

THE ECOLOGY AND CONSERVATION OF THE SMALLSCALE CROAKER *BOESEMANIA MICROLEPIS* (BLEEKER 1858–59) IN THE MAINSTREAM MEKONG RIVER, SOUTHERN LAOS

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ABSTRACT

The smallscale croaker *Boesemania microlepis* is a large species in the perciform family *Sciaenidae* reaching over a metre in length and at least 18 kg in weight. Although drums and croakers from this family are mainly marine, this freshwater species is found in the Mekong, Chao Phraya, Nan, Meklong, Tachin, and Bang Pakong River basins. It occurs in the Mekong River basin in Thailand, Laos, Cambodia and Vietnam, and parts of peninsular Malaysia and Western Indonesia. In the Mekong River, the species is known at least as far north as Louang Phrabang in northern Laos. This paper reviews the status of mainstream Mekong River populations of the smallscale croaker in southern Laos. We have identified seven known spawning grounds in Khong District, Champasak Province, southern Laos based on the dry-season occurrence of croaking individuals in spawning condition in these areas. We discuss habitat usage and the acoustic sounds made by smallscale croakers. Fish Conservation Zones have already been established to benefit the species, and this may be an excellent strategy for protecting populations. *Boesemania microlepis* should be considered for special IUCN conservation listing, based on widespread reports of severely declining stocks of this popular and expensive food fish in southern Laos and northeast Cambodia.

Key words: Laos; Mekong River; capture fisheries; biological conservation; fish acoustics

INTRODUCTION

The smallscale croaker, *Boesemania microlepis* (BLEEKER, 1858–59), is a benthopelagic fish species found in the Mekong, Chao Phraya, Nan, Meklong, Tachin and Bang Pakong Rivers and some connecting canals in Thailand (WONGRATANA, 1985). The species is found in parts of the Mekong River basin in Laos, Cambodia and Vietnam (WONGRATANA, 1985; BAIRD *ET AL.*, 1999), and has also been reported from Indonesia and West Malaysia (WONGRATANA, 1985; KOTTELAT *ET AL.*, 1993; M. Kottelat, personal communication, May 1999). In the Mekong River basin in the Lao People's Democratic Republic (Lao PDR or Laos), this large drum or croaker (Order Perciformes: *Sciaenidae*) is restricted to the mainstream Mekong River and large lowland tributaries close to the Mekong. Although most sciaenid croakers are marine (DAVIDSON, 1975; GOULDING, 1980; WONGRATANA, 1985; SASAKI, 1997), *B. microlepis* is one of the very few that is a freshwater species. In

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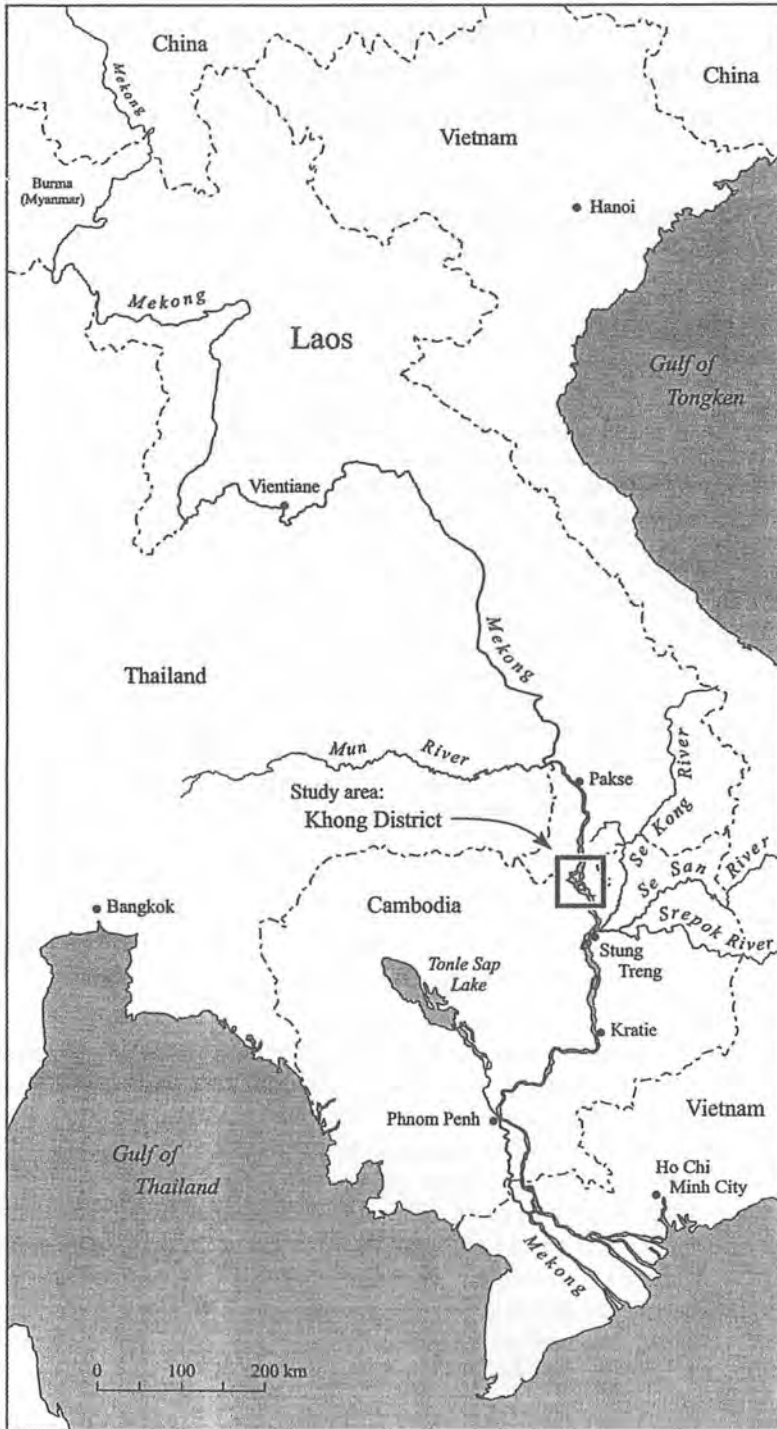


Figure. 1. Lower Mekong Basin

the Mekong River *B. microlepis* occurs at least as far upriver as Louang Phrabang in northern Laos (DAVIDSON, 1975). The smallscale croaker is one of the most desirable and highly priced large food fishes in the Mekong region (BAIRD, 1994; BAIRD *ET AL.*, 1999).

There has been considerable confusion in the past regarding the taxonomic status of *Boesemania microlepis*. CHEVEY (1934), SERENE (1951), BARDACH (1959), KAWAMOTO *ET AL.* (1972), TAKI (1974), DAVIDSON (1975), YEN *ET AL.* (1992), and others have reported the species under the names *Sciaena soldado*, *Nibeasoldado*, *Otolithoides aenecorpus*, *Johnius soldado* and *Pseudosciaena soldado*. SMITH (1945) did not list the species as occurring in Thailand. WONGRATANA (1985) finally clarified its true taxonomic identity.

RAINBOTH (1996) listed the maximum length of *B. microlepis* as not exceeding 28 cm (SL), YEN *ET AL.* (1992) listed its maximum length as 355 mm, taki (1974) and DAVIDSON (1975) both listed maximum length as 45 cm, and KOTTELAT *ET AL.* (1993) listed it as 550 mm. WONGRATANA (1985) got closer to the truth, listing maximum weight as at least 6 kg, with reports from the Menam Noi in Ayutthaya Province, Thailand, of individuals attaining 10 kg. We have seen a number of specimens of this species over a metre in length, and in 1993, the first author observed at least one that weighed 18 kg from the Mekong River at Ban Hang Khone, Khong District, Champasak Province, southern Laos. SASAKI (1997) also records maximum length for the species as being 1m.

DAVIDSON (1975: 95) provides the following description of *B. microlepis*:

“It is a light brown fish, with a greenish or grayish tint, with obscure ripple markings over the upper side of the body and a light underside. The fins are pale brown to yellow, but the tail fin is blackish and the spiny dorsal fish has a dark edge.”

The smallscale croaker is named “*pa kouang*” in Lao, “*pla ma*” and “*pla hang kew*” in Thai, “*trey promah*” or “*trey pama*” in Khmer, and “*Ca suu*” in Vietnamese (WONGRATANA, 1985; YEN *ET AL.*, 1992; RAINBOTH, 1996; BAIRD *ET AL.*, 1999).

In recent years, there have been persistent reports from fishers in southern Laos and northeastern Cambodia that smallscale croaker populations have declined. In some areas where the species was apparently once common, it is now either very rare or virtually non-existent (ROBERTS, 1993; BAIRD, 1994; ROBERTS & BAIRD, 1995; BAIRD *ET AL.*, 1999). *B. microlepis* is possibly very sensitive to polluted water, like other euryhaline fishes (WONGRATANA, 1985). For this reason, WONGRATANA (1985) reported that the species is expected to be extirpated from many freshwater habitats in Thailand, especially the lower courses of rivers. This expectation was based on the gradual disappearance of the species from the tidal influent area of the Tachin River since 1980 (WONGRATANA, 1985).

Unlike most other species of fish in the Mekong River in northeastern Cambodia and southern Laos, the dry season habitat and presumed spawning grounds of the smallscale croaker can be easily identified. Medium to large sized *B. microlepis* make loud croaking vocalisations in these deep-water areas (BAIRD *ET AL.*, 1999). This deep croaking sound, described as “*oot-oot-oot*” by the Lao, is often audible even above the surface of the water, and it makes the croakers vulnerable to directed gillnet fishing during their spawning season. This species may significantly benefit from deep-water Fish Conservation Zones (FCZs) in the mainstream Mekong. Increases in populations of this species in and around particular FCZs in Khong District, Champasak Province, southern Lao PDR have been reported. These apparent successes may be a result of villagers having protected *B. microlepis*

deep-water spawning habitat within the boundaries of certain FCZs (BAIRD, 1996; HOGAN, 1997; BAIRD *ET AL.*, 1999).

This paper reviews the known ecology and conservation status of smallscale croakers in the Siphandone Wetland area in southern Laos. Seven deep-water spawning grounds in Khong District are identified, based on the occurrence of *B. microlepis* vocalisations during the species' spawning season. The use of villager-managed FCZs as a tool for managing and conserving smallscale croakers is discussed.

BACKGROUND TO STUDY AREA

The Siphandone Wetland area (which literally means 4000 islands) is largely situated in Khong District, Champasak Province. It is a complex of channels, rapids, waterfalls, islands of various sizes, seasonally inundated forests, and deep-water pools included as part of the mainstream Mekong River in the extreme south of Laos (see figure I map of Khong in regional setting) (CLARIDGE, 1996; CESVI, 1998; ALTABELLI *ET AL.*, 1998). There are approximately 65,000 people in Khong, the vast majority of whom are ethnic lowland Lao rural peasant semi-subsistence paddy rice farmers with a long history of inhabitation of the area. Approximately 94 percent of families in the district subsist on fishing and many sell fish to generate income. The estimated total fish catch for the district in 1996/1997 was 4000 metric tonnes, and US\$ 1,000,000 worth of fish was reportedly exported from the district during the same year (BAIRD *ET AL.*, 1998a). The wild capture fisheries of Khong may be more important than in any other district in Laos. Of the 136 villages in Khong, 86 are situated on islands, and most of the rest are located along the eastern bank of the Mekong River (BAIRD *ET AL.*, 1998a). The aquatic environment of the area is characterised by high diversity and productivity. Over 200 fish species have been found in fish catches throughout the district since 1993 (BAIRD *ET AL.*, 1999).

METHODS

This paper draws upon a literature review and compilation of information about the smallscale croaker *Boesemania microlepis* collected during field studies in Khong District, Champasak Province, southern Lao PDR and other parts of Laos and northeastern Cambodia between January 1993 and May 1999. During much of that period, the authors were based in the small rural fishing and farming community of Ban Hang Khone, which is situated below the Khone Falls in the extreme south of Khong District (see ROBERTS, 1993; ROBERTS & BAIRD, 1995). At Ban Hang Khone a wide range of artisanal fisheries have been monitored and studied, some of which catch smallscale croakers (BAIRD, 1998a). Stomach contents for *B. microlepis* and other species have also been investigated (BAIRD, 1998b). The authors have relied heavily on "local wisdom" or "local ecological knowledge" (LEK) as a foundation for studying the complex biological, ecological and sociological processes that effect fish and fisheries in the Siphandone Wetland area. Over the years, large numbers of fishers in villages throughout Khong and other parts of southern Laos and northeastern Cambodia have contributed to our pool of knowledge by providing information about *B. microlepis* and other species of fish. We have also observed the seasonal croaking behaviour

of the *B. microlepis* in seven deep-water areas in Khong. Much of the basic biological information we have collected on the species has recently been published in Lao language (BAIRD *ET AL.*, 1999), but most of the details are presented here in English for the first time.

Although we have been using basic hydrophones to record the sounds of *B. microlepis* for many years, J. F. Borsani from the Tethys Research Institute in Milan, Italy, conducted the first systematic acoustic survey of *B. microlepis* vocalizations in the Ban Hang Khone area in early April 1998. A basic overview of his research is presented based on BORSANI (1999).

RESULTS AND DISCUSSION

Boesemania microlepis Spawning Grounds

Field investigations throughout Khong District between 1993 and 1999 have determined that there are presently seven confirmed spawning grounds for *B. microlepis* in the Mekong River in the District. The villages adjacent to these areas are shown on Figure 2. From south to north, the areas are described below.

1. *Boung Pa Kouang/Boung Pa Chouk* (spelled *Boong Pba Gooawng* and *Boong Pba Jook* in ROBERTS & BAIRD, 1995). These areas are adjacent 25 to 30 m deep-water pools with steep rock sides, hard rock and sand substrate, slow counter-current eddies in the dry-season, and many large boulders at the bottom. Both areas are below the Khone Falls and adjacent to the Cambodian border, south of the communities of Ban Hang Khone and Ban Hang Sadam.

The northern channel adjacent to the main pools has been protected by Ban Hang Khone village as a dry season FCZ since 1995, but the main southern channel where smallscale croakers and Irrawaddy dolphins *Orcaella brevirostris* are most abundant remains unprotected, and there is extensive gillnet fishing by Laotians and Cambodians in the area. Cambodians commonly use explosives for fishing during the dry season (BAIRD & MOUNSOUPHOM, 1997). In 1993, Ban Hang Khone transformed the main spawning area for smallscale croakers, *Boung Pa Kouang* (appropriately named after *B. microlepis*), into a village FCZ, but Cambodians from the other side of the border refused to respect the protected status of the area, leading to its dissolution in 1995, and the establishment of a replacement FCZ in the 20m deep inner channel of *Boung Pa Chouk*, which is closer to the village and outside of areas where Cambodians sometimes fish.

This area is an important spawning ground for vocalising *Hypsibarbus malcolmi* (*pa pak kom* or *pa pak nouat*) in November–December (ROBERTS & BAIRD, 1995; BAIRD & PHYLAVANH, 1999).

2. *Veun Tholathi*. This is a 25-m deep pool with slow counter-current eddies in the dry season, a hard rock and sand substrate, steep sides, and many large logs on the bottom. The area is directly in front of Ban Don Tholathi, a small island community situated just north of an extensive wetland forest area above the western side of the Khone Falls. The approximately 400 x 300-m area has been protected as a village FCZ since 1994, and it is one of the best examples in Khong District of how FCZs can benefit spawning populations of *B. microlepis*.

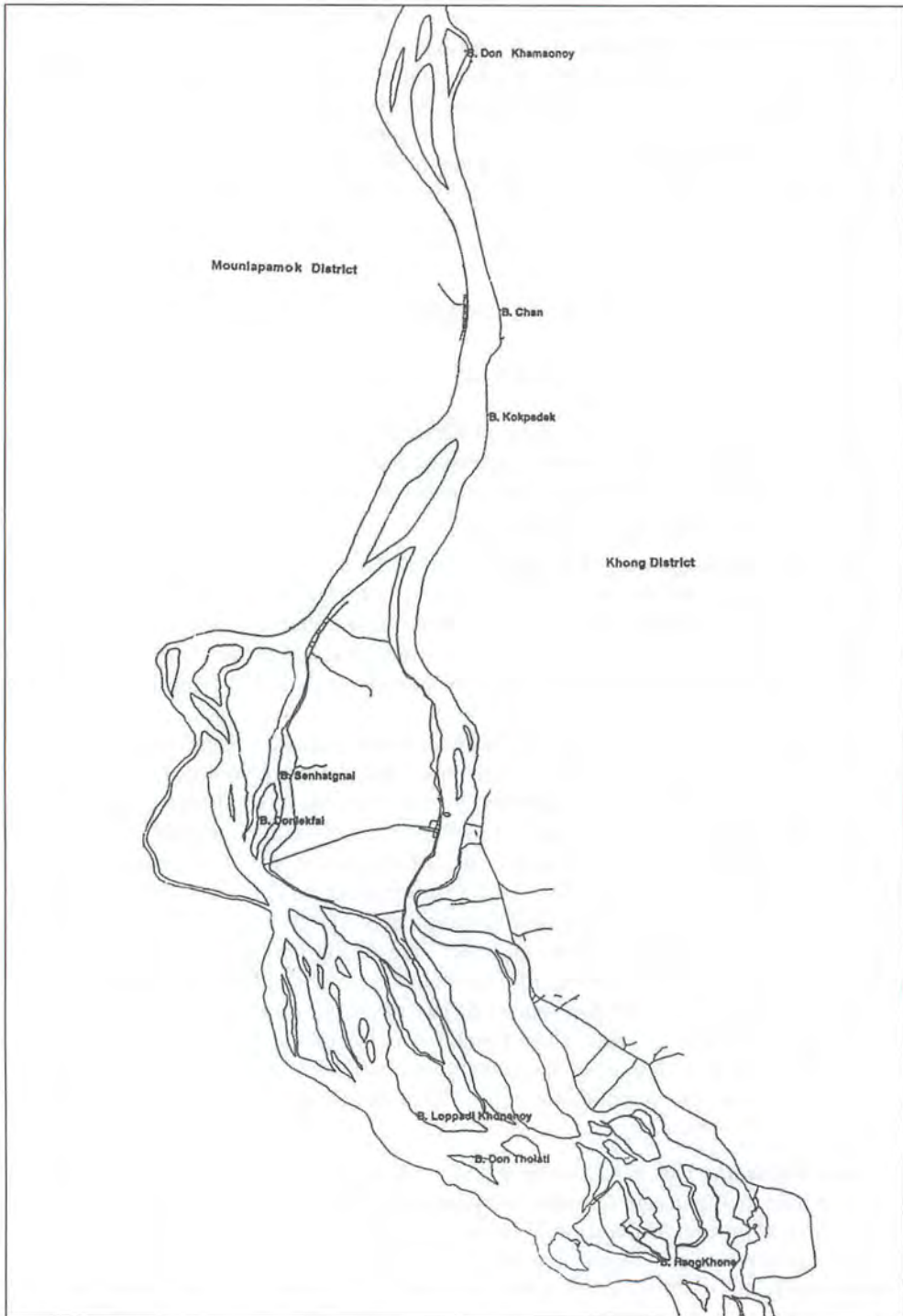


Figure. 2. Location of *Boesemania microlepis* spawning sites.

Villagers from Ban Don Tholathi believe that *B. microlepis* dry-season croaking has increased in *Veun Tholathi* every year since the establishment of the FCZ, and they have reported increases in catches of juveniles since establishing the FCZ. In 1999, villagers heard *B. microlepis* croaking not only in the FCZ, but also, for the first time in many years, in adjacent areas, including the *Tha Vat* and *Hang Don Kouay* areas. Further research and monitoring is required regarding changes in *B. microlepis* populations and habitat use near Ban Don Tholathi.

3. *Khoum Pa Tong/Peo Ta.* These are two adjacent 21-m deep pools in front of Ban Loppadi Khonenoy on the west side of Loppadi Island. They are both 200 x 100 m in size and can be characterised as having sand and small pebble substrates, steep rock sides, moderate counter-current eddies in the dry season, and large boulders in them. Both areas were established as village FCZs in 1995. However, despite efforts by villagers to protect them, Cambodians from across the river still regularly fish the areas in the dry season using explosives. As a result, the FCZs have so far not been effective in rejuvenating populations of *B. microlepis* or other fish species. However, the species has been heard vocalising in the area, and if Cambodian fishers cease their destructive fishing practices in the future, there is potential for *B. microlepis* to benefit from the FCZs.

4. *Veun Louk.* This 30-m deep area is situated adjacent to Ban Don Lekfai on the west side Don Lekfai Island. The area is approximately 150 x 150 m, and has a pebble and sand substrate, steep rock sides, large boulders in the area, and slow counter-current eddies in the dry season. The area is presently not protected as a FCZ, and stocks of *B. microlepis* have reportedly been greatly reduced due to many years of intense dry season gillnetting. We heard *B. microlepis* vocalisations in the area in 1994.

5. *Veun Phou That.* This area is approximately 70 m deep, and is situated adjacent to Ban Senhatgnai (including the sub-village of Ban Na Phou That) on the west side of Khong Island. The area is approximately 300?100 m, and has a hard rock substrate, large boulders and logs at its bottom, moderately steep rock sides, and slow counter-current eddies in the dry-season. It is not presently protected as a FCZ, and stocks of *B. microlepis* have reportedly been reduced due to dry-season gillnetting. *B. microlepis* croaking was heard in the area in early 1998.

6. *Veun Te/Veun Va.* This area is an approximately 32.5-m deep section of the Mekong River with slow counter-current eddies in the dry-season, a hard rock and silt substrate, steep rock sides with caves, and many large boulders and logs. This is one of the deepest parts of the Mekong River in Khong District, and is situated between the villages of Ban Kokpadek and Ban Chan. Villagers have protected the area as a FCZ since 1996. The FCZ is the largest in Khong, with a combined area of 18 hectares (600 x 300 m) including the two connected FCZs of Ban Kokpadek and Ban Chan, which are each 300?300 m in size.

Like *Veun Tholathi*, the *Veun Te/Veun Va* area is an excellent example of a FCZ that is protecting the spawning habitat of spawning smallscale croakers. Villagers have reported increases in *B. microlepis* croaking in the FCZ every year since its establishment. Increases in catches of juvenile croakers were reported in Ban Kokpadek in 1998, although catches of juveniles apparently declined over the same dry season months in 1999. In any case, villagers in Ban Chan and Ban Kokpadek remain convinced that *B. microlepis* is one of the important beneficiaries of their FCZs.

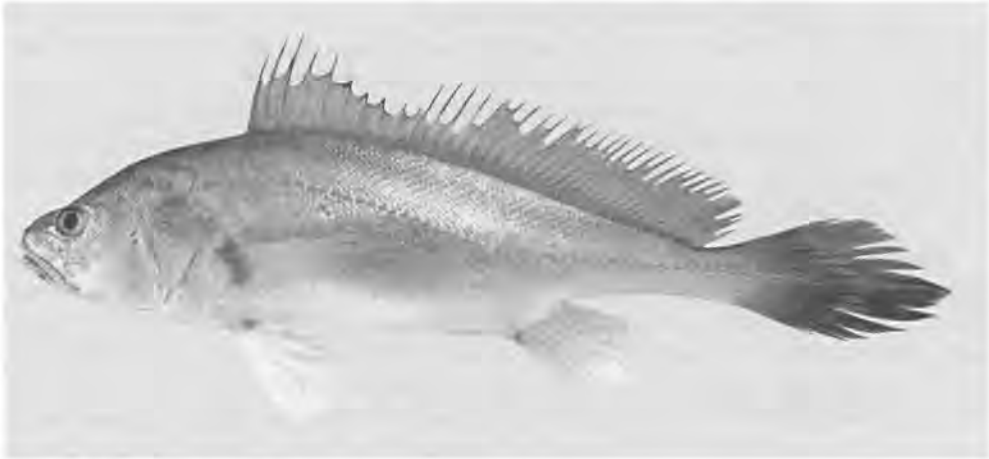


Figure 3. *Boesemania microlepis*

7. **Veun Hat Phou.** This area refers to two 20–40-m deep-water pools with hard rock and sand substrate, moderately spiraling counter-current eddies, and steep rock sides. This triangular-shaped area is approximately 0.8 hectares in size, and is situated on the west side of Don Khamaonoy Island adjacent to Ban Don Khamaonoy village in northern Khong District. The area has been protected as a village FCZ since 1996.

The first author heard *B. microlepis* vocalising in the area in March 1998, and villagers confirmed that the area is a known spawning ground. They have reported an increase in smallscale croaker vocalising since the establishment of the FCZ, and also more juveniles in their area.

Boesemania microlepis Acoustic Studies

J. F. Borsani from the Tethys Research Institute in Milan, Italy, collected acoustic recordings of the vocalizations of *Boesemania microlepis* in the *Boung Pa Kouang/Boung Pa Chouk* area near Ban Hang Khone in late March and early April 1998. It was the first time the sounds of *B. microlepis* had been professionally recorded and analysed, although other scienids are known to produce sounds in other parts of the World (BORSANI, 1999). The sounds Borsani recorded were produced during the mid- to late afternoon, and consisted of a series of loud fast pulses produced by the swim bladder. Borsani thought the vocalizations sounded “like the horn of a truck”. The sounds ranged up to 6 kHz in frequency, with the main energy located at 0.5 kHz. These sounds lasted up to 100 ms, and were repeated in bouts lasting several minutes (BORSANI, 1999). BORSANI (1999) suggested Irrawaddy dolphins (*Orcaella brevirostris*) near Ban Hang Khone might be able to use the sounds of the smallscale croaker for locating and capturing the fishes. We have not observed the dolphin’s actually eating *B. microlepis*, but local fishers report that they do. As part of Borsani’s acoustic research, he was able to determine exact locations of vocalizing fish. Hyperbolic locations of individual *B. microlepis* could be identified through recording vocalizations of individuals using a two-hydrophone array (CESVI, 1998). Locations of seven large *B. microlepis* were identified in the area from recordings (J. F. Borsani, personal

communication, April 1998). The sounds of fish could be used for estimating abundance of spawning pairs and hence monitoring the success of FCZs.

CRUZ (1998) reports that fisheries scientists in the USA are now beginning to use acoustic recordings of the “purring” and “knocking” sounds of reproducing fish in order to develop spawning maps that fishery managers can use to protect over-fished species and their habitats. BORSANI (1999) suggested that monitoring the sounds of spawning smallscale croakers could be an invaluable tool for preventing populations from being over-fished. The main limitations are the high cost of the recording equipment and the high level of technical skill required to use the equipment and analyse the acoustic data.

Even without recording equipment, however, villagers in Khong have already learned to monitor changes in the intensity of *B. microlepis* vocalizations over years in order to provide them with an idea of whether population sizes are increasing or decreasing. They simply listen to the sounds of the croaking, and qualitatively assess whether there is more or less compared to last year.

Biology and Ecology of *B. microlepis*

The most important ecological and biological factors related to smallscale croaker management and conservation are: (1) the species is a persistent dry-season inhabitant of deep-water pools in the Mekong River in southern Laos and northeastern Cambodia; (2) the species appears to be rather sedentary in the river, without any known migrations or movements into tributaries; and (3) the species spawns in deep-water sections of the Mekong River in southern Laos and northeastern Cambodia during the height of the dry-season, sometime between March and early May (CESVI, 1998). BARDACH (1959) suggested that the species spawns in May or June in Cambodia.

Smallscale croakers have not been recorded in catches of strongly migratory fish species moving up the Khone Falls in the Mekong River (SINGHANOUVONG *ET AL.*, 1996A, 1996B; BAIRD, 1998b). They have been recorded in small numbers in “*dai*” bagnet fishery catches in the Tonle Sap River in Cambodia, a fishery which primarily targets fish migrating from the Great Lake to the Mekong River at the beginning of the dry-season, and in December 1996, 199 metric tonnes of “*trey prama*” was estimated to have been landed (DIEP *ET AL.*, 1998). Thus it appears that the species moves from the Great Lake to the Mekong River at the very beginning of the dry season. Other freshwater croakers in the family *Sciaenidae*, such as *Plagioscion squamosissimus* (Heckel) from the Amazon River in South America, have not been shown to engage in clear-cut migrations (GOULDING, 1980). BARDACH (1959: 25) stated that,

[smallscale croaker] “spawning locations are unknown but the distribution of samples [in the Great Lake and Tonle Sap River] suggests more circumscribed migratory habits than those of the bulk of the “white fishes” which mostly move from inundated areas to rivers and back again.”

He therefore recommended “that research be done on the spawning habit of the fishes” (BARDACH, 1959: 25).

Smallscale croakers are known to be predatory (RAINBOTH, 1996). We examined the stomach contents of 28 freshly-caught specimens 15–40 cm in length: 14% had empty stomachs, 14% had remains of fish, 14% had insects, and 75% had the remains of shrimp

in their stomachs. Shrimp were found in stomachs of fish caught in the low and high-water seasons. One fish had bark in its stomach, another had a few leaves, and a third had a stomach full of gastropod snails. It is not known what species of shrimp the smallscale croaker consumes, as only seven species of crabs and ten species of shrimp have been recorded from the Mekong Basin so far. This probably accounts for only about 15 percent of the species that actually occur there (KOTTELAT & WHITTEN, 1996).

According to WONGRATANA (1985), fishers living along the lower courses of the Tachin and Bang Pakong Rivers catch the species during high tides using long lines in shallow waters of 2–3 m using fiddler crabs (*Uca spp.*) and rice crabs (*Somanniathelphusa spp.*) as bait. The best time of year to catch them there is June and July, and the best fishing spots are reportedly near the banks of turns in rivers (WONGRATANA, 1985). *B. microlepis* may be one of the few fish species in the Mekong River that feeds primarily on crustaceans. However, *Hemisiluris mekongensis* is one of the major species caught on shrimp-baited long lines, and is likely to feed heavily of shrimp as well (BAIRD, 1998b).

GOULDING & FERREIRA (1984) found that *Plagiscion squamosissimus*, a freshwater sciaenid croaker in the Amazon, feeds mainly on shrimp. They discovered that the species' diet changed from mostly shrimp when in white water rivers to mostly fish when in clear water and black water rivers. Since the Mekong River could certainly be described as a turbid whitewater river, especially in the rainy season, it is not surprising that *B. microlepis* appears to mainly consume shrimp. Because shrimp productivity in whitewater rivers tends to be higher than for clearwater rivers (GOULDING & FERREIRA, 1984), it is not surprising that *B. microlepis* rarely ventures very far up Mekong River tributaries, especially during the clearer water dry-season. However, it is likely that the croakers move into areas with inundated vegetation during the high-water season, since shrimp commonly congregate on flooded vegetation and roots in the rainy season (BAIRD, 1998b). Freshwater sciaenid croakers from the Amazon have been found in flood plain areas during the high-water season (GOULDING, 1980).

Large individuals of *B. microlepis* tend to prefer deep parts of pools, and spend little time in shallow areas. Croakers are only rarely ever seen in shallow areas near shore in the Amazon (GOULDING, 1980). However, in Khong District, fishers often encounter juvenile croakers congregating along the edges of sand banks in the Mekong River. Neither Khong nor Amazon fishers report distinct upstream migrations of croakers. In the Amazon, fishers visualize their movements as "hunting schools" that are often found near beach areas (GOULDING, 1980). The Lao also believe that the species is a "hunter".

B. microlepis tend to begin vocalizing in deep-water areas during the dry-season at around 1500 h each day, and continue their loud continuous croaking until after dark. Vocalizations have not been reported during the rainy season. It is presently not known what the exact linkage is between croaking and spawning behaviour, although a link is highly suspected. Croaking may begin before spawning actually occurs. *Hypsibarbus malcolmi* vocalize for a shorter period of time, and their croaks may be more directly associated with spawning behaviour (BAIRD & PHYLAVANH, 1999). However, it is possible that *B. microlepis* croaks are equally associated with spawning behaviour, but that the spawning season for the species is more drawn out. Villagers associate particularly loud smallscale croaker vocalizations with especially hot and sunny days. A similar association has been noted for spawning and vocalizing *H. malcolmi* carps in November (BAIRD & PHYLAVANH, 1999). The relationship between the intensity of *B. microlepis* and *H. malcolmi*

vocalizations and daily changes in water temperature during their spawning seasons, and the degree of association between croaking and actual spawning behaviour, is not known.

Vocalisations of *B. microlepis* differ considerably from those of *H. malcolmi*, which emits a higher sounding croak in November–December. They also differ markedly from the croaks of the small cyprinid *Henicorhynchus lobatus*, which make even higher pitched vocalizations in May and June before populations migrate south into Cambodia to spawn (ROBERTS & BAIRD, 1995; BAIRD *ET AL.*, 1998A; BAIRD *ET AL.*, 1999). Since all three species have very different sounding vocalizations that are emitted at different times of the year, there is little chance of confusing their sounds.

In southern Laos *B. microlepis* are usually caught in large-mesh gillnets, but also in some smaller hook and line, trap and castnet fisheries. WONGRATANA (1985) states that the species is mainly caught in gillnets, castnets and sometimes bagnets. Goulding (1980) reported that sciaenid croakers from the Amazon are frequently caught in gillnets, and often by the mouth. He suggested that croakers pursue their prey with open mouths, and that when they collide with a gillnet the line enters the mouth and cannot be dislodged. This habit of chasing prey with open mouths makes at least Amazon croakers more vulnerable to gillnetting than many other species, and this may be part of the reason why gillnetting has apparently had such a severe impact on populations of *B. microlepis* in Laos and other parts of the Mekong basin.

In the Amazon, fish-baited hand lines are used to locate the depth at which croakers reside. Fishers lower the bait repeatedly to determine at what depth the fish bite. The nature of the fishery suggested to GOULDING (1980) that “croakers are sensitive either to depth or temperature and inhabit distinct vertical zones in the water.” He could not, however, confirm whether these areas were natural feeding zones. It seems highly likely that *B. microlepis* inhabit distinct vertical zones in the Mekong, and specific habitat preferences may explain why there are only seven confirmed spawning grounds for the species throughout Khong District. It is not clear exactly what constitutes suitable dry-season habitat for smallscale croakers, but all seven of the presumed spawning areas for smallscale croakers found in Khong are characterized by being over 20 m deep, having hard rock or pebble and silt or sand substrate, having slow to moderate counter-current eddies in the dry-season, and having steep rock sides descending into the pools. Villagers believe that large croakers stay close to the sides of these cliffs, and in February and March fishers at Ban Hang Khone have been observed setting 18-cm mesh nylon gillnets down into deep pools adjacent to the steep cliffs in order to catch large croakers in spawning condition.

***Boesemania microlepis* Conservation Listings and International Trade**

The smallscale croaker *Boesemania microlepis* is presently listed in schedule II of Decree No. 118/MCC of the Ministry of Agriculture and Forestry, Lao PDR. However, it is listed as *Pseudosciaena soldado* (Lacepede), a junior synonym for the species also used by BARDACH (1959), TAKI (1974) and DAVIDSON (1975). A 1991 amendment to this decree made it illegal for anyone to catch schedule II species during their spawning seasons, or to sell individuals of the species throughout the year. However, smallscale croakers are still widely caught, sold and traded in Laos (BAIRD, 1994). DAVIDSON (1975) reported that the main fishing season for the species is between January and April, which coincides with its spawning period.

B. microlepis is a good candidate for listing in the IUCN Red Data Book, but so far insufficient information on the biology, ecology, and conservation status of the species has been available. More studies need to be conducted, especially related to the species' movements in the river and reproduction.

B. microlepis may also be a candidate for listing in Appendix II of the Convention on the International Trade in Endangered Species (CITES). Between November 10 and December 29, 1993, during 17 days of monitoring the fresh fish trade between Lao PDR and Thailand at Ban Veun Berk, Ubon Ratchathani Province, 367 kg of iced fresh *B. microlepis* were observed being imported into Thailand. This represented 2.8% of the total weight of fresh fish imported through this major fish trading point over the period investigated (Baird, 1994). The smallscale croaker was the eighth most abundant species by weight traded through Ban Veun Berk from Laos during that period (BAIRD, 1994). However, *B. microlepis* are mainly caught later in the dry-season between January and April (DAVIDSON, 1975), and the period when fish trade was monitored at Ban Veun Berk was not the peak season for catching *B. microlepis*. Therefore, it seems likely that many tonnes of smallscale croakers were imported into Thailand as food fish in early 1994. The author has also seen large amounts of large *B. microlepis* imported into Laos from Stung Treng Province, northeastern Cambodia.

In December 1993, the price of *B. microlepis* at Ban Veun Kham, on the Lao side of the Lao/Cambodia border, was the equivalent of US\$ 2.40/kg. The price of *B. microlepis* at Ban Veun Berk, Thailand, was US\$ 2.60/kg (BAIRD, 1994), and in May 1999 *B. microlepis* sold for 15,000 kip/kg (US\$ 2.14/kg) in Pakse, and 20,000 kip/kg (US\$ 2.86/kg) at the Lao/Thai border. This makes the species one of the most highly valued freshwater food fishes in the region. The high economic value of the species, its vulnerability to gillnetting during its dry season spawning season, and improved transportation routes and networks for trading fresh fish on ice to distant markets are probably all significant factors that have lead to increased fishing for *B. microlepis* and resultant declines in populations in many parts of the Mekong River.

***Boesemania microlepis* and Mainstream Mekong River Fish Conservation Zones**

Populations of *Boesemania microlepis* are apparently declining throughout much of the Mekong River basin. While Bardach (1959) listed smallscale croakers as one of 15 or so "principle commercial species" of freshwater fish in Cambodia, stocks of the species there have apparently greatly declined since then (Touch Saeng Tana, personal communication, 1996). Furthermore, in 1993 villagers from Ban Hang Khone reported that in recent decades smallscale croaker populations have plummeted. At the time, many believed that there were only as few as 10 or 20 percent as many individuals of *B. microlepis* around their village compared to 1970. Declines were believed to be mainly the result of a large increase in large-mesh gillnet use in deep-water areas (ROBERTS, 1993). In the 1970s, when gillnet use began increasing in the Khone Falls area, and southern Laos as a whole, one fisher from Ban Hang Khone reported catching 700 kg of smallscale croaker using gillnets each year. Although small individuals are still commonly encountered in fish catches (ROBERTS & BAIRD, 1995), few large individuals are landed.

The establishment of Fish Conservation Zones (FCZs) covering deep-water dry-season spawning habitat for *B. microlepis* may be one of the best options for reviving apparently

depleted populations in the Mekong River. *Veun Tholathi* and *Veun Te/Veun Va* are already two excellent examples of deep-water smallscale croaker spawning grounds that are being successfully protected from dry-season gillnetting. The first of the two areas was established as a village FCZ in 1994, while villagers set up the second area in 1996. It is useful to consider BARDACH's (1959: 22) statement, "The protection of spawning grounds, and subsequently of fry and fingerlings is undisputedly one the efficient tools of fish conservation." In the same vein, Joseph Luczkovich, an associate professor of biology at East Carolina University in the USA, was quoted as saying, "Almost every fisher person worldwide understands [that] if you over-harvest spawning aggregations, you're not going to have a future" (CRUZ, 1998:1).

FCZs have been successful in reviving depressed populations of *B. microlepis* at Ban Don Tholathi, Ban Chan and Ban Kokpadek, the villages adjacent to the above-mentioned two Khong District FCZs. In those communities, fishers have widely reported large increases in dry-season croaking of large *B. microlepis*. They have observed increased numbers of juvenile croakers caught in 2.5cm mesh gillnets at Ban Don Tholathi in November, and in 4–5 cm mesh gillnets at Ban Kokpadek and Ban Chan in January and February. Since the two FCZs are about 40 km apart, it is highly unlikely that there is any interaction between the *B. microlepis* populations in these areas.

While FCZs properly situated to protect spawning habitat of *B. microlepis* have the potential to benefit the species greatly, other biological and ecological factors not yet fully understood are also likely to influence whether the species is able to successfully spawn. Although villagers from Ban Don Tholathi, Ban Chan and Ban Kokpadek have reported annual increases in *B. microlepis* vocalizing since the establishment of their FCZs, the numbers of juveniles caught in gillnets from year to year apparently varies. Although villagers from Ban Don Tholathi have reported large numbers of juveniles every year since establishing their FCZ, this has not been the case for Ban Kokpadek and Ban Chan. During the dry season of 1998, villagers from Ban Kokpadek reported catching the largest quantities of juvenile *B. microlepis* in living memory. However, there were very few juvenile sciaenid croakers less than one year old caught at Ban Kokpadek during the dry season of 1999, even though *B. microlepis* spawners in the village FCZ were well protected the previous year. It is possible that factors related to hydrology and water temperature reduced spawning in 1998, in contrast with 1997.

Although FCZs are capable of protecting smallscale croakers at spawning sites, ecological factors unrelated to FCZs must also be suitable, or spawning may still be unsuccessful. However, this should not be taken as justification for neglecting to conserve spawning *B. microlepis*. Instead, we must recognise that we are dealing with complicated and stochastic ecological processes that cannot always be controlled through human management. When other factors are amenable for successful spawning, the protection of spawners is likely to have very positive results, especially when populations of the species are already low. The question is how much, and when and where, does the establishment of FCZs most influence the chances of successful spawning and recruitment. Again, more research is required.

CONCLUSIONS

This paper outlines the critical ecological and conservation factors most relevant to smallscale croakers in the mainstream Mekong River of southern Laos, although gaps in knowledge remain regarding the species' life-cycle stages and habitat preferences. The establishment of FCZs to revive populations of *Boesemania microlepis* is no guarantee that croaker populations will increase over a single year, but if spawning grounds for the species are protected over a number of years, as with *Veun Tholathi* and *Veun Te/Veun Va* in Khong District, there seems to be a strong likelihood that croaker populations will benefit. Still, the situation needs to be monitored over many years in order to learn more about the impact FCZs can have on smallscale croaker populations.

Village-based FCZs are only likely to receive adequate protection when communities largely agree with their establishment and are committed to enforcing rules themselves without payment. Forcing unwanted FCZs on villagers is unlikely to achieve the desired conservation or social results. Participatory extension activities designed to increase fisher awareness regarding the possible benefits of establishing FCZs, or initiating other fish management and conservation strategies, are likely to be an important factor in promoting village-based sustainable fisheries.

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