

Distribution, population status and threats of Marsh Crocodiles in Chotiari Wetland Complex Sanghar, Sindh-Pakistan.

Muhammad Saleem CHANG^{1,2,3,4,*}, Ghulam Sarwar GACHAL¹, Ayaz Hussain QADRI, Khadim Hussain MEMON⁴, Muhammad Yusuf SHEIKH¹ and Rab NAWAZ³

1. Department of Zoology, University of Sindh Jamshoro, Sindh Pakistan.

2. Department of Science and Technology, University of Sindh Hyderabad/Jamshoro.

3. WWF Pakistan, 606-607, Fortune Centre, PECHS 6, Shara-e-Faisal, Karachi.

4. College of Fisheries, Ocean University of China, Qingdao, P.R. China.

* Corresponding author, M.S. Chang, Mobile: 0092-3332643404, E-mail: saleem_khan74@yahoo.com

Received: 21. May 2014 / Accepted: 01. September 2014 / Available online: 09. April 2015 / Printed: June 2015

Abstract. Spotlight surveys were conducted from 2006 to 2009 to determine the distribution, population status and threats of Marsh Crocodiles (*Crocodylus palustris*) in Chotiari Wetland Complex, Sanghar Sindh, Pakistan. A total of 66 Crocodiles were observed and 86² km surveyed. We observed the total number of Marsh Crocodiles were sixty six (66) in the CWC among them forty four (44) were adult Crocodile, ten (10) were juveniles and twelve (12) were hatchlings. Encounter rates were highest in fish farm 1 and Simni Dhandh. The Chotiari Wetland Complex is filled by the Ranto Canal in the flood season. Crocodile is categorized as endangered reptilian species in the Red List of IUCN. Cattle are allowed to drink water and wallow in the reservoir. Adequate compensation may be rendered for loss of life or injury as a result of happenstance with humans. The major source of threat to Crocodiles is the construction of Dam, the irrigation networks, illegal skin trading, habitat destruction, through anthropogenic activities. The site is suitable for conservation and management of Crocodiles and eco-tourism. At present there are immediate threats to the continued survival of Crocodiles in CWC. Conservation actions should address the creation of additional protected areas in anticipation of future regional development.

Key words: marsh crocodiles, population, status, conservation, chotiari wetland complex.

Introduction

The Chotiari Wetland Complex is an artificial water reservoir which is located at 20 km North East of the city Sanghar Sindh, Pakistan, at 69°4'E Longitudes and 26°1'N Latitudes. The CWC was constructed in December 2002 which covers an area of about 86 km² (Qureshi et al. 2009). The reservoir has the total capacity of water storage is 0.75 million acre feet (MAF). The reservoir has received water from the Nara Canal through the Ranto Canal during the flood season. The depth of CWC was recorded from 15 to 30 ft. with sandy and salty bottom, which provides a suitable surface for the growth of algae and other aquatic plant species (Chang et al. 2013a). The area and depth of CWC was observed variable depending upon the influx of rain water. The CWC is a unique wetland complex and an ecologically rich biodiversity. The wetland complex is characterized by a mosaic of diverse habitats including forest, fresh and brackish water lakes, agricultural lands, rangelands, sand dunes scrub, reed beds, fish farms and swamps (Chang et al. 2013b). Despite a very hot and arid climate zone the area is ecologically most diverse and rare in the region. The wetland has high ecological importance as it is recognized home to many internationally important and endangered species listed in the IUCN Red List. The wetland has support among important mammalian endangered species of Hog Deer (*Axis porcinus*) and Fishing Cat (*Prionailurus viverrinus*) and two vulnerable species of Chinkara (*Gazella bennettii*) and Smooth Coated Otter, *Lutrogale viverrinus* (Sheikh et al. 2004). There are vulnerable species of birds, Marbled Teal (*Marmaronetta angustirostris*) a globally migratory bird, visit and breeds in this wetland and also Palla's Fish-Eagle (*Haliaeetus leucorhynchus*) a vulnerable bird species resides in the wetland (Birdlife International 2012, IUCN 2012). The most important key species of ecosystem and endangered species of Pakistan the Crocodile is also recorded from the CWC (WWF-P 2007).

Early writers commented on the abundance of Crocodiles in CWC. Khan et al. (1976), Khan (1987, 1988, 1989) and Javed et al. (2004) counted several hundred Crocodiles in Sindh including CWC. High quality leather can be prepared from Crocodile skin (Groombridge 1982, Whitaker 1987, Whitaker & Whitaker 1989) and over-harvesting depleted population throughout its habitat (Powell 1972, 1973, Alvarez del Toro 1974). Commercial Crocodile hunting began in CWC during the 1980s. Both professional and part-time hunters engaged in commercial hunting, most of which happened when low water levels concentrated Crocodiles during the dry season. Population declines were first noted in the late 1970s and by the late 1990s Crocodile was nearly extirpated from CWC.

Materials and methods

We used diurnal and nocturnal spotlight surveys to census Crocodile populations. Survey localities were selected on the basis of accessibility to vehicles, boats and landowner permission. Monthly spotlights counts were conducted at most locations. Crocodiles were sited with 12-volt headlights during canoe surveys, though 400,000 candle-power Q-beam spotlight was used with the ski. Survey routes were transverse before dark, habitation and navigational threats distinguished and surveys began 20 to 40 min after night fall. Time of night has not been demonstrated to bias spotlight counts. Beginning and end points of each survey were documented to allow replication by future investigators. For comparison with previous surveys, fish farms, lakes and canal were categorized as easily accessible, moderately accessible and inaccessible. Consignment to a category was established on a subjective assessment of accessibility to boats and vehicles. Sites where access was rigorously controlled by fish farmers, landowners, even if readily accessible to boats and vehicles, were classified as inaccessible. Counts and size were composed by the same observer on all surveys. The coordinates of the beginning and endpoint of each survey were determined with the help of handheld Global Positioning System (GPS). Crocodiles were captured when-

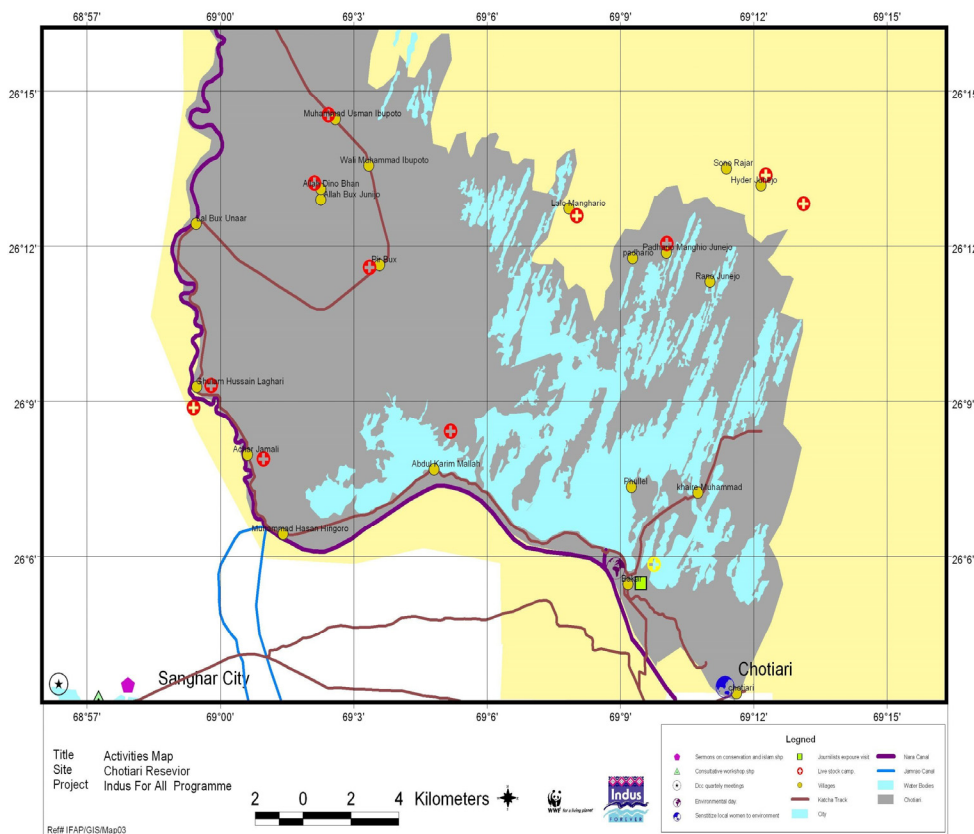


Figure 1. Map of Chotiari Wetland Complex Sanghar- Photo courtesy WWF-P.

ever conceivable to confirm size estimates and determine sex.

Measuring tape was used for the measurement eggs, fecal pellets and measured all the physical parts of Crocodile individuals. For taking the snaps, pictures and videos the digital camera was used and also take pictures of crocodile tracks, trials, signs, footprints, egg shell and other evidences of Crocodiles.

The study was based on; (i). Direct observation during the survey of study areas and (ii). Indirect evidence obtained during the interviewing of governments officials, game watcher, game warden, game inspector and from the local communities.

During the direct method, we have counted and observed the sighting habitats, basking spots, swimming at water surface and catching the reflection of eyes of Crocodiles during the survey of night observation. Diurnal surveys were carried to detect the active Crocodiles, tracks, trials and their nest sites.

We utilized the three categorize the individuals; the hatchlings (<0.5 mt), juveniles (0.5±1.0 mt) and adults (>2 mt). Marsh crocodiles were categorized based on their number; (i). Rare (<10 individuals), (ii). Common (10±30 individuals), (iii). Abundant (>30 individuals) and (iv). Extinct (there were no individuals available but crocodiles were known to occur in the past time).

Water samples were collected and then tested using a professional heavy metal kit for the presence and concentration of hazardous chemicals in the water (Data not shown).

Results

Diurnal and spotlights surveys were conducted from 2006 to 2009 throughout the wetland complexes zone of Chotiari Reservoir (Fig. 1). A total of 66 Marsh Crocodiles were observed along 86² Km of the survey route. Considerable variation in encounter rates was noted between the Fish farms,

Simni lake and Akanwari lake habitats (Table 1). Crocodiles were found at only 70.6% mainland sites were surveyed. However, failure to record Crocodiles particular sites should not be interpreted as a complete absence from an area. Instead, Crocodile may be present, but at such low densities that the probability of encountering one during a single survey is very small. Of these, (66.7%) were classified as adults, (15.1%) were juveniles and (18.2%) were counted or approached closely enough to estimate size.

During the study, in the areas of CWC, the total number of counted Crocodiles were sixty six (66), among them, 44

Table 1. Present population of Marsh Crocodile in Chotiari Wetland Complex.

S. No.	Name of the wetland	Adult	Juvenile	Hatchling
1.	Fauji Fish Farm	2	0	0
2.	Sueri bhit	3	1	0
3.	Bari Dandh	2	0	0
4.	Cutwari	3	1	0
5.	Makhi	2	0	0
6.	Fish farm 1	10	2	4
7.	Simani Dhandh	4	0	6
8.	Fish farm 2	2	0	0
9.	Wagu wala dandh	4	0	0
10.	Meena dandh	3	1	2
11.	Akanwari	4	2	0
12.	Jamali Fish Farm	2	2	0
13.	Paksiri	1	0	0
14.	Baqar Lake	3	1	0
Total		44	10	12

Table 2. Direct Sightings in CWC Sanghar.

S. No.	Direct sightings	Live/Dead	Location	Adult/Juvenile
1.	Direct sighting	Died	Ghundani Village	Adult
2.	Direct sighting	Live	Fish farm 1	Adult
3.	Direct sighting	Died	Chotiari Reservoir	Adult
4.	Direct sighting	Live	Nara Canal	Adult
5.	Direct sighting	Live	Paksiri	Adult
6.	Direct sighting	Live	Jadupur lake	Juvenile
7.	Direct sighting	Died	Fish farm 1	Adult
8.	Direct sighting	Died	Nara Canal	Juvenile
9.	Direct sighting	Live	Fauji Fish farm	Adult
10.	Direct sighting	Live	Nara Canal	Adult

Table 3. Indirect sightings in CWC Sanghar.

S. No.	Indirect sightings	Location	Adult/Juvenile	Remarks
1.	Indirect sighting	Fauji Fish farm	Adult	Foot print/Tracks
2.	Indirect sighting	Paksiri	Adult	Foot print
3.	Indirect sighting	Fish farm 1	Adult and Juvenile	Foot print/Faecal pellets
4.	Indirect sighting	Fish farm 2	Adult	Tracks
5.	Indirect sighting	Nara Canal	Adult and Juvenile	Tracks
6.	Indirect sighting	Chotiari Reservoir	Adult and Juvenile	Foot print
7.	Indirect sighting	Jadupur Lake	Adult and Juvenile	Foot print/Faecal pellets
8.	Indirect sighting	Simani Lake	Adult and Juvenile	Foot print/game watcher
9.	Indirect sighting	Waguwala Dhandh	Adult	Game watcher
10.	Indirect sighting	Jamali Fish farm	Adult and Juvenile	Foot print/Tracks
11.	Indirect sighting	Meena Dhandh	Adult and Juvenile	Foot print/Tracks
12.	Indirect sighting	Akan wari	Adult and Juvenile	Fisherman
13.	Indirect sighting	Baqar Lake	Adult	Foot print
14.	Indirect sighting	Cut wari	Adult	Foot print/Tracks
15.	Indirect sighting	Bari Dhandh	Adult	Fisherman
16.	Indirect sighting	Makhi Dhandh	Adult	Fisherman

were adult Crocodiles, 10 were juveniles and 12 were hatchlings recorded (Table 1). We observed through the direct and indirect sightings during the field survey in CWC (Table 3 and 4). It was recorded that the population of male Crocodile ratio was 37 and female was 29 (37:29) in CWC (Table 4). During the study, we used the measuring tape for the measurement of one selected adult Crocodile, juvenile and hatchling's body length (Table 5 and Fig. 2a,b and 3a-f).

Adults were more abundant than expected in mainland habitats and juveniles were less abundant than expected in the CWC. The high percentage of adults found in the fish farm 1 in the CWC could be due in part to sampling bias; juveniles may remain concealed within vegetation and escape detection during spotlight surveys. Only 19 (28.7%) Crocodiles for which size could be determined in this study had an estimated total body length greater than 365.76 cm. The largest was 3.6 m individual encountered in the Fish Farm 1. *C. palustris* is known to attain maximum total lengths of 4.8±5.0 m, although today individuals over 4.0 are rare (Thorbjarnarson 1989). Our observations indicate *C. palustris* of CWC may attain a larger body size than reported for other populations of Sindh region. It is unknown whether this is due to genetic and environmental factors, or past over-exploitation which removed most large adults. Sex was determined for 27 *C. palustris* captured during our study (Table 4). The resulting overall sex ratio and the sex ratio for mainland habitats and the Fish Farms and simni lake was not significantly different from parity. The sex ratio for the Fish Farm 2 and

Jamali Fish Farm was significantly different from 2:3 and was male biased.

Twenty-seven nests at 12 sites were located from 2006 to 2009. Two nesting sites (4.7%) were found at least on each site of CWC. Colonial nesting (more than one nest at a site) occurred at Fish farm 1 (6) nesting sites and accounted for 6 (8.7 %) nests. Nesting activity was concentrated in the Fish Farm 1, where 6 nests were found up to 7 clutches were deposited annually. Nesting sites are reused annually and nest-

Table 4. Population of male and female Marsh Crocodiles in CWC Sanghar.

S. No.	Name of Wetlands	Males	Females
1.	Fauji Fish Farm	1	1
2.	Sueri bhit	2	2
3.	Bari Dandh	1	1
4.	Cutwari	3	1
5.	Makhi	1	1
6.	Fish farm 1	8	6
7.	Simani Dhandh	4	6
8.	Fish farm 2	2	0
9.	Wagu wala dandh	2	2
10.	Meena dandh	4	3
11.	Akanwari	3	3
12.	Jamali Fish Farm	3	1
13.	Paksiri	1	0
14.	Baqar Lake	2	2
Total		37	29

Table 5. Measurement of one selected adult/juvenile/hatchling crocodile's sample.

S. No.	Description	Adult (m)	Juvenile (m)	Hatchling (m)
1.	Body condition	Active and alive	Active and alive	Active and alive
2.	Length (total)	2.8958	1.2192	0.2794
3.	Width (at center)	0.4572	0.1905	0.0762
4.	Head length	0.4572	0.2032	0.0508
5.	Head width	0.254	0.1143	0.0254
6.	Tail length Tail	1.6764	0.635	0.1524
7.	Tail width (at top)	0.254	0.0889	0.02
8.	Tail width (at center)	0.1968	0.0635	0.015
9.	Tail width (at top)	0.0378	0.025	0.01
10.	Fore limb length	0.4572	0.1778	0.0508
11.	Fore limb width	0.1143	0.0448	0.0254
12.	Hind limb length	0.6096	0.2986	0.0635
13.	Hind limb width (up)	0.2032	0.0762	0.0254
14.	Hind limb width (down)	0.0889	0.0508	0.0127
15.	Nails of fore limb	0.04	0.018	0.006
16.	Nails of hind limb	0.04	0.017	0.006
17.	Teeth of lower jaw	0.04 – 0.05	0.016	0.005
18.	Teeth of upper jaw	0.04 – 0.05	0.016	0.005
19.	Segments in tail	0.033	0.0023	0.002
20.	Teeth upper and lower jaw	0.03 – 0.03	0.003 – 0.003	0.001

ing occurred in multiple years at ten of 11 (91%) sites for which more than one year of data is available. Colonial nesting and nesting site reuse among *C. palustris* common, especially where suitable nesting habitat is scarce in CWC.

Most nests were found on elevated lakes/dhands composed of coarse sand. These lakes are often associated with shallow lagoons, which serve as critical nursery habitat for hatchling Crocodiles. These lagoons are rich in prey, offer abundant cover, shelter from wave action, and most importantly, provide a source of fresh or brackish water. Water salinity in these lakes is seasonally variable and strongly influenced by rainfall events. Salinity is lowest following heavy rains, which occur during late June and July, a period coinciding with hatchling emergence. Hatchlings cannot maintain body mass in hyper-saline water (25-36 ppt; Dunson 1982) and access to fresh or brackish water (410 ppt) is necessary for osmoregulation (Mazzotti et al. 1986). Hatchling survival is typically high where nursery habitat is available (Kushlan & Mazzotti 1989). At other site in CWC lacking suitable nursery habitat, hatchlings may be subject to prolonged periods of osmotic stress, resulting in decreased growth and survival.

Nesting habitat in CWC is limited due to a combination of natural and anthropogenic factors. Elevated lakes generally occur only on the eastern lakes of CWC and are absent on many, especially those inside the wetland. Additionally, lakes are highly sought as sites for fishing camps and tourist resorts, further reducing available nesting habitat.

Discussion

In the previous surveys, in the Sindh province small numbers of Crocodiles were recorded in the areas of Manghopir, Karachi Zoological Garden, Samzu Park and Khar Center, Karachi district (Captivity), Haleji Lake Thatta district (Captivity and Wild), Chotiari Wetland Complex Sanghar district

(Wild), Deh Akro II Shaheed Benazirabad district (Wild), Nara Desert Wildlife Sanctuary Khairpur district (Wild) and New Jatoti Farm Naushehferroze district in Captivity (Ahmed 1990, Chang et al. 2012a, 2013a, Chaudhry 1993, Ghalib et al. 1981, Javed et al. 2004). In Chotiari Wetland Complex (Previous known as Makhi/Bakar lake) the Crocodile population was recorded about five hundred only by the Pakistan Zoological Survey of Pakistan during the year of 1997. About more than one thousand Crocodile numbers in Chotiari Wetland Complex and its associated areas were recorded by Sindh Wildlife Department during the years of 1999-2000 (Javed et al. 2004). Two recent surveys were carried out on population status of Marsh Crocodiles by the Zoological Survey of Pakistan during the years of 2004 and 2005 respectively. WWF-Pakistan was carried out the survey on population status of Marsh crocodiles in Nara Canal and Chotiari Wetland Complex during the year of 2008-09. In the last decades, the crocodile population in Chotiari Wetland Complex, Deh Akro II and Nara Desert Wildlife Sanctuary was recorded in thousand numbers but unfortunately today their numbers are decreased and remained very few numbers due to the hunting pressure, fishing practices, habitat degradation, ecological changes, construction of Dam, land used for agriculture, increase human population, shortage of water and low quality of water.

Most Crocodile populations are resistant to over-exploitation and retort well to protection (Bayliss 1987). Elsewhere, quick recovery of *C. palustris* populations has not occurred following interruption of commercial hunting (Ross 1998). However, there is indication to suggest that recovery of *C. palustris* populations has not occurred in CWC. Our surveys specify populations remain low on most of lakes and *C. palustris* is extremely rare on the mainland. Encounter rates are among the lowest described anywhere and rarity of juveniles is strongly suggestive of diminished conscription. The largest *C. palustris* population and most nesting activity occurs in the Fish Farm 1. Additionally, this



Figure 2. (a) Crocodile killed by local community, (b) crocodile killed by local community.

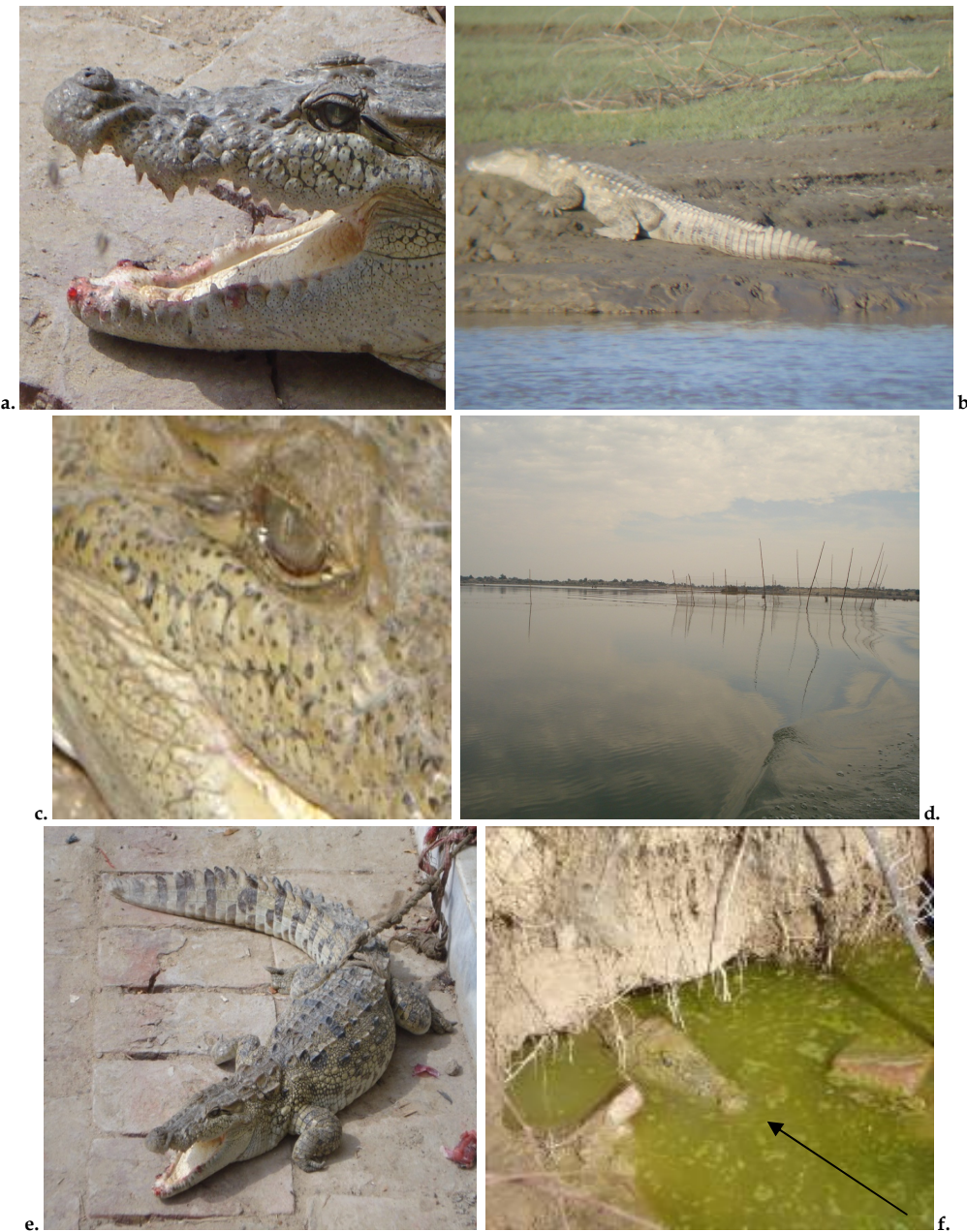


Figure 3. (a) crocodile in CWC, (b) crocodile basking in CWC, (c) crocodile in CWC, (d) fishing nets in CWC, (e) crocodile captured in CWC for measurement/weight, (f) a juvenile in CWC.

population appears to play a vital role in regional meta-population dynamics. The status of this population remains tenuous, though, as the CWC is inhabited by only 12 non-hatchling Crocodiles, and based on the number of nests, perhaps 20±25 breeding females. Reproduction is reliant on CWC lakes, which remain unprotected and vulnerable to development. Extrapolations, based on density estimates from the CWC, recommend a Sindh population of fewer than 1100 individuals. Furthermore, because Crocodiles in marshy habitats tend to disperse widely, many occurrences outside the reservoir may represent transient individuals rather than members of an established population. Despite legal protection, several threats remain to the continued survival of *C. palustris* in WCW. Although we found evidence of commercial poaching, opportunistic killing of Crocodiles is common place. Furthermost are explosion near fishing camps, a problem exacerbated by careless waste disposal practices, which tend to attract Crocodiles. Though, the highest cause of mortality appears to be the incidental drowning of Crocodiles in monofilament fishing nets. Whereas, it is impossible to quantify mortality from these sources, the loss of even a few Crocodiles from small populations, particularly adult females can have a significant negative impact. The demolition of nesting lakes and associated nursery habitat is the greatest threat to continued viability of *C. palustris* populations in CWC. Lake ridges, where most nesting happens, are extremely restricted and under increasing pressure for development. Consequently, these edges an associated plant communities are considered the most endangered habitat in the CWC. Moreover, lakes and freshwater pools adjacent to site ridges are critical for the survival of hatchling and juvenile Crocodiles. Without appropriate nursery habitat neonates may experience severe osmotic stress and a consistent reduction in survival.

The low population densities found in the Bari, Makhi and Paksiri, coupled with the loss of nesting and nursery habitat warrant the continued protection and classification of *C. palustris* as a critically threatened species in CWC. Population recovery is reliant upon the implementation of proper conservation strategies. The preservation of nesting and nursery habitat is essential for long-term population viability and the most important component of any conservation plan. It is overbearing to protect known nesting sites through sites or incorporation into existing protected areas. Also, proposed developments must be evaluated with regards to prospective nesting habitat before building permits are issued. We recommend integrating CWC into the national protection to Crocodile nesting ranges. Banning the use of monofilament fishing nets in all protected ranges of the CWC site will diminish accidental drowning of Crocodiles. Crocodiles could also be encouraged as an ecotourism attraction. Small-scale ecotourism is a favored option in recent development plans (McField et al. 1996) and local residents (e.g. tour operators and guide) whose livelihood depend on the continued survival of Crocodiles can be anticipated to support future conservation efforts.

Additionally, population recovery may advantage from a head-starting program, a management strategy in which wild caught hatchlings are reared in captivity until accomplishing a body size less vulnerable to predators and then released into suitable environment. This technique has been

used successfully to enrich recovery of other endangered Crocodiles (Thorbjarnarson 1992). Finally, a long-term (10+ years) populations monitoring program, established on net counts and spotlight surveys is needed to conclude population developments and evaluate the success of the conservation strategies.

Crocodiles are key source of raw materials where their skin are transported and used for the manufacturing of shoes, belts, handbags, medicines, various ornamental production due to its high demand for skin trade in the world (Ross 2001, Young 1981). The Crocodiles are considered as bio-indicator, which really focused attention on the major issues related with the pollution which are directly concerned with the human health and other life that directly used polluted water (Chang et al. 2012a, 2013b, Grizmeks et al. 1975). The shortage and quality of water was also considered serious effect on Crocodile's life (Abtin 2012, Chang et al. 2012b). Rais et al. (2012) reported that 32 species of reptiles including three species of fresh water turtles, 15 snakes, 13 lizards and one Crocodile species. While Rock Python and Indian Marsh Crocodile were recorded as threatened species of Pakistan.

The major threat is faced to Crocodiles the destruction of their habitats and seasonal flooding which can destroy the nesting and eggs of Crocodiles (Santiapillai et al. 2001). It was observed that the current Crocodile population disturbed with the interaction of peoples and boats, fishing nets; forest clearing fires usually reduces the suitability of habitat for crocodiles. After construction of reservoir the poverty enhanced in local communities and now they are struggling to generate their source of income on marginalized natural resources, due to these practices negative impacts on habitats and its related biodiversity.

Acknowledgement. The present study was funded with the financial support of WWF-Pakistan.

References

- Abtin, E. (2012): Habitat Suitability of Mugger Crocodile in Sarbaz River, Iran. *Wildlife Middle East* 6(2-3): 5.
- Ahmed, A. (1986): The distribution and population of Crocodiles in the province of Sindh and Baluchistan (Pakistan). *Journal of Bombay Natural Society* 83: 220-223.
- Ahmed, A. (1990): Pakistan Crocodile Specialist Group Newsletter 9(2): 15-16.
- Baillie, J., Groombridge, B. (1996): 1996 IUCN Red List of threatened animals. The IUCN Species Survival Commission. Gland, Switzerland IUCN, p.70. Introduction, 368p.
- Alvarez del Toro, M. (1974): Los Crocodylia de Mexico, Instituto Mexicano des Recursos Naturales Renovables, Mexico.
- Bayliss, P. (1987): Survey methods and monitoring within crocodile management programmes. pp. 157-175. In: Webb, G.J.W., Manolis, S.C., Whitehead, P.J. (eds), *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons Pty. Ltd, Sydney.
- Birdlife International (2012): *Marmoronetta angustirostris*. In IUCN 2012. IUCN Red List of Threatened Species. <www.iucnredlist.org>, accessed at 12.05.01.
- Chang, M.S., Gachal, G.S., Qadri, A.H., Sheikh, M.Y. (2012a): Bio-ecological status, management and conservation of Marsh Crocodiles (*Crocodylus palustris*) in Deh Akro 2, Sindh-Pakistan. *Sindh University Research Journal (Science Series)* 44(2): 209-214.
- Chang, M.S., Gachal, G.S., Qadri, A.H., Jabeen, T., Baloch, S., Sheikh, M.Y. (2012b): Distribution and population status of Marsh Crocodiles, *Crocodylus*

- Palustris* in Nara Desert Wildlife Sanctuary (NDWS) Sindh, Pakistan. Sindh University Research Journal (Science Series) 44(3): 453-456.
- Chang, M.S., Gachal, G.S., Qadri, A.H., Sheikh, M.Y., Chang, S. (2013a): Ecological impacts on the population of Marsh Crocodiles (*Crocodylus palustris*) in Chotiari Wetland Complex Sanghar, Sindh: A survey report. Canadian Journal of Pure and Applied Sciences 7(2): 2363-2373.
- Chang, M.S., Gachal, G.S., Qadri, A.H., Sheikh, M.Y. (2013b): Ecological impacts on the status of Marsh Crocodiles in Manghopir Karachi. International Journal of Advanced Research 1(1): 42-46.
- Chaudhry, A.A. (1993): Status of crocodiles in Pakistan. Crocodile Specialist Group Newsletter 12(1): 19-20.
- Dunson, W.A. (1982): Salinity relations of crocodiles in Florida Bay. Copeia 1982: 374-385.
- Ghalib, S.A., Rehman, H., Iffat, F., Hasnain, S.A. (1981): A checklist of the reptiles of Pakistan. Record: Zoological Survey Pakistan 8: 37-59.
- Groombridge, B., Wright, L. (1982): The IUCN Amphibia-Reptilia Red Data Book. Part 1, test dines, Crocodylia, Rhynchocephalia. IUCN, 426p.
- Javed, H.I., Rehman, H. (2004): Status of marsh crocodile (*Crocodylus palustris*) in Sindh. Record: Zoological Survey Pakistan 15: 22-30.
- Javed, H.I., Rehman, H., Fakhrai, S. (2005): On the status of Marsh crocodile in Balochistan. Record: Zoological Survey Pakistan 16: 40-45.
- Khan, M.S., Mirza, M.R. (1976): An annotated checklist and key to the Reptiles of Pakistan. Part-I: Chelonia and Crocodylia. Biologia 22: 211-221.
- Khan, M.K. (1987): Crocodile Specialist Group Newsletter 6 (Jan.-Dec.), 6p.
- Khan, A.A. (1988): The crocodiles of Pakistan: a dwindling resource. Tiger Paper (July-Sept.). pp.18-20.
- Khan, A.A. (1989): Crocodile Specialist Group Newsletter 8 (July-Sept.) pp. 5-6.
- Kushlan, J.A., Mazzotti, F.J., 1989. Population biology of the American crocodile. Journal of Herpetology 23: 7-21.
- Mazzotti, F.J., Bohnsack, B., McMahon, M.P., Wilcox, J.R. (1986): Field and laboratory observations on the effects of high temperature and salinity on hatchling *Crocodylus acutus*. Herpetologica 42: 191-196.
- McField, M., Wells, S., Gibson, J. (1996): State of the Coastal Zone report, Belize, 1995. Coastal Zone Management Programme, United Nations Development Programme and Global Environmental Facility. Project No. Bze/92/G31. Government Printing Oce, Belmopan, Belize.
- Qureshi, R., Waseem Ahmad, K., Babar K. (2009): Study of vegetation and smooth coated otter In Chotiari Wetlands Complex, Sanghar, Sindh, Pakistan. Pakistan Journal of Botany 41(5): 507-516.
- Powell, J. (1972): The Morelet's crocodile: an unknown quantity. Animal Kingdom 1972(2): 21-26.
- Powell, J. (1973): Crocodylians of Central America, including Mexico and the West Indies: Developments since 1971. In: Crocodiles: Proceedings 2nd Working Meeting of Crocodile Specialist Group. IUCN The World Conservation Union, Morges, Switzerland. pp. 27-31.
- Rais, M., Khan, M.Z., Abbass, D., Akber, G., Nawaz, R., Islam, S. (2011): A qualitative study on wildlife of Chotiari Reservoir, Sanghar, Sindh, Pakistan. Pakistan Journal of Zoology 43(2):237-247.
- Ross, J.P. (ed) (1998): Crocodiles Status Survey and Conservation Action Plan. IUCN/SSC Crocodile Specialist Group, 2nd Edition. IUCN, Gland, Switzerland.
- Ross, J.P. (2001): Commercial captive breeding of crocodylians. In: using the market to create incentives for conservation of crocodylians. A review. Edited by Hutton, J., Ross, J.P., Webb, G. IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland.
- Santiapillai, C., de Silva, M. (2001): Status, Distribution and Conservation of Crocodiles in Sri Lanka: Biological Conservations 97(3): 305-318.
- Sheikh, K.M., Molur, S. (2004): Status and Red List of Pakistan's Mammals. Based on the Conservation Assessment and Management Plan. IUCN Pakistan, 312p.
- Thorbjarnarson, J. (1992): Crocodiles An action plan for their conservation. Messel, H., King, F.W., Ross, J.P. (eds). IUCN/SSC Crocodile Specialist Group, Gland, Switzerland, 136p.
- Thorbjarnarson, J. (1989): Ecology of the American crocodile (*Crocodylus acutus*). In: Hall, P.M. (ed.), Crocodiles: Their Ecology, Management, and Conservation. IUCN-The World Conservation Union Publications. Gland, Switzerland. pp. 228-258.
- Whitaker, R.J. (1987): An application of Detrended Correspondence Analysis and Non-metric Multidimensional Scaling to the identification and analysis of environmental factor complexes and vegetation structures. Journal of Ecology 75: 363-376.
- Whitaker, R., Whitaker, Z. (1989): Ecology of the mugger crocodile. In: crocodiles. Their Ecology, Management and conservation. A Special Publication of the Crocodile Specialist Group. ICUN, Gland, Switzerland. pp. 276-297.
- WWF-Pak (2007): Detailed ecological assessment of fauna, including Limnological studies at Chotiari reservoir: Indus for All Program under Indus Eco-region Conservation Program 2008. World Wide Fund for Nature, Pakistan, pp. 1-175.
- Young, J.Z. (1981): The life of Vertebrates, 3rd edition, Oxford University Press New York, USA.