FI:PNG/85/001
Field Document No. 17
March 1993

PAPUA NEW GUINEA

Sepik River Fish Stock Enhancement Project
PNG/85/001

Recommendations regarding fish species
suitable for stocking:

Recommendation # 9: the stocking of the "Pacu", *Colossoma bidens* Spix (Characidae), and responses from the advisory group regarding its suitability in-line with the code of practice regarding fish species transfers

compiled by

DAVID COATES
(Chief Technical Adviser)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome 1993

This report was prepared during the course of the project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

For bibliographic purposes this report should be referred to as: Coates, D. 1993. Recommendations regarding fish species suitable for stocking: Recommendation # 9: the stocking of the "Pacu", *Colossoma bidens* Spix (Characidae), and responses from the advisory group regarding its suitability in-line with the code of practice regarding fish species transfers. A report prepared for the Sepik River Fish Stock Enhancement Project. FI:PNG/85/001 Field Document 17, FAO, Rome. 20p.

Keywords:

Papua New Guinea, Sepik River, Ramu River, Fish Introductions, Fish Stocking, Rivers, Lakes

TABLE OF CONTENTS

1. INTRODUCTION

This document serves to archive the recommendation made by project PNG/85/001 to stock the Sepik-Ramu river system with the fish *Colossoma bidens* and the responses from the project advisory group in this regard. The project follows the code of practice regarding fish species transfers (Turner 1988). The project advisory group have been familiarised with the supporting documentation available on the requirements and technical background for stocking the river system. This document assumes familiarity with this information and should not be considered in isolation.

The background and justification for stocking the Sepik-Ramu is summarised in Coates (1990a) which lists further supporting technical details and information on the situation. At the time of publication, other fish species recommended for stocking have been detailed by Coates (1990b, 1991a, 1991b).

2. BACKGROUND

Three major trophic niches are currently under-exploited by native fishes in Sepik-Ramu lowland freshwaters: (i) detritus, (ii) aquatic macrophytes, and (iii) allochthonous inputs of fruit, seeds and other vegetable matter from terrestrial vegetation (Coates 1989; Piscivores are a fourth category lacking but such species are not recommended for stocking). The present recommendation relates to the latter potential food resource (allochthonous inputs).

Inputs of vegetable matter (especially fruits, nuts and other seeds) into rivers and lakes are a major source of food for a considerable number of relatively productive fish species in many tropical freshwater systems. Plant matter of terrestrial origin (including the aerial parts of aquatic plants emerging from swamps etc.) is practically unexploited by the Sepik-Ramu ichthyofauna (Coates 1989). The only species utilising this resource is the halfbeak *Zenarchopterus kampeni* which feeds on very small seeds, but mainly insects, falling onto the water surface from surrounding vegetation (Coates & Van Zwieten 1992). The Sepik halfbeak is insignificant to the local fishery being a small species, up to 20 grams, and not particularly abundant. No other fish species consumes vegetable matter of terrestrial origin in the Sepik-Ramu (ariid catfishes occasionally have small seeds in their guts but this is likely consumed incidentally with decaying vegetation and the more preferred animal prey).

The Sepik-Ramu basin, obviously, is extensively vegetated. Of the 92,230 km^2 of basin area, an estimated 83,400 km^2 (>90%) is covered by forest, most of it pristine rainforest (Coates unpublished, based on good local maps produced in 1974; the percentage of deforestation since this time is small in the Sepik-Ramu). In lowlands, more than two thirds of the estimated 33,000 km^2 of floodplain is covered by seasonally inundated floodplain forest. At altitudes below 200 m (i.e. lowland floodplain and areas adjacent to floodplain) there is an estimated 55,000 km of permanent river channel (> 2.5 m wide), the majority of which is bordered by dense forest, generally flooding in the rainy season at altitudes below 50 m.

Inputs of vegetable matter into rivers, lakes and flooded forest from this large expanse of terrestrial vegetation are considered to be relatively high (in total and on a unit area basis). The diversity of the terrestrial vegetation in the Sepik-Ramu (and New Guinea in general) is regarded as high and comparable to other naturally forested regions of the humid tropics (Paijmans 1976). Biodiversity amongst the flora of New Guinea does not suffer from the biogeographic constraints that have determined the impoverished freshwater ichthyofauna. Certain differences exist between the flora of New Guinea and S. America, for example, especially at the generic level. However, it is assumed that the "general ecology" of New Guinea terrestrial ecosystems (e.g. flooded forest) is broadly similar to elsewhere in terms of plant products entering freshwaters. More specific comparisons are made later with reference to the natural diet of *C. bidens* in its native range (S. America).

New Guinea is devoid of a significant mammalian fauna feeding on fruits, nuts etc. from lowland forest (New Guinea mammals are mainly marsupials). For example, monkeys do not occur in New Guinea but are a major group utilising forest nuts in S. America (Goulding 1980). For such reasons it is more than likely that inputs of nutrient rich vegetable products into New Guinea freshwaters are higher than elsewhere.

The project considers it logical that this significant potential food resource in the Sepik-Ramu should be utilised by introducing a fish species adapted to exploit it. It is also considered that fish feeding on this resource are appropriate for introduction from an environmental standpoint.

3. *COLOSSOMA BIDENS*

3.1 Native range/general details

In S. America, fruit and seed eating fishes have evolved that have no true ecological parallel anywhere else in the world (Goulding 1980). The family Characidae contains the major genera of significantly important, and best known, fruit eaters from this region. The genus *Colossoma* is selected because of the attractive attributes of the species as detailed later. The species *C. bidens* is chosen because of its availability within the region (Malaysia - see later).

Four major species of *Colossoma* are reasonably well known in their native range and also beginning to be used in aquaculture. There is some uncertainty about distribution, and possibly taxonomy, of the species. *C. macropomum* has a wide distribution from the Orinoco basin in Venezuela to the Rio de la Plata in Argentina according to Merola & Cantelmo (1987). *C. bidens* is native to the Amazon and *C. brachypomum* to the Amazon/Orinoco according to Welcomme (1988). Merola & De Souza (1988) and Payne (1987) list *C. macropomum* and *C. brachypomum* as indigenous to the Amazon but make no mention of *C. bidens,* whilst *C. mitrei* is indigenous to the Parana-Uraguay basin (Welcomme 1988, Merola & De Souza 1988). The species are all broadly similar in their habits (see later).

Vernacular names for these fishes vary from region to region. For example, Petrere (1983) refers to *C. macropomum* as the "tambaqui" (a term also used by Goulding 1980, and Welcomme 1988), Goulding (1980) refers to *C. bidens* as the "pirapitinga", Welcomme (1988) agrees and also calls *C. mitrei* the "pacu"; Payne (1987) refers to *C. macropomum* as the "pacu" and *C. brachypomum* as the "tambaqui". For the moment, I have decided to complicate things even more by calling *C. bidens* the "pacu" because this name is widely used by aquarists for all *Colossoma* spp and it is the only option available that Papua New Guinea people can readily pronounce.

3.2 History of introductions

Welcomme (1988) lists only transfers of *Colossoma* spp within Latin America and to Cuba and Jamaica (*C. bidens, C. macropomum* and *C. mitrei*). The genus, however, has been subject to much attention recently for aquaculture. They are regarded as high value, rapidly growing species that can be fed a variety of vegetable wastes. *Colossoma* sp is known to have been introduced to Taiwan, China, Indonesia and Malaysia within the past eight years; probably also to quite a few other countries. A major interest in Indonesia and Malaysia, for example, is to use the fish to consume waste (peel) from pineapple canneries. There are no known records of establishment in natural waters outside the native range but the fish have only been transferred since about 1980 (mainly to experimental aquaculture facilities). *C. mitrei* is used for stocking reservoirs within its native range (Godhino & Godhino 1986).

The further importation of *Colossoma* spp into Malaysia has been banned because fry/fingerlings cannot be easily distinguished from those of piranhas (Ang *et al.* 1989). This has been done to avoid possible confusion over identifications at the point of entry into the country and not because of any reservations over *Colossoma* spp themselves. The latter are available for distribution to fish farms within Malaysia from certified stocks from the Malaysian Department of Fisheries.

3.3 Importance to fisheries - native range

All *Colossoma* spp are considered extremely important in capture fisheries in most of S. America. Payne (1987) notes that *C. macropomum* and *C. brachypomum* are of major importance in catches from the Rio Mamore (Amazon). Petrere (1983) lists *C. macropomum* as the most important "group" in catches in Amazonas State (Brazil) and it is often the only species caught. The high quality flesh and large size results in the fish commanding a high price. Overfishing of stocks is evident in many regions. *C. macropomum* is also first in importance in Rio Madeira (Amazon) catches with *C. bidens* fifth in importance (Goulding 1981).

3.4 Biology

Colossoma spp are large fish, even by Amazonian standards. *C. macropomum* can grow to over 32.0 kg, about 1.0 m (approx. 900 mm SL) (Petrere 1983). Payne (1987) lists the same species as growing to about the same size and living to about 9 years of age. *C. bidens* grows to 20 kg (800 mm SL) according to Goulding (1980). Most fish caught appear to be in the size range 3 to 8 kg.

Colossoma spp can be easily bred in captivity using a range of hormonal injections to induce spawning (e.g. Castagnolli & Donaldson 1981; Godhino & Godhino 1986).

All sources of information note that *Colossoma* spp are almost exclusively herbivorous feeding essentially on fruits and nuts etc. falling into the water from forest trees.

Under aquaculture conditions: *C. mitrei* adults are fed on cabbage and lettuce leaves whilst fry feed on rotifers and cladocerans (Castagnolli & Donaldson 1981); *C. bidens* in ponds are fed on bananas, watermelon, watermelon rind, guavas, cucumbers, fresh corn, beans, bean shells, local fruits (Lovshin & De Silva 1974); in Indonesia and Malaysia *Colossoma* sp are fed on vegetable waste (personal observation).

In the wild: *C. macropomum* juveniles and adults feed on plant seeds and fruits in the rainy season and zooplankton and wild rice in the dry season (Merola & Cantelmo 1987); Payne (1987) notes that *C. macropomum* and *C. brachypomum* feed preferentially on fruit and seeds. Petrere (1983) mentions that *C. macropomum* starts life as omnivorous (i.e. includes zooplankton in its diet) and becomes more herbivorous as length increases - he considers the species "independent" of other fish in the Amazon (i.e. it does not prey upon or compete significantly with other species). The most detailed account (available to the project in PNG) of the diet and general biology of these fish is provided by Goulding (1980) from which the following notes are provided:

(1) for *C. macropomum*:

Fish are usually black ventrally and golden to olive or moss green dorsally; dentition - broad, multicusped molariform and incisive teeth; no maxillary teeth (in contrast to *C. bidens*); evolved to crush hard nuts on which it heavily feeds; also has long and fine gillrakers that are used, especially in young fish, to capture zooplankton. It procures most food from flooded forest when fruits and seeds are falling into the water. Most young are confined to turbid water floodplains and their diets are probably different. The evidence from the Rio Machado flooded forests strongly suggests that a relatively small number of fruit and seed species are intensively exploited. Diet composition was as follows:

(a) High water - flooded forest (mean stomach fullness 72%):

Food item	Dominance in diet
Plant matter (nuts/fruits from):	
Hevea spruceana, Euphorbiaceae	46
Astrocaryum jauary, Palmae	17
Neolabatia sp., Sapotaceae	8
Unidentified fruit/seeds (5-8 spp)	9
Piranhea trifoliata, Euphorbiaceae	2
Eschweilera sp., Lecythidaceae	1
Macrolobium acacilifolium, Leguminosae	1
Genipa cf. *americana*, Rubiaceae	1
Ficus sp., Moraceae	-
Hevea brasiliensis, Euphorbiaceae	-
Sub-total fruits/seeds	88 (95% dominance, 94% by volume)
Animal matter:	
Faeces	4
Fish	1
sub-total animal matter	5 (5% dominance, 6% volume)

(b) Low water: lakes (mean stomach fullness < 1%):

	Dominance in diet
Zooplankton	12
Fish	1
Mayfly larvae	1
Fruits/seeds	1
Cockroaches	1

NOTE: Fish account for < 1% of the diet by volume or dominance during the flood or dry season. The species practically stops feeding in the dry season. Goulding states that "Tambaqui with its big mouth and blunted teeth, appears to be a [poor] predator, and only occasionally is fortunate enough to capture a fish".

Rubber tree seeds (*Hevea spruceana*) and palm nuts (*Astrocaryum jauary*) were the dominant food in about one sixth of the 96 tambaqui sampled (= two thirds of all fruits/seeds consumed). Goulding notes that these may be selected because they are hard and most other fishes cannot exploit them - other fruits/seeds are probably competed for by hundreds of other fish species. In very few cases was more than one or two seed species consumed at any one time - the fish searches out its favourites within a sequence of fruit and seed fall. Fish wait below trees for fruit to fall. As flooded forest drains they enter the river or lakes. The fish schools. Most fish in the dry season have little food in stomachs - algae, decomposing organic matter and occasional zooplankton. Spawns in turbid water rivers - maybe along grassy levees that are flooded as the river rises. Large fat reserves are built up during the flood season.

(2) (Goulding notes for) *C. bidens*:

Teeth similar to *C. macropomum* except premaxillae are distinctly different in that the back row is separated from the front - purpose partly related to its leaf eating habit. As per *C. macropomum* the species is highly adapted to eating fruits and seeds in flooded forest and is almost entirely vegetarian during inundation. Also exploits rubber seeds and palm nuts. Plant species consumed are similar to those listed above (+ Curcurbitaceae). During water level falls *C bidens* turns to eating leaves and grass (hence it has a much higher mean stomach fullness in the dry season than *C. macropomum*), faeces and the occasional invertebrate. Total animal material consumed during the flood season was 2% (fish consumed very rarely) and during low water was nil.

[The consumption of faeces by *Colossoma* in the Amazon is apparently because the fish confuse monkey excrement with nuts falling from trees and competition for nuts is so intense that they don't bother wasting time distinguishing the two - Goulding]

With regard to the availability of the above species of trees (providing nuts/fruits for *Colossoma* as listed by Goulding) in the Sepik/Ramu I have the following information: Paijmans (1976) records the following families also occurring in New Guinea (presumably also the Sepik-Ramu) - Euphorbiaceae, Palmae, Moraceae and Curcurbitaceae. Genera, however, differ from those noted by Goulding for the Amazon. This is likely due to both biogeographic differences and also differences in taxonomic treatments in the two regions. Paijmans (1976) lists 1465 terrestrial higher plant genera known to be indigenous to New Guinea and remarks that the plant taxonomy of the region is far from well studied. It is assumed that ecological correlates of Amazon plant species (providing food to *Colossoma*) occur in the Sepik-Ramu. Considering there is practically no utilisation of this resource by fishes in the Sepik-Ramu (and less exploitation before they reach the water) it is likely that *Colossoma*, if introduced, will find an abundant food supply.

3.5 Potential impacts in the Sepik-Ramu

3.5.1 Benefits

The potential benefits of successfully introducing *C. bidens* into the Sepik-Ramu obviously depend on its relative production. Considering the lack of competition for fruits/nuts amongst the existing Sepik-Ramu fishes (and terrestrial fauna before they enter the water), and the absence of Piscivores, *Colossoma* may be more productive than in its native range. Production from Sepik-Ramu lowlands (floodplains) is less than 10% of that achieved in S. America (Coates 1990a). Considering that *Colossoma* can contribute up to 50% of commercial catches in S. America then it would not be unreasonable to suggest that the fish has the potential to increase fish production in the Sepik-Ramu lowlands by two or three fold. About 285,000 people live in or near wooded freshwater swamp in the Sepik-Ramu (Coates & Mys 1989).

Even at an assumed maximum size of 10 kg, *C. bidens* would be by far the largest species in Sepik-Ramu catches (excluding mangrove jacks which are rarely caught). A *C. bidens* resource may provide local fishermen with the opportunity to substantially increase their incomes by the sale of high value and large fish. All other fish species so far recommended to be stocked in Sepik-Ramu lowlands are anticipated to be low-value species for boosting the subsistence food base (which *Colossoma* will also do).

The high fat content of the species (due to the build up of reserves during the intensive feeding period during the flood) is also a considerable advantage. Coates (1990a) noted that fat appears to be in short supply in the Sepik-Ramu and fatty fish are in high demand there.

There is some potential for the local culture of *Colossoma* although, at present, aquaculture is poorly developed in Papua New Guinea. Rubber tree nuts are one of the few "waste" products of agriculture in Papua New Guinea. The country has relatively large areas planted with rubber (introduced). The most abundant waste product in the country is coffee pulp but it is not known if *Colossoma* can utilise this as food (if it can, the fish would be extremely economical in aquaculture).

3.5.2 Potential risks

C. bidens is anticipated to remain within lowlands and not to enter faster flowing tributary streams and rivers much above the floodplain. As already noted, potential competition for food with local species is probably minimal. Fry may compete for zooplankton in rivers and lakes but the extent of exploitation of this food by juveniles of local fishes in unknown. Potential competition with the Sepik halfbeak is thought to be minimal. The halfbeak feeds mainly on allochthonous inputs of insects etc. and very small seeds. The halfbeak also occupies lower sections of tributary streams as they enter floodplains (Coates & Van Zwieten 1992) and *C. bidens* would be too big to enter such environments.

Overall, *C. bidens* (or any *Colossoma* sp) appears to have ecological attributes making it very compatible with the existing ichthyofauna amongst the array of fish species that could be chosen for stocking.

3.6 Source of stock

Any *Colossoma* sp would be difficult, and expensive, for Papua New Guinea to import from S. America due to the distances involved, quarantine requirements and the need to ensure that the correct fish were imported. Fortunately, *Colossoma* sp are available regionally from at least Taiwan, Indonesia or Malaysia. Malaysia is recommended as the source of stock because of the quarantine facilities available there (see below).

There may be some confusion as to the species available from Malaysia for the following reasons: Ang *et al.* (1989) simply refer to the Malaysian fish as *Colossoma* sp. ("pacu") and that it was imported from Taiwan in "about" 1984. Liao & Liu (1989) refer to the only species in Taiwan as *C. bidens* (which they call the "freshwater pompano") that were imported from Brazil in "around" 1986. The species in use in China is *C. brachypomum* according to Qian *et al.* (1989) and this stock also likely originated from Taiwan. Eidman (1989) provides a list of exotic fish species for Indonesia and makes no mention of *Colossoma*. However, I personally have seen *Colossoma* sp being cultured in Indonesia and local reports were that they were imported from Taiwan in about 1986. The Indonesian fish have conspicuous red bellies and throats which can be less marked in larger fish (their broodstock). As far as I can ascertain this makes the Indonesian stock more than likely *C. brachypomum*. Consequently, this suggests the Taiwan fish are also *C. brachypomum*. Two large adult Malaysian fish that I have seen (from a broodstock pond) were a faint pinkish colour on the undersides and dark grey towards the dorsal surface.

There is obviously a need to get the proposed source stock (Malaysian fish) properly identified. According to the literature it is *C. bidens* but quite possibly is actually *C. brachypomum*. This makes little difference to the present evaluation since consideration has been made of the biology of all *Colossoma* sp, including *C. brachypomum*. Advisory group member Dr. Payne is familiar with *C. brachypomum* in the field and will no doubt advise us of any errors in our assumptions in these respects. [Ed. Note: since writing this report it has been ascertained that *C. bidens* and *C. brachypomum* are the same species - which explains the aforementioned confusion].

3.7 Quarantine

The code of practice (Turner 1988) is recommended for use as a basic guideline for quarantine purposes. In that code, however, protocols differ according to the biology of the species in question and facilities at hand. At one extreme the suggested protocol (Turner 1988) involves the importation of disinfected fertilised eggs and rearing broodstock under quarantine and then introducing the F2 generation after testing throughout. Alternatively, the example protocol for eels (Turner 1988) is much less stringent (eels cannot be bred in captivity, neither can eggs be imported). It is appreciated that Papua New Guinea does not have the facilities to undertake full quarantine throughout a breeding cycle for late maturing fishes such as *Colossoma* (which likely matures at +3 years).

Quarantine requirements are under the control of the Department of Agriculture & Livestock in Papua New Guinea (not the project or P.N.G. Department of Fisheries). The project recommends that as much as possible of the quarantine and disease testing is done offshore at the source of stock. An outline of the recommended procedure is as follows:

(1) screen and test a sample of broodstock at source for known parasites and pathogens;

(2) induce spawn broodstock under quarantine conditions, fertilise the eggs, disinfect these and then place them in a separate (clean) source of water;

(3) fertilised eggs are imported into Papua New Guinea and placed in quarantine on arrival;

(4) continued testing on a significantly large sample of fry/fingerlings during an initial period after arrival in Papua New Guinea can further extend the quarantine period if desirable.

(Precise details of tests to be undertaken are at the discretion of local authorities, Dept. Agric. & Livestock, in consultation with independent overseas experts in these fields. These need not be listed here).

This procedure gives optimum quarantine under PNG conditions and certainly surpasses the safeguards applied in most other countries (developing or otherwise) with respect to live fish importations. It does, however, hinge on the aptitude of the technical staff and facilities at the source of stock. These problems have recently been addressed concerning the importation of *Puntius gonionotus* (Coates 1991a) and exhaustive consultations have led to a similar strategy being adopted by Papua New Guinea for that species. During the latter consideration it has been determined that Malaysia presently has one of the most capable fish disease testing facilities available within the region. Since that country also has an internal source of stock of *C. bidens* (kept in government controlled ponds) it is recommended that Papua New Guinea approach Malaysia for stock and technical assistance with pre-shipment quarantine.

4. CONCLUSIONS

It is not possible to provide comprehensive details of the biology of *C. bidens*. However, reasonable information is available on the group as a whole and this confirms that the fish are suitable for introduction into the Sepik-Ramu. The known ecological attributes of the species fit well with those required for species suitable for stocking. The fish has the potential to be productive, has potential for future aquaculture and may be a high value species under Papua New Guinea conditions.

It is acknowledged that the fish may be difficult to establish in the Sepik-Ramu. Assessment of this factor is difficult since the species has no track record of establishment in other regions (because it has only been transferred recently). Its late age of maturity make it difficult to mass produce fingerlings locally (importing broodstock is an increased quarantine risk). It may also migrate in order to breed (this habit makes stock establishment particularly difficult). Large numbers of fingerlings may need to be stocked to ensure a reasonable chance of establishment. On the other hand, the potential value of the species make a reasonable attempt at its establishment in the Sepik-Ramu warranted.

5. RESPONSES FROM THE ADVISORY GROUP

Original copies of the opinionaires received from five advisory group members are provided in the annex.

To the question "Has the project adequately evaluated all possible factors relating to this proposed introduction in the light of practicalities and constraints that exist" the average response was 3.4 (scored as per Turner 1988). To the question "Based on all of the available information, do the benefits of this introduction outweigh the risks" the average response was 3.75. Both responses from the advisory group are above the minimum required to support the introduction (Turner 1988).

6. REFERENCES

Ang, K. J., Gopinath, R. & Chua, T. E. (1989). The status of introduced fish species in Malaysia. In: *Exotic Aquatic Organisms in Asia* (ed. S. S. De Silva). Asian Fisheries Society, Manila. pp 71-82.

Castagnolli, N. & Donaldson, E. M. (1981). Induced ovulation and rearing of the Pacu (*Colossoma mitrei*). *Aquaculture* 25: 275-279.

Coates, D. (1989) Fish fauna of the Sepik and Ramu River floodplain regions: Summary of information on fish ecology, identification of vacant niches and categories of fish species suitable for stocking. FAO, PNG/85/001 Field Document No. 3. 57p.

Coates, D. (1990a) Sepik River Fish Stock Enhancement - Phase one final report and recommendations. Part I. Recommendations regarding fish stocking and alternative options. FAO/PNG/85/001 Field Doc. 12a. 61p.

Coates, D. (1990b) Sepik River Fish Stock Enhancement - Phase one final report and recommendations. Part II. Fish species suitable for stocking and stocking strategies. FAO/PNG/85/001 Field Doc. 12b. 84p.

Coates, D. (1991a). Sepik River Fish Stock Enhancement Project, PNG/85/001. Recommendations regarding fish species suitable for stocking. Recommendation # 4: The stocking of *Puntius gonionotus* into the Sepik-Ramu River system and responses from the advisory group regarding its suitability in line with the code of practice relating to fish species transfers. FAO/PNG/85/001 Field Document 15, FAO, Rome 23pp.

Coates, D. (1991b). Sepik River Fish Stock Enhancement Project, PNG/85/001. Recommendations regarding fish species suitable for stocking tributary rivers/streams (cold waters) and responses from the advisory group in-line with the code of practice regarding fish species introductions. Recommendation # 5: the introduction of *Schizothorax richardsonii* (Gray); Recommendation # 6: the introduction of *Tor putitora* (Hamilton); Recommendation # 7: the introduction of *Acrossocheilus hexagonolepis* (McClelland); Recommendation # 8: the introduction of *Labeo dero* (Hamilton). FAO/PNG/85/001, Field Document 16, FAO, Rome. 80pp.

Coates, D. and Mys, B. M. F. (1989). Preliminary report on population statistics and socioeconomic data for the Sepik and Ramu River catchments. FAO, PNG/85/001 Field Document No. 4. 50p.

Coates, D. & Van Zwieten, P. A. M. (1992). Biology of the freshwater halfbeak *Zenarchopterus kampeni* (Teleostei: Hemiramphidae) from the Sepik and Ramu River basin, northern Papua New Guinea. *Ichthyol. Explor. Freshwaters* 3: 25-36.

Eidman, M. H. (1989). Exotic aquatic species introductions into Indonesia. In: *Exotic Aquatic Organisms in Asia* (ed. S. S. De Silva). Asian Fisheries Society, Manila. pp 57-62.

Godhino, H. P. & godhino, A. L. (1986). Induced spawning of the Pacu, *Colossoma mitrei* (Berg 1895), by hypothysation with crude carp pituitary extract. *Aquaculture* 55: 69-73.

Goulding, M. (1980). *The Fishes and the Forest.* University of California Press, Berkeley.

Goulding, M. (1981). *Man and Fisheries on an Amazonian Frontier.* Developments in Hydrobiology 4. 123pp.

Liao I. C. & Liu, H. C. (1989). Exotic aquatic species in Taiwan. In: *Exotic Aquatic Organisms in Asia* (ed. S. S. De Silva). Asian Fisheries Society, Manila. pp 101-118.

Lovshin, L. L. & Da Silva, A. B. (1974). Preliminary pond culture test of Pirapitinga, *Mylossoma bidens*, and Tambaqui, *Colossoma bidens*, from the Amazon River Basin. FAO, Rome, 9pp.

Merola, N. & Cantelmo, O. A. (1987). Growth, feed conversion and mortality of cage-reared Tambaqui, *Colossoma macropomum*, fed various dietary feeding regimes and protein levels. *Aquaculture* 66: 223-233.

Merola, N. & De Souza, H. (1988). Preliminary studies on the culture of the Pacu, *Colossoma mitrei*, in floating cages: Effect of stocking density and feeding rate on growth performance. *Aquaculture* 68: 243-248.

Paijmans, K. (ed.) (1976). *New Guinea Vegetation.* Australian National University Press, Canberra. 213pp.

Payne, A. I. (1987). A preliminary stock assessment of the fishery at Trinidad on the Rio Mamore. Overseas Development Administration/Coventry Polytechnic, United Kingdom. 34pp.

Petrere, M. (1983). Yield per recruit of the Tambaqui, *Colossoma macropomum* Cuvier, in the Amazonas State, Brazil. *J. Fish Biol.* 22:133-144.

Qian, P., Shengzhong, Y. & Jingxiong, L. (1989). A preliminary report on high production of *Colossoma brachypomum* Cuvier in fish pond culture. *Freshwater Fisheries (China)* 1:29-30.

Turner, G. E. (1988). Codes of practice and manual of procedures for consideration of introductions and transfers of marine and freshwater organisms. EIFAC/CECPI Occasional Paper 23. 44pp.

Welcomme, R. L. (1988). International introductions of inland aquatic species. *FAO Fish. Tech. Pap.*, (294):318 p.

ANNEX
Copies of opinionaires received from the advisory group

Sepik River Fish Stock Enhancement Project

Opinionaire on the introduction of *Colossoma bidens*

NAME ______________ SIGNATURE ______________ DATE ______________

Dear Advisory Group Member,

Based on the information provided to you could you please provide your opinions on the following questions by circling only one of the alternative responses. You may provide whatever additional comments you wish as an attachment sent to the Project Chief Technical Adviser. These will be taken into account by the project and passed on to PNG authorities in their original form.

	RESPONSE					
(1) Is there a need to stock the Sepik/Ramu basin with a fish feeding on vegetable matter from terrestrial sources (fruits/nuts/seeds falling into the water) in order to improve the fishery ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(2) Is Colossoma bidens an appropriate species to stock for this purpose ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(3) Is the supportive information provided on Sepik/Ramu fish stocks, the habits of native species, socio-economic conditions and the fishery adequate to draw the conclusions presented by the project in relation to the introduction of C. bidens ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(4) Are the knowledge of C. bidens and experiences with this group of fish elsewhere adequate for the purposes of this proposal ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW

(5) Would most consequences of the introduction of <u>C. bidens</u> that could be reasonably anticipated be of benefit to humans ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(6) Are the safeguards against the inadvertent transfer of diseases and parasites adequate ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(7) Has the project adequately evaluated all possible factors relating to this proposed introduction in the light of practicalities and constraints that exist ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(8) Based on all of the available information, do the benefits of this introduction outweigh the risks ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW

Sepik River Fish Stock Enhancement Project

Opinionaire on the introduction of *Colossoma bidens*

NAME Peter Moyle SIGNATURE [signature] DATE 5 Oct 92

Dear Advisory Group Member,

Based on the information provided to you could you please provide your opinions on the following questions by circling only one of the alternative responses. You may provide whatever additional comments you wish as an attachment sent to the Project Chief Technical Adviser. These will be taken into account by the project and passed on to PNG authorities in their original form.

	RESPONSE					
(1) Is there a need to stock the Sepik/Ramu basin with a fish feeding on vegetable matter from terrestrial sources (fruits/nuts/seeds falling into the water) in order to improve the fishery ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(2) Is Colossoma bidens an appropriate species to stock for this purpose ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(3) Is the supportive information provided on Sepik/Ramu fish stocks, the habits of native species, socio-economic conditions and the fishery adequate to draw the conclusions presented by the project in relation to the introduction of C. bidens ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(4) Are the knowledge of C. bidens and experiences with this group of fish elsewhere adequate for the purposes of this proposal ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW

(5) Would most consequences of the introduction of <u>C. bidens</u> that could be reasonably anticipated be of benefit to humans ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(6) Are the safeguards against the inadvertent transfer of diseases and parasites adequate ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(7) Has the project adequately evaluated all possible factors relating to this proposed introduction in the light of practicalities and constraints that exist ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(8) Based on all of the available information, do the benefits of this introduction outweigh the risks ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW

I am very hesistant about recommending this species, as we know so little about it, esp. as an introduced species. ~~How~~ Do we know, for example, that its feeding will not interrupt the life cycle of a flood plain tree species. The New Guinea trees, as you point out, have not evolved with such seed predators about during the presumed dispersal stage. This introduction could be hazardous.

Sepik River Fish Stock Enhancement Project

<u>Opinionaire on the introduction of *Colossoma bidens*</u>

NAME A. I. Payne SIGNATURE A. I. Payne DATE 30/11/92

Dear Advisory Group Member,

Based on the information provided to you could you please provide your opinions on the following questions by circling only one of the alternative responses. You may provide whatever additional comments you wish as an attachment sent to the Project Chief Technical Adviser. These will be taken into account by the project and passed on to PNG authorities in their original form.

	RESPONSE					
(1) Is there a need to stock the Sepik/Ramu basin with a fish feeding on vegetable matter from terrestrial sources (fruits/nuts/seeds falling into the water) in order to improve the fishery ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(2) Is <u>Colossoma bidens</u> an appropriate species to stock for this purpose ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(3) Is the supportive information provided on Sepik/Ramu fish stocks, the habits of native species, socio-economic conditions and the fishery adequate to draw the conclusions presented by the project in relation to the introduction of <u>C. bidens</u> ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(4) Are the knowledge of <u>C. bidens</u> and experiences with this group of fish elsewhere adequate for the purposes of this proposal ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW

(5) Would most consequences of the introduction of C. bidens that could be reasonably anticipated be of benefit to humans ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(6) Are the safeguards against the inadvertent transfer of diseases and parasites adequate ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(7) Has the project adequately evaluated all possible factors relating to this proposed introduction in the light of practicalities and constraints that exist ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW
(8) Based on all of the available information, do the benefits of this introduction outweigh the risks ?	NO	UNLIKELY	POSSIBLY	PROBABLY	YES	DON'T KNOW