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Batagur affinis (Cantor 1847) – Southern River Terrapin, Tuntong

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Summary. – The Southern River Terrapin, *Batagur affinis* (Family Geoemydidae), is a large (carapace length to 625 mm) Critically Endangered river turtle inhabiting large rivers and estuaries of the southern Malay Peninsula (southern Thailand and West Malaysia), Sumatra, and a remnant population in Cambodia. Wild terrapins are omnivorous, but the bulk of the diet consists of vegetation and fruit. *Batagur affinis* does not feed in salinities exceeding 20 ppt as it has limited physiological adaptability to high saline concentrations. Nesting occurs during the dry season (November through March) when sand banks are exposed by falling river levels. Females move extensive distances up river to nest on riverine sandbanks. Conspicuous differences occur in the nesting behavior of populations in rivers on the eastern and western coasts of Malaysia. West coast populations tend to nest en masse, digging nests at the bottom of deep body pits and then constructing false body pits to confuse predators. Females of east coast populations nest solitarily and may divide the clutch presumably among multiple nests. Multiple clutches can be laid in a single season. In west coast rivers, young emerge from nests after an average of 88 days and emigrate directly downstream to tidal areas. The species, abundant throughout its range in the 19th and early 20th centuries, is severely depleted and Critically Endangered. A small recently discovered population in Cambodia survives on the Sre Ambel River System and produces about 3 nests/year. The species is considered extinct in the wild in Thailand, Vietnam, and Singapore. In Malaysia, only scattered nesting now occurs on the sand banks of west coast rivers where thousands formerly nested. Populations in east coast rivers are faring better and a recent increase in nesting has been reported for the Terengganu River. A newly discovered population on the Kemaman River produced 36 to 121 nests per year between 2012 and 2014. Surveys of Sumatra in the early 1990s found the species to be rare, but no recent information is available. The terrapin's decline has resulted from extensive exploitation of its flesh and eggs, exacerbated by indirect factors, including habitat alteration and destruction (e.g., deforestation, tin and sand-mining, dam building, erosion control, and pollution) that have damaged the turtle's nesting areas and feeding habitat. Malaysia has been a leader in conservation action for the species, establishing the first hatchery on the Perak River in 1967. This program has since expanded to include head-starting and captive breeding. Conservation programs now exist in Kedah, Perak, and Terengganu. These efforts have failed to stem the decline on the Kedah and Perak Rivers, but populations on the Terengganu River are now increasing. A population was discovered along the Kemaman River in 2010 and a conservation program was initiated in 2011. In 1987, Thailand established an *ex-situ* conservation program for the terrapin on the Klong La-ngu River in Satun Province. Thousands of young are being kept and raised, but to date none have been released. In 2001 in Cambodia the Sre Ambel Fisheries Administration began a small conservation program in Koh Kong Province, protecting habitat, nesting areas, and locating nests for a small hatchery program.

Distribution. – Cambodia, Indonesia (Sumatra), Malaysia (West), Singapore (extirpated, reintroduced), Thailand, Vietnam (extirpated).

Synonymy. – *Tetraonyx affinis* Cantor 1847, *Batagur affinis, Kachuga affinis, Batagur affinis affinis, Batagur siebenrocki* † Jaekel 1911.

Subspecies. – Two subspecies are currently recognized: 1) *Batagur affinis affinis* (Western Malay River Terrapin) (distribution: western coast of West Malaysia, adjacent southernmost Thailand, Sumatra); and 2) *Batagur affinis edwardmolli* (Eastern Malay River Terrapin) (synonymy: *Batagur affinis edwardmolli* Praschag, Holloway, Georges, Päckert, Hundsdörfer, and Fritz 2009) (distribution: eastern coast of West Malaysia, adjacent southernmost Thailand [extirpated], Cambodia, Vietnam [extirpated]).

Status. – IUCN 2015 Red List: Not Evaluated (*B. baska*, including *B. affinis* populations, assessed as Critically Endangered in 2000); TFTSG Draft Red List: Critically Endangered (CR, assessed 2011); CITES: Appendix I; USA Endangered Species Act: Endangered.

Taxonomy. — *Batagur affinis* is in the family Geoemydidae with its closest relatives appearing to be *B. baska* and *B. kachuga* of South Asia. Until 2007 all populations of this species inhabiting the lower Malay Peninsula and Sumatra were considered conspecific with the northern species, *B. baska* (Moll et al. 2009). However, Praschag et al. (2007), as part of a larger study of *Batagur* relationships using DNA sequences of the mitochondrial cytochrome b gene, demonstrated the widespread species *B. baska* actually comprised at least two genetically distinct species.

In a follow-up paper, Praschag et al. (2008) argued that, based on priority, the more northern species should retain the name *B. baska*. The specific epithet *affinis*, a name initially given by Cantor (1847) to a type series comprising two hatchling river terrapins and a hatchling painted terrapin (*Batagur borneoensis*) from Penang Island, was deemed available for the southern species occupying Thailand, Malaysia, and Indonesia (Praschag et al. 2008).

However, the problem appeared still more complex, as coloration, morphology, and behavior of terrapin populations on the west and east coasts of Malaysia differed significantly (Moll 1980) with the latter bearing obvious resemblance to a relictual population in Cambodia. Praschag et al. (2009) assessed the taxonomic status of the Cambodian relict population using phylogenetic analyses of three mitochondrial and three nuclear DNA fragments and compared them to all other *Batagur* species. Genetically, Cambodian *Batagur* were found to be closely related but distinct from *B. affinis* from Sumatra and the west coast of the Malay Peninsula. Morphologically, Cambodian *Batagur* resemble the distinctive *B. affinis* populations from the eastern Malay Peninsula that were not available for genetic study. Consequently, Praschag et al. (2009) described the unnamed *Batagur* populations from the eastern Malay Peninsula and Cambodia as the new subspecies *Batagur affinis edwardmolli* that presumably once inhabited estuaries surrounding the Gulf of Thailand.

Figure 1. Adult male *Batagur affinis edwardmolli* from the Setiu River, Terengganu, eastern Malaysia, in breeding color. Photo by E.H. Chan.

Description. — The Southern River Terrapin is a large river turtle (carapace length [CL] to 625 mm; body weight to 38 kg) with a deep, massive, heavily buttressed shell, large powerful limbs, broad fully webbed feet, and a skull bearing serrate tomia and a broad triturating surface. It is distinguished from most other large, riverine geoemydids within its range by having four claws rather than five on its forefeet (a trait shared with *B. baska*); and two, rather than one, longitudinal denticulated ridges on the triturating surface of the upper jaw (a trait shared with *B. baska* and *B. kachuga*). *Batagur baska* and *B. affinis* can be separated by mitochondrial and nuclear DNA differences (Praschag et al. 2007, 2008), minor morphological differences, coloration, and nesting ecology (Praschag et al. 2009).

River terrapins have relatively small heads with an upturned, somewhat attenuated snout. *Batagur a. edwardmolli* appears to have a narrower and sharper snout than *B. a. affinis* from the west coast of the Malay Peninsula, but this has not yet been quantified. The skin at the posterior end of the head is divided to form a number of irregularly-shaped scales. The upper jaw is bicuspid (a median notch flanked by pointed tooth-like projections). The lower jaw possesses a complimentary medial cusp flanked by a shallow notch on each side. The choanae are partially covered by a flap bearing a small papilla (type A of Parsons 1968).

The feet are fully webbed, with only the tips of the claws extending beyond the webbing. The forelimbs bear a series of transversely elongated, band-like scales. A flap of skin, reinforced by enlarged scutes, borders the forelimb laterally and merges with the webbing of the toes, giving the limb a paddle-like appearance. Scalation on the hind limb is reduced, but a lateral flap of skin and associated scutes are present.

The massive high-arched shell comprises a fourth to a third of the body weight. Vertebral scutes are wider than long. The plastron is truncated anteriorly, notched posteriorly, and is somewhat shorter than the carapace. The plastral formula is Ab>F><P>H>A>G. The entoplastron lies anterior to the humeropectoral seam. Buttresses of the shell are greatly expanded (obstructing about half of the anterior shell opening at their widest point) and extend nearly to the neural bones. Adult males retain costo-peripheral foramina, an unusual neotenic feature of the shell. Seams separating both the

Figure 2. Male *Batagur affinis edwardmolli* (453 mm CL) from the Dungun River, Terengganu, eastern Malaysia. Photo by E.H. Chan.

Figure 3. Adult female *Batagur affinis affinis* (538 mm CL) from the Perak River, western Malaysia. Photo by E.O. Moll.

Figure 4. Adult female *Batagur affinis edwardmolli* (503 mm CL) from the Terengganu River. Photo by E.O. Moll.

Figure 5. Carapace of male *Batagur affinis* (431 mm CL) showing costo-peripheral fontanelles. Photo by E.O. Moll.

Figure 6. Subadult *Batagur affinis edwardmolli* from Sre Ambel, Cambodia. Photo by Heng Kimchhay.

scutes and bones comprising the shell fuse with age. Shells of old individuals become smooth and seamless.

In hatchlings the shell is shield-shaped, being widest across the third vertebral, then tapering posteriorly. The periphery of the carapace is serrated, with the serrations on marginals 5–7 being the most pronounced and spine-like. Prominent spines are present on the mid-dorsal vertebral keel of the carapace and smaller spines occur along a pair of lateral keels on the plastron. A row of tiny spines (one on each pleural) represent the only vestiges of lateral keels in the species. The vertebral keel, spines, and serrations disappear with age. Hatchlings from the west coast of Malaysia average somewhat smaller than those from the east coast. A sample of 47 Perak River (west coast) hatchlings averaged 56.5 mm CL and 26.3 g (Moll 1980). Samples from two east coast rivers include 98 hatchlings from the Terengganu River, averaging 66.1 mm CL and 48.4 g (Moll, unpubl. data) and 189 from the Setiu River averaging 66.7 mm CL and 55.7 g (Chan et al. 2004). Hatchlings (n = 59) in Cambodia were somewhat larger with a mean CL of 70.0 mm (range = 65–75 mm) (Holloway 2003).

Juveniles and females from the western coast of Malaysia are drably colored. Soft parts vary from gray to greenish or bluish-gray dorsally, becoming lighter ventrally. The iris is brown and the mandible yellowish-gray or brown. The carapace is brown to olive-brown or gray and the plastron is pale yellow.

Like other members of the genus (except *B. dhongoka*), Southern River Terrapin males are sexually and seasonally dichromatic. On the west coast, non-breeding males tend to be a dark olive-brown (somewhat darker than females in shell and skin coloration) and have a yellowish to cream-colored iris. Males in breeding condition have a strikingly white iris, a dark cornea, and a jet black head, neck, limbs, and carapace. Well before sexual maturity, the eyes of males tend to be lighter in color than those of females.

Figure 7. Male *Batagur affinis affinis* (455 mm CL) from the Perak River, western Malaysia, in breeding coloration. Note the irregularly shaped scales on the posterior head. Photo by E.O. Moll.

Figure 8. Male *Batagur affinis edwardmolli* from the Dungun River, eastern Malaysia, in April, slightly after the breeding season. Photo by E.H. Chan.

Figure 9. Male *Batagur affinis edwardmolli* from the Dungun River , eastern Malaysia, in June, after the breeding season. Photo by E.H. Chan.

Coloration varies geographically. River terrapins from the eastern coast of Malaysia (*B. a. edwardmolli*) are colored similarly except that females and juveniles have a silvery patch on the lateral side of the head behind the eyes. East coast hatchlings are also more colorful, having a bright silvery head patch and an olive to olive-brown carapace bordered

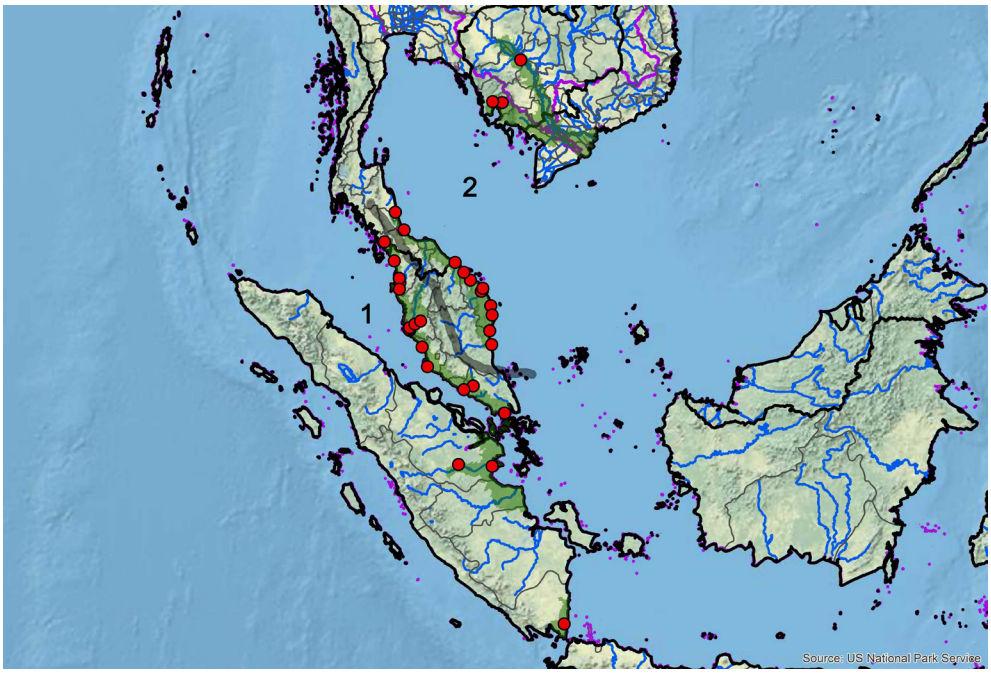

Figure 10. Historic distribution of *Batagur affinis* in Southeast Asia. Purple lines = boundaries delimiting major watersheds (level 3 hydrologic unit compartments – HUCs); red dots = museum and literature occurrence records based on Iverson (1992) plus more recent data, and the authors' personal data; green shading = projected historic native distribution based on GIS-defined level 10 HUCs constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009; TTWG 2014), and adjusted based on authors' subsequent data; broad gray line = approximate boundary between the two subspecies, with *B. a. affinis* (**1**) in the southwest and *B. a. edwardmolli* (**2**) in the northeast.

by a prominent yellow band. Males are dark brown to black, although eye coloration differs markedly. Breeding males have a yellowish to cream iris ringed with a bright orange cornea. Non-breeding males have a yellow iris with dull, pale, yellowish cornea. The eyes of females are dull, brown, and inconspicuous.

Based on data from Moll (1980), size and probably age at sexual maturity vary with sex. Perak River males (*B. a. affinis*) mature around 400 mm CL, and of 90 nesting females examined, all but three were 450 mm CL or greater. Males and females from the Perak River on Malaysia's west coast averaged 438 mm CL (400–502 mm, n = 76) and 488 mm CL (430–546 mm, n = 156), respectively. East coast terrapins (*B. a. edwardmolli*) averaged larger; females nesting on a Terengganu River beach (Moll, unpubl. data) averaged 552 mm CL (532–602 mm, n = 29), and a sample from the Dungun River (Chan, unpubl. data) averaged 537 mm CL (410–625 mm, n = 28). Based on Moll (1980), Gibbons and Lovich (1990) determined that female *B. affinis* were on average 11% larger than males in carapace length. Lovich et al. (2014) suggested that patterns of sexual size dimorphism among turtles are

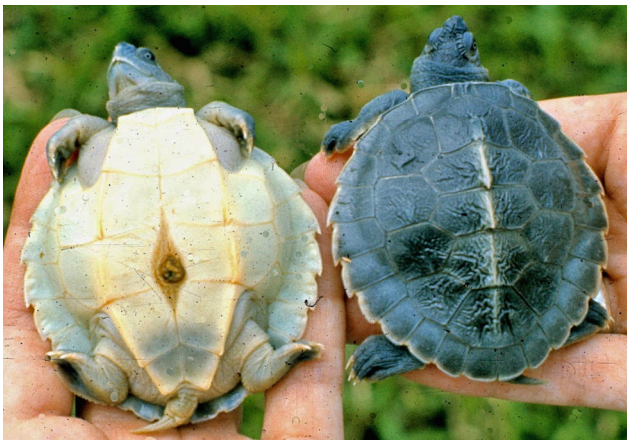

Figure 11. *Batagur affinis affinis* hatchlings from the Perak River, Malaysia. Photo by E.O. Moll.

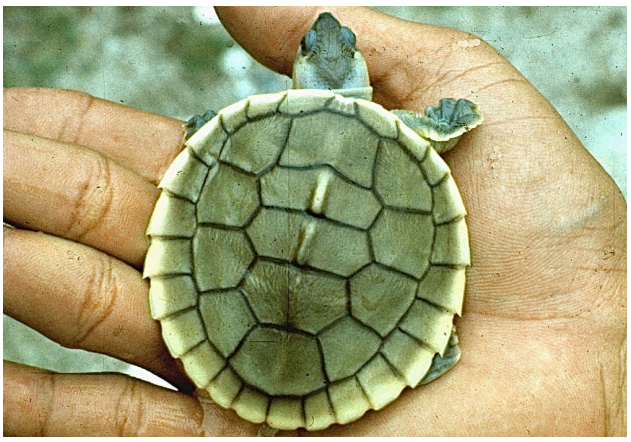

Figure 12. Hatchling *Batagur affinis edwardmolli* from the Terengganu River. Photo by E.O. Moll.

explained by the earlier maturing sex remaining smaller, on average throughout life. In addition to differences in body size and coloration, adult males can be distinguished from females by a longer, thicker tail in which the cloaca of the stretched tail extends posterior to the edge of the carapace (Moll 1978, 1980).

Little information is available on age at sexual maturity in the wild. Based on a small amount of growth information derived from recaptures, Moll (1980) hypothesized that maturity could be attained at 25 years. Data from captives is also limited, but 48 individuals have been raised at the Department of Wildlife and National Park (DWNP) terrapin conservation center in Bota Kanan, Malaysia, since hatching in 1968. None showed any signs of maturity after 8 years and averaged 339 (273–414) mm CL (Moll 1980). However, eight males at Bronx Zoo thought to be ca. 8 years of age were judged to be mature based on size and color change (Blanco et al. 1991). Chan et al. (2014) used 400 recapture events in a mark–recapture study to provide length-at-age data that generated growth parameters using the von Bertalanffy Growth Model. From the growth curve generated, it was estimated that the Southern River Terrapin takes 22 years to reach first maturity at 510 mm, the smallest nesting female encountered in field studies.

Currently the Bota Kanan, Malaysia, breeding facility maintains a pond of 45 adults (12 males, 33 females) that includes some of the aforementioned 48 individuals (now 47 years old and, according to facility personnel, all females). These breeders produced a total of 55 nests in 2013–2014, but when the original 48 began laying is unknown. The Bota Kanan facility also maintains a group of turtles that had not yet begun to nest when they were 22 years old in 2010, but were showing some breeding behavior (Horne, pers. obs.).

In the Sre Ambel, Cambodia, hatchery all nests are hatched *in-situ* and none are brought to the facility. Horne (pers. obs.) saw signs of maturity (notably the black head and yellow eyes) in males 4 to 5 years old, and it was possible to palpate the penis in males of this age range. Endoscopy of a number of juveniles found no evidence of developing follicles in the females.

Distribution. — *Batagur affinis affinis* occurs along the western coast of West Malaysia and eastern Sumatra in Indonesia and into southernmost Thailand on the western Malaysian Peninsula. *Batagur affinis edwardmolli* is distributed along the eastern coast of West Malaysia and the Songkhla region of adjacent southernmost eastern peninsular Thailand bordering the South China Sea, and Cambodia, where a relict population survives in the Sre Ambel River system. Formerly it extended into the Mekong delta of Vietnam, with animals occurring upstream to Tonle Sap Lake in Cambodia. Additionally, archaeological turtle fragments from the lower Bang Pakaong River of southeastern Thailand have been identified as *Batagur,* suggesting that *B. affinis*

Figure 13. *Batagur affinis affinis* nesting at night in January 1976 at Bota Kanan on the Perak River, Perak, Malaysia. The hillock in the photo was built by the egg collector who felt it attracted the female turtles. Photo by E.O. Moll.

historically inhabited all major rivers draining into the South China Sea. The isolated and now extirpated population of river terrapins from the southern Myanmar-Thailand border on the northwestern shore of the Malay Peninsula described by Nutaphand (1979) as the subspecies *B. b. ranongensis* is most likely attributable to the Northern River Terrapin, *B. baska*.

Habitat and Ecology. — Southern River Terrapins are estuarine, inhabiting tidal regions of large rivers. Turtle movements on certain rivers (e.g., Perak River) coincide with tides. They move up river with the rising tide, enter small tributary streams, and forage until the tide falls, when they return down river (Moll 1980). Despite inhabiting estuaries, *B. affinis* do not feed when salinities exceed 20 ppt as they have limited physiological adaptability to high saline concentrations (Davenport and Wong 1986; Davenport et al. 1992). In marine environments, terrapins utilize bank vegetation in lieu of floating vegetation to evade ingestion of highly saline water (Davenport et al. 1992).

Wild terrapins tend toward omnivory; the bulk of their diet is made up of vegetation and fruit, but on the Perak River mollusks can comprise almost a third of the diet (Moll 1980). The serrate jaws appear to be an adaptation for cutting and shearing vegetation (Moll 1980; Davenport et al. 1992), while the broad-ridged alveolar surfaces aid in crushing and macerating food. Among plants consumed by Perak River terrapins are the mangrove apple (*Sonneratia* sp.), sedges (*Scleria* sp.), screw palm (*Pandanus* sp.), *Colocasia* sp., figs (*Ficus* sp.), and water hyacinth (*Eichornia crassipes*) (Moll 1980; Davenport et al. 1992). In mangrove habitat, *Sonneratia* is a particularly important dietary staple. Based on studies of terrapin feces (C.L. Soh, unpubl. data) in Terengganu, several additional food plants were found: samples from the Setiu River included a vine (*Scindapsus* sp.), a grass (*Panicum repens*), and wild mangosteen (*Sandoricum* sp.), and in the Dungun River, large quantities of a grass (*Eleocharis* sp.)

were consumed along with figs (*Ficus* sp.), wild mangosteen, and Malay apple (*Syzgium longiflora*).

Captive juveniles readily eat fish, prawns, and water spinach (*Ipomoea aquatica*). The latter has been a dietary staple for juveniles at Malaysian head-starting facilities. Davenport et al. (1992) suggested that growth rates of captives could be enhanced by including fish in the diet. Norkamila et al. (2002) reported a diet comprising fish, water spinach, and pelleted Tilapia feed resulted in the best growth performance. Chen (2008) experimented with nutrition and stocking density, and confirmed that juvenile growth rates were enhanced by using commercially available pelleted feed, formulated for Tilapia culture, and supplemented by water spinach. A stocking density of 60 g/liter was indicated to avoid aggressiveness among the juveniles.

While the nesting ecology of female *B. affinis* has been fairly well documented, especially in Malaysia, there is a notable paucity of information on the reproductive biology of males. Yeng and Haron (1991) used electroejaculation to collect semen samples from a group of 15 captive male *B. affinis* and found semen volume averaged 3.3 ml (range = 0.85–7.45 ml) with a mean concentration of 2.3 million sperm/ml. Sperm motility averaged 4% (range = 0–24%) and the percentage of living sperm was 59%. Normal sperm were described as having "slightly curved narrow heads". Blanco et al. (1991) noted captive males exhibited breeding coloration from October–February and mating presumably occurred during this period.

Nesting occurs during the dry season (November to March) when sand banks emerge following the monsoon. Conspicuous differences occur in the nesting of populations on the east and west coast rivers of Malaysia. Most observations on nesting behavior of west coast populations come from the Perak River. Observations on east coast populations come chiefly from the Terengganu and Dungun rivers. In Malaysia the main nesting season is from November or December to February on the west coast and February through March on the east coast (Moll 1980). The Cambodian population nests from December through early March (Platt et al. 2003). At these times females may migrate moderate to long distances upstream from feeding areas in the estuaries to the sand banks used for nesting. Upstream movements as much as 50 to 80 km have been recorded for females in Cambodia (Holloway 2003; Holloway and Sovannara, unpubl. data) and on the Perak River of Malaysia (Moll 1985). As few males seem to accompany females on these migrations, mating presumably occurs in the feeding areas prior to the females' departure. Perak River females nest at night en masse. Formerly hundreds nested in aggregated fashion on Perak beaches, but today nesting aggregations of more than a few females are rare. In contrast, females on the Terengganu River tend to be solitary nesters with only one or a few individuals coming up on the same beach on the same night (Moll 1980).

Perak River terrapins (*B. a. affinis*) construct a body pit using both fore and hind limbs, then fashion a nest cavity at the bottom of the pit, using the hind feet alone. Based on 231 clutches from Malaysia, an average of 26 oblong (66 x 41 mm, 64 g), pliable to hard expansible-shelled eggs are laid per nest (Moll 1980). In a smaller sample of eight nests from Cambodia, 3 to 19 eggs with an average mass of 84.5 g (n = 65 eggs) were reported by Holloway (2003). After oviposition the female begins pulling sand into the cavity and periodically drops the weight of her body on to the sand to compact it. The resultant pounding sound, "tun tun," has given rise to the turtle's local name of "*tuntung*." Once the nest is covered, the turtle crawls a short distance away and digs another body pit which is then abandoned, possibly to confuse predators. Sand from the second body pit is usually kicked toward the true nest, helping to obliterate the previous signs of digging.

Terengganu River terrapins (*B. a. edwardmolli*) carry the behavior of digging extra body pits to another level, splitting clutches among two or more actual nests. One was observed to complete and cover four separate nest cavities. These were laid out in a near circle, approximately 6 m in diameter. Later examination revealed that only the first and fourth cavities contained eggs. Eggs were large (72 x 43 mm) and averaged l4 (4–32) per nest cavity in the 36 nests examined. The two largest clutches contained 42 and 43 eggs respectively. Both were split among three nests constructed within a single evening (Moll 1980 and unpubl. data).

Little information is available concerning clutch frequency. A 19th century sketch entitled "With a Casting Net" by Frank Swettenham, a British official in Perak (see reprint in Roff 1967), stated the River Terrapin nested three times annually on the beach known as Pasir Telor. Burkill (1966) interpreted this as indicating three clutches per female; however, there is no evidence the three nestings were from the same cohort of females. Moll (1990) observed a wild female from the Kedah River lay two separate clutches (24 and 29 eggs) separated by a two-week interval. Chan et al. (2008) monitored nesting activity in the Dungun River in 2006 and found five of 35 nesting females laid 2 clutches of eggs during the nesting season.

Incubation times are temperature dependent, decreasing as nest temperatures increase. Incubation periods of 60 to 102 days and 119 to 123 days have been reported from Malaysia (Moll 1980; Chan, unpubl. data) and Cambodia (Holloway 2003), respectively. *In-situ* nests on the Dungun River took 60–92 days to hatch (Chan et al. 2008). The Malaysian Department of Wildlife and National Parks reports that hatchlings typically emerge from the sand at their Perak River hatchery in an average of 87.6 days after the eggs are buried (Moll 1980).

Southern River Terrapins almost certainly have temperature-dependent sex determination (TSD) and pivotal temperatures determining males and females have tentatively been established. Endoscopic sex determination and TSD studies have been conducted collaboratively with Gerald Kuchling between 2004 and 2007. A preliminary study by Chan and Kuchling (2005) found eggs incubated in Styrofoam boxes at temperatures averaging 29.4 and 29.8ºC (range 25.4–33.5ºC) produced 100% males. Eggs in sand nests under natural conditions produced 100% female hatchlings in some years and a mixture of both sexes in others. In additional studies eggs were incubated at a range of temperatures using Styrofoam boxes, natural nests, experimental nests, and incubators. Findings suggest that pivotal temperature (producing equal numbers of males and females) for *B. affinis* eggs is ca. 31.5ºC (Chan and Kuchling 2005; Kuchling et al. 2007).

Hatchling emergence on the Perak River coincides with commencement of the wet season (April) and its associated rise in river levels. On the Terengganu River, hatchlings start to emerge in May, also at the onset of the monsoon. Perak River hatchlings (50 to 62 mm CL) emerge from their nests at night and immediately move to water. Moll (1980) was told by fishermen that they only find hatchlings around nesting areas during the period of emergence, and the presence of small juveniles in tidal estuaries suggests that neonates move downriver soon after emergence.

On the Setiu River in Malaysia, studies of headstarted river terrapins over an eight-month period (Chan and Chen, unpubl. data) have provided the following data. In 2009, with the help of local fishermen, 66 of 424 individuals released since 2007 were recaptured (a recapture rate of 15.6%). Juveniles hatched in 2004 and released between 2005 and 2007 averaged 301 mm CL and 4031 g when recaptured, demonstrating an average increase of 113 mm CL and 3121 g. Another cohort hatched in 2005 and released in 2007 and 2008 averaged 267 mm CL and 2811 g at recapture, an average increase of 33 mm and 969 g. Still another cohort, hatched in 2006 and released in 2009, averaged 235 mm CL and 2015 g, growing an average of 8 mm CL and 229 g after two to four months in the wild. These preliminary data demonstrate the ability of head-started terrapins to survive, grow, and adapt to natural food when released into the wild.

Adults have few predators aside from man. Although large estuarine crocodiles (*Crocodylus porosus*) may be able to eat a medium-sized terrapin, most predation takes place at the egg and hatchling stages. Monitor lizards (*Varanus* spp.) are adept at locating and excavating nests. Holloway (2003) reported the loss of a nest to a mongoose (*Herpestes* sp.). Otters and dogs have been observed pulling females off the nest to gain access to uncovered eggs. Juveniles share their habitat with a variety of potential predators (e.g., sea eagles, kites, crocodiles, carnivorous fish). Smith (1945) stated that a brackish-water shark (*Scoliodon walbeehmii*) took a heavy toll of hatchlings near the Tale Sap nesting area in peninsular Thailand. Siroky and Modry (2010) described a new species of *Eimeria* (*E. zbatagura*) from captive *B. affinis* on a farm in Singapore; otherwise, little is known about the parasites of this turtle.

Population Status. — Populations of this species are severely depleted throughout its range and extirpated from many former areas of occurrence.

Cambodia. — Pavie (1904) and Tirant (1884) reported river terrapins to be common in the Mekong drainage during the late 19th century. The turtle was being exploited for its eggs and flesh, and egg collecting was the prerogative of the "Queen Mother," which seems to have provided some protection. Bourret (1941) also noted that the turtle was common in Cambodia and Vietnam, but was probably quoting the above references. Van Dijk (in Jenkins 1995) positively identified a few shells from Cambodia dating from the 1940s as belonging to this species. River terrapins are also known to have inhabited Tonle Sap, the large lake system that communicates with the Mekong, but have since been extirpated (Platt et al. 2003, 2008). A small population was rediscovered in the Sre Ambel and Kaong River system in 2001 (Platt et al. 2003), and a juvenile was found in the Stung Proat River in neighboring Botum Sakor District (Holloway and Sovannara 2004). Heng Sovannara (pers. comm.) reported that over a five-year period (2002–2007) 23 nests were found on the Sre Ambel and Kaong Rivers, an average of 4.6 (range, 3–7) nests per year. However, only a single nest containing 23 eggs was found along the Sre Ambel in 2009 (Sovannara and Gately 2009).

Thailand. — Taylor (1970) stated that river terrapin "are not known to occur in numbers anywhere." Nutaphand (1979) reported that remnant river terrapin populations persisted in only three provinces, Phattalung, Songkhla, and Ranong. In a 1989–90 survey, Nutaphand found evidence that *Batagur* still occurred in two provinces near the Malaysian border, Phattalung (Pattharung) and Satun (Satoon) (Nutaphand 1990a; Moll 1990). In Phattalung no evidence of recent nesting was found, but fishermen occasionally brought in juveniles to the Department of Fisheries there. Occasional nests were found on sand banks lining the Klong Langu River in Satun Province as recently as 1990 (Moll 1990). Adults collected along this river are presently being kept for conservation-breeding purposes. Nutaphand (1990b) could obtain no information on recent observations of *Batagur affinis* in either Ranong or Pattani Provinces, where populations formerly existed (Boulenger 1903; Nutaphand 1979). Thirakupt and van Dijk (1994) and van Dijk and Palasuwan (2000) declared *B. affinis* to be extinct in the wild in Thailand, although Kalyar et al. (2007) reported a few wild individuals persist in the Klong Langu River.

Malaysia. — Southern River Terrapins were once very common on the major rivers throughout Peninsular Malaysia (Boulenger 1912). However, since the end of World War II the species has undergone a major decline and populations in the western river drainages are currently critically endangered. Exploitation of adult river terrapins in Malaysia has been less than in some countries of the region for several reasons. Islam, the predominant religion in Malaysia, teaches that the flesh of amphibious animals is "*haram*" (forbidden by religious law). Eggs, on the other hand, are considered to be a delicacy and thought to have aphrodisiacal properties. Throughout the 19th and early 20th centuries, harvesting of "*tuntung*" eggs was the prerogative of royalty, and nesting beaches were protected from general exploitation.

According to a British colonial official, Sir Frank Swettenham in his 19th century sketch (see Roff 1967), at least one prudent ruler, the Sultan of Perak, did not harvest eggs from the final laying of the year, so as to allow some recruitment into the population. River terrapin populations seemingly fared well in Malaysia until World War II and the Japanese occupation.

The case of the Perak River population was likely typical of what occurred throughout the country during the War. Prior to 1940, the nesting terrapin population probably exceeded 10,000 turtles, and some 375,000 to 500,000 eggs were laid annually on Perak sandbanks (Loch 1951; Khan bin Momin Khan 1964; Moll 1978, 1980, 1985; Siow and Moll 1981; Moll and Moll 2004). However, during the Japanese occupation food was scarce and previously unexploited sources of protein (such as the river terrapin) were heavily utilized. By the end of the war, *B. affinis* populations had been decimated. A survey conducted in 1976 estimated the numbers of nesting females to be between 400 and 1200 and egg production on the Perak River at less than 20,000 per year (Moll 1980). In 1989–90 the river terrapin population on the Perak River laid 25,098 eggs in 923 nests. Depending on whether these turtles average one, two, or three clutches per year, this would place the number of nesting females at between 307 and 923 (Moll 1990). In 1990–91 20,608 eggs were laid in 849 nests, indicating between 283 and 849 females in the nesting population. In 1999, only 677 nests were reported. Hendrie (2004) visited nesting sites on three Malaysian Rivers in February of 2004. On the Perak River, he reported that only eight nests were found in 2003 and that 20 had been reported as of 2 February in 2004 (near the end of the nesting season).

More recent data provided by the Department of Wildlife and National Parks (DWNP) to E.H. Chan indicate no more than 40 wild nests were found from Perak River sand banks between 2005 and 2009. After 2009 no records of wild nests were available. Captive females at the Bota Kanan facility made 35 to 55 nests per annum between 2010–2013.

The *B. affinis* population on the Kedah River in the state of Kedah was similarly hurt by exploitation during World War II, but post-war habitat destruction has been worse still. A construction boom in Alor Setar, the capital city of Kedah, during the early 1960s created a heavy demand for sources of sand. Much of the needed sand was taken from river beaches, thus destroying suitable nesting areas for the river terrapin in the process. Upstream dam construction prevented replacement sand from being carried downriver to restore that which had been removed (Moll 1997). Today relatively few *B. affinis* occur in the river. When turtles come up to nest, local egg collectors catch them and place them in pits that are partially filled with sand. Once a turtle lays its eggs, it is released back into the river (Moll and Moll 2004). DWNP data indicate that between 1994 and 2005, the number of eggs collected from nests of wild terrapins from the Kedah River ranged from 150 to 479 annually. Beginning in 2006 the DWNP staff stopped taking eggs from the wild and relied on captive breeders for their hatchery. These breeders originated from the wild and yielded about 20 nests per year.

On the Terengganu River, an island known as Pasir Lubok Kawah was for many years the most productive nesting beach for river terrapins. According to the staff at the Bukit Paloh Hatchery in Kuala Berang, an average of 60 females nested there annually from 1976 until 1987. Completion of a large dam upriver from the site in the early 1980s led to progressive erosion of the island until nesting suddenly plummeted with only seven females nesting there in 1988 and 1989 (Moll 1990, 1997). Due to the damage to nesting beaches along the Terengganu River, the hatchery and head-starting program of the Terengganu Department of Wildlife and National Parks shifted some of its egg collecting to the Dungun River. However, recent data from the DWNP suggests a reversal of nesting decline on the Terengganu River. In 2008, 99 nests from 95 females were recorded, representing the highest nest numbers since river monitoring began in 1977 (Chan et al. 2008b). These numbers have been maintained from 2009 to 2013, with numbers of nests ranging from 80 to 97 annually. In the Dungun River 30 to 49 nests have been recorded annually from 2009 to 2013 (DWNP data to E.H. Chan). The Setiu River in Terengganu has been monitored for nesting activity since 2004; Chan and Chen (2011) reported that from 2004–2009 the number of nests per year ranged from 17–30. This has dropped to no more than 10 in recent years. A newly discovered population in the Kemaman River has yielded 36–121 nests per year between 2012–2014 (P.N. Chen, unpubl. data).

Singapore. — Populations of the Southern River Terrapin no doubt historically occurred in the mangrove swamps surrounding Singapore, but are now thought to be extinct (Lim and Das 1999; Ng and Lim 2010). Introduced populations of unknown size are apparently present in several inland

reservoirs; whether or not these animals are reproducing has yet to be determined (Ng and Lim 2010; B.D. Horne, pers. obs.).

Indonesia. — Relatively few localities have been published for the Southern River Terrapin in Indonesia, all of them from Sumatra. Werner (1900) recorded the species in the "Tjinako-Fluss (Indragiri)." Nelly de Rooij (1915) listed three localities for *Batagur* in Sumatra: the Tjinako River, the Indrajiri River near Djapura, and Fort de Kock. The Museum Zoologicum Bogoriense has a specimen from Wai Sekampung in the Lampung District. A survey team assembled by Djoko Iskandar visited South Sumatra and Lampung Provinces in 1990 and surveyed 58 rivers and tributaries (Moll 1990). Information gathered from people living in these areas indicated that the species might occur in ten of these rivers, but specimens were found only in the Sungei Pasir and Wai Sekampung. A major difficulty for the survey team was that villagers often use the same local names for *B. affinis* and *B. borneoensis,* making it difficult to be sure which species was being reported. The general impression of the survey team was that both species were relatively rare in the region, while another large geoemydid turtle, *Orlitia borneensis,* was moderately common.

The team concluded that lack of development in the region was beneficial to the turtles. Sand mining was not observed on the known nesting beaches and the few roads made access to the beaches difficult. The team considered lumbering to be the most obvious negative indirect factor. Clearing of trees has opened the land to erosion, which in turn is leading to siltation of the rivers and increased flooding. Exploitation of river terrapins by local people (chiefly Muslim) has not been extensive, being mainly confined to taking eggs. However, in areas being logged, outsiders are brought in to work. Many eat turtle meat and villagers have begun collecting turtles to sell to the logging companies. As logging spreads, its impact on turtles in Sumatra can be expected to increase.

As a follow-up to the survey, in 1991 a two-man team visited Wai Tulang Bawang in Lampung to census reported nesting beaches there (D. Iskandar, pers. comm.). During two months of nightly observation and daily searches by boat, only six river terrapin were encountered and four tracks were found on nesting beaches. The survey team attributed the rarity of turtles to the high population of people near the site. Dogs harass turtles coming up to nest, many people patrol the nesting beaches looking for eggs, and sand mining has occurred since 1989, providing for the construction of housing to accommodate the rapidly growing population.

Mistar et al. (2012) conducted surveys of North Sumatra, Riau, Jambi, and Lampung provinces along the eastern coast of Sumatra and concluded that although historically present, *B. affinis* is now most likely extirpated from this region. Habitat along the rivers of eastern Sumatra has been heavily impacted by human settlements and sand mining. However, terrapin eggs (presumably *B. affinis*) were available for sale in local markets in 2010, and according to information received from local fishers a remnant population of *B. affinis* may still persist in the Indragiri River and mangrove swamps around Mumpa (Enok District, Indragiri Regency).

In recent years North and South Sumatra have been involved with exporting turtles internationally. As the Southern River Terrapin is a protected species, trade is illegal and thus not reported (Samedi and Iskandar 2000). However, given the massive unsustainable harvest of turtles that is underway in the region (Shepherd 2000; Iskandar and Erdelen 2006), survival of river terrapin populations in the country has likely been severely compromised.

Threats to Survival. — The Southern River Terrapin is heavily exploited both for its flesh and its large eggs, and also threatened by habitat destruction, sand mining, and construction of hydropower dams (Moll 1990; Moll and Moll 2000; Sharma and Tisen 2000; Iskandar and Erdelen 2006; Platt et al. 2008). In Thailand (Moll 1990) both types of exploitation have been significant and the species has been largely extirpated from the wild in that country, except for a small relict population in the Langun River area (Kalyar et al. 2007). In Malaysia religious beliefs and customs have reduced the killing of adult turtles for food. Sharma and Tisen (2000) listed dam construction, egg harvest, removal of riparian vegetation, sand mining, and incidental drowning in fishing nets as among the most important threats to the turtle. However, with the recent vast demand for turtles for consumption in China, poaching likely has been taking a steadily more significant toll (Rhodin 2000; van Dijk 2000; Compton 2000; Horne et al. 2011; Turtle Conservation Coalition 2011). The exploitation of the eggs in Malaysia became highly organized from the 1970s into the 1990s and included licensing of nesting beaches and commercial selling at rural and urban markets (Siow and Moll 1981; Moll 1984; Moll and Moll 2000, 2004). As of 2009, three licenses for collecting terrapin eggs were still given out to local villagers on the Perak River. The extent of poaching in Malaysia, due to its illegal nature, is not known but is likely significant, especially along the west coast, which has a larger Chinese population. Law protects the species, but enforcement in tidal areas tends to be lax. Interviews with riverine dwellers near Telok Intan (Moll 1990) indicated that terrapin caught incidentally by fishermen are often sold. Some fishermen purposely set nets for the terrapin (blocking small tributaries following high tide) while others fish for the turtle with hooks baited with mangrove fruit (e.g., *Sonneratia* sp.). An informant told one of us (EM) that, during an unusually dry period when the Perak River was low, a truckload of terrapins had been taken from the Telok Intan area. Egg collectors at Bota also claimed that female terrapins are being captured as they migrate upriver

to nest. Their captors keep them in captivity until they lay their eggs. In some cases these captors reputedly beat on the turtle's shell and hang them by their necks in order to make them drop their eggs. Other turtles are slaughtered to obtain the eggs.

Habitat alteration and destruction have become increasingly significant factors leading to the decline of river terrapins in many areas of Asia. Sand mining and dams are among the worst threats. Commercial sand removal for construction purposes is destroying nesting beaches throughout tropical Asia (Moll 1984, 1990, 1997). Dams located downriver from nesting sites prevent migrations between feeding and nesting sites. Dams upriver from nesting sites do not allow sand to move down river to replenish that lost to erosion or sand mining at nesting beaches. The Kedah River in Malaysia exemplifies the above problems. Dams have been built both above and below the nesting areas and sand mining has destroyed all significant nesting beaches (Moll 1984, 1987, 1997; Moll and Moll 2000, 2004).

Other important indirect factors include deforestation and siltation of rivers. On Malaysia's Perak River the combination of deforestation and tin mining has led to a major increase in the silt load which may be the cause of increased and unseasonal floods. Unseasonal floods are particularly damaging if they occur during the nesting season, when a high percentage of the annual reproductive effort may be destroyed. A 1967 flood not only destroyed the entire reproductive output on the Perak River, but also destroyed 200 eggs in the state Game Department's hatchery (Balasingam and Khan bin Momin Khan 1969; Khan bin Momin Khan 1977). Additionally floods deposit silt on nesting beaches that promotes the growth of tropical grasses on the sand. As nesting river terrapins require open sand banks for nesting, these grasses effectively destroy former nesting sites (Moll 1997).

Habitat destruction is also a problem in the feeding areas of the estuary. Clearing banks of vegetation in downstream areas has lowered the river's productivity and carrying capacity by directly eliminating food sources. In the Perak River, plantation clearance has destroyed riverside mangroves on which the turtles feed, and replaced them with rip rap (large rocks) to control erosion. Commercial prawn farms are transforming mangrove swamps into ponds. Tidal barrages have also been built which block entry into many of the small tributary streams where river terrapins feed during high tide (Lim and Das 1999; Moll 1984b, 1997; Moll and Moll 2000, 2004). A highway currently being constructed in Terengganu may affect nesting in the Terengganu River due to light pollution. Lights from a water treatment plant in the Dungun River illuminate the major nesting banks in Pasir Kumpal and Tok Chu. The plant has recently agreed to shut down this lighting during the nesting season (Chan, unpubl. data).

A large shrimp farm occupying 1000 hectares along the Chalok River (a branch of the Setiu River in Terengganu) has recently begun operations (Chan, pers. comm.). Its construction was approved despite opposition of conservation organizations such as WWF and many individuals. Huge marine shrimp farms located on the banks of rivers discharge effluents that can potentially increase salinization while introducing microbial pathogens and residues of chemicals and drugs. The water chemistry of the river is altered and the potential nutrient loading can cause eutrophication. Any increase in salinity is likely to impact the vegetation on which terrapins feed. Due to these concerns, the Department of Environment Malaysia in 2013 required this new shrimp farm to construct a discharge channel directly into the ocean.

Conservation Measures Taken. — The River Terrapin (as *B. baska*) has been listed as Critically Endangered throughout its range (A1bcd) since the 2000 IUCN Red List, based on a range-wide evaluation in December 1999 that included the populations now attributed to *B. affinis*. International trade in this species is prohibited by CITES, which lists *B. baska* (which includes *B. affinis*) on Appendix I (i.e., prohibited in international commerce by signatory nations). The United States federal listing of *B. baska* as an Endangered Species prohibits trade in the species to the USA. An action plan for the river terrapin (*B. baska* and *B. affinis*) was prepared by Platt et al. (2006). In most of these laws, regulations, and assessments the species is listed as *Batagur baska*, the name to which these *B. affinis* populations were previously attributed.

Malaysia. — The species was previously regulated in Malaysia by law at the state level (Sharma and Tisen 2000) but is now listed as a totally protected species in the Second Schedule of the new Wildlife Conservation Act 2010 of Malaysia. Control of terrapin exploitation was traditionally the prerogative of states rather than the National Government. This unfortunate situation long prevented standardized action to protect the species. Most states protected adult terrapins. Perak (from the late1960s) controlled collection of eggs by licensing, but set no limits on the harvest (Siow and Moll 1981). To obtain a license, egg collectors had to agree to provide one third of the eggs collected to the Sultan, and one third to the Department of Wildlife and National Parks (DWNP) for their hatchery. However, collectors seldom followed through with this commitment and the DWNP ended up buying eggs from the collectors at market prices in order to carry out their hatchery program. Presently two nesting banks have been set aside as reserves on each of the Perak, Kedah, Terengganu, and Dungun rivers to protect nesting females and their eggs. The Malaysian states of Kedah, Perak, and Terengganu currently have *ex-situ* conservation programs for the terrapin. Moll (1984) prepared a detailed recovery plan for the species in Malaysia. Chan and Chen

(2010) created a recovery plan specifically for Terengganu terrapins.

Malaysia has been the leader in conservation action for *B. affinis*. Having established the initial hatchery for the terrapin on the Perak River in 1967, the DWNP then expanded its conservation efforts to the Kedah, Terengganu, and Dungun rivers. The history of this now decades-old program has been chronicled by Balasingam and Khan bin Momin Khan (1969), Siow and Moll (1981), Moll (1984, 1987, 1990), Sharma (1999), Moll and Moll (2004), and Chan et al. (2008b). More recently in 2004 and 2011 conservation efforts were extended to the Setiu and Kemaman Rivers, respectively (Chan et al. 2008c; Chen and Chan 2012).

In Kedah, the DWNP terrapin center located in Bukit Pinang comprises nine concrete enclosures, one of which serves as a breeding pond. The 46 breeding adults (12 males and 34 females caught from the wild in 1977) produced 22 nests in 2007–2008. Twenty terrapins in another enclosure (8 males and 12 females hatched in 1994–1996) are being raised to become breeders. An additional 240 terrapins (91 hatched in 2001–2003 and 149 hatched in 2008) are being head-started for release. Some 6000 head-started terrapins were released into the Kedah and Muda rivers between 1983 and 2008. The center ceased collecting eggs from wild nests in 2006–07 due to low productivity of this effort and it now relies on the captive females to provide eggs for the program. In 2007 and 2008 captive females produced 20 and 22 nests, respectively. Formerly, all eggs were hatched in Styrofoam boxes inside a building. As the species almost certainly has temperature-dependent sex determination (Chan and Kuchling 2005), the sex ratio of these hatchlings was likely skewed toward males. Now, however, most eggs are placed outdoors in a sand hatchery adjacent to the breeding pond in order to produce females, and only a small portion are incubated in Styrofoam boxes with the intent of producing some males.

The Perak program, begun in 1967, is the oldest. Malaysia's Department of Wildlife and National Parks in collaboration with the Perak state government has developed a river terrapin center and "sanctuary" at Bota Kanan on the Perak River, which includes two protected nesting beaches, a hatchery, a head-start facility, a conservation-breeding population, and a small visitors' educational center.

Perak egg collectors have historically had to purchase a license assigning them to a beach where they had exclusive collecting rights. DWNP staff then purchased eggs from these collectors at market prices for the hatchery. Presently the conservation-breeding program provides many of the eggs for incubation. The current conservation-breeding population of 45 adult turtles (12 males and 33 females) is kept in a concrete pool adjoining a sand nesting area. Production for these captives has been gradually increasing from 113 eggs in 1989–90 to 854 in 2013–14.

Hatchery personnel related to Moll in 1990 that captive-laid eggs typically have lower hatching success compared to those obtained from egg collectors (25% versus 45%). Nevertheless, in 2007–08, a hatching success of 40% was attained for captive-laid eggs. From 2011–13, hatching rates increased to 46–58%. Most eggs have been incubated in simulated nests within an outdoor, fenced, concrete enclosure filled with sand. In order to obtain more male hatchlings, a portion of the eggs are currently being incubated in Styrofoam boxes that are kept indoors.

A second pond houses 340 terrapins (137 males and 203 females) hatched in 1986 that are being raised for breeding. Mating behavior has been observed among the group but no information is currently available as to whether or when nesting has occurred in this group. Juveniles being head-started include 164 hatched in 2007 and 134 hatched in 2008. These groups are typically raised for 1 to 3 years before release into the Perak River.

As of 2013 some 81,000 eggs have been incubated in the hatchery and 36,620 juveniles released into the river. Generally these releases have not been marked for subsequent recognition and thus no information has been obtained concerning juvenile survival or recruitment into the adult population. What is clear is that the restocking program has not produced increased nesting activity in the wild. Whether this represents a failure of the *ex-situ* conservation methods being used or reflects effects of some unknown factor, such as increased poaching, is unclear.

The Terengganu program, initiated in 1976, currently maintains some adults for potential use in conservation-breeding. It also has a hatchery and head-start facilities. All eggs are currently obtained from wild nests deposited on banks of the Terengganu and Dungun rivers. Initially eggs were collected only on Terengganu beaches but, following the construction of the Kenyir Dam, one of the important Terengganu beaches began eroding away due to dam-related causes (rapidly fluctuating water levels and reduction of replacement sand from upstream). By 1990 egg collection had diminished to the point that the program was shifted to other beaches on the Terengganu River as well as on the nearby Dungun River. More recently nesting on the Terengganu River has been recovering and numbers of nests have been on the rise since 2004. In 2008, an all-time high of 99 nests yielding 1373 eggs was found. From 1977 to 2013, 28,080 eggs were collected, producing 17,336 hatchlings (62% hatching success). To date 9104 juveniles have been released into the Terengganu River.

The Dungun River project has produced 9707 eggs and 7084 hatchlings (73% hatching success). The conservation program in this river was suspended from 2002 to 2005 due to lack of funds. Turtle Research and Rehabilitation Group (TRRG) of the University of Malaysia Terengganu (UMT), with the collaboration of the DWNP, reinstated the program

in 2006 with *in-situ* incubation (Chan et al. 2008a), but due to logistical problems had to be discontinued. Currently all eggs are taken to the DWNP Terrapin Conservation Center in Bukit Paloh for incubation. As in other centers, most eggs are incubated in simulated natural nests on open-air sand beaches. A small proportion is incubated in styrofoam boxes in order to produce some males.

A conservation program on the Setiu River was begun in 2004. As of 2013 some 2350 eggs have been rescued from human consumption. Using incubation methods designed to reduce sex ratio bias, the program has produced 1446 hatchlings (overall hatching success of 61.5%). To date 1286 juveniles aged 1 to 3 years have been released into the Setiu River (http://www.turtleconservationsociety.org.my/setiu-river-terrapin-recovery-project/). Cohorts from 2005 to 2009 were microchipped before release to enable subsequent identification in recapture studies.

Work on the newly discovered population in the Kemaman River was initiated in 2011. Between 2011 and 2015, a total of 3406 eggs were collected for incubation, and 2222 hatched (hatching success of 65%). To date, 2171 terrapins ranging from newly emerged hatchlings to 1.5 years old have been released into the Kemaman River (http://wwwturtleconservationsociety.org.my/projects/kemaman-river-terrapin-research-and-conservation-project/).

Thailand. — The species is nationally protected in Thailand by inclusion in Law 1, section 3 of the Wild Animals Reservation and Protection Act B.E. 2535 (1992); the species is classified as endangered (Humphrey and Bain 1990) and protected under the 1992 Thai Wildlife Conservation Act (Thirakupt and van Dijk 1994). An *ex-situ* conservation program is situated on the Klong Langu (river) in Satun Province. The project was maintaining a population of 52 *B. affinis* (29 females and 23 males) for captive breeding purposes when Moll visited the project with Nutaphand in 1990 and reviewed the breeding records. In 1987–88, 210 eggs were laid by the captives, of which 133 hatched (63% hatching success). The next year, 1988–89, 394 eggs were laid and 143 hatched (36% hatching success). Upon this visit in February 1990, 375 eggs had been laid but hatching had not yet begun. None of the hatchlings had yet been released. As of 1999, van Dijk and Palasuwan (2000) reported that 100 to 150 river terrapin were being kept at the facility but no mention was made of the breakdown between juvenile and adult individuals. In early 2009 members of the Turtle Survival Alliance (Rick Hudson, Brian Horne, and Shailendra Singh) visited the facility and reported that the river terrapin continues to breed well and that thousands are now present, but the facility has not reached its capacity. The group expressed concern about the incubation techniques that are not reliably controlled to produce both sexes. There had been no attempts to reintroduce the turtle into the wild (Hudson 2009).

Cambodia. — The species is nationally protected in Cambodia since 2005 by royal decree as the "National Reptile" and under sub-decree 123 A.N.Kr.B.K dated 12 August 2009 on Identification of Threatened Fisheries Species and its Production. Cambodia began a small conservation program for *B. affinis* in 2001. Administered by the Sre Ambel Fisheries Department of the Koh Kong Province, the program seeks to protect habitat and nesting areas, while performing awareness education and caging nests during the nesting season. Between 2002 and 2006, 19 nests containing 265 eggs were caged and 174 hatched. In 2006–07 the program expanded to include head-starting and 47 hatchlings were being raised. As of 2009, the head-starting facility contained 115 animals and release plans were being developed (Sovannara and Gately 2009). Two assurance colonies are being established in Cambodia; each consisting of 12 females and 13 males. These come from head-started animals on which micro-satellite analysis was performed to determine which groups would capture the greatest amount of genetic variability.

Indonesia. — The species is nationally protected in Indonesia under Government Regulation Act No. 7 and 8 of 1999, which is in application of Law No.5/1990 concerning the conservation of biological natural resources and their ecosystems.

Singapore. — Any native populations in Singapore (though apparently already extirpated) are protected under the Wild Animals and Birds Act, 1965, Chapter 351, and trans-shipments of the species are subjected to permits under the revised Endangered Species (Import and Export) Act of March 2006.

Conservation Measures Proposed. — To date, most conservation efforts in the region have emphasized *ex-situ* techniques (hatcheries, head-starting, and conservation-breeding). One problem with using this approach for long-lived species is that it can require decades to ascertain whether these strategies have been effective. A case in point is the Perak River program which, despite 40 years in operation, has failed to stem the decline of the local wild terrapin population which now borders on extirpation. Other problems with the *ex-situ* approach are that it is expensive, requiring permanent facilities and staff, and that it often treats only the symptoms of the problem (too few turtles) without dealing with the underlying causes of the decline (e.g., poaching of large adults, habitat loss, etc.). Unless such basic problems are resolved, dumping large numbers of juvenile turtles into the environment is unlikely to reverse downward population trends (see review in Moll and Moll 2004). Hence, on the Perak River, where habitat loss and poaching of adults are likely key problems, the *ex-situ* approach by itself has proven inadequate. Until the underlying problems of the decline are addressed there is little hope of local population recovery.

In Terengganu, sand mining along riverbanks has become quite rampant, resulting in loss of nesting habitat. Poaching has also been reported. Here *ex-situ* methods have been effective, as suggested by an observed increase of nesting on Terengganu beaches. Unfortunately there is no single conservation approach that is best (or practical) for all situations. Nevertheless, based on what is known about long-lived vertebrates and successful conservation programs (Klemens 2000; Moll and Moll 2004), there are several basic premises that can serve as guidelines for river turtle conservation actions.

1. Educate those involved or affected by the conservation program as to why the action is needed and if or how the program will benefit them. If possible, recruit and involve local residents to play an integral role in the conservation effort.

2. Ideally, all life history stages of the terrapin population should receive protection, but if this is not possible, adult females and older immature turtles should be given priority.

3. *In-situ* techniques should be favored where feasible and augmented by *ex-situ* techniques only when other options do not exist or are inadequate.

The following list of conservation measures is based on these premises and on recommendations that have been made in action and recovery plans from biologists familiar with each area (Moll 1984; Platt et al. 2006). In the final analysis workers familiar with each locality, local customs, and affected people, will have to pick and choose as to which are likely to be effective or practical in their specific situation. Each country within the species' range should prepare a national strategy for the conservation of *B. affinis,* including the following suggestions, as applicable.

Inasmuch as the Southern River Terrapin is a Critically Endangered species, the following immediate strict conservation actions are required for any river system that supports viable terrapin populations:

General Recommendations. — 1. Promote local and international education programs aimed at terrapin conservation. 2. Create protected areas or sanctuaries to safeguard the remaining terrapin habitat and nesting areas. 3. Protect all life history stages of the terrapin. 4. Ban all use and possession of wild terrapins or their products, except as needed by conservation programs. 5. Ban fishing of all types from sanctuary limits as well as fishing methods found dangerous to terrapins outside sanctuary limits. 6. Ban all sand mining from protected areas. 7. Control motorized boat traffic within sanctuary limits. 8. Provide adequate enforcement to implement these actions.

Feeding Areas. — 1. Protect adequate mangrove areas and other key feeding habitats, including adjoining small tidal streams, to provide foraging areas for river terrapins. 2. Improve feeding habitats by removing rip rap from banks and barrages blocking small tidal streams. 3. Replant mangrove and other food plants where needed.

Nesting Areas and Populations. — 1. Protect all major nesting areas. 2. Ban egg collection from the wild, and where feasible, use eggs from captive breeders for hatchery programs (in remote areas where egg bans are difficult to enforce, consider purchasing eggs from villagers for incubation, thus saving eggs that would otherwise be lost, while promoting community involvement in the conservation program). 3. Increase hatchling success by patrolling beaches to discourage natural, feral, and human predators and erase conspicuous signs such as tracks. 4. Cage nests if at all possible, but otherwise leave nests intact and as laid. 5. Allow hatchlings to naturally crawl to the river from the nest site.

Specific National Recommendations. — 1. Malaysia: regulate and prohibit sand-mining activities in the rivers where terrapins still occur, and conduct a national survey of all rivers in the country to determine the distribution of the terrapin. 2. Thailand: begin a pilot reintroduction program on a suitable river and initiate releases of head-started juveniles. 3. Indonesia: determine the current status of the species in Sumatra, including the feasibility of beginning a conservation program for any remaining population(s). 4. Cambodia: although protected by royal decree as a national symbol of the country, more protection is required.

Captive Husbandry. — As mentioned above, adults are currently being maintained in Cambodia, Malaysia, and Thailand for the purpose of conservation-breeding and eventual release. For descriptions of methods and facilities of specific conservation programs, see accounts under Conservation Measures Taken. These stocks may prove to be crucial for reintroduction as wild populations disappear.

Most of these captive facilities use techniques similar to those devised at Bota Kanan on the Perak River in Perak Malaysia (the Terengganu program comprises only a hatchery and head-starting facility without captive breeding). In the Perak program, breeding stock is housed in one or more partially shaded concrete pools with accessible man-made sandbanks. Eggs from breeders, along with those taken from the wild, are incubated in fenced, open, sandbanks. As this hatching technique can produce an excess of females, some facilities incubate a small portion of the eggs in sand-filled Styrofoam boxes within an enclosed shed in order to produce more males. Hatchlings and juveniles are raised in shallow, shaded, concrete pools for one to several years before release into the river. Turtles are fed water spinach (*Ipomoea aquatica*) as a staple and supplemented with banana and other fruits and vegetables, plus fish. Chen (2008) found a diet of commercial pellets formulated for *Tilapia* and supplemented with water spinach to be superior.

Several zoos hold or have held individuals of *B. affinis*. Pan (1990) listed zoos in Peninsular Malaya that were keeping the species. Only two had at least two adults but the sex distribution was not listed. At the time of Pan's writing, Malaysia's Zoo Melaka held 24 adults and Zoo Taiping

had two. Based on the AZA Giant River Terrapin Studbook (Poynter 2008), three zoos in the United States (San Diego, Honolulu, and Cleveland) and a private breeder held 10 males, 5 females, and 3 juveniles between them. However, there has been little success in breeding this species outside of Malaysia and Thailand. A female at the Bronx Zoo in New York laid 24 eggs in 1990 from which six hatchlings (3 normal and 3 deformed) emerged after an incubation period of 80 days (Blanco et al. 1991). Since that time, only the private breeder has met with limited success, hatching two eggs in 2007.

According to Blanco et al. (1991), captive-bred neonates were held for two days post-hatching in an incubator to facilitate yolk absorption before being moved into a water-filled aquarium with abundant plants for cover. Air and water temperatures of 27°C and 30°C, respectively, were maintained in the hatchling enclosure. Both adult turtles and hatchlings were fed *ad lib* 4–5 times weekly, the diet consisting of a wide variety of leafy greens (e.g., kale, spinach, bok choy, and dandelion), commercial turtle chow, and earthworms. The juvenile and adult diet was similar, although food provided to smaller turtles was finely minced. Supplemental feeding of vitamins and minerals was considered unnecessary. Florescent lighting of the enclosure was recommended.

Current Research. — In Cambodia, current research centers on quantifying survival and movement patterns of head-started *B. affinis* after release. Turtles are equipped with acoustic transmitters and monitored both actively and passively. Satellite telemetry is being used to monitor movement of adults from nesting areas to foraging areas between dry and wet seasons. Surveys for new nesting areas are planned, since the number of nests on the Kaong River appears stable (2–3 nests per year since 2009). Patrol teams are being trained in the Spatial Monitoring and Reporting Tool (SMART) to increase their effectiveness in deterring illegal fishing activities in hopes of reducing incidental capture of released head-started turtles. Habitat restoration of known nesting sandbanks and reforestation along denuded riverbanks is ongoing.

In Malaysia the Turtle Conservation Society plans to conduct radio-tracking studies to determine habitat utilization of the river terrapins. The study will focus on post-nesting females to investigate whether adjacent riverbanks are used and to study their movements during the nesting season. Other studies in the pipeline include a population genetics study of river terrapins, a study on the illegal poaching and trade of wild terrapins, and a survey of the distribution of river terrapins in Peninsular Malaysia.

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