Reservoir Fishery Management and Development in Asia

Proceedings of a workshop held in Kathmandu, Nepal, 23–28 November 1987
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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'état 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 recommandations 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 très tôt aux études de planification, notamment 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 limnológicos, 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 la 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.
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GROWTH OVERFISHING: A POTENTIAL DANGER IN THE SRI LANKAN RESERVOIR FISHERY

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National Aquatic Resources Agency, Crow Island, Colombo 15, Sri Lanka

Abstract The status of Oreochromis mossambicus was investigated in the fisheries of five man-made reservoirs in Sri Lanka. A declining trend in the mean landing size of O. mossambicus over the last three decades, at least in the case of one reservoir, indicates overexploitation. The data suggested that the mean body condition of O. mossambicus, measured as the theoretical weight of a 20-cm individual (W20) is negatively correlated (p < 0.05) to the percentage of undersized (20 cm) O. mossambicus in the commercial catches. The low stock abundance of O. mossambicus in some reservoirs of which the body condition is poor is possibly due to catching individuals before they attain a reasonable size. This situation, called "growth overfishing" is a potential danger in most of the reservoirs in Sri Lanka. The importance of maintaining a minimum catch size (20 cm) of O. mossambicus is discussed.

The low cost and high potential for protein production of freshwater fisheries in rural communities, have compelled Sri Lanka to focus on the development of inland fisheries. The inland fisheries of Sri Lanka are almost entirely confined to man-made reservoirs that were constructed for irrigation and hydroelectric purposes.

Since its introduction to Sri Lanka in 1952, Oreochromis mossambicus (Peters), an exotic cichlid, has played a major role in inland fish production. De Silva (1985a) has shown that O. mossambicus accounts for between 56 and 99% of the total fish yield in individual reservoirs and that, in most reservoirs, the percentage contribution of this species to production is more than 70%. Although invaluable contributions have been made to the development of reservoir fisheries in Sri Lanka (Fernando 1971, 1977; De Silva and Fernando 1980; De Silva 1983, 1985a), the information on reservoir fisheries management is inadequate. A declining trend in the mean landing size of O. mossambicus has been recorded in Parakrama Samudra, a Sri Lankan man-made reservoir (De Silva 1985a). However, in Sri Lankan reservoirs, no attempt has been made to investigate the effect on fish production of catching small, young fish ("growth overfishing") (Gulland 1983). This paper highlights and discusses the potential danger of growth overfishing in the reservoir fisheries of Sri Lanka.
Table 1. Some morphometric characters of the reservoirs, catch per unit effort (CPUE) for all species as well as Oreochromis mossambicus (O.m.), and sampling periods in individual reservoirs.

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Surface area (ha)</th>
<th>Depth (m)</th>
<th>CPUE (kg/net piece per day)</th>
<th>Sampling period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>All species</td>
<td>O.m.(^a)</td>
</tr>
<tr>
<td>Kaudulla</td>
<td>2537</td>
<td>9.1</td>
<td>1.624</td>
<td>0.576 (35.5)</td>
</tr>
<tr>
<td>Minneriya</td>
<td>2560</td>
<td>11.7</td>
<td>1.487</td>
<td>1.012 (68.1)</td>
</tr>
<tr>
<td>Parakrama Samudra</td>
<td>2662</td>
<td>7.6</td>
<td>0.941</td>
<td>0.659 (70.0)</td>
</tr>
<tr>
<td>Pimburettewa</td>
<td>834</td>
<td>7.3</td>
<td>1.339</td>
<td>1.205 (90.0)</td>
</tr>
<tr>
<td>Tabbowa</td>
<td>462</td>
<td>4.0</td>
<td>1.145</td>
<td>0.438 (38.2)</td>
</tr>
</tbody>
</table>

\(^a\)Values in parentheses represent the percentage of the CPUE accounted for by O. mossambicus.
The Fisheries

The five reservoirs studied are located in the dry zone of Sri Lanka, receiving less than 195 mm/year of precipitation (Table 1). Except in Pimburettewa, the mesh sizes of gill nets used range from approximately 76 to 140 mm. Mesh sizes below 102 mm are not permitted in the Pimburettewa fishery according to the regulations imposed by the fishermen (Amarasinghe 1987). In Parakrama Samudra, however, even some 69-mm mesh gill nets are used sporadically. In all the reservoirs, some fishermen beat the water with wooden poles from their nonmechanized, fiber glass, outrigger canoes to drive the fish toward the gill nets. This fishing technique is called "water beating" (Amarasinghe and Pitcher 1986). In Tabbowa, 76-mm mesh trammel nets made with 150-mm mesh outer net screens are used in the water-beating technique. In addition to this method, during the low-water months, the water beating is practiced in shallow areas of the reservoir using monofilament, 102-mm mesh gill nets and 76-mm mesh gill nets whose height exceeds the water depth in the fishing area. These fishing methods are more efficient than normal gill netting. During low-water seasons, beach seining, which is illegal, is carried out in Minneriya Reservoir in addition to normal gill netting and the water-beating technique.

Materials and Methods

Monthly length-frequency statistics of O. mossambicus (total length to the nearest 0.5 cm below actual length) were collected from the fish-landing sites of the five reservoirs studied (Fig. 1). The catches of all the practiced fishing methods were accounted for in the length-frequency data. Sampling periods in individual reservoirs varied (Table 1).

Catch per unit effort (CPUE) values for normal gill net fisheries are used to compare stock abundances in individual reservoirs (Table 1). Amarasinghe and Pitcher (1986) have shown that the best formulation of CPUE for the gill net fishery of Parakrama Samudra is catch per net piece per day; therefore, the same version of CPUE, which permits effort to be standardized, was used for all the reservoirs in this study.

Samples of O. mossambicus obtained from the commercial catches of Parakrama Samudra (148 fish) and Tabbowa (90 fish) during different months of the study period, packed in ice, were taken to the laboratory to determine total length (to the nearest 0.1 cm), somatic weight (to the nearest 0.1 g), and sex. The gonads of the females were grouped into six maturity stages according to Chandrasoma (1980). The percentage of mature females (stage III and above) in each length group (centimetre) of the Parakrama Samudra and Tabbowa reservoirs were calculated and the length at 50% maturity ($L_m$) was determined. The results are compared with data from three other Sri Lankan reservoirs (Table 2).

*Oreochromis mossambicus* enters the fishery in its 3rd year (De Silva 1985b; Amarasinghe 1977). Fish smaller than 20 cm, which corresponds to approximately 2 years of age (De Silva and Senaratne 1987; Amarasinghe 1987), were considered undersized.
**Fig. 1.** Length-frequency distribution of *O. mossambicus* in the commercial catches of five Sri Lankan reservoirs (n, number of fish measured).

**Table 2.** Body condition ($W_{20}$), maturity size ($L_m$), and percentage of *Oreochromis mossambicus* (O.m.) below 20 cm in the commercial catches of different reservoirs.

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>$W_{20}$ (g)</th>
<th>$L_m$ (cm)</th>
<th>&lt; 20 cm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaudulla</td>
<td>143.4$^{a}$</td>
<td>21.0$^{b}$</td>
<td>48.4</td>
</tr>
<tr>
<td>Minneriya</td>
<td>139.8$^{a}$</td>
<td>19.5$^{b}$</td>
<td>30.2</td>
</tr>
<tr>
<td>Parakrama Samudra</td>
<td>138.7</td>
<td>16.1</td>
<td>58.6</td>
</tr>
<tr>
<td>Pimburettewa</td>
<td>160.5$^{a}$</td>
<td>20.5$^{b}$</td>
<td>2.5</td>
</tr>
<tr>
<td>Tabbowa</td>
<td>138.2</td>
<td>15.5</td>
<td>61.7</td>
</tr>
</tbody>
</table>

$^a$Source: De Silva (1985c).
$^b$Source: De Silva (1986).

**Results**

Logarithmic total length - somatic weight relationships were computed for the *O. mossambicus* populations in Parakrama Samudra and Tabbowa. The relationships in both reservoirs were significant at the
0.1% level and are described by the following equations:

Parakrama Samudra

\[ \log_{10} W = \log_{10} 0.028 + 2.841 \log_{10} TL \ (r = 0.971) \]

Tabbowa

\[ \log_{10} W = \log_{10} 0.032 + 2.792 \log_{10} TL \ (r = 0.945) \]

where \( W \) is the somatic weight (grams) and \( TL \) is the total length (centimetres). The body condition of \( O. mossambicus \) in each of these reservoirs was expressed as the mean theoretical weight of a 20-cm individual (\( W_{20} \)), calculated using the above regression equations.

The mean body condition (\( W_{20} \)) of \( O. mossambicus \) in different reservoirs was negatively correlated to the percentage of undersized (<20 cm) \( O. mossambicus \) in the commercial catches according to the following relationship:

\[ Y = 157.73 - 0.3381X \ (r = -0.8804, \ p < 0.05) \]

where \( Y \) is \( W_{20} \) (grams) and \( X \) is the percentage undersized fish in the commercial catches. This relationship is only based on five reservoirs (\( df = 3 \)). Therefore, although a trend is suggested, more data are required from other reservoirs. No significant relationship was apparent between \( L_m \) and the percentage of undersized \( O. mossambicus \) (Table 2).

Discussion

Oreochromis mossambicus was the dominant fish species in Sri Lankan reservoirs until the late 1970's (De Silva 1985a). This study indicates that the contribution of this species is now less significant in Kaudulla and Tabbowa (Table 1). When the overall fish production is taken into account, Oreochromis niloticus, another exotic cichlid species, is the major species in these reservoirs (personal observation). The reason for the dominance of \( O. niloticus \) in these two reservoirs is unclear. Perhaps, after stocking with \( O. niloticus \) fingerlings, the conditions in these reservoirs were more favourable to this species. Chandrasoma (1986) reported that in Sorabora Wewa, another man-made reservoir in the dry zone of Sri Lanka, \( O. niloticus \) became the dominant species 4 years after its introduction. After this reservoir was drained a few years ago, it was refilled and stocked with \( O. niloticus \) fingerlings.

The low CPUE for \( O. mossambicus \) in Parakrama Samudra and Tabbowa (Table 1) indicates a low stock abundance for this species. In 1957, when the less-efficient cotton gill nets were in wide use (Indrasena 1965), the mean landing size of \( O. mossambicus \) in Parakrama Samudra was 34.2 cm; by 1978, it had declined to 21.8 cm (De Silva and Fernando 1980). The present study has revealed a further decline to 21.0 cm in 1985-86. This confirms the suspected overexploitation of \( O. mossambicus \). However, in shallow water bodies, the cichlids are said to maintain their reproductive capacity at its original level by changing their growth rate and maturity size, even at high mortality levels (Iles 1973). Hence, even at high fishing rates, recruitment
failures may not result in *O. mossambicus* populations in shallow reservoirs in Sri Lanka. The von Bertalanffy growth constant \((K)\) of *O. mossambicus* populations in 11 Sri Lankan reservoirs ranges from 0.32 to 0.7 (De Silva and Senaratne 1987; Amarasinghe 1987), indicating a varying growth rate from reservoir to reservoir.

Lowe-McConnell (1982) states that body condition and maturity size are indices of stunting in cichlids. De Silva (1985c) and the present study found that the body condition \((W_g)\) of *O. mossambicus* populations in some major reservoirs of Sri Lanka ranged from 138.2 to 167.8 g. In addition, the mean maturity size of female *O. mossambicus* in Parakrama Samudra has declined from 17.5 cm in 1978 (De Silva and Chandrasoma 1980) to 16.1 cm in 1985 (Table 2). From the information on growth rate, body condition, and maturity size, it is evident that *O. mossambicus* populations in some Sri Lankan reservoirs, if not stunted, are in danger of becoming stunted.

"Recruitment overfishing" (Guilland 1983) is unlikely for *O. mossambicus* in shallow, Sri Lankan reservoirs because the stocks can withstand high fishing mortality rates through their reproductive resilience. The problem of overexploitation of *O. mossambicus* populations, at least in Parakrama Samudra, therefore, is likely due to growth overfishing. Of the five reservoirs studied, low stocking densities and poor body conditions of *O. mossambicus* are found in Parakrama Samudra and Tabbowa. The relationship between body condition and percentage of undersized *O. mossambicus* in commercial catches (Table 2) indicates that a reduction in landing size results in poor body condition.

Conclusions

Catching smaller *O. mossambicus* has led to a depletion of fish stock sizes in some reservoirs and is a potential danger in other reservoirs in Sri Lanka. Unless measures are implemented to enforce a minimum landing size for *O. mossambicus*, a combination of increasing demand for freshwater fish and growth overfishing may result in a drastically reduced fish production. According to De Silva (1985a), the fishing pressure in Parakrama Samudra (9.9 craft days/ha per year) is lower than that of Pimburettewa (23.4 craft days/ha per year). Nevertheless, Amarasinghe (1987) has shown that overexploitation is not evident in the Pimburettewa fishery, where the minimum mesh size for a gill net is 102 mm. Therefore, it appears that *O. mossambicus* populations in Sri Lankan reservoirs can withstand high fishing intensities if the mesh size of the gill nets is maintained at or above 102 mm. Also, gill net selectivity experiments in Parakrama Samudra (Amarasinghe 1988) have indicated that the minimum mesh size for the gill net should be increased from 76 to 102 mm for optimal utilization of *O. mossambicus*. The minimum landing size of *O. mossambicus* should be maintained at or above 20 cm through mesh-size regulations.

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