Development of seed mass production of snakehead (*Channa striata*) in Indonesia

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Abstract. Snakehead (*Channa striata*) has a strategic position in contributing to the national economy due to its albumin content which has been proven to have been used as biopharmaceutical for postoperative treatment. This has led to an increase in the exploitation of snakehead in nature which has depressed its population. The snakehead culture is the right step in supplying material demanded for biopharmaceutical industries. The success of the development of this snakehead culture requires support, among others, of the availability of sufficient seeds in number and time as well. This paper, therefore, discussed the strategy to develop seed mass production of snakehead in a controlled condition in Indonesia. The method used was a desk study, collecting published papers and personal observations related to snakehead hatchery. The data were analysed descriptively. The results of the study indicated that the bio-reproduction information of snakehead in nature can be used as a reference in the process of brood-stock management and larval culture under controlled conditions. Commercial and / or home-made fish diet containing protein of 38–42% can ripen gonads and spawn snakehead brooder using hormone stimulation in a hatchery. Water sources can use ground water and / or pipe that has been previously treated, especially setting the pH, alkalinity, hardness, and water temperature. Proper feeding strategies can increase the growth and production of snakehead fish seeds. This snakehead hatchery can be done both inside and outside its habitat.

1. Introduction

More than 1,200 fish species live in inland waters of Indonesian having about 54 million hectares in area. The people living in the surrounding area use to utilize fishes resources for daily food table (food security) and income source for economically fish species. By the times, the need for fish tends to increases with increasing number of human population. Number of fish population consequently decline. The decline in fish population is accelerated by the aging process of aquatic resources. Economically important fish species such knife fish (*Chitala lopis*) [1] and snakehead (*Channa striata*) will be more endangered. Some relative highly price fish species should be developed in fish culture [2, 3]. Various efforts to conserve fish in mainland public waters have been carried out [4], but until now they have not had an impact on increasing the population of these fish in nature.

In the past five years, snakehead population has tended to decline rapidly. The contributing factor is the increasing market for snakehead fish to take albumin [5] as a biomedical agent for human who is in the process of healing wounds [6] and several other diseases [7]. The discovery of the benefits of
albumin from snakehead fish for human health will accelerate the threat of its extinction. Hence, snakehead rescue in nature is required.

Domestication of native fish is a strategic step for the preservation of snakehead [8]. This domestication encourages fish to adapt to culture conditions, namely the environment and feed. After adapting, the next process of domestication is controlled seed production in hatchery. The seeds produced can be used for the re-stocking of these fish in nature and or for the development of their culture.

Aquaculture is one way to suppress the decline in fish populations in nature. In fact, people living in the vicinity of mainland public waters have become accustomed to cultivating native carnivorous fish (snakehead) [9]. They make cages or ponds around their house as a container for rearing snakehead fish seeds, which are abundant in season. The cultivation of snakehead fish is underdeveloped due to limited seeds in nature and the use of natural feed. Several research results related to snakehead fish hatcheries, such as bio reproduction, gonad maturation, and hatchery starting from spawning, care for eggs and larvae, and seeds [10, 11] are available. Dependence on the use of natural food has been successfully overcome by using specially formulated artificial feed [3, 12, 13]. This proves that mass production of native fish seeds including snakehead can be done.

The success of snakehead fish in hatcheries requires basic information related to fish habitat and bio reproduction [14], and brood-stock management, water quality management, spawning management, egg and larva management, and seed management. The output of this fish hatchery is fish seeds that are ready to be stocked outdoors. This paper aims to provide a strategy for the development of controlled mass production of snakehead seed in Indonesia.

2. Methodology
The method used was desk study. Writing materials were collected from published scientific papers. In addition, the experience of the writer of snakehead fish hatchery has been used as one of the writing material. Data were analyzed descriptively and presented in figures.

3. Results and Discussion
3.1. Habitat and bio-reproduction
Snakehead fish inhabits in inland waters (rivers and swamps, lakes, reservoirs, rice fields) having a depth of 40 cm and preferring dark, muddy, slowing water current, and/or rocky places to hide in the Sunda Plate (Sumatra, Java, and Kalimantan), and then spread to other areas of Indonesia. The swampy waters is inhabited by snakehead fish to carry out their life cycles [14, 15, 16, 17, 18, 19, 20, 21]. This swampy waters have extreme conditions between the dry and rainy seasons. Snakehead fish can survive in swampy water conditions with low dissolved oxygen content, pH 4.5–6.0 and water temperature 23-27 °C [17, 18, 21].

The difference in the ecological conditions of the waters causes differences in the size of the snakehead fish when gonads are first matured [22, 23]. The highest spawning of snakehead fish occurs at the beginning of the rainy season [24]. During the dry season, snakehead forage for gonad growth. At the beginning of the rainy season, snakehead fish eggs are at a mature level. The size ranges from 18-21 cm or a minimum age of 9 months. The number of eggs (fecundity) ranges from 1,062-57,200 eggs per head [25]. The gonad maturity index (GMI) of the female snakehead in Sembujur Lake Central Kalimantan ranges from 2.51-3.54% [16, 21], and in Rawa Pening Central Java ranges from 0.043-4.324% [18]. This low GMI value indicates that snakehead fish spawned partially. Egg diameter ranges from 1.25 to 1.55 mm [19, 21, 25]. Fish that are spawning for the first time have relatively less fecundity than those that are older. The factors that control the gonad maturation and spawning processes are photoperiod, temperature, pH, and feed [22].

Male and female snakehead fish form foam as a nest for protection from fertilized eggs. The fertilized eggs are guarded by the male and hatch within 24 hours. The maintenance of the male parent
against the larva continues for 3 days. Fish seeds will crowd and one of the parents will look after them all the time [15].

During this spawning season, the people catches the seeds and broodfish respectively for cultivation and consumption. Meanwhile, changes in the aquatic environment due to reclamation and climatological changes will suppress the snakehead fish population in nature such as the carnivorous knife fish [1]. The re-stocking of snakehead fish in its habitat and/or domestication is an effort to preserve the snakehead population.

3.2. Snakehead domestication

Domestication is the first step in the controlled fish seed production process. Snakehead fish need to adapt to culture conditions, namely water quality, high stocking density and feed provided. After successfully adapting, the next steps are gonad maturation, fish spawning, and controlled care of eggs, larvae and seeds. The snakehead in adult size from nature is adapted to the culture conditions. This snakehead is easy to adapt to changes in water quality, but needs to be trained to be kept in high density and to accept the feed given. Natural feed is slowly being replaced with artificial feed, as in the case of the development of native fish of hoeven carp’s (Leptobarbus hoeveni) [3, 13]. The diet plays an important role in maturing gonad of native fish species.

For the development of snakehead culture, dependence on seeds from nature is not profitable because the availability is limited to the season and the quality is not guaranteed. The seeds from the hatchery are expected. The success of this mass production of snakehead fish seeds requires a process of adaptation of fish to cultivation conditions (domestication) [2, 3, 8]. Further more, domestication could be started from rearing snakehead fish in controlled containers for gonad ripening, spawning of matured brooder, hatching egg, and larval rearing to raise its size up to journenil and/or fingerling that are ready to be stocked or raised in pond to reach consumption size.

3.2.1. Gonad Maturation. Male snakehead is more easily than the female in gonad maturation. The ripening process of the gonad depends on the availability of feed containing complete and balanced nutrients. As with carnivorous fish, snakehead fish require relatively high protein which contains a complete array of essential amino acids. Other nutrients needed are fat with a composition of essential fatty acids, and various vitamins and minerals [12]. At the beginning of the domestication process, snakehead fish still rely on nutrient sources from nature. Referring to the carnivorous knife fish at the laboratory scale [26] and the field [27], the cultivation container for gonad ripening uses a soil pond that has been fertilized and stocked with small size fish and covered 25-50% of the surface area with plants water hyacinth (Eichornia crassipes) [20]. The ecological conditions of the captive pond are expected to grow a variety of aquatic animals as in nature for providing diet requirement for gonad maturation of the snakehead [27].

The provision of natural diet such trash fish and / or golden snails are usually given to the growing out of snakehead fish. In laboratory-scale experiments, various natural foods (trash fish, golden snails and bran) given to snakehead increased their growth [8]. This golden snail has the potential feed ingredient for diet of freshwater fish [28]. Through the adaptation process, the snakehead brooder developed their gonads up to a mature level by providing commercial feed containing 40% protein [3, 10]. According to [29], the provision of commercial feed, gold snails and trash fish to female snakehead male produces the same egg quality. Gonadal development can be accelerated by the addition of hormones in the feed [30, 31]. Male gonads mature is faster than the females [22]. Under controlled conditions and properly artificial feeding, snakehead can spawned throughout the year, regardless of the season [10].

3.2.2. Controlled spawning of fish. Snakehead spawning can be done naturally and or semi-naturally. The female (Figure 1) has a rounded head shape, a flabby and enlarged stomach, and a bright body colour. The male has an oval head shape, their body colour tends to be dark, the holes in the genitals are reddish, and will secrete a slightly clear white liquid when sorted [11, 32]. Recommendations for the
male and female for spawning is that the sizes is over 250 g [33] and the ratio is 1:1 [10]. Broodstock caught in nature can be spawned as long as the gonads are ripe [8]. Hormones [34] are injected into the fish body to stimulate natural spawning. The hormonal treatment or a combination of hormone manipulation with the environment is an alternative in triggering and spurring the gonad maturation process. The signal received by the central nerve and transmitted to the hypothalamus releases the hormone gonadotropin (GnRH). The gonadotropins produced include follicle stimulating hormone (FSH), leuteinization hormone (LH). This hormone acts as a control at the beginning of the reproductive cycle until the occurrence of spermation and ovulation in fish [30].

The success of snakehead spawning is influenced by the stress level of the parent, mastery of selecting mature gonads, injecting hormones and providing water quality, especially dissolved oxygen, pH and water hardness [10]. [35] reported that this snakehead fish can spawn in peatland pond conditions. Based on observation in the practical snakehead breeding, the use of controlled tanks results in better spawning than in ponds. A cylindrical fiber tank with a water volume of 1,000 L is covered by water hyacinth at half the water surface area (Figure 2). At the time of spawning, male fish will make a nest first. The nesting will be carried out for 1-2 days. Usually, snakehead fish will make nests in the corners of the container. Water plants serve to protect the egg storage media, as well as protect the nest from the stinging sun. The fertilized egg attaches to the foam and is removed by scope net.

3.2.3. Egg Care and Larva Rearing. Maintenance of fish eggs and larvae is carried in the hatchery. Indoor hatchery environmental sanitation is required as a prerequisite for disease prevention through strict biosecurity applications. The water temperature is kept stable, ranging from 28-30 °C. The eggs will hatch 2-3 days from spawning. Provision and control of water quality, especially pH, alkalinity and temperature at optimum conditions are required. The time for hatching eggs depends on the water temperature. The more you reach the optimum temperature level, the faster the eggs will hatch. The water temperature of the snakehead fish egg hatchery ranges from 28 ± 0.5 °C [36]. Giving aeration of 10 hours per day resulted in the highest hatching rate of snakehead fish [37], which is around 83% [31].

Egg yolk is a source of nutrients for larvae. Before the yolk runs out, the larvae need nutrients in the form of natural food. Incorrect provision of initial feed causes death in larvae due to disruption of ontogenic development [38]. Snakehead fish larvae are able to eat Moina sp. [39]. Moina sp requires nutrients so that the quality is maintained. Decreasing quality of Moina sp. Will cause growth disruption of larvae and increase mortality. According to [11], the provision of a “green water system” in a container for rearing snakehead larvae can maintain the quality of Moina sp. In rearing larvae of snakehead fish which were given green water (Chlorella sp.) With a frequency of feeding two, four, and six times a day gave survival performance (93.4%-94.3%) and the growth was not significantly different. The frequency of giving Moina sp twice a day as initial feed for rearing snakehead fish larvae with the
most efficient green water system for survival and larval growth. In general, the survival rate of the larvae ranges from 10-40% [33]. This survival rate indicates that the larvae are short of proper diet which causes cannibalism between them [3, 40].

3.2.4. Fry Rearing. After the enzyme performance and the shape of the digestibility organs of the feed are almost complete, artificial feed can be given to the fish larvae. This happens to snakehead fish when they are more than 20 days old [10]. The artificial feed must contain complete and balanced nutrients [12]. Commercial feed with a protein content of 40% can be given to snakehead fries. After reaching the seeds, the snakehead requires a diet containing about 35% protein [41].

The cannibalism of snakehead fish can be reduced through the use of optimum density [42]. Recirculation system is recommended for indoor snakehead raring. However, the snakehead rearing could be done in out-door. Use of water hyacinth in the snakehead culture is recommended [10].

4. Remarks and Recommendation
The availability of snakehead fish hatchery technology is a breakthrough for the development of its cultivation and/or restocking in nature. The availability of sustainable seeds in sufficient quantities and the ability of snakehead fish to feed artificial diet will ensure the sustainable development of snakehead fish farming. The snakehead fish seeds from the hatchery could be used for the re-stocking of the fish in the wild.

Snakehead fish hatchery requires quality and quantity water control. Although snakehead fish in Indonesia are found in almost all waters, from the upstream (mountains) to the downstream (areas bordering the sea), snakehead fish hatchery technology requires water quality requirements, especially pH, alkalinity and temperature to increase seed production. As long as the water quality in the hatchery is met, snakehead fish hatchery can be carried out in all locations. For the purposes of re-stocking, snakehead fish hatcheries could be established around mainland public waters. Furthermore, for the development of its culture, snakehead fish hatcheries are established in certain centers by taking into account the aspects of ease of distribution and cost as well.

Snakehead fish as carnivorous fish are seen as pests for freshwater fish farming. Eradication of snakehead fish from aquaculture containers is crucial. The such views of the community and even some policy makers should be considered in the development of the snakehead culture area.

In the future, improving seed quality, especially fish growth, feed efficiency, preventing disease and reducing cannibalism for snakehead, is a work that have to be completed.

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