Freshwater turtles of the TransFly

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FRESHWATER TURTLES OF THE TRANSFLY

This document is a report on a field trip to the TransFly region of Papua New Guinea from September 3 to September 19, 2005, to collect freshwater turtles. The study was exploratory, and so the aim was fairly ill-defined and the objectives were multiple. Our primary aim was to see what could be achieved in 2 weeks on the ground in a remote area of Papua New Guinea in progressing the broad scientific aims of our program on the evolution, systematics and zoogeography of the freshwater turtles of the Australasian region. Studies to date in Australia have been incomplete because it is not possible to ignore the strong historical connection between Australia and New Guinea during the many cycles of lower sea levels and the influence this has had on speciation and the current patterns of distribution of the Australian freshwater turtle fauna (Georges and Thomson in press).

The specific objectives of this study were to

(a) Collect tissue samples for three current projects. Samples of *Chelodina rugosa* and *Chelodina parkeri* are for the case study on the wildlife forensics of *Chelodina rugosa* funded by the Australian Federal Police (Alacs 2005); samples of *Emydura* are for a study of the phylogeography of these wide-ranging turtles (Shaffer *et al.* 1999; Georges *et al.* 2001); samples of *Elseya branderhorsti* and *El. novaeguineae* are for a revision of the genus *Elseya* based on molecular evidence.

(b) Explore the possibilities for a study of the pig-nosed turtle *Carettochelys insculpta* in Papua New Guinea, with special reference to management for conservation while concurrently meeting the needs and aspirations of indigenous people for its utilization.

(c) Evaluate the logistical parameters for work in New Guinea, including cost, transport and access to land, to enable future research proposals to be prepared that are feasible and appropriately costed.

(d) Make contact with the PNG Department of Environment and Conservation, community organizations and peak NGO bodies working in the New Guinea region with a view to exploring collaborative opportunities, as the start of an ongoing commitment.

BACKGROUND

The Chelidae is a group of side-necked turtles restricted in distribution to South America and Australasia, not known from outside this range even as fossils (Pritchard 1979). With the exception of the pig-nosed turtle, *Carettochelys insculpta*, all freshwater turtles from Australia belong to the Chelidae, comprising 21 species in 6 genera (Georges and Thomson in press). Regions of particular value for turtle biodiversity and endemism are the Mary-Burnett-Fitzroy region of coastal central Queensland (7 species, 3 endemics), the south-west corner of Western Australia (2 species, both endemic), and the rivers draining the Arnhem Land Plateau, including the Daly and Roper Rivers and adjacent drainages of the Northern Territory (10 species, 2 endemics). The Australian fauna has been reasonably well studied, in terms of their systematics (Goode 1967; Legler and Cann 1980; Cann and Legler 1994; Georges and Adams 1996; Thomson *et al.* 2000; Georges *et al.* 2002; McCord and Thomson 2002; Thomson *et al.* 2005), physiology (Kennett and Christian 1994; Booth 2002; Gordos *et al.* 2004; Georges *et al.* 2005), zoogeography (Georges and Thomson in press) and ecology (Kennett and Georges 1990; Doody *et al.* 2004; Armstrong and Booth 2005; Spencer and Thompson 2005).

Chelid turtles also dominate the fauna of the island of New Guinea to the north, with the southern lowlands home to the highest diversity of turtles in the Australasian region. A total of 10 species reside there – *Elseya branderhorsti*, *Elseya novaeguineae*, *Emydura subglobosa*, *Chelodina novaeguineae*, *C. parkeri*, *C. pritchardi*, *C. reimanni*, *C. rugosa* (formerly *C. siebenrocki*), *Carettochelys insculpta* and *Pelochelys bibroni*. Seven of these are endemic to the region. In contrast to the Australian fauna, very little indeed is known of the life history and ecology of the New Guinea forms. Much of what is known of their life history resides in the original descriptions (Rhodin and Mittermeier 1976; Rhodin 1994), the personal communications reported therein, and a few other papers (Georges and Rose 1993; Rhodin 1993; Rhodin *et al.* 1993; Rhodin and Genorupa 2000) and guides (Cann 1978; Pritchard 1979; Iskandar 2000).

This report contributes new knowledge on the diversity, distribution, habitat and reproductive biology of the freshwater turtles of the Transfly region of the Western Province of Papua New Guinea. The Transfly region comprises extensive lowland swamps, savannah woodland and monsoon forest between the lowland reaches of the Fly River and the border between Papua New Guinea and the Indonesia. It is sparsely populated by indigenous peoples who rely upon a subsistence economy built around small plot agriculture, hunting and fishing. Freshwater turtles are an important source of protein and are regularly harvested. We also report on harvest methods and trade in freshwater turtles and turtle products.

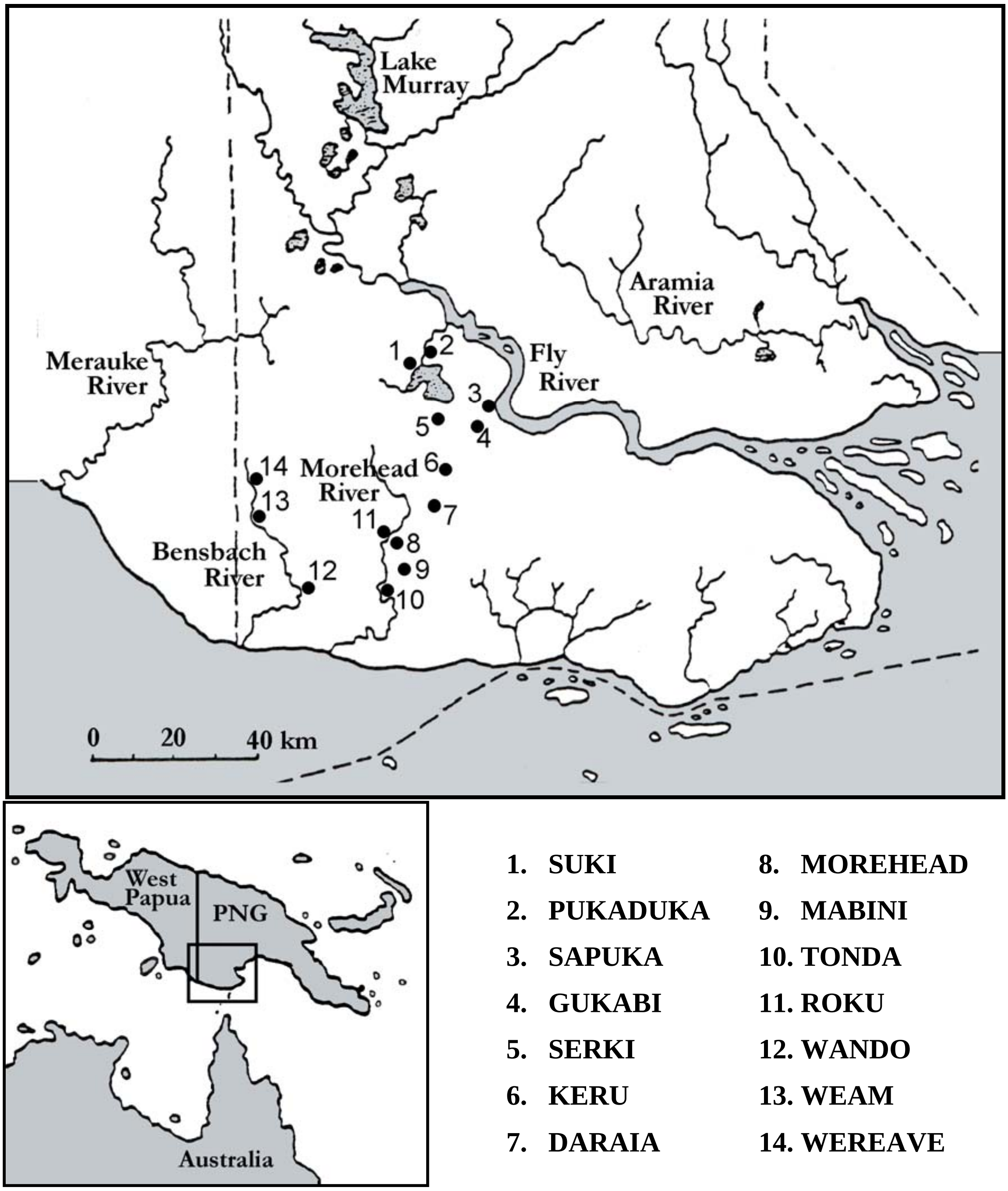

Figure 1. The study area showing the locations of villages on the Fly, Morehead and Bensbach Rivers where turtles were obtained. More precise locations of collection are given in Table 1. Map redrawn from Rhodin and Mittermeier (1976) and modified.

APPROACH

Our approach was to work within the World Wide Fund for Nature (WWF) network and with the Suki/Aramba Wildlife Management Committee to give advance warning of our visit and to request that villagers retain turtles for our examination before they were killed and consumed. We visited the villages and associated camps of Suki (08°02.97S, 141°43.50E), Pukaduka (07^{o}57.71S, 141^{o}46.07E), Gukabi (08:13.42S, 141:59.36E), Serki (08^{o}14.69S, 141^{o}45.99E), and Keru (East, 08^{o}32S, 141^{o}45.5E) in the Fly River catchment; Keru (West, 08^{o}26.68S, 141^{o}47.62E), Daraia (08^{o}37.00S, 141^{o}44.08E), Morehead (08^{o}42.95S, 141^{o}38.49), Mibini (08^{o}50.42S, 141^{o}38.14E), Tonda (08^{o}55.80S, 141^{o}33.64E) and Roku (08^{o}42.12S, 141^{o}35.92E) in the Morehead River catchment; and Wando (08^{o}53.42S, 141^{o}15.53E), Weam (08^{o}37.10S, 141^{o}08.09E) and Wereave (08^{o}31.25S, 141^{o}06.33E) in the Bensbach River catchment (Figure 1).

As standard procedure, villagers were asked for the name of their language group and the names they gave to turtles. Part of the questioning was to determine whether any of the names were generic (for any turtle) or whether any two names referred to a single species of turtle, perhaps because of joint use of names from a neighboring language group, or whether different names given to different morphotypes (juvenile vs adult) of the same species. Once a set of names was obtained, we matched these against species, by identifying diagnostic features (without leading) or with the aid of photographs in the field guides (Cogger 2000; Iskandar 2000). The names were confirmed when live specimens came to hand. By this method, we could identify which species were regularly harvested in the local area, regardless of which species were passed to us for examination. A total of 257 turtles were provided by villagers, and a further 16 were caught by us in funnel traps (after Legler 1960) baited with deer meat. Villagers were paid 2 kina for each turtle from which tissue was taken, and a further 3 kina for allowing examination of gonads.

Turtles presented for examination were identified with the aid of field guides (Cogger 2000; Iskandar 2000). Sex of adults was determined using external dimorphic characters, particularly the tail, which is much longer in mature males. Each turtle was measured (maximum carapace length, midline plastron length) with vernier calipers ($\pm$0.1 mm) and a small sliver of tissue was taken from the clawless digit of the rear foot and preserved in 75% ethanol for DNA analysis. The method and location of capture was requested and recorded.

When a specimen of *Emydura subglobosa*, *Elseya branderhorsti* or *Elseya novaeguineae* was to be killed for immediate consumption, we requested permission to examine its gonads to determine reproductive status (mature, immature) and reproductive condition. Oviducal eggs were counted when present, and egg length and width was measured with vernier calipers ($\pm$0.1 mm). Egg mass was estimated using a relationship between linear egg measurements and egg mass developed for Australian turtles (Weight = Length x Width^2 x 6.1468 x 10^{-4} – 0.12; units, g and mm; R^2 = 0.99) using the data of Judge (2001). Also counted were pre-ovulatory follicles, additional developing follicles and fresh corpora lutea on the ovary. Special attention was paid to determining if there were two or more sets of corpora lutea present, as an indication of multiple clutching (Georges 1983). Males were examined to determine if the testes were enlarged, pink and vascularized as an indication of spermatogenesis or spermiogenesis or if they were small, compact, yellow and lacking vasularization indicating quiescence (Georges 1983). Epididymides were examined to see if they were straight and translucent (an indication of immaturity), coiled and translucent (an indication of pending maturity), or coiled and white (an indication of maturity).

Details of harvest for trade was gained opportunistically. We recorded the species, the component of the turtle that was traded (live animal, meat, plastron), the buyer, and the amount received for the purchase.

RESULTS

Turtle Diversity

We obtained seven species of freshwater turtle as part of our survey (Table 1) and reliable reports of an eighth (*Pelochelys bibroni*). A possible ninth species could not be identified, and may be new. It resembled most closely *Emydura worrelli* from northern Australia. A dichotomous key to the species of the TransFly region is provided as a separate document (Attachment B) to resolve difficulties with identification, particularly with *Elseya branderhorsti* and *Elseya novaeguineae* as animals of the same size are superficially similar.

Questioning on specific names in a local language, followed by matching those names with species, is considered a robust, albeit indirect, method of ascertaining the number of species commonly encountered (Table 2). Where it was the most common species present, *Elseya branderhorsti* was acknowledged in several languages as the "regular" turtle by use of the unqualified general word for turtle (fisor, chelba, nthelon or forr). The red coloration of *Emydura subglobosa* resulted in a name drawn from the red bark of the Red Beech tree *Dillenia alata* (Mani, Maro, Mane, Mare) or from the fruit of the Walnut *Endiandra sp.* (Anki) which, when eaten, turn the lips red.

Table 1. Specimens of freshwater turtle examined from the Fly, Morehead and Bensbach Rivers. There is also a reliable report of *Pelochelys bibroni* in the Fly River, Supuka.

Waterbody	Location	Coordinates		*C. insculpta*	*C. novaeguineae*	*C. parkeri*	*C. rugosa*	*El. branderhorsti*	*El. novaeguineae*	*Em. subglobosa*	*Em. sp.*
Fly River											
Gigwa Swamp	Suki Village	08°04.00S	141°51.00E							1	
Suki Ck	Dibgwagi	08°04.00S	141°51.00E			1					
Suki Ck	Guaga Sagwari	08°07.57S	14°46.00E	1				1			
Suki Ck	Riti Village	08°04.00S	141°51.00E							4	
Suki Ck	Gwibaku	08°04.00S	141°51.00E					1			
Suki Ck	Pamena	08°07.88S	141°50.00E	7				1			
Sepuka Region	Sepuka Village	08°09.94S	142°00.03E	1	1	2					
Burei Ck	Gukabi Camp	08°13.42S	141°59.36E					4		22	2
Kouma Lagoon	Gukabi Camp	08°17.65S	141°54.60E					1		5	
Serki Swamp	Serki Village	08°14.69S	141°45.99E			4		1		31	
Bisereia Swamp	Serki Village	08°18.21S	141°59.00E							6	
Jikwa Swamp	Serki Village	08°18.21S	141°59.00E			2				48	1
Kikmatu Swamp	Serki Village	08°19.00S	141°53.04E			3				1	
Taua Taua Ck	Fosarrdebensam	08°17.43S	141°52.59E							1	
Dufideben	Keru Village	08o33.78S	141°42.63E			10				11	
Morehead River											
Aruba Ck	Keru Village	08°26.68S	141°47.62E					1	10	2	
Kasar	Keru Village	08°33.78S	141°42.63E					2			
Kerowanje Ck	Daraia Village	08°37.00S	141°44.08E					1			
Morehead R	Roku Village	08°42.12S	141°35.92E				1	3		3	
Morehead R	Morehead	08°42.78S	141°38.37E					2			
Cikire Swamp	Mibini Village	08°50.42S	141°38.14E				2				
Tonda Ck	Tonda Camp	08°55.80S	141°33.64E				9	13		2	
Tonda/Roku Region	Tonda Camp	08°55.80S	141°33.64E					29			
Bensbach River											
Bensbach R	Weam Village	08°37.10S	141°08.09E					1			
Nambilo Swamp,	Weam Village	08°44.52S	141°24.93E							1	
Mbale Swamp	Wando Camp	08°53.42S	141°15.53E				1	2			
Wando Region	Wando Village	08°53.42S	141°15.53E							3	
Bensbach R	Wando Village	08°53.42S	141°15.53E					1			

The name Kiya Eise used by the Suki people for *Pelochelys bibroni* is a reference to its soft shell margins, whereas its name Sokrere in Arammba (Serki people) means earthquake, a reference to the movement of the floating mats when *Pelochelys* passes underfoot. Budu Susa used for *Carettochelys* is a reference to the medial ridge of the posterior carapace (sharp back). The names for *Chelodina novaeguineae* are derived either from its terrestrial habits (m'bro – savannah, magi – land) or the pungent smell it emits when distressed (fasar – smell). Not surprisingly, the long neck of *Chelodina rugosa* and *Chelodina parkeri* is the basis of their common names (kakta, tanfer – long; kun, marr – neck). *Chelodina parkeri* and *C. rugosa* were not distinguished, as they did not to occur in sympatry nor were both within the range of a single language group.

It is clear from the names used in the villages of the three drainages that we visited (Table 2) that turtle species richness was highest in the Fly drainage and lowest in the Bensbach drainage, which is consistent with the species number we recorded for each of these drainages.

Harvest and Trade

Freshwater turtles and their eggs were regularly harvested for food by people of all villages we visited. All species are eaten with the exception of *Chelodina novaeguineae* whose pungent odour discourages many from consuming them. *Carettochelys insculpta* and *Elseya branderhorsti* are favoured by virtue of their large size. Typically, the plastron is removed as one piece to gain access to the meat and entrails. The gut is removed, cleared of contents and cut into small pieces. The gut, liver, heart and meat of the body, limbs, head and neck are boiled, often with kaukau (yams, *Dioscoria* sp.). Turtles provide an important source of protein to complement agricultural produce, together with Rusa Deer (*Cervus timorensis russa*), introduced by the Dutch in 1928 (Bowe 1996), Pig (*Sus scrofa/celebensis*), Wallaby (*Macropus agilis*), Cassowary (*Casuarius casuarius*), waterfowl and fish.

Turtles are captured in the rivers and streams on lines baited with deer meat, wallaby meat, fish or cashew nut, or in set gill nets, particularly *Carettochelys insculpta*, *Elseya branderhorsti* and more rarely, *Pelochelys bibroni*. Fishing beneath fruiting riparian vegetation is common, with the falling fruit attracting the turtles in. These turtles are also caught during the nesting season by digging pit traps in favored nesting areas, into which

Table 2. Names for freshwater turtles from the eight language groups we encountered during the study. Language groups were confirmed by reference to the Ethnologue (Gordon 2005) and other reports (Wurm and Hattori 1981; Ayres 1983). Spelling of names was confirmed with native speakers of the language. These names complement those published by Rhodin et al. (1980).

	Fly River		Fly/Morehead	Morehead River		Bensbach River		
	Suki (Suki, Puka-duka)	**Arammba** (Serki)	**Neme** (Keru)	**Nama Wat** (Daraia)	**Nama Was** (Mibini)	**Guntai** (Wando)	**Blafe** (Wereave)	**Rema** (Metafa)
Elseya branderhorsti	Medepka	M'bay	Fisor	Fisor Fifi	Rawk Rawk Sutafnarr	Chelba	Nthelon	Forr
Elseya novaeguineae			Fisor					
Emydura subglobosa	Tegma or Anki Kani	Maro Kani	Ngani Fisor	Mani Fisor	Mare Sutafnarr	Mare Chelba	Ntharase or Mari Nthelon	Mari Forr
Chelodina parkeri	Kunkakta	Kunkakta						
Chelodina rugosa			Tomba Kofe Fisor	Mbuirr	Weya Sutafnarr	Mbroyer	Fisuwar	Tanfer Marr Forr
Chelodina novaeguineae	Magipinini	Fasar Kani		Mboro arr	Mbro arr			
Carettochelys insculpta	Budu Susa	Budu Susa		Garr				
Pelochelys bibroni	Kiye Eise	Sokrere						
Emydura sp.	Riskap Kani							

the turtles fall when leaving the water to nest or when returning to water after nesting (Figure 2). If the eggs are laid, they are located and harvested. In the Suki swamps, nesting areas for *Elseya branderhorsti* are very limited, and the pit traps are constructed to provide an approach from water with attributes suitable for nesting (cleared of vegetation, upward slope, clay soil – Figure 2) to attract nesting turtles. In the Bensbach River, these turtles are collected primarily in the nesting season by patrolling nesting areas at night.

Figure 2. Nesting *Elseya branderhorsti* are caught in the Suki/Aramba Swamps by building pits in the limited areas of high land suitable for nesting by this species. The sloping clay deposited in front of the pit is thought to signal to the turtles the approach to a good nesting area. The female caught in this trap on the night of September 14 had nested, and fell into the pit while returning to water.

Emydura subglobosa and *Chelodina parkeri* are also captured on baited lines and in gill nets, but are caught more commonly by hand either when nesting or in shallow water. Several people form a line across a pool and move systematically across collecting the turtles as they collide with legs or arms. *Chelodina rugosa* was caught by probing the mud around the base of *Melaleuca* roots and fallen logs with a steel bladed arrow or a long bush knife. The aestivating turtle was then dug from the mud (Figure 3). A similar technique was used in the tidal reaches of Tonda Creek, where the turtles had moved from the drying swamps to seek refuge in undercut banks exposed at low tide. *Elseya branderhorsti* was caught by probing small pools in between the root masses of *Pandanus aquaticus* exposed by the falling tide. *Chelodina novaeguineae* and *Chelodina parkeri* are also caught opportunistically when encountered migrating over land.

Figure 3. Gambi Moiu retrieves a large specimen of *Chelodina rugosa* from its aestivation site beneath the root mass of a large fallen Melaleuca tree at Tonda.

All turtles collected during our visit were consumed locally. Some were traded between villagers or at informal markets, but there was no evidence of trade in live animals with the more substantial markets of Daru to the south or Sota to the west. Plastra were retained for trade. All were of value for trade with Indonesia through the border town of Sota, but the clean white plastra of juvenile *Elseya branderhorsti* yielded the greatest return. The plastra are prized as an ingredient in traditional Chinese medicine, based on centuries of traditional custom (Jenkins 1995). In Sota, plastra fetch approximately 10 kina per kg. Plastra are retained and traded for this market from as far away as Suki, using established trade avenues for deer antlers, but there was no evidence that this opportunity for trade increased harvest rate except at the PNG border communities of Wereave and Weam. Here nesting *Elseya branderhorsti* were heavily harvested during the breeding seasons of 2004 (300 turtles) and 2005 (60 turtles) for their plastra, though the meat was also consumed locally (Wereave Wildlife Officer, Silas Yanai, pers. comm.).

Live hatchlings of *Elseya branderhorsti* once fetched 25 kina per head in Sota, but a flooded market led to a drop in returns to 2.5 kina per head. Captive breeding of *Elsyea branderhorsti* is being explored in Morehead to capitalize on this opportunity for trade, but is yet to be successful in producing any hatchlings for sale. Harvested eggs were also sold locally, in groups or singly. One egg would typically fetch 10-20 toia, whereas a group of eggs would fetch between 1-2 kina. The income generated by the turtle trade provides important revenue for the purchase of rice, sugar, salt and fuel from Sota.

Habitat and Distribution

The freshwater turtles we observed differed considerably in habitat preferences and distribution. *Elseya branderhorsti* and *Carettochelys insculpta* were primarily both river turtles, but we found them also in large permanent lakes and lagoons of the Suki/Aramba swamps (e.g. Kouma Lagoon and Lake Tininseapu/Xanxu). *Carettochelys insculpta* was most common in the Fly River system and associated tributaries and lagoons, and infrequently captured in the smaller Morehead and Bensbach drainages. *Elseya branderhorsti* was most abundant in tributaries of the Morehead River (e.g. Tonda Creek, 08^{o}55.80S, 141^{o}33.64E) where fallen logs and undercut banks provided adequate cover, though substantial populations occurred also in the main channel of the Bensbach River, near Wereave (08^{o}31.25'S 141^{o}06.33E). *Emydura subglobosa* was found throughout these river systems, but is most abundant in the freshwater swamps and seasonally inundated grasslands and wetlands. Lowest densities were in the open water associated with these swamps. *Chelodina parkeri* and *Chelodina rugosa* are superficially similar (indeed not distinguished in local language), but *Chelodina rugosa* is restricted to the seasonally ephemeral *Melaleuca* swamps of the southern coastal regions where it aestivates beneath the mud during the annual dry or retreats to adjacent streams. In contrast, *Chelodina parkeri* was collected in the extensive swamps associated with the Fly River where it occupies habitat similar to that of *Emydura subglobosa*. These swamps and associated lagoons often contain water all year round, and are associated with permanent water lagoons. The habits of *Chelodina novaeguineae* are poorly known, but they spend extensive periods on land, aestivating in the dry season beneath leaf litter. The specimen we obtained was caught in terrestrial habitat.

Reproduction

Emydura subglobosa

Female *Emydura subglobosa* mature at a carapace length of 14-15 cm. The smallest mature female identified in the dissections had a carapace length of 15.33 cm and the largest immature female had a carapace length of 14.1 cm. Two mature males that were dissected had carapace lengths of 14.4 and 16.2 cm, whereas two immature males had carapace lengths of 11.9 and 15.1 cm. The latter had a translucent epididymides, but they were coiled indicating that sexual maturity was imminent. Males therefore also mature in the range 14-15 cm CL. This range is consistent with data on the maturity of males based on the external characteristic of tail length. The maximum observed size for females of 24.6 cm CL was greater than that for males at 17.4 cm CL.

The species lays white, hard shelled (calcareous), ellipsoid eggs typical of the *Emydura* in general. A total of 26 (39.4%) of the 66 mature females palpated for eggs were gravid at the time of our sampling (September 2-18). Multiple clutching was almost universal among the specimens examined by dissection. Of the 11 gravid animals for which full data were available, 8 had corpora lutea on the ovary in two sets – one corresponding in number to the eggs in the oviducts and one set of smaller structures corresponding to a previously laid clutch (Table 3). Six of these had a set of pre-ovulatory follicles and often also a set of additional developing follicles, indicating that another clutch or two clutches were to be laid in the future. Overall assessment indicated that one

Table 3. Reproductive parameters for three species of freshwater turtle from the TransFly region. Follicles were deemed to be pre-ovulatory when they contained yolked ova of a size comparable to the yolk in shelled eggs. Developing follicles were enlarged, yellow, but not yet of pre-ovulatory size. Both pre-ovulatory and developing follicles tended to be present in size classes, presumably corresponding to pending clutches of eggs. Atretic follicles were reddish or pink in colour resulting from the invasion of blood vessels and resorption of yolk (Georges 1983). Corpora lutea occurred in sets corresponding to the most recently laid clutch of eggs, and previously laid clutches of eggs. The first set could be reliably counted; presence of the second set was noted (+). An overall assessment of the number of clutches to be laid in the season is given as three digits (e.g. 1-1-2). The first digit gives the number of clutches laid prior to dissection (0 or 1), based on the number of sets of corpora lutea present minus those associated with oviducal eggs. The second digit indicates whether a clutch of eggs was in the oviducts at the time of dissection. The third digit gives and estimate of the number of clutches yet to come, based on counts of preovulatory follicles and the presence or absence of an additional set of developing follicles.

Date	Location	CL maximum (cm)	PL midline (cm)	Oviducal eggs	Sets of corpora lutea	Pre-ovulatory follicles	Additional developing follicles	Atretic follicles	Mean Egg length (mm)	Mean Egg width (mm)	Mean egg mass (g)	Number of Clutches	Source
Emydura subglobosa													
4-Sep-05	Kouma Lagoon	--	--	7	--	--	--	--	33.3 (32.6 - 34.2)	18.6 (18.0 - 19.1)	7 (6.5 - 7.3)	--	Nest
7-Sep-05	Serki Swamps	15.3	12.3	0	1 (3,0)	2	2	0	--	--	--	1-0-2	Dissection
7-Sep-05	Serki Swamps	15.4	12.3	4	1 (4,0)	1	2	0	31.9 (30.9 - 33.2)	18.1 (17.7 - 18.3)	6.3 (5.8 - 6.6)	0-1-0	Dissection
7-Sep-05	Serki Swamps	15.7	12.6	0	1 (5,0)	5	3	0	--	--	--	1-0-1	Dissection
7-Sep-05	Serki Swamps	16.7	13.5	4	1 (4,0)	4	0	0	35.3 (33.6 - 36.3)	18.6 (18.1 - 19.1)	7.4 (6.9 – 8.0)	0-1-1	Dissection
7-Sep-05	Serki Swamps	17.6	14.2	4	2 (4,+)	5	5	0	36.9 (35.5 - 38.6)	19.1 (18.9 - 19.2)	8.1 (7.8 - 8.6)	1-1-2	Dissection
7-Sep-05	Serki Swamps	17.8	14.4	0	1 (5,0)	6	4	0	--	--	--	1-0-2	Dissection

Date	Location	CL maximum (cm)	PL midline (cm)	Oviducal eggs	Sets of corpora lutea	Pre-ovulatory follicles	Additional developing follicles	Atretic follicles	Mean Egg length (mm)	Mean Egg width (mm)	Mean egg mass (g)	Number of Clutches	Source
7-Sep-05	Serki Swamps	18.0	14.5	0	2 (4,+)	5	5	0	--	--	--	2-0-2	Dissection
7-Sep-05	Serki Swamps	18.0	14.6	7	2 (7,+)	7	6	0	33.6 (31.9 - 34.9)	18.5 (18.1 - 18.9)	6.9 (6.7 - 7.1)	1-1-2	Dissection
7-Sep-05	Serki Swamps	18.5	15.0	5	1 (5,0)	7	7	0	38.8 (38.2 - 39.1)	19.2 (18.7 - 19.7)	8.7 (8.2 - 9.1)	0-1-2	Dissection
7-Sep-05	Serki Swamps	18.8	15.2	0	2 (+,+)	8	7	0	--	--	--	2-0-2	Dissection
7-Sep-05	Serki Swamps	19.2	15.5	4*	2 (5,+)	5*	4*	0	33.8 (33.2 - 34.4)	19.8 (19.6 - 20.1)	8.0 (7.9 - 8.2)	1-1-2	Dissection
7-Sep-05	Serki Swamps	19.6	15.9	7	2 (7,+)	8	6	0	35.6 (33.2 - 38)	18.4 (18 - 19.2)	7.3 (6.8 - 7.5)	1-1-2	Dissection
7-Sep-05	Serki Swamps	20.7	16.8	8	2 (6,+)	6	2	0	36.1 (35.2 - 36.9)	19.4 (19.2 - 19.7)	8.2 (8.1 - 8.4)	1-1-1	Dissection
7-Sep-05	Serki Swamps	20.8	16.9	8	1 (8,0)	11**	7**	0	36.3 (35.2 - 37.8)	20.0 (19.4 - 20.2)	8.7 (8.4 - 8.9)	0-1-2	Dissection
7-Sep-05	Serki Swamps	21.0	17.1	0	2 (9,+)	10	7	0	--	--	--	2-0-2	Dissection
7-Sep-05	Serki Swamps	21.8	17.7	0	1 (6,0)	13	0	0	--	--	--	1-0-1	Dissection
9-Sep-05	Tonda Creek	22.0	17.9	9	2 (8,+)	8	3	0	33.9 (28.9 – 36.0)	19.4 (17.0 – 20.0)	7.7 (5.0 - 8.4)	1-1-1	Dissection
13-Sep-05	Dufideben Swamp	19.4	15.7	8	2 (8,+)	3	0	2	36.7 (35.8 - 38.4)	18.3 (17.6 - 19.7)	7.4 (6.7 - 8.9)	1-1-0	Dissection

Date	Location	CL maximum (cm)	PL midline (cm)	Oviducal eggs	Sets of corpora lutea	Pre-ovulatory follicles	Additional developing follicles	Atretic follicles	Mean Egg length (mm)	Mean Egg width (mm)	Mean egg mass (g)	Number of Clutches	Source
13-Sep-05	Morehead River	21.5	17.5	11	2 (11,+)	9	>6	0	33.1 (32.1 - 34.1)	20.1 (18.6 - 20.6)	8.1 (6.9 - 8.5)	1-1-2	Dissection
Elseya branderhorsti													
7-Sep-05	Serki Swamps	38.4	31.5	32	1 (19,0)	0	0	2	47.9 (44.6 - 51.1)	27.2 (25.2 - 29.8)	21.6 (18.7 - 25.7)	0-1-0	Dissection
8-Sep-05	Tonda Creek	36.7	30.1	0	1 (10,0)	0	0	a+	--	--	--	1-0-0	Dissection
9-Sep-05	Tonda Creek	41.9	34.0	0	1 (23,0)	0	0	a+	--	--	--	1-0-0	Dissection
9-Sep-05	Tonda Creek	42.3	34.0	0	1 (27,0)	0	2	a+	--	--	--	1-0-0	Dissection
9-Sep-05	Tonda Creek	42.2	36.4	0	1 (27,0)	0	0	a+	--	--	--	1-0-0	Dissection
10-Sep-05	Morehead River	42.9	36.0	20	1 (20,0)	0	0	2	46.9 (43.4 - 52.6)	27.7 (26.8 - 28.9)	22.1 (19.4 - 25.3)	0-1-0	Dissection
2-Sep-05	Tonda Creek	--	--	15	--	--	--	--	46.3 (44.6 - 48.9)	26 (25.1 - 27.2)	19.2 (18 - 20.2)	--	Nest
14-Sep-05	Kouma Lagoon	40.5	32.6	0	1 (21,0)	0	0	0	--	--	--	1-0-0	Nesting, eggs eaten
4-Sep-05	Morehead River	44.5	35.4	23	--	--	--	--	--	--	--	0-1-0	Nesting, eggs eaten

Date	Location	CL maximum (cm)	PL midline (cm)	Oviducal eggs	Sets of corpora lutea	Pre-ovulatory follicles	Additional developing follicles	Atretic follicles	Mean Egg length (mm)	Mean Egg width (mm)	Mean egg mass (g)	Number of Clutches	Source
Elseya novaeguineae													
13-Sep-05	Aruba Creek	28.0	21.0	0	0	14	12	0	--	--	--	0-0-2	Dissection
13-Sep-05	Aruba Creek	25.8	20.5	0	0	13	5	0	--	--	--	0-0-2	Dissection
13-Sep-05	Aruba Creek	23.0	18.7	0	0	13	0	0	--	--	--	0-0-1	Dissection
13-Sep-05	Aruba Creek	23.4	19.3	0	0	11	9	0	--	--	--	0-0-2	Dissection

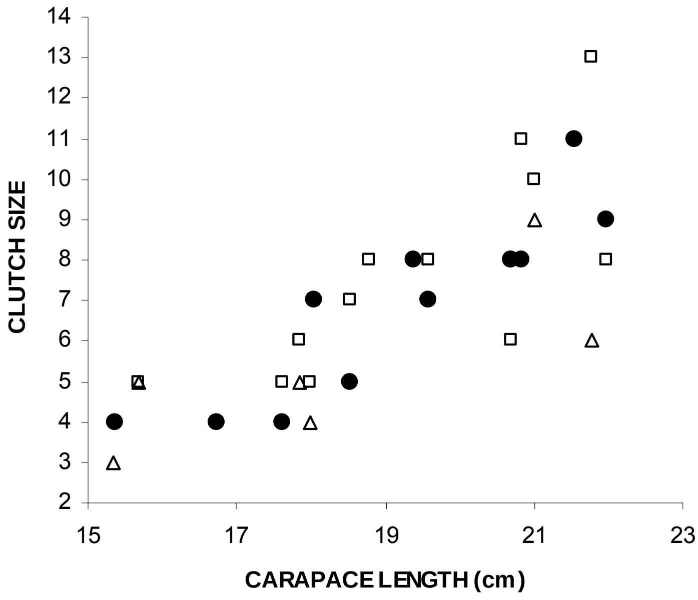

Figure 4. Clutch size as a function of carapace length for *Emydura subglobosa*. Clutch size was estimated from counts of oviducal eggs (●), corpora lutea (△), and pre-ovulatory follicles (□).

turtle would have laid 1 clutch, 4 would have laid 2 clutches, 6 would have laid 3 clutches, and 8 would have laid 4 clutches in the season.

Mean egg length was 35.0±0.05 mm, mean egg width was 19.0±0.02 mm and estimated mean egg weight was 7.68±0.20 g (n=13 clutches). Eggs ranged in length from 28.9 to 39.1 mm and in width from 17.0 to 20.6 mm. Eggs within a single clutch ranged by as much as 7.1 mm in length and 3.0 mm in width. Only egg width was significantly related to maternal body size ($F = 8.15$; df = 1,10; $p < 0.02$), but the positive relationship was weak ($R^2 = 0.44$).

Clutch size varied from 4 eggs to 11 eggs (n = 12) with an average clutch size of 7 eggs. Clutch size was strongly positively related to maternal body size, as indicated by plots of egg number from each of egg counts, counts of corpora lutea on the ovary and counts of pre-ovulatory follicles on the ovary (Figure 4). Clutch size could be predicted from maternal carapace length by the relationship

$$\text{Clutch Size} = 1.0 \times CL - 12.2 \qquad (R^2 = 0.8)$$

established from data taken from observed clutches only. Carapace length (CL) is in cm. Clutch mass averaged 51.1±5.2 g (n=13) and neither clutch size ($p = 0.44$) nor clutch mass ($p = 0.36$) were related to the number of clutches to be laid by the female in the season.

Figure 4. Typical nesting habitat for *Emydura subglobosa* in the Suki/Aramba Swamps. In this case, the nest was deposited in moist peat on a floating mat (arrow). The eggs and the substrate in which they were laid are shown as an inset. Photos: 5-Sep-05, late dry season.

From these data, we can confirm reports from local villagers that *Emydura subglobosa* is a late dry-season breeder that nests from August through to October. The species nests in moist peaty soils of the floating mats and levies in the extensive freshwater swamps in which it resides (Figure 5). Exposed areas, in some cases created by small fires set by hunters, are favoured locations. The path of nesting females in the vegetation can clearly be seen, and assists the collection of eggs by the local people. Many nests are destroyed soon after laying by unidentified predators, leaving tell-tale eggshells.

Elseya branderhorsti

The breeding season of *Elseya branderhorsti* was nearing completion at the time of sampling. Only 6 (23.1%) of 26 mature females palpated were gravid. The species also lays white, hard-shelled ellipsoid eggs, but they were much larger than those of *Emydura subglobosa*. Mean egg length was 47.0$\pm$0.05 mm, mean egg width was 27.0$\pm$0.05 mm and estimated mean egg weight was 9.00$\pm$0.90 g (n=3 clutches). Eggs ranged in length from 43.4 to 52.6 mm and in width from 25.1 to 29.8 mm. Eggs within a single clutch ranged by as much as 9.2 mm in length and 4.6 mm in width.

Clutch size varied from 15 eggs to 32 eggs (n = 8) with an average clutch size of 23.5 eggs. Clutch size was not related to maternal body size, though the range of female sizes examined may not have spanned the range of mature female sizes (CL 36.7-44.5 cm). Clutch mass was estimated to average 206.5$\pm$57.6 g (n=3).

Local people who hunt the gravid females during the nesting season report nesting in July and August, with two peaks in nesting activity, suggesting double clutching. The protracted nesting season, which with our data extends into early September, is also suggestive of multiple clutching. However, we could find no evidence of double clutching when examining ovaries (n = 8). No ovaries contained pre-ovulatory or developing follicles or more corpora lutea than there were eggs in the oviducts. If there is double clutching, then the inter-nesting period must be of sufficient duration for the corpora lutea from the first clutch to fully regress before the second clutch is laid.

Elseya branderhorsti deposits its nests in soil on banks adjacent to the streams or swamps it inhabits. At Kouma Swamp in the Fly drainage (08^{o}17.65'S, 141^{o}54.60'E, near Gukabi), the turtles moved up slope until vegetation blocked progress or the land leveled to deposit their nests in clay soil. At Tonda Creek in the Morehead drainage (08^{o}55.80'S, 141^{o}33.64'E, near Morehead), the females nested in small shallow offstream basins above the high tide mark but likely to be inundated with the first rise in water levels at onset of the wet season. The soil was loam overlaid by leaf litter and had ca 40% overstorey cover.

Elseya novaeguineae

The breeding season for *Elseya novaeguineae* had not yet begun at the time of sampling. The largest immature female (n = 3) had a carapace length of 16.9 cm and the smallest mature female (n = 4) had a carapace length of 18.7 cm suggesting a size at maturity of 17-18.5 cm for females. None of the 4 mature females examined were gravid, nor did their ovaries have corpora lutea, though all had pre-ovulatory follicles indicating that breeding was imminent. Three of the four mature females had a clear set of developing follicles in addition to the pre-ovulatory follicles, strongly suggesting that they would double clutch in the coming season. Average clutch size was estimated from these developing and pre-ovulatory follicles to range from 9 to 14 with an average of 12 eggs. From these data, we conclude that the nesting season for *Elseya novaeguineae* is late September and October. Nothing is known of its egg characteristics.

SCIENTIFIC CONCLUSIONS

This paper provides new information on a poorly studied group of freshwater turtles from the remote Western Province of Papua New Guinea. The distribution of *Chelodina parkeri* is extended with new locality data for the swamps south-west of the Fly River. It was previously recorded from the freshwater swamps associated with Lake Murray and Aramia River regions (Rhodin and Mittermeier 1976; Iverson 1992). We confirm its presence in similar habitat south and west of the Fly River (the TransFly region), but within the Fly drainage basin. Our study confirms that *Chelodina rugosa* (formerly *C. seibenrocki*) in the Western Province is restricted to the coastal swamps. Its habitat is consistent with that found in Australia – seasonally dry *Melaleuca* swamps where it survives the dry-season by burying in mud or seeking refuge in adjacent small permanent streams, in this case, tidal streams. This habitat is very different from the swamps occupied by *C. parkeri*, dominated by inundated grasses and extensive floating mats, subject to seasonal reduction but only complete drying in exceptionally dry seasons. It appears that habitat preferences maintain effective spatial separation between these two closely related species (Rhodin and Mittermeier 1976).

Carettochelys is reported to be widespread in southern New Guinea, but, in the region we visited substantial populations occurred, only in the Fly River drainage. It was occasionally caught in the Morehead and Bensbach drainages but, with the exception of Daraia, the villagers there do not have a name for it. When it has been caught, it is so unfamiliar that it has been released in the belief that it is a turtle spirit. In northern Australia, *Carettochelys insculpta* is sometimes caught in minor drainages such as the Adelaide River, but substantial populations occur only in the major drainages of the Daly River and Alligator Rivers region. It appears that the same may be true in New Guinea, with substantial populations in the Fly, Kikori and Purari (Georges and Rose 1993) and exceptionally low populations in smaller rivers such as the Morehead and Bensbach. It is impossible to judge if this is due to harvesting of populations, unsustainable by virtue of smaller population sizes, as some local people believe. *Pelochelys bironi* is widespread but rare in southern New Guinea (Rhodin *et al.* 1993) and it is not surprising that we did not obtain any.

In this paper we provide new information on the reproduction of three of the eight species we collected. *Elseya branderhorsti*, *Elseya novaeguineae* and *Emydura subglobosa* were selected because they were engaged in breeding activity at the time of our visit. Reproductive patterns in chelid turtles have been classified as temperate (typically nesting at the time of the Austral spring and early summer) and tropical (typically nesting at the time of the Austral winter) (Legler 1981; Legler 1985). Both patterns were evident in the species we examined. *Elseya branderhorsti* exhibited the tropical pattern expressed in other species of the *Elseya dentata* group (sensu Georges and Adams 1992; Georges and Adams 1996) and the *Chelodina rugosa* group (sensu Georges *et al.* 2002). *Emydura subglobosa* and *Elseya novaeguineae* exhibited the temperate pattern of the *Emydura* generally, *Elusor*, *Pseudemydura*, *Rheodytes*, the *Chelodina longicollis* group and the *Elseya latisternum* group. The multiple clutching demonstrated in *Emydura subglobosa* and *Elseya novaeguineae*, and not eliminated as a feature of the biology of *Elseya branderhorsti*, is typical of chelid turtles residing at latitudes with relatively long activity seasons (Georges 1983; Legler 1985).

MANAGEMENT ISSUES

Exploitation of freshwater turtles in New Guinea is thought to have increased in recent times (Rose et al. 1982; Georges and Rose 1993). More people moved to live along riverbanks as tribal warfare ceased, and the population of Papua New Guinea has doubled since 1971. Modern technologies have improved access, especially the introduction of outboard motors, and modern fishing gear has increased catch rates. Harvest rates may also be responding to the establishment and growth of a market economy (with the introduction of modern technologies improving market access) as opposed to increased subsistence rates being driven directly by population increase. In the Western Province, the impact of these factors is greatly moderated by the scarcity and cost of fuel and the lack of fundamental infrastructure to facilitate travel and transport of goods. The Asian turtle trade, feeding new and expanding markets in China, is resulting in often dramatic declines in freshwater turtle populations in the broader region (van Dijk *et al.* 2000), including neighboring Indonesia which has legalized trade and set generous quotas for a range of species common to both Papua New Guinea and Indonesian West Papua (Samedi and Iskandar 2000). Prices of up to $US2,000 for specimens of the chelid turtle *Chelodina mccordi* coupled with a legal quota of 450 animals rapidly sent this species to commercial extinction and threatened it with biological extinction in its natural habitat on Roti (Rhodin and Genorupa 2000; Samedi and Iskandar 2000). High commercial value for species found in Papua New Guinea provides motivation and proximity provides opportunity for illicit trade in turtles across the PNG/Indonesian border, trade that may lead to local population declines. Such trade has been well documented (Rhodin and Genorupa 2000), and is a major concern to the wildlife authorities in Papua New Guinea (Barnabas Wilmot, pers. comm., 2005). In the regions we visited, exploitation at a rate driven higher by trade opportunities with Indonesia was limited to villages close to the Indonesian border. The PNG Department of Environment and Conservation has received applications to legalize turtle trade, in much the same way as harvest trade in *Crocodylus novaeguineae* is legal and regulated (Hall 1990).

There are opportunities for revenue generation by remote communities, each with its own risks. The first is to provide hatchling turtles for the pet trade. This is best done through the regulated harvest of eggs using techniques developed for a similar industry in northern Australia (see Attachment A). The colorful *Emydura subglobosa* and the ornately patterned *Chelodina parkeri* show greatest potential among the chelid turtles. *Carettochelys insculpta* will always be in demand because of its striking appearance and unique position among turtle families. It is unlikely that trade in *Pelochelys bibroni* will be permitted, given its current conservation status.

Trade in hatchling turtles carries with it considerable commercial risk. This risk, clearly evident in the recent trade in *Carettochelys insculpta*, and to a lesser extent *Elseya branderhorsti*, is that while initial prices can be high, they are subject to dramatic collapse when the market is saturated. *Carettochelys insculpta* hatchlings are now available in Asian markets for $US5, and the initial price for *Elseya branderhorsti* hatchlings of 25 kina soon collapsed to between 2 and 3 kina. Supply and demand is often not under the control of any single enterprise which, having done all the development work, finds its market undercut by more efficient parties closer to commercial centres in their own country or in the countries generating the demand. Asian turtle aquaculture is becoming more sophisticated and can severely undercut a market if they obtain breeding stock. This risk can be ameliorated by associating the hatchlings with the source in a way that yields preferential treatment in the market. Hatchlings can be marketed on the basis of their association with legal and sustainable indigenous industry, such that the purchase of the hatchling is seen to support a community striving for self-determination while maintaining traditional cultural values among its youth. It is yet to be seen if such a strategy can result in a niche market.

Development of an industry based on hatchlings for the pet trade is impeded by lack of information on captive rearing for most species, and where it is available (e.g. *Chelodina rugosa*, Fordham *et al.* 2004), it is not accessible by local villagers. The one attempt at captive breeding suffered from a number of fatal deficiencies (housing, male:female ratios, densites) arising from the lack of knowledge of the fundamentals.

A second market is for adult turtles or turtle products. There is a clear market for turtle meat for the food trade and turtle products for the Asian medicinal trade. It is possible to capitalize on these opportunities through either farming or harvest of species valued by the market. The risk is that harvest of adult populations of almost any turtle is unlikely to be sustainable because of their life history attributes – almost all of their investment in the future resides in the adult, which are long lived and suffer low levels of natural mortality once beyond a certain size. Harvest of adults has demonstrably caused dramatic declines and extinctions among turtle populations globally, most recently as a result of the Asian turtle trade. There is insufficient demographic information on any New Guinea turtle species to make a reasoned judgment on the level of harvest that would be sustainable. This knowledge gap needs to be addressed before local communities can capitalize on the commercial opportunities provided by the turtle fauna without risking collapse of the resource and the implications for their concurrent subsistence economy that would follow. Breeding and rearing of turtles for the meat and medicinal trade may be possible, and could be explored in the case of species with rapid growth.

A final observation relevant to management relates to the impact of invasive exotic grasses. We observed vast tracts of wetland visually dominated by exotic grass, probably Para Grass (*Brachiaria mutica*), which is displacing native wetland communities. The impact of such invasions on waterfowl is well documented, but its impact on infauna such as freshwater turtle abundance and diversity should also be of concern.

OUTCOMES IN RELATION TO OBJECTIVES

(a) Tissue samples

We had a target of 30 animals per species per drainage or subdrainage, to allow accurate estimation of haplotype frequencies for population genetics. This target was achieved only for *Elseya branderhorsti* in the Morehead River and *Emydura subglobosa* in the

Fly River, with a sufficient sample of 22 *Chelodina parkeri* from the Fly River. Nevertheless, the samples obtained for all species in all rivers was sufficient to obtain useful information about sub-structuring of these populations, if any, across the TransfFy region. Further sampling may be necessary, depending upon the outcome of the molecular analysis. Sufficient numbers of *Chelodina rugosa* were obtained for the forensic study.

(b) Potential for a study of the pig-nosed turtle *Carettochelys insculpta*.

The TransFly region we visited was in the lower reaches of the Fly River drainage and the Morehead and Bensbach Rivers. *Carettochelys* was very uncommon in the Morehead and Bensbach Rivers, and although reasonably common in the Fly River (especially at the junction of the Fly River with Suki Creek), there were no substantial nesting banks in the vicinity that would allow for a fully integrated study of its conservation and management. The Kikori region may be more suitable for a study of this kind, given reports of the number of animals and eggs harvested there (Georges and Rose 1993, Matt Pauza, pers. comm., 2004). Sites further upstream in the Fly River may also be suitable. A site with nesting of both *Carettochelys insculpta* and *Pelochelys bibroni* would be ideal, because of their contrasting modes of sex determination.

(c) Logistic considerations and importance of liaison

Collecting freshwater turtles for study in Papua New Guinea to address a range of scientific and management questions is clearly feasible, provided a good relationship is established and maintained with local communities. The success of the current trip depended critically on the support of the local villagers communities and in particular, the Suki/Aramba Wildlife Management Committee, support that was brokered by the World Wide Fund for Nature (WWF). This demonstrates the need to work closely with NGOs and the local communities, and ensuring that the work meets objectives of mutual benefit.

A verbal report of this research was presented to the Department of Environment and Conservation, who indicated that the information gathered would be valuable for their planning. They committed to support future work.

Full costing for the field trip is included in Appendix 1 as a basis for future planning and marshalling financial support.

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APPENDIX 1

Financial Statement of Costs

		Unit Cost	x	Units	x	Units	Total	Cumul. Total	Comments
Collaborative Research									
Health	Malarone	110	3	weeks	2	person(s)	660	660	Malarial Prophylactic
	Riamett	129	1	treatment	2	person(s)	258	918	Malarial Treatment
	Antibiotics	20	1	treatment	2	person(s)	40	958	Broad Spectrum
	Immunization	120	3	sessions	2	person(s)	720	1678	PNG specific
	Consultations	70	3	sessions	2	person(s)	420	2098	
Travel (International)	Airfares (Canberra-POM-return)	2935	2	person(s)	1	null	5870	7968	Qantas Economy Fare
	Excess baggage (International)	14.7	75	kg	1	null	1102.5	9070.5	Quoted, Air Niugini
	Accommodation	88	5	days	2	person(s)	880	9950.5	Gateway Hotel, POM
Travel (Internal)	Airfares (POM-Suki-return)	269.12	2	legs	2	person(s)	1076.48	11026.98	Airlines PNG
	Excess baggage (Internal)	3.992	75	kg	2	legs	598.8	11625.78	Quoted, Airlines PNG
	Boat Hire (active)	60	6	days	1	boat	360	11985.78	Quoted, Naipu Trading
	Boat Hire (idle)	20	8	days	1	boat	160	12145.78	Quoted, Naipu Trading
	Boat Fuel	2	40	litres	6	days	480	12625.78	Quoted, Naipu Trading
	4WD Hire	160	5	days	1	null	800	13425.78	Quoted, Fesua Trading
	Accommodation and meals	65	14	days	2	person(s)	1820	15245.78	incl. accompanying persons
Wildlife Licenses and Fees	Turtle purchases	0.8	500	turtles	1	null	400	15645.78	
	Importation licenses	30	1	permit	1	shipment	30	15675.78	
	Freight of specimens	450	1	shipment	1	null	450	16125.78	
Consumables	Ethanol	25	3	litres	1	null	75	16200.78	
	Tubes	0.25	500	tubes	1	null	125	16325.78	
	Miscellaneous	300	1	null	1	null	300	**$16,626**	**TOTAL**
Consultancy Additional									
Salaries	Field (Chief Investigator)	478.26	21	days	1	person(s)	10043.48	26,669.26	
	Field (Research Assistant)	208.70	21	days	1	person(s)	4382.61	31051.87	
	Analysis and Reporting (CI)	478.26	3	days	1	person(s)	1434.78	32486.65	
	Analysis and Reporting (RA)	208.70	5	days	1	person(s)	1043.48	33530.13	
	Oncosts/overheads on salary	22339.13	0.8	multiplier	1	null	17871.3	**$47,054**	**GRAND TOTAL**