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Conservation of the Philippine crocodile *Crocodylus mindorensis* (Schmidt 1935): *in situ* and *ex situ* measures

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The endemic Philippine crocodile *Crocodylus mindorensis* is one of the most Critically Endangered crocodilian species in the world. Four major captive-breeding programmes for the Philippine crocodile have greatly contributed to our knowledge about the biology and natural history of the species. *In situ* conservation actions, such as reintroduction, conservation breeding in large semi-wild areas with no supplementary feeding and head-starting programmes, could result in increasing the numbers of extant wild and semi-wild populations. If concerted efforts are directed at *in situ* and *ex situ* conservation, and locating quality habitats in which to establish new conservation sites for Philippine crocodiles, the species is likely to become widespread in the next few decades. Conservation measures that address species-specific issues promoting healthy viable populations in natural habitats are presented in this paper.

Key-words: conservation breeding; *ex situ* measures; *in situ* measures; Philippine crocodile; release programmes.

INTRODUCTION

The Philippine crocodile *Crocodylus mindorensis* is the second rarest crocodilian species in the world, next to the Chinese alligator *Alligator sinensis*, and is listed as Critically Endangered (CR) (A1c, C2a, ver. 2.3) in *The IUCN Red List of Threatened Species* (Crocodile Specialist Group, 1996; IUCN, 2014). In 2012, a revised Red List assessment (as yet unpublished) considered the Philippine crocodile in the same CR category but changed its criteria (A2, C.D., ver. 3.1), based on the (1) observed and inferred population decline of 82% in both known localities in the last 75 years (causes understood and potentially reversible but ongoing) and (2) an inferred population size of 92–137 mature individuals with a continuing decline (Crocodile Specialist Group, unpubl. data, 2013).

This relatively small (barely 3 m long) and basically harmless Philippine endemic freshwater crocodile was once widespread on major islands of the Philippine archipelago. In the late 1970s to early 1980s, indiscriminate killing by humans, either because of fear or the hunting of this species for valuable skins, and land conversion for agriculture greatly diminished the area of natural habitat available to the Philippine crocodile, which has resulted in severely reduced wild populations (Ross, C. A., & Datuin, 1981; Ortega, 1996). Ross, C. A., & Alcala (1983) estimated the remaining Philippine crocodile population to be 500–1000 individuals both in the wild and in captivity. Although there is an informed population estimate of 100 non-hatchling individuals in the wild (Ross, J. P., 1998), no large populations are known to exist in any one area (Ortega, 1998). Remnant populations have become extremely rare in the wild and mostly occur in inland freshwater habitats that are difficult to reach (Ross, C. A., & Datuin, 1981; Mercado, 2008; Ross, C. A., 2008).

The Silliman University Environmental Center, Negros Oriental, Philippines, and

the Republic of the Philippines–Japan Crocodile Farming Institute [RP-Japan CFI; now the Palawan Wildlife Rescue and Conservation Center, Philippines (PWRCC)] are the two major facilities that first responded urgently to the plight of Philippine crocodile by establishing captive-breeding programmes and monitoring wild populations. These facilities acquired a minimum number of individuals from the wild and private collectors to form a nucleus population (Messel *et al*., 1992; Ortega *et al*., 1994; Ortega, 1998). These early successes in conservation breeding eventually sparked interest in the international zoo community which joined in the programmes to help augment conservation initiatives for crocodiles in the Philippines.

In situ conservation programmes recorded the existence of remnant populations of *C. mindorensis* on the small northern Island of Dalupiri (Oliveros *et al*., 2005), in wetland pockets in the foothills of the Northern Sierra Madre mountains and in several microhabitats in the coastal towns of the province of Isabela in north-eastern Luzon (van Weerd *et al*., 2000). Apart from the Philippine crocodiles in the lowlands, scattered populations have been reported in the river systems of central highland ridge along the provinces of Bukidnon, central Mindanao (Pontillas, 2000, unpubl.); large rivers and tributaries of Cordillera Central, Abra Province, Luzon (Manalo, 2008); and in a number of isolated highland geologic depressions or small lakes in the vicinity of Seven Lakes, Lake Sebu in southern Mindanao (Manalo *et al*., 2013; Mercado *et al*., 2013). The last finding is considered a new locality and altitudinal record (700–850 m a.s.l.). Furthermore, the occurrence of a culturally protected population (traditional veneration of the Philippine crocodile resulting in protection of the species by the Maguindanaon Tribe) has been reported in the Ligawasan Marsh Game Refuge and Wildlife Sanctuary, which is presumed to be the stronghold of this species (Pomares, Pomares & Escalera, 2008; Pomares, Tabora *et al*., 2008).

CONSERVATION-BREEDING AND REARING PROGRAMMES

There are four major *ex situ* crocodile conservation and rearing programmes providing support for the Philippine government: (1) the Silliman University Crocodile Breeding Facility, (2) PWRCC, (3) San Mariano Philippine Crocodile Rearing Station and (4) Pag-asa Farms Facility. These programmes have resulted in the documentation of breeding success, reproductive behaviour, and offspring growth characteristics at various national and international conservation-breeding facilities, augmenting our knowledge about the biology of the Philippine crocodile.

Silliman University Crocodile Breeding Facility

In early 1980s, the Silliman University Environmental Center pioneered captive breeding of the Philippine crocodile at the Silliman University Crocodile Breeding Facility, with technical and financial support from the Smithsonian Institute, Washington, DC, USA, and the World Wildlife Fund, administered by the Department of Vertebrate Zoology, Smithsonian National Museum of Natural History (Ross, C. A., 1982a). The programme documented the first-known nesting behaviour in a zoological facility based on a single pair of Philippine crocodiles (Ross, C. A., 1982b) and recorded the first captive propagation resulting in 14 hatchlings in 1982 (Ross, C. A., 1982a). The ♀ was wild caught in Pagatban River, southern Negros, and the ♂ originated from Zamboanga (Banks, 2005). During the programme, which started in 1981 and ceased in 2004, this pair laid 354 eggs, of which 114 hatched successfully [Silliman University – Angelo King Center for Research and Environmental Management (SUAKCREM) records]. Only a few hatchlings died and many of the crocodiles from Silliman University Crocodile Breeding Facility were distributed to zoos and private individuals who wished to participate in crocodile breeding

and conservation. The crocodile breeding programme ceased because space became a limiting factor and a ♂ breeder was lacking. At the time of writing, nine Philippine crocodiles bred at the Silliman University Crocodile Breeding Facility are still managed at the facility for exhibit purposes only. Efforts are now focused on locating appropriate habitat in Negros Oriental and assessing its suitability for future reintroduction projects in central Philippines.

In 1988, the Silliman University Environmental Center sent a ♀ Philippine crocodile to Gladys Porter Zoo, Brownsville, TX, USA, to be paired with a ♂ already located there. This action established the North American Philippine Crocodile Co-operative Breeding & Conservation Programme (Banks, 2005). This Programme aimed to establish a stable and genetically diverse population of Philippine crocodile within North American zoological facilities and private collections.

In 1993, the Silliman University Environmental Center transferred a pair of adult Philippine crocodiles to the Royal Melbourne Zoological Gardens, Parkville, Vic., Australia, following the signing of a Memorandum of Agreement. Silliman University Environmental Center was supportive of the strong commitment that Royal Melbourne Zoological Gardens had to captive breeding and other conservation-related activities for the Philippine crocodile (Banks, 2005).

In 2006, J. K. Mercado & Sons Agricultural Enterprises, Inc., adopted two Philippine crocodiles from Silliman University Environmental Center and ten more from PWRCC (http://www.jkmercado.com/p/conservation.html). These animals were maintained in a semi-wild captive-breeding facility at Pag-asa Farms, owned by the company, and subsequent hatchlings were collected for eventual release into a secure natural habitat (Cruz *et al*., 2012).

All the Philippine crocodiles that were transferred were done so under a loan agreement with the Department of Environment and Natural Resources (DENR) of the Republic of the Philippines and remain under the ownership of the Philippine government.

PWRCC

This project (formerly as RP-Japan CFI) was established to prevent the further decline of crocodile populations in the Philippines (Messel *et al*., 1992). PWRCC became the most modern and largest captive-breeding facility for crocodiles in the Philippines following a 7 year joint partnership between the Philippine government (through DENR) and the Japan International Cooperation Agency, which provided financial technical support (Ortega, 1998; Banks, 2005). The primary aims were (1) to conserve the two species of crocodiles found in the country and (2) to promote the socio-economic well-being of the local communities through the development and introduction of appropriate crocodile-farming technology (Ortega, 1998).

In 1989, PWRCC started a captive-breeding programme for Philippine crocodiles, dramatically increasing the population from *c.* 233 animals acquired from private sources and the wild (the majority from Mindanao), to 2252 individuals, of which 700 have reached maturity (Ortega *et al*., 1994; Rebong, 2007; van Weerd *et al*., 2011). Captive breeding was so successful at PWRCC that by 2001, the programme was discontinued as the population at the Center approached the 200 adult breeder management goal (Ortega *et al*., 1994). The decision to halt breeding was probably made in consideration of the space requirements and genetic management of such a large population (R. I. Manalo, pers. obs, 2001). At the end of the 2006 breeding season, there were 818 individuals housed at the PWRCC (Rebong, 2007). At that time, a large percentage of the animals were maintained in one place, where a catastrophic event could possibly put at risk the entire captive population. Therefore, some individuals were transferred to private institutions under loan agreements for conservation-breeding, education and other conservation activities.

San Mariano Philippine Crocodile Rearing Station

In 2005, a head-starting programme was initiated by the Mabuwaya Foundation, Inc., in the Municipality of San Mariano, Isabela. Hatchlings were collected from the wild and reared in captivity for 18–24 months at a facility in the San Mariano local government-managed Philippine Crocodile Rearing Station before the young crocodiles were released back into their natural habitats. A system of local protection groups was formed to protect nests from predators and to collect hatchlings for the head-starting programme.

In the early stages of the programme, the Philippine crocodiles were originally kept together. However, conspecific aggression resulting in injuries and deaths occurred as the crocodiles grew larger, so they are now separated into individual tanks after the age of 3 months to avoid such incidents. The crocodiles were fed every other day with raw meat, fish or shrimps, and provided with clean water daily (van Weerd & van der Ploeg, 2008). Growth and health were regularly monitored. Of the 250 hatchlings collected and reared between 2005 and 2011, 123 juvenile crocodiles were released back into the wild with a record of 50% survival after one year. It would appear that the crocodiles reared in captivity readily adapted to their natural habitat after release, avoiding humans and livestock (van Weerd & van der Ploeg, 2008). The annual survival rate in captivity increased to 72% after the rearing facilities were improved (van de Ven *et al*., 2009, 2012).

Pag-asa Farms Facility

In 2006, memoranda of agreements, drawn up between concerned Philippine government agencies, private crocodile farms and the academe, played an important role in the collective effort for *in situ* and *ex situ* conservation programmes for the Philippine crocodiles. The J. K. Mercado & Sons Agricultural Enterprises, Inc., is a member of the Crocodylus Porosus Philippines Inc. (CPPI), which is a coalition of six legitimate commercial crocodile farms in the Philippines (Manalo & Alcala, 2013). In 2006, the joint development of the J. K. Mercado – Protected Areas and Wildlife Bureau (now the Biodiversity Management Bureau) – Silliman University project for the conservation breeding of *C. mindorensis* was initiated at Pag-asa Farms, Kapalong, Davao Del Norte, Philippines.

Ten breeder Philippine crocodiles (8–10 years old) that had been reared together in a large communal fully concrete pen at PWRCC and two individuals from the Silliman University facility were transferred to a 4500 m^2 semi-wild enclosure at Pag-asa Farms. The ten adults from PWRCC were kept in these semi-wild conditions without the provision of artificial ponds, man-made shelters or an artificial water supply for 3 months prior to the arrival of the two adults from Silliman University. The crocodiles were introduced directly into this semi-wild enclosure, enabling them to establish their own territories. The enclosure had been constructed by the erection of an irregularly shaped concrete fence in a natural wetland on a 10° slope terrain. A small natural-flowing creek that is inundated throughout the year runs through part of the enclosure. Naturally growing trees provided shelter and a natural barrier for the crocodiles. In this pen, some antagonistic behaviour between the crocodiles was observed (Cruz, 2008) but, probably owing to the relatively large size and design of the enclosure, no actual fighting has occurred so far. Mortalities resulting from breeding aggression were recorded for one ♂ and one ♀ in 2010 and 2011, respectively. Three breeder crocodiles were released into a large swamp in 2009. The seven remaining crocodiles continued to breed in the semi-wild enclosure (Cruz *et al*., 2012) and no other founder stock has been added to the breeding pool.

A breeding ratio of 1:3 (♂:♀) was utilized in the semi-wild enclosure. The Philippine crocodiles at Pag-asa Farms have had to find their own food since their arrival at the facility and they depend solely on free-ranging

rodents, birds, snakes, turtles and other prey items in the area (J. K. Mercado, pers. comm., 2011; Anon. Reviewer, pers. comm., 2014). The abundance of free-ranging prey species was accounted for by the proximity of the enclosure to crops and livestock farms.

The first successful hatch from the original breeders occurred on 8 April 2009 when the crocodiles reached 11–12 years of age. Nine clutches from five breeding ♀♀ were recorded over a 40 month period (April 2009 to July 2012), with an average clutch size of 25·4 eggs (range 8–33) (Cruz *et al*., 2012). Around 56% (128 eggs) of the total 229 eggs laid were fertile, of which 54% (69 individuals) hatched successfully (Cruz *et al*., 2012). The incubation period of these eggs hatched in the semi-wild enclosure ranged from 95 to 100 days (Cruz *et al*., 2012). Hatchlings were not given any supplementary food and were observed seeking refuge from their parents. Five animals died at the hatchling stage, while three individuals reached the sub-adult phase and the remaining 61 are still juveniles. Human intervention was restricted to visual inspection of the enclosure and no other interaction with people occurred. Regular monitoring was carried out remotely using closed-circuit cameras installed in strategic areas.

Thirty-six F2 generation juvenile progeny from the conservation-breeding project at Pag-asa Farms were released at the Siargao Island Protected Landscape and Seascape in March 2013 for the Siargao Island Crocodile Research and Biodiversity Conservation Program for *C. mindorensis* (Cruz *et al*., 2012; Mercado *et al*., 2013).

SANCTUARY IDENTIFICATION AND RELEASE PROGRAMMES

Wild populations of the Philippine crocodile that occur in the inland freshwater habitats of the Philippine archipelago are now considered remnant populations. The search for habitats with wild Philippine crocodile populations has been ongoing for more than two decades. The Philippine government (through the DENR-PWRCC), together with the local government units, various non-governmental organizations and the academe, have been studying potential habitats since 1991 to prepare for the establishment of crocodile sanctuaries where captive-bred crocodiles can eventually be released for conservation purposes.

In situ conservation programmes

Collaborative efforts have resulted in the discovery of small remnant populations. Pontillas (unpubl.) highlighted the two previously unrecorded extant populations of the Philippine crocodile in San Mariano, Isabela, Luzon Island, and Pulangui River, Bukidnon, Mindanao Island. van Weerd *et al*. (2000) recorded the existence of Philippine crocodiles in wetland pockets in the foothills of Northern Sierra Madre National Park and several microhabitats in the coastal towns of Isabela, Cagayan. Isolated populations were recorded in the small island of Dalupiri (Oliveros *et al*., 2005).

The occurrence of local illegal trade (poaching) in the marginal communities of the Ligawasan Marsh Game Refuge and Wildlife Sanctuary (LMGRWS) in southern Mindanao and the nearby towns probably indicates an increasing crocodile population. According to Pomares, Pomares & Escalera (2008), this finding supports the assumption that the Marsh contains the stronghold of Philippine crocodiles. The occurrence of a population of the species in this culturally protected area and the presence of assorted lawless elements, make it a difficult location to conduct field studies. With the scarcity of suitable potential habitat in lowland areas, investigations in highland river and tributaries in Cordillera Central, Abra (Manalo, 2008), and in a number of highland crest/isolated geologic depressions or small lakes in the vicinity of Seven Lakes, Lake Sebu, southern Mindanao (Manalo *et al*., 2013; Mercado *et al*., 2013), have become necessary. Fieldwork in these highland areas has revealed new locality and altitudinal records (700–850 m a.s.l.) for the Philippine crocodile.

Among the identified noteworthy populations and potential habitats of Philippine crocodile, *in situ* conservation programmes in San Mariano, Isabela, in the Northern Sierra Madre National Park were started in 2000 by the Isabela State University, Philippines, and Leiden University, The Netherlands, through a Philippine crocodile research and conservation programme. The Crocodile Rehabilitation, Observance and Conservation (CROC) project implemented crocodile population monitoring, public awareness, information campaigns, community empowerment and capacity building in support of the on-site protection strategies in the municipality of San Mariano (van der Ploeg, Rodriguez *et al*., 2008; van Weerd & van der Ploeg, 2008). This has led the local government of the municipality of San Mariano to establish five Philippine crocodile sanctuaries in the lowland and coastal towns of Isabela Province within the municipalities of San Mariano, Maconacon, Palanan and Divilacan (Miranda *et al*., 2004; van Weerd *et al*., 2012). Post-release monitoring of released crocodiles had provided confirmation that the head-start programme increases hatchling survival rates and is facilitating the recovery of the Philippine crocodile population in San Mariano (van Weerd & van der Ploeg, 2008).

In 2006, CPPI was actively supporting field studies for the conservation of the Philippine crocodile in two of the important wetlands on Mindanao. The first documentation of crocodiles in Ligawasan Marsh and its tributaries was made in collaboration with the University of Southern Mindanao. Results indicated that Ligawasan Marsh and its environs still support a Philippine crocodile population (Pimentel *et al*., 2008; Pomares, Pomares & Escalera, 2008). There are no reliable estimates of the population of crocodiles in the Agusan Marsh (Ross, C. A., 1982a). A comprehensive study on the distribution and status of the Saltwater crocodile *Crocodylus porosus* and *C. mindorensis*, carried out by CPPI, indicated that the populations of crocodile in the Agusan Marsh are considered remnant and declining (Manalo *et al*., 2012). However, the exact population status of *C. mindorensis* in the region is still uncertain.

Release of captive-bred individuals

As a result of the decline of viable wild populations and the availability of quality habitat, release programmes were implemented in the north-eastern Luzon, and southern and north-eastern Mindanao protected habitats. In 2009, the DENR, the local government of Divilacan and the Mabuwaya Foundation, Inc., reintroduced 50 captive-bred sub-adult *C. mindorensis* from PWRCC into the 14 ha man-made Dicatian Lake using a hard-release process (no supplementary food provided after release) (van Weerd *et al*., 2011). Post-release monitoring identified high mortality rates and human–crocodile conflicts (van Weerd *et al*., 2012). Although young (12–18 months) head-started crocodiles from San Mariano Philippine Crocodile Rearing Station and slightly older (24 months) crocodiles that had been maintained in a semi-wild enclosure without supplementary feeding or much human contact adapted well to the release environment, the 50 sub-adult crocodiles (*c.* 1·2 m total length) hard-released into the Dicatian Lake area appeared to have difficulties in adapting to their new location (van Weerd *et al*., 2011). Even 2 years after the release, recaptured individuals showed very little growth and some had lost weight. Several crocodiles had left the area of Dicatian Lake and started to come into conflict with local residents after livestock on nearby farms were threatened (van Weerd *et al*., 2011). This was unexpected as the Dicatian Lake area was well supplied with potential prey items (van Weerd *et al*., 2011).

In 2009, the J. K. Mercado – Protected Areas and Wildlife Bureau (now Biodiversity Management Bureau) – Silliman University project released three [1.2 (♂.♀)] 10 year-old captive-bred adult *C. mindorensis* into a large swamp area at Pag-asa Farms in Santo Tomas, Davao del Norte in Mindanao. These crocodiles had been living in the semi-wild conditions at the Pag-asa Farms facility prior

to release (van Weerd *et al*., 2011). Initially, two of the crocodiles damaged young rice crops by walking through the farmland and they were captured and removed. Subsequently, these same two individuals were released back in the swamp a month after recapture and appeared to settle in successfully. There were no reports of human–crocodile conflict (J. K. Mercado, Inc., pers. comm., http://www.jkmercado.com/p/conservation.html) and the released crocodiles appear to have moved to a more remote area of the marshland. One of the most important aspects of Philippine crocodile releases is the involvement of the local community. The farmers know they can contact the Pag-asa Farms facility if they have any problems with the crocodiles and something will be done, and this makes them more tolerant of the animals. The different results from the releases of captive-bred Philippine crocodiles in northern Luzon and southern Mindanao indicate that there is a need for further study into the processes used for release programmes.

Experiences from these release programmes were used to refine the Philippine crocodile reintroduction protocols and strategy. On 22 March 2013, 36 healthy juvenile Philippine crocodiles were successfully introduced into Paghungawan Marsh, Siargao Island Protected Landscape and Seascape (SIPLAS) in Jaboy, Pilar, Surigao Del Norte (Mercado *et al*., 2013). The released crocodiles were captive bred and had been reared at Pag-asa Farms in Kapalong, Davao Del Norte, for almost 2 years without supplementary feeding (Cruz *et al*., 2012). In the SIPLAS Paghungawan Marsh area, the environment is semi-controlled, and will provide the Philippine crocodiles with a habitat of *c.* 120 ha in the dry season and 600 ha in the wet season (Howard, 2013).

This successful release was regarded by the Philippine government as a well-organized crocodile conservation-introduction action. Ecological assessments were carried out over 2 years to identify the extent of quality micro-habitat, availability of potential prey species and quantity of available food source. Veterinary care for release-candidate individuals, including quarantine protocols for disease prevention, was in place. Social preparation and community acceptability were acquired through public consultations and several public-awareness campaigns were also carried out in the impact areas to prepare the communities in the receiving environment. Support from national and local governments, such as local-community councils (Brgy. Jaboy Resolution no. 10, series of 2012; Brgy. San Roque Resolution no. 13, series of 2012), local government unit (Resolution no. 145, series of 2012), Protected Area Management Board (Resolution no. 2012-21), and the authorization of the DENR Secretary were secured through the issuance of clearances prior to the actual release date. A report on post-release monitoring efforts revealed that after 3 months, most of the released crocodiles were observed foraging near each other among the aquatic plants at the release site without any evidence of aggressive behaviour (Plate 1) (Bucol *et al*., 2013). On several occasions, some individuals were found searching for food under a limestone ledge surrounded by vegetation. Two individuals died, possibly as a result of being caught in fishing nets, and this led to the Barangay Jaboy local government banning the use of gillnets and hook-and-line fishing in the Paghungawan Marsh area (Bucol *et al*., 2013).

The presence of released Philippine crocodiles in the area further contributed to the development of the Paghungawan Marsh as an area of Community-Based Sustainable Tourism, featuring natural serene landscape, rich biodiversity and a ‘Crocodile Night Watch’ tour, which is a main attraction. Other potential attractions in the area may include guided observations of several threatened and endemic fauna (Bucol *et al*., 2013).

EDUCATION AND COMMUNICATION STRATEGIES

Information and awareness campaigns are believed to be the key consideration,

Plate 1. Released Philippine crocodile *Crocodylus mindorensis* **in Paghungwan Marsh, Siargao Island Protected Landscape and Seascape, Philippines, in 2014.** *Philip C. Baltazar, Crocodylus Porosus Philippines Incorporated***.**

especially to ensure successful introductions or effective protection of non-charismatic species such as crocodilians. All education programmes carried out for the Philippine crocodile pre-release were site-specific and designed to cater for focused audiences within the project conservation-priority areas, in consideration of the local background, culture and traditions (van Weerd & van der Ploeg, 2008; van der Ploeg *et al*., 2011; Manalo *et al*., 2012; Mercado *et al*., 2013). When featured in the media, crocodiles attract attention, which in turn provides opportunities to educate the public about crocodiles, including their conservation (Webb, 2013).

Since 1995, PWRCC has celebrated an annual week-long festival entitled 'Crocodile Conservation Week' supported by a local resolution from the city government of Puerto Princesa (Ortega *et al*., 1994; Banks, 2005). In 1998, '*watcha hatcha*' was introduced as a promotional activity to welcome hatching crocodiles into the world (Banks, 2005). This awareness-raising campaign has intensified the information-provision efforts, disseminating the ecological and economic importance of the Philippine crocodile, incorporating the characteristics of other endemic Palawan wildlife, and its role in the ecosystem. The use of a crocodile mascot gave maximum crowd exposure to school children, reaching a larger audience. Free lectures and guided tours for the visiting public have become popular for public education about biodiversity and wildlife tourism (Ortega, 1996; Catibog-Sinha & Heaney, 2006; Justo, 2007). The growth in the number of tourists visiting PWRCC for 10 years consecutively (since 1987) has made the area the number one tourist destination in Palawan, with an annual average of 40 000 guests (Ortega, 1998; Banks, 2005). Surveys on the impact of the conservation-information campaign on 1300 respondents revealed that 96% (1248 people) agreed that crocodiles should be conserved, 84% (1092 people) agreed to support PWRCC's conservation efforts and 83% (1079 people) gained a positive change in the way they perceive crocodiles (Ortega, 1998). In recent years, PWRCC continues to raise the levels of public awareness as it is a must-see tourist destination in the country.

In northern Luzon, an intensive communication, education and public-awareness campaign about the crocodile project has been implemented for over 10 years. Mabuwaya Foundation, Inc., in partnership with Isabela

State University, has kept rural communities that live near the habitats of Philippine crocodiles informed about the conservation of the species in the northern Sierra Madre, Philippines. Various communication, education and public-awareness materials, such as posters, calendars, radio plugs, billboards and storybooks, have been circulated in interactive communication and participation activities, such as puppet and cultural shows, school and field visits, film shows, mobile exposition and the appearance of a crocodile mascot (van der Ploeg, Rodriguez *et al*., 2008; van der Ploeg *et al*., 2011; Cureg *et al*., 2012). In 2001, community consultations took place around the Disulap River in San Mariano. These consultations were used to inform local residents about the crocodiles, and were instrumental to achieving a successful vote and support for establishing a sanctuary. Listening to public concerns and incorporating comments from the community into the plans made it possible to create this new protected site (Tarun *et al*., unpubl.). Probably the most effective way to communicate with farmers and fishermen in the relevant regions is community consultation. People in San Mariano now take pride in conserving the Philippine crocodile in their district (van der Ploeg, Cauilan-Cureg & van Weerd, 2008).

CPPI is implementing the Crocodile Community Awareness for Resource Education Campaign or 'Crocodile CARE Campaign', initially launched in Agusan Marsh, Mindanao. This activity addresses the issues surrounding human–crocodile conflict, preservation of indigenous knowledge systems/practices, and understanding the perception of local stakeholders to uphold human and crocodile coexistence through the development of community-based ecotourism. Print and electronic information materials, conveying indigenous knowledge about crocodiles and their ecological role, were disseminated to change adverse community perceptions about these animals. More recent observations have suggested that local migrants have infused negative perceptions towards the remaining population of crocodiles, with an inclination for killing rather than conservation (Manalo *et al*., 2012). However, notable Agusanon Manobo tribal Chieftains do not tolerate the removal of crocodiles from their respective areas as the fish and aquatic-fauna stocks that sustain their fishing practices are healthiest when the area is also inhabited by crocodiles (Manalo *et al*., 2012; Gonzales *et al*., 2013). It is hoped that the CPPI educational campaign will help stop the killing of wild populations of crocodiles.

It is important to stress that the conservation message disseminated to local communities should be clear and sincere. The focus of the information should not simply be about the economic value and environmental services because this may lead to unrealistic expectations. Support for the conservation of the Philippine crocodile will be most successful if local communities have an inherent pride in protecting the species in its range habitat (van der Ploeg *et al*., 2011). The indigenous knowledge system and practices of people and communities with direct contact with the crocodiles are equally important when designing and implementing protection and conservation approaches (Gonzales *et al*., 2013). A well-informed and empowered community makes an efficient steward not only for the present day but also for future generations (Widmann *et al*., 2008).

CONCLUSIONS

Captive-breeding programmes for Philippine crocodiles have been successful, contributing to the population management of the species in captivity and in the wild. The progeny of nuclear populations are distributed around the world, thereby increasing genetic variability and minimizing the risk of uncertain catastrophic events. *In situ* conservation actions have led to the discovery of remnant populations in habitats that could potentially be places to reintroduce captive-bred individuals. These habitats have been discovered in many areas of the country, especially at higher elevations. Reintroduction, conservation-introduction and head-starting

programmes provide evidence for the need for suitable crocodile habitats. However, releasing crocodiles in their early life stages within their geographical range would probably be best suited for improved human–wildlife coexistence.

There is a need for an intensified nationwide education programme that would encourage and promote positive public sentiment and perceptions towards crocodiles in the wild. With the increasing conservation initiatives and unearthing of new conservation sites for the species, the wild populations of *C. mindorensis* are expected to become widespread in the country in the next few decades.

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