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ARTISANAL FISHERIES AND FISH ECOLOGY BELOW THE GREAT WATERFALLS OF THE MEKONG RIVER IN SOUTHERN LAOS

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ABSTRACT

Fishes and fishing methods were studied in June-July 1993 at Ban Hang Khone, an important fishing village on Khone Island just below the great waterfalls of the Mekong River at Lee Pee, southern Laos. A total of 93 fish species were identified in catches, and their local (Lao) names recorded. A few additional species reported by fishermen but seldom captured are tentatively identified. Interviews with fishermen, supplemented by observations, yielded information on fishing methods, annual cycle of fish migrations, seasonal utilization of flooded forest by fishes, and recent decline of fisheries. Fishing methods include a variety of fixed and moveable traps, gillnets, hooks and spears. During May-July the most important fishing gear is large immoveable wing traps ("lee") set in rapids and large-meshed gillnets. There are three migratory periods, late January-February, May-July, and November-December, with major differences in size and species composition, reproductive condition, and direction. During the high water period of July-October, many species move into the flooded forest, where they feed heavily on terrestrial insects, earthworms, and other invertebrates, leaves, seeds, fruits, or prey on other fishes. Two large cyprinid species feed on toxic fruits, as a result of which they become inedible. There has been a gradual decline of fisheries since 1970, and a more rapid decline within the last four years. The entire fisheries has declined to about 20% of what it was in 1970. The endemic Mekong freshwater herring pa mak pang *(Tenualosa thibaudeaui)*, formerly one of the most abundant species, has almost disappeared. Several other species supporting substantial fisheries, including pa pawn *(Cirrhinus microlepis)*, pa johk *(Cyclocheilichthys enoplos)*, pa uhn (*Probarbus* spp), and pa gooawng *(Boesemania microlepis)* have declined to about 10% of their abundance prior to 1970.

INTRODUCTION

Ban Hang Khone is a fishing village of about 40 households located at the southern end of Don Khone (Khone Island), about 3 km below the fall line of the great waterfalls at Lee Pee (not to be confused with Don Khong, a much larger island above the falls). Here the Mekong swells into a large pool, or wang, occupied for many years by about 30 individuals of the so-called Irrawaddy dolphin, *Orcaella brevirostris* (Gray, 1866). Until 1970 crocodiles (possibly *Crocodylus siamensis* Schneider, 1801 and *Crocodylus porrosus* Schneider, 1801) were occasionally seen, but they seem to be no longer present. There reportedly are three large species of soft-shelled or trionychid turtles, one of which (pa paloo, probably *Pelochelys bibroni* (Owen, 1853)) is said to attain 100 kg. The waterfalls

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range across some 14 inter-island channels where the river (with its islands) is 8 km wide. All of the strongly migratory fish species and many other fishes can ascend and descend the falls, at least at certain times and places. For some species, however, the falls seem to be a sort of biogeographic barrier, the exact nature of which invites further investigation.

Ban Hang Khone and a number of other villages on Khone and nearby islands represent one of the most important inland fisheries based on naturally occurring fish stocks anywhere in Southeast Asia. A large proportion of the fish marketed in Pakse, second largest population center in Laos, comes from this area, as does some of the fish eventually marketed at Ubol Ratchatani, a major market center in Thailand.

There have been almost no previous ichthyological observations at Lee Pee. TAKI (1974) reported on a small number of species collected at the waterfalls by castnet.

From 22 June through 6 July 1993 direct observations were made on the fisheries and additional information was gained by interviews with fishermen at Ban Hang Khone and nearby villages below the waterfalls. This was done with the help of Ian Baird, who has been working at Ban Hang Khone since 1991 in connection with the Lao Community Fisheries and Dolphin Protection Project sponsored by Earth Island Institute and the Lao Department of Forestry.

Except figures 1–2 of pa mak pang or *Tenualosa thibaudeaui,* the photographs illustrating this article were taken in Bang Hang Khone and other places just below the waterfalls in June–July 1993. The photographs for figures 12–14 are by photojournalist Nantiya Tangwisuttijit; the rest are by the author.

SYSTEMATIC LIST OF FISH SPECIES

Most of the species observed were photographed, and specimens of many preserved for further work on identification and systematics.

Pristidae (sawfishes)	
?Pristis pristis (not observed)	salam
Dasyatididae (whiptailed stingrays)	
?Dasyatis laosensis (not observed)	fa hang
?Himantura chaophraya (not observed)	fa hang
Notopteridae (featherbacks)	
Chitala blanci	tong gai
Chitala ornata	tong khua
Notopterus notopterus	tong
Clupeidae (herrings)	
Tenualosa thibaudeaui	mak pang
Engraulididae (anchovies)	
Lycothrissa crocodilus	hang pah, maeo
Setipinna melanochir	mak jan, maeo
Cyprinidae (carps)	
Aaptosyax grypus	sanak
Amblyrhynchichthys truncatus	jon
Barbichthys nitidus	keenyang?

Catlocarpio siamensis (not observed)	galow?, kaho
Cirrhinus lineatus	soi
Cirrhinus microlepis	pawn
Cirrhinus mrigala (introduced)	
Cirrhinus ?siamensis	soi, mohk
Cirrhinus sp	soi
Cosmochilus harmandi	mak ban
Crossocheilus sp	soi, tohk toi
Cyclocheilichthys enoplos	jawk, johk
Cyprinus carpio (introduced)	nai
Hampala dispar	
Hampala macrolepidota	soot
Labeo chrysophekadion	pia
Labiobarbus leptocheilus	soi, lang kohn
Leptobarbus hoeveni	pohng
Lobocheilos melanotaenia	soi, kiang
Mekongina erythrospila	wa
Mystacoleucus sp	khao na?
Osteochilus microcephalus	
Osteochilus sp	
Paralaubuca ?typus	dtaep
Probarbus jullieni	uhn
Puntioplites proctozysron	sagang
Puntius altus	wien fai
Puntius daruphani	pak gohm
Puntius orphoides	pohk
Puntius pierrei	pak khao
Raiamas guttatus	sanak
Rasbora sp	siu ao, siu
Scaphognathops bandonensis	pien
Scaphognathops stejnegeri	pien
Sikukia ?stejnegeri	
Thynnichthys thynnoides	goom
Cobitididae (loaches)	
Botia modesta	moo
Bagridae (catfishes)	
Bagrichthys macracanthus	makahn makehr
Bagrichthys macropterus	makahn makehr, gooay sook
Leiocassis siamensis	kee hia
Mystus macronema	kanyeng, kanyeng koh
Mystus microphthalmus	kung
Mystus nemurus	goht
Mystus wyckii	goht mahw
Siluridae (catfishes)	
Belodontichthys sp	kohp

Hemisilurus mekongensis	nang daeng
Kryptopterus ?apogon	nang khao, sanghooa
Kryptopterus ?bleekeri	geht
Kryptopterus cryptopterus	peek gai
Kryptopterus ?limpok	peek gai
Ompok bimaculatus	seuam
Ompok hypophthalmus	peek gai
Wallago attu	khao
Wallago leerii	koon
Pangasiidae (catfishes)	
Helicophagus waandersii	noo
Pangasius bocourti	hua muam
Pangasius conchophilus	gae, paw
Pangasius gigas (not observed)	beuk
Pangasius hypophthalmus	sooai, sooai khaeo
Pangasius krempfi	sooai, sooai hang luang
Pangasius larnaudei	pboong
Pangasius macronema	nyawn
Pangasius pleurotaenia	nyawn tawng khom
Pangasius polyuranodon	nyawn hang hian?
Pangasius sanitwongsei	leum
Sisoridae (catfishes)	
Bagarius yarrelli	khae
Clariidae (catfishes)	
Clarias sp	duk
Ariidae (catfishes)	
Arius stormii	kaht oak
Hemipimelodus ?borneensis	kaht oak
Plotosidae (catfishes)	
?Plotosus canius (not observed)	duk taleh, lai fai fa?
Belonidae (needlefishes)	
Xenentodon ?cancila	katong
Ambassidae (glassperches)	
Parambassis apogonoides	kahpkawng
Parambassis siamensis	kahpkawng
Parambassis wolffii	kahpkawng
Datnioididae (tigerperches)	
Datnioides apogonoides	seua
Datnioides sp	mohng
Sciaenidae (croakers or drums)	
Boesemania microlepis	gooawng
Pristolepididae (combscaled perches)	
Pristolepis fasciata	gah
Polynemidae (threadfins)	
Polynemus ?paradiseus	jin

Eleotrididae (sleepers)	
Oxyeleotris marmorata	boo
Gobiidae (gobies)	
Glossogobius giuris	boo
Belontiidae (gouramis)	
Osphronemus goramy	men
Trichogaster trichopterus	salid
Trichopsis vittata	maht
Channidae (snakeheads)	
Channa marulia	gooan
Channa striata	kaw
Mastacembelidae (spiny eels)	
Macrognathus siamensis	laht
Mastacembelus armatus	loht
Cynoglossidae (tongue soles)	
Cynoglossus sp or spp (not observed)	lin mah
Tetraodontidae (pufferfishes)	
Tetraodon leiurus	pao

LAO FISH NAMES

Lao names of many Mekong fish species were recorded by TAKI (1974). Most of the names cited by him, however, were obtained in Vientiane and Luang Prabang, where usage evidently is somewhat different. Lao names presented here were all obtained at the fishing village of Bang Hang Khone, and will be most relevant to fish species found below the great waterfalls in southern Laos. The further away from this area, the less likely that the Lao names will apply to the same species.

Lao language is very similar to Thai, and Thai speakers have little or no difficulty pronouncing Lao. Spellings presented here will be helpful to English speakers, but they are only approximations. The only way to get correct pronounciation is by listening to native Lao speakers. As in Thai, Lao has consonants intermediate between "p" and "b" and between "d" and "t", indicated here as "pb" or "dt". All Lao fish names should be preceded by the prefix "pa", equivalent to the Thai prefix "pla". In addition to fishes, the prefix pa is used in Lao for dolphins (pa kha) and aquatic turtles (pa fa awn, etc.). Lao uses an "s" sound instead of the "ch" sound in Thai; thus the Thai name for shark, "pla chalam", is "pa salam" in Lao (used for sawfish). Lao has an "ny" sound in place of the Thai "y"; thus "pa kanyeng" for "pla kayeng" *(Mystus macronema)*. Like Thai, Lao is a tonal language, but no attempt is made here to indicate the tones in Lao fish names. It should be noted that they exist, however, and are needed to distinguish some fish names, such as pa khao (rising tone) for the catfish *Wallago attu*, and pa khao (middle tone) for large carps currently assigned to *Puntius*.

Some fish species have more than one Lao name at Ban Hang Khone. In several instances small fish have a different name from larger ones of the same species. Thus *Pangasius conchophilus* to about 40 cm are pa gae, larger ones pa paw; similarly

Cyclocheilichthys enoplos to 40 cm are pa jawk, larger ones pa johk. In addition to being used specifically for the most abundant small species of *Cirrhinus*, pa soi is used as a collective noun for several small cyprinid fishes commonly caught with these *Cirrhinus* (including *Crossocheilus* sp, *Labiobarbus leptocheilus*, and *Lobocheilos melanotaenia*). There is a tendency to refer to small individuals of several species of Pangasiidae as pa nyawn, some fishermen distinguishing young of various species more readily than others. The name pa nyawn is most consistently applied to *Pangasius macronema* (the smallest species of Pangasiidae).

SCIENTIFIC NAMES

Systematic study of Indochinese freshwater fishes is in a marked revisionary phase, with substantial changes in identification and nomenclature imminent. This is particularly true for species here assigned to genera such as *Cirrhinus, Labeo, Puntius, Kryptopterus,* and *Polynemus*. Identifications in these and some other groups are thus provisional. Scientific names of Pangasiidae follows the revision by ROBERTS & VIDTHAYANON, 1991. Authority (author and date of original scientific publication) of most of the scientific names can be found in KOTTELAT (1989). The exceptions are *Himantura chaophraya* Monkolprasit and Roberts, 1991; *Chitala ornata* (Grey, 1831); *Aaptosyax grypus* Rainboth, 1991; *Mystus microphthalmus* Day, 1878; *Pangasius conchophilus* Roberts and Vidthayanon, 1991; *Hemisilurus mekongensis* Bornbusch and Lundberg, 1989; *Parambassis apogonoides* Bleeker, 1851.

LEE PEE WATER FALLS AS A ZOOGEOGRAPHIC BARRIER

The lower Mekong River is characterized by a substantial number of fish species that have not been found in the middle and upper portions of the Mekong (i.e., above the waterfalls at Lee Pee). While some of these are adapted to brackish or tidal habitats and do not occur much above the Mekong delta, others are completely adapted to fresh water habitats. The 93 fish species identified from Ban Hang Khone include eight that are not known from above the waterfalls: the anchovy *Lycengraulis crocodilus*, silurid catfish *Ompok hypophthalmus*, pangasiid catfish *Pangasius polyuranodon*, ariid catfishes *Arius stormii* and *Hemipimelodus borneensis*, glassperch *Parambassis apogonoides*, threadfin *Polynemus ?paradiseus*, and goby *Glossogobius giuris*. Finding these species in the Mekong River immediately below the falls suggests that the falls act as a barrier between them and the rest of the Mekong River. The falls may also serve as a barrier to the dolphin and several additional fishes that were not actually observed, including the sawfish *Pristis pristis*, plotosid catfish *Plotosus canius*, additional species of Ariidae, scombrid *Scomberomorus sinensis*, and tongue soles (Cynoglossidae).

BIOLOGICAL NOTES

Sharks.— Several species of sharks have been reported or are considered likely to occur in the lower Mekong (KOTTELAT, 1989). Fishermen of Ban Hang Khone report that they have never seen any sharks. Sharks are unknown from the Mekong River above the

waterfalls. The species most characteristic of large rivers in tropical Asia, *Carcharhinus leucas* and *Glyphis gangeticus*, have not been reported from the Mekong.

Sawfish (Pristidae).— Fisherman report that sawfish (presumably *Pristis pristis;* see KOTTELAT, 1989:4) were occasionally caught in large gill nets near Ban Hang Khone as recently as ten years ago. Sawfish are unknown from the Mekong above the waterfalls.

Stingrays (Dasyatididae).— Fishermen at Ban Hang Khone recognize only a single large species of pa fa hang or stingray, attaining 30 kg or more (presumably *Dasyatis laosensis*). However, one fishermen reported a stingray of 500 kg, presumably *Himantura chaophraya*, the only ray species known to attain such large size in fresh water. Both species occur in the Mekong above the waterfalls.

Several fishermen report large (to 30 kg or more) stingrays caught near Ban Hang Khone having 3–4 or more small stingrays of about 10 cm diameter inside their spiracles.

Chitala.— About 20 large *Chitala* were caught in June–July 1993, the great majority of them *C. blanci*. Unlike the widely ranging *C. ornata*, it is known only from the mainstream of the Mekong River in places where there is fast current and rocky substrate. According to Ban Hang Khone fishermen both species enter the flooded forest in July–October and feed on fish, shrimps, crabs, and insects.

Tenualosa thibaudeaui (Figs. 1–2).— This microphagous freshwater herring is endemic to the lower and middle Mekong River. According to Ban Hang Khone fishermen, pa mak pang was formerly among the most abundant of all fish species in the Mekong, perhaps the only more abundant species being pa soi (*Cirrhinus* sp or spp) and pa dtaep (*Paralaubuca ?typus*). Its migrations formerly were exceeded in magnitude only by those of pa soi, pa dtaep, pa johk, and pa pawn, but there have been no large scale migrations of pa mak pang for about ten years. The species has declined steadily since 1970 until now it is relatively rare. Only four specimens were observed in June–July 1993.

The pa mak pang migrate upriver at Chinese New Year (late January to late February) in company with pa soi (*Cirrhinus* spp et alia) and pa moo (*Botia modesta*), and come downstream with pa soi in June and July. The largest fish are about 20 cm and 800 g or 1 kg, with most large spawning fish at 400–500 g. Fishermen of Ban Hang Khone consider that this species has decreased in abundance more than any other fish species and is the one most likely to disappear.

Suntorn, the most successful fisherman in Ban Hang Khone, reports that in early 1970's he caught 400 or 500 kg of pa mak pang daily in dtawn (fixed traps smaller than lee) during upstream migrations in February and downstream migrations in June–July. For 10 days in February about 10 years ago (1984?), the last year pa mak pang was abundant, he caught 20–30 kg/day.

Aaptosyax grypus.— This extraordinary predatory cyprinid reportedly attains 1.3 m and over 30 kg. All four large specimens observed by the author have had empty stomachs, including a gravid female of 99 cm and 15 kg caught at Khong Chiam in 1990. It is apparently restricted to the mainstream of the Mekong River, where it may well be the rarest of the larger fish species. A single small juvenile specimen from a castnet fishermen was obtained in June 1993.

According to Ban Hang Khone fishermen, the appearance of large pa sanak in December is a signal that the November–December migration of pa uhn *(Probarbus)* has ended.

The Lao name pa sanak (like the Thai name pla chanak) is shared by *Aaptosyax grypus* with the superficially similar but much smaller and more abundant cyprinid fish *Raiamas guttatus*.

Cirrhinus.— Three small species of *Cirrhinus* (under 15 cm) were observed in June–July 1993, of which *Cirrhinus* sp was by far the commonest. *Cirrhinus ?siamensis* resembles *Cirrhinus* sp but has a larger head and broader mouth; only a few specimens, all about 10 cm, were observed. *Cirrhinus lineatus* is also very similar to *Cirrhinus* sp but differs in having more or less sharply defined longitudinal stripes on body; again, relatively few specimens were observed, all about 8–9 cm. *Cirrhinus* sp may be the single most abundant fish species at Ban Hang Khone. Nearly all of those observed in June–July 1993 were in spawning condition, with gravid females as small as 49 mm standard length three times more numerous than ripe males (smallest observed 60 mm).

Pa pawn or *Cirrhinus microlepis* (Fig. 3), attaining 40 or 50 cm and 4–5 kg, is by far the largest species of *Cirrhinus* in the Mekong. Small pa pawn (non-reproductive) migrate upstream in February, large ones in spawning condition migrate downstream in February and again late in the rainy season (July). A downstream migration (post-spawning?) of large fish evidently occurs in August–September, but few fish are caught at this time and little is known about it. The majority of pa pawn are reddish, but a small percent (from 5 to 20%) are blue, a few individuals becoming deep caerulean blue. The spawning runs are much more sporadic than those of the smaller species of *Cirrhinus*, possibly requiring combined conditions of heavy rain with a sharp rise in water levels and dark moonless nights (Greg Chapman, pers. comm. July 1993).

Cyclocheilichthys enoplos (Fig. 4).— This large and strongly migratory cyprinid stays in the mainstream and larger tributaries of the Mekong (i.e. it does not enter the flooded forest). At Ban Hang Khone its migrations formerly were exceeded in magnitude only by those of pa soi and pa dtaep. It reportedly has declined more than any other species with the sole exception of pa mak pang *(Tenualosa thibaudeaui)*.

Leptobarbus hoeveni (Fig. 5).— Pa pohng *(Leptobarbus hoeveni)* and pa gooaw (a large unidentified cyprinid fish) are regarded as inedible. According to Ban Hang Khone fisherman, these are the only fish species that feed on two large poisonous fruits, mak gabao and mak ngooan. Eating these fish reportedly induces nausea and vomiting. Although *Leptobarbus* ordinarily is not consumed, the dorsal musculature can be eaten as lap (raw meat) after marination in vinegar and pepper.

According to local fishermen, pa pohng enter the flooded forest in July–September, feed heavily on fallen fruit, and attain a maximum weight of about 10 kg. Two large specimens were examined, one a ripe female of 50 cm standard length (4.8 kg). Both had distended gall bladders, the size and shape of a large duck egg, filled with a clear, chlorophyll-green liquid.

Feeding on fruits of *Hydnocarpus* by *Leptobarbus hoeveni* was reported by SMITH (1945:122), who also noted similar ill effects on people eating the fish.

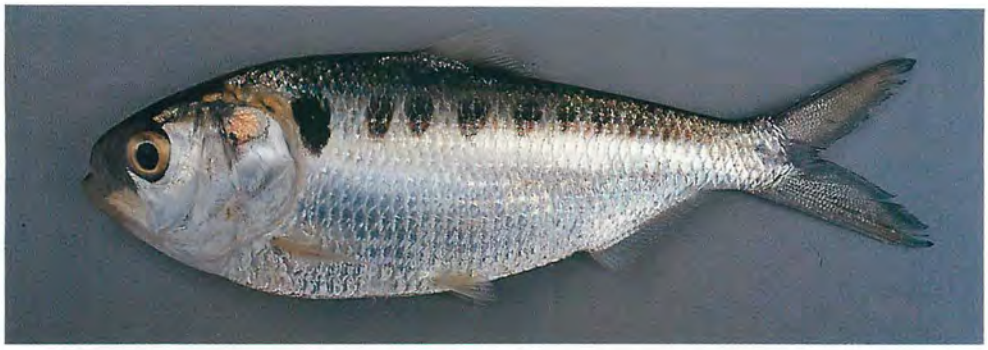

Figure 1. Pa mak pang, *Tenualosa thibaudeaui*, 159 mm standard length, Mekong River near That Phanom, Thailand, 6 April 1991.

Figure 2. Pa mak pang, *Tenualosa thibaudeaui* (close-up of specimen in Fig. 1).

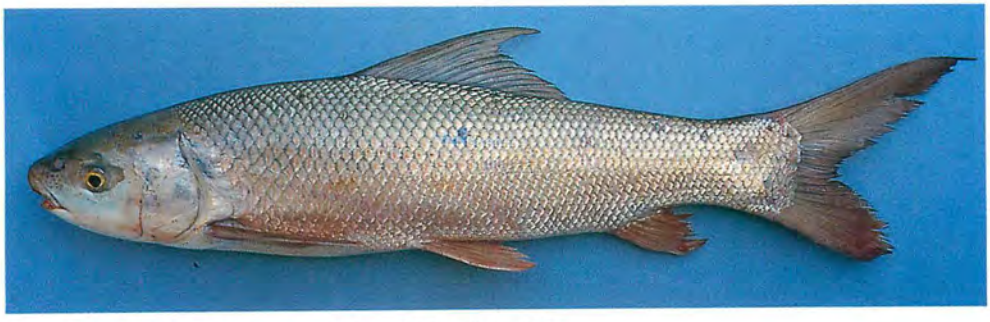

Figure 3. Pa pawn, *Cirrhinus microlepis*, reddish color variety.

Figure 4. Pa jawk, young *Cyclocheilichthys enoplos*.

Figure 5. Pa pohng, *Leptobarbus hoeveni*, 50 cm standard length, 6.3 kg (with mak gabao and mak ngooan).

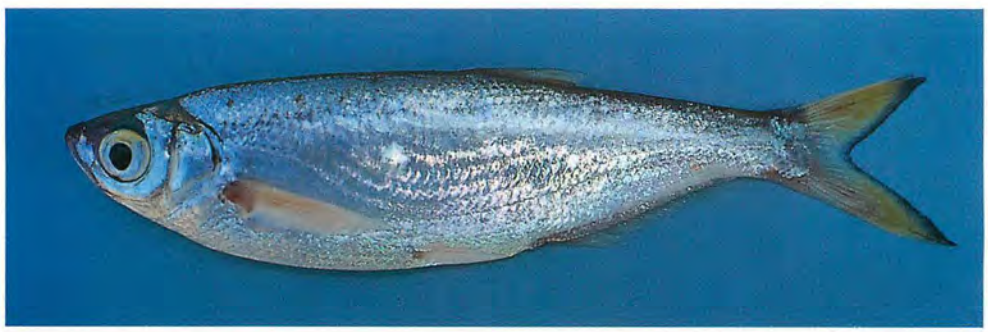

Figure 6. Pa dtaep, *Paralaubuca ?typus*.

Lobocheilos melanotaenia.— No fewer than seven species of the rheophilic cyprinid genus *Lobocheilos* have been reported from the Mekong (KOTTELAT, 1989:8). It seems, however, that Kottelat is correct in thinking that there is only one or two species in the Mekong. Certainly at Ban Hang Khone in June–July 1993 all of the numerous *Lobocheilos* observed belonged to a single species, here identified as *L. melanotaenia*. This species (pa kiang) migrates with pa soi in January–February and again in June–July. Fish observed in June–July were in spawning condition. According to Ban Hang Khone fishermen it enters the flooded forest in July–October and feeds on kai hin (filamentous algae). It is probably the most rheophilic of the species commonly associated with pa soi and caught in kah.

Paralaubuca ?typus (Fig. 6).— Pa dtaep, here tentatively identified as *Paralaubuca typus,* is one of the most abundant fish species at Ban Hang Khone. It migrates at the same times as, but physically separate from, pa soi, tending to stay nearer to the surface than to the bottom. Unlike pa soi, it is not caught in kah. Pa dtaep observed in June–July 1993 were in spawning condition.

Probarbus.— Only a single species of pa uhn or *Probarbus* was observed in June–July 1993, *P. jullieni.* This species undergoes important upstream migrations in October–December. Some large fish are caught in gillnets in June–July, but they are not migrating at this time. According to Ban Hang Khone fishermen pa uhn have declined 90% from their abundance prior to 1970.

It is now known that there are three species of *Probarbus* in the Mekong River (ROBERTS, 1992). Two of the species have been found in the lower Mekong, and all three probably occur there.

Sikukia ?stejnegeri.— We obtained a single small specimen at Ban Hang Khone. The species attains only about 15 cm, but is occasionally very abundant. On 19 July 1993 large numbers of very fresh fish were in the fish market at Pakse. It is probably one of the many smaller cypinid species involved in migrations at Ban Hang Khone.

Botia modesta.— The Mekong has at least eight species of the loach genus *Botia,* of which *B. modesta* is the largest and probably the most strongly migratory. It migrates upstream in large numbers with pa soi during the toot jin (Chinese New Year) migration in January–February. According to Ban Hang Khone fishermen they never see it with eggs. Only a few small specimens were observed in June–July 1993.

Belodontichthys sp.— The highly specialized piscivore *Belodontichthys* sp of the Mekong and Chao Phraya rivers usually has been identified with the Indonesian species *B. dinema,* from which it apparently differs in having a shorter head and shorter pectoral fins. The species participates in the June–July migrations with other members of the family Siluridae, and enters the flooded forest in July–October, where it feeds heavily on pa soi.

Wallago leerii.— Pa koon or *Wallago leerii* is the largest silurid catfish in the Mekong. Fish to 96 kg have been caught in Ngam Ngun Reservoir (Bounhong Mounsouphon, pers. comm.). Ban Hang Khone fishermen report that it is strictly piscivorous, feeding mainly on pa soi but also on pa pak (large *Puntius*) and pa goht *(Mystus nemurus).* During low water it stays near the edge of the forest, and during high water it enters the flooded forest.

It is caught mainly in jun (trap-door traps), only put out during the period of highest water (July–October), and by single hooks (bet ken) baited with pa soi.

Mystus microphthalmus (Fig. 7).— This is by far the largest bagrid catfish of the Mekong River, attaining 70 or 80 kg; fishermen at Ban Hang Khone report fish up to 30 or 40 kg. It often has a red caudal fin, a feature not observed in any other Mekong catfish. The species also occurs in the middle Mekong, Chao Phraya, Meklong, Tapi, Salween, and Irrawaddy Rivers (observations by the author). It has been reported previously from the Mekong as *Mystus wyckioides* and *M. aubentonii* (KOTTELAT, 1989:14); these are both junior synoyms of *M. microphthalmus*.

The species is caught throughout the year and probably is the most abundant large catfish at Ban Hang Khone. The fishermen consider that it is not a migratory species, but that it enters the flooded forest during the months of high water (July–October). It reportedly feeds on fish, shrimps, and crabs. A number of very small individuals were observed in June–July 1993 indicating that it reproduces locally. Most of the pa kung landed at Ban Hang Khone are caught on hooks, either bet ken or bet piak (individual hooks or setlines). Possibly local fishing intensity on this species has increased due to the declining catches of other species (an hypothesis not discussed with fishermen at Ban Hang Khone).

Pangasius bocourti.— Several pa hua muam of about 1 meter were caught during June–July 1993; we also observed a number of fish under 20 cm, suggesting that it reproduces locally. Fishermen are unclear whether it undergoes important migrations. During high water (July–October) it enters the flooded forest and feeds heavily on fruits. On 4 July we examined the stomach contents of a large one that had fed on fruit of gooay nam and many leaves of gohk goom.

Pangasius conchophilus. —This species (formerly misidentified with the Indonesian species *Pangasius nasutus*) is perhaps the most abundant naturally occurring member of the catfish family Pangasiidae in the Chao Phraya and Mekong basins. During June–July 1993 it was the most important pangasiid in the overall fish catch at Ban Hang Khone. During the high water period of July–October it enters the flooded forest and feeds heavily on fruit.

Pangasius gigas.— Pa beuk, or Mekong giant catfish, were not observed at Ban Hang Khone in June–July 1993. According to Suntorn, the number of fish caught each year (nearly all in the first half of the year) is regularly 3 or 4. In 1993, however, no fish had been caught in the area up to July 6. According to Suntorn, most pa beuk caught there are relatively small, 150 kg or less. The smallest fish he has seen was 37 kg.

The species is generally considered to attain a maximum weight of about 300 kg; Khun Gawpkhun (Mae Ti) of Phibun Mansahan (Ubol Province, Thailand), who has bought pla beuk from the Mekong at Khong Chiam for many years, reported one of 350 kg to the author.

Pangasius hypophthalmus.— Formerly known as *Pangasius sutchi,* this is one of the most important aquaculture species in Thailand where naturally occurring *P. hypophthalmus* are evidently now extremely rare. The author observed an undoubted wild fish only once in Thailand, a 15 kg specimen in the market at Nakhon Phanom in 1990. Two fish of about

Figure 7. Pa kung, *Mystus microphthalmus*.

Figure 8. Pa sooai hang leuang, *Pangasius krempfi*.

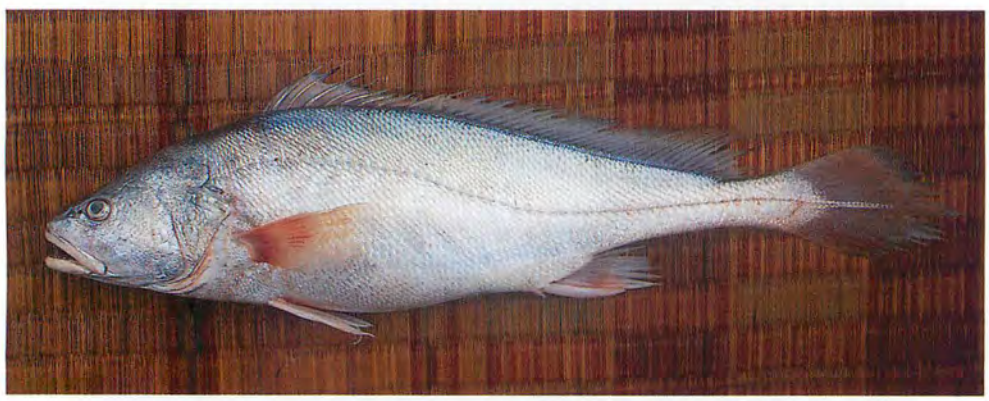

Figure 9. Pa gooawng, *Boesemania microlepis*.

Figure 10. Lee in channel of Nam Tok Somphamit, 25 June 1993.

Figure 11. Close-up of lee in Fig. 10.

7 kg were observed at Ban Hang Khone in June 1993. Cultured *P. hypophthalmus* (pla sawai in Thai) attain a maximum size of about 7 kg, while wild ones (called pla sooai in Issan) reportedly attain 50 kg. Ban Hang Khone fishermen are unsure whether the species is migratory.

Pangasius krempfi (Fig. 8).— Until recently known only from a few specimens collected in the South China Sea off southern China and northern Vietnam, this species occurs in the Mekong River at least as far upstream as Nong Khai (ROBERTS & VIDTHAYANON, 1991: 124–125). It is one of the most important migratory pangasiid species at Ban Hang Khone. For several weeks in May–June 1993 it was the most important species in the overall catch. The largest fish caught are about a meter long and 12–14 kg; no fish smaller than about 60 cm and 1.5 kg are seen. Reproduction presumably occurs in or along the Mekong delta. Migratory fish generally have empty stomachs. The species enters the flooded forest and feeds on mak deua.

Pangasius macronema.— The smallest species of Pangasiidae (largest fish about 20 cm), pa nyawn is among the most important species in the fisheries based on migrations in January–February and May–June. On 15 and 16 June 1993 Suntorn's two lees caught up to 600 kg each day. Ban Hang Khone fishermen say that pa nyawn does not spawn in their fishing area.

Pangasius polyuranodon.— Only a single specimen of this species was observed in June–July 1993, a gravid female of 63 cm standard length (900 g), with 22 gill rakers on first gill arch, 35 anal fin rays, and toothplates as illustrated for *P. polyuranodon* in ROBERTS & VIDTHAYANON (1991: 106, fig. 2i). The species, unlike most other pangasiids, frequently occurs in the brackish or tidal portions of large rivers (ROBERTS & VIDTHAYANON, 1991). It is known from the Chao Phraya and Bang Pakong rivers of central Thailand, Borneo and Sumatra, and the lower Mekong. It has not been found in the Mekong above the waterfalls.

Pangasius sanitwongsei.— Pa leum to 100 kg or more occasionally are taken with large hooks (bet ken) set in isolated gohk goom in the middle of the Mekong mainstream near Ban Hang Khone. The species apparently stays in the mainstream of the Mekong and its larger tributaries. Its abundance has declined considerably. A single specimen, 50 cm, less than one kg, was observed in June–July 1993. Although SMITH (1945: 364) mentions a *P. sanitwongsei* of 2.5 m, there is little information on the maximum weight attained by this species. Khun Gawpkhun reports fish to 200 kg from Khong Chiam; Khun Sunee Sairord, proprietor of the Giant Mekong Catfish Restuarant in Nakhon Phanom, informed the author of one of 300 kg.

Ariidae.— Ban Hang Khone fishermen recognize all Ariidae as pa kaht oak. Although *Hemipimelodus borneensis* and *Arius stormii* differ greatly in size and appearance, they are not distinguished. They report pa kaht oak (possibly *A. stormii*) to 30 or 40 kg. Several additional species of Ariidae are known from or expected to occur in the lower Mekong River (see KOTTELAT, 1989: 15). No ariids are known from the Mekong above the waterfalls (also confirmed by fishermen at Ban Hang Khone and Ban Wernkam).

Arius stormii, also known from Sumatra, Borneo (Kapuas and Barito rivers), and the

Chao Phraya (ROBERTS, 1989: 110), apparently is restricted to large rivers and probably is relatively or very rare throughout its range. SMITH (1945) reported only a single specimen from the Chao Phraya. I have observed only a single specimen from Thailand, a 30 cm live fish in an aquarium at Chatuchak Park, Bangkok, in 1990, said to have been caught at Chachoengsao (lower Bang Pakong River). Khun Kittipong Jarutanin, an aquarist in Bangkok, reports that he has regularly obtained several *Arius stormii* from the lower Bang Pakong each year since 1990, and that according to Bang Pakong fishermen the largest fish are 10 kg.

Parambassis apogonoides.— Previously known only from Sumatra and Borneo (ROBERTS, 1989: 162), this small insectivore has recently been identified by me from the Pahang River in Malaysia and from the Mekong River in collections made in Cambodia in the 1960's by F. d'Aubenton. Three specimens were obtained at Ban Hang Khone in June–July 1993.

Datnioides.— Ban Hang Khone fishermen recognize two species of *Datnioides,* pa seua *(D. microlepis),* with broad black bands, and pa mohng (rising tone) with thin black bands (*Datnioides* sp). They say pa seua attains 10 kg and feeds on fish as well as prawns and crabs, while pa mohng attains only about a half kg and feeds only on prawns and crabs. The species reportedly are not migratory, but enter the flooded forest. We obtained a single specimen of pa mohng, 240 mm standard length (600 g) and several small juvenile pa seua.

Boesemania microlepis (Fig. 9).— Several large pa gooawng were caught in gillnets in June–July 1993. Ban Hang Khone fishermen regard the species as non-migratory. The present catch is reportedly only about 10% of what it was in 1970.

Channa marulia.— Three specimens of *Channa marulia* were preserved at Ban Hang Khone and one additional specimen was observed at Ban Wernkam, about one km downstream. Two of the four specimens had the well marked caudal ocellus (dark center with pale white or orange ring) characteristic of *C. marulia.* The three preserved specimens have dorsal fin rays 48(1) and 50(2). Prachya Musikasinthorn examined these specimens and confirmed their identification as *C. marulia.* The species has not been recorded previously from the lower Mekong basin.

SEASONAL MIGRATIONS AND FISHING ACTIVITIES

January No migrations during all or most of January. Very little fishing, mainly with castnet and small to medium sized gillnets. Water going down.

Late January to late February Upstream non-reproductive migrations lasting about one week or 10 days, mainly of smaller cyprinid species, beginning on or near Chinese New Year Day (see "toot jin" in Glossary). Starts off with small pa soi hua lem, then pa soi (several species) and pa dtaep; then pa pien (*Scaphognathops* spp) (usually lasting no more than about 5 days, almost at the same time with pa sahee and pa gaeng); then several species start going at the same time: pa pak dtah leuang (species not identified); all species of pa pak (*Puntius* spp) except pa pak gohm; pa dawk niew (species not identified); pa moo *(Botia modesta);* pa nyawn *(Pangasius macronema,* the only catfish migrating during

Figure 12. Lee in narrow channel near northwest end of Don Khone, 25 June 1993 (photo Nantiya).

Figure 13. Suntorn's two lees in Hoo Saddam, 23 June 1993 (photo Nantiya).

Figure 14. Gasawn (photo Nantiya).

Figure 15. Jun.

Figure 16. Kah.

February); pa jawk (young *Cyclocheilichthys enoplos*); young pa mak ban *(Cosmochilus harmandi);* pa pia *(Labeo chrysophekadion);* pa wa (*Mekongina erythrospila)*; and pa pawn *(Cirrhinus microlepis).* None of these species are reproducing at this time. Fishing with oo and dtawn (traps), castnets, gillnets, sawn. Except for pa nyawn, which migrates only at night, all of these migrations occur mainly in the daytime. Water going down.

Middle to late February and March No migrations; very little fishing, mainly with castnets and gillnets. Water going down.

April Lowest water levels of the year. Pa nyawn *(Pangasius macronema)* migrates upstream at end of month; non-reproductive. Fishing with castnets, small gillnets, gasawn (funnel trap; Fig. 14), dtoom (big trap to catch small fish), lahn. Construction of lee.

May–July Water beginning to rise. Many large fish caught, mainly with gillnets, hooks, and lee (Figs. 10–13). Major migratory movements upstream and downstream. Biggest migrations are at end of May and early June; some migrations continuing to end of June and into July. Virtually all migrations, especially of catfishes, occur only at night.

Downstream migrations: many scaled fish species except pa uhn, pa pawn, and pa pak gohm, i.e. pa soi (*Cirrhinus* spp, *Crossocheilus* sp, *Labiobarbus leptocheilus, Lobocheilos melanotaenia*), pa pia (*Labeo chrysophekadion*), pa wa *(Mekongina erythrospila),* pa mak ban *(Cosmochilus harmandi),* pa johk (large *Cyclocheilichthys enoplos*), pa dawk niew (not identified) pa pak (*Puntius* spp.), pa gaeng (not identified), pa sahee (not identified).

Upstream migrations: pa gae-pa paw *(Pangasius conchophilus),* pa sooai hang leuang *(Pangasius krempfii),* pa nyawn *(P. macronema),* pa hua muam *(P. bocourti),* pa pboong *(P. larnaudei),* pa leum *(P. sanitwongsei),* pa beuk *(P. gigas),* pa kohp (*Belodontichthys* sp), pa sanghooa *(Kryptopterus ?apogon),* pa geht *(Kryptopterus ?bleekeri),* pa nang daeng *(Hemisilurus mekongensis).*

Pa soi caught in June–July 1993 almost always comprised the same four species, all in spawning condition: *Cirrhinus* sp (by far the most abundant), *Crossocheilus* sp, *Labiobarbus leptocheilus,* and *Lobocheilos melanotaenia.* They are caught mainly in kah (Fig. 16). Occasionally small numbers of other species occur in kah catches, such as *Cirrhinus lineatus* and *Cirrhinus* cf *siamensis.*

First half of May fishing methods same as in April; second half of May water goes up, fishing with large gillnets, lee, castnets, large-meshed sawn. June fishing with lee, large gillnets (mawng), kah, castnets, and hooks. Water continues rising in July, lee are washed away; fishing with large gillnets, bet ken and bet piak (single hooks and trotlines), and a variety of traps: kah, jun, lawp, lawp dtaung, and sai (see Glossary).

August–October No migrations. River highest and mainstream fishing activity least. Fishing in mainstream and channels similar to late July but no gillnets, greater variety of moveable traps, fewer kah. Most fishing in flooded forest.

November–early December Upstream reproductive migrations, mainly at night, of pa uhn (including *Probarbus jullieni*), pa pak gohm *(Puntius daruphani).* Water begins to go down. Fishing less with traps and more with nets; large-meshed gillnets for pa uhn.

End of December Large pa sanak *(Aaptosyax grypus)* appear (upstream reproductive migration?), signalling end of pa uhn migration. Fishing mainly with castnets and large gillnets.

FISHES IN THE FLOODED FOREST

The vegetation at Lee Pee is tropical monsoon forest, with many large broad leaved trees, at least some of which are evergreen. In July–October the Mekong is at its highest levels, flooding large areas of forest. Many fishes, large and small, enter the forest as soon as it is flooded, where they feed heavily on leaves and fruits, earthworms, insects and other terrestrial invertebrates, aquatic invertebrates including shrimp, crabs, and mollusks, and other fish.

The following account of fishes entering the flooded forest on Don Khone and Don Saddam, just below the waterfalls (except for the scientific names) and their food habits was provided by Sit. Only Sit's remarks on their food habits are included here, but it may be noted Sit's knowledge of food habits corresponds closely with the food habits of many of these species as observed in other places by the author:

Herbivorous fish species entering the flooded forest include the carps pa soi, *Cirrhinus* spp (filamentous algae); pa kiang, *Lobocheilos melanotaenia* (filamentous algae); pa pak, *Puntius* spp; pa pohng, *Leptobarbus hoeveni,* and pa gooaw, species not identified (fruits including mak gabao, mak ngooan); large pa sagang, *Puntioplites* (leaves, fruit); pa pia, *Labeo chrysophekadion* (filamentous algae); pa wa, *Mekongina erythrospila* (filamentous algae); pa mak wai, species not identified (fruits); pa pboong, *Pangasius larnaudei* (fruits); and the giant goramy, pa men, *Osphronemus goramy* (fruits, filamentous algae growing on tree trunks).

Carnivorous fishes entering the flooded forest include pa tong gai and pa tong keua, *Chitala blanci* and *C. ornata* (fish, prawns, insects); pa tong, *Notopterus notopterus* (insects, prawns); pa katong, *Xenentodon* cf *cancila* (small fish); pa gooan, *Channa marulia* (fish, animals); pa boo, *Oxyeleotris marmorata* (small fish, crab, shrimp); pa kung, *Mystus micropthalmus* (fish, crabs); pa kanyeng, *Mystus macronema* (earthworms, shrimp, insects) pa kohp, *Belodontichthys* (fish, insects); pa nang daeng, *Hemisilurus mekongensis* (earthworms, shrimp, crab, no fish); pa nang khao-sanghooa, large *Kryptopterus* (fish, shrimp, insects); pa koon, *Wallago leerii* (fish only); pa soot, *Hampala macrolepidota* (shrimp, fish); pa mohng, *Datnioides* sp (shrimp, crabs); pa seua, *Datnioides microlepis* (fish, shrimp, crab); pa kaho (fish, crab, shrimp); pa makahn makehr, *Bagrichthys* spp (shrimp, insects); pa kee hia, *Leiocassis siamensis* (earthworms, insects, shrimp); pa laht, *Mastacembelus siamensis* (shrimp, fish); pa loht, *Mastacembelus armatus* (shrimp, fish); pa gah, *Pristolepis fasciata* (ants, shrimp); and pa siu ao, *Rasbora* sp (red ants and their eggs).

Fishes with a mixed diet in the flooded forest include pa goht, *Mystus nemurus* (shrimp, crabs, fish, fruits); pa hua muam, *Pangasius bocourti* (insects, fish, leaves, fruit); pa gae-pa paw, *Pangasius conchophilus* (crab, prawns, mollusks, gooay nam, mak deua); pa noo, *Helicophagus waandersii* (mollusks, earthworms, shrimp, crabs, fruit of mak hoon); and pa mak wai, species not identified (shrimp, fruit especially figs).

The following list of plants utilized by fishes in the flooded forest is the result of walks in the forest with Ian Baird, Sit and other fishermen in June 1993, as well as separate interviews with Sit, Suntorn, and others:

ben nam ?*Olea* or ?*Linociera,* Oleaceae, fishes hide in dense bush.

gohk deua *Ficus variegata* Bl. var. *variegata,* Moraceae (very large, broad-leaved evergreen fig tree, with large masses of cauliflorous and ramiflorous figs throughout the year), fishes eat figs, hide in aerial roots (Figs. 17–19).

gohk ga lun fishes eat fruit.

gohk ga phoo *Allophyllus cobbe* (L.) Raeusch, Sapindaceae (small tree, small fleshy fruit with many seeds), fishes eat fruit.

gohk goom *Crateva nurvala* Ham. var. *nurvala,* Capparidaceae (medium size tree, medium sized fruit with rough rind, dry pulp, many seeds), fishes eat leaves and rind of fruit.

gohk goom ma *Flacourtia jangomas* (Lour.) Raeusch., Flacourtiaceae (small deciduous tree, widely cultivated, unknown in wild state, perhaps originated in India), fishes hide among roots and submerged branches; eat ants fallen from tree or drowned by rising water.

gohk hai pa soi *Ardisia* sp, Myrsinaceae (small tree; small pulpy fruit with single seed), fishes eat fruit.

gohk kem *Ixora* sp, Rubiaceae (shrub or treelet), fishes live in.

gohk laem saeng ?*Osbeckia* sp, Melastomataceae (large rheophilic tree), most important plant in middle of Mekong River below waterfalls, where pa leum is attracted to it and occasionally caught with large hooks; in river and in flooded forest many fish hide in roots and inside hollowed out trunks, including pa men, pa gooaw (not identified), pa mong phoo (*Datnioides* sp?), pa pia, pa pak, pa kaho, pa gaw, pa wa.

gohk nang dum fishes eat fruit.

gohk pee man *Albizia* sp, Leguminosae, Mimosoideae (deciduous very fast growing tree, rheophilic colonizer), fishes hide in roots and hollowed trunk.

gooay nam *Artabotrys spinosus* Craib, Annonaceae (woody climber), fishes eat fruit.

hai gawng fishes eat fruit.

hai kee moht fishes eat fruit.

kai gin mak pa men, pa nyawn, and pa pak eat flowers.

kai poo *Homonoia riparia* Lour., Euphorbiaceae (rheophilic shrub), fishes hide in bush.

keua lin haet *Tetracera loureiri* (Fin. & Gagnep.) Pierre ex Craib, Dilleniaceae (woody climber, probably deciduous), fishes eat leaves?

keua nam *Diospyros pilosanthera* Blanco, Ebenaceae (everygreen tree), fishes eat leaves.

keua nyon haeng *Passiflora foetida* L., Cucurbitaceae (weedy vine, introduced from tropical America), fishes eat leaves.

mak ben fishes eat leaves.

mak dtanai (vine on ground), fishes eat fruit.

mak eetok *Olax scandens* Roxb., Olacaceae (woody climber), fishes eat fruit.

mak gabao *Hydnocarpus anthelminthica* Pierre ex Lanessan, Flacourtiaceae (large broad-leaved evergreen tree, large fruit with toxic seeds) (Figs. 5, 20) eaten by pa pohng *(Leptobarbus hoeveni)* and pa gooaw (unidentified large cyprinid). Seeds of *Hydnocarpus* spp contain chaulmoogra oil, used in treating leprosy; active substances include glycerides of two fatty acids, chaulmoogric acid and hydnocarpic acid, as well as glycosides which discharge hydrocyanic acid; the seeds may also be used to poison fish (SLEUMER, 1954; 15).

mak gahn leuang fishes eat fruit.

mak hai mee fishes eat fruit.

mak het fishes eat fruit.

mak hoon fishes eat fruit and leaves.

mak ngooan *Quassia harmandiana* (Pierre) Nooteboom, Simaroubaceae (shrub; Fig. 21), pa pohng *(Leptobarbus hoeveni)* and pa gooaw (unidentified large cyprinid fish) eat poisonous fruit (Figs. 5, 21). Fruits of Simaroubaceae are usually bitter due to sesquiterpines and diterpenes such as quassin (Nooteboom, 1962).

mak panyahai fishes eat fruit.

mak pbawng pbaw *Physalis angulata* L., Solanaceae (native herbaceous weed of cultivation), fishes eat fruit.

mak wah fishes eat fruit.

mak wah kee mot *Eugenia* sp, Myrtaceae (everygreen tree), fishes eat fruit.

pak bia fishes eat leaves.

pak hom *Amaranthus spinosus* L., Amaranthaceae (herbaceous weed of open disturbed areas) fishes eat leaves.

sohm pa soi *Morindopsis capillaris* (Kurz), Rubiaceae, fishes eat fruit and leaves (Fig. 22).

yah get hoy fishes eat flowers and leaves.

As the waters continue to rise at the end of June and beginning of July they begin to flood the forests along the margin of the Mekong mainstream. Fallen fruits are swept by the current out into the channels and mainstream of the river, where they are fed upon by many fish species, presumably including some that do not enter the flooded forest. From the start the fish encounter the leaves of the gohk goom and of various grasses and vines in sandy areas with low plant diversity. As the water continues to rise and flood the forest, it deposits a rich layer of silt. Many smaller and medium sized fish species (pa soi, pa goht) take refuge in massive root systems of gohk deua, gohk laem saeng, gohk goom, gohk goom ma and other large tree species, and an increasingly greater quantity and variety of terrestrial animals (ants, other insects, earthworms, gastropod mollusks), aquatic animals (prawns, crabs, gastropod and bivalve mollusks) leaves, seeds, and fruits becomes

Figure 17. Gohk deua, *Ficus variegata* var. *variegata*.

Figure 18. Mak deua.

Figure 19. Aerial roots of gohk deua, with ripe mak deua on ground.

Figure 20. Gohk gabao, *Hydnocarpus anthelminthica*.

Figure 21. Mak ngooan, *Quassia harmandina*.

Figure 22. Sohm pa soi, *Morindopsis capillaris*.

available as food. Among the more important plant foods (in terms of abundance) available to fish are leaves of gohk goom and the fruits mak deua and mak hai. Many predatory fish (notably *Chitala ornata, Chitala blanci, Wallago leerii, Wallago attu, Mystus microphthalmus, Channa marulia, Channa striata, Datnioides microlepis*) move into the flooded forest to forage on herbivorous fishes, of which the most abundant are pa soi (*Cirrhinus* spp).

DECLINE OF FISHERIES AT BAN HANG KHONE

The fishermen of Ban Hang Khone are unanimous in the view that fisheries have declined markedly since 1970. The consensus is that the fisheries of today is only about one-fifth of what it was in 1970. As examples of species that were formerly common and migrated in far greater numbers than in more recent times, they name pa mak pang *(Tenualosa thibaudeaui),* pa pawn *(Cirrhinus microlepis),* pa johk *(Cyclocheilichthys enoplos),* and pa uhn (*Probarbus* spp). But they also insist that virtually all species have decreased, and that the overall fisheries is now only about 20% of what it was in 1970. Suntorn's quantitative observations on former abundance of pa mak pang are given above under the biological notes for this species. Suntorn also has provided quantitative data on decline of the fisheries since 1991. The total catches of his two lees placed in Hoo Saddam for the migratory period of May–July has dropped from 7000 kg in 1991 to 5000 kg in 1992 and only 3,500 kg in 1993. Other fishermen indicate that they have experienced similar decline. It is noteworthy that whereas in former times all able-bodied men of Ban Hang Khone were active fishermen, in recent years several have given up fishing and taken to buying fish instead. This is undoubtedly partly due to new opportunities provided by improved marketing facilities and expanding markets, but according to them it is also a response to decreasing catches for their fishing efforts.

Decline of the fisheries is the foremost topic of discussion and concern for the people of Ban Hang Khone. Several of them have considered taking up fish farming. They identify the following local causes for the decline of the fisheries: 1) lee; 2) gillnets; 3) explosives.

It seems probable that lee have increased steadily in number in the last two decades or so. One of the most reliable informants indicated he thought there were about 100 lee, but Baird and I observed at least 40 without making an extensive survey, and think the actual number during May–July 1993 may have exceeded 200. Also, lee constructed in recent years reportedly have tended to be built somewhat larger and to last a bit longer. Lee could be involved in decline of numerous species, notably *Tenualosa thibaudeaui, Cirrhinus* spp, *Puntius* spp, *Scaphognathops* spp, and *Pangasius macronema.*

Gillnets presumably have contributed to decline of some of the larger migratory fish species, including but not limited to *Pangasius gigas, Catlocarpio siamensis, Cirrhinus microlepis, Cosmochilus harmandi, Cyclocheilichthys enoplos,* and *Probarbus* spp. The large top level predator *Aaptosyax grypus,* endemic to the Mekong basin, would seem particularly prone to extinction due to fishing with large-meshed gillnets intended mainly for the much commoner pa uhn *(Probarbus)* of the same size. Unfortunately pa sanak is greatly esteemed and commands a price two or three times that of other fishes. Perhaps the only useful measure to protect the species would be to forbid its sale. Disappearance

of *Pristis* (sawfish) from Ban Hang Khone may well be due to gillnet fishing, to which this fish is extremely susceptible. Another species particularly likely to have declined mainly due to gillnet fishing is pa gooawng, *Boesemania microlepis*.

Explosives reportedly are used only by Cambodian fishermen and soldiers. Many of the bombs are made from landmines from the Cambodian civil war. The villagers of Ban Hang Khone are unanimous (or nearly so) in the belief that this has been the single most important reason for decline of fish stocks. It is difficult to evaluate this claim, or to tell which species may have been most seriously damaged. Most of the bombing occurs during the low water period of March–May. At this time most of the fish obtained by buyers in Ban Hang Khone have been killed by explosives (obs. Ian Baird). The villagers do not like to buy such fish, but do so in order not to offend the Cambodians and because they know that other buyers are more than willing to purchase such fish.

Fish killed by explosives can be recognized readily. Many of them show a highly characteristic loss of scales from the sides of the body where the girth is greatest (not at all like the more anterior loss of scales due to chafing against the mesh in fish that have been gillnetted). The catch of fish killed by explosives tends to consist predominantly of large cyprinids (catfishes, which sink to the bottom if killed outright, and smaller fishes, are seldom recovered).

Up to now the local people have not been aware that upstream nutrient reduction and habitat deterioration of the Mekong basin also may have played a major role in the decline of fisheries. Apart from the decline of fish, crocodile, and dolphin populations, there is little indication of deterioration of the Mekong ecosystem immediately below the waterfalls. In particular, we did not observe a single *Eichhornia* plant (water hyacinth, pak tohp jawa) in June–July 1993, and Ban Hang Khone fishermen are unfamiliar with it. On the other hand, we did find two exotic fish, albeit represented by very few individuals: *Cirrhinus mrigala* (native to India), and common carp, *Cyprinus carpio*. We also found the terrible weedy shrub *Mimosa pigra* L. (Leguminosae, Mimosoideae, "gratin ngahm" in Lao and Thai), established on the islands below the waterfalls but in relatively low density. This plant, introduced from tropical America, is one of the worst riverside weedy pests in Southeast Asia, spreading rapidly in burnt or otherwise disturbed areas. Human population density, rather high on the islands and mainland above Khone Falls, is still relatively low just below the falls. There is relatively little cultivation, and the forests are still relatively intact. However, this situation may not last much longer. A logging operation, as yet small scale, recently started on the Cambodian mainland immediately opposite Ban Hang Khone. As of now the riverside or riparian forest annually flooded and invaded by fishes is still relatively intact.

According to Ban Hang Khone villagers the Mekong dropped to the lowest levels they have ever seen in April 1993. The situation should be closely monitored from now on. Increasingly great differences between high water and low water levels could be an indication of a general deterioration of the Mekong ecosystem. On the other hand, the low water levels of April 1993 might be directly due to filling of the newly constructed Manwan Dam in Yunnan.

As with artisanal fisheries generally, repeatable studies of catch per unit effort will be difficult to make at Lee Pee, and to be of much value must be made over a period of several years. This is partly because of the unpredictable variations of water level and

other conditions resulting in some species of migratory fishes modifying their behavior from year to year, i.e., by using different hoos. Thus Suntorn usually catches large numbers of migrating pa nyawn in Hoo Saddam in the January–February and in the May–June migrations, but in 1993 he caught them only in May–June. Fishermen, of course, are strongly inclined to change the target species and otherwise modify their fishing efforts in response to changes in fish behavior or abundance, making it virtually impossible to make meaningful comparisons from catch per unit effort data over the years. On the other hand, an assessment of trends in fishing effort could be made. It should be particularly easy to make a yearly census of the number of lees and other large immoveable fishing traps and their locations.

The supply of landmines to bomb fishes presumably will abate with peaceful resolution of conflict in Cambodia. In the meantime it is desirable that UNTAC and other authorities involved with removal of landmines as a threat to people endeavour to prevent them from being redeployed to kill fishes. Bombing is a very wasteful procedure compared to fishing with gillnets or lees in that only a small proportion of fish killed is recovered. It seems pointless to impose restrictions or limitations on other fishing methods, however, unless major governmental and international efforts are made to reverse or at least curb the overall deterioration of the Mekong river ecology due to deforestation, dams, industrial wastes, pesticides, water hyacinth, and other largescale negative impacts.

SUGGESTIONS FOR FUTURE RESEARCH

Khone Island offers an excellent site (perhaps the best site) for a scientific field station on the Mekong River. Although there is considerable fishing activity, local human environmental impacts are otherwise minimal. The variety of habitats and biodiversity is probably as great or greater here than anywhere else in the Mekong basin. The waterfalls at Lee Pee are a significant physiographic and faunal boundary between the lower and middle Mekong basin. The rapids below the waterfalls are the most important of any large lowland river in tropical Asia. The importance of these rapids in providing habitat for many species and in contributing to the productivity of the lower Mekong River needs more study, including extensive sampling and identification of the biota.

The present list of some 100 species at Khone Island represents only a small fraction, perhaps less than one fourth, of the fishes expected to be found there. Only some ten species, collected by castnet, have been reported from the rapids (TAKI, 1974). The best time to collect fishes in the rapids is during the low water period of March–April, when small amounts of chemicals such as rotenone can be used in channels with water gently flowing between and underneath massive rocks and rocky ledges. The need to do such collecting is urgent, because engineering projects such as mainstream dams, upstream or downstream of Lee Pee, or canalization of the Mekong River for shipping may soon destroy the rapids and all the fishes in them. The same urgency of course applies to other studies at Lee Pee.

Ecological study of fishes at Lee Pee should include continued efforts to record Lao names of fish species. While the names are of linguistic interest, the main reason for learning them is to be able to converse with fishermen about the fishes, and to obtain biological clues from the names themselves. Efforts to equate Lao names one-to-one with

scientific names are misguided for several reasons. Firstly, Lao fishermen do not necessarily share our concept of the species as a biological unit, so there is no reason for them to base their names on such a concept. Systematists such as Linnaeus recognized the need to apply a single scientific name to each plant and animal species, largely because local or vernacular names are not standardized. Even when westernized or acculturated Lao fishermen have a species concept similar to ours, there is no reason for them to apply a single name to each species, and in fact they do not do so. But the really important reason to obtain all of the local names used for a species is for clues to local knowledge of their biology. This inevitably will contribute to a better linguistic and ethnographic knowledge as well. Names should not be ignored just because they are only used by a minority of fishermen for a given fish species. At the same time, a vigorous effort must be made to assure the scientific names are connected correctly to the local names, and this can only be done by persons who have learned the scientific identifications of the fish species.

Lao fish names mentioned at Ban Hang Khone that have not been identified scientifically (all prefixed by pa) include dawk niuw, gabong dong, gooat, gooaw, kaiee, khoi kha, ling, mak wai, mang poo, nyang, pak dtah leuang, pak ngai, sa-ee, soi hua lem, uhn moom, wa sooang. Names doubtfully identified are pa galow (=pa kaho, *Catlocarpio siamensis*?), pa keenyang *(=Barbichthys nitidus?),* pa khao na *(=Mystacoleucus?),* and pa lai fai fa (literally, electric eel; =*Anguilla* or *Plotosus canius*?).

Only a broad outline of the yearly cycle of the biology of fish migrations and utilization of the flooded forest at a single site on the lower Mekong River has been presented here. This outline is based mainly on interviews with local fishermen, with some direct confirmation of species identification and biology during June–July 1993. The interviews and observations should be extended to other times of the year, and other places, especially in Cambodia, where there is a vast area of annually and permanently flooded lowland forest with high biodiversity of plants and fishes.

Identification of migratory species is needed for the periods late January–February and October–November. Food habits of fishes at all times, but especially during the months of July–October when they use the flooded forest, need to be confirmed by direct observation. The more exact the quantitative and qualitative observations of migrations and food habits are, the more valuable they will be. The comparative approach should be especially valuable. Comparisons should be made of the food habits of large predatory catfishes such as *Belodontichthys, Mystus microphthalmus,* and others. Much more work needs to be done to obtain herbarium-quality specimens and identify plants of the flooded forest utilized by fishes. An effort should be made to determine whether germination and dispersal of seeds of some plants is facilitated by fishes feeding upon them. Special attention should be focused on shifts in feeding behavior as species move from one major habitat to another. The entire field of fish reproductive biology, including timing and stimulus of reproductive migrations, time, place, and other requirements for spawning, morphological and physiological adaptations of eggs and larvae, and comparative reproductive biology of carps, catfishes, and other groups under natural conditions, is largely untouched for the Mekong fishes. At this point, we do not even know which species spawn in the flooded forest and which ones spawn in the rapids.

GLOSSARY OF LAO WORDS RELATED TO FISH AND FISHING

bet fish hook.

bet ken fish line with single hook.

bet piak trotline or setline with numerous hooks.

don island.

dtoom big trap to catch small fish in April (not observed).

gasawn funnel-type trap (Fig. 14).

gohk tree.

gohk lam saeng main tree species in middle of Mekong River and on edge of flooded forest below Lee Pee.

gohk pee man second most important tree species in middle of Mekong River and along margin of flooded forest below Lee Pee.

hae castnet.

hae teuang old style castnet made of vines of gohk teuang or gohk bahn (now rare; not seen in June–July 1993).

haew waterfall or rapids.

hahk roots; roots of a number of trees provide important cover for many fish species (especially pa soi, pa goht) in the flooded forest, channels, and mainstream of the Mekong River.

hoo literally "ear"; Thai as well as Lao speakers designate various fish structures as hoo, including the spiracles of sawfishes, stingrays, and gyrinocheilids; reduced pectoral fins of anguillid eels; and sometimes color marks on or just behind the head, such as the black tympanic spot of *Pangasius larnaudei;* hoo in Lao also refers to a large river channel, such as Hoo Saddam between Don Khone and Don Saddam.

jun trapdoor trap (Fig. 15), especially effective for catching large soft-shelled turtles (pa fah awn) and large catfishes such as pa kung, *Mystus microphthalmus,* and pa koon, *Wallago leerii.* At Ban Hang Khone used only during the period of high water, July–October. Traps of identical construction were observed by me in August 1993 on the Sai Yok portion of the Meklong River in western Thailand. At Sai Yok the traps are also called jun, and catch mainly soft-shelled turtles and pla kang (the local name for *Mystus microphthalmus*).

kah widemouthed plaited basket trap for catching pa soi. The kah is filled with dried vines or grass, similar to the cover naturally sought by pa soi (Fig. 16)

kai hin filamentous green algae attached to stones (hin); fed on by various fishes including pa kiang *(Lobocheilos melanotaenia),* pa men *(Osphronemus goramy).*

keegaduan earthworm; fed upon by fishes (mainly catfishes) in the flooded forest; also

used as bait (yeua).

keua vine; leaves, flowers, and seeds of several vine-like plants are eaten by fishes.

lahn fish trap used in April (not observed).

lawp dtaung cylindrical basket trap with slit-like entrance for length of one side; one observed near Ban Hang Khone was 1.5 m long and 60 cm diameter.

lee large immobile wing trap used in rapids just below Lee Pee (Figs. 10–13); mostly constructed in April–May, and washed away by the end of July; catches large quantities of migratory pangasiids, mainly pa gae-pa paw *(Pangasius conchophilus)* and pa nyawn *(P. macronema)*. Traps similar or identical to lee were formerly used in the Mekong and Chao Phraya rivers and their tributaries in Thailand, but have now largely disappeared from these places. The wings of a lee are made of stakes driven into the river bed to form a large V entering the catch area, a bamboo platform starting below water level and rising out of the water posteriorly (until the river rises completety over it). The wings face into the current and augment the current into the trap. Thus fish are swept into the wings and up onto the bamboo platform or catch. Fishermen reach the catch by a catwalk extending from shore. Often a series of lee is connected by catwalks.

lem spear, used mainly for catching fish hiding in tree trunks in the flooded forest (July–October).

mak, mak mai fruit.

mawng gillnet.

mawng foo drifting gillnet.

mawng loom set gillnet.

nam kuhn rising water.

nam long falling water.

nam tok waterfall. The largest waterfalls at Lee Pee are, from the left (Lao) to the right (Khmer) bank: Khone Papaeng (largest), Haew Ee Toot, Somphamit (second largest), and Tam Ee Daeng (or Khone Fang).

nok laew gaew *Elanus caeruleus* (Desfontaines, 1798), the black-shouldered kite; according to fishermen of Ban Hang Khone the appearance of this small raptor in December signals the end of the pa uhn migration; it also shows up at the end of the pa soi migration in February.

oo large fish trap used in January–February (not observed).

pa (equivalent to Thai "pla"); prefix for all Lao fish names; also used for dolphin (see pa kha) and soft-shelled turtles or Trionychidae (see pa fah awn).

pa daek (northeastern Thai pla la) fermented fish; most important of several local methods of preserving fish. See pa haeng and pa khem. Pa daek is notorious for its role in

transmission of human liver fluke, *Opisthorchis viverrinae* (Poirier, 1886) Stiles & Hassall, 1896, the secondary hosts of which (all members of the family Cyprinidae so far as known) include pa soi (*Cirrhinus* spp), pa soot *(Hampala macrolepidota),* pa lang kohn *(Labiobarbus leptocheilus),* pa pak (*Puntius* spp), pa pohk *(Puntius orphoides),* and pa nai *(Cyprinus carpio).* Pa daek made from fish caught at Lee Pee is far less likely to be infected than that from fish raised in ponds or caught in rice paddies.

pa fa awn soft-shelled turtles, Trionychidae. Caught mainly in jun set on the river edge and in the flooded forest in July–September. Large soft-shelled turtles known or expected at Lee Pee include *Trionyx cartilageneus* (Boddaert, 1770), *Dogania subplanus* (G. Saint-Hilaire, 1809), and *Pelochelys bibroni* (Owen, 1853).

pa haeng dried fish.

pa kha dolphin, *Orcaella brevirostris.* Feed on large fish, which they bite in half. Most fishermen at Lee Pee avoid catching or injuring dolphins, but some are killed each year by bombs or gillnets.

pa khem salted fish.

pa kuhn lohng literally "fish go up come down"; fish migration.

pa kuhn upstream migration of fish.

pa lohng downstream migration of fish.

pak tohp jawa *Eichhornia crassipes* (Mart.) Solms or water hyacinth (Pontederiaceae); originally from South America but introduced throughout the tropics of Africa and Asia, including Java, Thailand and Laos, where it is the most serious aquatic plant pest; none observed in the Mekong River just below the waterfalls of Lee Pee in June–July 1993.

peek literally "wing", as of a bird; pectoral and pelvic fins of fishes.

sai small trap similar to lawp, but with opening on side; catches mainly pa goht *(Mystus nemurus).*

sawn scoop net with two long sticks.

tao unidentified floating vegetable matter (filamentous alga *Spirogyra?*) eaten by pa pia and pa wa in the flooded forest.

toot jin traditional Chinese New Year; on the second new moon after the winter solstice in China (on or about 22 December), thus between 21 January and 19 February each year (in 1993 on 23 January). Upstream non-reproductive migration of pa soi and other small scaled fishes starts on or about this day.

wang (also in Thai) large space or pool in river, such as the wang at Ban Hang Khone where the dolphins hang out.

yeua bait; the fish most often used for baiting hooks is pa soi (*Cirrhinus* spp). Other baits are earthworms and fruits. Jun and other traps also are baited.

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REFERENCES

KOTTELAT, M. 1989. Zoogeography of fishes from Indochinese inland waters with an annotated check-list. *Bull. Zool. Mus. Univ. Amsterdam* 12, 54 pp.

NOOTEBOOM, H.P. 1962. Simaroubaceae, pp. 193-226 in Flora Malesiana 6.

ROBERTS, T.R. 1989. The freshwater fishes of western Borneo (Kalimantan Barat, Indonesia). *Mem. California Acad. Sci.* 14, xii+210 pp.

ROBERTS, T.R. 1992. Revision of the Southeast Asian cyprinid fish genus *Probarbus*, with two new species threatened by proposed construction of dams on the Mekong River. Ichthyol. Expl. Freshw. 3: 37-48.

ROBERTS, T.R., and C. VIDTHAYANON. 1991. Revision of the tropical Asian catfish family Pangasiidae with biological observations and descriptions of three new species. *Proc. Philadelphia Acad. Nat. Sci.* 143: 97-144.

SLEUMER, H. 1954. Flacourtiaceae, pp. 1-106 in Flora Malesiana 1.

SMITH, H.M. 1945. The Fresh-water Fishes of Siam, or Thailand. *Bull. U.S. Nat. Mus.* 188, xii+622 pp.

TAKI, Y. 1974. The Fishes of the Lao Mekong Basin. USAID Mission, Agric. Div., Vientiane, vi+232 pp.