

## Trade in Wildlife in Bali, Indonesia, for Medicinal and Decorative Purposes

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### INTRODUCTION

Bali, Indonesia's smallest province, is a popular tourist destination, renowned for its pristine beaches and coral reefs, as well as its Hindu temples and cultural art forms. In 2012, some three million international tourists visited the island, in addition to over six million domestic visitors (Admojo, 2013). In the area of wildlife trade, Bali is a significant location for the exploitation of marine turtles, mostly for meat (Sudiana *et al.*, 2009), as a transit point for the export of coral and marine fish for the aquarium trade (Bentley, 1998; Lunn and Moreau, 2004), and, to a lesser extent, the live bird and primate trade for pets (Nijman, 2005; Jepson, 2010). Efforts to tackle the trade in the Bali Starling *Leucopsar rothschildi* that led to its near extinction in the wild, date back to the early 1980s (e.g. De longh *et al.*, 1982; Van Balen *et al.*, 2000) and have been operating more or less continuously, but many other wildlife trade-related initiatives appear to be less consistent. Bali's trade in wildlife for medicinal purposes or sale as decorations or curios (items of interest or curiosity) has not been explored in any depth, and to date has not been widely reported.

### LEGISLATION

Indonesia has strong environmental laws, and many vulnerable native species are protected from exploitation under *Law No 5* of 1990. Harvest and trade in non-protected species for designated purposes (such as "live pet trade"), is subject to a quota system (Shepherd, 2010; Nijman *et al.*, 2012). All trade in protected species is prohibited, and the law clearly states that offenders are liable for fines of up to IDR100 000 000 (USD10 000) as well as imprisonment for up to five years. Indonesia has been a Party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1978 and has ratified the Convention on Biological Diversity. It is not a member of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), however, Indonesia has signed CMS's Memorandum of Understanding for conserving marine turtles of the Indian Ocean and South-east Asia; it has not agreed to similar MoUs for the Dugong *Dugong dugon* or sharks.

### METHODS

Between 19 and 23 June 2013, the authors surveyed three markets on Bali that provided for the animal curio and medicinal trade, i.e. Satria and Kreneng markets in the capital city Denpasar, and Beringkit market in the town of Mengwi, some 18 km west of Denpasar. Each outlet potentially selling wildlife was surveyed and all wildlife products on display were counted. Wildlife products were sold in shops or stalls specializing in wildlife items, but many also typically sold other items such as gemstones, fossils and antiques (Fig. 1). Five traders visited during this survey could be described as "healers" or "mystics", selling their products for medicinal purposes and dispensing medicinal advice. All traders catered to the general public, although at least four traders in Satria also supplied wildlife items to the wholesale

markets (primarily stingray tails and decorative items to Balinese antique traders). Wildlife items were openly on display and there was no recourse for the authors to employ undercover techniques during this survey. The first author is fluent in Bahasa Indonesia, the official language of Indonesia, and discussions with traders were conducted in that language. Only items that were on display in outlets were recorded and photographed. No purchases were made. Ubud and Tampaksiring, two towns in central Bali, were also visited by the authors in June 2013, where a brief spotcheck was made of a selection of locations.

All animal parts and products on display in market stalls were identified and counted. This survey focused on trade of wild (i.e. not domesticated) animal species and excluded all trade in live animals, which was mainly confined to a separate section in Satria market. Large suid canines were included as they could have derived from Wild Boar *Sus scrofa* (found on Bali) or even Javan Warty Pig *S. verrucosus* (found on nearby Java). Ivory items were examined to confirm that they were made from genuine elephant ivory, and not bone or resin, noting that elsewhere on Bali (in the village of Tampaksiring) the authors had observed the presence of mammoth and Walrus *Odobenus rosmarus* ivory (Nijman, pers. obs., June 2013). Also seen were a number of canine-shaped items that resembled large cat canines but which were found to be carved from Dugong bones. Whenever possible, specimens were classified to the lowest taxonomic level. For a few specimens, much of the available characterization was to genus level only; however, where there was a high likelihood of species identification but uncertainty due to a lack of distinct physical characteristics and/or unknown origin, such cases were recorded as genus cf. species (e.g. *Nycticebus cf. javanicus*). Prices collected for Dugong items quoted in Indonesian Rupiah have been converted into US dollars at an exchange rate of IDR10 000 to the dollar.

## RESULTS AND DISCUSSION

### General observations

At least 28 species were observed during the course of the survey; specimens of 26 species were seen in Satria market (28 outlets selling wildlife curios), 16 species in Beringkit (16 outlets selling wildlife curios) and 11 species in Kreneng (five outlets selling wildlife curios) (Table 1). The authors recorded large numbers of fakes, especially large cat and bear claws (some even had small pieces of “fur” attached that was obviously not genuine), teeth (made from resin or carved from bone) and skin (painted goat skins, some of which had been made into dagger handle covers). All observed rhinoceros products (horn, teeth, skull, some allegedly fossilized) were deemed to be fake. Trade was largely directed at local Balinese or visitors from other parts of Indonesia and there was no indication that foreign tourists were specifically targeted. Visitors to the markets were overwhelmingly Indonesian and all signage was in Bahasa Indonesia.

### Purported uses of items on sale

Most species were traded either as curios, as talismans or for decorative purposes; these included marine shells, antlers and skulls, and feathers of Green Peafowl *Pavo muticus* (classified by IUCN as Vulnerable). Teeth of various species (sharks, carnivores, Dugongs) and bones of Javan Slow Loris *Nycticebus cf. javanicus* are used as amulets for protection. A smaller number of species were traded specifically for medicinal purposes, although it was sometimes difficult to differentiate between medicine and mysticism. These included cobras and skinks (rendered down “cobra oil” being offered to cure a wide range of skin ailments such as eczema and burns; “skink oil” to cure skin ailments as well as allergies, open wounds and ulcers); deer and muntjak antlers (with small slices being sold to be boiled down into a tonic). Slow loris bones that had been rendered into a tonic or a paste,

were said to relieve the symptoms of asthma. One trader claimed that stingray tails cured osteoarthritis, but more frequently were said to be used to protect a house from the influences of black magic and to maintain domestic harmony. Sawfish *Pristis* spp. heads and/or rostrums, as well as the rostrums of Swordfish *Xiphias gladius*, were also said to be used to protect home, kitchen and garden. Finally, Dugong bones, carved into peg-like shapes and placed around wet rice fields, were stated to be used by farmers to ward off pests. Dugong “tears” (*Mata Air Duyong*, a mixture of the eye’s gelatinous vitreous body and alcohol, when genuine) and Dugong oil (rendered down fat mixed with alcohol) were on sale for use as a love potion, to reconcile couples or to bring fortune.

### Status of species for sale

A large number of species observed in trade were CITES listed (n=14) and/or were considered globally threatened (i.e. Critically Endangered, Endangered or Vulnerable according to IUCN Red List threat criteria) (n=10), and almost 60% of species (n=17) observed were protected under Indonesian law. For each species, the number of curio or medicinal items on display ranged from just one or a few pieces being sold by a single trader, to up to a hundred or more pieces sold in a dozen outlets. There was no appreciable difference in the number of items for sale at each outlet or the number of stalls that displayed specimens of species, and the species’ IUCN Red List status, nor was there a difference between the number of items for sale at each outlet that were of protected species and those that were not protected, or ones that were included in the CITES Appendices or ones that were not. The trade was open and the authors did not get the impression that other species or items were being kept hidden or that protected species were treated differently from non-protected species.

Apart from six species, all those recorded in trade are found on Bali or its surrounding waters but none of them exclusively so. The six species not found on Bali are all present in other parts of Indonesia: the trade in teeth and claws of Sun Bear *Helarctos malayanus* and Tiger *Panthera tigris*, and elephant ivory, suggest trade links with Sumatra and possibly Indonesian Borneo; the observation of Green Peafowl and Javan Slow Lorises *Nycticebus cf. javanicus* suggests trade links with eastern Java. Babirusa *Babirusa cf. celebensis* skulls originated from the island of Sulawesi or its off-lying islands, to the north of Bali.

### Significant trade

**Marine molluscs:** while only small numbers of Horned Helmet *Cassis cornuta*, Triton’s Trumpet *Charonia tritonis* and Chambered Nautilus *Nautilus pompilius* were observed in the markets in Denpasar and Mengwi, some 89 Chambered Nautiluses were seen in one shop alone in Ubud (a town in central Bali visited briefly by the authors in June 2013), indicating that the trade in this mollusc species may be thriving in Bali. The specimens



Fig. 1. Wildlife products for sale, including Dugong bone, Slow Loris bones, shark teeth and cat claws, Beringkit market, Bali, June 2013.

Species common name	Scientific name	Market	Stalls	Status	whole	teeth	tail	claw	bones	skull	antler	other
Chambered Nautilus	<i>Nautilus pompilius</i>	S	2	P	5							
Horned Helmet	<i>Cassis cornuta</i>	S	2	P	11							
Triton's Trumpet	<i>Charonia tritonis</i>	S	2	P	3							
Kuhl's Stingray	<i>Neotrygon kuhlii</i>	SKB	12	DD		284						
Cowtail Stingray	<i>Pastinachus sephen</i>	SKB	11	DD		98						
Hammerhead shark	<i>Sphyrna</i> spp.	S	2							4		
Shark		SKB	8			>200				7		
Sawfish	<i>Pristis</i> spp.	SB	4	P,CR,I		7				5		
Swordfish	<i>Xiphias gladius</i>	SKB	11			232						
Cobra	<i>Naja</i> spp.	B	1		20							18 bottles cobra oil
Salt-water Crocodile	<i>Crocodylus porosus</i>	SB	2	II		3						
Common Sun Skink	<i>Eutropis multifasciata</i>	B	1		45							
Hawksbill Turtle	<i>Eretmochelys imbricata</i>	S	1	P,CR,I								15 bekklo pieces
Dugong	<i>Dugong dugon</i>	SKB	14	PVU,I	I	13			12			See Table 2
Dolphin		S	3	P,II		2				I		
*Javan Slow Loris	<i>Nycticebus cf javanicus</i>	SB	2	P,EN,I					2			
Long-tailed Macaque	<i>Macaca fascicularis</i>	S	1	II						I		
Sunda Porcupine	<i>Hystrix javanica</i>	S	1									3 sets of quills
Leopard Cat	<i>Prionailurus bengalensis</i>	SK	4	P,II				30		I		
*Tiger	<i>Panthera cf tigris</i>	S	6	P,EN,I		2		8				
*Sun Bear	<i>Helarctos malayanus</i>	SKB	8	PVU,I		15		24		I		
Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	S	1							I		I skin
*Red Muntjak	<i>Muntiacus muntjak</i>	SKB	6	P						10		10
Javan Deer	<i>Rusa timorensis</i>	SKB	7	PVU						3		10
*Babirusa	<i>Babirusa cf celebensis</i>	S	1	PVU,I						3		
Wild Boar	<i>Sus cf. scrofa</i>	SKB	6			25						
*Asian Elephant	<i>Elephas maximus</i>	SB	2	P,EN,I								2 ivory pieces
*Green Peafowl	<i>Pavo muticus</i>	S	1	P,EN,II								10 feathers
White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	K	1	P,II						I		
Frigate bird	<i>Fregata</i> spp.	B	1							I		I foot

**Table 1. Animals and animal products for sale at Satria (S), Krenang (K) and Beringkit (B) markets, Bali, between 19 and 23 June 2013, inclusive.**

Status: P=protected in Indonesia; DD=Data Deficient, VU=Vulnerable, EN=Endangered, CR=Critically Endangered; I=Appendix I and II=Appendix II of CITES. Species not occurring on Bali or in Balinese waters are preceded by an asterisk.

of these three species were claimed by retailers to have derived from the seas surrounding Bali, and not imported from elsewhere in Indonesia (Fig. 2). It is increasingly recognized that the international trade in Chambered Nautilus for the international shell trade has detrimental effects on population survival. In preparation for CoP15, held in March 2010, the US Fish and Wildlife Service initiated a public consultation process requesting input on potential species proposals. The Humane Society of the United States and the Humane Society International responded with a request to consider submitting an Appendix-II listing proposal for Chambered Nautilus due to concerns that populations were at risk of over-exploitation. Together with the National Marine Fisheries Service (NMFS), FWS began an assessment of the taxa. Their findings concluded that, while several nautilus life history traits render them vulnerable to being overharvested in the wild, and aspects of the fishery and trade have the potential to lead to overfishing, biological information and global industry data are insufficient to fully assess the impact of international trade on these taxa. For these reasons, the USA did not propose listing nautilus in the CITES Appendices at CoP15 (De Angelis, 2012).

**Rays:** the dried tails of two species of stingray—Kuhl's Stingray *Neotrygon kuhlii* and Cowtail Stingray *Pastinachus sephen*—were available for sale in large numbers (Table 1) for medicinal or decorative purposes. Some shops offered single tails, but most specimens were displayed in bundles of ten or more, such that reported counts in this survey are likely to be an underestimate of the total volume of trade. While rays are not protected under Indonesian law, no quota has been established allowing these taxa to be traded commercially, deeming all observed trade illegal. Skulls and the saw-like rostrum of the Critically Endangered sawfish *Pristis* spp.—species of ray—were offered for sale in Satria (with one rostrum at Beringkit). In recent years it has been increasingly clear that the trade in rays is not sustainable, and Parties have discussed the role of CITES in regulating this trade at the last three meetings of the Conference of the Parties (Vincent *et al.*, 2013; Lack and Sant, 2012).

**Dugong:** Dugongs *Dugong dugon* are coastal marine mammals found in the Indo-Pacific region, and threatened in part by overexploitation and trade. Dugong parts were the most commonly available items derived from protected species on offer in the Bali markets surveyed, with sales attributed to both medicinal and decorative purposes. Of all the species surveyed, Dugong items were openly displayed in the greatest number of outlets and were recorded in all three markets (Table 2). It was difficult to verify whether the items claimed to be Dugong were genuine; however, the apparent frankness and openness of traders, as well as the frequency of unsolicited responses by numerous traders identifying the items as *Ikan Duyong* [Dugong], suggests authenticity. Dugong ribs and other long bones are very solid and contain little or no marrow, which, according to traders, make them ideal for carving.



Fig. 2. Chambered Nautilus for sale in Ubud market, Bali, June 2013.



Fig. 3. Eight Babirusa skulls were observed in Bali in June 2013, including this one photographed in Tampaksiring.

Fig. 4. Carved dagger handles made from Dugong bone, for sale in Bali, June 2013.



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Cigarette pipes mostly carved from rib bones, as well as other bones or tusks, were the most frequently recorded item pertaining to Dugong. These pipes were typically sold alongside other pipes made from resin or other synthetic material. The custom of selling a combination of authentic and artificial products was similar to the situation in Sumatran wildlife markets, although the pipes there were made out of elephant ivory (V. Nijman, unpubl. data from surveys in 2008–2010). The most expensive items made of Dugong parts were two carved dagger handles (Fig. 4), offered for USD150 each. One healer/mystic had a complete Dugong skeleton on display, and other traders offered bottled Dugong “tears” for sale. Dugongs are hunted throughout their range for their meat (Marsh *et al.*, 2002) which may potentially be the source of the bones and tusks (E. Burgess, *in litt.*, October 2013); trade in Dugong parts as curios and for medicinal purposes has been reported in small quantities from nearby Thailand, Viet Nam, Malaysian Borneo and eastern Indonesia, but hitherto not from Bali (Marsh *et al.*, 2002; Rajamani *et al.*, 2006).

**Primates:** one Long-tailed Macaque *Macaca fascicularis* skull was observed for sale in Satria market, and two sets of slow loris bones—one each in Satria and Beringkit. Long-tailed Macaques are found throughout Bali and while often revered by the Hindu inhabitants, are also traded as pets. Slow lorises are not native to Bali and reach their easternmost distribution in Java (Nekaris, 2013). It is uncertain which of the eight species of slow loris were observed for sale but the use of the word “*Tukang*” suggests the individuals were derived from adjacent eastern Java. In the authors’ experience, the term “*Tukang*” is only used in that part of Indonesia as opposed to the more widespread “*Kukang*”. Hence it is likely the slow lorises in Bali were Javan Slow Lorises *Nycticebus javanicus*. In late 2012, P. Harzani (pers. comm. 2013, with photographs shown to the authors) observed 30 dried slow lorises for sale at Satria market, said to be obtained from the easternmost part of Java.

Item	No. of items (shops)	Price (USD)
Whole skeleton	1 (1)	-
Vertebrae	6 (1)	-
Ribs	4 (3)	8.00–10.00
Ear bones	2 (1)	25.00 pair
Carvings	70 (11)	-
Small cigarette pipe	15 (4)	10.00–15.00
Large cigarette pipe	6 (4)	15.00–20.00
Large cat canine	47 (8)	10.00–30.00
Statue	2 (1)	150.00
Teeth	13 (4)	5.00–15.00
Bottled eye fluid	3 (2)	-
Bottled fat (100 ml)	2 (1)	7.00

**Table 2. Body parts of Dugong *Dugong dugon* for sale in three medicinal markets, Bali, June 2013.**

While slow lorises are traded throughout Indonesia as pets and medicinal trade in these animals is known elsewhere in South-east Asia (e.g. Cambodia), (Nekaris *et al.*, 2010), trade for medicinal purposes within Indonesia has been rarely documented.

**Sun Bear:** teeth and claws from Sun Bears were frequently offered for sale, and one shop displayed the skull of an adult individual. Sun Bears, which are protected in Indonesia, are found on the islands of Sumatra and Borneo, suggesting long trade routes from these locations to Bali.

**Deer and Babirusa:** a relatively large number of Javan Deer *Rusa timorensis* and Red Muntjak *Muntiacus muntjak* antlers (including some with the skull attached) were observed. In Beringkit, sawn parts of Javan Deer antler were on sale for medicinal purposes; three Babirusa skulls were seen in Satria, in addition to one in Ubud and another four in Tampaksiring (Fig. 3). All of these ungulate species are protected under Indonesian law, and babirusa species are listed in CITES Appendix I and prohibited from international trade. Trade in babirusa, mainly for meat, has been reported from Sulawesi, with animals being transported within the island (Milner-Gulland and Clayton, 2002). Melisch (1995) reported that it was demand for their skulls for souvenirs that had contributed to increased hunting pressure on babirusa populations in south Sulawesi. The authors’ observations are amongst the few of trade of babirusa outside Sulawesi.

## CONCLUSIONS AND FUTURE DIRECTIONS

A significant and open trade in protected and globally threatened wildlife was detected on the island of Bali during the course of this survey. The level of illegal trade in such public areas, particularly the high diversity of species on offer, may suggest that this trade is having a negative impact on biodiversity conservation on this small island. For globally threatened species, such as sawfish, Dugong, Javan Deer, Javan Slow Loris and babirusa, the volumes in trade warrant concern, especially when sourced locally from within Bali or elsewhere in Indonesia, where populations may be small already; any additional pressure imposed on local populations by wildlife trade may imperil their survival. The trade in stingray tails and Chambered Nautilus requires more detailed investigation to determine provenance, the volumes traded, and how the markets in these species operate. A similar investigation is needed for the Dugong trade. It is important to establish whether Dugongs are deliberately targeted to supply the curio and medicinal trade, or whether the Dugong parts observed in trade are derived from fisheries by-catch.

Immediately following this survey, the authors reported their findings to the Governor of Bali (I Made Mangku Pastika), the Director General of the Indonesian Ministry of Forestry (Darori) and the Director of Biodiversity Conservation (Dr Novianto Bambang Wawandono), urging them to take action consistent with

Indonesian wildlife protection laws; no response has been received to date. Economically, Bali is largely dependent on its tourism industry. It is likely that many of the tourists and visitors to the island are ignorant of Bali's involvement in the trade of endangered and protected wildlife species. While the markets included in this survey are not on the main tourist track and cater mainly for the internal Indonesian market, with several million foreign tourists visiting Bali each year and many long-term foreign residents, their opinion on these matters may be a force for good. The authors urge Bali residents and visitors alike, to express their concern about this trade to the relevant authorities, including those linked to tourism.

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### REFERENCES

- Atmojo, W. (2013). Domestic tourists flood Bali on vacation. *Jakarta Post* 25 June 2013.
- Bentley, N. (1998). An overview of the exploitation, trade and management of corals in Indonesia. *TRAFFIC Bulletin* 17:67–78.
- De Angelis, P. (2012). Assessing the impact of international trade on chambered nautilus. *Geobios* 45(1):5–11.
- De Jongh, H.H., Komara, A., Moeliono, M., Soemarto, P., Soebrata, S., Spliethoff, P.C., and Sunarja, I.S. (1982). A survey of the Bali mynah *Leucopsar rothschildi* Stresemann 1912. *Biological Conservation*, 23(4):291–295.
- Jepson, P. (2010). Towards an Indonesian bird conservation ethos: reflections from a study of bird-keeping in the cities of Java and Bali. Pp.313–330 in Tideman, S. and Gosler, A.G. (eds). *Ethno-ornithology: Birds, indigenous peoples, culture and society*. London, Earthscan.
- Lack, N., and Sant, G. (2012). An overview of shark utilization in the Coral Triangle region. *TRAFFIC and WWF*, Cambridge.
- Lunn, K.E., and Moreau, M.A. (2004). Unmonitored trade in marine ornamental fishes: the case of Indonesia's Banggai cardinalfish (*Pterapogon kauderni*). *Coral Reefs* 23:344–351.
- Marsh, H., Penrose, H., Eros, C. and Hugues, J. (2002). *Dugong Status Reports and Action Plans for Countries and Territories*. UNEP, Nairobi.
- Melisch, R. (1995). Babirusa skulls on sale in south Sulawesi. *TRAFFIC Bulletin* 15(2):99.
- Milner-Gulland, E.J., and Clayton, L. (2002). The trade in babirusas and wild pigs in North Sulawesi, Indonesia. *Ecological Economics* 42:165–183.
- Nekaris, K. A. I. (2013). Family Lorisidae (Angwantibos, Pottos and Lorises). Pp.210–235 in Mittermeier, R., Rylands, A., Wilson, D.E. (eds). *Mammals of the World, Vol 3 Primates*. Lynx Edicions, Barcelona.
- Nekaris, K.A.I., Starr, C.R., Shepherd, C.R., Nijman, V. (2010). Revealing culturally-specific patterns in wildlife trade via an ethnoprimate approach: a case study of slender and slow lorises (*Loris* and *Nycticebus*) in South and Southeast Asia. *American Journal of Primatology* 72:877–886.
- Nijman, V. (2005). *In Full Swing. An Assessment of the Trade in Gibbons and Orangutans on Java and Bali, Indonesia*. *TRAFFIC Southeast Asia*, Kuala Lumpur.
- Nijman, V., Shepherd, C.R., Mumpuni, and Saunders K.L. (2012). Over-exploitation and illegal trade of reptiles in Indonesia. *Herpetological Journal* 22:83–89.
- Rajamani, L., Cabanban, A.S., and Rahman, R.A. (2006). Indigenous use and trade of dugong (*Dugong dugon*) in Sabah, Malaysia. *AMBIO: A Journal of the Human Environment* 35(5):26.
- Shepherd, C.R. (2010). Illegal primate trade in Indonesia exemplified by surveys carried out over a decade in North Sumatra. *Endangered Species Research* 11(3):201–205.
- Sudiana, I., Ardika, I.W., Parimartha, I., and Titib, I. (2009). Exploitation and protection of turtles at Serangan and Tanjung Bena villages, south Bali in the perspective of cultural studies. *E-Journal of Cultural Studies* 3(2):1–9.
- Van Balen, S., Dirgayusa, I., Adi Putra, I., Prins, H.H. (2000). Status and distribution of the endemic Bali starling *Leucopsar rothschildi*. *Oryx* 34:188–197.
- Vincent, A.C., Sadovy de Mitcheson, Y.J., Fowler, S.L., and Lieberman, S. (2013). The role of CITES in the conservation of marine fishes subject to international trade. *Fish and Fisheries* (in press).

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