Feeding appropriate formulated diet for improving gonad maturation and spawning of brooder of some native fishes of Indonesia

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Abstract. More than 1200 native Indonesian fish species inhabiting Indonesian inland waters have been used as human daily fish consumption. It brings to decline their population and even its species by year. Efforts of spawning some native fish species have been conducted, but the successful spawning limited during the rainy season. This paper, therefore, reviews the results of research related to using appropriate formulated diets for gonadal maturation and spawning some economically important native fishes. The tested fishes used were hoven’s carp (Leptobarbus hoevenii), knife-fish (Chitala lopis), Asian red-tail catfish (Hemibagrus nemurus), kissing gourami (Helostoma temmincki), snake-head (Channa striata), and hard-lipped barb (Osteochilus hasselti). This study showed that in general, formulated diet containing about 35% protein fed on these species resulted in gonad maturation whole year and successfully spawned under controlled hatchery. The larvae survived at a high rate after feeding a natural diet up to 30 day-age. Mass production of the juvenile could support the development of its culture and be used as restocking in inland open-waters as well.

Keywords: native fishes, formulated diet, gonad maturation, spawning

1. Introduction

Waters cover more than 38 million Ha of the land area of Indonesia, consisting of the river and its branch, lake, human-made lake and swampy area. This inland-waters inhibits more than 1200 fish species, mostly spreading in Jawa, Sumatera, and Kalimantan. The fish resources are used to be utilized as daily fish consumption, generating income of the family, district, and national as well. Even, some fishes are used for special food menu and/or a part of material of particular food such knife fish (Chitala sp) in South Sumatera [1, 2], climbing perch (Anabas testudineus) in South Kalimantan [3], for biomedical material of albumin of snakehead (Channa striata) [4] and for ornamental or exotic fish of clown loach (Chromobotia macracanthus) [5]

Fish population and even species, particularly having high economic importance tends to decline by a year because of many ecological pressure [6] such as industrial waste [7, 8], mining [9, 10] and reclamation of swampy area [11] as well as incredible increasing fish catch. Many efforts to recover fish resources in inland waters have been made [12] i.e. establishing fisheries reservart [13, 14, 15, 16, 17], integrated management of rivers [18, 19], and fish restocking [20]. These efforts, however, were not impact on increasing fish production in nature. Restocking of introuced fish species of nile tilapia...
(Oreochromis sp) is bringing to the negative impact such a case of decreasing knife fish in Man-made of Riam Kanan, South Kalimantan [1]. Development of native fish culture for satisfying market demand and decreasing fish catch as well in the next future, therefore, is necessary.

Sustainable development of fish culture has to be supported by the availability of seed in quality and quantity as well as of commercial feed having economical price. A traditional native fish culture such as Hoeven's carp [21] and snake-head [22] using seed collected from nature have been done, but the availability of the seed is seasonal. The seed-producing from a hatchery in a mass is required.

The success of mass production of native fish species needs a domesticated process of the fish to environmental culture (waters, stocking density, and artificial diet given). It is usually started from the brooder size of fish. Artificial diet plays an essential role in fish growth (somatic and gonad). It should contain complete and balance nutrients required by fish. Up to date, commercial artificial feed for brood fish is less available in the market. Fish farmers used to grower feed for any size and species as well of fish in their own business fish culture and sometimes added animal protein sources in wet basis for growing candidate broodstock of fish. This treatment influences gonadal development of fish to achieve at maturation level. The effort of native breeding fish have been conducted since 1980 used commercial feed; therefore, it is unpredictable. If it succeeds, it may occur during the rainy season.

Gonado development of native fish is commonly required relatively high protein containing in feed, besides micro vitamins particularly vitamin E and C. Information on nutrient requirements for brood fish needs basic research taking relatively long time. Besides, native brood fish is difficult to catch in nature, should be raised in captive from juvenile size. Basic data on fish habitat, food and feeding habit of native fish is valuable for predicting requirements of culture enviroment and protein diet as well. Since commercial feed containing high protein level is less available, feed for brood native fish should be made by breeders. Pellet machines having been distributing in fish culture centers [23, 24], particularly since 2015 through Program Gerakan Pakan Mandiri (GERPARI) initiated by the Government of Indonesia is hopefully able to produce local feed for native brooder fish. This paper, therefore, reviewed a series of research on formulated feed for increasing performances of reproduction and spawning of some native brooder fish in Indonesia. Juvenile production of the native fish under controlled condition in a hatchery could hopefully be used for needs of their culture and restocking in nature as well. This would impact on the development of native fish culture, reducing their exploitation and inclining their productin in nature.

2. Methodology
This research used the desk study. Data and information was collected from previous study conducted by authors and/or others. The data needed was related to habitate, food habit, nutrient requirement, formulated diet application for native fish and feeding strategy for growing larvae up to juvenile size. This study focused on native fishes such as hoeven’s carp (Leptobarbus hoevenii), knife-fish (Chitala lopis), Asian red-tail catfish (Hemibagrus nemurus), kissing gourami (Helostoma temmincki), snake-head (Channa striata), and hard-lipped barb (Osteochilus hasselti).

3. Results and Discussion

3.1. Native fish habitat
In general, various wild fishes live along river flow from up-stream to down having water salinity range of 3-5 ppt. Middle part of river has high fish production and water productivity, inhabited by many fish species which could be grouped to black fish i.e. kissing gouramy and snake-head, and white fish i.e. hoeven’s carp, knife-fish, Asian red-tail catfish, and hard-lipped barb. During rainy season, wild fishes live in deep part of waters (called lebung) for their gonad maturation. They will leave this area for spawning propose during rainy season where the water flood surrounding river area. Newly flooded area is rich in natural food for growing larvae of many species to juvenile size.
3.2. Food habit and nutrient requirements of fish

In nature, each fish species is looking for food and feed them on specifically diet according to complitiveness of their digestive organs, enzyme activities, and physiological condition. Less active fishes such as snake-head and kissing gourami tend to live around a substrate as their shelter and getting a food. Active fishes such as hoeven’s carp, asian red-tail catfish, and hard-lipped barb are always moveable to look for food. Based on food habit, wild fishes could be grouped into three, namely: herbivourous fish relying on plant materials as a nutrient source, carnivorous fishes mostly feeding animal protein, and omnivororous fishes being able to feed both plant and animal proteins. Snake-head and knife-fish are true carnivorous, and the rest are omnivororous tending to herbivorous.

In captive, food habit of all fishes basically could be changed. These fishes could be trained gradually their food habit to grasp an artificial diet. Their growth performance will depend on the quality of diet and quantity as well. The quality of diet affects on balance and complete nutrient in diet, relates to protein-essential amino acids (EAA), fat-essential fatty acids (AFA), carbohydrates, and various vitamins and minerals as well. Protein and EAA should be considered in diet formulation. Brooder fishes in general require relatively high protein of 35-40% to support protein body and gonad as well. Maintaining energy requirements for daily activity of the brooders should be provided in diet, and its energy source is avoided from protein, but from fats and carbohydrates. Ratio of energy and protein in diet ranges 8-10 kcal per g protein.

Fat and AFA are required for gonado development, and reproduction process of the brooder [25], and for embryological development of larvae. Freshwater brooder fishes generally need linoleat fatty acid and linolenat in an enough amount and a balance for gonado development, but each fish varies in number [26]. Brooders of catfish-pangaside (Pangasius sp) and Asian red-tail catfish require a diet containing fat at a respective level of 4% [27] and 12 - 14% [28]. According to [27], lack and/or over ratio of fatty acid of n-3 and n-6 in yolk eggs of fish larvae will affect on inhibition of embryology development of the larva.

3.3. Diet formulation for brooder native fish species

Artificial feed is formulated using various ingredients to fill requirements of energy and essential nutrients (EAA, EFA, vitamins and minerals) of brooder of native fishes. These nutrients are bounded in various ingredients. Feed ingredients and their composition in feed must considered capability of fish to digest them and availability of essential nutrients. In diet formulation, ingredients containing essential should be considered such as fish meal and soybean cake meal as sources of protein and EAA, oils of fish and plant as source of fat and EFA, vitamins (E and C) and minerals. Adding attractant and yeast in the diet formulation is recommended [29]. Besides, considering anti nutrient factors at minimum level, fiber and ash at a maximum level in diet formulation to increase feed digestion is necessary. The SNI-for fish feed could be used as a reference. Feed price is not a problem for formulating the brooder feed.

Jelawat juvenile was brought to Bogor, from East Kalimantan, raised in a concrete pond and fed on commercial feed (protein 26-28%). After the next ten years, the fish grew up to 3 kg in individual weight and successfully spawned artificially using hormone treatment during the rainy season [30]. In 1980, candidate of brooder of Hoeven's carp was about 1.5 kg in individual weight raised in floating wooden cage. The cage was 5x2x1.5 m in dimension size with 50 fish per cage in oxbow-lake Mudung, Jambi and fed on a commercial diet (protein 26-28%) for a year did not develop their gonad at maturation level [31]. After feeding commercial feed changed to formulated feed having protein of 35% and added fresh Ipomea sp weekly, the gonadal brooder was matured [32] and the fish could be spawned artificially at any time using hormone injection [33,34,32,35]. Up to now, the technology of juvenile production of Hoeven’s carp has widely been developing in West Kalimantan [36,37] and other provinces of Indonesia.

Knife fish. This carnivorous fish plays an significant role in Sumatera and Kalimantan as a material for using traditional human food [2] and exotic fish [38]. Brooder of knife fish was raised in pen set in swampy area in South Sumatera and fed on natural food for gonado maturation [39]. Also, the knife fish could be spawned naturally during rainy season. According to [40], the big size of knife fish
preferred live food such common carp, nile tilapia and prawn in small size. Application of feeding these live food in pond in swampy area indicated that the knife fish could be spawned naturally and/or semi-naturally using hormone treatment at any time kolam [41]. The brooder pond was covered by water hyacinth (Eichhornia crassipes) at much as 50% of total pond area.

Asian red-tail catfish. This species was available in Sumatera, Kalimantan, and Java. Domestization program of this species has been conducted in Research Institute for Inland Water Fisheries, Palembang since 1981 and continued since 2000 in Bogor. Feeding an artificial diet containing 30-40% protein resulted in gonadal development at a maturation level during the rainy season. Since 2016, feed formulated using local ingredients to have protein of 35% and the ratio of n-3 and n-6 at 1:1 and given to the brooder produced matured gonad at any time and could be spawned every 20-30 days [42]. Value of survival activity index (SAI) was up to 10 days. This formulated diet have been applied in West Java (Districts of Cianjur, Bogor, and Majalengka).

Kissing gouramy, this species inhabited in the swampy area and tended to grasp plankton [43]. Spawning this species was during the rainy season. In the pond, kissing gouramy was raised traditionally, relying on natural food and rice-brain as supplementary diet. In the captive tank, this species could be spawned in semi-natural using hormone treatment at any time after feeding a formulated diet containing protein of 37-42%. Relative fecundity of this species was about 26,000 eggs per 100g fish weight.

Hard-lipped barb. This species is a herbivore. Spawning this species is easy using the natural method. In culture condition, feeding formulated diet containing protein 30% produced gonadal development at a mature level monthly [44].

Snake-head. Beside for human consumption, snake-head have been used as biomedical material of albumin [4]. This situation brings to increase market demand of the snake-head. In culture, the snake-head accepted commercial feed after being adapted in those feed that produced gonadal development at a maturation level. The brooder of snake-head could be spawned using natural method and semi-natural using hormone treatment at the rainy season [45].

3.4. Artificial diet for larvae and juvenile
A critical phase in the life cycle of fish is on the larvae stage. Yolk-egg of larvae is a primary source of nutrient required by the larvae, but before yolk sac empty, the nutrient source for larvae was gradually replaced by natural food and then changed artificial diet after 30 day-olds of the larvae. Feeding strategy on larval rearing is necessary i.e., Hoeven's carp [46,47]. Plankton collected from greenish pond or chicken yolk eggs emulsion could be fed on the Hoeven's carp larva as an initial feed for 14 days old larvae rearing [48], changed by the combination of Tubifex sp live and artificial feed at 1:1 in a ratio. After 40 days old, the juvenile required a diet containing protein of 38-40% [49,50] that fed as much as 10% of biomass a day [51], divided at five times a day[52].

Larvae of any fish species are carnivorous habit, and if lack of diet, they tend to prey each other, including snakehead [53,54,55] resulted in mortality rate of up to 70 % [56,57]. Feeding live food of Moina sp on snake-head larvae raised in greed media containing live of Chlorella sp at twice a day increased its survival up to 93.42% [58]. Transition feeding period of the snake-head of 30-day old using a combination of artificial diet (protein 40%) and Tubifex sp dried at 1:1 could increase its survival and growth performance [59]. Juvenile of snake-head required protein of 35% in the diet [60]. Live food of Artemia sp is used to feed on larvae of any fish in hatchery. The use of Artemia sp could be reduced by direct stocking of larvae at seven days old in the fertilized pond [61]. This ponds could be fertilized using urea dan TSP at a respective rate of 1.5 kg N dan 0.75 P per m2 per day for reducing protein diet from 30% up to 25% [50], and in line to increase stocking rate at an optimum level (Sunarno and Yakupitiyage 2002).

4. Conclusion
Artificial feed containing protein at 35-40% could be fed on native fish species of Hoeven's carp (Leptobarbus hoevenii), Asian redtail catfish (Hemibagrus numerous), and kissing gourami (Helostoma temmincki), and snakehead (Channa striata), but at 30% for hard-lipped barb (Osteochilus
hasselti). Knife-fish (Chitala lopis) still relied on live food of fish at a small size. These feed could increase gonad maturation at any time. At larvae rearing under controlled condition, live food of Moina sp enriched by Chlorella sp, Artemia sp, or Tubifex sp could be feed as an initial diet for the larvae. Reducing this natural diet could be executed with direct stocking larvae at seven days old to fertilized ponds.

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