POPULATION ECOLOGY OF IRRAWADDY DOLPHIN (*Orcaella brevirostris*) IN RAJANG AND SARIBAS RIVERS, SARAWAK, MALAYSIA

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ABSTRACT

The Irrawaddy dolphin (*Orcaella brevirostris*) is the most common cetacean species inhabiting the coastal waters of the main estuaries of Sarawak. Their habitats are highly overlapping with the areas of intensive use by human activities, which have evolved potential threats to their very survival. The study was conducted in Rajang and Saribas rivers, Sarawak with the objectives to determine their spatial and temporal occurrence and distribution, density and abundance patterns, their association with environmental water parameters, and to identify their 'hot spot' area. Data collection was carried out from April 2009 to October 2010. Surveys were conducted using modified boat strip-transect technique, with the width of the river as the strip width for each transects and each river was divided into segments. Irrawaddy dolphins were found in all segments of both Rajang and Saribas rivers but they were not distributed evenly. Higher mean sighting frequency, mean number of individual sighted per survey, sighting rate, probability of sighting, density and abundance of Irrawaddy dolphins were recorded at the lower river segment of Rajang and Saribas rivers. Probability of sighting was highly significant between the Kuala Rajang-Sarikei and Sarikei-Sibu segments (McNemar: $\chi 2$ =38.726, df=1, p=0.000). Probability of sighting was highly significant between the Kuala Saribas and and Pusa-Sebemban segments in Saribas River (McNemar: $\chi 2$ =37.770, df=1, p=0.000). The density (Mann-Whitney: U=28.0, n=9 and 7, p=0.758) and abundance (Mann-Whitney: U=24.0, n= 9 and 7, p=0.470) of animals between the river segments in Rajang River are not statistically different. There is no statistically significicant different on density (Mann-Whitney: U=24.0, n=12 and 8, p=0.069) and abundance (Mann-Whitney: U=23.0, n=12 and 8, p=0.57) of animals between the river segments in Saribas River. The probability of sighting between the seasons in both Rajang and Saribas rivers was not statistical significant difference. The abundance of *O. brevirostris* was not statistically different between seasons for both in Rajang River (Kruskall-Wallis: H=2.768, df=2, p=0.251) and Saribas River (Kruskall-Wallis: H=0.323, df=2, p=0.851). Distribution of *O. brevirostris* in Rajang River is significantly associated with salinity with weak correlation, while in Saribas River their distribution is significantly associated with turbidity, surface water temperature and salinity with water temperature has strong negative correlation. The 'hot spot' of O. brevirostris in Rajang River was identified between Sungai Sebubal to Sungai Barong while in Saribas River, the area is situated between the waters of Kampung Sepinang-Kampung Beladin Hilir. The conservation and protection of *O. brevirostris* and their habitats in the two river systems need to be managed holistictically with specific recommendations on conservation education to raise public awareness about the importance of protecting the new identified 'hot spot' areas, developed the the newly identified 'hot spots' as new eco-tourism tousim site for dolphin watching and continue carry out more detail researches to overcome the knowledge gaps that required to produce a 'Species Conservation Management Plan' for *O. brevirostris* in these areas.

ABSTRAK

POPULASI EKOLOGI IKAN LUMBA-LUMBA (Orcaella Brevirostris) IRRAWADDY DI SUNGAI RAJANG DAN BATANG, SARAWAK

Lumba-lumba Irrawaddy (Orcaella brevirostris) merupakan spesis setasean yang paling kerap dijumpai di kawasan persisiran pantai dan kuala sungai utama di Sarawak. Habitatnya selalu bertindih dengan kawasan yang digunakan oleh aktiviti manusia dan berpotensi mendatangkan ancaman kepada kemandiriannya. Kajian telah dijalankan di Sungai Rajang dan Sungai Saribas, Sarawak dengan objektif untuk menentukan corak kehadiran, taburan, kepadatan dan kelimpahan mengikut kawasan dan musim, hubungan kaitnya dengan parameter air persekitaran dan mengenalpasti 'hot spot' atau 'kawasan tumpuan' O. brevirostris. Pengumpulan data telah dilakukan dari April 2009 hingga Oktober 2010. Tinjauan telah dilakukan dengan menggunakan teknik bot jalur-transek yang diubahsuai dengan menggunakan kelebaran sungai sebagai jaluran setiap transek. O. brevirostris ditemui di kesemua segmen pada kedua-dua sungai tetapi taburannya tidak sekata. Purata frekuensi penemuan, purata jumlah individu ditemui per tinjauan, kadar penemuan, kepadatan dan kelimpahan adalah lebih tinggi pada segmen yang terletak di hilir sungai. Kebarangkalian penemuan secara statistiknya sangat sagnifikan di antara segmen pada Sungai Rajang (McNemar: $\chi 2$ =38.726, df=1, p=0.000). Kebarangkalian penemuan di antara segmen di Sungai Saribas juga secara statistiknya sangat sagnifikan (McNemar: $\chi 2$ =37.770, df=1, p=0.000). Kepadatan (Mann-Whitney: U=28.0, n=9 and 7, p=0.758) dan kelimpahan (Mann-Whitney: U=24.0, n= 9 and 7, p=0.470) O. brevirostris di antara segmen di Sungai Rajang adalah secara statistiknya tidak signifikan. Corak yang sama ditunjukkan pada kepadatan (Mann-Whitney: U=24.0, n=12 and 8, p=0.069) dan kelimpahan (Mann-Whitney: U=23.0, n=12 and 8, p=0.57) O. brevirostris di antara segmen di Sungai Saribas. Kebarangkalian penemuan di antara musim adalah secara statistiknya tidak signifikan di Sungai Rajang (Kruskall-Wallis: H=2.768, df=2, p=0.251) dan Saribas (Kruskall-Wallis: H=0.323, df=2, p=0.851). Taburan O. brevirostris di Sungai Rajang adalah secara statistiknya signifikan berhubung kait dengan saliniti dengan korelasi yang lemah, manakala di Sungai Saribas taburan mereka secara statistiknya signifikan berhubung kait dengan turbiditi, suhu permukaan air dan saliniti dengan korelasi negatif yang kuat. 'Kawasan tumpuan' O. brevirostris di Sungai Rajang telah dikenalpasti di antara Sungai Sebubal dan Sungai Barong manakala, di Sungai Saribas terletak di antara Kampung Sepinang ke Kampung Beladin Hilir. Pemuliharaan dan perlindungan O. brevirostris dan habitat mereka di kedua-dua sungai tersebut perlu diuruskan secara menyeluruh dengan saranan yang khusus terhadap: pendidikan konservasi untuk mempertingkatan kesedaran awam tentang kepentingan menjaga 'kawasan tumpuan', membangunkan 'kawasan tumpuan' baru sebagai tapak eco-pelancongan untuk pemerhatian lumba-lumba dan meneruskan kajian terperinci untuk mengatasi jurang pengetahuan bagi menghasilkan Pelan Pengurusan Pemuliharaan O. brevirostris di kawasan-kawasan tersebut.

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LIST OF ABBREVIATIONS

AIC	-	Akaike Information Criterion
BEACON	-	Biodiversity, Environment and Conservation
CBD	-	Convention on Biological Diversity
CeMMS	-	Centre for Marine Mammal Studies
CI	-	Confidence Intervals
CITES	-	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DoF	-	Department of Fisheries
EEZ	-	Exclusive Economic Zone
FDS	-	Forest Department Sarawak
FGRS	-	Fundamental Research Grant Scheme
GPS	-	Global positioning system
HCVA	-	High conservation value area
HiCOE	-	Higher Institution Centre of Excellence
ICZM	-	Integrated coastal zone management
IOES	-	Institute of Ocean and Earth Science
IPPCS	-	Institut Penyelidikan Perikanan Cawangan Sarawak
IUCN	-	International Union for Conservation of Nature
MareCet	-	MareCet Research Organisation
MLNG	-	Malaysian Liquefied Natural Gas
MNMSRN	-	Malaysian National Marine Mammals Stranding Respnse Network
MNS	-	Malaysian Nature Society
MOHE	-	Ministry of Higher Education
MOSTI	-	Ministry of Science, Technology and Innovation
MPA	-	Marine Protected Area
MPAs	-	Marine Protected Areas
NGO	-	Non-Governmental Organization
NPBD	-	National Policy on Biological Diversity
NRE	-	Ministry of Natural Resource and Environment

NTU	-	Nephelometric turbidity unit
QGIS	-	Quantum Geographic Information System
SCS	-	South China Sea
SEAMAM	-	Southeast Asian Marine Mammal Symposium
SFC	-	Sarawak Forestry Corporation
SHELL	-	Sarawak Shell Berhad
SST	-	Sea surface temperature
SWD	-	Sabah Wildlife Department
TPS	-	Totally protected species
UAV	-	Unmanned aerial vehicle
UMS	-	University Malaysia Sabah
UMT	-	University Malaysia Terengganu
WWF	-	World Wide Fund for Nature

LIST OF SYMBOLS

%	-	Percentage
°C	-	Degree Celcius
M	-	Meter
Km	-	Kilometer
km^{-2}	-	Per square Kilometer
kmh-1	-	Kilometer per hour
Mt	-	Metric tonnes
NTU	-	Nephelometric Turbidity Unit
Nm	-	Nautical mile
Psu	-	Practical Salinity Units
mg/l	-	Milligram per liter
mS/cm	-	Milisiemem per centimeter
day^{-1}	-	per day
H	-	hour
h^{-1}	-	per hour
Min	-	minute

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CHAPTER 1

INTRODUCTION

1.1 Irrawaddy dolphin

The earliest mentioned of the Irrawaddy dolphin (*Orcaella bevirostris*) in literature is by Owen (1866), who described a specimen found in 1852 at the mouth of the Vizagapatam (now known as Vishakhapatnam) river along the east coast of India (Stacey and Leatherwood, 1997). The species' name *brevirostris* derives from Latin, literally meaning short-beaked.

The Irrawaddy dolphin is one of the six subspecies of river dolphins which remain extant today (Beasley, 2007). Leatherwood and Reeves (1994) stated that the Irrawaddy dolphins are described as facultative river dolphins due to their ecological flexibility that allows them to inhabit both marine and freshwater environment (Figure 1.1).

Figure 1.1: Irrawaddy dolphins of Rajang River.

Irrawaddy dolphins are patchily distributed in shallow nearshore tropical and subtropical marine waters of the Indo-Pacific from the east coast of India in the Bay of Bengal, to Papua New Guinea, and from the northern part of Australia through the coast of Indo-China (Stacey and Arnold, 1999). However, recently the *Orcaella* were split into two species based on genetics, morphology and habitat preferences between Asian and Australia/Papua New Guinea specimens (Bearsly et al., 2002a, 2005). The Australian/Papua New Guinea stocks of *Orcaella* were then designated as a separate species named Australian Snubfin dolphin (*O. heinsohni*) (Beasley et al., 2002b).

1.2 Taxonomy and morphology

Once reaching adulthood, the Irrawaddy dolphin is about 2.0 - 2.5 m long. This dolphin has a rounded head that overhangs the mouth and a crescent-shaped blowhole. A neck crease is visible in some individual. Its dorsal fin is small, triangular, and slightly swept back with a blunt tip. Colouration is almost all grey but gets lighter towards the belly (Jefferson et al., 2008). A new born has an average mass between 10 - 12 kg. Adults can be from 2.1 - 2.3 m long and has an average mass of 114 - 133 kg (Arnold and Heinsohn, 1996). It is also equipped with a broad triangular dorsal view. The crescentic blowhole is displaced towards the left. The neck crease is usually distinct in some individual, about half way between the eye and anterior insertion of the flipper (Stacey and Arnold, 1999). The flippers are about 16% of body length, with a smooth curved anterior margin and maximum breadth less than half of the length along the anterior margin (Marsh et al., 1989; Stacey and Arnold, 1999). The dorsal fin, situated over halfway along the back, is rather small for a delphinid. Mean height ranged from 2.9% body length in Southeast Asian animals to 4.4% in Northeast Australian animals (Arnold and Heinsohn, 1996). The species obscure two to three-tone colour patterns from uniformly dark grey on the dorsal and lateral field, with variable shading among individuals, and is much lighter on the ventral field, which extends from the lower chin to the anus (Smith, 2008). The genital aperture is more anterior in males than females, and no other sexual dimorphism has been demonstrated (Stacey and Anold, 1998). The skull has a short rostrum (43 - 45% of condylobasal length), with a well-developed mesethmoid crest. Its teeth have an expanded crown but are not compressed. The dental formula is

variable; published values include 13 to 17 (upper jaw)/12 to 14 mandible (Anderson, 1879), 16 to 20/15 to 19 (Arnold and Heinsohn, 1996 and 19/15 (Lloze, 1973).

1.3 Research and conservation of marine mammals in Malaysia

The workshop on the Biology and Conservation of Small Cetacean and Dugongs of Southeast Asia (SEAMAM I) held from 27 - 30 June 1995 in Dumaguete, Philippines concluded that the prospects for a long-term persistence of many populations are generally poor and proposed surveys to determine the status and development of national programs in the conservation of inshore cetaceans and Dugongs in the region (Perrin et al., 1996). Malaysia was not represented due to the fact that, before 1996, there was no research establishment dedicated to study or conserve marine mammals in the country (Jaaman, 2006). In July 2002, a second similar workshop (SEAMAM II) was held in the same venue and highlighted the large and growing problems of cetaceans and Dugongs incidental catch in fisheries in Southeast Asia. Malaysia was represented by staff from the Forestry Department of Sarawak (FDS) and University Malaysia Sabah (UMS). The workshop concluded that unless is the issues are addressed in an immediate, aggressive manner, major losses of biodiversity are inevitable and has proposed a Regional Action Plan to be developed and implemented in a phase-like manner, beginning with public awareness and an educational phases, (Perrin et al., 2005). The third Southeast Asian Marine Mammal Symposium (SEAMAM III) was organized in Fave Hotel, Langkawi, Malaysia from 4-10 March 2013. Malaysian delegates comprising of staff from Governmental agencies, universities and Non-governmental organizations (NGOs) conferred and discussed on several issues and miscellaneous matters, pertaining to domestic marine mammals.

UMS through the Centre for Marine Mammal Studies, CeMMS (formerly known as the Marine Mammals and Whale Shark Research and Conservation Programme) has initiated the research on marine mammals in Malaysia in 1996. From there, extensive and scientific studies on marine mammals were extended to Sarawak and Peninsular Malaysia. For the past 15 years, conservation and research efforts on marine mammals in Malaysia were focused on documentation of their occurrences and distributions, assessment on their population size, assessment and threats, and community perceptions.

Jamal Hisne et al., (2013) listed a number of initiatives on the marine mammals in Malaysia that was conducted by various management authorities, universities and non-governmental organizations (NGOs) through government grants or sponsorships by private sectors: Eight of postgraduate research projects in East Malaysia (Sabah and Sarawak) by CeMMS of UMS funded by the Ministry of Science, Technology and Innovation (MOSTI) e-Science Fund from 2008-2010); Evaluation on Management and Public Opinions for the Conservation of Marine Mammals in West Coast of Sabah by CeMMS from 2008 to 2010 sponsored by the Ministry of Higher Education(MOHE) under Fundamental Research Grant Scheme(FGRS); by Tioman Dolphin Project in 2010 by Malaysian Nature Society (MNS), and Institute of Ocean and Earth Sciences (IOES) of University Malaya (UM); Marine Mammals Surveys within the proposed Tun Mustapha Park area, Sabah by World Wide Fund for Nature-Malaysia (WWF Malaysia) in collaboration with the University of St. Andrews, Scotland in 2012; Numbers of research programs on Marine Mammals (Dugongs, Whale and Dolphins) by the Universiti Malaysia Terengganu, UMT under the Ministry of Higher Education (MOHE) Higher Institution Centre of Excellence (HiCoE) in Marine Science Project started from 2012; Langkawi Dolphin Research Program in Pulau Langkawi conducted by The MareCet Research Organization (MareCet) and IOES of UM in 2010; A collaboration project between MareCet and UM on an Ecology and Conservation of coastal cetaceans in The Matang Mangrove Forest Reserve and adjacent coastal waters, Perak in 2012; A study of dolphins of the Kinabatangan River in Sabah by the Land Empowerment Animals People and Sabah Forestry Department in collaboration with the University of St. Andrews, Scotland in 2010; and the establishment of the Malaysian National Marine Mammal Stranding Response Network (MNMMSN) involving a collaboration of multiple government agencies, non-governmental agencies, universities and private companies to provide effective response to stranding incidents around the country in 2013.

1.4 Research and conservation of Irrawaddy dolphins in Sarawak

Bali and Tisen (2008) reported that 15 of the species of marine mammals have been recorded in Sarawak, notably Bryde's whale (*Balaenoptera edeni*), Killer whale (*Orcinus orca*), Pygmy Sperm whale (*Kogia breviceps*), Sperm whale (*Physeter macrocephalus*), Risso's dolphin (*Grampus griseus*), Fraser's dolphin (*Lagenodelphis*

hosei), Indo-Pacific Humpback dolphin (*Sousa chinensis*), Irrawaddy dolphin (*Orcaella brevirostris*), Indo-Pacific Finless porpoise (*Neophocaena phocaenoides*), Dugong (*Dugong dugon*), Indo-Pacific Bottlenose dolphin (*Tursiops aduncus*), Common Bottlenose dolphin *(Tursiops truncatus*), Humpback whale (*Megaptera novaeangliae*), Long-snouted Spinner dolphin (*Stenella longirostris*) and Pan-Tropical Spotted dolphin (*Stenella attenuata*).

Although there are some publications on marine mammals from Sarawak were published in 1990s by Lydekker (1901); Weber, (1923); Bank, (1931); Gibson-Hill, (1949;1950); Fraser, (1956); Lewin, (1956); Harrison, (1957;1960); Harrison and Jamuh, (1958); Morzer-Bruyns, (1966); Beasley and Jefferson, (1997), extensive researches and conservation efforts only had begun with the establishment of collaboration studies between UMS and FDS in 2000. Since then, more information on marine mammals in Sarawak have been documented, compiled, reviewed and published in local and international journals; Jaaman et al., (2000; 2001; 2002), Jaaman, (2004; 2006); Jaaman, 2010; Lah-Anyi & Jaaman, 2002; W.Y. Chin, (2008); Bali, (2005); Bali et al., (2008; 2012); Bali and Tisen, (2008); Minton et al., (2019;2011;2013;2014). Past researches and conservation programmes conducted in Sarawak are: Interview surveys from fishermen, village headmen and/or knowledgeable villagers that were conducted along the coast of Sarawak from Lawas to Sematan in 2000 by UMS in collaboration with FDS; Aerial and in-shore boat surveys which were carried out along the coast of Sarawak in 2001 by UMS and FDS. Dialogue between SFC with tourism industries on marine mammals watching guideline in Sarawak was held in Kuching on March 2007; Aerial surveys on marine mammals along the coast of Sarawak conducted by the SFC in collaboration with UMS and Sabah Wildlife Department (SWD) from 19 June to 6 July 2007 (Bali, 2008); aerial surveys to monitor the Dugong population over Kuala Lawas was carried out from the 11-13 April 2008 (Bali and Tisen, 2008); offshore boat survey on marine mammals along the coast of Sarawak was conducted by the SFC in collaboration with UMS, *Institut Penyelidikan Perikanan Cawangan Sarawak* (IPPCS) and FDS from 18th June-2nd July 2008 (Bali, 2008); Number of collaboration studies between SFC and UMS on sea grasses and Dugongs distribution in Lawas, Sarawak from 2000 to 2008; Sarawak Dolphins' Project in 2008 to 2009 by the Sarawak Shell Berhad (Sarawak

SHELL), SFC and Universiti Malaysia Sarawak (UNIMAS); and Studies on the Occurrence and Distribution of Marine Mammals in the Malaysian South China Sea, and Species Composition, Distribution and Abundance of Sea grass and their Relationship with Dugong's population Ecology in Malaysian Bay of Brunei under MOHE HiCoE project by UMT in collaboration with SFC in 2013 to 2015; and Cetacean Survey and Monitoring in Bintulu waters under Biodiversity, Environment and Conservation (BEACON) project by Malaysian Liquefied Natural Gas (MLNG) group of companies and SFC from 2013 to 2018.

1.5 Significance and objectives of the study

There are four species of inshore cetaceans, namely the Irrawaddy dolphin (*Orcaella brevirostris)*, Indo-Pacific Bottlenose dolphin (*Tursiops aduncus*), Indo-Pacific Humpback dolphin (*Sousa chinensis*) and Finless porpoise (*Neophocaena phocaenoides*), inhabiting the coastal waters and main estuaries of East Malaysia. (Beasley and Jefferson, 1997; Jaaman et al., 2001; Jaaman et al., 2000; Jamaan et al., 2000b). Out of these four species, the Irrawaddy dolphin is the most common species and is considered as the flagship species in Sarawak.

Despite having laws to protect and conserve this species in Sarawak for more than decades, Irrawaddy dolphin's population size, ecology, abundance and threats to their population have been poorly studied and monitored due to lack of funding and experts. Applied population biology and ecology can contribute greatly to the management of this species, (Primack, 2002; Beasley, 2007).

Occasional sightings, stranding, and death of few of these animals have attracted the media and public attention; hence the awareness of their presence in the state. Based on published and unpublished papers, reports and personal observations, Irrawaddy dolphins are mostly abundant in the Saribas and Rajang rivers as compared to the other river tributaries in Sarawak. There are reasons for concerns about the population ecology of the Irrawaddy dolphins in these two river systems. In addition to their habitats that overlapped with areas of intensive use by human which has invoked potential threats to their survival, this species is also known to get trapped accidentally in fishing gears, threatened by declining fish resources,

loss or degradation of aquatic habitats, and direct hunting for Puffer fish baits, (Beasley and Jefferson 1997; Beasley 1998; Jaaman et al., 2001; Jaaman, 2000; 2001; Jamaan and Lah-Anyi, 2002; Pers. obse.). When managing threats and impacts, it is vital to have robust scientific understanding of a species' ecology, its distinctive characteristics, population status, and the dynamic processes that affect population size and distribution (Slooten and Lad, 1991; Primack, 2002). Primack (2002) stressed that conservation biologist need to answer question about species' environment, distribution, biotic interaction, systematic and morphology, physiology and life history, behavior, and genetic, to implement effective population-level conservation efforts. Thus, the main goal of this study is to provide scientific information as a foundation to plan conservation management strategies of Irrawaddy dolphins in Rajang and Saribas river systems.

To achieve the goal of this study, the following primary objectives have been set up:

a. To determine the spatial and temporal occurrence, distribution, density and abundance patterns of Irrawaddy dolphin in Rajang and Batang rivers.

b. To determine the association of Irrawaddy dolphins distribution in Rajang and Saribas rivers with environmental water parameters.

c. To identify and map the 'hot spot' for Irrawaddy dolphins in Rajang and Saribas rivers

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution

Irrawaddy dolphins have been described as facultative river cetaceans, due to their ecological flexibility that allows them to inhabit the marine and freshwater environments (Leatherwood and Reeves 1994). They are apparently riverine, estuarine and coastal, often associated with mangrove forests (Dhandapani, 1992). There are some populations of Irrawaddy dolphin in Asia that are restricted to fresh water, and it is doubtful whether they would venture further offshore. Irrawaddy dolphins are found upstream in the Ayeryarwady (Irrawaddy) river system of Myanmar, the Mahakam river system in East Kalimantan, Indonesia, and the Mekong river system of Laos, Cambodia and Vietnam. The dolphins are present in the Ayeryarwady River to at least 1,287 km upriver from its mouth (Anderson, 1871; 1879; Thien, 1977). Tas'an and Leatherwood (1984) described that the species distributed in coastal waters near the river mouth of the Mahakam and upstream for at least 200km. However, Kreb (2002) revealed that the dolphins sporadically move as far as 80 km and 600 km down-and upstream, respectively. After the Australian/Papua New Guinea stocks of *Orcaella* were designated as a separate species named Australian Snubfin dolphin (*O. heinsohni*), Irrawaddy dolphins' distributions restricted to Indo-Pacific from the east coast of India in the Bay of Bengal (Beasley et al., 2002b). (Figure 2.1).

2.1.1 Distribution in South Asia and Southeast Asia

In Bangladesh, Irrawaddy dolphins prefer coastal areas associated with muddy, brackish water at the river mouth, ranging offshore as far as the extent of freshwater plume-often only a few km but more than 60 km at the Meghna river mouth and waterways of the Sundarbans mangrove forest (IUCN, 2008).

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