Effectiveness of head-starting to bolster Philippine crocodile *Crocodylus mindorensis* populations in San Mariano municipality, Luzon, Philippines

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SUMMARY

The freshwater Philippine crocodile *Crocodylus mindorensis* (endemic to the Philippine archipelago) is the most threatened crocodilian in the world with an estimated wild population of less than 100 mature individuals. Due to low survival of wild hatchlings, a head-starting program was initiated in 2005. Hatchlings are collected from the wild just after hatching and released back into their natural habitat after being raised in captivity for 14-18 months. Several ponds were created to provide suitable release habitat. Between 2005 and 2008, 88 hatchlings were collected. Hatchling survival after one year in captivity was 63 out of 88 (72%), compared to 47% for 36 hatchlings monitored in the wild (as low as 13% in some areas). Thirty two head-started crocodiles were released back into the wild (31 still held in captivity in 2009). Of the 32 released crocodiles, minimum survival after one year in the wild was 50%. Post release observations and recaptures showed that the released juvenile crocodiles adapted well to natural conditions and were increasing in size. The ultimate goal of the program will only be achieved if the head-started crocodiles survive to maturity and reproduce.

BACKGROUND

The Philippine crocodile *Crocodylus mindorensis* is listed as Critically Endangered on the IUCN Red list. Extant populations are severely fragmented and there is a continuing decline in area of occupancy (IUCN 2008). Based on surveys from 1982 to 2002 covering most of the Philippines, it is evident that the Philippine crocodile survives in only very few localities, at extremely low densities (van Weerd and van der Ploeg 2003). Habitat loss, indiscriminate killing, commercial hunting (a main reason for population declines in the 1970s and 80s) and the use of unsustainable fishing methods e.g. dynamite and cyanide techniques which can directly kill crocodiles, and indirectly through depleted fish stocks (and hence reduced crocodile food supply), have led to the near extinction of this species in most of its historical distribution range (van Weerd & van der Ploeg 2004).

Following the discovery of a remnant Philippine crocodile population in the Northern Sierra Madre Natural Park in 1999 (van Weerd 2000) this species has been monitored and protected in the municipality of San Mariano, Isabela province, northern Luzon (van der Ploeg *et al.* 2008a). A variety of education programmes and empowerment tools are being used to involve local communities in crocodile

and wetland conservation. This has led to broad local acceptance of and pride in having this rare crocodile present in their region (van der Ploeg *et al*. 2008b). Local wardens are officially employed (salaried by the municipal government) to enforce environmental protection laws. Crocodiles are no longer purposely killed, and three crocodile breeding sites are now protected (Miranda *et al*. 2004).

However, despite protection and education campaigns, the population remains small and fragmented. This is mainly because of low recruitment rates as a result of naturally low hatchling survival rates. In San Mariano an additional problem is the destruction of suitable nesting and hatchling habitat; almost all natural lakes, which previously served as nursery pools for hatchling crocodiles, have been converted to rice fields (paddies). As a result crocodiles often build their nests on the banks of fast flowing rivers. In these sub-optimal locations hatchling survival is very low, probably because of strong currents and high river water levels after heavy rainfall resulting in very high mortality. Therefore a conservation initiative was implemented, aiming to 'head-start' wild crocodile hatchlings and recreate suitable hatchling habitat for subsequent releases back into the wild (van Weerd & van der Ploeg 2008).

ACTION

A head-starting program (a conservation approach in which young animals are collected from the wild and captive-reared for varying lengths of time to a larger size in an attempt to increase survival rates prior to release back into natural habitats), was initiated in the municipality of San Mariano in 2005 (Fig. 1). The first batch of nine crocodiles was collected (in San Mariano municipality) on July 15, 2005. These hatchlings were raised in an improvised facility, where, due to intra-specific fighting five crocodiles died before they could be housed separately. In following years, this was avoided by separating hatchlings after three months.

To increase crocodile nest success, in 2006 a nest protection scheme was also set up. Local community members are hired to guard the nests from predators or accidental destruction starting on the date the nest is found up to the hatching date. To provide additional incentives for localized nest protection, a monetary reward is given to villages where a nest successfully hatches (equivalent to approx. US$ 10 per hatchling). In 2006, 35 hatchlings were collected from localities with unfavorable hatchling habitat.

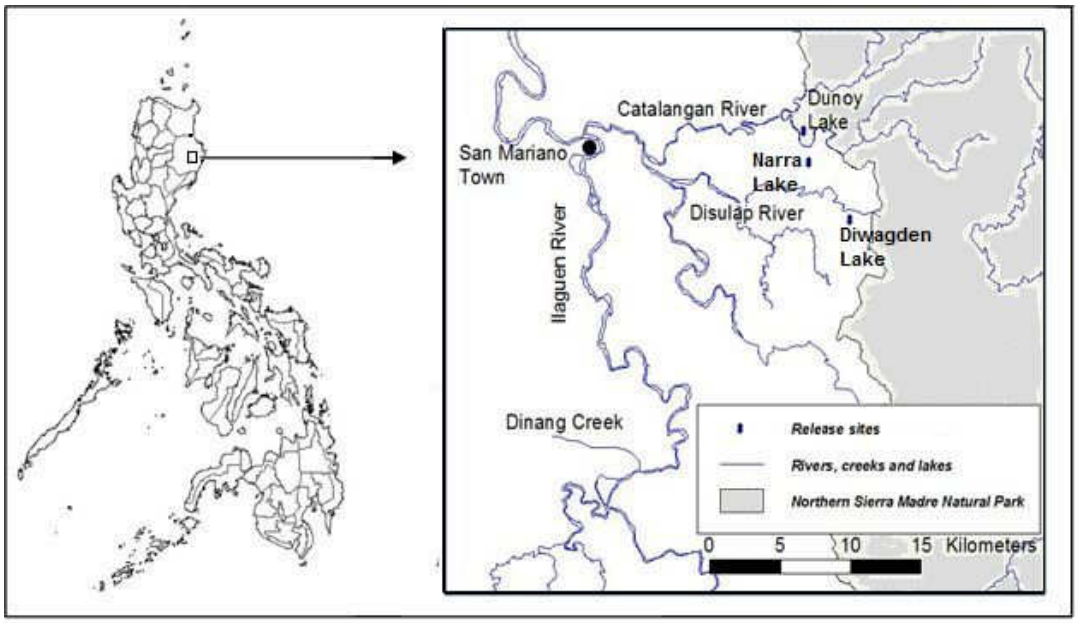

Figure 1. Research area in the municipality of San Mariano on Luzon, the Philippines.

Collected hatchlings are brought to the Municipal Philippine Crocodile Rearing Station in San Mariano Town. Here they are raised in captivity for 14-18 months, after which they are released. They are fed every other day with meat, fish or shrimps and the water is changed daily. Their health is checked regularly and growth is measured monthly. Climatic conditions are controlled by increasing heat and light when ambient temperatures fall too low.

Release ponds: Two release ponds were created: Diwagden Lake in 2006 (75m^2) and Dunoy Lake II in 2007 (450m^2). Community members (mainly farmers and fishermen) were involved in the planning process and were hired to dig the ponds. These ponds are situated next to creeks, rivers or ponds inhabited by wild Philippine crocodiles.

Releases and monitoring: The four surviving crocodiles collected in 2005 were released in Diwagden Lake in January 2007 (Fig. 2). In 2008, 28 juveniles of the 35 collected in 2006 were released in various sites in San Mariano, including several individuals at each of the two release ponds at Diwagden and Dunoy. Each was marked by clipping an individually recognizable combination of tail scutes prior to release. Their behavior and survival was monitored for four months after release. Regular (usually quarterly) surveys and recapture efforts (4 months and 1 year after release) were undertaken to monitor growth and survival rates. Surveys are done at night using flashlights; the strong red reflection of the retina of crocodile eyes enables surveyors to detect (the otherwise elusive) crocodiles. By blindsiding the crocodile with a flashlight they can be approached closely and recaptured using a manually operated noose-trap.

In an attempt to give some indication of survival rates of wild (non-head-started) hatchlings, 36 hatchlings from five nests situated in various habitats (adjacent to creeks, ponds and fast-flowing rivers) were monitored during one year after hatching between 2000 and 2006 through quarterly surveys (van Weerd *et al*. 2006).

Figure 2. Releasing a head-started Philippine crocodile in the newly created Diwagden Lake, 2007 (photo: M. van Weerd).

CONSEQUENCES

Between 2005 and 2008, 88 hatchlings were collected. Due to improvements in the rearing station facilities and rearing strategy, survival rates increased from the initial four of nine (44%) in 2005 to 27 of 32 (84%) in 2008, with an overall survival of 63/88 (72%) after one year. Overall average survival to 1 year of age of the 36 non-head-started hatchlings in the wild was 17/36 (47%) from the five nests monitored between 2000 and 2006. Survival rates varied greatly however, from 13% in fast flowing rivers (e.g. Disulap River) to 100% in marshes and ponds indicating that hatchling habitat quality plays an important role in hatchling survival (Table 1).

Table1. Survival of wild hatchlings from five monitored nests between 2000-2006.

Year	Locality	Hatchlings (n)	Survival to 1-year of age	%	Nest habitat
2000	Disulap River	8	1	13	Natural environment next to fast flowing river
2002	Dunoy Lake	12	9	75	Natural environment next to small pond
2004	Dunoy Lake	2	2	100	Natural environment next to small pond
2005	Dunoy Lake	3	2	67	Natural environment next to small pond
2006	Dinang Creek	11	3	27	Small buffer zone of a creek in human dominated landscape
Total		**36**	**17**	**47**	

Behavioral observations indicated that after release, the juvenile head-started crocodiles behaved naturally, i.e. spending most of their time basking or floating in the water near hiding places and submerging upon the approach of humans. As time went by, fewer crocodiles were observed during night surveys: one week after the release in 2008 all crocodiles could still be confirmed in the area of release, one month later not all crocodiles could be found (75%) and after four months only about half were located. This could indicate mortality or dispersal. However upon recapturing four months after release (June 2008), 75% of the crocodiles were discovered to be still alive; a sign that they adapt well to natural conditions. The juveniles released in 2007 have colonized a creek and nearby river, although they still visit the release pond during periods of heavy rains when water levels and currents are high.

All four individuals released in 2007 were still alive after one year, and at least three were seen two years post-release (75%). Of the 28 released juveniles in 2008, at least 21 were still alive four months later (75%). During recapture efforts (for measurements, Table 2) and night surveys in March and May 2009, a combined total of 13 of the 28 individuals released in 2008 were recorded (46%), although few could be recaptured as they effectively hid when people entered the water. As a result growth data is lacking but it shows a further adaptation to the wild as Philippine crocodiles are naturally shy of people.

The overall survival of released juveniles after one year in the wild is at least 53% (2007 and 2008 combined 17/32). This is a minimum count; unrecorded individuals could have dispersed to other areas, or missed during the surveys. No crocodiles were found dead. Recaptured crocodiles were measured and weighed; all had grown and appeared healthy.

Discussion: We will ultimately be able to call the Philippine crocodile head-starting program a success only if released crocodiles survive and reproduce. In this light it is interesting to note that an adult captive raised Philippine crocodile that was released in August 2006 bred in the wild in 2008. However the head-started juveniles are still sub-adult and thus will not breed until they mature. At this point in time we thus conclude that head-starting has been effective in increasing the recruitment of juvenile Philippine crocodiles within extant wild populations in San Mariano municipality. Survival rates of head-started hatchlings, both in captivity and after release, appear higher than that of wild crocodiles. Head-started crocodiles seem to adapt well to natural conditions and behave naturally. The selective collection of hatchlings in areas where hatchling mortality is highest, combined with nest protection and increased survival rates of wild crocodiles has resulted in an increase of the non-hatchling crocodile population in San Mariano. The number of non-hatchling crocodiles counted in San Mariano has increased from 34 in 2006 to 64 in 2009.

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Table 2. Juvenile crocodile total length (TL; cm) and weight (g) at release and recapture, 2007-2008.

No	Release year	At release		4 months after		1 year after		2 years after	
		TL	Weight	TL	Weight	TL	Weight	TL	Weight
1	2007	72.5	1370			87.0	2400	98.5	3000
2	2007	64.7	910			74.4	1000	85.2	1940
3	2007	66.5	950			89.0	2450		
4	2007	75.0	1550			89.0	2100		
5	2008	47.0	290						
6	2008	54.1	600						
7	2008	55.2	610						
8	2008	45.3	270	49.8	260	73.5	1230		
9	2008	51.8	440						
10	2008	50.2	380						
11	2008	48.9	510						
12	2008	47.0	510			50.9	500		
13	2008	47.3	330			68.2	880		
14	2008	52.2	537			61.2	650		
15	2008	50.6	380						
16	2008	48.7	330	64.6	810				
17	2008	47.7	340	58.4	510				
18	2008	59.8	402						
19	2008	50.6	519			58.3	550		
20	2008	54.8	646						
21	2008	49.7	420	66.5	890	77.3	1400		
22	2008	50.6	420	54.8	400	55.2	410		
23	2008	46.4	320	49.4	250				
24	2008	48.5	370	51.1	310				
25	2008	48.0	330						
26	2008	47.0	300						
27	2008	46.5	-	53.0	340				
28	2008	49.3	390	62.0	700				
29	2008	51.0	420	63.3	750				
30	2008	46.5	330	50.3	300				
31	2008	46.2	310	50.0	300				
32	2008	49.0	340	53.6	310				

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