The Durability of Different Fish Cage Materials and the Pros and Cons of Cage Rotation

MIKKEL S. CHRISTENSEN

Background: Cage Durability

Wood and bamboo are widespread construction materials for fish cages in Southeast Asia, where both are common and affordable resources. One factor that seriously affects profit margins for cage enterprises is the durability of materials: frames and netting. This must be known in order to predict costs and to avoid material failure. Techniques have been proposed and tested to improve durability; e.g., sensitive to ultraviolet light may be covered with sacking material and/or be painted with tar and netting can be impregnated with anti-fouling and UV-resistant compounds (Beveridge 1987).

In East Kalimantan, Indonesia, ephemeropteran insect larvae *(Povilla corporaali)* [identified by Dr. J. Polhemus, Entomologist at the University of Colorado Museum] cause major damage to wooden and bamboo cages in freshwater. A design that allows a cage to be rotated should reduce the impact of these insects and fouling organisms, as all cage sections will be dried and wetted at periodic intervals. This approach has been applied successfully with net cages elsewhere (Beveridge 1987) and was tested in East Kalimantan using medang wood *(Litsea* sp.*)* chosen for preliminary trials on the durability of various locally available materials for cages (Table 1).

Durability Tests

Durability was estimated by constructing ironwood *(Euscleroxylon zwageri)* frames (1.5 x 1 m) onto which tested materials were attached. The frames were hung alongside a cage station and inspected biweekly over an 18-month period. All woods tested were dried for three to four months before use, whereas both freshly cut and dried bamboo (*Bambusia* sp.) were utilized. In addition, full-size net cages made of ironwood, medang, meranti *(Shorea* sp.*)*, kapur *(Dryobalanops lanceolata)* and bamboo were used for fish growth trials over several years and their durability compared with that of the frames. Cages were stocked throughout the trials with two cyprinids, *Leptobarbus hoevenii* and *Puntius schwanenfeldii*, at a density of 120 fish/m^3.

For a rotating-cage trial, eight-sided cages each with a submerged volume of 3 m^3 were constructed of medang wood. Duplicate cages were either not rotated, or rotated a one-quarter turn twice weekly, once a week, once every second week, or once every four weeks. After 18 months, four wood samples (250 x 15 x 15 mm) were taken from the same position on each cage and dried by placing on shaded racks for three weeks at ambient temperature. Subsamples were taken, dried at 60°C for 72 hours and analyzed for density at 0% moisture (DIN.52182,

The procedures described are standard methods used in the European Union to quantify wood quality. Samples used here were smaller than the standards laid down in the DIN-system (12 x 12 x 16 cm) as Litsea *is a small tree and planks of the required size are unobtainable. The use of equally sized samples means that the results presented here can be compared with each other but unfortunately not with data in the literature.*

Wood is dried first at ambient temperature in the shade to reduce moisture content to an even 11-12%. Part of the sample was then oven-dried to 0% moisture content and its specific density determined by weighing a subsample of 128 cm^3 (4 x 4 x 8 cm). Strength of expansion of the wood is determined as the percentage by which the wood sample can be pulled apart parallel and vertical to the grain before it breaks. Compression and bending strengths and elasticity are measured by compressing, bending and pulling wood sample in a machine specially designed to determine the forces required.

Table 1. Calculated unit construction costs and estimated durability for 9-m^3 floating cages fabricated of various materials for freshwater use.

Cage materials	Costs (Rp)[a]	Durability (months)	Comments
Natural materials			
Ironwood (*Euscleroxylon zwageri*)	180,000	36-48	heavy, scarce
Kapur wood (*Dryobalanops lanceolata*)	60,000	12	light, common
Medang wood (*Litsea* sp.)	75,000	18-30	light, common
Meranti wood (*Shorea* sp.)	60,000	12	light, common
Bamboo (*Bambusia* sp.)- fresh	45,000	3-4	rots rapidly
- dry	45,000	6-8	insect-prone
Rattan	-	3-6	rots rapidly
Netting materials			
Knotless, imported	300,000	48-60	all netting is
Blue, 2 mm barmesh	40,000	6-12	easily damaged
Black, 2 mm barmesh	40,000	12-18	by driftwood
Wiremesh materials			
Galvanized chicken wire mesh	50,000	3-4	all rust
Chromed squaremesh	50,000	4-5	rapidly

[a] Indonesian Rupiah (1992): US$1=Rp2,040

g/cm^3). Further subsamples were taken, with a moisture content of 11-12% at ambient temperature, and the strengths of expansion (DIN.52184, α_r radial and αt tangential in %), compression and bending (DIN.52185 and DIN.52186, β_d and β_b in N/mm^2) and elasticity (DIN.52186, E_b in N/mm^2) determined (see Box). These measurements were kindly carried out by Messrs. Maulana, Ramli and Scharai-Rad of the Department of Wood Science and Technology in the Forestry Faculty of Mulawarman University in Samarinda, East Kalimantan.

Table 2. Effects of rotating an eight-sided wooden-framed net cage on the quality of medang wood (*Litsea* sp.) after an 18-month culture period in freshwater: for explanation of wood quality terminology and units, see Box.

Treatment	Density (g/cm^3)	Expansion α_r (%)	Expansion α_t (%)	Strength β_b (N/mm^2)	Strength β_d (N/mm^2)	Elasticity E_b (N/mm^2)
New wood	0.72^a	4.23^a	8.71^a	84.1^a	46.7^a	12,103.5^a
No rotation	0.43^b	3.62^b	8.32^b	62.5^b	28.5^b	6,044.0^b
Rotated 2x weekly	0.46^c	3.76^b	8.42^b	69.0^c	36.8^c	8,506.0^c
Rotated 1x weekly	0.47^c	4.07^a	8.32^b	69.1^c	38.9^c	8,225.2^c
Rotated once biweekly	0.47^c	3.54^b	7.60^b	69.9^c	39.6^c	7,986.5^c
Rotated once in 4 weeks	0.43^b	3.71^b	8.40^b	63.5^b	31.3^b	7,484.0^c

* Figures in the same columns with different superscripted letters differ significantly from one another ($P<0.05$).

Results

Durability

The unit construction costs and durability of cages constructed of various materials are given in Table 1 and the effects on wood quality of rotating the cage in Table 2. The most effective construction material was medang wood. It was relatively durable (1.5-2.5 years) and a 9-m^3 cage cost Rp75,000 to build. *Litsea* spp. are relatively fast growing, common swamp species that cannot be used for other purposes, as they cause skin irritation and inflammation in birds, mammals and humans. No such negative effects were observed on fish.

Ironwood lasted twice as long, but is expensive and heavy. Ironwood cages are also difficult to maneuver. It is a scarce and valuable building material and the tree is slow-growing.

The monofilament nylon netting materials used were suitable, but were prone to damage by driftwood in large rivers and by some predators, as described by Beveridge (1987). In East Kalimantan, the moonrat and pufferfish (*Tetraodon* spp.) posed special problems for net cage culture. The moonrats are fish predators. They bite through the cage netting. Pufferfish were a lesser but still significant problem. They consumed *aufwuchs* growing on the cage net walls and their sharp teeth damaged the material.

Rotation

The effects of rotating cages on wood quality were significant (Table 2). The quality of cage wood after submersion was significantly lower than that of freshly-cut wood before use, irrespective of whether or not the former had been rotated. The wood from cages that had been rotated either once or twice weekly, or once every second week, was stronger than wood from cages that had been rotated every four weeks or not at all. Almost 20% of the frames in these last two cage categories were completely rotten after 18 months, whereas <2% of the others were in an equivalent condition.

Conclusions

Overall, there was considerable variation in the durability of these cage construction materials. Locally available mesh materials and bamboo lasted three to eight months. This contrasts with data on bamboo published elsewhere (Coche 1979; Beveridge 1987), where dried bamboo was described as lasting 1.5-2.0 years. The low durability observed in East Kalimantan was possibly due to the characteristics of the local bamboo species used or of the local water conditions, or both.

Although cage rotation here increased durability by 10-20%, this is not sufficient to make it of economic interest. The average medang wood cage lasts for two growing seasons (1.5-2.5 years) if maintained and repaired, whereas a rotated cage only lasts three to four months longer. This period is not as long as a full growing period, so that the fish would have to be transferred to a new cage, with the risk of fish loss during the transfer process from a weakened cage.

This was indirectly confirmed. Fish farmers in East Kalimantan observed the trials and tested the techniques of their own accord. They abandoned rotation after one growing season because, in their own words, the savings in wood costs did not compensate adequately for the time spent in building more complex cages and rotating them.

Acknowledgements

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH financed this work under the auspices of the TAD (Technical Cooperation for Area Development) rural development project in East Kalimantan, Indonesia.

References

Beveridge, M.C.M. 1987. Cage culture. Fishing News Books Ltd., Farnham, Surrey, UK. 352 p.

Coche, A.G. 1979. A review of cage culture and its application in Africa, p. 428-441. *In* T.V.R. Pillay and W.A. Dill (eds.) Advances in aquaculture. Fishing News Books, Farnham, Surrey, UK. 653 p.

M.S. CHRISTENSEN *is currently assigned by GTZ-GOPA as Project Leader of an inland fisheries development project in northeast Brazil (PAPEC, Caixa Postal 52731, CEP 60151.970 Fortaleza, Ceará, Brazil).*