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Reservoir Fishery Management and Development in Asia

Proceedings of a workshop held in Kathmandu, Nepal, 23–28 November 1987

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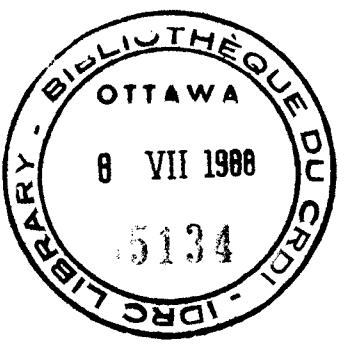

Postal Address: P.O. Box 8500, Ottawa, Ont., Canada K1G 3H9

De Silva, S.S.

Nepal. Dept. of Agriculture, Fisheries Development Section NP XP
IDRC, Ottawa, Ont. CA XN

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ABSTRACT

This publication presents the results of an IDRC-funded workshop held in Kathmandu, Nepal, 23-28 November 1987. Representatives from 15 countries reviewed the status of reservoir fishery research in Asia under the following topics: existing fisheries, limnological aspects, biological and resource aspects, management aspects, and culture. Papers were presented on these topics, but the discussion sessions were the main element of the workshop. Summaries of these discussions as well as a series of general recommendations that were generated during the final discussion are presented in this book. The potential for increased fish production in reservoirs and the need for early involvement of fisheries scientists in the planning and preimpoundment studies before dam construction are emphasized.

RÉSUMÉ

Cet ouvrage présente les résultats d'un atelier financé par le CRDI à Katmandou, au Nepal, du 23 au 28 novembre 1987. Des représentants de 15 pays ont examiné l'etat de la recherche sur l'élevage du poisson en étangs en Asie, en particulier les aspects suivants : les systèmes actuels, les aspects limnologiques et biologiques, les ressources, la gestion et l'élevage. Des exposés ont été présentés sur ces sujets, mais les discussions ont été l'élément le plus important de l'atelier. L'ouvrage présente également un résumé des discussions ainsi que les recommendations générales issues de ces discussions. On met l'accent sur la possibilité d'augmenter la production de poissons en étangs et la nécessité pour les ichtyologistes de participer trés tôt aux études de planification, notament de la mise en étangs du poisson, qui précèdent la construction d'un barrage.

RESUMEN

Esta publicación presenta los resultados de un taller auspiciado por el CIID en Kathmandu, Nepal, del 23 al 28 noviembre de 1987. Representantes de 15 países analizaron el estado de la investigación sobre pesquería asiática en embalses desde los siguientes ángulos: pesquería existente, aspectos lomnológicos, aspectos biológicos y de recurso, aspectos de manejo y cultivo. Las ponencias versaron sobre estos temas, pero las sesiones de discusión fueron el principal elemento del taller. Este libro ofrece los resúmenes de estas discusiones, así como una serie de recomendaciones generales emanadas de ls discusión final. Se subraya el potencial para incrementar la producción pesquera en embalses y la necesidad de una participación temprana de los científicos del área en la planificación y los estudios de apropiación que anteceden a la construcción de represas.

CONTENTS

SOME BIOLOGICAL ASPECTS OF THE PREDOMINANT FISH SPECIES IN THE JATILUHUR RESERVOIR, WEST JAVA, INDONESIA

Atmadja Hardjamulia, K. Endi Setiadi, and N. Sweta Rabegnatar

Research Institute for Freshwater Fisheries, Agency for Agricultural Research and Development, Bogor, Indonesia

Abstract *Five of around 20 autochthonous fish species, i.e., "hampal" (Hampala macrolepidota), "jambal" (Pangasius pangasius), "tagih" (Puntius bramoides), "tawes" (Puntius gonionotus), and "lalawak" (Puntius bramoides) are the predominant species in the 8300-ha, multipurpose Jatiluhur Reservoir in West Java, Indonesia. Some biological aspects of these species, i.e., distribution, food and feeding habits, spawning, growth, and population dynamics are described. The effects of the extensive fluctuations in water level on these biological aspects are evaluated. The reservoir, estimated to have an average annual fish production of 27.8-30.2 kg/ha and a present total production of 451.9 t/year, seems to have reached its optimum level of production. A knowledge of the biological aspects of the predominant species of the reservoir is of prime importance to ensure effective fishery management.*

The Jatiluhur Reservoir, also known as the Juanda Reservoir, was formed by damming the Citarum River. Construction of the dam was completed in 1965. It is a multipurpose reservoir primarily intended for agricultural and hydroelectric-power purposes and, secondarily, for fisheries. The reservoir is 107 m above sea level and surrounded by a limestone chain of mountains. It has a maximum water surface area of 8300 ha, a maximum depth of 95 m, an average depth of 36.4 m, and an average slope of 30% (Anon. 1974). Being a multipurpose reservoir, the water level fluctuates greatly. The highest and lowest water levels may differ by 20 m.

Fisheries activities started as soon as the reservoir was formed in 1965. By 1985, there were 350 full-time and 150 part-time fishermen. Gill nets, long lines, cast nets, lift nets, and scoop nets are utilized. Under stable conditions, the average annual production of the reservoir is 27.8-30.2 kg/ha (Kartamihardja 1985). The present total production (451.9 t/year) has likely reached an optimum level (Kartamihardja 1987).

The reservoir contains at least 20 autochthonous species and 8 exogenous species introduced for stocking purposes (Kartamihardja 1987). The fish population was initially dominated by predatory species. Efforts were made to improve the predator/prey ratio by stocking the reservoir with herbivorous "tawes" (Puntius gonionotus).

The efforts have improved the predator/prey ratio from 65:35 in 1982/83 to 55:45 in 1984/85 to 45:55 in 1985/86 (Kartanihardja 1985).

The fish species that dominate and contribute substantially to the production of the reservoir are "hampal" (Hampala macrolepidota), "tawes" (Puntius gonionotus), "tagih" (Macrones nemurus), "lalawak" (Puntius bromoides), "jambal" (Pangasius pangasius), and "nila" (Oreochromis niloticus). Therefore, a knowledge of the biological aspects of these species is important for the rational management of the reservoir. This paper describes the major biological aspects of these species and suggests methods of applying this knowledge to the management of the reservoir.

Biological Aspects

Hampal

Hampal (Hampala macrolepidota) are responsible for the major portion of the total fish catch of the reservoir. They are carnivorous. In the Ogan Komering River and Lake Cangkuang in Sumatera, they feed on fish, prawns, insects, and larvae (Vaas et al. 1953). In the reservoir, the main food of hampal measuring 185-507 mm and weighing 90-1420 g are fish, crustaceans, and insects (Rahardjo 1977). Hampal weighing 115-180 g feed mainly on Daphnia sp., Macrobrachium sp., fish, insects, and insect larvae (Tjahjo 1985). The predatory hampal becomes piscivorous when it reaches 200 mm.

Like other cyprinids, adult hampal migrate upstream to spawn at the beginning of high water (Soehardi 1971). In the reservoir, hampal spawn at the beginning of the rainy season, i.e., September-October (Achmad 1970) or August-October (Rahardjo 1977). The fecundity of hampal measuring 206-507 mm ranges from 5,398 to 56,109 eggs: $\log F = -1.4039 + 2.2056 \log L$ ($r = 0.78$), where F is the fecundity (eggs) and L is the total length (millimetres). Hampal growth is isometric (Table 1); therefore, at the same total length, the female hampal tends to be heavier than the male.

Jambal

Jambal (Pangasius pangasius) grow well in the reservoir and their population has increased over the last 10 years. It has been spawned using the hypophyseal technique (Ondara 1986). Using the "relative importance index" (Kartamihardja 1977), jambal measuring 125-795 mm and weighing 30-3700 g were found to feed mainly on crustaceans, insects, molluscs, rotifers, algae, and, rarely, small fish, i.e., "teri" (Chela oxygastroides) and "paray" (Rasbora argyrotaenia). In the Ogan Komering River of southern Sumatera, jambal feed on aquatic plant material, insects, insect larvae, and bottom worms (Vaas et al. 1953). In the estuarine Matlas and Kulti in India, jambal feed on the remains of organisms, aquatic insects, molluscs, crustaceans, isopods, and amphipods and are not piscivorous (David 1963). This diverse variety of foods seems to indicate that jambal are mainly omnivorous, but may also feed on small or dead fish.

In the Hooghly River in India, the ovaries of jambal begin to mature when the fish reaches a length of 790 mm (David 1963). In the

Table 1. Length-weight relationships of the six predominant species of the Jatiluhur Reservoir.

Species	n	Length (L) (mm)	Weight (W) (g)	L-W relationship	r	Growth[a]
Hampala macrolepidota[b]						
Male	-	185-340	90-500	$W = (2.33 \times 10^{-5}) L^{2.8821}$	-	Isometric
Female	-	198-507	100-1420	$W = (3.18 \times 10^{-5}) L^{2.8242}$	-	Isometric
Pangasius pangasius						
Male	-	125-560	40-1250	$W = (1.41 \times 10^{-5}) L^{2.9204}$	-	Isometric
Female	-	145-795	30-3700	$W = (1.78 \times 10^{-5}) L^{2.8814}$	-	Isometric
Macrones nemurus[c]	100	145-550	35-3450	$W = (4.90 \times 10^{-6}) L^{3.2099}$	0.988	Allometric
Puntius gonionotus	150	145-405	40-1405	$W = (4.13 \times 10^{-6}) L^{2.2311}$	0.995	Allometric
Puntius bromoides	106	100-260	20-260	$W = (5.53 \times 10^{-5}) L^{2.7592}$	0.953	Allometric
Oreochromis niloticus	63	135-440	50-2000	$W = (3.69 \times 10^{-5}) L^{2.8992}$	0.993	Isometric

[a]Growth is isometric if factor b in the L-W relationship ($W = aL^b$) equals 3; if factor b does not equal 3, growth is allometric.

[b]Source: Kartamihardja (1977).

[c]The condition factor (weight/length^3) of tagih, especially the female fish, varies from 0.404 to 0.556 depending on the season.

reservoir, however, the ovaries of jambal measuring 795 mm and weighing 3700 g are only at stage III of gonadal maturation; gonadal maturity is attained when the fish measures 1000 mm and weighs over 6000 g (Kartamihardja 1977). The fish are believed to spawn in the upper area of the reservoir in the deeper part of the Citarum River around the beginning of the rainy season (Anon. 1973; Kartamihardja 1977). The mature brood fish migrate to the Citarum River to spawn and their larvae and fry are washed downstream into the reservoir by the current. The male/female ratio at the beginning of rainy season is 1:1. Jambal growth is isometric; therefore, at the same total length, the female jambal tends to be heavier and larger than the male.

Tagih

Eight species of Macrones have been recorded in the rivers and lakes of Indonesia. In Kalimantan and southern Sumatera, tagih (Macrones nemurus) are cultured in cages in rivers. In the Jatiluhur Reservoir, Macrones nigriceps and Macrones micracanthus are found in addition to tagih. Tagih are found mainly in the upper area of the reservoir around the Citarum River inlet.

The food and feeding habits of tagih in the reservoir have been studied by Sastrawibawa (1979). This species feeds on crustaceans, fish, and insects. In the Kapuas River in Kalimantan, Vaas et al. (1953) reported that tagih fed on cladocerans, copepods, rotifers, insects, insect larvae, crustaceans, fish, and crabs, making tagih an omnivorous predator. In the Jatiluhur Reservoir, studies indicate that tagih are carnivorous and predatory.

The long genital papilla of male tagih distinguishes it from the female, which possesses a round papilla. In the reservoir, the fish spawn from October to March in the Citarum River or in the upper, muddy-bottom region of the reservoir; the male/female ratio is 1:1. The eggs are buried in the mud. A fecundity of 64,769 eggs of 0.5-1.7 mm diameter has been observed (Sastrawibawa 1979). Female fish reach maturity at a length of around 320 mm (Djajadiredja et al. 1977). Tagih growth is allometric (Table 1).

Tawes

Tawes (Puntius gonionotus) is an important species of the rivers and lakes of Java, Sumatera, and Sulawesi. It is also a common cultured species. The fish can live up to 800 m above sea level at a minimum temperature of 15°C; its optimum temperature range is 25-35°C (Djajadiredja et al. 1977).

In the reservoir, the fish are derived from both the Citarum River and stocking. The species has successfully adapted to the environmental conditions of the reservoir and is becoming the most dominant species in the reservoir. Tawes are naturally herbivorous. In the reservoir, they feed on plant and animal matter, detritus, and planktonic copepods (Cyanophyceae and diatoms). Smaller tawes feed mainly on unicellular algae and zooplankton.

Like most other cyprinids, tawes spawn at the beginning of the rainy season in the upper, shallow areas of the reservoir, especially in areas that were dry during the previous low water. Sexually mature

tawes are usually found from August to November. Tawes grow allometrically (Table 1).

Lalawak

Lalawak (Puntius bromoides) in the reservoir are derived from the Citarum River. They can reach a length of 400 mm and a weight of 500 g. The fish caught by fishermen usually range from 145 to 300 mm and from 50 to 400 g.

Sutardjo (1980), who studied the feeding habits of lalawak in the Jatiluhur Reservoir based on an "index of prepondarance," found that the fish feed primarily on detritus and plant matter and secondarily on crustaceans, insects, Bacillariophyceae, "particulate matter," protozoans, and Chlorophyceae. Based on the abundance of food types, the fish are omnivorous. The index of prepondarance indicates that the fish feed mainly on plants in September and December and on detritus in October.

Like tawes, lalawak spawn at the beginning of the rainy season (August) in the upstream areas of the reservoir that have just been submerged by high water. Lalawak grow allometrically (Table 1).

Nila

Nila (Oreochromis niloticus) were first imported in 1969 and are now found throughout Indonesia. The fish were introduced into the reservoir in 1972 and, in 1976, they accounted for 0.2% of the total fish catch. Nila grows fast and reach a maximum length of 500 mm and a maximum weight of 3000 g.

Nila are omnivorous, feeding on detritus, phytoplanktonic diatoms and Chlorophyceae, zooplanktonic copepods, cyclopods, and soft plant particulate matter. The most dominant food groups are detritus and plankton.

In the reservoir, sexually mature nila are usually found from July through September and especially in August. Fecundity ranging from 1950 to 4550 eggs has been recorded for a female nila measuring 200-260 mm. The oval eggs were 2.95-2.98 mm in diameter and 1.95-2.30 mm in width. Sexual maturation may occur when the fish reaches a total length of 190 mm. In the reservoir, their spawning grounds have been noted at Ubrug, Pegadungan, Sukasari, Cimanggu, Cidadap, and Warung Jeruk. During high water, schools of nila fry have frequently been noted in these areas. Nila grow isometrically (Table 1).

Fish Population Dynamics

The biological aspects of the predominant fish species are reflected in the population dynamics of the reservoir. During the early life of the reservoir, the total fish production was as low as 41 t/year. Three years after the creation of the reservoir, total fish production increased to 310 t/year. In subsequent years, production decreased, probably because of a decreasing food supply and the failure of certain fish species to adapt to the environmental conditions of the reservoir, retarding growth and propagation. Only 6

of the 20 autochthonous fish species initially inhabiting the reservoir, i.e., hampal (Hampala macrolepidota), tagih (Macrones nemurus), jambal (Pangasius pangasius), tawes (Puntius gonionotus), lalawak (Puntius bromoides), "genggehek" (Mystacoleucus marginatus), and the small fish species paray (Rasbora argyrotaenia), teri (Chela oxygastroides), and "bobosok" (Stigmatogobius bimaculatus), have been found to grow and propagate well in the reservoir. "Arengan" (Labeo crysophaekadion), which, up to 1979, were caught in appreciable numbers, are no longer among the predominant species of the Jatiluhur Reservoir.

The ratio of predator fish (P) to prey fish (F) was probably also responsible for the decrease in fish production. Subsequent stocking of the reservoir improved the P/F ratio from 65:35 in 1982/83 to 45:55 in 1985/86. A balanced P/F ratio was expected because of the increasing prey-fish populations of tawes and nila. Tawes grow and adapt well in the reservoir probably because of their ability to feed on detritus.

Biological Management

Knowledge of the biology of the predominant fish species in the reservoir is important to ensure rational fishery management. Based on this biological knowledge, certain management measures can be implemented to maintain the maximum sustainable yield of the reservoir and conserve resources. Such measures may include restocking of the reservoir to maintain a balanced P/F ratio, controlling fishing seasons as related to spawning seasons, controlling types and mesh sizes of fishing gear, and establishing natural fish reserves to protect brood fish and their fry. All of these measures have been applied at the Jatiluhur Reservoir with promising results. However, the biological behaviour of the fish species, the population dynamics, and the environmental conditions of the reservoir must be closely monitored to ensure continued effective management of the reservoir.

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