munshi *et al.*, 1986) and cultured with Clarias batrachus (magur) and Heteropneustes fossilis (singhi) in swampy, derelict and sewage water as well as paddy fields unsuitable for carp culture (Dehadrai *et al.*, 1986; Dehadrai and Kamal, 1993). Demand of this species is growing day-by-day in different parts of the country but fish farmers are not getting enough seed for commercial aquaculture. Since enough seed is essential for diversification of aquaculture (Kutty, 2001), development and standardization of seed production technology of the candidate species is required (Khan 1972; Khan and Mukhpoadhyay, 1975; Thakur 1991; Tripathi, 1990; Nayak *et al.*, 2000, 2001; Pandey and Koteeswaram 2004; Singh and Pandey 2009; Chaturvedi *et al.*, 2012, 2013). Though the climbing perch is not a catfish but cultured with singhi and magur, however, culture of the species has not yet picked up in India due to poor seed availability owing to non-availability of brooders or lack of breeding and hatching technology (Dehadrai and Kamal, 1993; Kumar *et al.*, 2012). An attempt has, therefore, been made to induce breeding and larval rearing of the commercially important *A. testudineus* under agro-climatic conditions of Raipur (Chhattisgarh). Since physico-chemical conditions of water like pH, dissolved oxygen, temperature, alkalinity as well as metabolites play important role in fish breeding (Dwivedi and Ravindranathan, 1982), these parameters were monitored regularly and kept optimal while undertaking induced breeding and larval rearing experiments on the climbing perch.

Materials and Methods

For breeding experiments, mature and healthy brooders of Anabas testudineus were procured from Private Fish Farm (30 km away), transported to Chhattisgarh State Fisheries Department, Raipur, given bath treatment in KMn04 solution (3 ppm) and acclimatized in cemented cistern size (3x2x1 m) with water depth of 10-12" under hatchery conditions. Physico-chemical parameters of water such as pH, temperature, dissolved oxygen, alkalinity, nitrite and nitrate were monitored regularly and found to be within the optimum range (Table 1). Since body colouration in A. testudineus appears only during breeding season (Mookerjee and Mazumdar, 1946; Dehadrai et al., 1973; Banerjee and Prasad, 1974; Banerjee and Thakur, 1981; Behera et al., 2015), male and female brooders were identified based on secondary sexual characters - the males being darker in colour with oozing milt by applying slight pressure on the belly while females possessed light brown pigmented spot on body with bulging abdomen (Fig. 1-2) . Females were given intraperitoneal (i.p.) injection of ovatide @ 0.06 ml/100 g body weight while males were administered (i.p.) with the hormonal drug @ 0.04 ml/100 g body weight (Fig. 3). In one set, ovatide was also given intramuscular (i.m.) injection in the

Fig. 1: Brooders of *Anabas testudineus*.

Fig. 2: Checking of male brooders.

Fig. 3: Intraperitoneal injection to brooder.

Fig. 4: Intramuscular injection to female brooder.

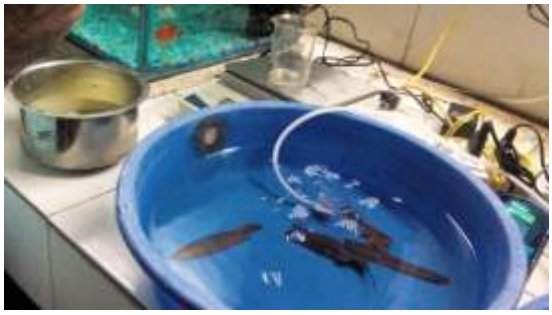

Fig. 5: Spawn of *Anabas testudineus*.

Fig. 6 : Rearing of *Anabas testudineus* spawn.

Table 1: Physico-chemical parameter of hatchery water at Raipur.

Sl. No.	Date	pH	Temperature (°C)	DO_2 (ppm)	Alkalinity (ppm)	Nitrite (ppm)	Nitrate (ppm)	Hatching hours
1	20.07. 2015	7.4	27.4	3.4	100	0.02	Nil	23.4
2	21.07.2015	7.2	27.8	3.8	120	0.01	0.01	-----
3	22.07.2015	7.6	28.2	3.6	110	0.01	0.01	-----
4	23.07.2015	7.4	27.2	4.0	130	0.02	Nil	24.0
5	24.07. 2015	7.2	28.2	3.8	110	0.03	0.01	-----
6	25.07.2015	7.5	27.8	4.2	110	0.02	0.01	-----
7	26.07. 20175	7.5	27.0	3.8	120	0.02	0.01	24-25
8	27.07. 2015	7.4	27.6	4.0	120	0.01	Nil	-----

Table 2: Details of Induced breeding experiments on *Anabas testudineus* at Raipur.

Sl. No.	Date	Weight of fishes (gm) body weight)		Dose of hormone (ml/100 g)		Number of fertilized eggs	Hatching (%)	Number of spawn	Fry
		Male	Female	Male	Female				
1	20.07.2015	32.0-32.5	42.0	0.02-0.02	0.06	4,800	90	4,320	1710
2	23.07.2015	32.0-36.0	38.0	0.02	0.05	2,600	80	2,080	1248
3	26.07.2015	33.0-42.0	39.2	0.03	0.04	3,200	90	2,880	1728
Total									4,686

above dose (Fig. 4). The injected brood fish sets comprising one female and two males (sex ratio 2:1) were released in cement cistern (Banerjee and Thakur, 1981). Breeding was observed in all the 3 sets of climbing perch but the latency period prolonged to 18-28 hours. Interestingly, A. testudineus given intramuscular (i.m.) injection of the hormonal drug also elicited successful spawning but the latency period was prolonged to 2-3 more hours. Fertilized eggs were transferred to fiber glass tub (size 3×2×1') with water depth 10" provided with aeration (Fig. 5). Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators (Fig. 6). Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators. Flowing water were stopped and spent brooders taken out with the help of hand net.

Results

Effects of ovatide administration on induced spawning of the climbing perch, *A. testudineus*, have been summarized in Table 2. In the present study, induced breeding was achieved successfully in all the three sets of *A. testudineus* without sacrifice of any male or female but the latency period prolonged to 18-28 hours (2 hours more in case of i.m. injection). The eggs (released in batches) were very minute and floating on the surface of water. The fertilized eggs were bright clear and transparent while unfertilized eggs appeared milky and opaque. The diameter of fertilized eggs ranged between 0.6-0.7 mm. Mookerjee & Mazumdar (1946), Banerjee & Prasad (1974), Khan & Mukhopadhyay (1975) and Zalina *et al.* (2012) also recorded diameter of fertilized eggs of the climbing perch between 0.7-

0.85 mm. Average fertilization rate was 90% under the hatchery conditions indicating successful natural spawning (without stripping) in A. testudineus. Fertilized eggs were transferred to fiber glass tub (size 3x2x1') with water depth 10" provided with aeration. Hatching of fertilized eggs took place in cemented cistern by supplying oxygen through aerators. Flowing water were stopped and spent brooders taken out with the help of hand net. Hatching took place in 18-22 h and the newly-hatched larvae measured 2.0-2.3 mm on day 1, 2.6-2.8 mm on day 2 and 3.0-3.6 mm on day 3. Air-breathing organ developed on day 10 and larvae measured 10.6-11.8 mm. Indoor rearing of the larvae was done on feed such as plankton, egg custard and chopped molluscan meat with water depth of 6-8". From the three sets of brooders, 10,600 hatchlings and ultimately 4,686 fry were produced.

Discussion

In spite of moderate growth, A. testudineus is esteemed for flavour and medicinal values of flesh and prolonged freshness out of water which call to extend and intensify production through cultural practices (Banerjee and Prasad, 1974; Zalina *et al.*, 2012; Chakraborty and Haque, 2014; Chakraborty, 2015). It has been recommended for culture in swamps, pens and even in carp ponds where advanced fingerlings (over 10 cm) are stocked (Alikunhi, 1957; Hora and Pillay, 1962; Banerjee and Prasad, 1974; Dehadrai and Kamal, 1993 and Tuan and Hau, 2012). With the success of induced spawning by hypophysation in carps for seed production (Chaudhuri and Alikunhi, 1957; Chaudhuri, 1960; Chaudhuri *et al.*, 1966; Varghese *et al.*, 1975; Bhowmick *et al.*, 1977; Chaudhuri and Singh, 1984; Mahanta *et al.*, 1998), this technique was also extended to induce spawning in other commercially important including air-breathing fishes for diversification and expansion of freshwater aquaculture in swampy, derelict and sewage water which were unsuitable for carp culture (Ramaswamy and Sundararaj, 1956, 1957; Devaraj *et al*, 1972; Khan, 1972; Khan and Mukhopadhyay, 1975; Zonneveld *et al.*, 1988; Kohli, 1989; Kohli and Vidyarthi, 1990; Tripathi, 1990; Rao and Janakiram, 1991; Thakur, 1991; Chondar, 1999)). With the discovery of GnRH-based drugs, induced breeding technique has been simplified and successfully employed for breeding and seed production of carps and other commercially important fishes (Peter *et al.*, 1988, 1993; Kouril *et al.*, 1986; Lee *et al.*, 1986; Nandeesha *et al.*, 1989, 1990; Alok *et al.*, 1993, 1997; Lin and Peter, 1996; Lakra *et al.*, 1996; Tharakan and Joy, 1996; Pandey *et al.*, 1998; Nayak *et al.*, 2000, 2001; Pandey and Singh, 2003; Pandey and Koteeswaran, 2004; Chaturvedi et al., 2015).

Observations on breeding and life-history (including larval development) of *A. testudineus* have been documented and induced breeding through hypophysation (pituitary gland extract) also reported (Mookerjee and Mazumdar, 1946; Khan,1972; Banerjee and Prasad, 1974; Khan and Mukhopadhyay, 1975; Mahmood, 2006; Akter et al., 2014; Sarkar et al., 2015) but survival of the larvae has been poor partly due to pronounced cannibalism (Khan and Mukhopadhyay, 1975; Zworykin, 2012). Banerjee and Prasad (1974) observed spawning in *A. testudineus* with single low dose (15-20 mg /kg body weight) of carp pituitary gland extract (PGE). Mass scale seed production of the climbing perch for commercial aquaculture is also hampered owing to low fecundity (Khan and Mukhpoadhyay, 1972; Banerjee and Prasad, 1974; Zalina et al., 2012). Induced spawning of *A. testudineus* using GnRH-based drugs has also been attempted during the recent years (Sarkar *et al.*, 2005, 2015; Bhatta-charyya and Homechaudhuri, 2009; Kumar *et al.*, 2010; Zalina *et al*, 2011, 2012; Loh and Ting, 2015; Singh *et al.*, 2015) with varying success. In the present study, ovatide in the dose of 0.06 ml/100 g body weight in females and @ 0.04 ml/100 g body weight in males induced successful spawning in A testudineus. Sarkar *et al.* (2005), Perera *et al.* (2013) and Singh *et al.* (2015) also achieved success with similar dose of GnRH-based drugs, however, Kumar *et al.* (2010) used ovaprim in the dose of 15 ml/kg body weight for successful induced spawning of the species in different seasons (February through August). In the present study, spawning took place in batches similar to those reported by other workers in *A. testudineus* (Mookerjee and Mazundar, 1946; Banerjee and Prasad, 1974; Kumar et al., 2010). Since water temperature and pH play pivotal role in induced spawning and larval rearing

of the climbing perch, it ranged between 27.4-28.20C and 7.2-7.6, respectively in the present study which were within the optimum range. Mookerjee and Mazundar (1946) and Zalina et al. (2012) also found 26-270C to be optimum temperature for induced spawning of the climbing perch. In the present study, air-breathing organ developed on day 10 when larvae measured 10.6-11.8 mm. Hughes et al. (1986) reported air-breathing in 13-14 days old hatchling. Average fertilization rate of 90% under the hatchery conditions found in the present study indicates successful natural spawning (without stripping) in the species. Indoor rearing of the larvae was done on feed such as plankton, egg custard and chopped molluscan meat with water depth of 6-8".

From the three sets of brooders, 10,600 hatchlings and 4,686 fry of A. testudineus were produced under agro-climatic conditions of Raipur (Chhattisgarh) Though A. testudineus has been kept under Data Deficient-ver 3.1 category of IUCN Red List of Threatened Species (Pal and Chaudhry, 2010), population of this species has declined drastically in some of its natural habitats and declared vulnerable in West Bengal (Mukherjee *et al.*, 2002) and endangered in Bangladesh (Rahman and Marimuthu, 2010; Chakraborty and Haque, 2014), the successful induced spawning of the climbing perch pave the way for rehabilitation of this species through conservation aquaculture (True et al, 1996; Anders, 1998).

References

Akter, A., M.J. Sarkar and M. Shamsuddin (2014). Hatchery operations of Thai koi (Anabas testudineus) in a freshwater fish farm in Bangladesh. Turkish Fisheries Research, 3 (2): 6-10.

Alikunhi, K.H. (1957). Fish culture in India. Farm Bull. (ICAR), 20: 53 & 115.

Alok, D., T. Krishnan, G.P. Talwar and L.C. Garg (1993). Induced spawning of catfish, Heteropneustes fossilis (Bloch), using D-Lys6 salmon gonadotropin-releasing hormone. Aquaculture, 115: 159-167.

Alok, D., D. Pillai and L.C. Garg (1997) Effect of D-Lys6 salmon sGnRH alone and in combination with domperidone on the spawning of common carp during the late spawning season. Aquaculture International, 5: 369-374.

Anders, P.J. (1998). Conservation aquaculture and endangered species: can objective science prevail over risk anxiety? Fisheries (Bethesda), 23 (11): 28-31.

Banerjee, S.R. and D. Prasad (1974). Observation on reproduction and survival of Anabas testudineus (Bloch) in Bihar region. Journal of Inland Fisheries Society of India, 6: 6-17.

Banerjee, S.R. and N.K. Thakur (1981). Observation on the spawning behaviour of Anabas testudineus (Bloch). Indian Journal of Animal Sciences, 51: 651-654.

Behera, S., L.M. Devi, S. Kumar, R. Gogoi, P. Samanta, O. Jomang and S. Baksi (2015.) External morphology and sexual dimorphism of Anabas testudineus in natural environment. International Journal of Science and Nature, 6: 288-292.

Bhattacharyya, M. and S. Homechaudhuri (2009) Assessment of captive breeding of Anabas testudineus with synthetic hormone, ovaprim. Proceedings of the Zoological Society (Calcutta), 62: 23-27.

Bhowmick, R.M., G.V. Kowtal, R.K. Jana and S.D. Gupta (1977). Experiments on second spawning of Indian major carps in the same season by hypophysation. Aquaculture, 12: 149-55.

Chakraborty, B.K. (2015). Sustainable aquaculture practice of climbing perch Koi, Anabas testudineus (Bloch, 1792) under semi-intensive aquaculture system in Bangladesh. Proceedings of the Zoological Society (Calcutta), 69: 133-140.

Chakraborty, B.K. and S.M. Haque (2014). Growth, yield and returns to Koi, Anabas testudineus (Bloch, 1792) under semi-intensive aquaculture system using different seed types in Bangladesh. Journal of Fisheries and Livestock Production, 2 (1): 1-7.

Chaturvedi, C.S., Somdutt and A.K. Panday (2012). Successful induced breeding and hatching of Clarias batrachus and Heteropneustes fossilis under agro-climatic conditions of Lucknow (U.P). National JournalLife Sciences, 9: 163-167.

Chaturvedi, C.S., Somdutt and A.K. Panday (2013). Successful induced breeding of freshwater catfish, Clarias batrachus (Linnaeus), by ovaprim administration under agroclimatic conditions of Uttar Pradesh. Journal of Experimental Zoology India, 16: 163-167.

Chaturvedi, C.S., N. Ram, K.D. Raju and A.K. Pandey (2015). Induced breeding of Indian major (Catla Catla) and sliver carp (Hypophthalmicthys molitrix) employing synthetic hormone analogues under agro-climatic conditions of Andaman and Nicobar islands, India. Journal of Experimental Zoology India, 18: 731-735.

Chaudhuri, H. (1960). Experiments on induced spawning of Indian major carps with pituitary injection. Indian Journal Fisheries, 7: 20-49

Chaudhuri, H. and K.H. Alikunhi, (1957). Observation on the spawning of Indian carps by hormone injection. Current Science, 26: 382-383.

Chaudhuri, H. and S.B. Singh (1984). Induced Breeding of Carps. Indian Council of Agricultural Research, New Delhi.

Chaudhuri, H., S.B. Singh and K.K. Sukumaran (1966). Experiments on large-scale production of fish seed of the Chinese grass carp, Ctenopharyngodon idellus (C. & V.) and the silver carp, Hypophthamichthys molitrix (C&V) by induced breeding in ponds in India. Proceedings of the Indian Academy of Science, 63B: 80-95.

Chondar, S.L. (1999). Biology of Finfish and Shellfish. SCSC Pub. (India), Howrah.

Dehadrai, P.V. and M.Y. Kamal (1993). Role of air-breathing fish culture in rural upliftment. In: Souvenir: Third Indian Fisheries Forum (October 14-16, 1993). College of Fisheries, G.B. Pant University of Agriculture & Technology, Pantnagar, pp. 28-33.

Dehadrai, P.V., S R. Banerjee, N.K. Thakur and N.K. Das (1973). Sexual dimorphism in certain air-breathing teleosts. Journal of Inland Fisheries Society of India, 5: 71-78.

Dehadrai, P.V., M.Y. Kamal and R.K. Das (1986). Package of Practices for Increasing Production of Air-breathing Fishes. Aquaculture Extension Manual No. 3. Central Inland Fisheries Research Institute Barrackpore. pp. 1-4.

Devaraj, K.V., T.J. Verghese and G.S.P. Rao (1972). Induced breeding of freshwater catfish, Clarias batrachus (Linn.), by using pituitary glands from marine catfish. Current Science, 41: 868-870

Dwivedi, S.N. and V. Ravindranathan (1982). Carp hatchery model CIFE D 81- a new system to breed fish even when rain fails. Bulletin Number 82. Central Institute of Fisheries Education, Mumbai. pp. 3-8.

Hora, S.L. and T.V.R. Pillay ((1962). Handbook on Fish Culture in the Indo-Pacific Region. FAO Fisheries Biology Technical Paper, 14: 34-35.

Khan, H.A. (1972). Induced breeding of air-breathing fishes. Indian Farming, 22 (4): 44-45.

Khan, H.A. and S.K. Mukhopadhyay (1972) On the fecundity of climbing perch, Anabas testudineus (Bloch). Journal of Inland Fisheries Society of India, 4: 212-213.

Khan, H.A. and S.K. Mukhopadhyay (1975). Production of stocking material of some air- breathing fishes by hypophysation. Journal of Inland Fisheries Society of India, 7: 156-161.

Kohli, M.P.S. (1989). Natural breeding of air-breathing fishes in Andaman and Nicobar Islands. Journal Anadaman Science Association, 5: 96-97.

Kohli, M.P.S. and S. Vidhayarthi (1990). Induced breeding, embryonic and larval development in Heteropneustes fossilis (Bloch) in the agro-climatic condition of Maharashtra. Journal Indian Fisheries Association, 20: 15-19.

Kouril, J., T. Barth, J. Hamalkova and M. Flegel (1986). Induced ovulation in tench (Tinca tinca) by various LHRH synthetic analogues: effect of site of administration and temperature. Aquaculture, 54: 37-44.

Kumar, K., U.L. Mohanty, S. Dasgupta and A.K. Sahu (2010). Induced spawning of Anabas (Anabas testudineus, Bloch) under captivity in pre-monsoon and monsoon months. Journal of Inland Fisheries Society of India, 42 (2) : 8-13.

Kumar, K., U.L. Mohanty, R. Kumar, D. Damle, N. Janan, J.K. Jena and A.E. Eknath (2012). Culture of freshwater climbing perch, Anabas testudineus. Aquaculture Asia Magazine, 17 (3): 27-28.

Kutty, M. N. (2001). Diversification of aquaculture. In: Sustainable Indian Fisheries (ed. Pandian, T. J.). National Academy of Agricultural Sciences (ICAR), New Delhi. pp. 189-212.

Lakra, W.S., A. Mishra, R. Dayal and A.K. Pandey (1996). Breeding of Indian major carps with the synthetic hormone drug ovaprim in Uttar Pradesh. Journal of Advanced Zoology, 17: 105-109.

Lee, C.S., C.S. Tamaru, C.S. Kelley and J. Banno (1986). Induced spawning of milkfish, Chanos chanos by a single application of LHRH-analogue. Aquaculture, 58: 87-88.

Lin, H.R. and R.E. Peter (1996). Hormones and spawning in fish. Asian Fisheries Science, 9: 21-33

Loh, J.Y. and A.S.Y. Ting (2015). Comparative study of analogue hormones and the embryonic, larval and juvenile development on the induced breeding of climbing perch (Anabas testudineus, Bolch, 1792). International Journal of Fisheries and Aquatic Sciences, 2: 277-284.

Mahanta, P.C., K.G. Rao, G.C. Pandey and A.K. Pandey (1998). Induced double spawning of an Indian major carp, Labeo rohita, in the same breeding season under the agro-climatic conditions of Assam. Journal of Advanced Zoology, 19: 99-104.

Mahmood, S.U. (2006). Comparison between single and double injection of pituitary gland (PG) on the breeding performance of climbing perch, Anabas testudineus (Bloch). Journal of Bio-Science, 14: 57-60.

Mookerjee, H.K. and S.R. Mazumdar (1946). On the life-history, breeding and rearing of Anabas testudineus (Bloch). Journal of the Department of Science Calcutta University, 2: 101-140.

Nandeesha, M.C., S.K. Das, E. Nathaniel, T.J. Vargehese and H.P.C. Shetty (1989). Ovaprim - a new drug for induced breeding of carps. Fishing Chimes, 9 (4): 13-15.

Nandeesha, M.C., K.G. Rao, R. Jayanna, N.C. Parker, T. Verghese, P. Keshavanath and H. P.C. Shetty, (1990). Induced spawning of Indian major carps through single application of ovaprim. In: Proceedings of the Second Asian Fisheries Forum (Hirano, R. and I. Hanyu, eds.). Asian Fisheries Society, Manila, Philippines. pp. 581-585.

Nayak, P.K., A.K. Pandey, B. N. Singh, J. Mishra, R.C. Das, and S. Ayyappan (2000). Breeding, Larval Rearing and Seed Production of the Asian Catfish, Heteropneustes fossilis (Bloch). Central Institute of Freshwater Aquaculture, Bhubabeswar. 68 p.

Nayak, P.K., T.K. Mishra, B.N. Singh, A.K. Pandey and R.C. Das (2001). Induced maturation and ovulation in Heteropneustes fossilis by using LHRHa, pimozide and ovaprim for production of quality eggs and larvae. Indian Journal of Fisheries, 48: 269-275.

Olson, K.R., J.S.D. Munshi, T K. Ghosh and J. Ojha (1986). Gill microcirculation of the air-breathing climbing perch, Anabas testudineus (Bolch): relationships with the accessory respiratory organs and systemic circulation. American Journal of Anatomy,176: 305-320.

Pal, M. and S. Chaudhry (2010). Anabas testudineus. The IUCN Red List of Threatened Species. http://dx.doi.org/10.22305/IUCN.UK.2010-4.RLTS.T1665434A6232945.en

Pandey, A.K. and B.N. Singh (2003). Recent advances in broodstock management, induced breeding and larval rearing of the Indian catfish, Heteropneustes fossils (Bloch). Journal of Experimental Zoology India, 6: 163-168.

Pandey, A.K. and R. Koteeswaran (2004). Ovatide induced breeding of the Indian catfish, Heteropneustes fossilis (Bloch). Proceedings of the Zoological Society (Calcutta), 57: 35-38.

Pandey, A.K., R.S. Patiyal, J.C. Upadhyay, M. Tyagi and P. C. Mahanta (1998). Induced spawning of endangered golden mahseer (Tor putitora) with ovaprim at State Fish Farm near Dehradun. Indian Journal of Fisheries, 45: 457-459.

Peter, R.E., H.R. Lin and G.van der Kraak (1988). Induced ovulation and spawning of cultured freshwater fish in China: advances in application of GnRH analogues and dopamine antagonists. Aquaculture, 74: 1-10.

Peter, R.E., H.R. Lin, G. van der Kraak and M. Little (1993). Releasing hormones, dopamine antagonists and induced spawning. In: Recent Advances in Aquaculture. IV (Muir, J.F. and R.J. Roberts, eds.). Blackwell Science Publications, London. pp. 25-30.

Rahman, M.A. and K. Marimuthu (2010). Effect of different stocking density on growth, survival and production of endangered native fish, climbing perch (Anabas testudineus Bloch) fingerlings in nursery ponds. Advances in Environmental Biology, 4 (2): 178-186.

Ramaswamy, L.S. and B.I. Sundararaj (1956). Induced spawning in the Indian catfish. Science, 123: 1080.

Ramaswamy, L.S. and B.I. Sundararaj (1957). Induced spawning in the catfish, Clarias. Naturewissenchaften, 44, 344.

Rao, G.R.M. and K. Janakiram (1991). An effective dose of pituitary for breeding Clarias batrachus. Journal of Aquaculture in Tropics, 6: 207-210.

Sahoo, S.K., S.S. Giri and A.K. Sahu (2005). Induced spawning of Asian catfish, Clarias batrachus (Linn.): effect of various latency periods and sGnRHa and domperidone doses on spawning performance and egg quality. Aquaculture Research, 36: 1273-1278

Sarkar, S., B. K. Rai, D. Bhutia, S. Singh and J. Pal (2015). Study on the breeding performance and developmental stages of of climbing perch, Anabas testudineus (Bloch, 1792), in the laboratory (Siliguri, India). International Journal of Fisheries and Aquatic Studies, 2 (6): 198-201.

Sarkar, U.K., P.K. Deepak, D. Kapoor, R.S. Negi, S.K. Paul and S.P. Singh (2005). Captive breeding of climbing perch, Anabas testudineus (Bloch, 1792) with Wova-FH for conservation and aquaculture. Aquaculture Research, 36: 941-945.

Singh, A.A., S. Nanda, N.K. Moharana and S. Priyadarsini (2015). Comparative study on the effect of ovaprim and Wova-FH on induced breeding response on Anabas testudineus. Asian Journal of Animal Science, 10: 64-68.

Talwar, P.K. and A.G. Jhingran (1991). Inland Fishes of India and Adjacent Countries. Vol. 1 & 2. Oxford & IBH Pub. Co., New Delhi. 1158 p.

Thakur, N.K. (1991). Possibilities and problems of catfish culture in India. Journal of Inland Fisheries Society of India, 23 (2): 80-90.

Tharakan, B. and K.P. Joy (1996). Effects of mammalian gonadrotropin-releasing hormone analogue, pimozide, and the combination on plasma gonadotropin levels in different seasons and induction of ovulation in female catfish. Journal of Fish Biology, 48: 623-632.

Tripathi, S.D. (1990). Present status of breeding and culture of catfish in South Asia. Aquatic Living Resources, 9: 219-228.

True, C.D., A. Silva-Lora and M. Castro-Castro (1996). Is aquaculture the answer for the endangered totoaba? World Aquaculture, 27 (4): 38-43.

Tuan, N.N. and N.T. Hau (2012). Hau Giang climbing perch, a potential species for aquaculture. In: International Conference on Sustainable Land Use and Rural Development on Mountain Areas (April 16-18, 2012). Hohenheim, Stuttgart, Germany. pp. 119-120.

Verghese, T.J., G.P.S Rao, K.V. Devaraj and B. Chandrashekar (1975). Preliminary observations on the use of marine catfish pituitary glands for induced spawning of Indian major carps. Current Science, 44: 75-78.

Zalina, I., C.R. Saad, A.A. Rahim, A. Christianus and S.A. Harmin (2011). Breeding performance and the effect of stocking density on the growth and survival of climbing perch (Anabas testudineus, Bloch). Journal of Fisheries and Aquatic Sciences, 6: 834-839.

Zalina, I., C.R. Saad, A. Christianus and S.A. Harmin (2012). Induced breeding and embryonic development of climbing perch (Anabas testudineus, Bloch). Journal of Fisheries and Aquatic Sciences, 7: 291-306.

Zonneveld, N., W.J.R.V. Rustidja, and W. Mundane (1988). Induced spawning and egg incubation of Asian catfish, Clarias batrachus. Aquaculture, 74: 41-47.

Zworykin, D.D. (2012). Reproduction and spawning of climbing perch, Anabas testudineus (Perciformes, Anabantidae) in an aquarium. Journal of Ichthyology, 52: 379-388.