NAT. HIST. BULL. SIAM SOC. 55(1): 121–148, 2007

FISHES AND FORESTS: THE IMPORTANCE OF SEASONALLY FLOODED RIVERINE HABITAT FOR MEKONG RIVER FISH FEEDING

Ian G. Baird[1]

ABSTRACT

The Mekong River supports a rich diversity of fish species and seasonally inundated riparian forest habitats, including those in the Siphandone Wetlands in Khong District, Champasak Province, southern Laos and adjacent areas in Stung Treng and Kratie Provinces in northeastern Cambodia. However, there has been little systematic research done regarding the relationships between fishes and seasonally flooded forests in the Mekong River Basin. This paper confirms that terrestrial plants are important food sources for some important fish species, by means of a study of fish stomach contents conducted at Ban Hang Khone, a rural fishing village situated on an island in the Mekong River just below the Khone Falls. A total of 1,617 fish specimens belonging to at least 73 species, 52 genera and 20 families were examined. At least 35 species of forest fruits, 13 species of fresh leaves, and 3 species of flowers were found in fish stomachs along with bark, roots and a wide variety of other fish foods. Species in the family Pangasiidae were found to be the most important consumers of fruits and other fresh vascular plant material. *Hypsibarbus* spp., *Tor tambroides, Leptobarbus hoeveni* (Cyprinidae), *Osphronemus exodon* (Ospronemidae) and other fishes also consume considerable amounts of plant matter. Villagers mentioned 73 plant species believed to be consumed by fishes, including 9 suitable for baiting hooks for catching fish. The importance of seasonally inundated forests to the aquatic ecosystem of the Mekong River is considered, including the possible role of fishes as plant seed dispersers and predators. Flooded forests along the Mekong River are threatened by hydrological changes caused by the construction of large dams both up and down river.

Key words: Cambodia, fish diet, fish feeding, flooded forests, Laos, wetlands

INTRODUCTION

There are often important relationships between freshwater fish species and seasonally inundated vegetation, or flooded forests. In the tropics, fish–forest feeding relationships in the Amazon River Basin have been particularly well studied (GOULDING, 1980; 1983; 1993; GOULDING & FERREIRA, 1984; ARAUJO-LIMA *ET AL.*, 1998; SAINT-PAUL *ET AL.*, 2000). In the Mekong River Basin and other parts of Southeast Asia, many freshwater fish are known to feed on forest fruits and other seasonally flooded vegetation (ROBERTS, 1993), but there has been surprisingly little research done to document the feeding habits of freshwater fish in relation to seasonally inundated forests.

[1]Geography Department, University of British Columbia, Vancouver, B.C., Canada; and Global Association for People and the Environment (GAPE), P.O. Box 860, Pakse, Lao PDR. Correspondence: 1235 Basil Ave., Victoria, B.C., Canada V8T 2G1. Email: ianbaird@shaw.ca
Received 19 April 2006; accepted 25 February 2007.

Figure 1. The Lower Mekong River Basin, showing the location of the Siphandone Wetlands, in Khong District, Champasak Province, southern Lao PDR

The seasonally inundated riparian habitat of the southern-most part of the Lao People's Democratic Republic (Lao PDR or Laos) and northeastern Cambodia constitutes an important part of the aquatic ecosystem of the Mekong River Basin. The Siphandone Wetlands in Khong District, Champasak Province, southern Laos—and areas along the Mekong River between Kratie Province in northeastern Cambodia, and the border between Laos and Cambodia in Thalaborivath District, Stung Treng Province—support some of the most important seasonally inundated habitats and associated fish populations (ROBERTS, 1993; CLARIDGE, 1996; BAIRD *ET AL.*, 1999; DACONTO, 2001; BARAN *ET AL.*, 2005). The Khone Falls are situated in the southern-most part of the Siphandone Wetlands (Fig. 1).

The objective of this study was to investigate the feeding patterns of various Mekong River fish species found near seasonally inundated forests in the Khone Falls area in order to gain a better understanding of the relationships between fish and seasonally inundated forests. Although preliminary results are given for 73 fish species, detailed data are provided for only those species found to consume significant amounts of seasonally inundated vegetation. Local knowledge regarding the relationship between fishes and seasonally inundated riverine habitat in the Mekong River in southern Laos and northeastern Cambodia was also utilized. In this paper I consider the possible repercussions of seasonally flooded riverine habitat destruction on indigenous fish populations and biodiversity in the Mekong River Basin, and consequently on the local people who depend on wild-capture fisheries for subsistence and income, especially with regard to the construction of large dams upriver.

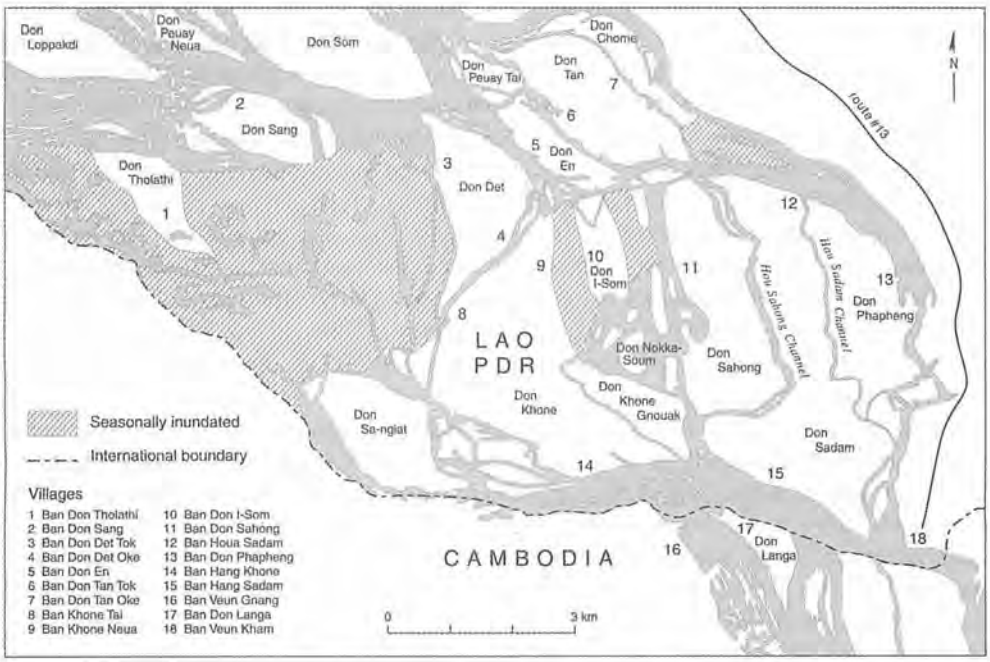

Figure 2. The Khone Falls in Khong District, in the lower part of the Siphandone Wetlands, in Champasak Province, southern Laos. The Falls cross the middle of the map from west to east.

STUDY AREA

The Siphandone Wetlands are situated in the mainstream Mekong River in the southern-most part of Laos and consists of a complex system of channels, rapids, deep water pools, waterfalls, large and small inhabited and uninhabited islands, and various kinds of seasonally inundated forests (CLARIDGE, 1996; DACONTO, 2001). The Khone Falls is a series of waterfalls and channels running parallel from west to east in the southern-most part of the Siphandone Wetlands (Fig. 1). Ban (village) Hang Khone, where the study was conducted is situated on Don (island) Khone, which straddles the Falls (Fig. 2, #14).

FLOODED FORESTS

The seasonally inundated wetland habitat of Siphandone and adjacent parts of northeastern Cambodia is unlike other seasonally flooded areas in the Amazon basin or even the Tonle Sap Lake of Cambodia. In the Amazon, large floodplain areas are inundated for many months each year as a result of varying rainfall patterns in different parts of the basin, creating ideal conditions for fish habitation. In many ways the flooded rivers of the Amazon are a product of hydrological conditions similar to those of the Mekong, but the fish and plant species are entirely different (GOULDING, 1980; 1983; SAINT-PAUL *ET AL.*, 2000).

In Cambodia, the annual reversing of the direction of the Tonle Sap River during the rainy season contributes significantly to the Tonle Sap Lake being filled up by the high-waters of the Mekong River (LIENG *ET AL.*, 1995), expanding the inundated area from 2,520 km^2 in the dry season to a peak of 15,780 km^2 in the rainy season (RAINBOTH, 1996). ROLLET (1972) recognized the Tonle Sap forest to be of largely endemic or autochthonous origin, and evolutionarily related to, but not identical with, forests that occupy riparian zones of the Mekong River. He noted the shared presence of *Crateva, Cynometra, Homonoia, Hydnocarpus*, and *Samandura* in the Tonle Sap area and along the Mekong proper, but also pointed out a number of key plant species in the flooded forests of southern Laos and north-eastern Cambodia that are absent in the Tonle Sap Lake. These include *Ficus racemosa* L. var. *racemosa* (Moraceae), *Anogeissus rivularis, Acacia harmandiani,* and *Telectadium edule*, to name a few. MCDONALD *ET AL.* (1997) confirmed that no more than 20% of the vascular plant species found in flooded forests in the Tonle Sap Lake are also found in and along the mainstream Mekong in southern Laos and northeastern Cambodia, and most of those that do exist represent secondary and upper-floodplain species. Thus, the relationships between fishes and forests can be expected to differ.

Critically, the riverine flooded forests discussed here are associated with a largely linear river system with seasonally moderate-to-fast flowing water, unlike the lacustrine-like environment found in the Tonle Sap Lake in Cambodia where water levels rise without associated increases in water velocity. Riparian plants in and along the mainstream Mekong must, however, adapt to the swift rainy season current. Substrate in the Tonle Sap Lake is also markedly different, with sands and silts dominating, whereas rocky areas dominate northeastern Cambodia and southern Laos (ROBERTS & BAIRD, 1995; RAINBOTH, 1996; DACONTO, 2001). The amount of flooded area changes immensely in the Tonle Sap Lake, while along the Mekong River in southern Laos and northeastern Cambodia horizontal flooding is much less extensive.

Figure 3. Typical flooded forest area during the dry season below the Khone Falls near Hang Khone village, Khong District, Champasak Province, Lao PDR

Figure 4. Large flooded forest area during the dry season just above the Khone Falls, Khong District, Champasak Province, Lao PDR

Figure 5. *Ficus racemosa* L. var. *racemosa* (Moraceae) tree and ripe fruits (*mak deua* in Lao) adjacent to the Mekong River near Hang Khone village, Khong District, Champasak Province, Lao PDR. Many fish species eat these fruit when they fall into the water, and the fruits are also used as bait to catch some fish species with hooks

Figure 6. *Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae) ripe fruits (*mak houn* in Lao). These fruits are used as bait to catch fish with hooks, especially *Pangasius polyuranodon* (*pa gnone hang hian* in Lao) the rainy season from the Mekong River below the Khone Falls in Hang Khone village, Khong District, Champasak Province, Lao PDR

Figure 7. An example of a *Pangasius polyuranodon* (*pa gnone hang hian* in Lao) fish caught on a floating hook baited with *Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae) ripe fruits (*mak houn* in Lao) in the Mekong River near Hang Khone village, Khong District, Champasak Province, Lao PDR

Figure 8. An elderly experienced fisher from Sang village, Khong District, Champasak Province, Lao PDR demonstrates how *Crateva manga* (Lour.) DC. (Capparaceae) leaves (*bai koum* in Lao) are used to bait fish hooks to catch mainly *Pangasius bocourti* (*pa nyang* in Lao). If the leaves are not positioned on the hook the right way, there is no hope of catching any fish, emphasizes the fisher

Figure 9. *Pangasius pleurotaenia* (*pa nyone thong khom* in Lao), one of the important fish species in the Hang Khone village area that eats flooded forest leaves and fruit

Figure 10. *Pangasius conchophilus* (*pa pho* (large sized fish) and *pa ke* (small sized fish) in Lao), one of the important fish species in the Hang Khone village area that eats flooded forest leaves and fruit

There are many types of inland 'flooded forests' throughout the world. Here, 'seasonally inundated riparian or riverine habitat' or 'flooded forest' is defined as the area up to and including the moving littoral zone which is subject to sporadic flooding or inundation as a direct or indirect result of seasonal changes in the water levels of the Mekong River or her tributaries.

It is not yet known how much seasonally inundated riparian habitat exists in northeastern Cambodia and southern Laos, and while it is unlikely to be anywhere close to the area surrounding the Tonle Sap Lake (RAINBOTH, 1996) or the 300,000 km^2 in the Amazon Basin (SAINT-PAUL *ET AL.*, 2000), these forests do, nonetheless, play an important ecological role in the aquatic ecosystem. In all cases, these habitats are closely linked to seasonal hydrological conditions.

The seasonally inundated habitat of southern Laos and northeastern Cambodia can be classified in many ways. ALTOBELLI & DACONTO (2001) and MAXWELL (2001) recognized 7 distinct wetland categories in the Siphandone Wetlands in terms of flora. However, for the purposes of this study, it is useful to divide the wetland forests directly adjacent to or within the mainstream river bed into 3 main groups. The first I term 'riparian vegetation usually not flooded'. This includes riparian trees and plants, which are usually flooded for only short periods (a few days) during the rainy season, and rarely inundated for long periods (several weeks). These trees often hang over the Mekong River during the high-water season when most fruiting occurs (ALTOBELLI & DACONTO, 2001). One of the most important groups of fruiting trees are figs *Ficus* spp. (Moraceae), but there are many other species which also provide fruits, leaves, flowers, barks and roots that are eaten by fishes (ROBERTS, 1993; BAIRD, 2001).

The second category can be classified as true 'flooded forest'. It is primarily situated in the mainstream Mekong River, and its plant species are specially adapted to survive up to 6 months of partial or total inundation during the rainy season. They also flourish during the dry season when not under water. Fruiting generally occurs late in the dry season or very early in the rainy season before water levels rise. These species also shed all their leaves when they are inundated, to reduce resistance to strong high-water currents. Thick 2–3-m tall shrubs dominate certain areas, while sparse shrubs cover other rocky areas (ALTOBELLI & DACONTO, 2001; MAXWELL, 2001). Some key plant species found in these areas include *Crateva manga* (Lour.) DC. (Capparaceae), *Telectadium edule* H. Baill. (Asclepiadaceae), *Homonoia riparia* Lour. (Euphorbiaceae), *Rotula aquatica* Lour. (Boraginaceae), and *Phyllanthus jullienii* Beille (Euphorbiaceae) (ALTOBELLI & DACONTO, 2001; MAXWELL, 2001). This type of habitat dominates the mainstream Mekong above the Khone Falls because of hydrological factors; where flood levels are relatively lower compared to below the falls (ALTOBELLI & DACONTO, 2001; DACONTO, 2001).

The third category is another type of 'flooded forest' occurring just below the Khone Falls in southern Laos and extending south into northeastern Cambodia as far as Kratie Province (ALTOBELLI & DACONTO, 2001; MAXWELL, 2001). Ban Hang Khone (Fig. 2) is situated adjacent to this kind of true 'flooded forest'. Trees and other plants found there are especially adapted to survive up to 6 months of total or partial inundation during the rainy season between May and October, when water levels rise from 6 to 8 m (ALTOBELLI & DACONTO, 2001; MAXWELL, 2001). Fruiting generally occurs in the late dry season, and leaves are shed during the flood season. Many plant species are the same as those found in the Mekong River bed above the Falls, including *Homonoia riparia*. However, two species of current-bent, deciduous trees up

to 10 m tall dominate these areas, viz. *Anogeissus rivularis* (Gagnep.) Lec. (Combretaceae) and *Acacia harmandiana* (Pierre) Gagnep. (Leguminosae, Mimosoideae), both of which are almost absent above the Falls (MAXWELL, 2001). These forests are apparently unique to this part of the Mekong River, as they have special physical and hydrological requirements, including rocky substrate for anchoring roots, a large seasonal change in water level, and high water velocity during the rainy season. These are harsh conditions for plants to survive in, and as a result in some areas plant diversity is low (MAXWELL, 2001).

METHODS

All of the fish examined during this study were caught just below the Khone Waterfalls near the Lao/Cambodian border by 10 fishers from Ban Hang Khone (Fig. 2). The fish examined were identified, their weights and lengths recorded, and stomach contents examined in the field minutes after the fish were landed. All data were collected over an extended period between 1993 and 1999. The vast majority of species had well defined stomachs. The field conditions did not make preservation of the stomach contents for future study possible.

The fish were all caught using set mono/multi-filament nylon gillnets with 2.5 to 20 cm mesh sizes (*kang mong*), cast-nets (*he*), drop-door bamboo basket traps (*chan*), and hooks (*bet*) baited with land earthworms, mole crickets (Family Gryllotalpidae), and *Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae) fruits (see CLARIDGE *ET AL.* (1997) and DEAP *ET AL.* (2003) for Mekong fishing method descriptions). Most were landed either around 0600 h or 1800 h, but almost all of the *Pangasius polyuranodon* were caught in the late morning or early afternoon using free floating hooks and lines (*bet tao*) baited with *C. trifolia* fruits. No other species were caught using this fishing method. All fish were examined within a few hours (maximum 12) of being caught by gillnets, hooks, or traps, because the fishers checked their fishing gear at least twice a day, in the early morning and in the evening. Most fish died only moments before their stomachs and intestines were cut open.

Local fishers with considerable knowledge of seasonally inundated riverine habitat and fishes were sometimes asked to help identify some of the forest fruits and leaves found in fish stomachs. Second and third opinions were solicited when deemed prudent. In cases when positive identifications of fish stomach contents could not be made, the contents were simply designated 'miscellaneous fruits', 'miscellaneous leaves', etc.

It was not possible to quantify the amount of each substance consumed, as is sometimes done (GOULDING & FERREIRA, 1984). Therefore, substances listed for a fish stomach indicate presence only.

During the course of investigations, a number of experienced fishers from Ban Hang Khone and Ban Hang Sadam (Fig. 2) were interviewed regarding flooded forest/fish relationships, which helped broaden my understanding. To remain conservative, I have only included information that the majority of villagers interviewed were in agreement on.

RESULTS

Fish Stomach Contents Study

The stomach contents of 1,617 fish specimens belonging to 20 families, 52 genera, and at least 73 species were examined (Table 1). Further documentation, incorporating information from interviews with local fishers and literature, is provided for some fish species specifically selected due to the relatively high occurrence of flooded forest fruits and vegetation in their stomachs.

FAMILY CYPRINIDAE (CARPS AND MINNOWS)

Hypsibarbus lagleri.—Two specimens (220 and 150 g) of this carp were examined. One had green leaves and both had pulverized bark in their stomachs. This species probably consumes considerable amounts of plant matter from seasonally inundated forests during the rainy season. RAINBOTH (1996) reported that this species feeds on zooplankton, worms and algae, but it undoubtedly eats more.

Hypsibarbus malcolmi.—Forty-one specimens of this carp were examined (25–3,400 g, mean 500 g). Thirty specimens were examined between July and November, and 50% of those had large amounts of green leaves in their stomachs, 3 had filamentous algae, 2 had fine algae, and 2 had eaten an unidentifiable dirt-like substance or detritus and pulverized bark. One each had grasses, insects, roots and forest fruits, and 2 had empty stomachs. Eleven specimens were examined during the dry season between March and early May. One had small gastropod snails in its stomach, and another had larger *'khe'* gastropods. Three had eaten large amounts of filamentous algae, 1 had eaten leaves, and 1 had an empty stomach. The data indicate that this carp feeds heavily on forest leaves during the high-water season and relies mainly on algae and snails for food during the dry season.

Hypsibarbus pierrei.—Four specimens of this migratory species were examined in April and May 1994 (110–510 g), and all had gastropods in their stomachs. One also had leaves, and another had bark and the seeds of the non-native riverine plant species, *Mimosa pigra* L. (Mimosoideae). Villagers report that this fish feeds on both fruits and leaves in the flooded forests during the high-water season. Snails are believed to be the species' main source of food during low-waters.

Hypsibarbus wetmorei.—Twenty-four specimens of this species were examined (115–1,600 g, mean 573 g). Three were examined between January and March. One of those had filamentous algae in its stomach, another fine algae, and 2 had leaves. Twenty-one were examined in the rainy season (May–October): 81% had green leaves, 14% had grasses, 14% had filamentous algae, 1 had fine algae, 1 had pulverized bark, 1 had roots, and 1 had consumed the leaves of the flooded forest shrub *Phyllanthus juillienii* Beille (Euphorbiaceae). This species clearly relies heavily on forest leaves for food in the rainy season, while consuming algae in the dry season. Its meat is occasionally toxic to humans in the high-water season, apparently because it eats toxic flooded forest fruits like those of *Hydnocarpus anthelminthica* Pierre ex Lanessan (Flacourtiaceae) and *Samandura mekongensis* Pierre (Simaroubaceae) (BAIRD *ET AL.*, 1999). The seeds of both plants are toxic (SMITH, 1945; ROBERTS, 1993). However, even when the meat is toxic, it apparently causes only slight dizziness and nausea.

Tor tambroides.—Only 3 specimens of this uncommon large cyprinid species were examined (9.2 kg, 95 cm (TL); 2.45 kg, 60 cm; and 7.4 kg, 84 cm). Only found in fish catches at Ban Hang Khone during November and December, when large adults are caught in gillnets (BAIRD *ET AL.*, 1999). One specimen had a stomach full of forest fruits, including *'mak sam phan'* (unidentified fruit) and *Coccinia grandis* (L.) Voigt (Cucurbitaceae). There were also many flooded forest leaves, such as those of *Aegle marmelos* (L.) Corr. (Rutaceae), *'bai ta deng'* (unidentified leaf) and others. An insect, called *'meng khap'* (unidentified) was also found. There were numerous fruits and seeds that were unrecognizable because they were crushed beyond recognition—this fish masticates its food. Another specimen had pulverized bark, and the third had grasses, pulverized bark and one gastropod snail in its stomach. *T. tambroides* is notorious for eating poisonous fruits such as *Hydnocarpus anthelminthica* and *Samandura harmandii* (ROBERTS, 1993). Some villagers report that the meat is safe to eat in the low-water season or when its eyes are not red, but nobody ever eats its internal organs (BAIRD *ET AL.*, 1999).

Leptobarbus hoeveni.—Six specimens of this large cyprinid species were examined during the rainy season (1.9–3.75 kg, mean 2.62 kg). Two had empty stomachs, 1 had consumed *'khai ping'* yellow algae, 2 had eaten unidentifiable forest fruits, and 1 had the fruits of *Diospyros* sp. (Ebenaceae) and *Ficus heterophylla* L. (Moraceae) in its stomach. The species conducts local trophic migrations to and from inundated forests (RAINBOTH, 1996). Most Hang Khone villagers will not eat its meat, and especially its internal organs, as it also eats the fruits of *Hydnocarpus anthelminthica* and *Samandura harmandii*. However, preserving the meat with salt (called *'pa som'*) makes it edible (BAIRD *ET AL.*, 1999). This species also sometimes masticates the seeds of fruits it consumes.

FAMILY PANGASIIDAE (CATFISHES)

Pangasius bocourti.—Forty-one specimens of this important species were examined (5–2,200 g, mean 465 g). This species has a varied diet, consuming mainly leaves and fruits in the rainy season and fish, mollusks, algae and shrimp, amongst other things, during the dry season. Table 2 lists the items found to have been consumed by the species, as well as 3 other pangasiid catfishes that also have varied diets. Experienced village fishers catch *P. bocourti* at the height of the high-water season by baiting hooks with *Crateva manga* leaves. A fisher will approach a half submerged *C. manga* tree and check whether fishes have nibbled the leaves that are touching the water. If they have, he will tie a line with hook to the trunk or branches and carefully bait it with 3 *C. manga* leaves. The bait and hook are left to flicker at the surface of the water next to the tree. It takes a special skill to correctly bait the hooks, and this method is used particularly to catch this species.

Pangasius conchophilus.—A total of 216 specimens were examined (2–4,300 g, mean 216 g). Table 2 includes a breakdown of the contents of the stomachs examined. *P. conchophilus* has a varied diet and is a gluttonous eater (ROBERTS & VIDTHAYANON, 1991). A 140-g specimen was found to have over 200 small gastropods in its stomach, and many other specimens had 50 to 100 small snails. Snails are especially important in the low-water season (January to May). Dense green algae is an important food between January and March. Forest fruits and leaves are the dominant foods between late April and September, and leaves are important in September and October. In the rainy season, *P. conchophilus* is often caught with long-line

hooks baited with *Cayratia trifolia* fruits, earthworms, and mole crickets (Family Gryllotalpidae). In late May or early June it undertakes an economically important and large-scale migration upriver and it is the main species caught in large wing traps (*li*) in the rapids below and in the Khone Falls (ROBERTS, 1993; ROBERTS & BAIRD, 1995; BAIRD *ET AL.*, 2004).

Pangasius hypopthalmus.—Six specimens of this large catfish were examined (350–1,000 g, mean 717 g). Five had empty stomachs and one had consumed small unidentifiable fruits. It probably eats forest vegetation and fruits during the rainy season. RAINBOTH (1996) lists its diet as fishes, crustaceans and vegetable debris.

Pangasius larnaudii.—Fifteen specimens of this highly migratory pangasiid catfish were examined (125–2,100 g, mean 964 g). All specimens were examined in the rainy season between May and October. Five fish had empty stomachs, 6 had *F. racemosa* fruits, 2 had *'mak hai' Ficus* sp. (Moraceae) fruits, 2 had earthworms, 1 had crickets and 2 contained an unidentifiable dirt-like substance or detritus. This species feeds heavily on fruits and leaves during the rainy season, and is often caught on *F. racemosa* fruit-baited longlines at the beginning of the rainy season.

Pangasius macronema.—Thirty-three specimens of this highly migratory and economically important species were examined (10–105 g, mean 41 g). All but 2 specimens were examined during the high-water season. Three had consumed *F. racemosa* fruits, 1 had *Crateva trifolia* fruits, 8 had unidentifiable leaves, 1 had pulverized wood, 1 had 5 pieces of an unidentifiable mushroom, 2 had earthworms, 2 had mole crickets, 2 had ants, 1 had a *'douang'* beetle, 2 had *'meng peng'* insects, 1 had a *'bong ki'* insect, 1 had eaten a *'meng po'* dragonfly insect, 6 had consumed other unidentifiable small insects, 7 had an unidentifiable dirt-like substance or detritus, and 1 had unidentifiable material. This fruit, leaf, and insect-eating species is caught on hooks baited with mole crickets (Family Gryllotalpidae), land earthworms and *C. trifolia* fruits. RAINBOTH (1996) listed its diet as consisting of only aquatic insects, but it obviously consumes a wide variety of foods. It undergoes important migrations upstream past the Khone Falls, where it supports an important communal fishery (BAIRD *ET AL.*, 2001).

Pangasius pleurotaenia.—Thirty-nine specimens of this important flooded forest species were examined (5–110 g, mean 59 g) (Table 2). Although RAINBOTH (1996) listed its diet as consisting of terrestrial and aquatic insects as well as a small amount of plant matter, it may be more herbivorous than RAINBOTH suggested, especially during the rainy season. *P. pleurotaenia* also feeds on large quantities of the flowers of *Telectadium edule*, when they are blooming and fall into the water in November and December. People from Don Tholathi village, which is just above the Khone Falls in Khong District (Fig. 2), often bait set hooks and lines and longlines with the flowers of *T. edule* to catch this species.

Pangasius polyuranodon.—Two hundred and eighteen specimens were examined (50–1,150 g, mean 309 g) (Table 2). RAINBOTH (1996) listed *P. polyuranodon*'s diet as consisting of insect larvae, bottom-dwelling worms and submerged plants, but it has a much more varied diet. This gluttonous eater, often found with a full stomach, consumes large amounts of forest leaves and fruits in the high-water season (June–October). It was mainly caught in deep waters using free floating hooks and lines (*bet tao*) baited with *Cayratia trifolia* fruits between August and November. The species feeds very close to the surface during the high-

water season, and is probably a heavy consumer of dense green algae in the low-water season. All 4 of the specimens examined in February 1994 had stomachs full of algae. It also appears to consume many insects during the monsoon season. This omnivorous species also eats fish, snails, crabs, shrimp, and even frogs, but not in large quantities.

Pangasius sanitwongsei.—Eight small specimens of this species of endangered giant catfish (GROOMBRIDGE, 1996) were examined. Although the species can reach over 200 kg in weight, villagers from Hang Khone did not catch any individuals weighing over 1.5 kg between 1990 and 1999. Four small specimens examined in the dry season had empty stomachs and one had leaves in its stomach. Three specimens (150, 85, and 75 g) were examined in July 1994. Two had insects in their stomachs, and 2 had large amounts of *Craveta manga* leaves. Juveniles are sometimes caught on hooks baited with *Cayratia trifolia* fruits, earthworms and fish. Villagers report that it especially likes to eat rotten meat, and locals have long baited large hand-made hooks, called *'bet pa leum'* with rotten fish, dog, buffalo, chicken, etc.

FAMILY OSPHRONEMIDAE (GIANT GOURAMIES)

Osphronemus exodon. Only one specimen (50 g and 14 cm) of this recently described Mekong endemic (ROBERTS, 1994) was examined, in September of 1996. It had pulverized bark, roots and insects in its stomach. Like its close relative *Osphronemus goramy*, it is an important consumer and inhabitant of inundated forest vegetation. ROBERTS (1994) reported that it feeds mainly on plant material, including fruits, leaves, and flowers, with some insects and crustaceans. Young fish may feed more on insects, while adults are likely to consume more plant matter (ROBERTS, 1994). The extraordinary oral dentition of this species, including rows of enlarged teeth on the external surface of the jaw and entirely outside of the mouth when shut, may facilitate plant and especially root foraging and feeding. Don Tholathi villagers use hooks and lines baited with the *Telectadium edule* flowers in November and December to catch *O. exodon.* Hooks are set near the surface in non-flowing pools surrounded by flooded forest. Earthworm-baited hooks catch it in pools amongst wetland forests during the dry season. In March and April this species collects vegetation using its complex set of teeth in order to build nests near the bottom of pools 0.5–1.0 m deep. The female stays inside the burrow of the nest for over a month during the spawning season while the male 'guards' just outside the nest. This is the only Mekong fish species known to construct a nest using vegetation.

In summary, we found a total of at least 35 species of forest fruits, 13 species of fresh leaves, and 3 species of flowers in fish stomachs. Barks and roots were also found in a number of fishes. Most of the fruits, leaves and flowers were found in pangasiids. Cyprinid fishes in the genus *Hypsibarbus* are important leaf eaters. I have probably underestimated the actual number of fruit and leaf species consumed, because fruits and leaves found in fish stomachs were sometimes unidentifiable or unknown to us.

Villager Interviews

Villagers claim that *Channa* spp., *Morulius* spp., *Bangana behri, Labeo erythropterus, Hypsibarbus* spp., *Osphronemus exodon* and others fishes are often found inside the submerged trunks of large forest trees like *Anogeissus rivularis* and *Acacia harmandiana.* Villagers exploit this situation by putting gillnets near the openings of these refuges and bang the trunks to scare the fish into the waiting nets.

Other species of seasonally inundated riverine flora such as *Homonoia riparia* and *Telectadium edule* are also believed to slow water flow and thus create important refuge habitat for fishes. *Morulius* spp. are sometimes speared (*lem*) when they are hiding amongst inundated vegetation during the rainy season.

Villagers highly value flooded forests, realizing that they serve as important habit for wildlife, especially indigenous fish and other aquatic animals. These habitats also serve as essential commons areas where villagers fish; extract medicinal plants, edible fruits, and vegetation; and harvest various wood products. They are critical for local livelihoods.

Fishing with Fruits Leaves and Flowers

The following forest fruits, leaves and flowers were identified by villagers at Ban Hang Sadam and Ban Hang Khone as being suitable for baiting hooks for fishing:

1) *'mak khika'* (unidentified fruit—possibly passion fruit) can be put on hooks to catch *Osphronemus exodon.*

2) *'mak kham pome'* (unidentified fruit).

3) *Hydnocarpus anthelminthica* fruits can be put on hooks to catch *Tor tambroides* and other fish species.

4) *Ficus racemosa* fruits can be put on hooks to catch many species, especially pangasiid catfish. [This species was incorrectly identified as *Ficus variegata* Bl. var. *variegata* (Moraceae) in ROBERTS (1993).]

5) *Crateva manga* leaves can be put on hooks to catch *Pangasius bocourti.*

6) *Cayratia trifolia* fruits can be put on hooks to catch many species.

7) *Nauclea orientalis* fruits can be put on hooks to catch many species.

8) *Telectadium edule* flowers can be put on hooks to catch mainly *Pangasius pleurotaenia* and some *Hypsibarbus malcolmi, Hypsibarbus wetmorei* and *Osphronemus exodon.*

9) *Diospyros pilosanthera* Blanco (Ebenaceae) fruit can be put on hooks to catch many fish species.

Eight out of the 9 types of fruits, leaves and flowers identified above were found in the stomachs of fishes during this study. Only *Nauclea orientalis* (Rubiaceae) was not found. The above information is important as it helps indicate food preferences for fishes and also helps link fish species to the forests.

Diversity of Natural Fish Foods

Table 3 includes a list of some forest fruits, flowers, leaves, and roots that Ban Hang Khone and Ban Hang Sadam villagers claim that Mekong River fishes in their area regularly feed on. There are 72 nominal species of flora and their plant parts included. Of those, it has so far been possible to apply some level of scientific taxonomic identification to 58 species. However, this list is undoubtedly far from complete. It does, however, demonstrate that fish rely on a large number of plant species, not just a few.

DISCUSSION

The Fishes and the Forests

There are many indirect ecological links between flood forest habitat and fish in the Mekong. Many insects rely heavily on seasonally inundated riverine habitats for food and shelter, and in turn, fish rely on these insects as important food sources. For example, ants are abundant on the tree *Flacourtia indica* (Burm f.) Merr. (Flacourtiaceae), and fish are known to congregate under these trees, where they feed on ants that fall into the water. The fish *Toxotes microlepis* spits water up into plants in order to knock insects into the water before it feeds on them (SMITH, 1945). Many other fish species feed on insects that fall into the water. In the Amazon, fishes rely on insects that fall from the canopy as food, and GOULDING (1993) reported that 80 species of fish that eat insects are known from the Rio Negro, many of which fed on arthropods, particularly beetles and spiders. Flying insects, ants and mole crickets appear to be the most common insects found in fish stomachs in the Mekong. As in the Amazon (GOULDING, 1993), I do not know of any fish species that eat only one or a few kinds of insects. It appears that, as in the Amazon, smaller fish species are the main insect eaters and are generally more successful at catching insects.

Shrimps, crabs, snails, and bivalve mollusks also rely heavily on flooded forests for habitat and food. They are numerous amongst the fine roots of many seasonally inundated shrubs and trees such as *Anogeissus rivularis* and *Ficus* spp. These aquatic animals constitute an important source of food for many species of fish. Some species of zooplankton and phytoplankton also rely on inundated plants.

In the Amazon Basin fishes feed mainly on decomposing leaves rather than fresh leaves (GOULDING, 1993), but in the Mekong there are a number of species that feed heavily on fresh leaves, including the osphronemid, *Osphronemus exodon*, all species of pangasiid catfish except for *Helicophagus waandersi*, all species of the cyprinid *Hypsibarbus, Leptocheilus hoeveni, Tor tambroides,* and others. Detritus is also a source of food for many fish species in the Mekong.

It seems likely that many fish utilize seasonally inundated riparian habitat as important spawning and nursery grounds. The young of many species probably rely heavily on seasonally inundated forests as refuges for avoiding predation during the high-water season. These areas are also rich feeding grounds.

Many small cyprinid fishes rely on seasonally inundated riverine habitat in the Mekong River to shield themselves from strong currents during the beginning of the high-water season. Villagers use branch-bundle fish-attractant pull-traps, called *'kha'* in Lao, filled with vegetation to catch these fish. Small cyprinid fishes, including *Henicorhynchus lobatus, Henicorhynchus siamensis, Crossocheilus reticulatus, Lobocheilus melanotaenia,* and *Pristolepis fasciata* are mainly caught. This fishing method can only be effectively used between May and July. Later, water levels are too high and many of the small cyprinids species migrate downriver (BAIRD *ET AL.*, 2003). *L. melanotaenia*, along with small quantities of other small cyprinids, are also caught by villagers with their bare hands in July and August when they can be found very close to shore and amongst vegetation. Most of these smaller species were not carefully investigated during this study, but that should not imply that seasonally inundated areas are not important for them. Seasonally inundated riparian habitats serve many other important ecological functions such as creating shade for fishes, reducing the evaporation of water, and

preventing soil erosion (CLARIDGE, 1996; BAIRD *ET AL.*, 1999; DACONTO, 2001).

Although morphological adaptation in fishes specifically related to fruit feeding has not been observed in the Amazon Basin (GOULDING, 1983), I believe that the extraordinary oral dentition of the Mekong endemic goramy *Osphronemus exodon*, noted above, may be an evolutionary adaptation designed to facilitate feeding and foraging on roots and other plant matter.

Fish as Seed Dispersers and Seed Predators

Fishes in the Mekong Basin have not previously been shown to play an important role as dispersers of plant seeds through the consumption and defecation or regurgitation of fruits and seeds. In fact, outside of South America there have been few reports of frugivorous fishes (GOULDING, 1983), although CHICK *ET AL.* (2003) have provided some information about fishes as seed dispersers in North America. Frugivorous fishes have not been reported from inland areas throughout continental Africa, and in South Asia only a few species have been reported in the literature (GOULDING, 1983). SMITH (1945) reported that the cyprinid *Leptocheilus hoeveni* feeds on the large fruit of the chaulmoogra-tree *Hydnocarpus* (Flacourtiaceae), and WHITMORE (1975) reported that the walking catfish *Clarias batrachus* eats the fleshy fruits of *Gonystylus bancanus* (Miq.) Kurz (Thymelaenceae). There have also been a few marine fishes, like catfish in the genus *Arius* that feed on fruits in mangrove forests. However, GOULDING (1980; 1983) has provided convincing evidence that fish in the Amazon Basin play important roles as seed predators and dispersers. Seed predator fishes crush and masticate seeds, killing them. Fishes that disperse seeds are defined as those that often swallow fruits whole and generally do not damage the protective coatings of the seeds with their teeth or guts. However, even fishes that are essentially seed predators, such as the characins of the Amazon, disperse some seeds because not all the seeds they consume are crushed and masticated (GOULDING, 1983).

Many fishes in the Mekong may well be both seed predators and dispersers. However, I have not been able to identify a single fish species that is entirely frugivorous. This is probably because fruits are not available all year round. Pangasiid catfishes are potentially the most important seed dispersers in the Mekong River because, like many catfishes in the Amazon, they have poorly developed jaws and teeth (ROBERTS & VIDTHAYANON, 1991). This results in catfishes generally not being able to masticate seeds of the fruits they eat (GOULDING, 1983). I have observed many whole fruits in the stomachs of the 9 species that I have found to be fruit eaters, and I did not find masticated fruit seeds in their stomachs.

Although characins, the main group of Amazonian seed predators, are not found in the Mekong Basin, at least two species of cyprinids from the Mekong can be described as seed predators: *Tor tambroides* and *Leptobarbus hoeveni*. As with characins, some of the seeds in the stomachs of these species were not masticated. Therefore they could be both seed dispersers and predators.

GOULDING (1983; 1993) states that in the Amazon catfish and characins are the principal fishes that disperse seeds, and that fish-dispersed seeds are associated with fleshy fruit material, which is what makes the seeds attractive to the fishes as food. He has also shown that seed coats of seeds are not destroyed during digestion—either by characins or catfish. He also believes that the buoyancy of many fleshy fruits in water is not only advantageous for water dispersal, but conveniently positions fruit at the surface where they can be easily found

by fishes. In the Mekong River the siltiness of the river makes visibility low at the bottom so when fruits are near the surface they are much easier for fish to find. Figs are important fish foods in both the Amazon and the Mekong (GOULDING, 1983; BAIRD *ET AL.*, 1999). Most other fruits that fish feed on in the Mekong, including figs, are buoyant, and some pangasiid catfishes, including *Pangasius polyuranodon* and *Pangasius pleurotaenia*, stay near the surface during the main fruit feeding season. GOULDING (1983) has pointed out that even if catfish had developed enough teeth to masticate seeds, they would still not be able to crush the many small seeds of figs. Thus figs are well adapted for dispersal by fish although it is unclear if they are the selective agents.

As in the Amazon (GOULDING, 1983), many of the possible seed dispersers of the Mekong River are highly migratory. Some pangasiid catfishes are known to undertake long seasonal migrations up the mainstream Mekong (ROBERTS & BAIRD, 1995; BAIRD *ET AL.*, 1999; BAIRD *ET AL.*, 2001; BAIRD *ET AL.*, 2004; HOGAN *ET AL.*, 2004), and hence may disperse seeds far upriver. GOULDING (1983) has suggested the same for characins and catfish in the Amazon, and expects that seeds remain inside fishes for between 1 and 7 days. However, for the Mekong evidence is still lacking. In the Mekong, pangasiid catfishes could be dispersing seeds upriver, but some pangasiids eat little to nothing during strong migratory periods. For example, *P. krempfi* have empty stomachs when they migrate past Hang Khone (BAIRD *ET AL.*, 2004). Another parallel between the Mekong and the Amazon is that many of the expected migratory seed dispersers in both river systems are found in large whitewater rivers.

The Importance of the Flooded Forest of the Mekong

The information presented herein, including the empirical stomach contents data and the explanations of other ecological relations between fish and forests, demonstrates the role of riparian vegetation as sources of food, as shelter for prey, and as habitat for fishes of the mainstream Mekong River in northeast Cambodia and southern Laos. It appears that pangasiid catfishes heavily depend on forest fruits and vegetation as food sources, especially in the rainy season. Many others, like cyprinids, *Hypsibarbus* spp., *Tor tambroides, Leptobarbus hoeveni*, and the osphonemid, *Osphronemus exodon* are also at least partially dependent on forest fruits and seasonally inundated vegetation as direct sources of food. It is also possible that some of these species contribute to the propagation of seasonally inundated forests by dispersing the seeds of fruits they consume, although some probably also destroy most seeds that they consume.

Small fish species were not carefully considered in this study, but many are probably heavily dependent on flooded forests for food. Other carnivorous and algae-eating fish species probably rely heavily on flooded forests for habitat and indirectly for food. Some species of fish may utilize flooded forests as spawning and nursery grounds. Seasonally inundated riverine habitats constitute important habitat and food sources for a variety of species of insects, shrimps, crabs, snails and microorganisms that fish feed on. Seasonally inundated riverine habitats also serve a number of other important ecological functions, and are important habitat for birds, reptiles and mammals. Basically, the whole aquatic ecosystem of the mainstream Mekong River is closely linked to seasonally inundated areas.

Because of the linkages between fish populations, the flooded forests, and the well being of the local people in southern Laos and northeastern Cambodia, the survival of these forests is critical (BAIRD & FLAHERTY, 2005; BAIRD, 2006). Seasonally inundated riverine habitats

are probably some of the richest and most significant fish feeding grounds and habitats in the Mekong River Basin. This can be seen by the fact that Ban Don Sang Island, which is situated next to a large wetland forest area just above the Khone Falls (Fig.2), reported the highest fish catches per family out of the 14 villages surveyed (BAIRD *ET AL.*, 1998). It is believed that these high fish catches are largely associated with the richness of the wetland forests surrounding the village.

As in the Amazon Basin (GOULDING, 1993), international attention in Southeast Asia in recent years has focused on the destruction of tropical forests in upland watersheds. More effort needs to be devoted to conserving riparian forests in northeastern Cambodia and southern Laos, as they are important to the riverine ecology and associated local livelihoods. These wetland habitats have been severely degraded along much of the Mekong River on the Lao-Thai border as well as in other parts of the Mekong Basin. Hydrological changes caused by the construction of large dams in the Mekong Basin represent some of the most serious threats, through habitat destruction caused by direct inundation in reservoir areas, and hydrological induced changes including downstream erosion, which has already been shown to be a serious problem in the case of the Yali Falls dam in Vietnam, and downstream impacts in the Sesan River in northeastern Cambodia (BAIRD & MEACH, 2005; FISHERIES OFFICE, RATANAKIRI PROVINCE & NTFP PROJECT, 2000).

Returning to the three flooded forest habitats described at the beginning of this paper, it is difficult to assess which of these habitats is relatively more or less important for fish species, as they serve different purposes and benefit different species during different seasons. For example, many of the plant products consumed by fish come from 'riparian vegetation usually not flooded'. The second category of flooded forest listed earlier is also an important source of plant-based fish foods, but the third category, which includes the tallest riparian tree species, apparently is less important as a direct food source for most fish species. However, the second and third categories are certainly much more important than the first category insofar as fish habitat is concerned. Thus, while the third category may be less important as a source of food, it could make up for that through the important role it plays as habitat. In any case, all these habitats are extremely vulnerable to changes in hydrological conditions caused by large dams. Already, it appears that changes in the hydrology in the mainstream Mekong River caused by upriver dams in China may be the cause of the deaths of large numbers of flooded forest trees in the Mekong River in Stung Treng Province, northeastern Cambodia.

We need to recognize the immense value of these seasonally inundated riparian forests for fish, and local livelihoods dependent on fish, and the potentially serious impacts of large dam construction to these critical habitats. We need to work together to sustainably use and protect the Mekong's underappreciated flooded habitats, for present and future generations.

ACKNOWLEDGMENTS

Thanks to Bounpheng Phylavanh, Bounhong Mounsouphom, Phongsavath Kisouvannalath, Vixay Inthaphaisy, Khamsouk Xaiyamanivong, Peter Cunningham and Bounthong Vongsenesouk for their assistance in identifying fish stomach contents, and also to Songma, Sai, Tha, Nin, Phonexay, Vilay, Sounthone, Mai, Keo, Sone, Sit, Veng, Sout and Yeun for allowing us to examine the stomach contents of their fish. Thanks to Sit, Chan Khoun, Chan Nou, Souay and Sout for their invaluable assistance with identifying flooded forest plants

and flooded forest fruits found in fish stomachs. Mr. J. F. Maxwell identified the flooded forest plant specimens and provided comments on an earlier draft. Thanks also to Mr. Klaus Berkmueller for reviewing an earlier draft. Mr. Ole Heggen from the Geography Department of the University of Victoria, Canada, prepared the maps. The research conducted from 1993–1997 was done under the auspices of the Lao Community Fisheries and Dolphin Protection Project, and the work done between 1997–1999 was done through the Environmental Protection and Community Development in Siphandone Wetland Project, implemented by the NGO CESVI Cooperation and Development and funded by the European Commission. Thanks also for the detailed comments provided by two anonymous referees and the editor, Warren Brockelman.

REFERENCES

ALTOBELLI, A., AND G. DACONTO. 2001. Study of land cover through remote sensing and development of a wetland GIS. Pages 39–46 *in*: G. DACONTO (ed.), *Siphandone Wetlands*. CESVI, Bergamo, Italy.

ARAUJO-LIMA, C. A. R. M., M. GOULDING, B. FORSBERG, R. VICTORIA, AND L. MARTINELLI. 1998. The economic value of the Amazonian flooded forest from a fisheries perspective. *Verhandlungen des International Vereinigung fuer Limnologie* 26: 2177–2179.

BAIRD, I. G. 2001. Aquatic biodiversity in the Siphandone wetlands. Pages 61–74 *in*: G. DACONTO (ed.), *Siphandone Wetlands*. CESVI, Bergamo, Italy.

BAIRD, I. G. 2006. Strength in diversity: fish sanctuaries and deep-water pools in Laos. *Fish. Manage. Ecol.* 13: 1–8.

BAIRD, I. G., V. INTHAPHAISY, B. PHYLAIVANH, AND P. KISOUVANNALAT. 1998. A rapid fisheries survey in Khong district, Champasak province, southern Lao PDR. Technical report prepared for the Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Pakse, Laos.

BAIRD, I. G., V. INTHAPHAISY, P. KISOUVANNALATH, B. PHYLAVANH, AND B. MOUNSOUPHOM. 1999. *Fishes of Southern Laos* (In Lao). Lao Community Fisheries and Dolphin Protection Project, Ministry of Agriculture and Forestry, Vientiane, Laos.

BAIRD, I. G., Z. HOGAN, B. PHYLAIVANH, AND P. MOYLE. 2001. A communal fishery for the migratory catfish *Pangasius macronema* in the Mekong River. *Asian Fish. Sci.* 14: 25–41.

BAIRD, I. G., M. S. FLAHERTY, AND B. PHYLAVANH. 2003. Rhythms of the river: lunar phases and migrations of small carps (Cyprinidae) in the Mekong River. *Nat. Hist. Bull. Siam Soc.* 51(1): 5–36.

BAIRD, I. G., M. S. FLAHERTY, AND B. PHYLAVANH. 2004. Mekong River Pangasiidae catfish migrations and the Khone Falls wing trap fishery in southern Laos. *Nat. Hist. Bull. Siam Soc.* 52(1): 81–109.

BAIRD, I. G., AND M. S. FLAHERTY. 2005. Mekong River fish conservation zones in southern Laos: assessing effectiveness using local ecological knowledge. *Env. Manage.* 36(3): 439–453.

BAIRD, I. G. AND MEACH MEAN. 2005. Sesan River Fisheries Monitoring in Ratanakiri Province, Northeast Cambodia: Before and After the Construction of the Yali Falls Dam in the Central Highlands of Viet Nam. Sesan Protection Network, Ban Lung, Ratanakiri Province, Cambodia.

BARAN, E., I. G. BAIRD, AND G. CANS. 2005. *Fisheries Bioecology at the Khone Falls (Mekong River, Southern Laos)*. World Fish Center, Penang, Malaysia.

CHICK, J. H., R. J. COSGRIFF, AND L. S. GITTINGER. 2003. Fish as potential dispersal agents for floodplain plants: first evidence in North America. *Can. Jour. Fish. Aqua. Sci.* 60: 1437–1439.

CLARIDGE, G. F. (COMPILER). 1996. *An Inventory of Wetlands of the Lao PDR*. Wetlands Programme, IUCN - the World Conservation Union, Vientiane.

CLARIDGE, G. F., T. SORANGKHOUN, AND I. G. BAIRD. 1997. *Community Fisheries in Lao PDR: A Survey of Techniques and Issues*. IUCN - The World Conservation Union, Vientiane.

DACONTO, G. (ED.). 2001. *Siphandone Wetlands*. Environmental Protection and Community Development in Siphandone Wetland Project, CESVI, Bergamo, Italy.

DEAP, L. P. DEGEN, AND N. VAN ZALINGE. 2003. Fishing Gears of the Cambodian Mekong. Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Phnom Penh.

FISHERIES OFFICE, RATANAKIRI PROVINCE AND NTFP PROJECT. 2000. A study of the downstream impacts of the Yali Falls dam in the Se San River basin in Ratanakiri province, northeast Cambodia. NTFP Project, Ban Lung, Ratanakiri Province, Cambodia.

GOULDING, M. 1980. *The Fishes and the Forest: Explorations in Amazonian Natural History.* University of California Press, Berkeley and Los Angeles.

GOULDING, M. 1983. The role of fishes in seed dispersal and plant distribution in Amazonian floodplain ecosystems. *Sonderband. Naturwissenschaft Vereins Hamburg* 7: 271–283.

GOULDING, M., AND E. L. G. FERREIRA. 1984. Shrimp-eating fishes and a case of prey-switching in Amazon rivers. *Revista Brasileira de Zoology, Sao Paulo* 2: 85–97.

GOULDING, M. 1993. Flooded forests of the Amazon. *Sci. Amer.* March 1993: 80–86.

GROOMBRIDGE, B. 1996. *The 1996 Red List of Threatened Animals.* WCMC, Cambridge and IUCN, Gland, Switzerland.

HOGAN, Z. S., P. B. MOYLE, B. MAY, M. J. VANDER ZANDEN, AND I. G. BAIRD. 2004. The imperiled giants of the Mekong. ecologists struggle to understand - and protect - Southeast Asia's large migratory catfish. *Amer. Sci.* 92: 228–237.

LIENG, S., C. YIM, AND N. P. VAN ZALINGE. 1995. Fisheries of the Tonlesap River Cambodia, I: the bagnet (dai) fishery. *Asian Fish. Sci.* 8: 258–265.

MAXWELL, J. F. 2001. Vegetation in the Siphandone wetlands. Pages 47-54 *in*: G. DACONTO (ed.), *Siphandone Wetlands.* CESVI, Bergamo, Italy.

MCDONALD, A. J., P. BUNNAT, P. VIRAK, AND L. BUNTON. 1997. Plant Communities of the Tonle Sap Floodplain. Unpublished Final Report in contribution of Tonle Sap as a Biosphere Reserve for UNESCO's Man in the Biosphere Program, Phnom Penh, 30 pp +.

RAINBOTH, W. J. 1996. *Fishes of the Cambodian Mekong River System.* Food and Agriculture Organization of the United Nations, Rome.

ROBERTS, T. R. 1993. Artisinal (sic) fisheries and fish ecology below the great waterfalls of the Mekong River in Southern Laos. *Nat. Hist. Bull. Siam Soc.* 41(1): 31–62.

ROBERTS, T. R. 1994. *Osphronemus exodon*, a new species of giant gouramy with extraordinary dentition from the Mekong. *Nat. Hist. Bull. Siam Soc.* 42: 67–77.

ROBERTS, T. R. AND I. G. BAIRD. 1995. Traditional fisheries and fish ecology on the Mekong River at Khone waterfalls in southern Laos. *Nat. Hist. Bull. Siam Soc.* 43: 219–262.

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.* 45: 171–203.

ROLLET, B. 1972. La vegetation du Cambodge. *Revue Bois et Forets des Tropiques* 144: 3–16 ; 145 : 23–38; 146 : 3–20.

SAINT-PAUL, U., J. ZUANON, M. A. VILLACORTA CORREA, M. GARCIA, N. N. FABRE, U. BERGER, AND W. J. JUNK. 2000. Fish communities in central Amazonian white and blackwater floodplains. *Env. Biol. Fishes* 57: 235–250.

SMITH, H. M. 1945. The fresh-water fishes of Siam, or Thailand. *Bulletin of United States National Museum*, 188: 1–622.

WHITMORE, T. C. 1975. *Tropical Rain Forests of the Far East.* Clarendon Press, Oxford.

Table 1. Summary of foods eaten and relative importance for some Mekong River fishes, based on stomach contents examined in Hang Khone village, Khong District, Champasak Province, southern Laos, interviews with local fishers, and a literature review (XXX = a lot; XX = moderate; X = little; ? = considerable uncertainty).

#	Family & Species	Lao Name	Detritus	Plant Matter	Fruits/ Seeds	Algae	Zooplankton	Insects	Mollusks	Shrimps	Crabs	Fish	Earthworms
1	NOTOPTERIDAE												
	Notopterus notopterus	*pa tong na*		X				XXX		XX	X?	X	X
2	*Chitala blanci*	*pa tong kai*	X	X				X?	X	XX	X?	XXX	X?
	CLUPEIDAE												
3	*Tenualosa thibeaudaui*	*pa mak phang*				XXX	XX?						
	CYPRINIDAE												
4	*Amblyrhynchichthys truncatus*	*pa ta po*	XX?			XXX?	XXX?						
5	*Barbodes altus*	*pa vian fai*		XX?	X?	XX			X	X			X
6	*Cirrhinus cirrhosus*	*pa nang chan*		XX?		XX?							
7	*Cirrhinus microlepis*	*pa phone*		XX?		XXX							
8	*Cirrhinus molitorella*	*pa keng*		X?		XXX?							
9	*Cosmochilus harmandi*	*pa mak ban*	X	X		XX			XX				X
10	Cyclocheilichthys enoplos	*pa chok*	XX	X		XX	X?		XX	.X?	X?	X?	X
11	*Cyclocheilichthys* spp.	*pa doke ngieu*	X			X?							XXX?
12	*Cyprinus carpio*	*pa nai*	X	X		X?		X?		X?	X?	X?	X?
13	*Gyrinocheilus pennocki*	*pa ko*				XXX	X?	X?					
14	*Hampala macrolepidota*	*pa sout*	X					XX		XX	X?	X?	X?
15	*Hypsibarbus lagleri*	*pa pak pe*		XXX	X?	X?	X?	X?					X?
16	*Hypsibarbus malcolmi*	*pa pak kom*	X	XXX	X?	XXX		X?	X				
17	*Hypsibarbus pierrei*	*pa pak ta leuang*		XX	X	X?		X?	XXX				
18	*Hypsibarbus wetmorei*	*pa pak kham*		XXX	X?	XX		X?					
19	*Labeo* cf. *erythropterus*	*pa va souang*				XXX							
20	*Leptobarbus hoeveni*	*pa phong*		XX?	XXX		X?	X?		X?	X?	X?	X?
21	*Lobocheilus melanotaenia*	*pa khiang*	XX			XXX	X?						
22	*Luciosoma bleekeri*	*pa mak vai*		XX?	XX?			XX?		X?	X?	X?	X?
23	Mekongina erythrospila	*pa sa-i*				XXX							
24	*Osteochilus melanopleurus*	*pa nok khao*	X	XXX?	X?	X	XXX?						
25	*Probarbus jullieni*	*pa eun deng*	X	X?	X	X?		X	X	X?	X?		
26	*Puntioplites falcifer*	*pa sakang*	XX	XX		XX		X					XX

#	Family & Species	Lao Name	Detritus	Plant Matter	Fruits/ Seeds	Algae	Zooplankton	Insects	Mollusks	Shrimps	Crabs	Fish	Earthworms
27	*Raiamas guttatus*	*pa sanak*						XX				XX	
28	*Sikukia gudgeri*	*pa khao na*		X	X								X
29	*Tor tambroides*	*pa koua*		XX	XXX			X	X				
	BAGRIDAE												
30	*Bagrichthys macracanthus*	*pa mak khan mak kheu*	XXX					XX		X?	X?		XX
31	*Bagrichthys macropterus*	*pa kouay souk*	XXX					XX?		X?	X?		XX?
32	*Pseudomystus siamensis*	*pa khi hia*	XX	X	X			XXX	X	X?	X?		XX
33	*Mystus singaringan*	*pa khagneng*					X?	XXX				X?	
34	*Hemibagrus nemurus*	*pa kot leuang*		X				XX	X?	XX	X?	XX	XX
35	*Hemibagrus wycki*	*pa kot mo*							X?	XXX	XX	XX	X
36	*Hemibagrus wyckioides*	*pa kheung*						XX	X	XX	XX	XX	XX
37	Belodontichthys truncatus	*pa khop*		X				X				XXX	
	SILURIDAE												
38	*Hemisilurus mekongensis*	*pa nang deng*						X		XXX	XX	XX	
39	*Kryptopterus cryptopterus*	*pa doke boua*	XX					XX		X?	X?	X?	XX
40	*Kryptopterus spp.*	*pa pik kai*	XX			X		XXX		X	X?	X?	X
41	Micronema bleekeri	*pa nang ngeun*		X								XXX	
42	*Micronema micronema*	*pa nang khao*								X	X?	XXX	
43	*Ompok bimaculatus*	*pa seuam*	X						X?	X?	X?	XX?	XX
44	*Wallago attu*	*pa khao*		X								XXX	
45	*Wallago leeri*	*pa khoun*										XXX	
	PANGASIDAE												
46	*Pangasius hypophthalmus*	*pa souay kheo*		XX?	XXX?					X?	X?	X?	
47	*Helicophagus waandersi*	*pa nou*							XXX	X?	X		
48	*Pangasius bocourti*	*pa houa mouam*	X	XXX	XXX	X?		X	XX	X?	X	X	X
49	*Pangasius conchophilus*	*pa pho/pa ke*	XX	XX	XXX	XX		X	XXX	XX	XX	X	X
50	Pangasius krempfi	*pa souay hang leuang*		XX?	XXX?	XX?				X?	X?	X?	
51	*Pangasius larnaudii*	*pa peung*	X	XX?	XXX			X		X?	X?	X?	X
52	*Pangasius macronema*	*pa gnone thamada*	XX	XX	XX	X?		XX		X?	X?		X
53	*Pangasius pleurotaenia*	*pa gnone thong khom*		XX	XXX	X		XXX		X?	X?	X	X

#	Family & Species	Lao Name	Detritus	Plant Matter	Fruits/ Seeds	Algae	Zooplankton	Insects	Mollusks	Shrimps	Crabs	Fish	Earthworms
54	*Pangasius polyuranodon*	*pa gnone hang hian*	XX	XX	XXX	X		XXX	X	X	X	X	X
55	*Pangasius sanitwongsei*	*pa leum*		XX	XX?			X		X?	X?	XX?	X?
	SISORIDAE												
56	*Bagarius yarrelli*	*pa khe*	X?					X		XX	X	XX	X
	CLARIDAE												
57	*Clarias batrachus*	*pa douk*			X?			X	X?	X?	X?	X?	XX
	ARIIDAE												
58	*Arius stormi*	*pa khat ok*		X		X		X?		X	XX	XXX	
59	*Hemipimelodus borneensis*	*pa khat ok*	XX	X		XXX		XX		X?	X?	XX	
	MASTACEMBELIDAE												
60	*Mastacemblus armatus/favus*	*pa lat*	X	X?				XX?					XXX
	AMBASSIDAE												
61	*Parambassis wolffi*	*pa khap khong*				X	X?	XX?		X?	X?	X?	
	COIIDAE												
62	*Coius undecimradiatus*	*pa seua*						X?		XX	X?	XXX	X?
	POLYNEMIDAE												
63	*Polynemus longipectoralis*	*pa chin*	XX					X	X	XXX	X?		XX
	SCIAENIDAE												
64	*Boesemania microlepis*	*pa kouang*						X	X	XXX	X?	X	
	TOXOTIDAE												
65	*Toxotes microlepis*	*pa mong*					X?	XXX		X?	X?		
	NANIDIDAE												
66	*Pristolepis fasciata*	*pa ka*			XX?	X?			X				XX
	GOBIIDAE												
67	Glossogobius giuris	*pa bou khao*								X	X?	X?	
	OSPHRONEMIDAE												
68	*Osphronemus exodon*	*pa men*			XX	XX		XX		X?	X?		XX?
	CHANNIDAE												
69	*Channa marilius* or spp.	*pa kouan*						X		X?	X?	XX?	X
70	Channa micropeltes	*pa meng phou*								X?	X?	XXX	X?
71	*Channa striata*	*pa kho*	X					X		X?	X?	XX	XX
	SOLEIDAE												
72	*Euryglossa panoides*	*pa pan gnai*	X?										X
73	*Cynoglossus microlepis*	*pa lin ma*	X?										

Table 2. Stomach contents of Mekong River *Pangasius polyuranodon*, *Pangasius bocourti*, *Pangasius conchophilus* and *Pangasius pleurotaenia* (number indicates how many fish the item was found in) at Hang Khone village, Khong District, Champasak Province, southern Laos.

Species (Lao and Latin names)	Pangasius polyuranodon	Pangasius bocourti	Pangasius conchophilus	Pangasius pleurotaenia
pa fish	5	1	15	2
kapou crabs	2	2	18	0
koung shrimp	2	0	18	0
kop frogs (*Rana* sp.)	1	0	0	0
meng mai miscellaneous insects	31	2	25	10
douang beetles	0	0	2	0
meng po dragonfly	3	0	1	2
meng chou chi dung beetles	5	0	1	0
meng khi nai mole crickets (Family Gryllotalpidae)	27	3	7	0
tak ten crickets	3	0	0	1
mot ants	1	2	1	5
khikadeuan land earthworms	2	3	5	1
hoi gastropods	4	4	68	0
hoi ki bivalves	0	0	16	0
hoi khe gastrodods	0	3	0	0
hoi sai gastropods	0	1	0	0
kouay nam fruit *Polyalthia modesta* (Pierre) Fin. & Gagnep. (Annoncaeae)	22	0	3	0
koi fruit *Ampelocissus martini* Pl. (Vitaceae)	3	0	5	0
koum fruit *Crateva manga* (Lour.) DC. (Capparaceae)	3	0	0	0
koum leaf *Crateva manga* (Lour.) DC. (Capparaceae)	15	10	1	5
koum bark *Crateva manga* (Lour.) DC. (Capparaceae)	0	1	0	0
deua fruit *Ficus racemosa* L. var. *racemosa* (Moraceae)	33	3	4	1
pong po fruit *Physalis angulata* L. (Solanaceae)	1	0	0	0
kheua nam fruit *Diospyros* sp. (Ebenaceae)	13	3	0	0
kheua sap fruit ? *Ipomoea obscura* (L.) Ker-Gawl. (Convolvulaceae)	2	0	0	0
hai fruit *Ficus* spp. (Moraceae)	47	1	4	7
takop fruit *Muntingia calabura* L. (Tiliaceae) (naturalized)	2	0	0	0
kabao fruit *Hydnocarpus anthelminthica* Pierre ex Lanessan (Flacourtiaceae)	1	2	0	0
houn fruit *Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae)	26	0	4	10
phan hang fruit (unidentified forest fruit)	4	0	0	0
sak fruit (teak) *Tectona grandis* L.F. (Verbenaceae) (naturalized)	1	0	0	0
nang dam fruit *Diospyros malabarica* (Desr.) Kostel. var. *siamensis* (Hochr.) Pheng. (Ebenaceae)	4	2	0	0
tang nai fruit *Ficus heterophylla* L. f. (Moraceae)	45	3	7	0
tang nai leaf *Ficus heterophylla* L. f. (Moraceae)	1	0	0	0
khai kham leaf *Phyllanthus juillienii* Beille (Euphorbiaceae)	18	0	0	0
khai kham flower *Phyllanthus juillienii* Beille (Euphorbiaceae)	0	1	0	0
kapou fruit *Allophyllus cobbe* (L.) Raeusch (Sapindaceae)	0	0	1	2
kheua hep fruit *Limacia scandens* Lour. (Menispermaceae)	15	0	3	0
kheua chi nai fruit unidentified forest vine fruit	1	0	0	0
kheua chi nai leaf unidentified forest vine leaf	2	0	0	0
kheua tam nin fruit *Coccinia grandis* (L.) Voigt (Cucurbitaceae)	0	1	0	0

Species (Lao and Latin names)	Pangasius polyuranodon	Pangasius bocourti	Pangasius conchophilus	Pangasius pleurotaenia
khi nok fruit *Grewia eriocarpa* Juss. (Tiliaceae)	6	0	2	0
seng nam fruit *Strynchnos nux-vomica* L. (Loganiaceae)	1	0	0	0
seng kheua fruit *Tiliacora triandra* (Colebr.) Diels (Menispeermaceae)	1	0	1	0
kan houng fruit *Albizia lebeck* (Leguminosae, Mimosoideae)	4	0	0	0
kan houng leaf *Albizia lebeck* (Leguminosae, Mimosoideae)	0	0	1	0
soum seng fruit *Xanthophyllum lanceatum* (Miq.) J.J. Sm. (Polygalaceae)	3	0	0	0
tin pet fruit *Alstonia scholaris* (L.) R. Br. var. *scholaris* (Apocynaceae)	1	0	0	0
tam nin fruit *Coccinia grandis* (L.) Voigt (Cucurbitaceae)	2	0	0	1
khai kin mak fruit *Telectadium edule* H. Beill. (Asclepiadaceae)	1	0	0	0
khai kin mak leaf *Telectadium edule* H. Beill. (Asclepiadaceae)	0	1	0	0
khai kin mak flower *Telectadium edule* H. Beill. (Asclepiadaceae)	6	0	0	0
khai hang nak/ khai kheua leaf *Rotula aquatica* Lour. (Boraginaceae)	2	0	0	1
pong po fruit *Physalis angulata* L. (Solanaceae)	0	0	1	0
va nam fruit *Eugenia mekongensis* Gagnep. (Myrtaceae)	0	1	0	0
ngiang douk unidentified fruit	1	0	0	0
kan houng leaf *Albizia lebeck* (Leguminosae, Mimosoideae)	0	1	0	2
mak houm unidentified leaf	1	0	0	0
khi ka unidentified fruit - possibly passion fruit	1	0	0	0
kadan fruit *Garcinia cowa* Roxb. (Guttiferae)	3	0	1	0
kham pome unidentified fruit	1	0	0	0
kathan leaf unidentified leaf	0	0	1	0
kho unidentified fruit	1	0	0	0
kang pa leaf (Europhorbiaceae) (*Sauropus, Breynia*)	2	0	2	1
kathin nam fruit *Mimosa pigra* (Mimosoideae)	1	0	2	0
van leaf ? *Cassia* sp.	7	0	0	0
pheo nam leaf *Polygonum odoratum* Lour. (Polygonaceae)	2	0	0	0
mian flower & fruit identified	0	1	0	0
khong leaf unidentified leaf	0	0	1	0
hak foi fine roots	7	0	1	0
gna grasses & sedges	8	0	0	0
khi thao dense green filamentous algae	5	0	21	1
khai ping yellow algae	0	0	1	0
khai hin fine green algae	0	0	1	0
unidentifiable dirt-like substance/detritus	37	3	37	5
lep mou ban toenail of domestic pig	0	0	1	0
peanut-like substance (?)	3	0	0	0
miscellaneous grasses	0	15	1	1
miscellaneous wood	0	0	3	0
miscellaneous vines	3	0	0	0
miscellaneous roots	0	0	0	1
miscellaneous seeds	1	0	7	2
miscellaneous leaves	76	4	16	12
miscellaneous flowers	5	0	0	0
miscellaneous fruits	84	3	50	10
miscellaneous barks	10	3	1	1
miscellaneous mushrooms	1	0	1	0
empty stomachs	0	0	7	0
Total number of specimens	218	41	216	36

Table 3. Plant species that fishers from Hang Khone and Hang Sadam villages, Khong District, Champasak Province, southern Laos, report to be regularly eaten by fish from the Mekong River.

No	*Latin Name*	*Lao Name*	*Category*	*Type*
1	*Acacia harmandiani* (Pierre) Gagnep.(Leguminosae, Mimosoideae)	*phiman nam*	Tree	Fruit, Leaf & Flower
2	*Adenia heterophylla* (Bl.) Kds. spp. var. heterophylla (Passifloraceae)	*kheua sap*	Vine	Fruit
3	*Aegle marmelos* Corr. (Rutaceae)	*toum*	Tree	Leaf
4	*Albizia lebeck* (Leguminosae, Mimosoideae) (naturalized)	*kan houng*	Tree	Fruit & Leaf
5	*Allophyllus cobbe* (L.) Raeusch (Sapindaceae)	*kapou*	Tree	Fruit
6	*Alstonia scholaris* (L.) R. Br. var. *scholaris* (Apocynaceae)	*tin pet*	Tree	Fruit
7	*Amaranthus spinosus* L. (Amaranthaceae)	*phak hom nam*	Herb	Leaf
8	*Ampelocissus martini* Pl. (Vitaceae)	*kheua koi*	Vine	Fruit
9	*Anogeissus rivularis* (Gagnep.) Lec. (Combretaceae)	*lam seng*	Tree	Root
10	*Ardisia* sp. (Myrinaceae)	*hai pa soi*	Tree	Fruit
11	*Azadirachta indica* Juss. (Meliaceae) (naturalized) (neam)	*kadao*	Tree	Fruit
12	? *Cassia* sp.	*phak van nam*	Herb	Leaf
13	*Cayratia trifolia* (L.) Dom. var. *trifolia* (Vitaceae)	*kheua houn*	Vine	Fruit
14	*Combretum trifoliatum* Vent. (Combretaceae) or *Olea* ? (Oleaceae)	*ben nam*	Shrub	Root, Flower & Leaf
15	*Coccinia grandis* (L.) Voigt (Cucurbitaceae)	*tam nin*	Vine	Fruit
16	*Crateva manga* (Lour.) DC. (Capparaceae)	*koum*	Tree	Root, Fruit & Leaf
17	*Datura metel* L. (Solanaceae)	*kheua ba*	Vine	Fruit
18	? *Diospyros malabarica* (Desr.) Kostel. var. *siamensis* (Hochr.) Pheng. (Ebenaceae)	*nang dam*	Tree	Fruit
19	*Diospyros* sp. (Edenaceae)	*kheua nam*	Vine	Fruit
20	*Diplazium esculentum* (Retz.) sw. (Athyriaceae)	*phak kout*	Herb	Leaf
21	*Eclipta prostrata* (L.) L. (Compositae)	*gna pong pai*	Grasses	Leaf
22	*Elaeocarpus* ? *grandiflorus* J.E. Sm. (Eleaeocarpaceae)	*kadon nam*	Tree	Flower
23	*Eugenia mekongensis* Gagnep. (Myrtaceae)	*va nam or va khi mang*	Shrub	Fruit
24	*Eugenia* sp. (Myrtaceae)	*khi mot*	Tree	Fruit
25	*Ficus altissima* Bl. (Moraceae)	*hai mi*	Tree	Fruit
26	*Ficus heterophylla* L. F. (Moraceae)	*kheua tang nai*	Tree	Leaf
27	*Ficus racemosa* L. var. racemosa (Moraceae)	*deua*	Tree	Fruit
28	*Ficus rumphii* Bl. (Moraceae)	*hai pho*	Tree	Fruit
29	*Garcinia cowa* Roxb. (Guttiferae)	*kadan*	Tree	Fruit & Leaf
30	*Grewia eriocarpa* Juss. (Tiliaceae)	*khi nok*	Tree	Fruit
31	*Heliotropium indicum* L. (Boraginaceae)	*ngouang sang*	Herb	Leaf & Flower
32	*Hydnocarpus anthelminthica* Pierre ex Lanessan (Flacourtiaceae)	*kabao*	Tree	Fruit & Flower
33	*Ipomoea aquatic* Forssk. (Convolvulaceae)	*phak bong*	Vine	Leaf
34	*Limacia scandens* Lour. (Menispermaceae)	*kheua hep*	Vine	Fruit
35	*Merremia umbellata* (L.) Hall.f.ssp. *orientalis* (Hall f.) Oost. (Convolvulaceae)	*phak kheua khikadeuan*	Vine	Leaf
36	*Mimosa pigra* (Leguminosae, Mimosoideae) (naturalized)	*kathin nam*	Shrub	Fruit
37	*Morinda tamyi* (Pierre ex Pit.) Craib (Rubiaceae)	*gno nam*	Tree	Fruit
38	? *Morindopsis capillaris* (Kurz) (Rubiaceae) (#530 of J. F. Maxwell collection April/98)	*som pa soi*	Tree	Fruit
39	*Muntingia calabura* L. (Tiliaceae) (naturalized)	*takop*	Tree	Fruit

No	*Latin Name*	*Lao Name*	*Category*	*Type*
40	*Nauclea orientalis* (L.) L. (Rubiaceae)	*kan leuang*	Tree	Fruit
41	*Olax scandens* Roxb. (Olacaceae)	*itok*	Tree	Fruit
42	*Passiflora foetida* L. (Cucurbitaceae) (naturalized)	*kheua gnon hang*	Vine	Fruit & Leaf
43	*Phyla nodiflora* (L.) Gaertn. (Gramineae)	*gna phak khouay*	Grasses	Leaf
44	*Phyllanthus juillienii* Beille (Euphorbiaceae)	*khai kham*	Shrub	Root & Flower
45	*Physalis angulata* L. (Solanaceae)	*pong po*	Tree	Fruit
46	*Polyathia modesta* (Pierre) Fin. & Gagnep. (Annonaceae)	*kouay nam*	Tree	Fruit
47	*Polygonum odoratum* Lour. (Polygonaceae)	*phak pheo nam*	Herb	Leaf
48	*Rotula aquatica* Lour. (Boraginaceae)	*khai hang nak/ khai kheua*	Tree	Flower & Leaf
49	*Samandura mekongensis* Pierre (Simaroubaceae) or *Quassia* ?	*ngouan*	Tree	Fruit
50	(Europhorbiaceae) (*Sauropus, Breynia*)	*kang pa*	Tree	Fruit & leaf
51	*Strynchnos nux-vomica* L. (Loganiaceae)	*seng nam*	Tree	Fruit
52	*Tectona grandis* L.F. (Verbenaceae) (naturalized) (teak)	*sak*	Tree	Fruit
53	*Telectadium edule* H. Beille (Asclepiadaceae)	*khai kin mak*	Shrub	Fruit & Flower
54	*Tetracera loureiri* (Fin. & Gagnep.) Pierre ex Craib (Dilleniaceae)	*kheua lin het*	Vine	Leaf & Flower
55	*Tiliacora triandra* (Colebr.) Diels (Menispermaceae)	*seng kheua*	Vine	Fruit
56	*Xanthophyllum lanceatum* (Miq.) J.J. Sm. (Polygalaceae)	*soum seng*	Tree	Fruit, Flower & Leaf
57	(Asclepiadaceae)	*kheua phak mai*	Vine	Leaf
58	15 additional plant species not scientifically identified			Fruits, Leaves and Flowers