

on humans in Florida, stress and the crocodilian immune system, alligator population genetics in southwest Georgia, Nile crocodile ecology in St. Lucia, South Africa, and American crocodile ecology, ecotoxicology, and conflict with humans in Costa Rica. The symposium was again followed by a dinner/social where speakers and attendees enjoyed the spring evening weather and a Lowcountry Boil of seasoned potatoes, sausage, corn, and shrimp, and continued conversations about crocodilian research, management, and conservation late into the night.

Thomas R. Rainwater, *Tom Yawkey Wildlife Center & Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Highway 17 North, P.O. Box 596, Georgetown, SC 29440-0596, USA; trrainwater@gmail.com.*

South Asia and Iran

India

RESULTS OF ANNUAL CENSUS OF SALTWATER CROCODILES (*CROCODYLUS POROSUS*) IN BHITARKANIKA WILDLIFE SANCTUARY, ODISHA, INDIA. The annual census conducted in the river systems of Bhitarkanika Wildlife Sanctuary/National Park in January 2017 resulted in the sighting of 1682 Saltwater crocodiles (608 hatchlings, 334 yearlings, 266 juveniles, 172 sub-adults, 302 adults). The relative density of crocodiles has increased from 0.87/km in 1976 (61 juveniles, 6 sub-adults, 29 adults) to 13.36/km in 2017 - a 1652% increase in total numbers.

In addition, more than 70 female Saltwater crocodiles (both released and wild) have bred annually, a 1300% increase compared to the mid-1970s with respect to nesting in the wild. With initiation of the Government of India/FAO/UNDP Project "Crocodile Breeding and Management", the Crocodile Conservation and Research Project was launched in different states of India in 1975. The Saltwater Crocodile Conservation and Research Programme, implemented in the State of Odisha, has been a great success. At the national level it is at the top as far as "rear and release" and building up the depleted wild population is concerned. The *C. porosus* population in the Bhitarkanika river systems has gradually been built up over the last 41 years.

The main Bhitarkanika River (from Khola to Pathasala), Thanapati, Mahinsamada, Suhajore and Baunsagada Creeks, and Kalibhanjadia, reported the highest densities of crocodiles, since they satisfy all the basic requirements for survival of the species in this mangrove ecosystem. Bhitarkanika now holds the largest population of wild Saltwater crocodiles in India, which represents about 70% of the total Indian population of the species.

Sudhakar Kar, *former Senior Research Officer, Odisha Forest and Environment Department and "Subhadra Nibas", Sampur, Bhubaneswar 751003, Odisha, India.*

Nepal

DOING THE NEEDFUL IN NEPAL: PRIORITIES FOR GHARIAL CONSERVATION

Time to Re-Focus

A recent paper entitled "Conservation and Population Recovery of Gharials in Nepal" (Acharya *et al.* 2017) presents an optimistic overview of conservation efforts in Nepal over the past decade, following the pioneering work of the late T. Maskey (Maskey 2008) and to whom the paper is dedicated. The main message of Acharya *et al.* (2017) is that the decades long *ex-situ* program of egg collection and captive rearing has run its course, and that the Nepal program needs to refocus on the remaining wild populations before it is too late. The authors argue further that: 1) since 2005 wild populations have been gradually "increasing"; 2) there is evidence of "natural recruitment" in the two remaining wild populations at Chitwan National Park (CNP) and Bardia National Park (BNP); and, 3) that these populations are overwhelmingly "female-biased". They conclude by suggesting that future *in-situ* efforts should be channeled toward field assessments, habitat management, and ecological and behavioral research.

Here I comment on this paper, and add my personal assessment of Gharial conservation in Nepal as it now stands and as these efforts are carried forward into the future. My assessment is based on two recent field visits in April and in July 2016, where I stayed at CNP and at BNP and spoke with workers in Government [Department of National Parks and Wildlife Conservation (DNPWC)], the major NGOs [National Trust for Nature Conservation (NTNC), WWF Nepal, Zoological Society of London (ZSL)] as well as independent researchers working with these agencies. I particularly thank all of these people who generously and graciously shared information with me. I emphasize here that my comments are offered to help clarify and refocus current and future conservation efforts in Nepal toward our common goal of Gharial conservation. For the record, I am in full agreement with the main message that the time is right to reframe and refocus Gharial conservation in Nepal, but I also question the assertions that wild population numbers are increasing, and that significant natural recruitment occurs under the current management regime.

Too Many Gharial in Captivity

First of all, the refocus away from the *ex-situ* approach, and squarely on the status and fate of the two remaining wild populations is long overdue and most welcome. At present, the Gharial Conservation and Breeding Centre (GCBC) at Kasara, within CNP, contains in excess of 600+ Gharial, including several small breeding groups of adults and primarily large juveniles and small sub-adults of unknown sex, most 1.5-2+ m in size and 5-12 years of age. The facility is over-crowded and the feed bill is unmanageable, given the current level of staffing and support. Visitors to CNP have the option to pay a fee and tour the GCBC, but officials

are privately embarrassed by the condition of the facilities, despite the best efforts of the understaffed and underfunded management.

Since 1981, 1156 captive-reared Gharial have been released into five major rivers in lowland Nepal, with 875 released directly into CNP (see Figure 4 in Acharya *et al.* 2017). Although several hundred have been released annually in recent years, these are increasingly older, possibly stunted individuals, with no experience under wild conditions. Many of the recent releases have been done during the winter months, with attendant ceremonies, but little follow-up.

Lack of an Effective Release Strategy

This situation, in which captive animals reared primarily from eggs taken from wild nests, and being held until they reach large juvenile or small sub-adult sizes, is increasingly unworkable and more importantly, is of questionable value for the conservation of the two remaining wild populations. The few surveys of released Gharial indicate the loss of 50% within the first year, with only 20% recorded after two years, and an overall survival of ~7% (Ballouard *et al.* 2010; Maskey and Percival 1994). In CNP, if all of the increase in wild numbers surveyed through 2016 were attributable to these released Gharial, the increase would represent only 11% of those released (95/875; Acharya *et al.* 2017). The fate of the other 89% (780/875) is unknown, but anecdotally it is assumed that the survivors ultimately travel down the Narayani and cross into India at the Narayani-Gandak barrage. Nearby, in recent years on the Gandak at the Indo-Nepal border, a small breeding group has been noted with evidence of a small number of successful nests (Choudhury *et al.* 2016).

The larger issue here, and one that is seldom addressed or discussed, is the lack of a comprehensive, coordinated release strategy that targets releases of head-started Gharial 1) in appropriate localities to minimize disturbance and/or predation, and to maximize feeding, basking, etc., 2) at the appropriate age/size to establish residency in the released area, 3) at the appropriate season of the year (ie post-monsoon versus cool winter months, 4) with adequate marking, tracking, and assessment to evaluate the efficacy of the release protocols. All of these elements need to be incorporated into any head-starting and captive-release approach.

Clearly, in the current Nepal situation, the whole *ex-situ* program needs a serious “rethink” and “reboot,” aimed at: 1) drastically reducing captive numbers; 2) targeted release at much younger ages, smaller sizes, of known sexes, etc.; 3) in carefully selected, protected localities; and, 4) in strategic ways (eg right time of year, “soft” releases from *in-situ* enclosures, etc.). As Acharya *et al.* (2017) suggest, most wild nests should be left in place on the nesting banks, with adequate protections and Gharial “guards,” and the *ex-situ* program limited only to rescuing natural nests in jeopardy of flooding or other damage. Resultant hatchlings should be released soon after hatching. They also note that limited continuation of the *ex-situ* program may be an effective hedge

against the vagaries of climate change, with likely changes in river flow and associated habitat changes.

Increasing Numbers in the Wild Populations?

Acharya *et al.* (2017) contend that the surveys conducted since 2005 indicate “increasing” population numbers at the two remaining wild localities - CNP and BNP. They state that “the population of Gharials remains low at these locations” (61 in 2004; 156 in 2016), but the numbers of sub-adults have increased. A major factor confounding the survey counts is that fact that hundreds of captive-reared Gharial (1-2+ m TL) have also been released at these locations since 2005 (see Figure 4 in Acharya *et al.* 2017). There is little to no evidence that the presence of sub-adults, or increases in the numbers of sub-adults, indicates successful *in-situ* breeding at either location. In fact, few hatchlings have been recorded at either locality during nationwide surveys conducted in 2008, 2011, 2013 and 2016 (Khadka *et al.* 2008; WWF-Nepal 2011; DNPWC and WWF-Nepal 2013; National Crocodile Survey 2017, draft report cited in Acharya *et al.* 2017).

At this juncture the survey data on adult numbers at these localities are equivocal, in my view. It may be useful to hold judgment on this issue until the 2016 National Crocodile Survey results are detailed in an upcoming report due later in 2017 (Naresh Subedi, NTNC, pers. comm.). However, additional data from the 2013 National Crocodile Survey (comparable in scope and extent of coverage to the 2008, 2011 and 2016 surveys; DNPWC and WWF Nepal 2013) are available, but were not presented or discussed in Acharya *et al.* (2017). Similarly, valuable survey protocol guidelines are outlined in a recent report not referenced (Malla and Thapa 2016).

I have commented on these recent survey data at length in an unpublished critique (downloadable at Academia.edu, Jeffrey Lang). In brief, the 2013 survey shows counts slightly higher than those done previously in 2008 and in 2011, but the 2013 counts are much lower, by 2-3x than the counts reported for the 2016 survey. In my view the 2016 numbers cited in Acharya *et al.* (2017) for CNP and BNP are inexplicably high, and should be viewed with caution pending completion of the Final Report for the National Crocodile Survey in 2016.

Natural Recruitment in Wild Populations?

Likewise, the evidence for “natural recruitment” at both remaining wild localities, CNP and BNP, is equivocal. Despite surveys in 2008, 2011, 2013 and 2016, no hatchlings were recorded at the Babai River within BNP and only several were noted in the large Karnali River that borders BNP on the west. The claim of natural recruitment in the Babai in recent years is based on the presence of sub-adults during these surveys (Acharya *et al.* 2017). However, captive-reared stock from the GCBC at Kasara have been released at BNP in recent years, totaling at least 80 animals (10 in 2010, 50 in 2014 and 20 in 2015; unpublished DNPWC report; R.C. Kandel, pers. comm.). In contrast, there is evidence of limited natural recruitment at CNP, in both the Narayani and Rapti Rivers

where hatchlings have been noted in various earlier surveys, but not detected in the 2016 survey (Table 1 in Acharya *et al.* 2017).

A better indicator of natural recruitment is the number of natural nests found in these wild populations. Natural nest numbers are indicative not only of the likelihood of natural recruitment, but also of the number of reproductive females remaining in these populations. To date there is no definitive evidence of natural nesting in BNP in recent years, and no evidence yet of nesting along the Babai River, whose upper course is protected as it runs through the eastern half of BNP. Thus, although BNP is often referred to as the second location of a wild Gharial population in Nepal, evidence that the BNP population is self-sustaining is lacking. Gharial are now extirpated or nearly absent from the large riverine habitats along the Karnali where formerly they were present. In BNP Gharials are confined, with a few possible exceptions, to the smaller Babai River with its source in hills upstream.

In CNP the numbers of natural nests per year on both the Narayani and Rapti Rivers are: 6, 10, 8, 9, 7, 7, 5, 5, 6, 4, 7, 9, 11, 11, 12, 13, 14 and 11, for each year from 2001 through 2017 respectively (Bed Khadka, pers. comm.). During this 18-year period the mean nest number was 8.6, ranging from 5 to 14. This extensive dataset indicates that regular natural nesting occurs in CNP annually at low levels, and also suggests a very moderate increase since 2012, with 10+ nests recorded through 2017. These data, in turn, suggest that despite egg collection for captive rearing from the natural nests at CNP in most years, natural nesting persists in CNP where one or several small breeding wild population reside.

A caution re: inferences about adult female numbers from these nesting numbers - in Nepal, Gharial may not nest annually, but rather every other year, or on a longer cycle (Bed Khadka, pers. comm.). Thus, it is likely that the number of mature reproductive females may be as high as 40, but if only half of these nest each year, then the anticipated nest number would be ~20 nests annually, rather than 40. Studies in captivity of annual breeding should be instructive in this regard, but have not been reported. The actual number of nests, ~10+ annually, recorded at CNP suggests that there are fewer females than the 2016 survey indicates. Acharya *et al.* (2017) report 48 adults in the Narayani, and 20 in the Rapti, for a total of 68 “females” in CNP (2017).

Recent field observations by an independent researcher, Sunil Rajbhandari, in early 2017, recorded two breeding groups in the Narayani adjacent to CNP. He recorded two large ghara males, one within each group and a total of 40 adult females. A total of 89 animals were tallied, including 46 sub-adults and one juvenile in February 2017 at these two sites. Subsequently, 11 nests were located, half at the downstream site, and half upstream near the Rapti confluence (S. Rajbhandari, pers. comm.).

Additionally, Acharya *et al.* (2017) report that available surveys strongly suggest that the remaining adult populations, particularly at CNP, are female-biased, with few mature,

big ghara males recorded. In the 2016 survey at CNP, only one large ghara male was observed. The observations of Rajbhandari and co-workers indicate the presence of at least two large males at CNP, but recently (June 2017), a large male was found dead, entangled in a fishing net on the Narayani near CNP. The loss of a large male at CNP has prompted a discussion of whether additional males should be translocated to CNP, and whether such an action would be an effective solution for the apparent predicament of few mature males in the CNP wild breeding population. This discussion is ongoing, and has garnered considerable media attention, since cross-border solutions could include Indian involvement.

A More Realistic in-situ Strategy Directed at Human Threats to Wild Gharial

In concluding their paper, Acharya *et al.* (2017) recommend that the *in-situ* approach be augmented by further studies aimed at management and conservation of the wild populations, at both CNP and BNP. In a field assessment conducted in 2016, more robust suggestions emerged that directly addressed the very real and counterproductive human activities which presently threaten the survival and well being of the remaining wild Gharial, particularly at CNP. These *in-situ* actions include: 1) an allocated budget for *in-situ* conservation; 2) declaration of a no-go restricted zone to exclude fishing, sand and boulder collection, and reduce human disturbances where Gharials reside; 3) restoration of the River Rangers program to patrol and monitor Gharial activities; 4) intensive outreach with local communities using the river, especially those with legal fishing licenses; and, 5) coordination and collaboration with other Gharial conservationists and scientists working worldwide. Additional *in-situ* activities should also include: 6) long-term studies of spatial and nesting ecology; 7) identification of additional release sites; 8) direct protection and monitoring of natural nests; and, 9) penalties for habitat encroachment and destructive fishing practices.

Some of these *in-situ* elements were included in the recent Lacoste-funded program organized by the DNPWC and WWF-Nepal. This program appears to have ended in 2013 when funding ceased. It should be revived and reinvigorated with additional innovative people-directed programs aimed at the local fisher communities bordering the CNP and BNP. Many of these *in-situ* actions were initially successful and are described in Malla *et al.* (2012). In Nepal, conservationists and wildlife scientists have already pioneered many effective ways to conserve large, charismatic megafauna, such as rhinos, elephants, and tigers with buffer zones and community forests managed by local communities. Now is the time to make a major push to engage in similar efforts with local communities which live with their “aquatic tigers,” the Gharial, together with the other river fauna, including the many bird species, otters, river turtles and dolphins along Nepal’s rivers.

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Jeffrey W. Lang, Senior Scientific Advisor, Gharial Ecology Project, Gharial Conservation Alliance and Madras Crocodile Bank Trust, Post Bag 4, Mammalapuram 603104, Tamil Nadu, India (jeff.w.lang@gmail.com).

Latin America and the Caribbean

Venezuela

RANCHING OF ORINOCO CROCODILE FOR CONSERVATION PURPOSES IN VENEZUELA. In May 2017, within the framework of the Orinoco Crocodile Conservation Program in Venezuela, 347 wild *Crocodylus intermedius* hatchlings were collected in the Cojedes and Capanaparo Rivers (the two main populations of the species in the country), and taken to rearing facilities for grow-out and subsequent release back to the wild in 2018.

This activity was coordinated through the Ministry of Environment (MINEA), the Institute of National Parks (INPARQUES), the National Science Academy Foundation (FUDECI), and the Crocodile Specialist Group of Venezuela (GECV), and reflects the strategy of using the reproductive potential of remaining wild populations to support the captive breeding program, boosting the numbers annually reared and increasing chances of survival of wild new-born crocodiles. It also represents a cost-effective way to compensate for the decline in fecundity of older captive adults in the existing breeding facilities, some of which are already reaching the end of their useful lives as breeding stock. It would also help to lessen the possible effect on reduced fitness by the repeated use of captive-reared parents to reinforce wild populations for numerous generations.

The possibility of swapping reared specimens from one locality to the other is also proposed (with strict veterinary screening) in order to increase the genetic variability and reduce inbreeding in both populations, which despite sustained efforts of reinforcement are currently at low levels of abundance and have been geographically isolated for at least half a century.

The importance of this action not only lies in the rearing of crocodiles *per se*, but also during these field activities a detailed census of nests and hatchling pods was performed, which is the best index of the actual population status and reproductive potential of the species in both locations, and complements the data of the national census of the Orinoco crocodile that the GECV is carrying out in 2017 and 2018.

The bad news is that 40% of nests detected in the Capanaparo River were poached by local people. The encouraging news is that in the same river, in the area in which 16 females hatched in the Dallas World Aquarium were released in 2009 (as 2- and 3-years-old), the number of nests has doubled - from 5 to 10.

Perhaps the 27-year population reinforcement program has not yet managed to save *C. intermedius* from the path to extinction path in Venezuela, but it has undoubtedly been a critical factor in reducing the rate of decline. Until the main factors that affect these populations can be reduced to manageable levels, this effort must be maintained at all costs.

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CHAIRMAN:

Professor Grahame Webb
PO Box 530, Karama, NT 0813, Australia

EDITORIAL AND EXECUTIVE OFFICE:

PO Box 530, Karama, NT 0813, Australia

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COVER PHOTOGRAPH: Philippine crocodiles (*Crocodylus mindorensis*) at Palawan Wildlife Rescue and Conservation Centre (previously Crocodile Farming Institute). Photograph: Charlie Manolis.

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