

# **PROJECT TOMISTOMA**

## **SECOND REPORT ON THE ECOLOGY OF THE FALSE GHARIAL (TOMISTOMA SCHLEGELII) IN SUMATERA**

**Mark R. Bezuijen, Pandu Hartoyo, Murray Elliott and Bryan A. Baker**

**A STUDY COORDINATED BY THE IUCN-SSC CROCODILE SPECIALIST  
GROUP, WILDLIFE MANAGEMENT INTERNATIONAL PTY. LIMITED AND  
THE DIRECTORATE-GENERAL OF FOREST PROTECTION AND NATURE  
CONSERVATION OF INDONESIA**

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**PROJECT TOMISTOMA: SECOND REPORT ON THE ECOLOGY OF THE  
FALSE GHARIAL (TOMISTOMA SCHLEGELII) IN SUMATERA**

**PRODUCED BY WILDLIFE MANAGEMENT INTERNATIONAL PTY.  
LIMITED  
PO BOX 530, SANDERSON, NORTHERN TERRITORY  
AUSTRALIA 0812**

## EXECUTIVE SUMMARY

1. This report documents the results of a field trip to Sumatera (21 July-19 October 1996) to investigate the distribution, nesting biology and other aspects of the ecology of the False Gharial (*Tomistoma schlegelii*), a freshwater crocodile species confined to Indonesia and Malaysia.
2. The Crocodile Specialist Group (CSG), of the Species Survival Commission of the IUCN-World Conservation Union, has recognised *T. schlegelii* as one of the least-known of world crocodilians, and a species in urgent need of research. Wildlife Management International Pty. Limited (WMI), an environmental consultancy firm based in Darwin, agreed to co-ordinate a co-operative research project on the species on behalf of the CSG. With the largest remaining populations thought to exist in Sumatera and Kalimantan, research efforts were directed at Indonesia. In 1994 preliminary field trips and interviews were conducted in Sumatera and East Kalimantan (Ramono 1994). In March 1995 a trip was made to South Sumatera Province to ascertain fieldwork logistics and identify areas for research (Bezuijen *et al.* 1995a). The first extensive field trip to Sumatera Selatan Province was undertaken in August-October 1995 (Bezuijen *et al.* 1995b).
3. The aims of this second major field trip, in 1996, were to:
  - obtain a broad overview of the current and historic distribution of *T. schlegelii* within Sumatera as a whole;
  - conduct surveys in new river systems in eastern Sumatera;
  - return to an area studied in 1995 to conduct additional surveys and describe new nests;
4. Prior to the 1950s, *T. schlegelii* appear to have occurred from south-eastern Aceh Province to southern Lampung Province. Intensive hunting in the 1950s-1970s and increasing human use of habitats has reduced this range by approximately 30%. Currently, *T. schlegelii* are thought to occur from south-eastern Sumatera Utara Province to southern Sumatera Selatan Province, with an isolated population in Way Kambas National Park, Lampung Province. Western limits to their range are probably the foothills of the Barisan Mountain Ranges. *Tomistoma schlegelii* are not known from Sumatera Barat and Bengkulu Provinces (western Sumatera), and it is unlikely that the species ever occurred west of the Barisan Mountain Ranges.

5. In nearly all areas visited, local people reported there were fewer *T. schlegelii* now than in the 1950s-1960s. However, *T. schlegelii* remains widespread in Jambi and Riau Provinces, although in low densities. Jambi and Riau Provinces are probably the strongholds of the species within Sumatera.
6. *Tomistoma schlegelii* were recorded during spotlight surveys on Air Hitam Laut River and Simpang Melaka Creek of Berbak National Park in Jambi Province (0.26 *T. schlegelii* sighted per kilometre) and the Merang River (Sumatera Selatan Province) (0.18 sighted per kilometre).
7. Seven *T. schlegelii* were captured and measured: six from the Merang River and one from the Alai River (Jambi Province). Six were male and one female. Mean Snout-Vent Length (SVL) of males was  $53.6 \pm 11.6$  cm (37.4-62.0 cm). The female was 100.4 cm SVL.
8. Two nests were located on the Merang River (Sumatera Selatan Province). Mean egg size (mass) was almost double that for any other species within the Order Crocodylia, which confirms findings from 1995, that the species has exceptionally large eggs (Bezuijen *et al.* 1995b). Nesting season is from June to October (nest making and egg laying in June-July and hatchlings appearing in September-October).
9. *Tomistoma schlegelii* nest in at least two categories of forest: peat swamp forest and lowland secondary forest. Differences between these two habitat categories were quantified. Peat swamp forest was recorded in Berbak National Park and Merang River and is well-represented in both. Lowland secondary forest was found in all other areas visited in eastern Sumatera and was clearly more common.
10. Twenty-five interviews were conducted with fishermen and former crocodile hunters in the eastern and southern Provinces of Sumatera. These interviews resulted in a diversity of general information on distribution, abundance, taxonomy, nesting biology, beliefs and trade in *T. schlegelii*. Of particular interest were two nesting records of *T. schlegelii* from a farm in Jambi Province, and mating behaviour on a farm in Sumatera Utara Province. Successful nesting at the farm in Jambi Province is significant in view of the difficulties experienced by many institutions in captive breeding of *T. schlegelii*. A former hunter in Lampung Province used to collect eggs of *T. schlegelii* in the 1960s, incubate them, and then raise the hatchlings until ready for skinning. This was the only record encountered of ranching: incubation of wild-collected clutches by hunters for the purpose of commercial trade.

11. Human activities were evident along all rivers surveyed. Nesting habitats are disturbed by logging, slash/burn cultivation, buffalo grazing, land clearance and fishing activities. There is occasional use of specimens caught incidentally in fish traps and nets, either for food or as curios, and the odd individual may be sold from time to time. However, the species is widely recognised as having no value or market and is not subject to deliberate hunting for commercial purposes.

## SUMMARY OF RECOMMENDATIONS

### 1. Habitat protection

Berbak National Park in Jambi Province is the only protected area in eastern Sumatera which is currently known to hold breeding populations of *Tomistoma schlegelii*. Protected areas in Jambi, Lampung, Riau and Sumatera Selatan Provinces are concentrated in the western mountain ranges or near the coast, but do not cover representative areas of lowland forest within the centre of these Provinces. Should Indonesia wish to protect an area specifically for *T. schlegelii*, a river system in this area could be considered.

### 2. Further research

- Annual surveys on the Merang River (Sumatera Selatan Province).
- Assess the status of *T. schlegelii* in Kalimantan.

### 3. Education

Should Indonesia wish to conduct further studies on *T. schlegelii*, a brief training program for Forestry officers may stimulate interest and encourage officers to record and report sightings. Training in surveys will encourage the development of an independent monitoring program for *T. schlegelii*.

## ACKNOWLEDGMENTS

This field trip was undertaken jointly by staff from WMI (Australia) and Central and Provincial PHPA offices in Indonesia. LIPI identified fish and crustaceans. Bumi Raya Utama Group, CV. Sumatera Aquaprima, P.D. Budiman and P.T. Sinar Gunung Mas Jaya provided enormous help, and their involvement and support for the Project was vital to its success.

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**GLOSSARY**

Batang	river
BRUI	Bumi Raya Utama Group (Logging Company with rights to the Medak, Kepahyang and Merang Rivers on the Lalan River, South Sumatra)
BYL	Bayung Lincir Village
Danau	lake
Kabupaten	Regency. Largest administrative division of a province
Kecamatan	District. Administrative division within Regency
Ketek	any motorised wooden boat larger than a canoe (ie > 15 ft), usually with a diesel engine
KSDA	Konservasi Sumber Daya Alam (Conservation of Natural Resources). Provincial PHPA office
Lebuk	deep pool in a stream or river
Lebung	as for 'Lebuk'
LIPI	Lembaga Ilmu Pengetahuan Indonesia (Indonesian Institute of Sciences)
PHPA	Perlindungan Hutan dan Pelestarian Alam (Directorate General of Forest Protection and Nature Conservation, within the Ministry of Forestry)
Pondok	hut
Prahu	canoe
Sum-Sel	Sumatera Selatan (South Sumatra Province)
Sungai	river
WMI	Wildlife Management International Pty. Limited



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## 1.0 INTRODUCTION

The 1992 IUCN-Species Survival Commission *Action Plan for Crocodiles* classified *Tomistoma schlegelii* as one of the highest priority crocodylians for conservation action (Thorbjarnarson 1992). In 1994 the Crocodile Specialist Group (CSG) of the IUCN-World Conservation Union raised funding for a research project to begin on the species. Preliminary surveys were undertaken in 1994 in eastern Sumatera and East Kalimantan (Ramono 1994) and a fact-finding trip to Palembang (Sumatera Selatan Province) took place in March 1995 (Bezuijen *et al.* 1995a) to identify study areas. A major field trip was undertaken from August-October 1995 to several rivers in Sumatera Selatan, to conduct surveys and document nesting biology (Bezuijen *et al.* 1995b).

In July - October 1996 a second major field trip to Sumatra was undertaken to:

1. Obtain a broad overview of the current and historical distribution of *T. schlegelii* in Sumatera;
2. Conduct spotlight surveys in river systems not previously surveyed in eastern Sumatera;
3. Return to an area studied in 1995 to conduct spotlight surveys and describe new nests;
4. Quantify habitats of *T. schlegelii* ;
5. Conduct further interviews with fishermen and former crocodile-hunters.

In fulfilling these aims:

6. A 22-day trip (19 August-10 September 1996) was undertaken to assess the current and historic distribution of *T. schlegelii* within Sumatera. Each province of Sumatera was visited, and interviews were conducted with local people and Forestry officers. River systems containing *T. schlegelii* were identified for later surveys;
7. Spotlight surveys were conducted in six previously unsurveyed river systems, in three Provinces of eastern Sumatera;
8. Spotlight surveys and new nesting data were collected from the Merang River in north-eastern Sumatera Selatan Province (identified as a nesting site in 1995);
9. Forest habitat was quantified in all river systems using a series of standard quantitative measurements;
10. Interviews were conducted with local residents on all river systems surveyed.

## 2.0 METHODS

### 2.1 Study areas

Sumatera is the second largest island of Indonesia (after Kalimantan), and extends from 5°40'N, 95°10'E (northern tip of Aceh Province) to 5°55'S, 106°00'E (south-eastern tip of Lampung Province). The island is divided into eight Provinces (Fig. 1). Western Sumatera is dominated by the Barisan Mountain Ranges, a large chain of mountains which extend from the northern to southern tips of Sumatera. In many areas of western Sumatera, only a narrow strip of coastal plain separate the mountains from the Indian Ocean. Rivers in western Sumatera are relatively short, rocky and drain west into the Indian Ocean. In contrast, eastern Sumatera is dominated by large plains of low elevation, characterised by

long, meandering rivers which drain east into the Malacca Strait. Mudflats dominate the eastern coast.

The climate of Sumatera varies considerably due to its varied topography. Average annual rainfall is 2500 mm/year, but ranges from 1500 mm/year (some areas of eastern Sumatera) to 6000 mm/year (west of the Barisan Mountains) (Whitten *et al.* 1984). Eastern Sumatera is characterised by a poorly-defined Wet Season lasting seven to nine months (October to April) and a Dry Season lasting 3-5 months (May to September). The equator bisects Sumatera through West Sumatera and Riau Provinces. Mean annual temperatures in eastern Sumatera range from 23°C to 31°C and mean annual relative humidity is 85%. In eastern Sumatera Selatan there is usually one tidal cycle per day, but can be two per day during neap tides. Tidal range can be up to 5 m in some areas, but is highly variable; tidal influence extends well upstream into totally freshwater areas (Hadi *et al.* 1977).

Rivers were surveyed within the eastern Provinces of Jambi, Riau and Sumatera Selatan. Within Jambi Province, the Alai, Air Hitam Laut and Batang Hari Rivers were surveyed (Fig. 2). Air Hitam Laut River is within Berbak National Park, which was the only protected area where field work was conducted. Berbak National Park lies within the south-east corner of Jambi Province (Fig. 2). The Batang Hari River is one of Sumatera's longest rivers, stretching more than 700 km from the Barisan Mountain Ranges of western Sumatera to the sea. The Alai River is a small tributary of the Batang Hari River, located 465 km upstream from its mouth (Fig. 2). Within Riau Province the Kubu and Teso Rivers were surveyed (Fig. 3). The Kubu River originates in south-eastern Sumatera Utara Province and extends to the sea in north-east Riau Province. The Teso River is a tributary of the Kampar Kiri River (Fig. 3), in southern Riau Province. In Sumatera Selatan Province, the Merang and Benu Rivers were surveyed. The Merang River (Fig. 2) is a tributary of the Lalan River (Fig. 2). The Benu River lies on the border of Sumatera Selatan and Jambi Provinces (Fig. 2) and partly represents the southern boundary of Berbak National Park.

## 2.2 Interviews

Interviews with fishermen, former crocodile hunters and Forestry officials were a principle source of information on *Tomistoma schlegelii*.

Interviews were conducted whenever possible. A standard set of questions were asked and answers were recorded on an interview form (Fig. 1 in App. 4). Preliminary questions were asked to assess how much the interviewee knew; a complete interview was only conducted with people with obvious knowledge on the species. Not all questions were asked in every interview, depending on how much the interviewee appeared to know. Complete interviews (ie asking all questions as opposed to casual conversation and some brief questioning) took 1-1.5 hours per person. Interviews were conducted in National ('bahasa') Indonesian and were designed to provide information on the rivers people were most familiar with (most fishermen interviewed had spent the majority of their life on one river and were not familiar with others). Questions covered: distribution (current, historical); abundance (changes in numbers and size structure over time); taxonomy (different colour forms); nesting biology; local customs and beliefs, and trade (past and present).

In order to assess the broad-scale distribution of *Tomistoma schlegelii* in Sumatera, a 22-day trip was undertaken to all Provinces of Sumatera except Sumatera Selatan Province, where recent information already exists (Bezuijen *et al.* 1995b, Ramono 1994). In each Province, meetings were held with the Head of Sub-Balai KSDA, and if possible, the Head of Kanwil (see App. 13 for structure of Ministry of Forestry). The number of days spent in each Province was limited by the Project budget and a need to return to fieldwork before the onset of the rainy season.



False Gharials (*Tomistoma schlegelii*). Note the dark colouration and distinctive dorsal banding.

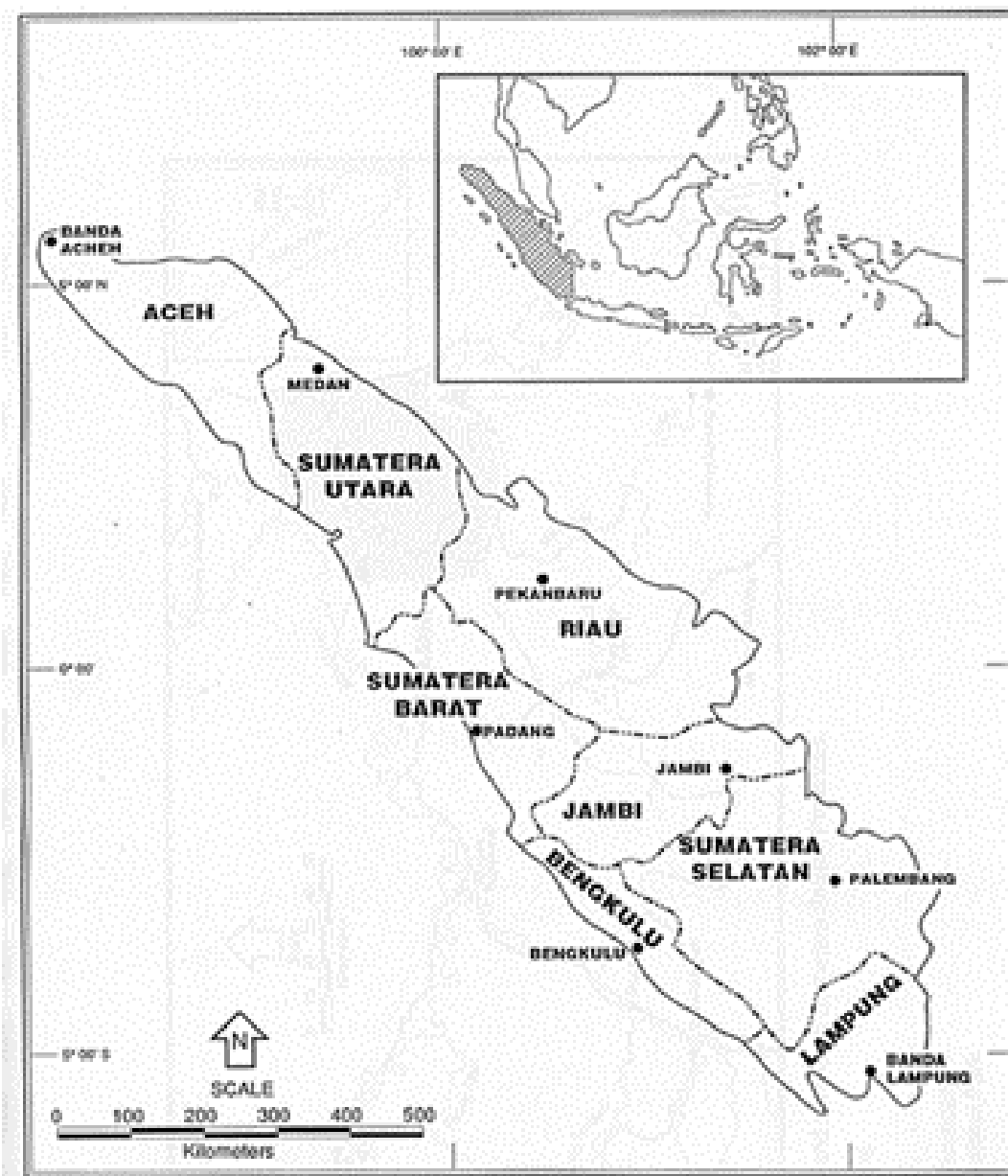


Fig. 1. Sumatra. Dots represent provincial capital cities.

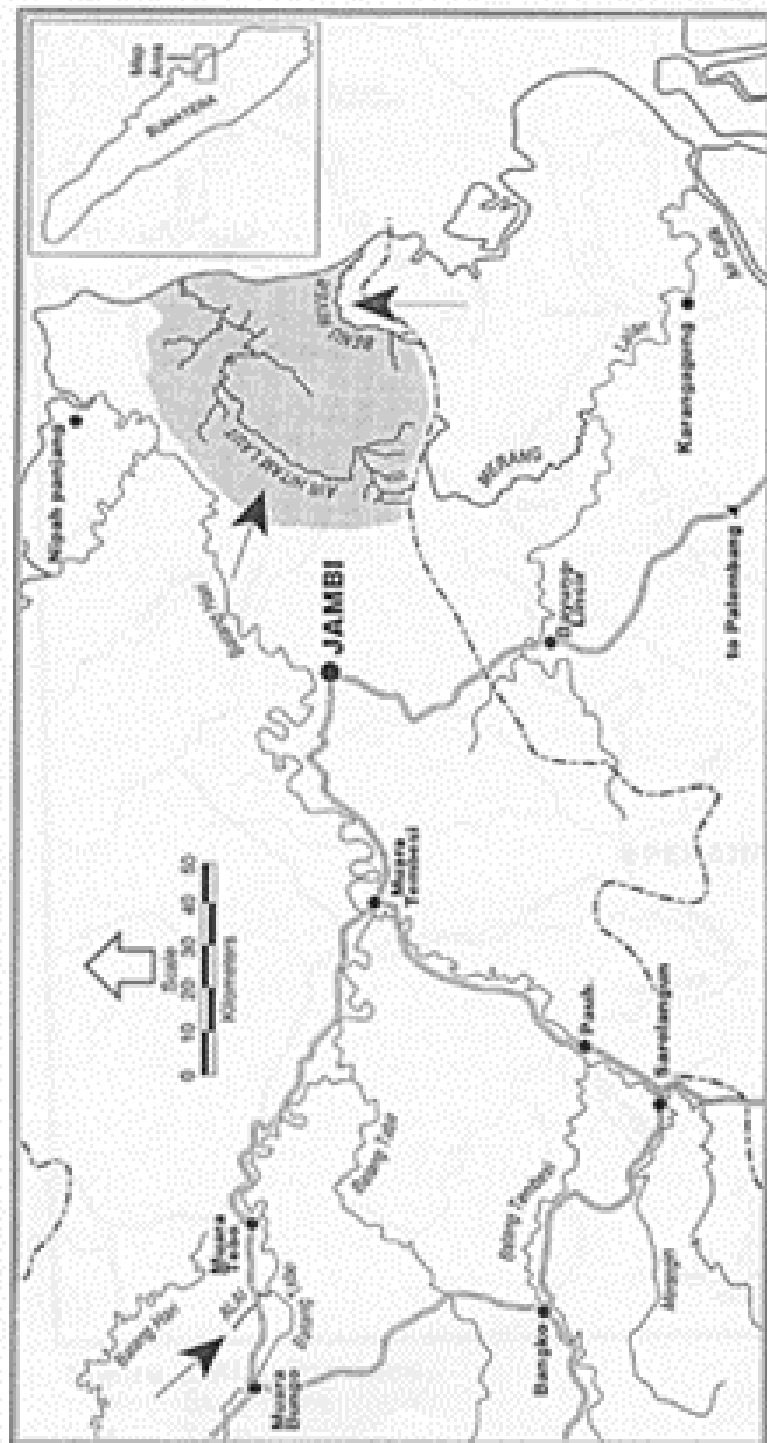
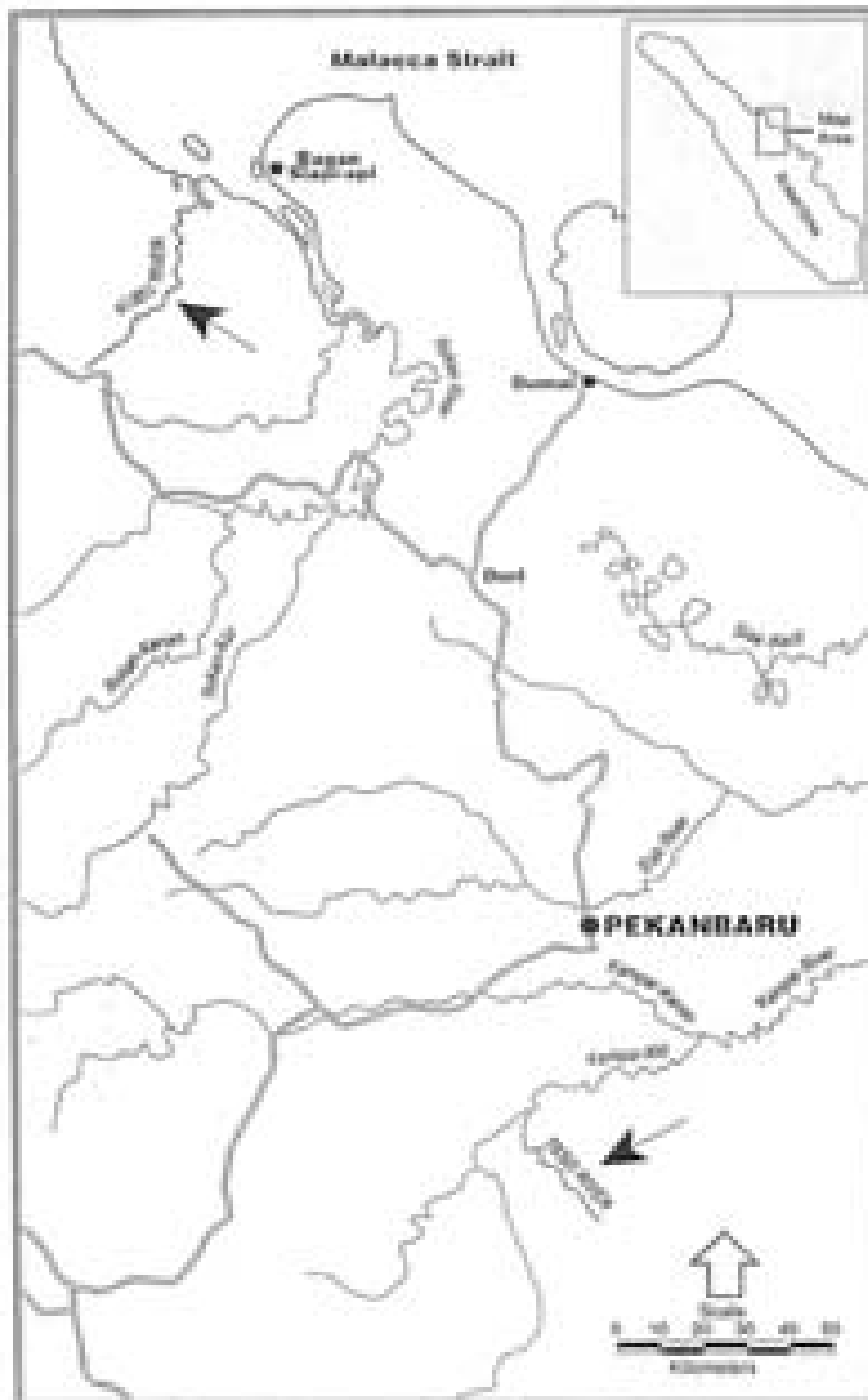


Figure 2. Jambi and north-east Sumatra Selatan Provinces.

- Study rivers
- Town
- Road
- - - Province boundary
- ▨ Berbak National Park



**Figure 3. Riau Province.**

- Study rivers
- Town
- Road



Information on current and historical distribution of *T. schlegelii* were gathered from: interviews with crocodile farmers and reptile traders; KSDA records; discussion with KSDA wardens who made regular field patrols; and, information gained from local people.

In Jambi, Lampung and Riau Provinces 1-3 day trips were made (by car) away from the capital cities. Trip routes were planned on roads and tracks that crossed as many rivers as possible. Stops were made at all major river crossings and some smaller tributary crossings, where broad habitat descriptions (river width, vegetation height, dominant land use and extent of clearance) were recorded. The Village Head was met wherever possible, and the survey aims discussed. Interviews were conducted with local fishermen.

### 2.3 Surveys

Densities of *Tomistoma schlegelii* were assessed by surveys from a speedboat (40 HP engine) or canoe, depending on stream depth. Spotlights (12 V/100 W bulb on a 6" sealed-beam face) were powered from a 12 V truck battery in speedboats. Six volt *Dolphin* (Eveready) torches were used for canoe surveys.

Crocodiles were identified to species or recorded as 'Eyeshine' (ES). Sighting location was recorded on a 'sightings' map.

On some rivers, sections of river were surveyed more than once. To account for repeat sightings of the same individuals, sightings of *T. schlegelii* on *repeat surveys* were *ignored* for the final tally, *unless* they were crocodiles greater than one size class apart. For example: On Night 1, a survey from km 0-10 revealed 10 crocodiles. On Night 2, a survey from km 5-15 revealed 5 crocodiles, of which 3 were between km 5-10. These 3 were ignored as they may be animals seen on Night 1. Final tally is 10+2 = 12 crocodiles. Density was calculated by dividing the final tally by length of river surveyed (e.g. 12/15 km = 0.8 crocodiles/km). All ES were assumed to be *T. schlegelii*, unless seen within a few kilometres of the sea and in brackish water, where they were assumed to be *Crocodylus porosus*. Results by Bezuijen *et al.* (1995b) were recalculated as above to allow comparison with survey results in this report.

### 2.4 Maps

All reported sightings of *Tomistoma schlegelii* from interviews were located on 1:250 000 topographic maps (*Peta Rupabumi Indonesia, Peta Ikhtisar Topografi Sumatera 1:250 000 JANTOP TNI-AD, 1985/86*) and latitude/longitude recorded. Reported sightings were summarised for each Province, with the record identified by latitude/longitude, Kabupaten (regency), Kecamatan (district) and broad compass-location (e.g. south-west corner, Jambi Province). General topographic maps (available in most bookshops in Indonesia) were used to plan trip routes.

Topographic maps were used for navigation during surveys. For the Merang River (Sumatera Selatan Province), 1:50 000 survey maps from Bezuijen *et al.* (1995b) were used. For all other rivers surveyed, 1:250 000 maps (*Peta Rupabumi Indonesia, Edisi I-1986*) were used. Topographic details and useful landmarks were added to maps for future surveys.

### 2.5 Capture, morphometrics, scalation and diet

Capture was attempted of all individuals. Capture was by hand, bamboo tongs or fishtrap (incidental catch by fishermen using fishtraps across creek mouths). Scale counts and morphometrics measurements were recorded [see Bezuijen *et al.* (1995a, Section 4.2) for methodology]. Capture and release location and general notes (injuries, abnormalities etc) were recorded. Stomach contents were removed following Webb *et al.* (1982).

## 2.6 Nests

Sidecreeks and mainstream banks were searched for nests.

When nests were located, details were recorded using data sheets formulated by Scott (1994), which provided for: nest type (eggs, no eggs, etc), substrate (mat, bank, swamp, other), dominant vegetation at the nest, temperatures (eggs and ambient), female notes (present? defending? size? etc) and general nest notes. Local fishermen provided local names for dominant tree species at a nest site. Scientific names were later identified for some of these. Nest dimensions recorded were: vertical height from the bottom of the nest to water level (visually estimated to the nearest 10 cm); vertical height from top of nest to top of top egg and vertical height from top of nest to bottom of bottom egg (measured to 0.1 cm with a 7.5 m *Taskmaster* metal tape rule). Exposure to the sun was measured as the % of shade the nest would receive at 0600-0900, 0900-1200, 1200-1500 and 1500-1800 hours (visually estimated to the nearest 5 %). The location of nests in relation to peat hummocks and surrounding sidecreeks was described and drawn.

Clutch size, egg mass, egg width, egg length and notes on the general condition of the eggs were recorded. All eggs in a nest were processed. Egg mass was weighed to 1 g using a 500 g *Pesola* spring balance (Oskar Ludi and Co., Switzerland). Egg width and length were measured to 0.01 mm using *NSK Max-Series Electronic Digital Callipers* (Japan Micrometer MFG. Co. Ltd).

One egg was removed from each nest, opened, and the embryo preserved in 10 % formalin. Approximate embryo age was estimated using the morphological age series of Webb *et al.* (1987a) for *Crocodylus porosus* and *C. johnstoni*.

Photos were taken of all nests, eggs and embryos.

## 2.7 Habitat quantification

The following measures were recorded in rivers surveyed for *Tomistoma schlegelii*.

### 2.7.1 Forest structure quantification

Measurements were recorded in 2 m x 2 m quadrats laid 5 m away from the waters edge on the forest floor adjacent to the stream, at 1-2 km intervals along each river (intervals depended on river length and time available). Only one bank was measured; any significant differences in vegetation or land use on the opposite bank were noted (eg forest on right bank, old slash/burn site on left). 'Right' and 'left' bank were delineated facing *upstream*. Within each quadrat the following were recorded:

- Basal Circumference at chest Height (BCH) (to 1 cm). Circumference of all trees within the quadrat taller than chest height were measured with a 7.5 m *Taskmaster* metal tape rule. If a tree partly within the quadrat was 50% or more within the quadrat it was included;
- Tree species were identified by local fishermen in local dialect or National ('bahasa') Indonesian language. Family (and if possible genera and species) were identified by Riza Kadarisman (KSDA Officer), Danielsen and Verheugt (1990) and de Wulf (1978). If a species was unknown to the fishermen it was labelled 'species a, b', etc. Several tree species on the Merang River (Sumatera Selatan Province) were photographed;
- Visual estimate of mean canopy height (MCH) above quadrat (to 1 m); visual estimate of height of emergent tree (EH) above quadrat (if present - not all quadrats contained a tree noticeably higher than others in the quadrat) (to 1 m); visual estimate of % canopy cover (CC) directly over the centre of the quadrat (10% intervals: 0% = no cover,

100% = dense cover); visual estimate of % water, % peat mound and % 'other' (mud or leaf litter mostly) on the ground within the quadrat (10% intervals); visual estimate of the basal circumference (to 1m) of all peat mounds within quadrat (PMC). Thus, if the quadrat fell over 3 separate peat mounds, individual PMC of all 3 was recorded. Maximum peat mound height (HPM) was recorded (to 0.1 m) with a metal *Taskmaster* tape rule.

### 2.7.2 Catena (forest cross-section)

A catena representing a 'typical' section of forest and river was drawn on four rivers, illustrating forest strata and heights, river width and depth and dominant bankside vegetation.

### 2.7.3 River length and depth

Mainstream depth was measured at 1-10 km intervals. A 3 m pole with 10 cm graduations or a fishing line and weight (lowered to the river bed) were used to measure depth. Width was estimated visually (to 5 m), and was the width of open water (e.g. if dense aquatic plant growth blocked all but 3 m of a section in the river, width was recorded as 3 m). Some indication of the mainstream habitat available to crocodiles on the Merang River (Sumatera Selatan Province) was obtained by counting all sidecreeks (defined as any channel branching off from the mainstream) from km 45-66. In all cases, the fishermen (who walk them continually), knew the approximate the length and depth, and when checked, these estimates were reasonably accurate. Number of sidecreeks were not recorded elsewhere, as the banks of most other rivers were submerged.

### 2.7.4 Temperature

Water temperature was measured in mid-stream at approximately 75 cm below water surface with a calibrated thermometer to 0.5 °C. Ambient temperature was measured. Corrected temperatures were later derived from individual calibration equations for each thermometer used. Time of measurement and location were recorded.

### 2.7.5 Salinity and pH

A crude measure of salinity was obtained with a salinometer, which measured salinity from 0-50 parts per thousand. Accuracy of the salinometer was tested by comparing salinity readings against a *Hamon Salinity and Temperature Bridge* (Yeo-Kal, model 602). Readings from the salinometer were 1-5 ‰ greater than the *Hamon Salinity and Temperature Bridge*. pH was measured with litmus paper [*Merck Universalindikator pH 0-14 Kit* (No. 1.09535)]. Water samples were collected 60 cm below the surface in a plastic specimen jar. pH was measured at 0.5 colour intervals (1.0, 1.5, 2.0 etc).

## **2.8 Reference collection**

To aid with analyses of *Tomistoma schlegelii* stomach contents from the Merang River (Sumatera Selatan Province), fish and crustaceans were collected from fishermen's traps and nets, photographed and local names recorded. Small specimens were preserved in 10% formalin and species identified at LIPI Zoological Museum, where they were re-preserved in 70% alcohol. Large specimens were only photographed. Specimens were identified using Bott (1970), Chace and Bruce (1993), Kottelat *et al.* (1993) and Weber and De Beaufort (1916, 1950). Incidental observations of mammals, reptiles and amphibians along the Merang River were recorded.

### 3.0 RESULTS AND DISCUSSION

#### 3.1 Distribution, abundance and status

The current distribution of *Tomistoma schlegelii* extends from south-eastern Sumatera Utara Province to southern Sumatera Selatan Province (Fig. 4), where it appears to exist in widespread areas but in low densities. What appears to be an isolated population exists in Way Kambas National Park in Lampung Province (Fig. 4) and is probably the southern-most extent of the species range in Sumatera. Historically, *T. schlegelii* was more widely distributed, from south-eastern Aceh Province to southern Lampung Province - almost the entire length of eastern Sumatera (Fig. 4). By calculating the approximate area of historical and current distribution (based on interviews) it is estimated that the range of *T. schlegelii* in Sumatera may have been reduced by approximately 30 % within the last 30-40 years.

Sixty-six reports of *T. schlegelii* were recorded during interviews with local people. These reports were from twenty-eight rivers in six Provinces of northern, eastern and southern Sumatera (one river in Aceh Province, seven rivers in Jambi Province, four in Lampung Province, seven in Riau Province, eight in Sumatera Selatan Province and one in Sumatera Utara Province) and included both recent and historical sightings. Included are thirteen incidental reports of *Crocodylus porosus* in Bengkulu and Sumatera Barat Provinces (reports of *C. porosus* were otherwise not asked for). There are no reported sightings of *T. schlegelii* west of the Barisan Mountain Ranges, now or historically (Fig. 4). There were no reported records of *T. schlegelii* from Bengkulu Province, and only one from Sumatera Barat Province, on its eastern border with Riau Province. Most records of *T. schlegelii* were from Jambi Province (n=35). Details of reported sightings are in App. 5.

Surveys in Jambi, Riau and Sumatera Selatan Provinces provided additional information on the distribution, abundance and status of *T. schlegelii* in eastern Sumatera. Seven rivers were surveyed in these three Provinces. During surveys *T. schlegelii* were seen on the Merang River (Sumatera Selatan Province) and the Air Hitam Laut River (Jambi Province). No other crocodiles were seen in Jambi and Riau Provinces, largely because surveys were affected by very high water levels, with many areas of forest adjacent to the banks submerged. In some areas water extended 1-2 km into the forest. According to villagers, the rains had arrived 'earlier than usual' in 1996. A full and waning moon may have also hindered surveys in Jambi Province. Surveys in Riau Province were on moonless nights. However, fishermen interviewed on all survey rivers stated *T. schlegelii* were present.

According to the majority of people interviewed, *T. schlegelii* have declined in abundance within the last fifteen years. Two interviewees (from Teso and Kubu Rivers, Riau Province) felt local populations had increased, with more sightings in recent years. One fisherman (Air Hitam Laut River, Jambi Province) stated the population had not changed in 15 years. Twenty-seven interviewees had seen *T. schlegelii* within the last six years on the river they were living on; twenty-one had seen *T. schlegelii* in 1995-96. Numbers seen per interviewee in 1995-96 ranged from 1-60, with 1 the most common (n=3).

##### 3.1.1 Aceh Province

A 1993 sighting in south-east Aceh by a KSDA warden was the only reported record for Aceh Province (Table 1 in App. 5). No further details were available, and the warden has been contacted for further information. No interviews or surveys were conducted in Aceh Province. This single record may represent the northern-most extent of the species range, at least in its historical distribution.

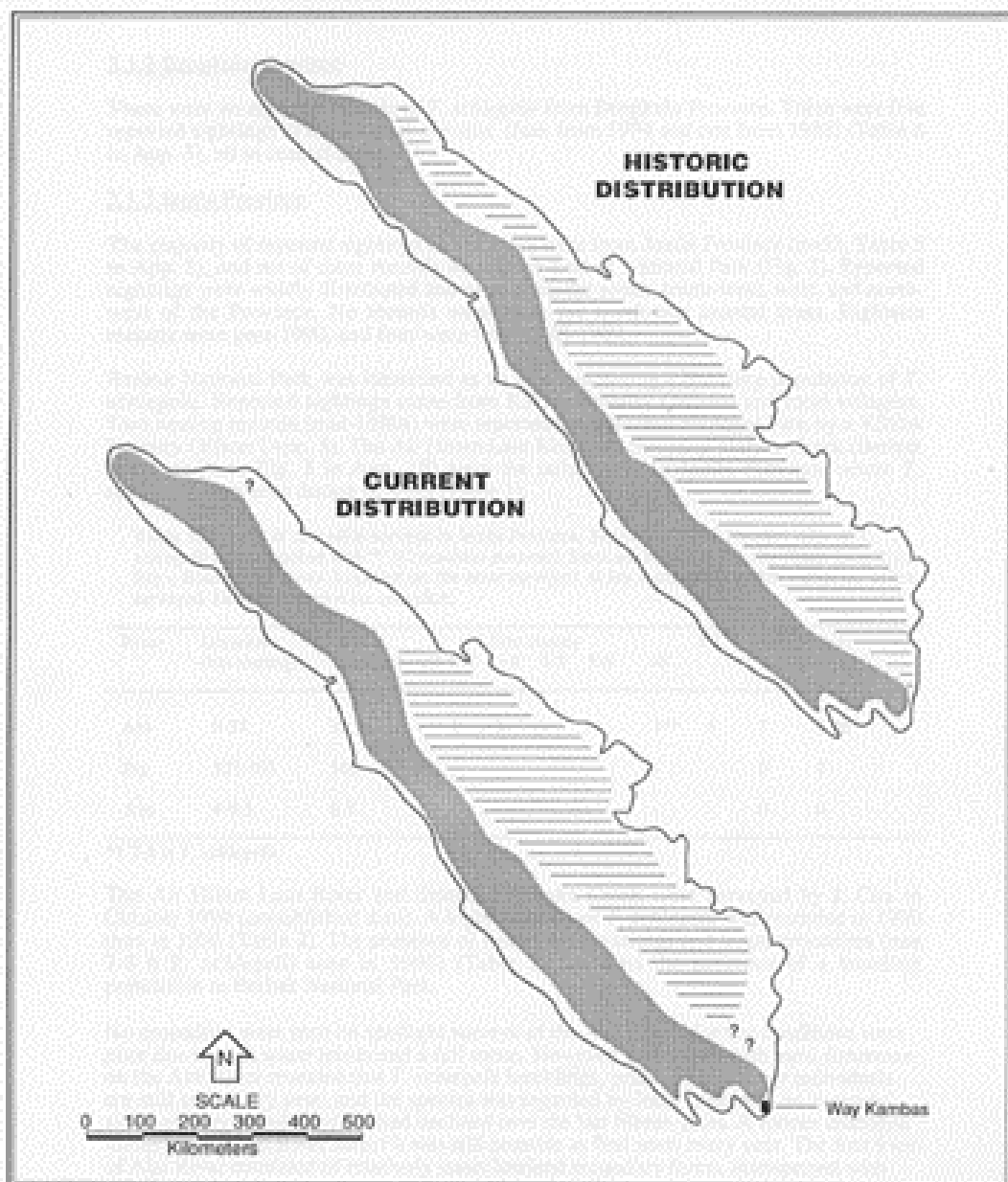


Fig. 4. Historic (pre-1960s) and current distribution of *Tomistoma schlegelii*, based on interviews with villagers and Forestry records, collected from all provinces of Sumatera. The 1960s were chosen to define 'historic', as a record of *T. schlegelii* around Medan (North Sumatera) in the 1960s indicated a relatively recent far-northern distribution. ? - indicates a single 1993 record from Aceh. ?? - scattered populations may still occur in southern Sumatera Selatan. A single population is known from Way Kambas National Park, Lampung.

### 3.1.2 Bengkulu Province

There were no reported records of *T. schlegelii* from Bengkulu Province. There were five reported sightings of *Crocodylus porosus* (four from 1994 and one from 1985) (Table 6 in App. 5), all in coastal areas.

### 3.1.3 Jambi Province

The majority of reported sightings in Sumatera were from Jambi Province (n=35, Table 5 in App. 5), and ten of these records were from Berbak National Park (Fig. 2). Reported sightings were widely distributed and were from the south, south-west, west, and north-west of the Province. No records were from the north-east coastal areas. Eighteen records were post-1990, and four were from 1980-1989.

Berbak National Park was identified as an area containing a breeding population of *T. schlegelii*. Reported sightings came from KSDA Forestry Officers and local villagers. Two nesting records (mid-1980s) were reported from Berbak National Park by a KSDA Forestry Officer (App. 5). The Air Hitam Laut River and Simpang Melaka Creek (Berbak National Park, Fig. 3 in App. 10) were the only rivers in Jambi Province where *T. schlegelii* were seen during surveys (Table 1).

**Table 1.** Results of crocodile surveys in Jambi Province, September 1996. Number refer to *T. schlegelii* unless marked with '\*' (*Crocodylus porosus*). Sizes are in feet. Ahl = Air Hitam Laut River. Btg = Batang Hari River. Location are the areas surveyed, as km readings. Total km = total no. of km surveyed. Density (Dens) = no. crocs/km.

River	Location (km readings)	Km surveyed	Size classes						ES	Total	Dens
			<2'	2-3'	3-4'	4-5'	5-6'	>6'			
Ahl	0-27	35.5	-	1	1	-	-	1**	4	7	0.26
Btg	325-465	162	-	-	-	-	-	-	-	0	0
Alai	4-9.5	8.5	-	-	-	-	-	-	-	0	0

\*\* 7-8 ft *T. schlegelii*.

The Air Hitam Laut River and Simpang Melaka Creek were surveyed by J. Cox in October 1990 (unpublished data). A higher density of *T. schlegelii* was recorded in 1990 than in 1996 (Table 2). The presence of hatchlings, yearlings and larger crocodiles (one 7-8 ft *T. schlegelii* seen in 1996) (Table 2) confirms the presence of a breeding population in Berbak National Park.

No crocodiles were seen on spotlight surveys of the Alai River. Survey conditions were poor due to high water levels and a full moon. However, interviews with local fishermen on the Alai River revealed that *T. schlegelii* hatchlings, yearlings and larger individuals are still seen every year, and the species was regarded by local fishermen as 'common', although they stated numbers had declined over the last fifteen years. A former crocodile hunter on the Alai River stated it was still possible to find nests every year. The first 9 km of Alai River consisted of relatively intact lowland secondary forest, interspersed with small slash/burn cultivation. Areas beyond km 10 were not surveyed but residents reported that very little forest was left due to a large transmigration settlement and deforestation. It is likely that any nesting is concentrated in km 0-9.

**Table 2.** Survey results for *Tomistoma schlegelii*, km 0-25, Air Hitam Laut River and Simpang Melaka Creek, Berbak National Park, Jambi. Sizes are in feet. Dens = Density (number of *T. schlegelii* per km over 27 km [25 km of AHL and 2 km of Simpang Melaka Ck]). 1990 data are from J. Cox (unpublished data). Note that density for Cox's data is over 20.5 km.

Yr	<2	2-3	3-4	4-5	5-6	6-7	7-8	>8	ES	Tot	Dens
90	4	1	-	-	-	-	-	-	3	8	0.39
96	-	1	1	-	-	-	1	-	3	6	0.22

No crocodiles were seen during spotlight surveys of the Batang Hari River. Survey conditions were poor due to high water levels and a full moon. There was evidence of constant human activity along most of the River, including logging factories and fishing. In many areas banks were lined by villages or regularly grazed by cattle. Patches of forest were often mixed with cultivated species. Residents at most villages along the Batang Hari River had not seen or heard of any crocodiles. However, in May 1996 a 4.10 m *T. schlegelii* was caught at a village 430 km from the mouth of the Batang Hari River. The individual had apparently been seen in the area for a few months, and was caught and transported to a zoo in Jambi Town. It was weighed by the army at 200 kg, and was the subject of a local newspaper article (*Independent*, Jambi Province, 27 May 1996). A resident of the village was interviewed briefly and stated other *T. schlegelii* had been seen in the last few years. Small populations of *T. schlegelii* may still exist along the Batang Hari River, and nesting may occur along undisturbed sidecreeks.

*Tomistoma schlegelii* are widely distributed throughout Jambi Province. A breeding population was confirmed in Berbak National Park. Small breeding populations probably exist on many rivers throughout Jambi Province, but nesting habitat is disturbed through fishing and logging activity.

#### 3.1.4 Lampung Province

Thirteen reported sightings were recorded from interviews in Lampung Province (Table 7 in App. 5). Records were from the northern border (Mesuji River), north-central Lampung (Tulung Bawang River), central Lampung (Pengkuan and Way Terusan Rivers) and central-east Lampung (Way Kambas National Park). Records were from the 1950s-1996. Six records were post-1990. Records from 1996 were from Way Kambas National Park. The most recent nesting record was a sighting by a fisherman of a nest on Pengkuan River (central Lampung Province) in 1980. A former crocodile hunter collected *T. schlegelii* eggs from nests every year along Tulung Bawang River (north-central Lampung Province) in the 1960s.

Most areas in eastern Lampung have been deforested and converted to large-scale crop plantations e.g. tapioca, rubber, oil palm. Any *T. schlegelii* populations in north and central Lampung Province are probably under pressure from habitat reduction. Way Kambas National Park was the only area observed to have suitable nesting habitat for crocodiles and may represent the southern-most extent of the species range in Sumatera.

#### 3.1.5 Riau Province

Fourteen reported sightings were recorded (Table 3 in App. 5). Eleven were from south-west, southern and south-east Riau Province and were post-1990. Three were from west, north-west and north-east Riau Province. Although fewer reports were obtained than in Jambi Province, Riau Province is larger, and both are relatively well-forested, compared to Lampung and Sumatera Selatan Provinces. Many areas in Riau Province may still hold suitable nesting habitat for *T. schlegelii*.

Surveys on the Teso and Kubu Rivers did not yield any crocodile sightings (Table 3); this may have been due to poor survey conditions (high water levels, with many areas adjacent to the river banks flooded). Searching for nests in these flooded conditions was also ineffectual. *Tomistoma schlegelii* were regarded by fishermen on these rivers as 'common'. A fisherman on the Teso River claimed he had seen four *T. schlegelii* nests from 1981-82 and one in 1985. Another fisherman on the Teso River stated he had found two *T. schlegelii* nests, one in 1994 and one in 1995. This fisherman felt the population of *T. schlegelii* had either increased or remained the same over the last fifteen years, and stated he still saw hatchlings every year. A former crocodile hunter on the Teso River stated that during the 1960s and 1970s, *T. schlegelii* were widespread along many of the small tributaries of the Kampar Kiri River (Fig. 3), of which the Teso River is a tributary.

**Table 3.** Results of crocodile surveys in Riau Province, October 1996. Number refer to *T. schlegelii* unless marked with '\*' (*Crocodylus porosus*). Sizes are in feet. Location are the areas surveyed, as km readings. Total km = total no. of km surveyed. Density (Dens) = no. crocs/km.

River	Location (km readings)	Km surveyed	Size classes						ES	Total	Dens
			<2'	2-3'	3-4'	4-5'	5-6'	>6'			
Teso	0-14	14	-	-	-	-	-	-	0	0	0
Kubu	26.5-34	7	-	-	-	-	-	-	0	0	0

Local fishermen on the Kubu River stated they 'often' see *T. schlegelii* while fishing at night and that hatchlings are seen every year. One fisherman stated he had seen a nest in 1970. A fisherman who had lived on the Kubu River for fifteen years stated that the population of *T. schlegelii* was increasing every year, and had done so since the late 1960s/early 1970s, since hunting for skins had stopped. The most recent sighting by a fisherman was in August 1996, of a 'small' *T. schlegelii*. A single, tentative sighting of a crocodile was made at km 28 of Kubu River, 7 October 1996, by M. Bezuijen. A fisherman claimed he had passed a crocodile resting on a submerged log, with its head above the water a few minutes earlier. M. Bezuijen returned to the spot immediately and saw what appeared to be a crocodile head on a log 20 m away, before it slipped into the water, but it could not be confirmed as a crocodile, and may have been a lizard.

*Tomistoma schlegelii* are widely distributed throughout Riau Province. The upper reaches of the Teso River are currently being logged, but the lower reaches consist of relatively undisturbed lowland secondary forest. The Kubu River is under more intense logging and fishing pressure. Many forested areas were observed in Riau Province and, like the Teso and Kubu Rivers, may hold breeding populations of *T. schlegelii*.

### 3.1.6 Sumatera Barat Province

A single record of *T. schlegelii* was reported from Sumatera Barat Province, from a river close to the border with Jambi Province (i.e. on the eastern side of the Barisan Mountain Ranges). This report came from a reptile dealer in Jambi Province, who stated that fishermen from this river travelled to a town in Jambi to sell fish and turtles, and 'often' told the dealer they saw *T. schlegelii* in the river. Seven sightings of *Crocodylus porosus* were reported from widely distributed localities along the west coast of Sumatera Barat Province (App. 5). *Crocodylus porosus* records were from 1993-96 (Table 4 in App. 5).

The sightings of *T. schlegelii* in Sumatera Barat Province in a river at the foothills of the Barisan Mountain Ranges probably constitute the western-most extent of the range of the species.



### 3.1.7 Sumatera Selatan Province

Interviews with villagers by Ramono (1994) showed that *T. schlegelii* occur, or used to occur, along the Lumpur, Jeruju, Lebonghitam and Pedada Rivers in the south-east of the Province. A fisherman born on Lumpur River (Interview 16 in App. 4) stated that in the early 1980s there were 'many' *T. schlegelii* on Lumpur River, but had heard of only a few being seen or caught in the 1990s. In 1996, fishermen on Lebonghitam River tried to sell 'young' *T. schlegelii* to a crocodile farm in Palembang (capital of Sumatera Selatan Province) and stated there were 'many' along this river (Mr Hasan, pers. comm., 1996).

Fishermen along the Lalan River (Fig. 2) claim *T. schlegelii* are widely distributed throughout the north and north-east of the Province, along the upper Lalan and its tributaries (particularly the Medak, Merang and Kepahyang Rivers) and Mukut Swamp along the Air Calik River (Fig. 2) (Bezuijen *et al.* 1995b). The Lalan, Medak and Kepahyang Rivers were surveyed in 1995 (Bezuijen *et al.* 1995b). Two *T. schlegelii* were seen on the Medak River. The Kepahyang River, the upper reaches of the Medak River and many other tributaries of the Lalan River have been damaged by intensive logging, transmigration settlements and large fires in 1993-94.

Spotlight surveys in 1996 were along the Benu and Merang Rivers (Fig. 2). Surveys were conducted before the onset of heavy rains in September, and water levels were relatively low for all surveys. Surveys were on moonless nights and survey conditions were good. No *T. schlegelii* were seen on the Benu River, although one *Crocodylus porosus* and two 'eyeshines' close to the sea (thought to be *C. porosus*) were seen (Table 4).

**Table 4.** Results of crocodile surveys in Sumatera Selatan Province, August 1996. Number refer to *T. schlegelii* unless marked with '\*' (*Crocodylus porosus*). Sizes are in feet. Location are the areas surveyed, as km readings. Total km = total no. of km surveyed. Density (Dens) = no. crocs/km.

River	Location (km readings)	Km surveyed	Size classes						ES	Total	Dens
			<2'	2-3'	3-4'	4-5'	5-6'	>6'			
Benu	0-38	73	-	-	-	1*	-	-	2*	0	0.08
Merang	0-66.5	88	-	3	2	-	1	-	6	12	0.18

One fisherman on the Benu River had seen a 1-2 ft *T. schlegelii* in April 1996. The animal was caught in his fishtrap, set at the mouth of a small creek which originated in nearby Berbak National Park. A fisherman who had lived on the River since 1980 stated that in the early 1980s *T. schlegelii* were abundant, and in this period he had seen 'small' and 'large' individuals. The fisherman stated that sightings decreased from 1987-1994, when a logging company operated in the area. The last *T. schlegelii* he had seen was a 1-2 ft individual in 1993. He had never found any nests. A third fisherman interviewed stated he regularly saw *T. schlegelii* at an abandoned freshwater canal 2-3 km south of the Benu River, which he had been visiting since 1995. He had been to the canal about six times and seen individuals every time; the last time he went was in July 1996, when he found seven *T. schlegelii* hatchlings caught in his traps. He had not seen any nests.

The first forty kilometres of the Benu River have been subjected to heavy logging and little intact forest is left. Patches of secondary/tertiary forest are regrowing (App. 6) but many areas are dominated by large areas of grassland. The first 10 km of river bank are lined with *Nypa fruticans* and may provide suitable nesting habitat for *Crocodylus porosus*. The Merang River was the only area other than Berbak National Park (Jambi Province) where *T. schlegelii* were recorded during surveys. The Merang River had previously been surveyed by J. Cox in 1990 (unpublished) and in 1995 (Bezuijen *et al.* 1995b). Densities of *T. schlegelii* on the Merang River in 1990, 1995 and 1996 are presented (Tables 5 and 6). Merang River results are divided into km 0-45 and km 46-66.5, reflecting different

survey conditions in these sections (Tables 5 and 6) (km 0-45 are wide and deep and were surveyed by spotlight and speedboat; km 46-66.5 are narrow, with dense bankside vegetation and were surveyed by canoe and torch). Densities of *T. schlegelii* in Berbak National Park in 1996 (Table 2) were higher than in all surveys on the Merang River.

**Table 5.** Spotlight survey results for *Tomistoma schlegelii*, km 0-45, Merang River, Sumatera Selatan Province. Sizes in feet. Dens = Density (number of *T. schlegelii* per km). 1990 results are by Cox (unpublished data). Note Cox only surveyed km 0-23.

Yr	<2	2-3	3-4	4-5	5-6	6-7	7-8	Other (ft)	ES	Tot	Dens
90	1 <i>Tomistoma</i> seen, no size given								0	1	0.04
95	-	2	-	2	-	-	-	-	3	7	0.16
96	-	1	-	-	-	-	-	-	1	2	0.04

**Table 6.** Spotlight survey results for *Tomistoma schlegelii*, km 46-66.5, Merang River, Sumatera Selatan Province. Sizes in feet. Dens = Density (number of *T. schlegelii* per km).

Yr	<2	2-3	3-4	4-5	5-6	6-7	7-8	Other (ft)	ES	Tot	Dens
95	-	2	-	-	-	-	-	-	5	7	0.34
96	-	2	2	-	1	-	-	-	5	10	0.49

In comparing the number of crocodiles seen in 1995 and 1996 on the Merang River, allowance should be made for the amount of survey effort for different sections of the river (ie the number of times particular sections were surveyed). To assess survey effort per river section, the River was divided into 5 km sections and the number of times each section was surveyed was recorded (Table 7). Raw survey data are in App. 1.

**Table 7.** Summary breakdown of Merang River surveys into 5 km river sections, km 0-66.5. Minimum number of *Tomistoma schlegelii* seen in each section is given, with size in brackets. Size is in feet. ES = Eyeshine. Refer to App. 1 for a breakdown of all surveys.

Survey Sections (km)	No. times whole or part surveyed	No. <i>T. schlegelii</i> (size)
0-5	1	0
5-10	1	0
10-15	1	0
15-20	1	1 [2-3]
20-25	1	0
25-30	1	0
30-35	1	1 [ES]
35-40	1	0
40-45	1	0
45-50	1	0
50-55	6	3 [1-2, 2-3, ES]
55-60	6	2 [ES]
60-65	5	5 [2-3, 3-4 (x2), 5-6, ES]
65-70	1	0

Thirteen nests have been recorded from the Merang River in 1995 and 1996, including nest sites from the 1987 nesting season (information provided by local fishermen).

Reported sightings of *T. schlegelii* in Sumatera Selatan Province come from northern, south and south-eastern areas. Much of the Province has been developed and subjected to

large transmigration settlements. Surveys in 1995 and 1996 revealed that in the north, many areas which fishermen claimed once held *T. schlegelii* had since been logged or burnt. Prior to intensive logging and burning the Benu River may once have held a relatively large population of *T. schlegelii*. Today, scattered reports indicate *T. schlegelii* are still present and nesting in some areas. This scenario may be representative of many rivers. The Merang River was the only River surveyed which had intact, mature forest and many areas which appeared suitable for nesting. Logging and fishing intensity were low compared to nearby tributaries. Surveys confirmed that the Merang River contains a breeding population of *T. schlegelii*.

### 3.1.8 Sumatera Utara Province

Three reported sightings were recorded (Table 2 in App. 5). Two reports were from an area in south-eastern Sumatera Utara Province, one from the 1970s and the other from 1996. This area of sightings is close to the Kubu River of Riau Province, surveyed in 1996. Fishermen on the Kubu River claimed *T. schlegelii* were 'common'. The third record is of a river running through Medan (Fig. 1), where *T. schlegelii* were seen in the 1960s.

*Tomistoma schlegelii* are currently found in the south-east corner of Sumatera Utara Province. This may represent the current northern limit of their range. A record from the 1960s indicates that until 20-30 years ago, *T. schlegelii* were found near the border with Aceh Province. If this record is accurate, then a single report of a *T. schlegelii* seen in south-east Aceh Province in 1993 (Section 3.1.1) would seem feasible, and would extend the current known range by approximately 400 km north.

## 3.2 Nests

### 3.2.1 Nest Searching

#### 3.2.1.1 Merang River

Seven people searched for nests. Target areas were characterised by: large peat mounds; dense stands of *Hanguana malayana* or *Thoracostachyum sumatranum*; sidecreeks >0.5 m deep; isolated creeks some distance from the mainstream. Sections of mainstream bank from km 52.5-64 and Ketel, Senin, Pulau Kepangen and Buntung Creeks (Fig. 2 in App. 10) were searched. A total of 9.7 km of sidecreek and mainstream in a belt 50 m either side of the sidecreek or mainstream was walked (Table 8). A total area of 0.49 km<sup>2</sup> was searched for nests.

**Table 8.** Areas searched for *Tomistoma schlegelii* nests, Merang River (Sumatera Selatan Province) 5-15 August 1996. Ck = Creek, MS = Mainstream, PK = Pulau Kepangen Creek.

Area	From (km)	To (km)	Total km
Buntung CK	0	1.5	1.5
Ketel Ck	0	2	2
PK Ck	0	0.1	0.1
Senin Ck	0	1	1
MS	56	59.8	3.8
MS	60.5	60.6	0.1
MS	61.3	61.4	0.1
MS	63.0	64.1	1.1
		Total	9.7

Fishermen regularly search all sidecreeks and mainstream in 1-2 week stints for fish and soft-shelled turtle, and their searching intensity is probably higher than the team's.

### 3.2.1.2 Berbak National Park

Eleven kilometres of mainstream and sidecreek were searched (Table 9). Three people searched for nests at Berbak.

**Table 9.** Breakdown of areas searched for *Tomistoma schlegelii* nests, Berbak National Park, 18-21 September 1996. Ck = Creek, MS = Mainstream Air Hitam Laut River.

Area	From (km)	To (km)	Total km
Melaka Ck	0	2.5 (right bank)	2.5
Melaka Ck	0	2.5 (left bank)	2.5
Gajah Ck	0	1 (right bank)	1
Gajah Ck	0	1 (left bank)	1
MS	19.5	22.5 (left bank)	3
MS	21.5	22.5 (right bank)	1
		Total	11

### 3.2.1.3 Other

Searches for nests were not conducted on other rivers as most areas of forest adjacent to the mainstream were flooded.

## .c.3.2.2 Nesting Biology

### 3.2.2.1 Nests and eggs

Interviews with local fishermen and former crocodile hunters provided much information on the nesting biology of *T. schlegelii*. Seventeen of thirty-three interviewees had seen a *T. schlegelii* nest. Six had seen them within the last 6 years (four of those in 1995), six in the 1980s, four in the 1970s and one in the mid-1960s (Table 3 in App. 4). All except one interviewee described the nest as a mound. The single exception described the nest he had seen as a slight depression in the ground, filled with leaves and twigs, and the eggs on top, with the female sitting on top of them.

All interviewees claimed the nests they had seen contained eggs. Reported clutch size ranged from 6-80 eggs. Reported clutch sizes were grouped into three categories: 5-20, 21-40 and >40 eggs. Reports which included two categories were counted twice. Clutch size of 21-40 eggs was the most commonly reported (n=8 interviewees), followed by a clutch size of 5-20 eggs (n=5). Two interviewees gave clutch sizes of 40-50 and 50-80 eggs respectively. Eight interviewees stated a *T. schlegelii* was present at the nest (either on top of it, next to it or in the water near to it) when they found the nest. Nesting habitat was reported as peat swamp forest (n=7) and lowland secondary forest (n=9) (in most cases, the area close to reported nest sites were visited by the team and the habitat described first-hand).

The number of nests seen by interviewees in 1995-96 was 0 (n=11), 1 (n=1), 5 (n=1) and 9 (n=1). The nine nests were from the Merang River (Sumatera Selatan Province) (Bezuijen *et al.* 1995b and this volume). Numbers of nests seen from 1980-1993 are low (most commonly sightings of single nests, n=11), with no trends in numbers apparent for areas (i.e. no consistent nesting on a particular river, no trends in nest numbers along a river). Most sightings appear to be opportunistic, single occurrences. Reported nest sightings from 1980-1996 were from 11 rivers in eastern and southern Sumatera (2 in Lampung Province, 2 in Sumatera Selatan Province, 3 in Jambi Province and 4 in Riau Province).

Interviewees reported that nests were made and eggs laid from June-August. One interviewee stated eggs are laid in March. Hatchlings were reported to appear in September-October. Two interviewees stated the nesting season was from October-March and June-September respectively.

Two nests of *T. schlegelii* were located by the team during surveys in 1996. Both were within peat swamp forest on the Merang River (Sumatera Selatan Province) at km 61.3 and 64. Summary data are in Table 10 (raw data in App. 3). A live egg was collected from each nest. The eggs were estimated to be laid in early June and July respectively (Section 3.2.3), in agreement with egg laying dates provided by interviewees. The nest at km 64 was on an old nest site which had been examined in 1995 (= nest 11 in Bezuijen *et al.* 1995b). This nest was reportedly last used in about 1987 according to local fishermen. The 1996 nest at km 64 was *directly on top of the old nest*. The nest at km 61.3 was a new nest at a new site (no old nest was at this location in 1995). A total of fifteen nest sites have now been located on the Merang River (thirteen in 1995 and two in 1996). Three nests (two in 1996) contained intact eggs. A nest with eggs raided by pigs in 1995 (= nest 5 in Bezuijen *et al.* 1995b) contained two relatively intact eggshells and their length and width were recorded (Table 10). Two *T. schlegelii* eggs at a crocodile farm in Jambi in 1996 were measured with a ruler (no callipers were present) (Table 10). Both were rotten (no sign of embryo).

**Table 10.** Summary data for three *Tomistoma schlegelii* nests found on the Merang River (Sumatera Selatan Province) (1 in September 1995 and 2 in August 1996) and dimensions of eggs derived from the shells of a predated 1995 nest. Dimensions of two eggs from a crocodile farm in Jambi Province are presented. It was claimed that these were *T. schlegelii* eggs, but this could not be confirmed and their size suggested they may be *C. porosus* eggs, which were also breeding on the farm. Presented are mean egg mass, egg length and egg width  $\pm$  standard deviation (range, n), Total Clutch Mass (TCM), Nest Temperature (NT), Embryo Head Length (EHL) and Estimated Age of embryo (EA, in days). One embryo was taken from each clutch for aging.

Nest Size	Clutch (g)	Egg Mass (mm)	Egg Length (mm)	Egg Width (g)	TCM ( $^{\circ}$ C)	NT (mm)	EHL	EA
1 ('96)	34 n=32	244 $\pm$ 13.17 (221-276, n=32)	98.15 $\pm$ 2.73, (92.30-104.82, n=32)	64.99 $\pm$ 1.12, (63.01-67.90)	8300	31.8	13.23	24-25
2 ('96)	29 n=29	231 $\pm$ 4.67 (215-236, n=29)	97.19 $\pm$ 1.89 (94.76-102.06, n=29)	63.39 $\pm$ 0.70 (61.82-64.82, n=29)	6692	32.4	34.39	52-53
8 ('95)	35 n=34	278 $\pm$ 9.82 (253-295, n=34)	102.83 $\pm$ 2.44 (97.63-109.45, n=34)	64.85 $\pm$ 0.67 (63.47-66.00, n=34)	8759	31.4	35.88	57-58
5 ('95)	-	-	96.44, 95.11	57.67, 55.46	-	-	-	-
Jambi croc farm	-	-	86, 86	47, 57	-	-	-	-

A single nest with intact eggs was located in 1995 (= nest 8 in Bezuijen *et al.* 1995b). The site was visited in 1996 to assess the fate of the nest. Eggshell fragments were within the nest (not scattered around it) and the nest was not pulled open (other nests examined in 1995 had been raided by pigs and were pulled apart), suggesting young had hatched successfully. At another nest site located in 1995 (= nest 2 in Bezuijen *et al.* 1995b), a fresh tail drag was evident across the old 1995 mound in 1996. The site is next to the

mainstream and is openly visible; local fishermen thought that increased human activity in 1996 had scared a female from nesting here again.

### 3.2.2.2 Egg aging

A single live embryo was preserved from each of the two nests located on the Merang River (Sumatera Selatan Province). Age estimates were derived for these and the 'nest 8' embryo from 1995 (Table 11).

1. The 'nest 1' (1996) embryo had a Head Length (HL) of 13 mm. Based on data for *Crocodylus porosus* and *C. johnstoni*, assuming incubation at 30 °C, this embryo would be 28-30 days of age (at 30 °C) (Webb *et al.* 1987). Nest temperature was 31.8 °C, and based on *C. porosus*, this would involve a Development Rate Coefficient (DRC) of approximately 1.2 (Webb *et al.* 1987). That is, the real age of the embryo was closer to **24 days of age**.

2. The 'nest 2' (1996) embryo had a HL of 34.4 mm and was clearly in the last one-third of incubation, when embryo size scales to egg size (Webb *et al.* 1987). By extrapolating egg size scaling factors for a 34 mm HL *C. porosus* (Webb *et al.* 1987) from 90 mm egg length to 98.3 mm, the 30 °C age of this embryo would be about 63 days. Nest temperature was 32.4 °C, but given metabolic heat the DRC for 32 °C (1.2) was applied. This indicated the real age was about **52.5 days**.

3. The 'nest 8' (1995) embryo had a HL of 35.9 mm, and was clearly in the last one-third of incubation, when embryo size scales to egg size. By extrapolating egg size scaling factors for a 36 mm HL *C. porosus* from 90 mm egg length to 102.4 mm, the 30 °C age of this embryo would be about 64 days. The nest temperature was 31.4 °C and the DRC for 31 °C (1.13) was applied. This indicated the real age was about **57 days**.

**Table 11.** Estimated embryo age at 30°C and dates of egg-laying for two 1996 nests and a 1995 nest of *Tomistoma schlegelii*, Merang River, Sumatera Selatan Province. For details on Nest 8, see Bezuijen *et al.* (1995b).

Nest	Date collected	Embryo Age (days) at 30 °C (°C)	Nest Temp (°C)	Estimated Real Age (days)	Estimated laying date
1 (1996)	9 August	28-30	31.8	24	16 July
2 (1996)	13 August	63-64	32.4	53	20 June
8 (1995)	6 September	64-65	31.4	57	11 July

## 3.3 Captured animals

### 3.3.1 Capture

Seven *T. schlegelii* were caught and measured. Six were from the Merang River (Sumatera Selatan Province) km 54-65 and one was from the Alai River (Jambi Province) km 0. Until this trip, all captured crocodiles (Bezuijen *et al.* 1995a, 1995b) were from the Merang River. The Alai River individual is the first examined from another Province. All individuals were released upon completion of measurements. Raw data are presented in App. 2. Fig. 2 (App.2) presents an example of a field data sheet.

One animal was hand-caught during surveys and six were from fish traps. Three *T. schlegelii* at the Merang River had been caught in fish traps in late July 1996, and retained

by fishermen for the arrival of the survey team, who they felt would be interested in the captured individuals. Two individuals were caught in traps whilst the survey team were on the Merang River. Fish traps are constructed from 'rattan' vine (*Calamus* sp.) and are 2-5 ft long. Mouths of sidecreeks are blocked with cut tree saplings, to funnel fish toward the trap, positioned in the centre of the creek mouth. All specimens were released after processing.

*Tomistoma schlegelii* scute cut '8' was caught in a fish trap in July 1996, measured and released on 9 August and recaptured on 12 August 1996. When found on 12 August, the animal was caught on a 3 cm fish hook attached to a line set for soft-shelled turtles, with the hook embedded in the rear left leg. Re-capture site was km 59.5, 50 m upstream from the release site. There were no large injuries present from the hook. The animal appeared in healthy condition. No sign of infection was present in the scute cut and the skin was already stained brown from the dark peat waters. According to local fishermen, this was the first time a crocodile had ever been caught on a hook. The hook was removed and the animal released on the spot.

### 3.3.2 Morphometrics

Maximum and minimum sizes of captured *T. schlegelii* were 100.4 cm Snout-Vent Length (SVL) (190.0 cm Total Length) and 37.4 cm SVL (76.1 cm TL) (Table 12). The sex ratio was 6 male : 1 female. The female was the largest animal measured. Summary morphometrics are presented in Table 12.

**Table 12.** Summary morphometrics for six male and one female *Tomistoma schlegelii*. Values presented are the mean  $\pm$  standard deviation (range, n). SVL=Snout-Vent Length, HL=Head Length, HW=Head Width, SE=Snout-Eye, SW=Snout Width, PP=Point-to-Point, MP=Mid-Point, IO=Inter-Ocular. See App. 2 for explanation of measurements.

	Males	Females	All
SVL	53.6 $\pm$ 11.6 (37.4-62.0, n=6)	100.4 (n=1)	60.3 $\pm$ 20.6 (37.4-100.4, n=7)
HL	19.2 $\pm$ 3.9 (14.2-22.3, n=6)	34.3 (n=1)	21.4 $\pm$ 6.7 (14.2-34.3, n=7)
HW	6.8 $\pm$ 1.5 (4.8-8.0, n=6)	13.0 (n=1)	7.7 $\pm$ 2.7 (4.8-13, n=7)
SE	13.6 $\pm$ 3.0 (9.7-15.9, n=6)	25.1 (n=1)	15.2 $\pm$ 5.1 (9.7-25.1, n=7)
SW	1.5 $\pm$ 0.3 (1.2-1.8, n=6)	2.4 (n=1)	1.7 $\pm$ 0.4 (1.2-2.4, n=7)
PP	4.4 $\pm$ 0.9 (3.1-5.1, n=6)	7.8 (n=1)	4.9 $\pm$ 1.5 (3.1-7.8, n=7)
MP	4.1 $\pm$ 0.7 (3.0-4.6, n=6)	7.3 (n=1)	4.5 $\pm$ 1.4 (3-7.3, n=7)
IO	0.7 $\pm$ 0.1 (0.5-0.8, n=6)	1.5 (n=1)	0.8 $\pm$ 0.3 (0.5-1.5, n=7)

The most commonly reported size classes seen by interviewees in 1995-96 were 0-1 m and 1-2 m. The most commonly reported size class from 1980-1993 was 2-3 m and 0-1 m (Table 2 in App. 4). No differences in size between males and females were reported by interviewees. Staff at a crocodile farm in Palembang (Sumatera Selatan Province) thought that flaccid Single Caudal Verticils (SCVs) indicated a female crocodile (regardless of species) while firm, upright SCVs indicated a male crocodile.



Forestry Officer recording the morphometrics of a captured False Gharial on the Merang River (Sumatera Selatan Province). Provincial Forestry Officers were taught survey and capture techniques.



### Maximum size of *Tomistoma schlegelii*

A *T. schlegelii* seen closely in 1995 at km 57.5, Merang River, was estimated at 16-17 ft (Bezuijen *et al.* 1995b). Capture was attempted but unsuccessful, and no measurements were obtained. Photographs taken during attempted capture are consistent with this size. A harpoon sleeve on a catching pole is next to the head in one photo, and the head length was estimated from this at 78 cm. A simple linear regression equation for calculating total length (TL) from head length (HL) was derived from measurements of 49 *T. schlegelii* (captive and wild-caught) and applied to this head length of 78 cm. This gave a predicted TL of 502 cm (16.5 ft), consistent with visual estimates. However, this regression was based on individuals up to several feet smaller, and larger *T. schlegelii* must be measured before accurate size-prediction equations can be formulated for the species.

That *T. schlegelii* is a relatively large crocodylian is without doubt however, and individuals observed on crocodile farms in Sumatera Utara Province and Jakarta Zoo (Java) have been estimated at 16-17 ft TL (M. Bezuijen, pers. obs.).

#### 3.3.3 Scalation

Four new patterns of precaudal scalation were described (Types 17-20) (Fig. 1 in App. 2). A total of 20 patterns of precaudal scalation have been recorded from *T. schlegelii* in 1995-1996. Post-occipital patterns of all individuals were drawn. Belly, gular and verticil scale counts are presented in Table 13.

**Table 13.** Mean (range, n) numbers of belly and gular scales, Double Caudal Verticils (DCVs) and Single Caudal Verticils (SCVs) of *Tomistoma schlegelii* from Merang River (Sumatera Selatan Province) and Alai River (Jambi Province).

	Males	Females	All
Belly	23.0 ± 0.9 (22-24, n=6)	22 (n=1)	22.9 ± 0.9 (22-24, n=7)
Gular	23.2 ± 1.2 (22-25, n=6)	23 (n=1)	23.1 ± 1.1 (22-25, n=7)
DCVs	18 ± 0 (18-18, n=6)	18 (n=1)	18 ± 0 (18-18, n=7)
SCVs	18.7 ± 4.3 (16-22, n=5)	18 (n=1)	18.6 ± 4.0 (11-22, n=7)

#### 3.3.4 Teeth

All *T. schlegelii* from the Merang River (Sumatera Selatan Province) had brown, stained teeth. The individual from Alai River (Jambi Province) had white teeth. This may be due to physical and chemical characteristics of each river: Merang River water is dark brown-black, peaty and acidic; the Alai River is light brown, not peaty and less acidic. Mean numbers of teeth are in Table 14.

**Table 14.** Mean numbers of teeth in the upper and lower front and back of the jaw in seven *Tomistoma schlegelii*.

	Males (n=6)	Females (n=1)
Upper front	5	5
Upper back	16	16
Lower front	4	4
Lower back	15	15

Iordansky (1973) presents a dental formula for *T. schlegelii*:  $\frac{pm(4) + m(17)}{d(19-20)}$ .

This formula was based on only one specimen, but is in agreement with the number of teeth recorded in the upper and lower jaw of males and females examined in this study (n=6) and by Bezuijen *et al.* (1995a) (n=53): number of teeth in the upper jaw range from **20-21** and in the lower jaw from **19-20**.

### 3.4 Diet

Twenty-three interviewees provided information on the diet of *T. schlegelii*. Monkeys (n=7 interviewees), pigs (n=4) and snakes (n=3) were the most commonly reported items eaten by *T. schlegelii* (interviewees either observed these animals being caught or had opened the stomachs of dead *T. schlegelii*). Other reported prey were fish, shrimp, birds, otters, turtles and monitor lizards. *Tomistoma schlegelii* on farms in Jambi, Sumatera Selatan and Sumatera Utara Provinces are fed snake meat (often python *Python* spp.), monitor lizard (*Varanus* spp.) meat, adult chickens and late-age chicken embryos. A former crocodile hunter from Lampung Province stated he would 'often' find 'up to 3 kg' of small stones in the stomachs of *T. schlegelii* he had killed.

Interviewees who had witnessed monkeys being caught by *T. schlegelii* described the capture as a swift lunge and grab of a monkey on the river bank. The crocodile would then either smash the monkey repeatedly against the bank until dead or else submerge immediately with it. Predation of a Crab-eating Macaque (*Macaca fascicularis*) by *T. schlegelii* was observed by Galdikas and Yeager (1984), who reported that the crocodile lunged out of the water at a Macaque sitting on a river bank and then rapidly submerged with the monkey in its jaws. Galdikas and Yeager (1984) note that the local people in Tanjung Puting Reserve (Kalimantan Tengah Province, Central Borneo) traditionally used Macaques as a bait to catch *T. schlegelii*.

Stomach contents were extracted from three *T. schlegelii* on the Merang River. Two were caught in fish traps and had been in the traps for some time: a maximum of 12-15 hours for one and a maximum of 72 hours for the other (fishermen check traps irregularly). The third was captured during a spotlight survey and stomach contents extracted upon return to camp. Stomach contents contained shrimp and some *Pandanus* spp. leaves, but will be analysed in more detail later.

In order to aid identification of stomach contents and to provide an idea of what *T. schlegelii* may eat on the Merang River, seven fish, one prawn and one crab species were collected from the Merang River. Specimens were photographed and preserved. Local fishermen were asked to judge the relative abundance and approximate sizes of common fish and crustaceans along the Merang River. All incidental observations of fish, amphibians, reptiles and mammals were recorded during field work on the Merang River in 1995 and 1996. A total of 16 fish, 1 prawn, 1 crab, 2 turtle, 1 lizard, 7 snake, 1 toad, 3 frog and 17 mammal species were observed (App. 9). This list, particularly of reptiles and amphibians, is probably far from complete.

### 3.5 Local knowledge (Interviews)

Interviews with local fishermen and former crocodile hunters in Sumatera yielded much information on the ecology of *T. schlegelii*. Thirty-eight interviews have been conducted since 1995 (twenty-five in 1996). Appendix 4 presents a summary of all interviews (Table 1 in App. 4) and an example interview form used for 1996 interviews (Fig. 1 in App. 4). Data from all interviews are summarised in Tables 2-4 (in App. 4). Information from interviewees have been assimilated into the previous sections on distribution and abundance, nesting biology and captured animals. Information from interviews on other aspects of *T. schlegelii* are presented here.

### 3.5.1 Local names, colour forms and varieties

Twelve local names were recorded for *Tomistoma schlegelii* (Table 2 in App. 4). 'Julung' was the most widely used, recorded in Sumatera Selatan, Jambi, Riau and Lampung Provinces. Other names were often specific to a river or village (local dialect) eg 'boho-senjulung'. Some are descriptive e.g. 'buaya ikan', literally 'fish crocodile'.

Six forms were described by villagers in eastern Sumatera (Table 2 in App. 4). Most interviewees recognised at least two forms: a yellow form with a long snout ('*bhoung kwang*') and a dark form with a shorter snout ('*julung*'). Three interviewees recognised a 'whitish' form. Dark forms were described by some as 'black' and by others as 'chocolate'. Fourteen of twenty-one interviewees recognised dark and yellow forms. One interviewee claimed there were separate black and chocolate forms. Two stated there was an especially large form of *T. schlegelii* ('*jokok*').

### 3.5.2 Behaviour

Mating behaviour of captive *T. schlegelii* was witnessed by staff at a farm in Jambi Province and in Sumatera Utara Province and related by farm staff:

- **Jambi Province.** A *T. schlegelii* nest with eggs was present when the farm was visited by the team in 1996. Mating was described thus: male approaches female, and swims around her, followed by a lot of commotion in the water, with both animals hitting each other with their tails (no biting). This continues for 5 days and then they mate: the male mounts the female and wraps his tail around and under hers. They mate for about 1 hour, and only once a day. During mating they emit a strong odour, easily smelt. One month or more after mating, the female begins gathering nesting material. After gathering some, she sits on top of the material, then the following night collects more. The female makes the nest only at night, and takes about 3 nights to complete it, lying on the nest after each session of material-gathering. The male does not help. Eggs are laid about 1 week after completion of the nest. From time of material gathering to egg laying is about 2 weeks. Staff did state that eggs were laid over 2-3 nights, with the female laying some, covering them and then laying more on top and covering these, until all are laid. This behaviour would be highly unusual for crocodiles and requires confirmation.
- **Sumatera Utara Province.** After an individual laid eggs (infertile) in a pen, the owner placed 3 male and 5 female *T. schlegelii* in a large breeding pond; soon after, they began courting behaviour, described by the owner thus: male approaches female and swims around her. Female lifts her head and opens her mouth slightly. Male slides on top of female and wraps his tail around and under hers. The owner stated he did not know how long they stay coupled, or how many times they mate, but said that the male and female stay together for one week; he noted this was different from *C. porosus*, which he said mated once and then separated soon after. He stated *C. porosus* were very vocal when courting, but *T. schlegelii* were quiet. Mating was said to occur in the 'rainy season'. Mating behaviour had been observed for the last few years.

*Tomistoma schlegelii* at the farm in Sumatera Utara Province had never nested, probably due to a lack of suitable habitat within the main breeding pond. *T. schlegelii* at the farm in Jambi Province had nested, and a nest with eggs was present when the team visited the farm. The female (10-11' TL) was in the breeding pond when the nest was approached. Upon stamping the ground at the nest, she surfaced then swam over to the edge of the pond. She did not leave the water. Upon being approached to within 2 m, she raised her back out of the water and arched her tail. The nest was not opened. The nest was a messy structure, not compact, made from banana leaves and grass, the only material available in the pen.

The majority of interviewees (n=12) had never seen any specific behaviour of *T. schlegelii*, but eight stated that *T. schlegelii* were most commonly seen in shallow water on the edge of the bank. *Tomistoma schlegelii* was recorded as basking on the bank (n=3), basking on top of *Hanguana malayana* (aquatic floating vegetation) (n=1) and on a sandbar (n=1). One interviewee claimed to have seen two *T. schlegelii* fighting. The team observed a *T. schlegelii* enlarging a wallow at Kasang Kulim Zoo.

### 3.5.3 Survivorship

Six interviewees named factors affecting mortality: egg predation by wild pigs (n=2), egg consumption by villagers (n=2), nest flooding (n=1), hatchling predation by wild animals (n=1), egg and hatchling predation by Kubu tribe (a lowland tribe in Sumatera Selatan and Jambi Provinces) (n=1). One interviewee claimed there were no factors which affect mortality. Five stated they had never seen any flooded nests and were adamant nests do not become flooded, as the young hatch before waters rise. Twenty-one of twenty-three interviewees stated they had witnessed *T. schlegelii* caught in fishing nets or traps.

### 3.5.4 Beliefs

There were no beliefs specifically concerning *T. schlegelii*. One interviewee stated the presence of horse/march flies indicated the presence of a crocodile nearby. Some hunters used chanting and prayer ('mantra') to enable them to catch crocodiles (n=2) and one fisherman would wear a charm to protect him from crocodiles when fishing (see Section 2.5.6.1, Bezuijen *et al.* 1995b). Specific beliefs were associated with *Crocodylus porosus*. In general, most villagers feared crocodiles. Crocodile hunters are regarded with respect. Crocodile shamen are men reputed to possess powers enabling them to turn into a crocodile, to summon and control crocodiles. Pemulutan Village, south of Palembang (the capital of Sumatera Selatan Province) is well-known throughout the Province as where many crocodile shamen originate from.

### 3.5.5 Historical trade

The majority of crocodile hunting was in the 1950s-1970s. It was widely recognised that *T. schlegelii* skins were less valuable than those of *C. porosus*. The most common capture methods were harpoon (n=10) and baited hooks set above the water (n=7). 'Rattan' vine (*Calamus* spp.) was used instead of rope. The most valued animals were up to 1 m Total Length (TL). A former crocodile hunter from Lampung described how he collected all eggs from any nests he found. Eggs were incubated in boxes filled with the original nesting material. Hatchlings were kept in boxes 2 x 2 m, filled with a few inches of water, and were fed on prawns and fish. They were graded on the basis of size while being raised, and were killed and skinned when 'just less than 1 m TL'. This ex-hunter stated he had never tried to breed *T. schlegelii*.

Interviewees stated that historically crocodiles were skinned, salted once and then sold. Dealers would visit villages and buy skins from hunters, or hunters would visit dealers in towns. One ex-trader stated he would only accept live crocodiles, which his staff then killed and skinned. Skinning methods were different for crocodiles of different sizes. When describing skinning, former hunters used Total Length (metres) and/or Belly Width (inches). The entire skin of crocodiles <1 m TL (or 5-12" Belly Width) were sold. Crocodiles >1 m TL, or >12" Belly Width, were skinned and only the belly skin sold, with the backstrap discarded.

Skins were sold to dealers in Palembang (Sumatera Selatan Province), Pekanbaru (Riau Province) and Medan (Sumatera Utara Province). Former hunters interviewed from Jambi, Lampung and Sumatera Selatan Provinces stated they all sold skins to a single dealer in Palembang in the 1950s-1970s. In many villages visited by the team in Jambi, Lampung and Sumatera Selatan Provinces, villagers stated hunters had come from Palembang. Dealers traded skins to Jakarta and Singapore. Skin prices had varied greatly. In the

1960s, *T. schlegelii* skins ranged from 100 R - 40 000 R/inch Belly Width, and in the 1970s, from 60 R - 450 000 R/inch. *Tomistoma schlegelii* skins were considered by all former hunters to be of less quality and value than *C. porosus*. The owner of a crocodile farm in Jambi Province stated that during the 1970s, *T. schlegelii* skins were half the price of *C. porosus* skins (4 000 R/inch compared to 8 000 R/inch for *C. porosus*). A former crocodile hunter from Lampung Province stated that in the mid-1960s, *T. schlegelii* skins were sold to dealers for 100 R/inch compared to 200 R/inch for *C. porosus* skins.

### 3.6 Habitat of *Tomistoma schlegelii*

The physical environment inhabited by *T. schlegelii* in six rivers in eastern Sumatera was quantified by measuring forest and river structural and chemical characteristics. Forest and river structure on four of these rivers have been summarised in diagrams (Figures 5-8, Section 3.6.4).

#### 3.6.1 Habitat types

Two broad categories of forest were identified on six rivers in eastern Sumatera where *T. schlegelii* are known to occur. The first and most common was lowland secondary forest, recorded on the Alai River and Batang Hari Rivers (Jambi Province) and Teso and Kubu Rivers (Riau Province). The second was peat swamp forest, recorded on the Merang River (Sumatera Selatan Province) and Simpang Melaka Creek (Berbak National Park, Jambi Province).

During travels through Jambi, Riau and Sumatera Selatan Provinces, lowland secondary forest was the most commonly observed forest type.

#### 3.6.2 Forest structure along rivers

Tables 15 and 16 present summary data on forest structure of six rivers in eastern lowland Sumatra. Broad descriptions of habitat and land use are in App. 6, and raw data on forest and river measurements are in App. 7.

Peat swamp forest along the Merang River (Sumatera Selatan Province) and in Berbak National Park (Jambi Province) was characterised by the presence of peat mounds (peat accumulations around root masses of trees). Depending on the size of tree and hence root mass, these mounds sometimes formed small islands (Fig. 5). These islands are where all *T. schlegelii* nests located in 1995 and 1996 were found. Peat mounds were also recorded on the Kubu River (Riau Province) (Fig. 8, Table 15). These peat mounds break up the continuity of the river banks, forming a myriad of small waterways adjacent to the main channel. In contrast, banks along the Alai and Batang Hari Rivers (Jambi Province) and Teso River (Riau Province) were well-defined, with a dry forest floor only a short distance behind the river banks. Another peat swamp characteristic is the acidic, black water (described by Giesen [1991] as the colour of weak tea). Water acidity on the Merang River and in Berbak National Park was greater than any other river (Table 17). Peat swamp forest characteristically occurs in areas of very low elevation. De Wulf *et al.* (1982) state that maximum elevation in most areas of Berbak National Park is 16 m above sea level.

The peat swamp forests of the Merang River and Berbak National Park are in close proximity: km 40-66 of the Merang River are 50 km SSW of Air Hitam Laut River (Berbak National Park). Numerous short, shallow sidecreeks were counted on the Merang River (n=228, mean length = 18 m, mean depth = 0.4 m) (Section 3.0 in App. 12); these exist as a result of the individual peat mounds which make up the river channel, which allow the water to disperse into adjacent forest. The presence of numerous waterways adjacent to the mainstream may increase nesting habitat for *T. schlegelii*. Within Berbak National Park, well-defined, individual peat mounds were only encountered on Simpang Melaka Creek (Table 11 in App. 7). Banks along the Air Hitam Laut River were mostly

continuous, with few individual peat mounds obvious (Fig. 5). Forest structure and species diversity in Berbak National Park have been measured in detail in other studies e.g. Giesen 1990, Silvius *et al.* 1984. Structurally, the Kubu River (Riau Province) (Fig. 8) was most similar to the peat swamp forest of the Merang River and Berbak National Park, due to the presence of peat mounds along the river channel. All three rivers were characterised by dark, almost black waters.

The majority of forest structural measurements were not recorded on the Teso River (Riau Province) as most areas were inundated when the River was visited for field work in late September. However, some information was recorded on a brief preliminary trip to the River in late August. Dry lowland secondary forest surrounded the river. Banks along the mainstream channel were well-defined, in places 2-3 m high, and no peat mounds were recorded. During the 4-week interval between the initial trip and the return trip, the river had risen more than 2 m in places. The Teso River (Riau Province) and Alai River (Jambi Province) contained a noticeably different forest and river structure from the Merang River and Berbak National Park, with well-defined, often raised, river banks and a relatively dry forest floor close to the river (Fig. 7).

**Table 15.** Summary data, forest structural characteristics, for six rivers in eastern Sumatera. Values are the mean for each river. PMC = Peat Mound Circumference (m). HPM = Height of Peat Mound (m). Ground Cover (10% intervals): PM = Peat Mound. CC = Canopy Cover (10% intervals). NR=Not Recorded. Simpang Melaka Creek is within Berbak National Park (Jambi Province). \* Teso River could not be measured as most areas were flooded.

River	PMC	HPM	Ground Cover		Other	CC
			PM	Water		
Merang	16.6	0.9	45.6	7.7	46.7	82.2
Simpang Melaka	12.5	0.4	50	7.5	42.5	80
Batang Hari	None	–	0	0	100	NR
Alai	None	–	0	5	95	80
Teso*	None	–	NR	NR	NR	NR
Kubu	17**	1.0**	14.3	0	85.7	61

\*\* single value (1 peat mound). All other areas flooded.

The Merang River, Simpang Melaka Creek and Alai River had highest canopy cover values (Table 15). Simpang Melaka Creek had the highest mean canopy height and basal circumference, whilst the Merang River had a noticeably higher Emergent Height than any other river (Table 16), suggesting that these peat swamp forests were the most mature of those examined. Peat swamp forest on the Merang River and in Berbak National Park was less disturbed than forest along the other rivers. Tree species diversity was highest on the Alai River (Table 16). Due to harsher growing conditions (low pH and low organic matter content) peat swamp forest has a lower species diversity compared to other forest types (MacKinnon *et al.* 1996). Two hundred and sixty-one plant species have been recorded in Berbak (Giesen 1990); 175 species (67 %) are trees and shrubs.

Few forest measures were taken on the Batang Hari River as most forest was highly disturbed by human activity and contained domestic species (eg bananas, coconut palms).

**Table 16.** Summary data, forest structural characteristics, for six rivers in eastern Sumatera. Values are the mean for each river. MCH = Mean Canopy Height (m). EH = Emergent Height (m). Total tree sp. = total number of tree species recorded in all quadrats. It was assumed that each local name represented a different species. BCH = mean Basal Circumference at Chest Height (cm) (of all quadrats, n=total number of individual trees measured). SM Creek = Simpang Melaka Creek. NR=Not Recorded. Few measures were recorded on Batang Hari River as most areas were cultivated.

River	MCH	EH	total tree sp.	no. sp/quadrat	BCH
Merang	16.1	31	41	3.5 (over 20 km)	16.2 (n=75)
SM Creek	18	14	10	2 (over 6 km)	81.3 (n=7)
B' Hari	NR	NR	4	2 (1 reading only)	NR
Alai	13	11	28	4.3 (over 10 km)	15.5 (n=68)
Teso	NR	NR	NR	NR	NR
Kubu	16	22*	23	3.6 (over 12 km)	24.3 (n=30)

\* n=1

### 3.6.3 River structure

Most rivers were greater than 3 m deep, although the Merang River had a mean depth of 1.3 m from km 42-66 (Table 17). Several deep pools ('lebungs') along the Merang River were 2-3 m deep (pers. obs.). Difference in depth may be due to timing of measurements: the Merang River was measured in early-mid August and the other rivers from mid-September to mid-October, after a month of frequent rain. Mean river width varied from 10 m (Merang River) to 218 m (Batang Hari River) (Table 15). Raw data are in App. 7.

Six rivers were characterised by acidic water. Highest acidities were recorded in peat swamp forest in Berbak National Park and the Merang River (Table 17). Water temperature ranged from 27.2 °C - 28.8 °C and air temperature from 26.2 °C - 32.7 °C (Table 17).

In five rivers where *Tomistoma schlegelii* occur the water was fresh (Table 17). Salinity in the Merang and Benu Rivers were not measured, but given the similar geographical locations of these rivers compared with the locations of the other rivers it is very likely that these rivers are also fresh most of the time. During the dry season a salt wedge may move upstream (these measures were taken after 3-4 weeks of rain).





Peat Swamp Forest, Air Hitam Laut River (Berbak National Park, Jambi Province). Surveys confirmed a breeding population of False Gharials.



Lowland Secondary Forest, Teso River (Riau Province). This was the most commonly observed forest-type. Fishermen on the Teso River reported they often saw False Gharials.



**Table 17.** Summary water measurements for seven rivers in eastern Sumatera. Values are the overall mean for each river. Depth (m) mostly noted as >3m. Width in metres. Salinity = parts per thousand (‰). WT = Water Temperature (°C). AT = Ambient Temperature (°C). NR=Not Recorded. AHL=Air Hitam Laut River (Berbak National Park).

River	Depth	Width	pH	Salinity	WT	AT
Benu	>3	22	NR	NR	28.6	28.0
Merang	1.3*	10.4*	4.0	NR	27.7	30.0
AHL	>3	28	3 <sup>^</sup>	0	28.2	32.7
B' Hari	>3	218	5.5	0	28.7	29.6
Alai	4.5	17	5.0	0	28.8	29.9
Teso	>3	26	4.5	0	27.3	26.2
Kubu	3.4	21	4.5	0	27.2	28.1

\* mean values for km 42-66. Mean width of km 0-40 = 50m.

<sup>^</sup> does not include km 0 (pH 7); mouth borders sea.

#### 3.6.4 Catenas

Figures 5-8 show representative profiles (catenas) of the Merang, Air Hitam Laut, Alai and Kubu Rivers of eastern Sumatera.

#### 3.6.5 Tree identification

Twenty-five tree species and forms were photographed at Merang River, 14-15 August 1996. Species photographed were those recorded at nest sites and species said to be common by local fishermen. Trees were identified from local names (App. 8).

### 3.7 Social and cultural conditions on the Merang River

Information on the social and cultural conditions of the Merang River (Sumatera Selatan Province) was obtained from discussions with local fishermen. The future of this river was considered significant as it was the only river where nests of *Tomistoma schlegelii* were found during field trips in 1995 and 1996. Any future management of the area must be familiar with land ownership and fishing traditions. The information below refers to km 45-66 of Merang River, the section where *T. schlegelii* nests have been recorded.

#### 3.7.1 Ownership and fishing rights

A traditional system of river ownership exists in Sumatera Selatan Province, known as '*lebak lobang*'. Annual auctions are held on each river and all Village Heads meet and bid for fishing rights to a section of a river or tributary:

- the Village Head represents the village, and all fishermen within the village contribute money to bid for the river;
- the lease for a river is for one year (1 January-31 December);
- auctions for the Merang River are held at Bayung Lincir Village (Fig. 2) and the lease is paid to the Head of Bayung Lincir District, within the Musi Banyuasin Regency;

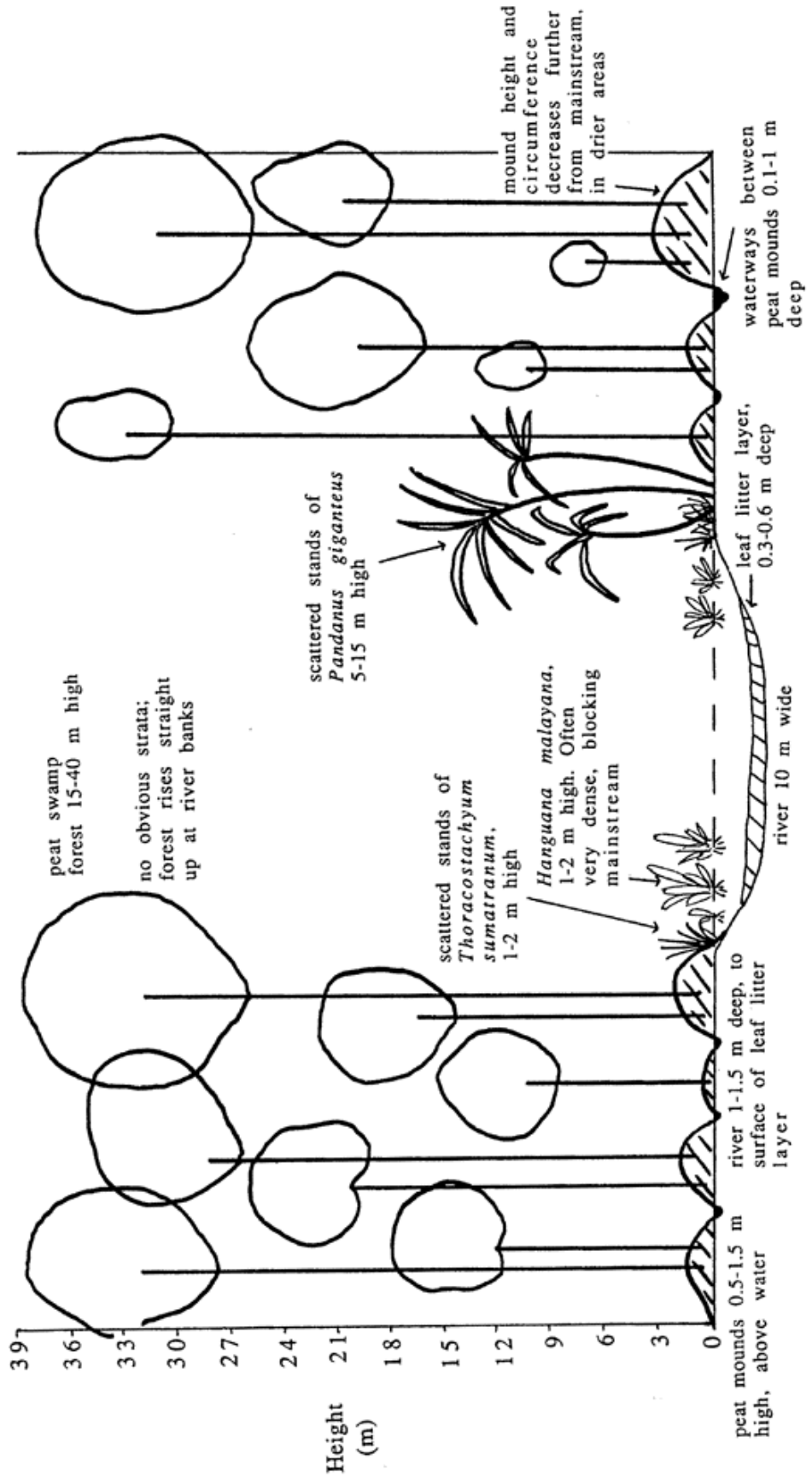


Fig. 5. Catena of peat swamp forest, km 59 Merang River, Sumatera Selatan. Vertical axes are to scale (1 cm = 3 m), horizontal axis is not.

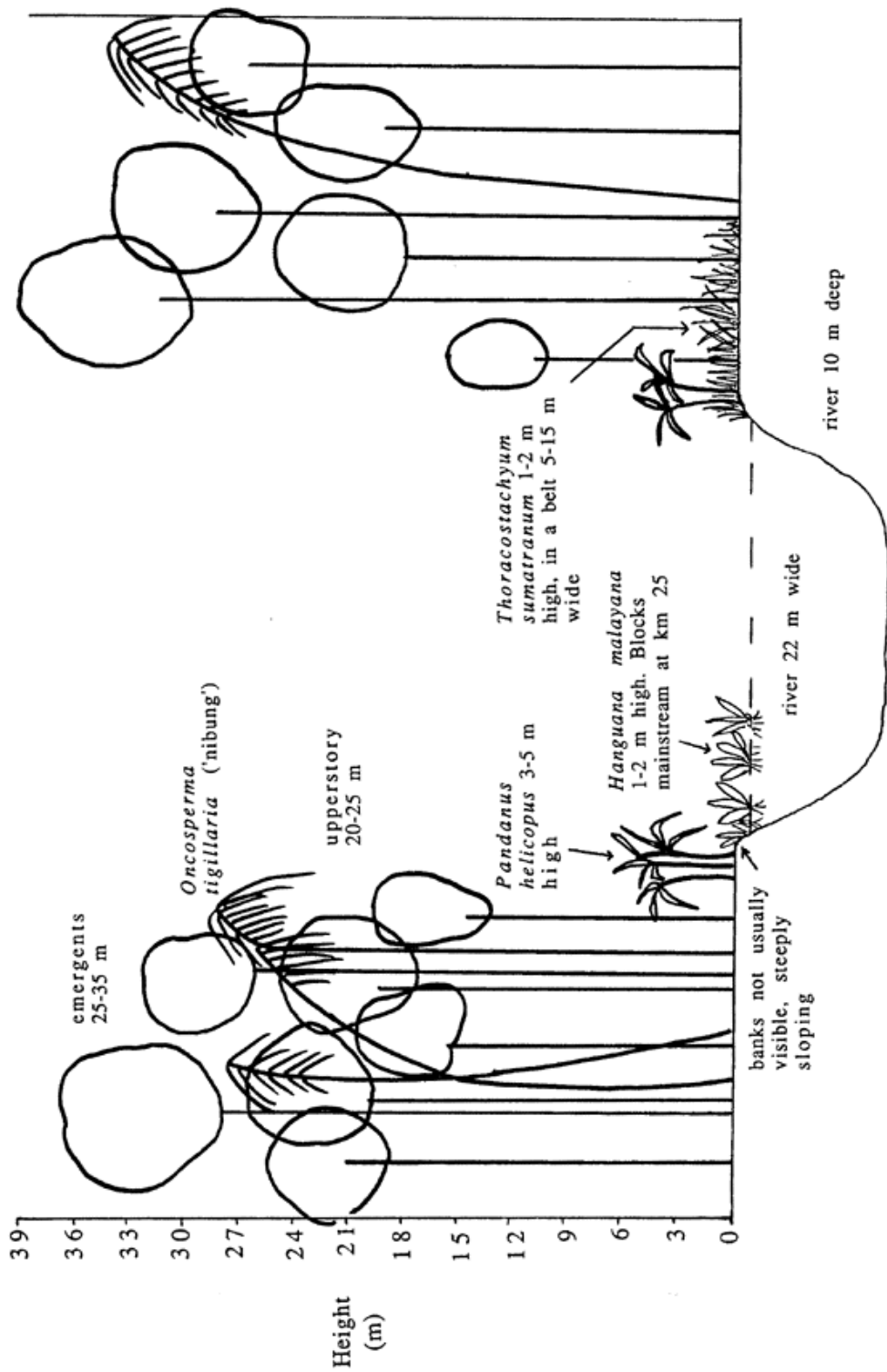


Fig.6 . Catena of peat swamp forest, km 22, Air Hitam Laut River (Berbak National Park), Jambi. Vertical axes are to scale (1 cm = 3 m), horizontal axis is not. Peat mounds are mostly connected and form a continuous bank.

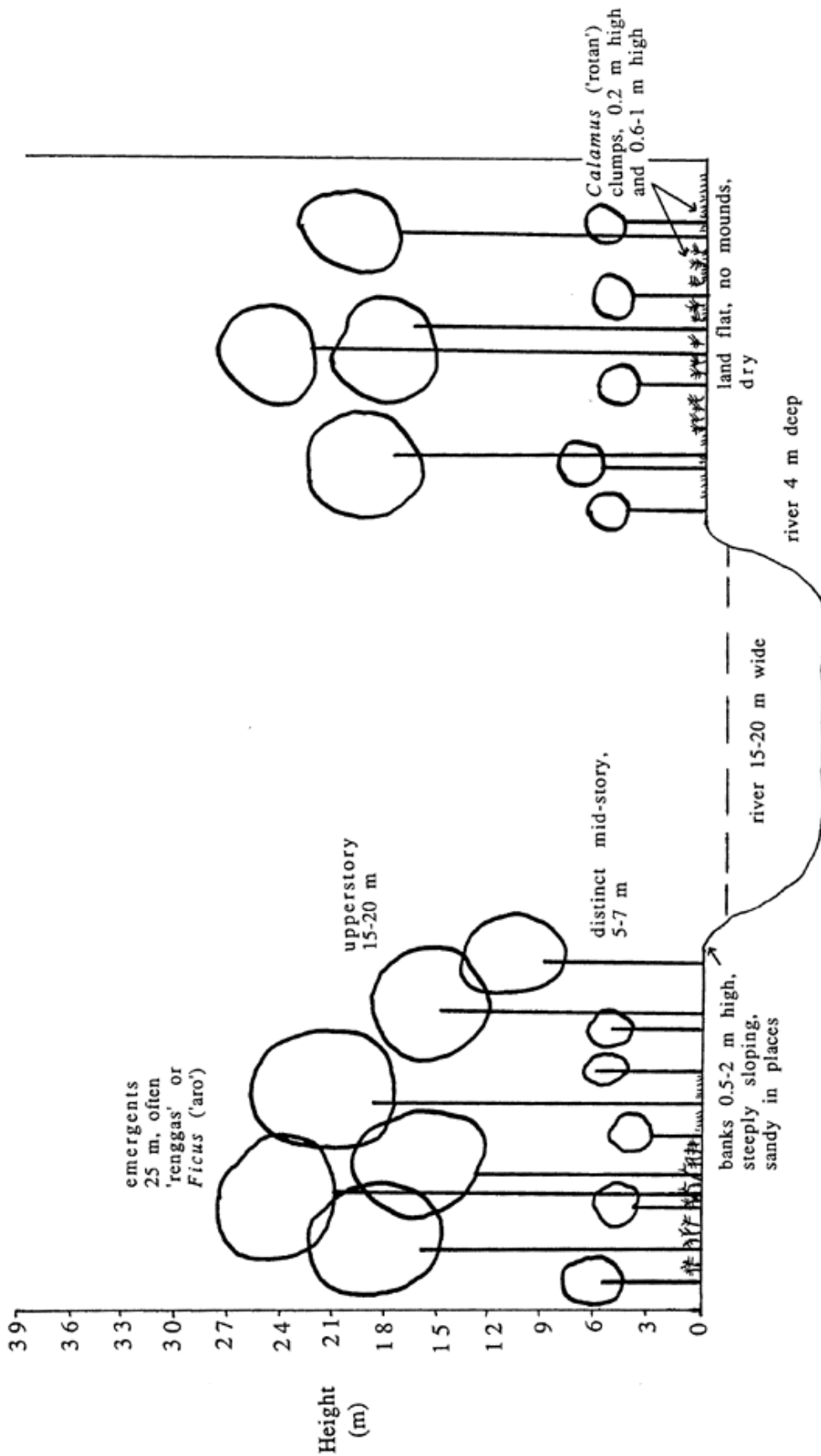


Fig.7 . Catena of lowland secondary forest, km 3.5, Alai River, Jambi.  
Vertical axes are to scale (1 cm = 3 m), horizontal axis is not.

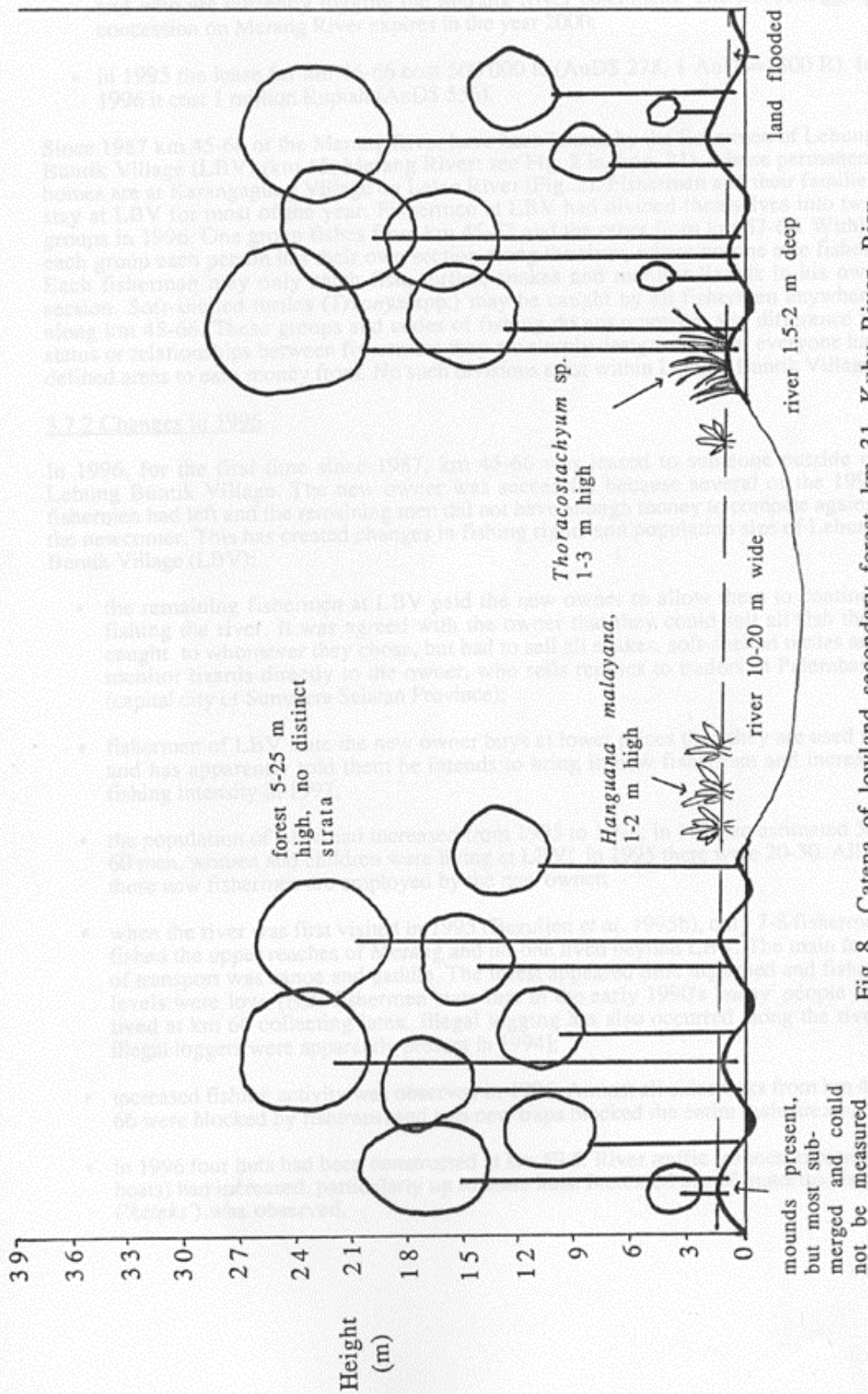


Fig. 8. Catena of lowland secondary forest, km 31, Kubu River, Riau. Vertical axes are to scale (1 cm = 3 m), horizontal axis is not. Forest adjacent to mainstream was flooded and most peat mounds were underwater.

- leasing is made in agreement with Bumi Raya Utama Group (BRUI) Logging Company, who have a logging concession along much of the Lalan River (Fig. 2) and who are currently logging the Merang River catchment. The BRUI logging concession on Merang River expires in the year 2000;
- in 1995 the lease for km 45-66 cost 500 000 R (AuD\$ 278, 1 AuD\$=1800 R). In 1996 it cost 1 million Rupiah (AuD\$ 556).

Since 1987 km 45-66 of the Merang River have been leased by the fishermen of Lebung Buntik Village (LBV) (km 45, Merang River: see Fig. 2 in App. 21), whose permanent homes are at Karangagung Village on Lalan River (Fig. 2). Fishermen and their families stay at LBV for most of the year. Fishermen at LBV had divided themselves into two groups in 1996. One group fishes from km 45-57 and the other from km 57-66. Within each group each person has their own section along the river, where no-one else fishes. Each fisherman may only catch fish, turtles, snakes and monitor lizards in his own section. Soft-shelled turtles (*Trionyx* spp.) may be caught by all fishermen anywhere along km 45-66. These groups and codes of fishing do not represent any difference in status or relationships between fishermen; they are simply designed so that everyone has defined areas to earn money from. No such divisions exist within Lebung Buntik Village.

### 3.7.2 Changes in 1996

In 1996, for the first time since 1987, km 45-66 was leased to someone outside of Lebung Buntik Village. The new owner was successful because several of the 1995 fishermen had left and the remaining men did not have enough money to compete against the newcomer. This has created changes in fishing rights and population size of Lebung Buntik Village (LBV):

- the remaining fishermen at LBV paid the new owner to allow them to continue fishing the river. It was agreed with the owner that they could sell all fish they caught to whomever they chose, but had to sell all snakes, soft-shelled turtles and monitor lizards directly to the owner, who sells reptiles to traders in Palembang (capital city of Sumatera Selatan Province);
- fishermen of LBV state the new owner buys at lower prices than they are used to, and has apparently told them he intends to bring in new fishermen and increase fishing intensity in 1997;
- the population of LBV had increased from 1995 to 1996: in 1996 an estimated 50-60 men, women and children were living at LBV; in 1995 there were 20-30. All of these new fishermen are employed by the new owner;
- when the river was first visited in 1995 (Bezuijen *et al.* 1995b), only 7-8 fishermen fished the upper reaches of Merang and no-one lived beyond LBV. The main form of transport was canoe and paddle. The forest appeared little disturbed and fishing levels were low. [NB: fishermen state that in the early 1990's 'many' people had lived at km 66 collecting latex. Illegal logging has also occurred along the river; illegal loggers were apparently present in 1994];
- increased fishing activity was observed in 1996. Almost all sidecreeks from km 46-66 were blocked by fishtraps, and two new traps blocked the entire mainstream.
- in 1996 four huts had been constructed at km 59.5. River traffic (canoes, motorised boats) had increased, particularly up to these huts. Increased use of motorised boats ('keteks') was observed.



Measuring a captured False Gharial with the help of local fishermen, on the Merang River (Sumatera Selatan Province). Local people were very interested in the project and were a valuable source of information on False Gharials.

Until 1996 disturbance by BRUI Logging Company has been minimal (logging blocks have been some distance away from the river). The 1996-98 logging strategy is to log the upper Merang River from approximately km 50-60 (BRUI Camp Manager, pers. comm.). Most *T. schlegelii* nests have been found along this section of river. Indonesian law prohibits logging 250 m either side of rivers.

Upon expiry of the BRUI logging lease, the government will decide the river's future: the river may be declared a protected area, opened to transmigration, or other forms of development (e.g. oil drilling).

In August 1996 fishermen of the Merang River requested help from the team in ensuring their continued use of the river. In September 1996, Mark R. Bezuijen, Murray Elliot and Pandu Hartoyo met with Mrs Kusmarini of PHPA in Sumatera Selatan Province. The conditions of the Merang River and the fishermen's request was passed on (see '11 September' in App. 15). A written summary of the above conditions and changes was given to Mrs Kusmarini.

#### 4.0 SUMMARY AND CONCLUSIONS

1. The current distribution of *Tomistoma schlegelii* extends from south-eastern Sumatera Utara Province to southern Sumatera Selatan Province. An isolated population is present in Way Kambas National Park in Lampung Province and probably represents the southern-most extent of the species within Sumatera. There were no reports of *T. schlegelii* from Sumatera Barat and Bengkulu Provinces, and it is unlikely that the species has ever occurred in western Sumatera. Geographically, both Provinces are isolated by the Barisan Mountain Ranges, with only a relatively narrow area of coastal plain between the mountains and the Indian Ocean. The majority of reported sightings come from the lowlands of eastern Sumatera, from the Provinces of Jambi, Riau and Sumatera Selatan. Reported sightings are widely distributed within these Provinces. In comparison to Sumatera Selatan and Lampung Provinces, Jambi and Riau Provinces are relatively well-forested and may be the strongholds of the species.

2. Historically, *T. schlegelii* was widely distributed, from south-eastern Aceh Province to southern Lampung Province: almost the entire length of eastern Sumatera. Interviews with local people indicate that the contraction in range has been relatively rapid - within the last 30-40 years. Based on interviews, the range of *T. schlegelii* in Sumatera may have been reduced by 30 % within this period.

3. In its current distribution, *T. schlegelii* appears to survive in widespread areas but in low densities. Almost all local people interviewed stated *T. schlegelii* numbers had declined in the last fifteen years, with fewer seen in the 1990s compared to the 1980s. Seven rivers in eastern Sumatera were spotlight surveyed. *Tomistoma schlegelii* were only seen on two rivers, the Merang River (Sumatera Selatan Province) and Air Hitam Laut River (Jambi Province), although this may reflect poor survey conditions rather than absence of crocodiles.

4. Within Jambi Province, the Alai, Air Hitam Laut and Batang Hari Rivers were spotlight surveyed. *Tomistoma schlegelii* were seen on the Air Hitam Laut River, within Berbak National Park. The Park was relatively undisturbed by humans and had the highest densities of *T. schlegelii* recorded during surveys. No crocodiles were seen on the Alai and Batang Hari Rivers. Residents on the Alai River claimed *T. schlegelii* were 'common' and that hatchlings were seen every year; a small breeding population probably still exists, although residents had not seen nests in the last ten years. The first ten kilometres of river were forested and appeared relatively undisturbed. Large sections of the Batang Hari River have been cleared for villages and cultivation, and many patches of remaining forest contain domestic species. Few areas appear suitable for nesting, although a large *T. schlegelii* was caught in 1996 and indicates they still occur: nesting may still occur in isolated areas along the Batang Hari River.



5. Within Riau Province, the Teso and Kubu Rivers were spotlight surveyed. No crocodiles were seen on either river, but survey conditions were affected by high water levels. Fisherman on both rivers claimed *T. schlegelii* were 'common' and regularly seen. One fisherman on the Teso River claimed to have recently seen two *T. schlegelii* nests, one in 1994 and one in 1995. The fishermen of Kubu River had never seen a nest. Despite logging and fishing activity, both rivers contained sections of undisturbed forest and small breeding populations are probably present on these rivers.

6. Within Sumatera Selatan Province, the Merang and Benu Rivers were spotlight surveyed. *Tomistoma schlegelii* were seen on the Merang River. Higher densities of *T. schlegelii* were seen on the Merang River in 1995 than in 1996, although this may reflect differences in survey effort: along km 0-45, more *T. schlegelii* were seen in 1995 than in 1996, and along km 46-66.5 more were seen in 1996 than in 1995. Survey results may have been affected by higher water levels in 1996. Two *T. schlegelii* nests were found along the Merang River in 1996. Km 46-66.5 represents an example of mature, relatively undisturbed peat swamp forest. Fishing intensity is low compared to surrounding rivers and there is little logging activity. The Merang River contains a viable breeding population of *T. schlegelii* and is clearly an important nesting area for the species. No *T. schlegelii* were seen on the Benu River, but *Crocodylus porosus* were. Interviews with local fishermen indicate *T. schlegelii* were once common but have declined in the last ten years, possibly as a result of intense logging. Few forested areas remain along the river. Several sightings in 1996 from the Benu River and a nearby abandoned canal suggest a small breeding population may still occur. The Benu River borders Berbak National Park and animals nesting in the Park may wander into the Benu River.

7. *Tomistoma schlegelii* inhabit and nest in at least two types of habitat: peat swamp forest and lowland secondary forest. Peat swamp forest was characterised by the presence of well-defined peat mounds along the banks, poorly-defined river channels and a myriad of short waterways adjacent to the mainstream, low pH and very low elevation. Peat swamp forest was only recorded on the Merang River (Sumatera Selatan Province) and Air Hitam Laut River (Jambi Province).

Lowland secondary forest was characterised by well-defined river channels and river banks, absence of peat mounds, dry land adjacent to the river channel (i.e. few waterways adjacent to the mainstream), a higher pH and higher elevation. This forest type was termed 'secondary' as virtually all forest visited had been subjected to logging at some time. Lowland secondary forest was recorded on the Alai, Kubu and Teso Rivers in Jambi and Riau Provinces and was the most common type of forest observed in eastern lowland Sumatera. All rivers were freshwater and all interviewees stated *T. schlegelii* inhabited freshwater.

8. Two nests of *T. schlegelii* were located in 1996. A total of three nests with intact eggs have been examined (two in 1996 and one in 1995). All were found in peat swamp forest on the Merang River (Sumatera Selatan Province). Nests were mounds and located on peat mounds at the base of large trees and often hidden by dense stands of vegetation. Based on egg ages and interviews with local people, nesting season is from June-October, with nest making and egg-laying in June-July and hatchlings appearing in September-October. Eggs are very large relative to other crocodile species and egg size (mass) is almost double that of most crocodilians. *Tomistoma schlegelii* appear to lay small clutches of very large eggs. The most commonly quoted clutch size by fishermen and former crocodile hunters in eastern Sumatera was 21-40 eggs.

9. Searching effort for nests was higher in 1996 than in 1995. That fewer nests were found in 1996 may reflect increased disturbance on the Merang River (increased fishing activity). Low numbers of nests may reflect a combination of low nesting densities and difficulty searching within swamp forest. The most commonly reported numbers of nests

seen by fishermen in eastern Sumatera were 1-2 nests, often over several years, implying low density nesting.

**10.** *Tomistoma schlegelii* have a broad diet and are not specialist fish-eaters. Fishermen and former crocodile hunters reported seeing *T. schlegelii* catch and eat monkeys, snakes, wild pigs, birds, otters, turtles and monitor lizards, in addition to fish. Crocodile farms feed their captive *T. schlegelii* snake meat, adult chickens and late-age chicken embryos. One former crocodile hunter stated he would 'often' find 'up to 3 kg' of small stones in the stomachs of *T. schlegelii* he had killed. Stomach contents of *T. schlegelii* captured during surveys contained prawns and small amounts of leaf matter.

**11.** Interviews with fishermen and former crocodile hunters provided a large amount of information on the ecology of *T. schlegelii*. In addition to information contributed on distribution, abundance, status, nesting and diet, local people provided the following:

- *Colour forms and varieties:* 12 local names and 6 forms of *T. schlegelii* were identified by interviewees. The most commonly described was a yellow form with a long snout ('*bhoung kwang*') and a dark form with a shorter snout ('*julung*');
- *Behaviour:* *Tomistoma schlegelii* have been observed basking on banks, on top of floating aquatic vegetation and on sandbars. They were most often seen by interviewees at night, in shallow water on the edge of a stream. A captive *T. schlegelii* was observed by the team enlarging a wallow. Mating behaviour of captive *T. schlegelii* was described by two crocodile farms;
- *Survivorship:* causes of mortality listed by interviewees were egg and young predation (particularly by wild pigs), villagers eating eggs, and drowning in fish traps. Most interviewees stated nests do *not* become flooded;
- *Beliefs:* no specific beliefs are associated with *T. schlegelii*. Some hunters use chanting and prayer prior to hunting to ensure a successful crocodile hunt. Specific beliefs *are* associated with *Crocodylus porosus*;
- *Historical trade:* The majority of crocodile hunting in eastern and southern Sumatera was in the 1950s-1970s. *Crocodylus porosus* skins were of higher value than *T. schlegelii* skins and all former hunters agreed *C. porosus* skins were of better quality. Hunters sold *T. schlegelii* skins for about half the price of *C. porosus* skins. Crocodiles were mostly hunted with harpoon and line and baited hooks set above the water. Animals up to 1 m Total Length (TL) were the most valued. One hunter formerly collected eggs from nests, incubated the eggs and raised the young until just less than 1 m TL, then killed and skinned them. Skinning techniques differed according to crocodile size. Most hunters only salted skins once prior to selling. Dealers would visit villages or buy skins from hunters in towns. A main dealer for south-eastern Sumatera during this period was in Palembang (capital of Sumatera Selatan Province). *Tomistoma schlegelii* is still widely recognised as having little commercial value and there was no evidence of any commercial hunting of *T. schlegelii* on this trip.

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