

## Peat swamp forest and the false gharial *Tomistoma schlegelii* (Crocodilia, Reptilia) in the Merang River, eastern Sumatra, Indonesia

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**Abstract** *Tomistoma schlegelii* is a threatened crocodilian whose current range is restricted to Sumatra, Borneo (Kalimantan and Sarawak) and Peninsular Malaysia. During surveys undertaken in eastern Sumatra in 1995–1996, 15 *T. schlegelii* nests were located in peat swamp forest along a single tributary, the Merang River. No other areas with equivalent nest densities have yet been described. Although much peat swamp forest has been lost to logging and fire, it remains the dominant habitat in most of the current range of *T. schlegelii*. In the Merang River the peat swamp and *T. schlegelii* are

threatened by a series of ongoing activities and both may be lost unless some form of innovative management programme is introduced. Peat swamp forest supports a range of other rare and threatened species, and would appear to have high conservation value. This paper reviews current information on the role of peat swamp forest in the ecology of *T. schlegelii* and describes the conservation threats to *T. schlegelii* in the Merang River.

**Keywords** Crocodilian, false gharial, Indonesia, peat swamp forest.

### Introduction

The false gharial *Tomistoma schlegelii* Müller 1838 is a large, freshwater crocodilian restricted to eastern Sumatra, Borneo (Kalimantan and Sarawak) and Peninsular Malaysia. Despite being the largest predator (4–5 m total length) throughout much of its range, its global Red List status was until recently classified as Data Deficient by the International Union for Conservation of Nature (IUCN) (IUCN, 1996; Ross, 1998a) and it was considered one of the world's least known crocodilians. Concern about its status and the ongoing loss of swamp habitats it was known to occupy (Thorbjarnarson, 1992; Sebastian, 1993a, b) prompted regional surveys and new research on its status, distribution, biology and ecology (Muin & Ramono, 1994; Ramono, 1994; Bezuijen *et al.*, 1995a, b, 1997; Ross *et al.*, 1998; Simpson *et al.*, 1998). IUCN subsequently revised the global status of *T. schlegelii* to Endangered (using criterion C1: estimated <2500 mature individuals and continuing decline of at least 20 per cent within 5 years or two generations) (Ross, 1998b; Hilton-Taylor, 2000), although no proper estimate of global population size is available.

This paper is based on surveys undertaken in eastern Sumatra during July–October (the dry season) in 1995

and 1996; a total of 90 days of fieldwork, including 50 nights of spotlighting, were conducted on 10 rivers in the provinces of South Sumatra (Sumatera Selatan), Jambi and Riau (Bezuijen *et al.*, 1995a, b, 1997, 1998). We describe the role of peat swamp forest as nesting and foraging habitat for *T. schlegelii*, and discuss the management issues associated with the conservation of *T. schlegelii* and the habitats it occupies in the Merang River, eastern Sumatra, Indonesia.

### Study area

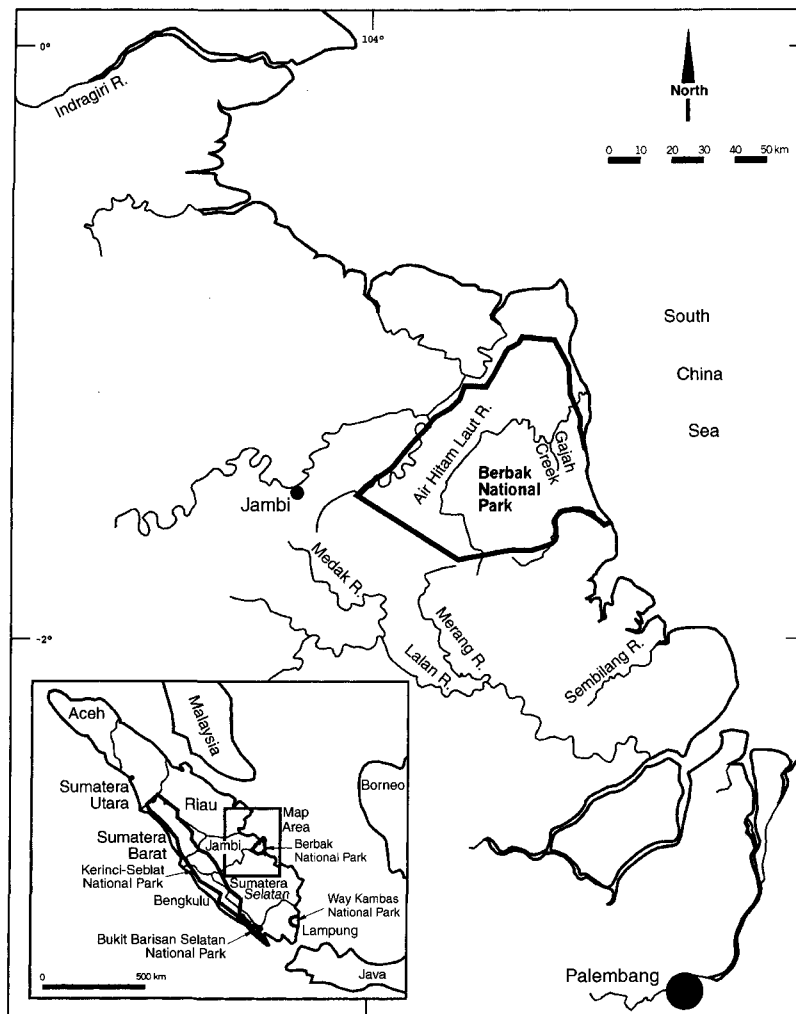
The Merang River is a 66-km freshwater tributary of the Lalan River, in South Sumatra Province (1°59'S, 104°00'E; Fig. 1). It is one of few rivers in eastern Sumatra where *T. schlegelii* is known to live and nest regularly (Bezuijen *et al.*, 1998). From the mouth to 45 km upstream, the river banks have been modified by logging and burning, and support secondary forest (approximately 10 m high), scrub (3–5 m) and grasses, with areas of cleared or burnt banks. Side creeks are few in number and are typically narrow (<1 m wide), shallow (<0.5 m deep) and drain completely at low tide (there is usually one tidal cycle per day in eastern Sumatra, and tidal influence extends upstream into freshwater areas, Hadi *et al.*, 1977). There is little swamp adjacent to the river.

The upper reaches (46–66 km upstream) are without tidal influence, and in 1996 had not been logged for over a decade. They showed no evidence of recent burning, and retained mature secondary and some primary peat swamp forest. The upper reaches are characterized by extensive swamp adjacent to the mainstream (extending up to several hundred metres into the forest), with

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**Fig. 1** Eastern Sumatra, Indonesia, illustrating river systems mentioned in the text.

numerous side creeks and discrete peat mounds. These mounds, up to a few metres high and 8–50 m in circumference (5–200 sq m), usually supported one or several trees. Although not quantified, larger mounds usually supported larger trees. All *T. schlegelii* nests on the Merang River were recorded in the upper reaches, 50–60 km upstream, although individual *T. schlegelii* were observed from the mouth to 63 km upstream (Bezuijen *et al.*, 1995b, 1997).

The upper reaches of the Merang River are approximately 20 km from the western boundary of Berbak National Park in Jambi Province (Fig. 1). The Park encompasses more than 171,000 ha of swamp forest, with possibly the most intact peat swamp forest remaining in South-east Asia (Davie & Sumardja, 1997).

### Nesting

Most *T. schlegelii* sightings and nest records in the literature are from ombrogenous (rain-fed) peat swamp

forest, along slow-flowing freshwater tributaries. Some are under tidal influence and others not, and most adjoin swamps and lakes, often fringed with floating aquatic macrophytes (Butler, 1905; Witkamp, 1925; Frazier & Maturbongs, 1990; Frazier, 1994; Sebastian, 1994; Bezuijen *et al.*, 1995b, 1997; Lading & Stuebing, 1997; Ross *et al.*, 1998; Simpson *et al.*, 1998). Peat swamp forest, historically one of the most extensive lowland vegetation communities in eastern Sumatra, Kalimantan, and Sarawak, has waterlogged, anaerobic soil and receives most of its nutrient and water input from rainfall and the slow decomposition of organic matter (Blasco *et al.*, 1983; Whitten *et al.*, 1984; MacKinnon *et al.*, 1996). This gives rise to peat soil (a soil with 65 per cent or more organic matter content, Driessen, 1978), with low soil and water nutrient content, and acidic 'blackwater' rivers with relatively low levels of primary productivity (Whitten *et al.*, 1984; MacKinnon *et al.*, 1996).

Fifteen nests (new and old) in peat swamp forest on the Merang River, and one old nest on an adjacent

tributary, the Medak River (Fig. 1), had several common characteristics (Bezuijen *et al.*, 1998):

- nests were compact mounds, 117–144 cm basal diameter and 36–60 cm high. All consisted of peat soil and leaf litter raked up by the females;
- each nest was situated at the base of a large tree, themselves on discrete peat mounds typically 25–30 m circumference (50–72 sq m), and demarcated by narrow, shallow channels of water;
- most nest sites (15 nests) were adjacent to the main stream draining a swamp; one nest was about 100 m away from the main stream;
- nest sites were within 2–4 m of a permanent waterway, and the nest base was 0.5–1.5 m (mode 1.0 m,  $n = 15$ ) above water level at the time they were located; and
- nest sites were always in shaded locations, with all nests receiving at least 50 per cent shade, and 13 nests (81 per cent) receiving 80–100 per cent shade in a day.

There are no other documented *T. schlegelii* nest data from Sumatra for comparison, but local people elsewhere in Sumatra, and documented nest records from Borneo and Peninsular Malaysia (Butler, 1905; Witkamp, 1925; Cox & Gombeck, 1985; Lading & Stuebing, 1997; Ross *et al.*, 1998), indicate *T. schlegelii* also nests in freshwater swamp forest and secondary lowland forest. Freshwater swamp forest, which is periodically inundated by mineral-rich floodwaters and which has less acidic water and soils and greater primary productivity than peat swamp forest, is much less extensive in Sumatra and Kalimantan than peat swamp forest (Whitten *et al.*, 1984; MacKinnon *et al.*, 1996). Two *T. schlegelii* nests were observed in Berbak National Park, eastern Sumatra, by local forestry officers in the mid-1980s; although the habitat was not recorded, the Park supports extensive peat swamp and freshwater swamp forest. *T. schlegelii* were observed recently during spotlight surveys in the Park (Bezuijen *et al.*, 1997, 1998).

Logging, burning, shifting cultivation and other activities have resulted in a mosaic of derived, secondary forests in successive stages of regrowth along many of the lowland waterways of eastern Sumatra (pers. obs.). Historically these areas contained peat swamp, freshwater swamp or moist evergreen forest (Blasco *et al.*, 1983). Local people reported *T. schlegelii* nesting along five rivers with secondary forest in eastern Sumatra (Bezuijen *et al.*, 1997). Although not quantified precisely, these rivers appeared to differ from the Merang River in a range of edaphic, hydrological and structural attributes, including: well-defined, often sloping clay/mud river banks, absence of peat mounds and swamp, muddy (not black) waters and less acidic waters (pH 4.5–5.5 compared to pH 3–4 along the Merang River) (Bezuijen *et al.*, 1997). Recent logging, burning

and agricultural activity were widespread in the upper and lower reaches of these rivers.

Witkamp (1925) described three *T. schlegelii* nests in East Kalimantan, all of which were in peat swamp forest similar to that found in the Merang River. Nests were several metres from the river's edge and positioned between trees. Three additional nests in East Kalimantan were described by Ross *et al.* (1998), with one in peat swamp forest, one in 'secondary forest with few streams' and the third in 'post-fire freshwater swamp regrowth'. In Sarawak, local hunters report that *T. schlegelii* nests along the banks of 'blackwater tributaries' in peat swamp forest (Cox & Gombeck, 1985), and a *T. schlegelii* nest was recently found in a logged peat swamp forest, at the base of a tree, one metre from a stream (Lading & Stuebing, 1997; Stuebing *et al.*, 1998). A nest found on a stream bank in Selangor State (Peninsular Malaysia), was reported to be 'on a little high ground with swamps all round' (Butler, 1905), in a region of peat swamp forest.

The attributes of peat swamp forest that make it suitable for *T. schlegelii* nesting are unclear. Successful nesting along the Merang River (Bezuijen *et al.*, 1997) indicates that internal nest temperatures do not exceed lethal limits, which could reflect both the energy content of the peat and the tendency to locate nests in the shade. In recently logged swamp forest in eastern Sumatra, peat mounds tended to be absent, or when present around the bases of trees, appeared too small to support *T. schlegelii* nests (Bezuijen *et al.*, 1997); it is unclear whether these mounds were an original or derived state.

### Foraging and other resources

Although limited, the available data indicate that *T. schlegelii* has a broad diet, which includes: fish, shrimp, monkeys, wild pigs, snakes, birds and other mammals and reptiles (Galdikas & Yeager, 1984; Bezuijen *et al.*, 1997). The diet of juvenile *T. schlegelii* is largely unknown, but the stomach contents of three juveniles captured on the Merang River contained shrimp (Bezuijen *et al.*, 1997). Other juvenile *T. schlegelii* prey items probably include small aquatic invertebrates and fish. It seems unlikely that food availability is itself an important factor linking *T. schlegelii* to peat swamp forest. The faunal assemblages of peat swamp forest are impoverished compared to freshwater swamp forest (Whitten *et al.*, 1984; MacKinnon *et al.*, 1996), although some potential prey, for example long-tailed macaque *Macaca fascicularis* and silvered langur *Presbytis cristata*, occur at higher densities in peat swamp forest than in other lowland forest along rivers (MacKinnon *et al.*, 1996). Galdikas & Yeager (1984) observed predation of a long-tailed macaque by a *T. schlegelii* in Tanjung Puting National Park, Central Kalimantan.

The abundance of peat, leaf litter and fallen wood debris in peat swamp forest provides ample cover for *T. schlegelii* of all sizes to hide and avoid predation. The extensive side creeks and swamp along the Merang River may provide more foraging and nesting habitat than along lowland rivers with little swampy ground adjacent to the mainstream.

### Conservation threats in the Merang River

At the time these surveys were undertaken, the Merang River catchment was under a 20-year logging concession, which expired in 2000. Until at least 1996 a logging mill, a few hundred personnel and some fishing families lived about 42 km upstream from the mouth. A logging railway provided access to forest beyond the terminal reaches of the river. Logs were transported by railway to the mill, then floated to a larger mill on the adjoining Lalan River. A small fishing village at km 45 was the upstream limit of permanent settlement, and from the mouth to km 45 the river was subject to regular human activity, including motorized and non-motorized boat traffic, vegetation clearance, firewood collection and fishing.

In South Sumatra Province a traditional system of river ownership (*lebak lobang*) regulates fishing activity on some rivers. Annual district auctions are held for villages to bid for exclusive, 1-year fishing rights to a river or portion of river. From 1987 to 1995 the annual fishing lease for the upper reaches was owned by several families who lived at km 45. In 1995, 20–30 people were resident at this village, and only eight fishermen regularly visited the upper reaches where the peat swamp forest and nesting *T. schlegelii* are found. Due to a combination of exclusive fishing access and absence of recent logging, the upper reaches had not been subjected to high levels of disturbance for at least the last decade.

In 1996 increased logging and fishing activities were apparent in the upper reaches. The regional logging company's strategy for 1996–1998 was to target the Merang River from 50 to 60 km upstream. At the same time, a new fisherman won exclusive fishing rights to the upper reaches. These changes resulted in the use of two motorized boats, and construction of four permanent huts, in the upper reaches (59.5 km upstream), and doubled the number of residents at 45 km upstream to 50–60 people. In 1996 fishing intensity had increased substantially, and was reported as approximately twice that in 1995. Most side creeks in the upper reaches were blocked with fish traps, and three fish traps blocked the mainstream.

Conservation threats to *T. schlegelii* documented in 1996 included: habitat loss and fragmentation, increased

noise and visual disturbance as a result of elevated fishing and logging activity, incidental drowning in fishnets and traps, and egg predation by introduced pigs *Sus scrofa*. Small-scale, incremental removal of potential nesting habitat was observed along the mainstream during hut construction, and will probably increase as human settlement increases. Direct loss of nesting habitat as a result of legal logging appeared to be minor because Indonesian law prohibits logging closer than 250 m to waterways (although *T. schlegelii* were recorded on some side creeks extending more than 200 m into the forest, Bezuijen *et al.*, 1997).

Although the relative importance of these threats is unclear, we note the following. Between 1995 and 1996 local people reported that at least six *T. schlegelii* were caught during fishing activities; three were found drowned and three, still alive, were released. These included two individuals observed during our visits: one had been snagged on a fish hook and line set in the midstream, and one was caught in a fish trap. These individuals were 0.6 and 1.9 m, respectively (Bezuijen *et al.*, 1997), indicating that a range of different sized *T. schlegelii* are susceptible to incidental capture. Mortality of *T. schlegelii* during fishing activities will probably increase as human settlement increases.

Of seven documented *T. schlegelii* nests on the Merang River in 1995, four (57 per cent) appeared to have been predated by wild pigs (Bezuijen *et al.*, 1997). At least some female *T. schlegelii* remain beside their nests when visited by humans (M. Bezuijen, pers. obs.), and may defend their nests against predators. Dead or rotten eggs in a clutch, in the absence of females, provide olfactory cues that may attract predators, but does not necessarily contribute to increased predation rates of live embryos (Webb *et al.*, 1983). According to local fishermen, who apparently leave nests alone if discovered, humans do not consume *T. schlegelii* eggs and do not deliberately kill *T. schlegelii* (pers. comm.). However, occasional human consumption of *T. schlegelii* eggs was reported on other rivers in eastern Sumatra (Bezuijen *et al.*, 1997) and could occur on the Merang River.

In captivity *T. schlegelii* is considered to be a relatively shy crocodylian, that is easily stressed (M. Bezuijen, pers. obs.; J. Jong Soon, pers. comm.). If so, nesting female *T. schlegelii* may have low tolerance to elevated human activity, which may lead to nest abandonment.

### Discussion

In South-east Asia the highest densities of *T. schlegelii* and the majority of *T. schlegelii* nests so far documented are in locations with relatively intact and extensive ombrogenous peat swamp forest. These records, although scattered and incomplete, suggest peat swamp



forest was and remains an important habitat for this species. Unburnt forest that has not been logged appears to provide suitable platforms for nesting that are elevated above water level, and suitable conditions (food, temperature and water) to sustain adults and newly hatched young. It also appears to provide suitable materials for nest construction, which meet the needs of gas and water exchange, and acceptable incubation temperatures, within the final nest mound. Records in the literature from freshwater swamp forest and modified, secondary forest confirm that *T. schlegelii* is not restricted to peat swamp forest, although it may be a favoured habitat; it is not unusual for crocodylian adults to live and nest in relatively small subsets of the total habitats that they occupy through different life stages (Webb *et al.*, 1983).

Records from modified, secondary forest suggest that it supports fewer *T. schlegelii* than undisturbed habitats. For example, local people in eastern Sumatra commonly stated that numbers of *T. schlegelii* had declined in the last few decades as human activity had increased. Nesting reports from previously logged or burnt areas were typically of single nests that were often several years old (Bezuijen *et al.*, 1997).

The 1997/1998 fires in Sumatra and Kalimantan (Kinnaird & O'Brien, 1998; Barber & Schweithelm, 2000) may have destroyed large areas of *T. schlegelii* nesting habitat. Peat swamp forest is vulnerable to burning, which removes peat layers and subsurface root formations, and exposes the soil to erosion, slumping, hydrological changes and weed invasion (GOI-World Bank, 1995). In eastern Sumatra the banks of a tributary surveyed in 1995 (Bezuijen *et al.*, 1995b) had been burnt in 1994, and the post-fire vegetation was grassland with low tree regrowth. No *T. schlegelii* were recorded, and local people reported that none had been seen since the fire. In contrast, *T. schlegelii* was recorded in adjacent tributaries that had not been burnt (Bezuijen *et al.*, 1995b). That fire can lead to crocodylians abandoning areas of traditional nesting habitat has been demonstrated in northern Australia. In one case, all nesting by *Crocodylus porosus* in a freshwater swamp ceased after a fire and, despite the recovery of the vegetation after 2 years, nesting is virtually non-existent 14 years later (G. Webb, pers. obs.). The ongoing, incremental loss or modification of swamp forest habitat in eastern Sumatra and elsewhere in South-east Asia (Khan, 1995; Bezuijen *et al.*, 1998; Ross, 1998a) is probably the greatest threat to the long-term global status of *T. schlegelii*.

Other human-related threats to *T. schlegelii* in eastern Sumatra include incidental drowning in fish nets and traps, and occasional egg consumption. Fishing-related mortality of *T. schlegelii* is widespread; for example, 21 of 23 fishermen interviewed in three provinces of eastern

Sumatra had witnessed *T. schlegelii* caught in fishnets or traps (Bezuijen *et al.*, 1997). Although subject to trade between the 1950s and 1970s, *T. schlegelii* skin and flesh are widely recognized among local people as having no commercial value. No evidence of commercial trade was observed in eastern Sumatra in 1995–1996 (Bezuijen *et al.*, 1997). Only one report of flesh consumption was recorded, from a fisherman in Jambi Province, who claimed he had observed a member of the Kubu tribe consume *T. schlegelii* flesh (Bezuijen *et al.*, 1997).

On the Merang River, the most significant human threats to *T. schlegelii* in 1996 resulted from increasing human activity associated with the steady upstream movement of permanent and semi-permanent settlements. Unsurveyed since 1996, it seems likely that the status of the peat swamp forest and nesting aggregation of wild *T. schlegelii* has declined. Bezuijen *et al.* (1998) recommended that a management plan be developed for the Merang River, and that the upper reaches be included within a regional conservation strategy for forested coastal wetlands (GOI-World Bank, 1995; Davie & Sumardja, 1997). This regional strategy, which proposed that the southern boundary of Berbak National Park be extended to encompass the Sembilang River system (Fig. 1), was supported by the provincial and local government in South Sumatra Province in 1996, and was in the process of being gazetted prior to the onset of the economic crisis and changes in national government in 1998 (J. Davie, pers. comm.).

The inclusion of the Merang River into this regional strategy would have numerous advantages. No other rivers are currently known that support comparable *T. schlegelii* nest densities, many rivers in eastern Sumatra no longer retain intact and extensive peat swamp forest, and a range of other rare and threatened fauna have been documented along the Merang River, including tigers *Panthera tigris*, asiatic elephants *Elephas maximus*, flat-headed cats *Priornailurus planiceps*, white-winged wood ducks *Cairina scutulata* and Storm's storks *Ciconia stormi* (Lambert, 1988; Danielsen & Verheugt, 1990; Bezuijen, 2000; M. Bezuijen, unpubl. data; local people, pers. comm.).

With the expiry of the Merang River logging concession in 2000, now may be an opportune time for Indonesia to reconsider proposals for protecting the peat swamp forest and its *T. schlegelii* population. Any such proposal would need to provide a sustainable future for the local people who depend on the waters for fishing and other resources. The traditional system of exclusive annual fishing rights and history of low intensity fishing in the upper reaches are conducive to the development of an innovative management strategy for the river. Some level of external financing and assistance may be needed. A more detailed survey to

assess the current status of the peat swamp forest and *T. schlegelii* population is also warranted.

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### Biographical sketches

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