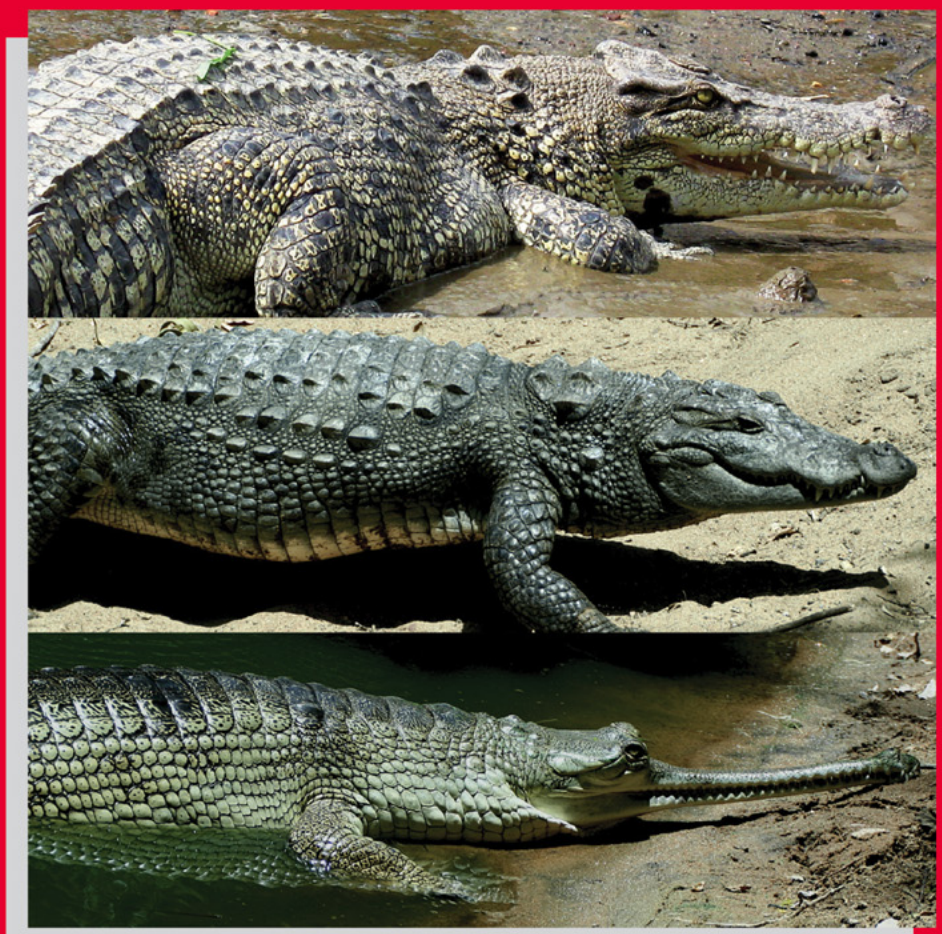
Crocodile Specialist Group, Species Survival Commission

CROCODILES



World Crocodile Conference

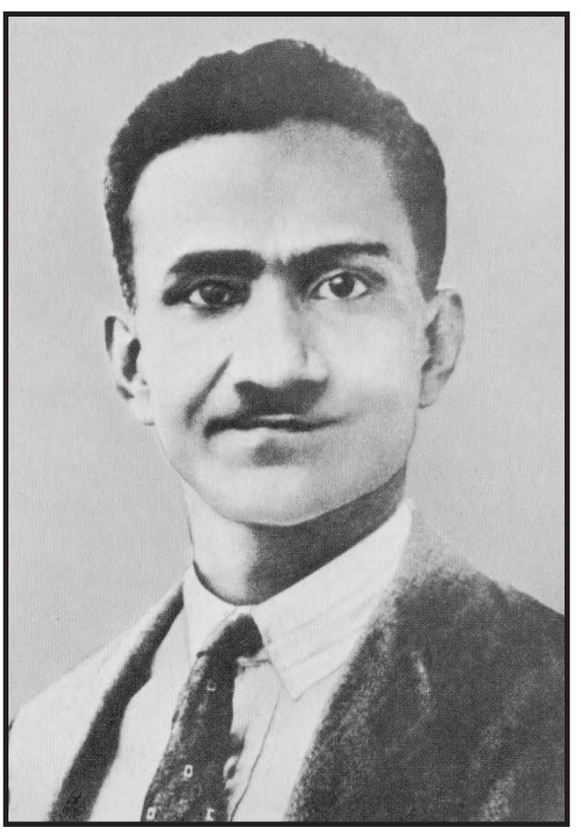
Proceedings of the 22nd Working Meeting of the Crocodile Specialist Group
Negombo, Sri Lanka, 21-23 May 2013
(Unreviewed)

2013

IUCN

CROCODILES

Proceedings of the
World Crocodile Conference, 22nd Working Meeting of the
Crocodile Specialist Group of the
Species Survival Commission of the IUCN
convened at Negombo, Sri Lanka, 21-23 May 2013



Dedicated to Dr. Paulus Edward Pieris Deraniyagala
(8th of May 1900 - 1st December 1973)

(Unreviewed)

International Union for Conservation of Nature (IUCN)
Rue Mauverney 28, CH-1196, Gland, Switzerland

2013

Front cover: Saltwater Crocodile, *Crocodylus porosus.* © Ruchira Somaweera
Mugger Crocodile, *Crocodylus palustris.* © Ruchira Somaweera
Gharial, *Gavialis gangeticus.* © Ruchira Somaweera

Title Page : P.E.P. Deraniyagala. © Siran Deraniyagala

Literature citations should read as follows:
For individual articles:

[Authors]. (2013). [Article title]. Pp. [page numbers] *in* World Crocodile Conference. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

For the volume:
Crocodile Specialist Group (2013). World Crocodile Conference. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

Compilers note

Under each subject the papers are listed alphabetically according to the principal author. The papers are not reviewed. However, to maintain consistency in the publication, the compiler took the liberty only to change the format. In instances where the full papers were not received by the compiler, the abstracts sent for the ***Book of Abstracts*** were included to make the publication a complete one.

Additionally, we have also included a biographical sketch of Dr. P.E.P. Deraniyagala remembering his contribution towards crocodilians of South Asia and 3 invited papers.

Anslem de Silva
Compiler
September, 2013

TABLE OF CONTENTS

Veterinary and Husbandry

General research

Crocodilian Status

Sri Lanka papers

Red Listing

Posters

Invited papers

CSG Thematic and Working Group Reports

Hosts, sponsors and donors

With generous sponsorship from

Sri Lanka Tourism Promotion Bureau
Sri Lanka Convention Bureau
Lacoste
FDB & Save Your Logo
Madras Crocodile Bank Trust/Centre for Herpetology
Department of National Zoological Garden, Sri Lanka
ODEL
Cleveland Metroparks Zoo
Hayley's Consumer
Zeppelin Advertising Services (PVT) Ltd
Multi Creative Solutions
Goldi Sands Hotel, Negombo
International Union for Conservation of Nature (IUCN)
Lanka Exhibition & Conference Services (Pvt.) Ltd

With gratitude to

The Director and the staff of the National Zoological Gardens of Sri Lanka, Dr. D. Mahaulpatha and University of Sri Jayewardenepura for providing facilities for the hands-on-training workshop on crocodilian veterinary techniques. All the photographers who contributed for the photographic exhibition. Mr. Jayantha Jinasena for exhibiting his paintings of crocodiles of Sri Lanka

For helping with the volume

Ruchira Somaweera

Page formatting

R.H. Thilini Dilhara

Printed by

A.M.P. Print Shop (Pvt) Ltd, Gampola.

Forward

At the 21st Working Meeting of the CSG in the Philippines (Manilla 21-25 May 2012), Anslem de Silva proposed that that the next CSG Working Meeting be in Sri Lanka. He came well prepared with various pledges of assistance from Government and the private sector. The proposal was warmly accepted, not simply because of Anslem's enthusiasm (and determination), but because Sri Lanka, is a special place with regard to crocodilians. It has two species, the mugger and saltwater crocodile, and the recent status of both was poorly known despite a national passion in Sri Lanka for wildlife conservation in general. So we did eventually all assemble in Negombo, for the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. Some 164 people attending from 27countries.A truly international and open forum in which to discuss crocodilian conservation and management on a global scale. The CSG itself is of course extremely grateful to Anslem, to the Government of Sri Lanka, to the various private sector donors, and to each attendee, some of whom have travelled across the world at their own expense, to contribute to the meeting.

One of the world's pioneering crocodile biologists, Dr Paulus Edward Pieris Deraniyagala (1900 to1973), as Director of the National Museum of Ceylon from 1939 to 1963. A skilled scientist with diverse interests, Dr. Deraniyagala's early publications on crocodilian biology, ecology, taxonomy and embryology were pioneering and pivotal studies in the 1960's and 1970's, when global interest in crocodilian biology and conservation began to escalate. In the 1970's, Rom Whitaker travelled to Sri Lanka and undertook a series of surveys, providing the newly formed CSG of the day with a clear picture of the general status of Sri Lankan crocodiles. Muggers appeared to be widely distributed, especially among the historical water tank systems throughout the dry zone of the country, whereas saltwater crocodiles were not faring as well in the coastal rivers, creeks and associated wetlands and swamps.

Through the 1980's and 1990's crocodiles were protected under national legislation in Sri Lanka, but had few people to champion their cause. This has changed enormously over the last few years. A true highlight of the meeting agenda was the number of Sri Lankan scientists now actively working on crocodiles and both presenting and discussing their results. In revising the IUCN Red List assessment for muggers, under the direction of Dr. Perran Ross, it was very clear that Sri Lanka now has a significant national quantum with crocodiles, which in this case enthusiastically combined their first-hand knowledge of distribution and abundance to make an accurate evaluation very expediently.

Human-crocodile conflict in Sri Lanka and elsewhere was once again a significant theme in the CSG Working Group agenda. It stands as an anachronism that if conservation efforts are successful with most large crocodilian species, and their numbers increase, so to do attacks on local people and livestock. The attacks create incentives for local communities to oppose ongoing conservation efforts, and often to destroy crocodiles, in the interests of public safety, regardless of national laws. Reducing the probability of attacks at the village level by the use of Crocodile Exclusion Enclosures is a practical and cost-effective way of reducing the probability of attack, and examples are now included on the CSG website. Ontop of this, creating positive values for crocodilian conservation through publiceducation and through innovative ways of gaining sustainable but tangibleeconomic benefits from expanding crocodile populations, is being practicedaround the world. It needs to be considered in all countries where communitysupport for ongoing crocodile conservation starts to wane due to attacks.

As the contents of this proceedings demonstrate, there was once again a great diversity of research results presented at the CSG Working Meeting something for everyone. From the functioning of cells and the immune system, to the functioning of wild populations. From the secret lives of crocodilian parasites to the complexity of pen design, and the ways that may be available for assessing the links between pen design and health. Within and outside the formal sessions the level of information exchange and professional camaraderie was truly heartening. New relationships were forged and new partnerships and projects generated. The 22nd Working Meeting of the IUCN Crocodile Specialist Group in Sri Lanka was a very successful meeting and its proceedings once again provide a wealth of information on crocodilian conservation, management, sustainable use and general biology.

Dr Grahame Webb
Chairman
IUCN-SSC-Crocodile Specialist Group

List of Participants

Abyerami Sivaruban
Department of Zoology,
University of Jaffna
No: 57, Thirunelvely, Jaffna
Sri Lanka
abyerami@gmail.com

A. M. Nishani L. Abesinghe
Uve Wellassa University
Faculty Of Animal Science & Export Agriculture,
Uva Wellassa University,
Badulla, Sri Lanka
nishani04002@yahoo.com

Abhijit Das
Aaranyak
Head, Division of Herpetology
50 Samanwoy Path, Survey, Beltola,
Guwahati PIN: 781028,
assama indiaabhijit@aaranyak.org

Abu Syem Muhammad Arif
Reptiles Farm Limited
Hatiber, Uthuru, Bhaluka,
Mymensingh 2240, Bangladesh
arif.croc@yahoo.com

Adam Britton
Big Gecko
Senior Researcher
PO Box 1281
Australia
abritton@crocodilian.com

Adrian Gabriel
Akbar Bros. Ltd
334, T. B. Jayah Mawatha,
Colombo 10 Sri Lanka .
adrian.gabriel01@gmail.com

Agata Staniewicz
University of Bristol
School of Biological Sciences,
Woodland Road, Bristol BS8 1UG,
United Kingdom
agata.staniewicz@gmail.com

Akira Matsuda
CRCPC
(Crocodilian Rescue Center Preparatory Committee)
2F, 27Bldg, 1-5, Nishi 7-chome,
Minami 2-jo, Chuo-ku, Sappro, 060-0062,
Japan
nonprofitinitiatives@gmail.com

Alejandro Larriera
Proyecto Yacare
Director
Pasaje Privado 4455. Sante Fe, 3000
Argentina
alelarriera@hotmail.com

Alexander Meurer
DGHT
Chairman of ag krokodile
Alfred-nobel-str. 1 e, 55411 bingen/rhine
Germany
ameurer@online.de

Alvaro Jose Velasco
Fauna silvestre productos y servicios
Director
Apartado postal 66597 Caracas
Venezuela
velascocaiman@gmail.com

Amali Malshani Samaraweera
Uva wellassa University
Department of Animal Science
Passara road,
Badulla., Sri Lanka
Amamalsh@gmail.com

Amila Chanaka
Young zoologist association of sri lanka
Sri Lanka

An Hsing Lee
Taipei Zoo
30 2 sec hsin kung rd Taipei
Taiwan, province of China
sux03@zoo.gov.tw

Anslem de Silva
Conference Director
15/1 Dolosbage road, Gampola
Sri Lanka
kalds@sltnet.lk

Asghar Nawab
WWF-India
Senior projects coordinator
172-b, lodi estate, New Delhi - 110003
India
anawab@wwfindia.net

Ashley Pearcy
Organization for tropical studies/
4004 buck matthews rd Columbia,
tn 38401, United States
ashley.pearcy@gmail.com

Ashoka Dangolla
University of Peradeniya
Faculty of veterinery medicine
Peradeniya
Sri Lanka
adangolla@gmail.com

Avinda Godahewa
29/5, Arnold place, Egodauyana,
Moratuwa, Sri lanka
avindagodahewa@yahoo.com

Avishka Godahewa
29/5, Arnold Place, Egodauyana, Moratuwa
Sri Lanka
avishka_godahewa@rocketmail.com

Béatrice Langevin Martin
Vetopierrelatte
Clinique vétérinaire ave de lattre de
tassigny 26700 Pierrelatte,
France
bea.langevin@wanadoo.fr

Bed Bahadur Khadka
Department of National Parks &
Wildlife Conservation
Assistant conservation officer
Chitwan national park
Nepal
bed.khadka@gmail.com

Benedict Ong Solco
Coral agri-venture farm, inc.
90 e. Rodriguez je. Ave.,
Ugong Norte murphy Q.C. 1110
Philippines
wilcon@wilcon.com.ph

Bernhard L Seidel
Technical office ecological research
Nibelungenstr 51, 3680 Persenbeug
Austria
Bernhard.seidel@univie.ac.at

Brandon Michael Sideleau
Crocodilian.com
Crocodile specialist
2900 Bayham circle
United States
bsideleau@gmail.com

Brian Pecaoco Sibongga
Coral agri venture farm, inc.
90 e. Rodriguez jr., ave.,
ugong norte murphy q.c. 1110
Philippines
wilcon@wilcon.com.ph

Brian Wright
Crocodile Consultancy International
Principal consultant
20 down street freshwater cairns Queensland
Australia
brianwright.cci@bigpond.com

Brij Kishor Gupta
Central Zoo Authority. New Delhi, India
Evaluation and monitoring offi C-280, arjuna,
10th cross street sector beta-i greater noida
201310 district gautam budh nagar Uttar Pradesh,
India
brijkishor68@yahoo.com

Bruce Shwedick
Crocodilian conservation center of Florida
Director
Po box 3176 plant city, Florida 33563
United States
bshwedick@aol.com

Catherine Margaret Shilton
Berrimah Vaterinary Laboratories
Veterinary pathologist
Gpo box 3000, Darwin, nt, 0801
Australia
cathy.shilton@nt.gov.au

Catriona Hendry
The George Washington University
Gwu dept of biological sciences, 2023 g st nw,
lisner hall 340, Washington dc, 20052,
Uunited States
hendry@gwu.edu

Chamara Amarasinghe
Jetwing Blue
Ethukale, Negombo
Sri Lanka
chamara@jetwinghotels.com

Chaminda Jayasekera
Jetwing vil uyana Rangirigama, Sigiriya
Sri Lanka
chaminda@jetwinghotels.com

Chandani Ganga Wijesinghe
Dept. of National Zoological Gardens
Anagarika dharmapala mawatha, Dehiwala
Sri Lanka
Sandesh.gw@gmail.com

Charlie Manolis
Wildlife Management International
Chief Scientist
Po box 530, Karama, nt 0812
Australia
cmanolis@wmi.com.au

Chiranjibi Prasad Pokheral
National trust for nature conservation
Senior conservation officer
Khumaltar, Kathmandu
Nepal
Pokheralchiran@gmail.com

Christine Lippai
Christine Lippai Consultancy
308 murray street, Brooklyn, Pretoria
South Africa
lippainomad@gmail.com

Christopher Moran
University of Sydney
Emeritus Professor
37 croydon st, Petersham nsw 2049
Australia
christopher.moran@sydney.edu.au

Colin James Stevenson
Madras Crocodile Bank Trust
Post bag no.4, Vadanamelli
Mamallapuram-603 104, Tamil Nadu
India
colin@madrascrocodilebank.org

Crizelle Chan
Crocodylus porosus philippines inc.
2188 elisco road, brgy. Ibayo tipas,
Taguig city Philippines
jchan@goldenacres.com.ph

Csaba Geczy
Mbzo
Green mubazzarah chalet b1-09
po box 17015 al ain, Abu Dhabi
United Arab Emirates
sbcsaba@gmail.com

D L W S Pushpakumara
Biodiversity protection unit
Department of Customs
headquarters ,
Colombo 11, Sri Lanka.
pushpakumaradlws@gmail.com

D. M. Sameera S. Karunarathna
Young Zoologist Association of
Sri Lanka
B-1/g-6, de soysapura
housing scheme, Moratuwa
Sri Lanka
dmsameera@gmail.com

Damien D Mario
Young Zoologist Association
Sri Lanka

David Oudjani
Biologist
18 Rue Naudin
France
david_oudjani@hotmail.com

Deepani Jayantha
Born free foundation
No: 07, selna homes, lakeroad,
Malabe.
Sri Lanka
deepanij@yahoo.com

Dharmin Samarajeewa
Sri lanka institute of national
tourist guide lectures
No.37/35, temple road, Colombo 10
Sri Lanka
dharminsamarajeewa@gmail.com

Dinal Samarasinghe
487/4 old road Kottawa Pannipitya
Sri Lanka
dinal.salvator@gmail.com

Dinesh Eransake Gabadage
Taprobanica nature conservation society
150/6, stanley thilakaratne mawatha,
Nugegoda, Sri Lanka
degabadage@gmail.com

Don Ashley
Ashley associates
President
Po box 430, Sopchoppy, fl 32358
United States
jdalligator@aol.com

Enrico Chiesa
Ittalhide s.p.a.
Managing Director
Via mauro macchi 35, Milan
Italy
enricochiesa@italhide.it

Erin Britton
Big gecko
Senior Researcher
Po box 1281
Australia
abritton@crocodilian.com

Fabian Schmidt
Zoo leipzig
Pfaffendorfer str. 29
Germany
office@zoo-leipzig.de

Fanindra raj Kharel
Ministry of forest & soil conservation, nepal
Under secretary, technical
Singhdarbar, Kathmandu
Nepal
fkharel@gmail.com

G. A.Tharaka Prasad
Department of wildlife conservation
811 / a, jayanthipura Battaramulla
Sri Lanka
Tharakaprasad@yahoo.com

Geoff Mcclure
Crocodile farming consultancy
Consultant
Po box 44, clifton beach, 4879.
Queensland, Australia
crocconsult@bigpond.com

Giovanna Webb
Crocodile Specialist Group
Po box 530, Karama, nt 0812
Australia
Gwebb@wmi.com.au

Grahame John Warren Webb
Crocodile Specialist Group
Chairman
Po box 530, Karama, nt 0812
Australia
gwebb@wmi.com.au

Hasantha Lokugamage
Jetwing lagoon,
Pamunugama road,
Thalahena, Negombo, Sri Lanka
hasantha@jetwinghotels.com

Hasantha Wijethunga
Young Zoologist Association of Sri Lanka
Sri Lanka

Himanshu Rajeev Joshi
Canids veterinary centre
A/402, samruddhi chs, final plot no.393, l
ink road, near link view hotel,
opp don bosco school, boriv, India
himanshu.joshi87@gmail.com

Hiran Suraj Rodrigo Goonewardene
Appe kale project
28/1, hill street, Gampola
Sri Lanka
hsr.wild@gmail.com

Honxing Jiang
Research institute of forest, ecology and protection
No:02, dongxiaofu, yiheyuanhou,
Haidian district, Beijing
China
jianghongxingcaf@163.com

Ivan Rehak
Prague zoo
Research a. Conservation advis
U trojskeho zamku 3,
171 00 praha 7 Troja,
Czech Republic
ivan.rehak@volny.cz

Jagath Jayasekara
Dept. Of National Zoological Gardens
No.407/7, kotte road, Pitakotte
Sri Lanka
jagathvet@gmail.com

James l. Chan
Crocodylus porosus philippines inc.
2188 elisco road, brgy. Ibayo tipas,
Taguig city
Philippines
jchan@goldenacres.com.ph

Janith Jjayarathne
Young Zoologist Association of Sri Lanka
Sri Lanka

Jeffrey William Lang
U. Minnesota/n. Dakota
Conservation Biologist
1385 brompton street, saint paul,
Minnesota 55108-1622, USA
jeff.w.lang@gmail.com

Jennifer Brueggen
St. Augustine alligator farm
999 anastasia blvd. St. Augustine,
Florida 32080
United States
jbrueggen1@aol.com

Jennifer R. Hewlett
30 charles court lake hawea rd2 Wanaka
New Zealand
jenn_croc@yahoo.co.uk

Jigar N. Upadhyay
B/1 shreeji baug society,
nigam soc. Road,
near smruti mandir, ghodasar,
Ahmedabad -380050 Gujarat
India
jigarupadhyay@hotmail.com

Jindawan Siruntawineti
Department of Zoology,
Faculty of Science,
50 ngamvongvan rd., chatuchak,
Bangkok, Thailand
fscijws@ku.ac.th

Johanna Plendl
Free University Berlin
Institute of veterinary anatom
Koserstrasse 20
Germany
johanna.plendl@fu-berlin.de

Johannes Christoffel Els
Environment and protected areas authority,
Hod: herpetology & freshwater
P.o.box 29922, Al Sharjah,
United Arab Emirates
johannesels@ymail.com

John Caldwell
Consultant
37 edinburgh drive, st ives,
Cambridgeshire
United Kingdom
john.caldwell@mad.scientist.com

John David Brueggen
St. Augustine alligator farm
999 anastasia blvd. St. Augustine,
Florida 32080
United States
jbrueggen1@aol.com

K. E. Abesiriwardana
Dept. of National Zoological Gardens
Anagarika dharmapala mawatha,
Dehiwala, Sri Lanka

K. Nihal Senarath De Silva
Dept. of National Zoological Gardens
Anagarika dharmapala mawatha,
Dehiwala, Sri Lanka
zoosl@sltnet.lk

K. Sacheendra Deepankara De Silva
Young Zoologist Association of Sri Lanka
No.77/a, Colombo road, Rattenapetiya,
Boralasgamuwa, Sri Lanka
sacheendra.deepankara@gmail.com

Kamal Prasad Gairhe
Chitwan national park
Senior veterinary officer
Singhdarbar, Kathmandu
Nepal
kamalgairhe@hotmail.com

Kaoru Sato
Ueno zoological gardens
Senior keeper of reptile
9-83 ueno park, Taito-ku,
Tokyo 110-8711
Japan
ueno-zoo@tzps.or.jp

Katarina Rehakova
Prague zoo
Research a. Conservation advis
U trojskeho zamku 3, 171 00 praha 7 - Troja
Czech Republic
ivan.rehak@volny.cz

Kelum Nalinda Manamendra-Arachchi
Post graduate institute of archaeology, 407,
Bauddhaloka mawatha,
Colombo 07, Sri Lanka
onlinecss.kelum@gmail.com

Ken Richardson
Murdoch University
Veterinary Anatomy
South street, Murdoch
Australia
k.richardson@murdoch.edu.au

Kent Allen Vliet
University of Florida
Coordinator of laboratories
Department of biology 208 carr hall,
po box 118525 Gainesville, fl 32611-8525
United States
kvliet@ufl.edu

Lesley Pickering
University of Sydney
Emeritus professor
37 croydon st, Petersham nsw 2049
Australia
Christopher.moran@sydney.edu.au

Libor Kopecny
Czech association for keeping and
conservation of Vice president
Raduzova 3, Prague 6
Czech Republic
krokodylari@centrum.cz

M.D. Hasan Zahid Chowdhury
House # 22, pallabi extension housing
Mirpur 11 1/2 Bangladesh
crocodilefarmer@gmail.com

M.D. Mesbahul Hoque
Reptiles farm limited
Chairman & managing director
Suite 5b, 1/8 block - d, lalmatia,
Dhaka-1207, Bangladesh
mesbahulhoque@gmail.com

Madhava Suranjith Botejue
Taprobanica nature conservation society
150/6, stanley thilakaratne mawatha, Nugegoda
Sri Lanka
madhavabotejue@gmail.com

Maheshwar Dhakal
Department of national parks and
wildlife Ecologist
P.o box 860, babar mahal, Kathmandu
Nepal
maheshwar.dhakal@gmail.com

Majintha Madawala
Iucn/csg, young zoologist association
18, Ratmal Mawatha, Sirimal Uyana,
Ratmalana, Sri Lanka
majintham@yahoo.com

Manori Gunawardena
Environmental foundation ltd
146/34 Havelock Road, Colombo 5
Sri Lanka
manorig07@gmail.com

Marcos Ula Gonzales Jr
Local government of the municipality of loreto
Municipal civil registar
Municipality of loreto agusan del sur
Philippines
wilcon@wilcon.com.ph

Maria Theresa Rodriguez Aquino
Crocodylus porosus philippines inc.
Veterinarian
Puerto princesa city, Palawan
Philippines
dugongdoc@gmail.com

Marisa Tellez
University of California, Los Angeles
Ph.d. Candidate m.a. Biology ucla hershey hall
612 charles e. Young drive,
East Los Angeles, ca 90095-7246
United States
marisatellez13@gmail.com

Mark Merchant
Mcneese state university
Dept chemistry, 450 bearegard dr.,
kirkman hall rm 221a, lake charles,
Louisiana, USA 70609
mmerchant@mcneese.edu

Masiha Akther
Bancroc associates
2-b, 1/8 block - d lalmatia, Dhaka - 1207
Bangladesh
crocodilefarmer@gmail.com

Matt Plummer
Hcp
108 cairns street, cairns north,
Queensland
Australia 4870
matt_plummer@hotmail.com

Meneka N. K. Pathirage
Dept. Of national zoological gardens
Anagarika dharmapala mawatha, Dehiwala
Sri Lanka
m_pathirage@yahoo.com

Michael Vincent Francisco Cruz
J.k. Mercado & sons agricultural enterprises,
inc Business development
2636 tramo line cor. Alvarez st.
Pasay city 1300, Philippines
mykecruz@hotmail.com

Moin Ahmed
Regional co ordinator
2600 eagan woods drive, suite 50,
Eagan, mn 55121-1170 USA
moin_alig@yahoo.com

Mushtaq Ahmed
Bancroc associates
Managing director
2-b, 1/8 block - d lalmatia, Dhaka - 1207
Bangladesh
crocodilefarmer@gmail.com

Nadun Kushan Athulathmudhali
Dept. of National Zoological Gardens
Anagarika dharmapala mawatha, Dehiwala
Sri Lanka
zZoosl@sltnet.lk

Naresh Subedi
National trust for nature conservation, Nepal
Senior conservation officer
Khumaltar, Kathmandu
Nepal
nareshsubedi@gmail.com

Nikhil Romulus Whitaker
Madras Crocodile Bank Trust
Post bag no.4,
vadanamelli village east coast road,
Mamallapuram-603 104, Tamil Nadu, India
nikhil.whitaker@gmail.com

Nikita Nishit Salian
Nagpur veterinary college
G-512, sarita lok darshan,military road,
marol, andheri (east),Mumbai-400059, India
nikita_salian28@yahoo.in

Nilantha Kodithuwakku
Keells hotels management services
No.130, glennie street, Colomo 02
Sri Lanka
nilantha@chaayahotels.com

Nirmal Kulkarni
Madras Crocodile Bank Trust
Post bag no.4,
vadanamelli village east coast road,
Mamallapuram-603 104,
Tamil Nadu, India
ophidian.nirmal@yahoo.com

Nirmala Hirantha Balasooriya
334, temple road, dalugama, Kelaniya
Sri Lanka
nirmala.hiranthaya@gmail.com

Oswald Braken Tisen
Sarawak forestry
Acting deputy general manager,
Lot 218, kcld, jln tapang, kota sentosa,
Kuching Malaysia
oswaldtisen@sarawakforestry

P. D. Ravindra S. Pethiyagoda
University of Sri Jayawardenepura
Gangodawila, Nugegoda.
Sri Lanka
ravipethiya@yahoo.com

P. H. Sahani Prabha Chandrasir
University of Sri Jayawardenepura.
Gangodawila, Nugegoda.
Sri Lanka
spchandrasiri@gmail.com

P. M. Dharmatilake
Department of Wildlife Conservation
811 / a, jayanthipura battaramulla
Sri Lanka
dharmatilake.pm@gmail.com

P. Premasiri Peiris
Dept. of National Zoological Gardens
Anagarika dharmapala mawatha, Dehiwala
Sri Lanka

Panduka De Silva
15/1 Dolosbage road, Gampola
Sri Lanka

Paolo Riccardo Martelli
Ocean park corporation
Chief veterinarian
180 wong chuk hang road, Aberdeen
Hong Kong
paolo.martelli@oceanpark.com.hk

Pedro Gallamaso Mendoza
J.k. Mercado & sons agricultural enterprises,
inc Crocodile caretaker
Pag-asa farms pag-asa, kapalong,
davao 8113 Philippines
Philippines
admin@jkmsons.com.ph

Perran James Ross
University of Florida
Red list Authority
1919 sw 63 ave, Gainesville fl 32608
United States
pross@ufl.edu

Philip John Cunliffe-steel
368d cambridge road, Bethlehem,
Tauranga New Zealand
walkaboutsteel@gmail.com

Pradeep Rathnasiri
Department of Wildlife Conservation
Mihinthale wildlife bunglow,
Mihinthale
Sri Lanka

R. J. Rao
Jiwaji University Gwalior,
M. P. India - 474011
India
rjrao09@gmail.com

Rainier Ibanez Manalo
Coral agri-venture farm, inc.
90 e. Rodriguez jr. Ave.,
ugong norte murphy q.c. 1110
Philippines
wilcon@wilcon.com.ph

Rajib Shome
Reptiles farm limited
3/7, block-c, lalmatia, Dhaka - 1207
Bangladesh
shome.rajib@googlemail.com

Rambli Ahmed
Sarawak forestry
Ecologist, protected areas & b
Lot 218, kcld, jln tapang,
kota sentosa, Kuching
Malaysia
rambliahmed@sarawakforestry.com

Ramesh Kumar Thapa
Department of National Parks &
wildlife conservation
Bardia national park,
Nepal
rameshkthapa@gmail.com

Renuka Bandaranayake
Dept. of National Zoological Gardens
162/a, quarry road, Dehiwela
Sri Lanka
nouchali@yahoo.com

Ricardo O. Pusey
Environment agency abu dhabi
Al reef villas,
Mediterranean village st 9 villa 28
United Arab Emirates
lepidus99@yahoo.com

Robby James Mcleod
Koorana crocodile farm
Reproduction supervisor
290 eldon street, berserker, qld 4701
Australia
mcleod_robby@hotmail.com

Robert Gandola
Herpetological society of Ireland
27 ayrfield park
Ireland
robertgandola747@hotmail.com

Romulus Earl Whitaker
Madras Crocodile Bank Trust
Post bag no.4,
vadanamelli village east coast road,
Mamallapuram-603 104,
Tamil Nadu, India
kingcobra.two@gmail.com

Ruchira Somaweera
Biologic environmental survey
Senior zoologist
50b, angove street, North Perth, wa 6006
Australia
ruchira.somaweera@gmail.com

Ruhana Hassan
Universiti Malaysia Sarawak
Aquatic science department ,
faculty of resource scienece and technology,
Universiti Malaysia Sarawa,
Malaysia
hruhana@gmail.com

Rupika Rajakaruna
University of Peradeniya
Dept. of Zoology
Peradeniya
Sri Lanka
rupikar@pdu.ac.lk

S. M. A. Rashid
Chief executive & vice chair i
H:545, rd: 11,
baitul arman housin society,
adabor 1207 Dhaka
Bangladesh
carinam95@yahoo.com

S. V. Shositha Liyanage
Young zoologist association of
Sri Lanka

S.P.A. Gamini V. Samarakoon
National wildlife training centre
Giritale
Sri Lanka
gaminievijith@gmail.com

Sabita Malla
WWF Nepal
Senior research officer
Baluwatar, Kathmandu
Nepal
sabita.malla@wwfnepal.org

Sally Robyn Isberg
Contract scientist
Po box 329, noonamah,
Northern Territory 0837,
Australia
sally@crocfarmsnt.com

Sampath Gunasinghe
Keells hotels management services
No.130, glennie street, Colomo 02
Sri Lanka
tranz-travelcounter@chaayahotels.com

Samson Samuel
Ss farm.
82 rathstewart crensent, athy,
co. Kildare.
Ireland
samsonsamuel@yahoo.co.uk

Samuel Martin
La ferme aux crocodiles
Les blachettes 26700 Pierrelatte
France
s.martin@lafermeauxcrocodiles.com

Sanath Velarathna
Heritance kandalama
Naturalist
P.o box 11, Dambulla
Sri Lanka
sdc.kandalama@heritancehotels.com

Sarath R.B. Dissanayaka
Department of Wildlife Conservation
811 / A, Jayanthipura Battaramulla
Sri Lanka
sarathdisa@yahoo.com

Shakthi Sritharan
Gharial conservation alliance / mcbt
Vadanemmeli village, east coast road,,
mamallapuram 603104
India
shakthi.sritharan@gmail.com

Shamal Samaranayake
Dept. of National Zoological Gardens
No.35, 1st lane, gothami road, Colombo 05
Sri Lanka
sha_samar@yahoo.com

Shant Raj Jnawali
WWF Nepal
Coordinator - biodiversity con
P.o box 7660, baluwatar, Kathmandu
Nepal
shant.jnawali@wwfnepal.org

Simone Comparini
Pantera srl
Via pallesi 7/c p.o.107 56029 santa
croce sull arno
Italy
renzocomparini@libero.it

Sirilak Yamkong
Department of Zoology, Faculty of Science,
50 ngamvongvan rd., chatuchak,
Bangkok, Thailand
fsciwcc@ku.ac.th

Sisira Darshana Jayasinghe
Wildlife Conservation Society- Galle
Biodiversity education & research center,
Hiyare reservoir, Galle
Sri Lanka
info@wildlife.lk,
jayasinghesisira85@gmail.com

Snehal Rajesh Bhavsar
Gujarat society for prevention of cruelty to anima
60 kunj society, alkapuri, vadodara, Gujarat, India
snehalrajeshbhavsar@gmail.com

Suvarna Gowri Santosh Mallapur
Madras Crocodile Bank Trust
Post bag no.4, vadanamelli village east coast road,
Mamallapuram-603 104, Tamil Nadu,
India
gowri@madrascrocodilebank.org

Szu-Lung Chen
Taipei zoo
No. 32 sec. 2 xinguang road, Taipei 11656
Taiwan, Province of China
dwx24@zoo.gov.tw

T. R. Pradeep
Muthurajawela sanctuary
23, dalapura, Ja-ela
Sri Lanka

Tarun Nair
Madras Crocodile Bank Trust
Post bag no.4,
Mamallapuram-603 104,
Tamil Nadu, India
tarunnair1982@gmail.com

Theja Hemamali Abayarathna
Rajarata University of Sri Lanka
"sandun", kurundankulam, Galgamuwa
Sri Lanka
theja112@yahoo.com

Thilanka. L .Samaraweera
Sri Lanka customs bio diversity,
cultural and national heritage protection division
No 41, custom house, main street,
Colombo, Sri Lanka
Bpuslcustoms@gmail.com /
thilanka555@yahoo.com

Thomas Michael Dacey
IUCN SSC Crocodile Specialist Group
Po box 72, Smithfield, qld 4878
Australia
tomdacey@ozemail.com.au

U. K. Lakshman Peiris
Department of Wildlife Conservation
811 / A, Jayanthipura Battaramulla
Sri Lanka
lakshman.peiris@ymail.com

Valentine Lance
11579 lake vicente drive, lakeside,
California 92040
United States
lvalenti@sunstroke.sdsu.edu

Vicente Penalosa Mercado
Crocodylus Porosus Philippines, inc.
2636 tramo line cor. Alvarez st.
Pasay city 1300
Philippines
vpm@microlabphils.com.ph

Vijaya Anand
Rainforest Rescue International
No: 169, Mathara road, Megalle, Galle
Sri Lanka
vijayaananda2004@yahoo.com

Vishvapali Kobbekaduwa
University of Peradeniya
No.06, palace square, Kandy
Sri Lanka
vishvapali@gmail.com

Vyas Rajendrakumar Vajubhai
Vadodar municipal corporation
No.505, krishnadeep tower, mission road,
fatehgunj vadodara Gujarat
India
razoovyas@hotmail.com

W. A. Dharshani Mahaulpatha
University Of Sri Jayawardenepura
Gangodawila, Nugegoda.
Sri Lanka
mahaulpatha@yahoo.com

W. A. Sarath
Department of Wildlife Conservation
Hunuwilagama
Sri Lanka

Win Chaeychomsri
Kasetsart University
50 pahonyothin rd. Dep. Zoology fac.
Science kasetsart university Bangkok
Thailand
fsciwcc@ku.ac.th

Yoichi Takehara
Japan leather & leather goods association
No: 1-12-13 komagata toitu-ku. Tokyo
Japan

Plate 1. World Crocodile Conference
(22nd CSG Working Meeting)

1. Makara logo of the WCC and CSG Sri Lanka (Traditional oil lamp designed and constructed by the Dept. of National Zoological Gardens, Sri Lanka and Young Zoologists' Association)

2. The WCC main Hall back drop.

3. Participants at the Hands-on-training program on crocodilians, Dehiwala Zoological Gardens

4. The Sri Lanka delegation at WCC

5. WCC delegates

Plate 2. Hands-on-training at the National Zoological Gardens

1. Director and the Deputy Director, Dept. of National Zoological Gardens welcoming the delegates

2. VIPs at the high table, opening comments by Anslem

3. Paolo Martelli's talk on restraining and examining crocodilians

4. Paolo and C. Stevenson demonstrating techniques to obtain blood

5. About to dissect a saltwater crocodile

6. Cathy Shilton's demonstration on dissecting a crocodile

7. Cathy's demonstration

8. The stomach contents

Plate 3. Steering Committee Meeting and Opening of the 22nd CSG- Working Meeting

1. Alejandro Larrierra opening Steering Committee session

2. The Steering Committee session

3. Charlie Manolis addressing the committee

4. S.M.A. Rashid presenting the country report for Bangladesh

5. Registration Desk

6. The VIP's about to be escorted to the conference hall by traditional dancers

7. Opening comments by Ruchira Somaweera

8. Chief Guest H. D. Ratnayake (Director General, Dept of Wildlife Conservation, Sri Lanka) lighting the traditional oil lamp.

Plate 4. Opening of the 22nd CSG- Working Meeting

1. Grahame Webb lighting the traditional oil lamp

2. Tom Dacey lighting the traditional oil lamp

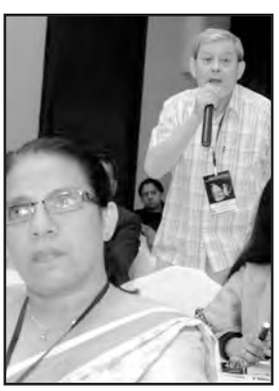
3. Hearty laugh by Hon. Tikiri Kobbekaduwa
(Governor of Central Province)

4. WCC delegates in the main conference hall

5. WCC delegate in action

6. WCC delegate in action

7. WCC delegate in action



8. WCC delegate in action

9. WCC delegate in action

10. WCC delegate in action

11. WCC delegate in action

12. WCC delegate in action

Plate 5. 22nd CSG - Working Meeting sessions

1. Veterinary Working Group round table discussion

2. A wide spread of Sri Lankan spicy food

3. The WCC financiers Imran, Aasim and Mariesz

4. Ashley Pearcy, Brandon Sideleau, Adam Britton and Rom Whitaker

5. Poster sessions

6. The two darlings of the WCC with Anlem de Silva

7. Raffle draw by Giovanna Webb

8. Charlie presenting the price to Chaminda Jayasekara, the lucky winner of the Raffle draw

Plate 6. The Gala dinner of the WCC

1. Anslem proposing the toast

2. The 'Ice crocodile' and food frenzy

3. All sorts of grills

4. Delegates enjoying

5. Part of Philippine delegation

6. Cathy toasting

7. Delegates enjoying the auction

8. Lushes Sri Lankan traditional dancers

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 23 - 25

P. E. P. Deraniyagala: the pioneer crocodilian researcher of South Asia

Anslem de Silva[1], Kelum Manamendra-Arachchi[2] and K.H. S. Rangika Premarathne[2]

1). 15/1 Dolosbage Road, Gampola, Sri Lanka (kalds@sltnet.lk)
2). Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka.

Paulus Edward Pieris Deraniyagala was born in Colombo on 8th May 1900, the eldest son of Sir Paul E. Pieris Deraniyagala Samarasinghe Siriwardhana and Hilda Obeyesekere. Sir Paul was an eminent Sri Lankan historian, a renowned lawyer and, in 1917, the first Asian to be awarded a D. Litt. from the University of Cambridge. Hilda Obeyesekere was a prominent philanthropist.

Paulus' interest in natural history started at the age of eight, when the family lived in the coastal town of Kalutara. Here he saw his first live sea turtles and crocodiles, animals that later became his chief herpetological interests (Adler, 1989). As a boy Deraniyagala kept a menagerie of assorted invertebrates in his bedroom (Pethiyagoda, 2007). Deraniyagala had his early education at St. Thomas' College, Colombo. After his primary and secondary schooling in Sri Lanka, in 1919 he proceeded to Cambridge University to study zoology, graduating with a BA in 1922 and MA in 1923. He spent one year in Harvard College, USA and got his A.M. in 1924 (Adler, 1989). Up to this time he was known as Paul Edward Pieris, the Portuguese Christian names given at baptism but on his return to the island he resumed his ancient family name Deraniyagala. On 28th June, 1934, P. E. P. Deraniyagala married Prini Eknaligoda Molamure, a great niece of the Maduwanwela Disawa (one of the famous chieftains of the country during late 1800), a union which produced four sons: Arjun, Ranil, Siran and Isanth (Manamendra-Arachchi, 2012).

P. E. P. Deraniyagala was a prolific writer on diverse subjects and during the period 1929-63 a vast number of books and research papers were published: 54 on ichthyology and fisheries, 79 on herpetology, 15 on ornithology, 60 on mammalogy, 74 on palaeontology and geography and 32 on prehistory. The number of his research papers exceeded 300 and appeared in the National Museums Research Bulletin, *Spolia Zeylanica*, the *Journal of the Royal Asiatic Society* (Ceylon Branch) and many foreign journals. The list below represents only his publications on crocodiles. His first book, published in 1939, was the *Tetrapod Reptiles of Ceylon Vol. 1. Testudinates and Crocodilians* (Figure 2) is considered his most important work scientifically (Adler, 1989) is undoubtedly the pioneering research work done in the country. Here, Deraniyagala provide details of the external morphology, reproductive cycle, food habits and distribution of both species of the country from pages 308 to 391. In 1953 Deraniyagala published his '*A Coloured Atlas of some Vertebrates from Ceylon',* volume 2 which included accounts of the two crocodile species and in 1958 Deraniyagala published a book on Pleistocene life in Sri Lanka titled '*The Pleistocene of Ceylon'* which is still considered the definitive study of the subject.

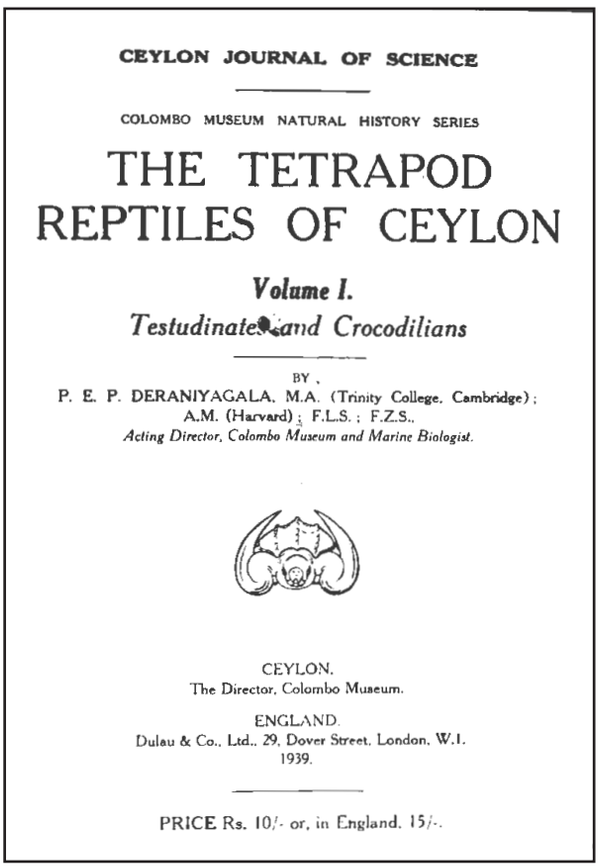
Deraniyagala was undoubtedly one of the most outstanding Sri Lankan herpetologists to date. He was also an artist and most of his papers were illustrated with his own paintings and sketches. During his career, Deraniyagala described 22 species and subspecies of reptiles including *Melanochelys trijuga parkeri*, 1939; *Bungarus ceylonicus karavala*, 1955; *Calliophis melanurus sinhaleyus*, 1951; *Chrysopelea ornata sinhaleya*, 1945; *Eryx conica brevis*, 1951; *Lycodon striatus sinhaleyus*, 1955; *Macropisthodon plumbicolor palabariya*, 1955; *Platyplectrurus madurensis ruhunae*, 1954; *Ptyas mucosus maximus*, 1955; *Rhinophis dorsimaculatus*, 1941; *Rhinophis tricolorata*, 1975; *Uropletis ruhunae*, 1954; *Calodactylodes illingworthi* 1953; *Cnemaspis podihuna* 1944; *Geckoella yakhuna* 1945; *Hemidactylus maculatus hunae* 1937; *Hemidactylus triedrus lankae* 1953; *Hemidactylus brookii parvimaculatus* 1953. *Ophisops leschenaultii lankae* 1953; *Ophisops minor minor* 1971; *Mabuya carinata lankae* 1953; *Nessia didactylus* 1934; *Nessia hickanala* 1940 and *Sphenomorphus dorsicatenatus* 1953.

Deraniyagala discovered many invertebrate and vertebrate fossils from the Miocene deposits and plant and fish fossils from the Jurassic deposits of Sri Lanka. His discoveries from alluvial deposits of the Pleistocene period contain many fossils of mammals and reptiles such as lion, hippopotamus, gaur, two species of rhinoceros, elephant etc. He is best remembered by the Sri Lankan general public for his naming of the Mesolithic man in Sri Lanka as “Balangoda Man”. Deraniyagala stressed the importance of this prehistoric human and his geometric microliths in the stone age of Sri Lanka.

Deraniyagala occupies a unique place in the annals of Sri Lankan scholarship. In addition to being the foremost Sri Lankan prehistorian of his time (in fact, it is doubtful whether any Sri Lankan prehistorian has surpassed him since), he also excelled as a marine-biologist, zoologist, palaeontologist, archaeologist, historian, anthropologist and was a painter

of international repute (Manamendra-Arachchi, 2012). At Cambridge University during early 1920's he was a champion boxer and is said to have been the first national boxer that Sri Lanka has produced. As a pupil of Seizo Usui, a member of the imperial bodyguard of the Emperor of Japan, Deraniyagala inaugurated the Amateur Judo Association of Sri Lanka of which he was the President for several decades.

Figure 1
P. E. P. Deraniyagala in the field



CEYLON JOURNAL OF SCIENCE

COLOMBO MUSEUM NATURAL HISTORY SERIES

THE TETRAPOD REPTILES OF CEYLON

Volume I.

Testudinates and Crocodilians

BY

P. E. P. DERANIYAGALA, M.A. (Trinity College, Cambridge); A.M. (Harvard); F.L.S.; F.Z.S.,
Acting Director, Colombo Museum and Marine Biologist.

CEYLON.
The Director, Colombo Museum.

ENGLAND.
Dulau & Co., Ltd., 29, Dover Street, London, W.1.
1939.

PRICE Rs. 10/- or, in England, 15/-.

Figure 2
Facsimile of the title page (original edition)

He received his first appointment in Sri Lanka on 26 June 1925 as the Second Assistant Marine Biologist, Dept of Fisheries, Colombo. Deraniyagala was appointed the Director of the Colombo Museum on 14 March, 1939, the first native Sri Lankan to hold that office. In addition to his own duties at the Museum he also acted as the Director of Fisheries, Ceylon until 17January 1941 in an early demonstration of his versatility and capacity. With the re-organization of the museums under the Department of National Museums, Dr. Deraniyagala became its first Director, a post which he held until his retirement in 1963.

Deraniyagala was also a Visiting Professor of Anthropology at the Vidyodaya (now Sri Jayawardenapura) University from 1959 and also served as the Dean of the Faculty. He was elected as the Vice-President of the Indian Museums Association in 1944 and also served on the Editorial Advisory Board of the Journal *Museum* published by UNESCO, Paris. Deraniyagala was the elected President of the Ceylon Association for the Advancement of Science (now SLAAS) for the year 1950 and President of the Royal Asiatic Society, Ceylon Branch in 1952. It is a testimony to the esteem he was held in by the authorities that Deraniyagala was asked to act several times for the Archaeological Commissioner in addition to his own duties. He also functioned as the President of the Sri Lanka National Committee of the International Council of Museums. Deraniyagala was a member of the University of California Scientific Expedition to Africa in 1947, where he described extinct hippopotamus, tortoise and human species from the vicinity of Lake Victoria.

Although Deraniyagala was among the foremost Asian scholars in several related fields, his chief contribution to scientific knowledge has been his studies and publications on the living and extinct fauna and prehistory of Sri Lanka. His researches were extensive and have contributed immensely to the furtherance of the knowledge of fauna, not only of Sri Lanka, but also of the Indian region. A work continued with distinction by his son Siran whose *magnum opus*, "Prehistory of Sri Lanka", is recognized as the "mother book" for South Asian prehistory.

In recognition of his achievements, Deraniyagala was elected a Fellow of the American Society of Vertebrate Palaeontologists, a member of the Indian Association of Systematic Zoology, Honorary Herpetologist to the Indian Pacific Fisheries Council, Honorary Fellow of the Indian Academy of Zoologists, Honorary Advisor to the American Foundation for the Study of Man and Honorary Advisor to the Food and Agriculture Organization on the reptiles of the Indian Ocean. The International Prehistoric Congress elected Deraniyagala to the Permanent Council of the International Union of Prehistoric and Protohistoric Sciences. He served as a member of the UNESCO Committee to Study the Key Zoological Collections of South and Southeast Asia. In 1960 he was awarded an Honorary Doctorate of Science by the Vidyodaya University, Sri Lanka for outstanding research in various fields.

In addition to his outstanding academic achievements, he was also a painter of repute. Like his brother Justin who was one of Sri Lanka's best-known artists, Deraniyagala received his early instructions in drawing under 'doyen of painters in Ceylon' Gate-Mudaliyar A. C. G. S. Amarasekera. His paintings were exhibited at the International Exhibition of Paintings staged in honour of the visit of the Duke and Duchess of Edinburgh. He was associated with the Ceylon Society of Arts for a considerable period and also served as the Honorary Secretary of the National Committee of Plastic Arts of Sri Lanka.

Contributions on crocodiles by P. E. P. Deraniyagala

It is of interest to note that Heinz Wermuth of Berlin Museum and P. E. P. Deraniyagala, when he was Director National Museums, Sri Lanka issued an appeal on the urgency of the protection of crocodiles worldwide. Their appeal was first submitted to the International Union for Protection of Nature in Brussels and then circulated to 160 herpetologist's across the globe (Alice, 1956). Sri Lanka and Germany had together taken an early leading role in promoting the conservation of crocodilians of the world.
Dr. Deraniyagala passed away on the 1st of December 1973.

Acknowledgements

Dr. Siran U Deraniyagala for the two images of P.E.P. Deraniyagala and information on his father and we thank John Rudge for his comments on the final draft.

Literature cited

1. Adler, K.1989. *Contributions to the History of Herpetology*. Society for the Study of Amphibians and Reptiles. Oxford, USA, 200 pp.

2. Alice. 1956. Crocodiles. *Loris,* 7(4): 322-323.

3. Das, I & Anslem de Silva. 1996. *A directory of herpetologist of South Asia.* Amphibia and Reptile Research Organization of Sri Lanka. 43 pages.

4. de Silva, Anslem. 1998. *The Testudines and Crocodilians of Sri Lanka: A Checklist and an Annotated Bibliography.* GEF/UNDP/FAO, 42 pp. ISBN: 955-8135-00-3

5. de Silva, Anslem. 2001. *The Herpetofauna of Sri Lanka: Historical Aspects and Current Status*. Ministry of Environment, 100 pp + 150 plates .ISBN 955-96005-0-8.

6. de Silva, Anslem. 2013. *The Crocodiles of Sri Lanka* (*Including Archaeology, History, Folklore, Traditional Medicine, Human-Crocodile Conflict and a Bibliography of the Literature on Crocodiles of Sri Lanka*). Published by the Author. Printed at AMP Print Shop, Gampola, 254 pp + 72 plates. ISBN: 978-955-52061-1-2.

7. Manamendra-Arachchi, K.N. 2012. Dr. Paulus Edward Pieris Deraniyagala: the pioneer in palaeobiodiversity. IN: *PEP Deraniyagala 39th Felicitation volume*. Biodiversity Secretariat, pp. 2-33.

8. Pethiyagoda, Rohan. 2007. *Pearls, Spices and Green Gold: an illustrated History of Biodiversity Exploration in Sri Lanka*. WHT Publications (private) Limited, Colombo. 241 pp.

Publications on crocodiles by Paulus Edward Pieris Deraniyagala

1. Deraniyagala, P. E. P. 1927. The reptiles of Ceylon. *Ceylon Observer Illustrated Christmas Number*: 95-97. (Includes brief note on the 2 species of crocodiles, *palustris* to be common, both killed for hide).

2. Deraniyagala, P. E. P. 1930. Crocodiles of Ceylon. *Spolia Zeylanica* 16(1): 89-95 + 2 plates (ecological notes, reproduction and distribution of the 2 species)

3. Deraniyagala, P. E. P. 1934. Neoteny in *Crocodylus porosus*. *Spolia Zeylanica* 19(1): 97- 100.

4. Deraniyagala, P. E. P. 1936. A new crocodile from Ceylon. *Spolia Zeylanica* 19(3): 276- 286.

5. Deraniyagala, P. E. P. 1937. The nest-guarding habit of the estuarine crocodile of Ceylon. *Spolia Zeylanica* 20(2): 253-254 (1 plate).

6. Deraniyagala, P. E. P. 1939. *The Tetrapod reptiles of Ceylon. Vol.1 Testudinates and crocodilians*. National Museum, + 412 pp. (pp. 307-391 a comprehensive account of the two species of crocodiles of Sri Lanka)

7. Deraniyagala, P.E.P. 1947. A new genus for the Chinese alligator. *Proc. 3rd Annual Sess. Ceylon Assn. Science*.

8. Deraniyagala, P.E.P. 1948. Some Vertebrate animals of Ceylon. *Nat. Mus. Pictorial Ser*.

9. Deraniyagala, P. E. P. 1949. *Some vertebrate animals of Ceylon* Vol.I. The National Museums of Ceylon Pictorial Series. 119 pp. (page 30 and 45-49 key and illustration of the 2 species of crocodiles)

10. Deraniyagala, P.E.P. 1951. The generic status of the Chinese alligator. *Spolia Zeylanica*, 26(1): 143-145.

11. Deraniyagala, P. E. P. 1953. *A coloured atlas of some vertebrates from Ceylon.* Vol. 2. National Museums Publication. Ceylon Govt. Press. 101pp. and 35 plates.

12. Deraniyagala, P. E. P. 1955. A new race of estuarine crocodile from Ceylon. *Spolia zeylanica* 27(2): 277-279. (names the Sri Lankan *porosus* as a distinct subspecies - *Crocodylus porosus minikanna*)

13. Deraniyagala, P. E. P. 1958. *The Pleistocene of Ceylon*. Ceylon National Museums Natural History Series. Govt. Press. Colombo, 164 pp. and 43 plates. (pp. 51-52 a brief account of an extinct crocodile from Kuruvita area)

14. Deraniyagala, P. E. P. 1963. Our vanishing wild life. *Times of Ceylon Annual 1963*.15p. (The Ceylon Swamp crocodile and an account of *C. palustris*, occasional specimen 20 ft and weighing 250 lbs.)

15. Field, C. J. & Deraniyagala, P. E. P. 1936. Crocodile's nest. *The Field* September: 686. (NOT checked)

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 26 - 28

A preliminary investigation into nesting and nest predation of the critically endangered, gharial (*Gavialis gangeticus*) at Boksar in Corbett Tiger Reserve, Uttarakhand, India

S. M. Chowfin[1*] and A. J. Leslie[2]

[1]C/o The Gadoli and Manda Khal Wildlife Conservation Trust, P.O. Box 27, District Pauri Garhwal, Uttarakhand, India | [2] Department of Conservation Ecology & Entomology, Faculty of Agrisciences, University of Stellenbosch, Matieland, 7600, South Africa |
Corresponding author: Email: schowfin@yahoo.com

Abstract

The gharial, *Gavialis gangeticus*, is an endemic crocodilian of the north Indian subcontinent and is also found in the Corbett Tiger Reserve. Surveys in Corbett National Park in 1974 recorded only five gharial whereas current estimates are 42 adults inclusive of 10 adult males and 59 individuals of smaller size classes. This study confirms that the expanded population in the Kalagarh Reservoir is breeding, although nests appear to be subject to significant predation, thought to be by *Varanus bengalenis*. Varanids are serious predators on crocodilian eggs in a number of countries. In this case, it is unclear whether such high predation levels are natural situations that apply when they live in a free-flowing river environment, or whether it is a derived state linked to the lake-type environment in which they now reside.

Key words: Gharial, *Gavialis gangeticus*, Corbett Tiger Reserve, Corbett National Park, Boksar, nest predation.
Abbreviations: Corbett Tiger Reserve (CTR), Corbett National Park (CNP)

Introduction

The gharial, *Gavialis gangeticus*, is an endemic, river dwelling crocodilian of the North Indian subcontinent, whose wild populations have been depleted throughout much of its former range (Ross and Magnusson, 1990). The western-most historic occurrence of the Gharial was the Indus River in present day Pakistan and the eastern-most (albeit from only two records in the scientific literature) was the Irrawaddy River in present day Myanmar. Today three widely separated breeding populations remain in India (Chambal River, Girwa River and the Kalagarh Reservoir/Ramganga River in Corbett Tiger Reserve) and one in Nepal (Rapti/Narayani River). The wild population was subject to an intensive conservation action program in the 1970's supported by United Nations Development Programme (UNDP)/Food and Agriculture Organization (FAO), which included 'head-starting', establishing protected areas, partial mitigation of anthropogenic pressures and physical enforcement of wildlife laws. In 1975, a breeding conservation project for gharial (and other crocodilians) was initiated with the Government of Orissa at the Nandankanan Zoological Park (Achariyo et al., 1996). The wild population recovered significantly, which was hailed a success. By the mid 2000's, the wild population was once again recognized as being in serious decline with the global adult population at no more than 200 individuals. In 2007, the International Union for Conservation of Nature (IUCN) red listing for gharials was upgraded from "Endangered" to "Critically Endangered" (IUCN, 2012).

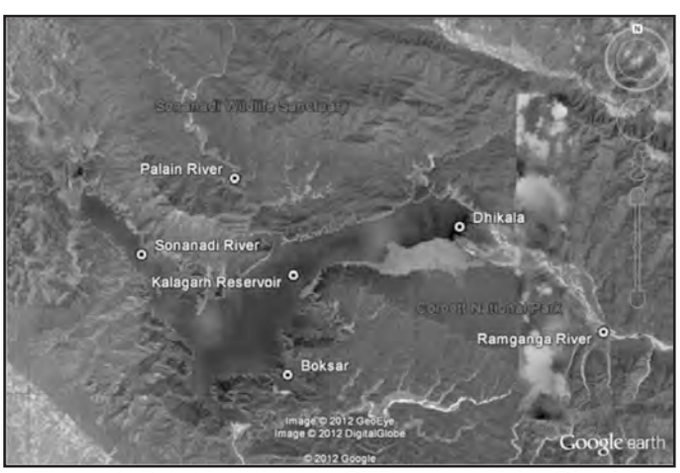


Figure 1. Point locations in CTR surveyed for Gharial.

The Corbett Tiger Reserve (Fig. 1) is one of the habitats where recruitment from released stock resulted in an increase in the adult population after the construction of the Kalagarh Dam (Basu, 1995). Surveys of the Ramganga River in Corbett National Park in 1974 recorded only five gharial and there was no evidence of any breeding, either in the form of nests or hatchlings (Whitaker, 1979). Boksar, the best known gharial habitat in the park was being inundated at the time due to the filling of the then new Kalagarh Dam (Whitaker, 1979). Gharial nesting was documented in Boksar in Corbett NP and the Palain River in the Sonanadi Wildlife Sanctuary of Corbett Tiger Reserve during extensive surveys in 2008. Nesting was during also found in 2011 preliminary nesting surveys in Boksar in Corbett National Park. The 2008 surveys were the first record of gharials breeding in the area (Chowfin 2011). Surveys of Boksar 2011 also reconfirmed gharial nesting in the area during which only Corbett National Park was surveyed. Sonanadi Wildlife Sanctuary was not surveyed as the surveys were preliminary in nature. However, predation of gharial nests in Boksar (Figure 2 and 3)was observed on both occasions with the common Monitor Lizard, *Varanus bengalensis,* being identified as the predator based on visual confirmation and spoor. The findings are of special significance as it confirms that Gharial nesting in Boksar is recent in nature.

Figure 2. Gharial nest predated by *Varanus bengalensis* in Boksar in 2008

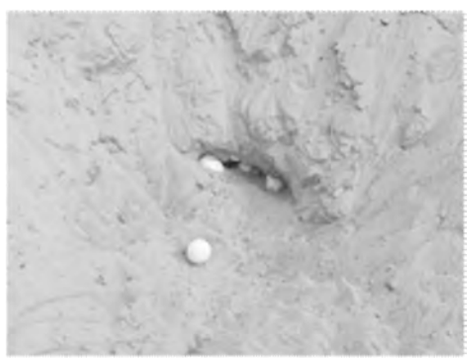


Figure3. Gharial nest predated by *Varanus bengalensis* in Boksar in 2011

Materials and Methods

Nesting surveys in CTR were conducted by six forest staff in groups of two or three in boats or on foot in 2008 (Chowfin 2010, 2011). The areas covered in the survey included the Ramganga River near Dhikala, the reservoir at Boksar, Gaujeda, the Palain and Sonanadi Rivers in 2008 and Boksar (Figure 4), Dhikala and the Ramganga River in 2011. Surveys were conducted from late March to late April which is the most frequently reported nesting period for the species in most parts of its range (Whitaker and Basu,1981). During 2008, nesting sites were identified by searching the river and reservoir banks for any signs of nesting activity and/or nests and eggshell remnants during daylight hours. Signs of nesting activity included body prints in open, sunny, sandy areas; entry and exit trails to and from the water's edge; attempted digging of egg chambers ("probe" holes) and eggshell remnants (Figure 5) towards the end of the nesting season. A global positioning system (GPS) location was recorded at all possible nesting sites during the first survey of the season. These sites were then revisited later in the nesting season to confirm actual nesting. (Chowfin, 2011)

Figure 4. Gharial nesting habitat in Boksar (CNP).

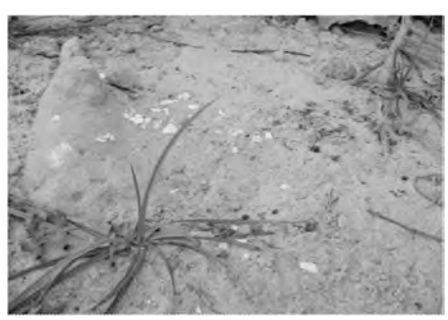


Figure 5. Egg shell remnants of one of the predated gharial nests in Boksar

Results

At Boksar (CNP) during the nesting surveys in 2008, a clutch of at least 36 eggs was found: 11 eggs were intact and banded to the distal poles, six egg shells were predated, with the tracks indicating *Varanus,* 14 eggs were intact but with

broken eggshells and five additional eggs with broken eggshells were infected with a black fungus like growth. Twelve eggs were fertile. The fertile eggs, with opaque banding reaching the distal poles, were clearly in an advanced stage of development. Eggshell remnants were found at five more discrete locations in the Boksar area, indicating the presence of at least five more nests (which had been completely predated). Surveys at Boksar 2011 again confirmed the presence of gharial nesting with an intact clutch of at least 48 eggs found in the same general location as one found in 2008. In this clutch, 45 eggs were fertile and in an advanced stage of development with banding reaching the distal poles. However, many of the fertile eggs had damaged egg shells or had been predated (Figure 6 and 7). Based on observed spoor at the nest site, *Varanus bengalensis* was identified as the predator.

Fig. 6. Predated Gharial egg from a nest in Boksar in 2008.

Fig.7. Predated Gharial egg from a nest in Boksar in 2011.

Discussion

Gharials in Boksar, although originally in a free-flowing river ecosysem, seem to have successfully adapted to the lake-like environment created by the Kalagarh Dam in 1974.

Breeding is clearly occurring, although predation rates seem very high, with *V. bengalensis* the likely predator. They may be constraining the recovery of the species. These results, although preliminary, indicate that the Corbett Tiger Reserve could contain a significant breeding population of gharials, which are highly depleted throughout their range. Additionally, it is the only known population of the species to be living in a lake-like environment, as opposed to a free-flowing river system.

This suggests that nesting surveys and monitoring of nesting sites in Boksar and other areas in CTR should be undertaken more regularly, perhaps annually, and more intensely, to gain a better understanding of the productivity of the population of adult female gharials living in the area. Surveys at the time of hatching may give a better indication of the number of nests laid but not predated. The loss of eggs to predators appears to be very significant, which could be a natural occurrence (Webb et al., 1983), or a derived one linked to the lake environment.

Either way, it suggests that if the conservation goal is to increase the resident population of gharials, then a nest protection program increasing the numbers of hatchlings recruited to the wild could be warranted. Corbett Tiger Reserve may prove to be a suitable study site for examining gharial nesting in more depth, including nest site attributes and basic clutch and female characteristics.

Acknowledgements

We thank the Mohamed bin Zayed (MBZ) Species Conservation Fund for its valuable support towards this project. We also thank The Rufford Small Grants Foundation for a RSG. Dr. Srikant. Chandola, IFS, (PCCF (Wildlife)/Chief Wildlife Warden), CCF Mr. Paramjit. Singh, IFS, Uttarakhand Forest Department, Mr. R. K. Mishra, IFS, (CF and Field Director), Corbett Tiger Reserve and Mr. U. C. Tiwari, Park Warden, Corbett Tiger Reserve are thanked for their assistance. Mr. Nandan Singh Rawat and Mr. H. Dhyani were exceptional in their boat operating skills. We would specially like to thank The Gadoli and Manda Khal Wildlife Conservation Trust for its continuing support towards this important research.

Literature Cited

01. Achariyo, L.N; Kar.S.R and Patnaik S.K. (1996) Studies on Captive Breeding of the Gharial, *Gavialis gangeticus* (Gmelin) in Orissa; JBNHS 93 (2); 210-213
02. Basu, D. (1995). Report of a short survey of gharial *Gavialis gangeticus* in the Corbett National Park. *mimeo.* 6 pp. (In Hindi).
03. Chowfin, M.S. (2010) Gharial Estimation and Habitat Assessment Survey 2008, Corbett Tiger Reserve, Uttarakhand, India, Project Report Submitted to the PCCF (Wildlife), Uttarakhand Forest Department
04. Chowfin M.S (2011). Gharial Estimation and Habitat Assessment Survey, Corbett Tiger Reserve, Uttarakhand, India: Field Survey Report; Cheetal Vol. 49 No.3 Pp 96 104
05. Whitaker R (1979). The Crocodilians of Corbett National Park; Indian Journal of Forestry, Vol.2. No.1 pages 38-40
06. Whitaker R. (1979). Gharial Survey and Observations on the Ramganga River, Corbett National Park, U.P.; Hamadryad; Supplement No.2.
07. Whitaker R and Basu D. (1981). The Gharial: A review. JBNHS Vol. 79 Pp.531- 548
08. Ross, C.A. and Magnusson, W.E. (1990). Living Crocodilians. *In*: Crocodiles and Alligators, Pp 58-75. (Ed C.A.Ross). Merehurst Press, London.

Web Sources: www.subirchowfin.blogspot.com

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 28 - 35

An assessment of assisted recovery of *Gavialis gangeticus* in the river systems of Northeast India.

***Abhijit Das[1], Arup Kumar Das[1] and S. K. Dutta[2]**
[1]Aaranyak, 50 Samanwoy Path,Survey, Beltola, Guwahati-781028, Assam, India
*[2]Visiting Professor, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012 Karnataka, India *abhijit@aaranyak.org*

Abstract

We present here, the result of gharial habitat suitability study in the protected riverine stretch of Northeast India between November 2010 - April 2011. We recorded suitable habitat parameters (Water depth, River bank, Midriver Island, anthropogenic disturbancs, confluence, presence of other wildlife) at either 200 m or 500 m intervals. The suitable habitats are mapped using ArcGIS software. Buffers of the each sample points were overlapped over the habitat map derived from recent satellite imagery. The study showed in terms of habitat quality, the Siang river stretch along D' Ering memorial wildlife sanctuary of Arunachal Pradesh contain the greatest proportion of suitable areas followed by the complex of Brahmaputra and Diffolu river in Kaziranga National park of Assam. Among the Other study areas, protected part of Beki River in Manas found to contain 40%, Jia Bhoreli in Nameri 29% and Brahmaputra in Orang 28% of suitable habitat for Gharial. The study identify Kaziranga- Orang complex (~140 km) and D'Ering-Dibru-Saikhowa complex (~70 km) for prioritization in future Gharial rehabilitation programme in Northeast India.
Key words: Gharial, Habitat suitability, Northeast India.

Introduction

Historical records of *Gavialis gangeticus* (Gmelin, 1789) are available from sixteen rivers of Northeast India. Four (Dibang river, Siang, Subansiri and Manas river) are the northern tributaries of Brahmaputra river. Five (Noa-Dihing, Buri- Dihing, Kopili, Kulsi, and Dhansiri rivers) are the southern tributary of Brahmaputra. Gharial occurrence records are also available from six tributaries (Makru river, Irang river, Dholeshwari river, Katakhal river and Kushiyara river) of river Barak in Southern Assam and Manipur. Eastern Assam region represent the highest number of Gharial sighting records (N~29) followed by western Assam (N~16) (Choudhury, 1992, 1998; Whitaker *et al* 1974). Barak river system contributes 8 historical records for gharials (Cooper 1951, Choudhury 1997). In last decade, authentic reports of stray sub-adult Gharials were available from Western Assam. However, our follow-up survey failed to substantiate report of "nesting populations" by Saikia et al (2011). We presume that currently no breeding population is known from river systems of Northeast India (*sensu*, Whitaker 2007).

Distribution of Gharial largely corresponds to distribution of *Nilssonia gangeticus* and *Platinista gangeticus*. Gharials Prefers deep fast flowing rivers. Adults show a preference for the comparatively velocity free State found in the deep "Kunds" or holes at river bends and confluences (Whitakar and Basu, 1983). Hussain (2009) found that 62% of gharials were seen basking on sand, 37% on rocks substrata and only 0.8% on clay. The study thus revealed that sandy part of the river banks and sand bars were the preferred basking sites for gharial. Comparatively less preference was shown for rocky banks and rocky outcrops. Clay areas are largely avoided.

Human disturbance seems to be the critical factor for basking site selection. Mid river sandy island and newly emerged mid river sand bars are often used as preferred basking sites in Girwa river of Katerniaghat wildlife sanctuary (*pers obs*.). In situations where undisturbed sandy sites are not available, gharials seem to prefer rocky outcrops as second alternative sites for basking.

Juvenile gharial <120 cm known to preferred water depths 1-3 m and avoided water depths >3.0 m. Gharial > 120-180 cm. avoided water depths 1-2 m and preferred water depths 2-3 m. They mostly used water depths >4.0 m when available. The subadult and adult gharial of size class >180 cm showed preference for water depths 4.0-5.0 m. Subadult gharials avoided water depths <2m while adults avoided depths <4m.

Lang and Whitaker (2010) reported those Gharial make seasonal movements that were shorter (4-7 km) or longer (14-16 km). Seasonal movement averaged 9.6 km. In dry season, more time is invested for basking. During high water level gharials disperse and feed. Gharial responds quickly to the riverside activity by moving away from potential threats temporarily or shift residency to other location if disturbed often.

Study area

We selected riverine stretch which comes under protected status in states of Assam and Arunachal Pradesh Beki river in Manas National Park (26°35'-26°50'N, 90°45'-91°15'E), Jia Bhoreli river in Nameri National Park (26°50'27°02'N 92°38' 93°00'E); Brahmaputra stretch in Orang National Park (92°16' -92°27' E, 26°29'-26°40' N); Brahmaputra stretch in Kaziranga National Park (26˚ 34N- 26˚ 46N 93˚ 08-93˚ 36E); Brahmaputra stretch in Dibru Saikhowa National Park (27° 30' N- 27° 45' N 95° 10' E- 95° 45' E) and D'Ering Memorial Wildlife Sanctuary (27°56'16"N, 95°26'45"E) lies sandwiched between the Siang and Sibya Rivers in East Siang District of Arunachal Pradesh.

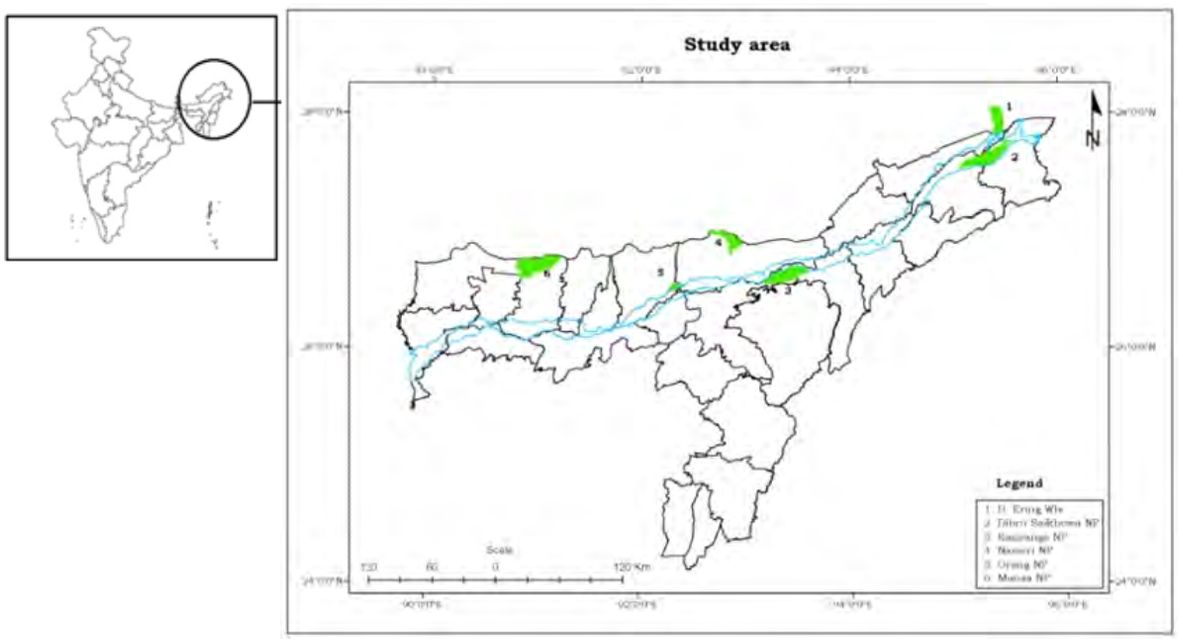


Figure1: Map of study area

Methodology

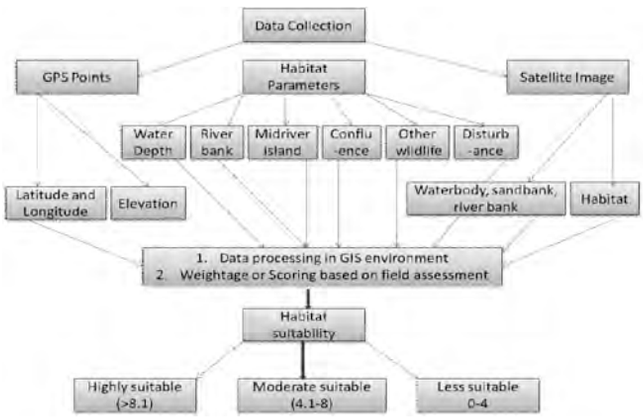
The habitat evaluation survey was conducted between November 2010 - April 2011. The survey team comprises of atleast three surveyors, GIS expert, and three Boatmen familiar with the area. In most of the cases mechanized boat was used for survey except in the case of survey in Beki River and Jia Bhoreli River where we used rubber raft of six person capacities. We followed the channel adjacent to the protected area and often getting down at the mid-river island to assess the habitat condition. Boat speed was reduced in confluences, meanderings, mid-river islands and in case of any encounter with aquatic wildlife. Two 7x 50 binoculars were used for the survey during the day.

Data collection

Habitat suitability parameters were gathered from reports of Rao and Singh (1987), Hussain (1991, 2009), Maskey et al, (1995), Whitakar and Basu (1983). In Orang and D'ering habitat parameters were recorded at 200m interval, in Manas and Nameri at 250 m interval. While in Kaziranga National Park and Dibru Saikhowa National Park data gathered at each 500 m interval. Following habitat parameters were considered for habitat suitability assessment of Gharials from present study areas- Water depth (0-2.5m, less suitable, score 1; 2.6-5 m, moderate, score 2; >5 m highly suitable, score 3) River bank (Sandy, highly suitable, score 3; Rocky, moderate, score 2; clay, less suitable score 1) Midriver Island (Present, score 1; absent, score 0), Disturbance (High disturbance, score 1; Moderate disturbance, score 2; undisturbed, score 3) confluence (Present, score 1; absent, score 0) other wildlife (Present, score 1; absent, score 0).
Midriver Island also includes the large sandbars. Extensive occurrence of sand bars and River Island is a prominent feature in the braided river channel of Brahmaputra.
Presence of other wildlife is an assessment of the tranquility of the habitat and includes presence of Water birds flocks, *Nilssonia* spp, *Pangshura* spp. and *Platinista gangeticus*.

Anthropogenic disturbance is considered as high in areas where we encountered combinations of fishing areas (gill nets, fishing camps and boat) and human settlement (cattle shed or illegal encroachments along riverbank). Moderately disturbed are the areas where we observed small scale illegal fishing practices (gill net, hook nets but no settlement along bank and no permanent fishing camp). Undisturbed areas are those devoid of any human interference except occasional forest department patrolling boat movement.

Survey track and location were recorded with a Garmin-60 GPS. Attributes (field informations) were given to each points based on field data and weightage was given according to low to high order ranges from 1 to 3 or binary data 0 and 1. Distribution mapping of sample sites was done with ARC GIS 9.3 and ERDAS 9.1 software. Finally all the weightage values were added to get the final suitability status for Gharial at each sampling points of study areas. The suitability status was divided into three classes referred to as Low, medium and high values ranging from 0 to 4, 4.1 to 8 and above 8 subsequently. Buffer analysis was used for each sample location based on the size of the river. Buffers of the each sample points were overlapped over the habitat map derived from satellite imagery.



Flow chart showing methodology

Results

In Manas National Park, the elevation varies from 97 m upstream of Beki river to 53m at downstream and average midriver water depth is 4m. Out of the 32 sampling sites 65% represent Rocky River bank and 28% sand bank. 62% of the riverine stretch is undisturbed, while 34.37% of the stretch is found to be moderately disturbed especially at lower reaches. The elevation of Jia Bhoreli river in Nameri National Park varies from 153 m at Bhalukpong point to 69 m at downstream. Average water depth is 3m. 47% of the Jia-bhoreli stretch under the Nameri Natioanl Park is having rocky bank and 41% is sandy. The rest of the river bank represent admixture of rock-sand deposition and clay deposition. 62% of the stretch is undisturbed, 24% moderately disturbed and 12% highly disturbed.

Average water depth in riverine stretch of Orang National Park is 3.12 m. Much of the river bank is sandy. 45% of the riverine stretch is undisturbed, 12% moderately disturbed and 41% highly disturbed especially at western boundary of the park due to thick human population in those areas. The elevation of the riverine stretch in Kaziranga National park varies from 54-63m. The Brahmaputra river bank is mostly sandy and the river is extensively braided in appearance. Average water depth in Brahmaputra River is 4.45m, while in Diffolu river (from confluence upto waypoint 41) average water depth is 2.3 m. 81% of the riverine stretch in Kaziranga is undisturbed, 17% moderately disturbed and only 2% highly disturbed . The elevation difference between upstream and downstream at Dibrusaikhowa varies from 92-117m. River banks are mostly sandy. Average water depth is 4.01m. 35% of the riverine area designated as undisturbed while 43% moderately disturbed and 21% highly disturbed owing to the presence of settlements along riverbank or for fishing activities. Average midriver water depth in Siang along D'ering sanctuary is >5m. 16% of the river bank of Siang River along D'ering sanctuary is rocky, 83% riverbank is sandy. 77% of the riverine stretch showed presence of midriver Islands or sandbars. 72% of the stretch is undisturbed, 16% moderately disturbed and 11% at southwestern boundary of the sanctuary is highly disturbed (owing to the presence of Ferry ghats and fishing camps).

The study showed in terms of habitat quality, the Siang river stretch along D'ering memorial wildlife sanctuary of Arunachal Pradesh contain the greatest proportion of highly suitable areas (83.33% suitable areas) followed by the complex of Brahmaputra stretch and Diffolu river in Kaziranga National park of Assam (70.8% suitability) that corresponds to suitable Gharial habitats.

Table 1: Categories of habitat suitability of the study areas as observed in the study (in percentage).

	Manas	Nameri	Orang	Kaziranga	D'ering	Dibru Saikhowa
High	40.62	29.88	28	70.8	83.33	53.94
Moderate	59.37	68.96	61.42	29.26	11.11	45.09
Low	0	1.14	10	0	5.5	2

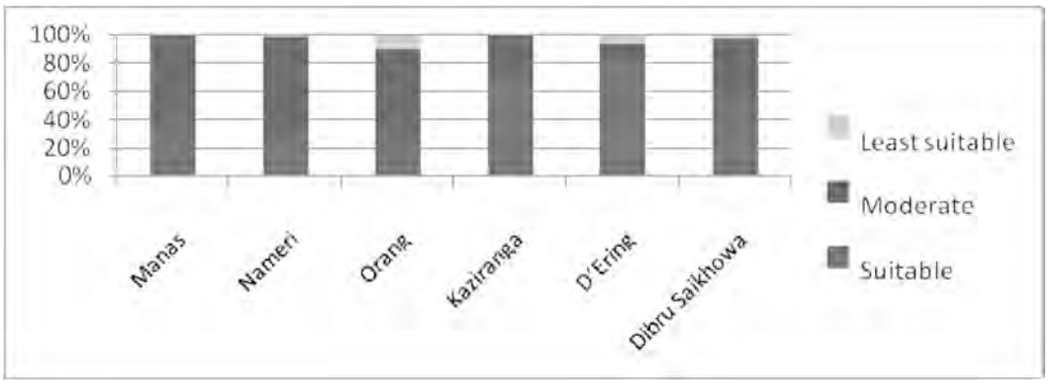


Fig. 5. Gharial habitat suitability in different study areas of Assam and Arunachal Pradesh

Discussion

The study showed in terms of habitat quality, the Siang river stretch along D' ering memorial wildlife sanctuary of Arunachal Pradesh contain the greatest proportion of suitable areas (83.33%) followed by the complex of Brahmaputra and Diffolu river in Kaziranga National park of Assam (70.8% suitability) that corresponds to suitable Gharial habitats. Among the Other study areas, protected part of Beki in Manas found to contain 40%, Jia Bhoreli in Nameri 29% and Brahmaputra in Orang 28% of suitable habitat for Gharial.

The riverine stretch of Kaziranga National park is found to be the most tranquil with 80% of undisturbed area followed by D'Ering Sanctuary of Arunachal Pradesh (72%). Brahmaputra River at Orang National Park registers highest percentange of disturbed area (41%) particularly at western boundary of the park.

The study showed that Siang river stretch along D'ering sanctuary contain the greatest proportion of suitable areas (83.33%) followed by the Brahmaputra and Diffolu river in Kaziranga National park of Assam (70.8% suitability). Thus the ~34 km long Siang river along the western boundary of the sanctuary and the Sibia river along the eastern boundary of the D' Ering might represent a future gharial conservation unit in the northeast India.

Similarly, the Brahmaputra channel along the northern boundary of Kaziranga (~56 km) is the best protected part of the river in Assam with least fishing activity. This assumption is supported by study of Wakid (2009). We recorded an average water depth in this section as ~5 m with extensive sandbank and midriver Islands. With the abudance of Fish resource and presence of undisturbed smaller tributaries (Diffolu River, ~ 38 km in length) add to the suitability of Kaziranga National Park as a possible gharial Habitat.

The locations of the Brahmaputra-tributary confluences are constantly changing due to bank erosion by the Brahmaputra. The north bank tributaries originate in the Himalayas and have high gradient and hence they carry a heavy sediment load of coarser material such as gravel and cobbles. Our survey showed that Beki River in Manas contain 65% rocky bank while 47% of the protected bank of Jia Bhoreli is rocky. Downstream sandy areas of both the rivers however falls outside the protected boundary and thus under anthropogenic pressure.
Thus we propose D'ering- Dibrusaikhowa complex (~70 km) and Kaziranga- Orang-Burachapori-Laokhowa complex (~144 km) is the largest protected stretch available among the 900 km course of Brahmaputra River in Assam and should be considered for future Gharial restocking programme in Northeast India. However, we recommend further upliftment of the protection status of D'ering sanctuary and the Orang National Park that presumbly help in future conservation effort of critically endangered crocodile.
We propose, Kaziranga- Orang-Burachapori-Laokhowa complex (~144 km) and D'ering-Dribru-Saikhowa complex (~70 km) should be prioritized for the future Gharial conservation programme in Northeast India.

Acknowledgments

We extend our sincere thanks to Ashoka Trust for Research in Ecology and Environment and CEPF small grant for funding the work. We thank Assam Forest Department, Arunachal Pradesh Forest department for permission and logistic support. Thanks to Dhrubajyoti Basu, Romulus Whitaker, Gowri Mallapur, Sailendra Singh, Suresh Choudhury, P.C. Bhattacharjee, Indraneil Das, Anwaruddin Choudhury, Saibal Sengupta, Parag Deka, K. Vasudevan, B. C. Choudhury, Bibhab Kumar Talukdar, Pranjit Kumar Sharma, Abdul Wakid, M. Firoz Ahmed, Bibhuti Prasad Lahkar, Ashok Dey, Bhaskar Sarkar, Shyamal Dutta, Madhumita Borthakur, Nripen Nath, Rathin Barman, Rajeev Basumatary, Amarendra Kumar Singh, Neelam Dutta, Mayur Bawri, Anil Das and Biraj Saikia, Santanu Dey, Naorem Lingthoi, Aashutosh Tripathy, Sanjay Das and Sandeep Das for their support and assistance in the field.

References

01 Cooper, W. E. D. (1951). Forty years of Sports on the little knew Assam Rivers. Part I. *J. Bombay Nat. Hist. Soc*. 50(1): 91-100.

02. Choudhury, A. U. (1992) Records of the Gharial from Dhakuakhana area of Assam. *J. Bombay Nat. Hist. Soc*. 89(3): 380-381.

03. Choudhury, A, U., (1997). Records of Gharial *Gavialis gangeticus* (Gmelin) from the Barak river system of Northeastern India. *J. Bombay Nat. Hist. Soc*. 94: 162-164.

04. Choudhury, A, U., (1998). Status of Gharial *Gavialis gangeticus* in the main Brahmaputra River, *J. Bombay Nat. Hist. Soc*. 95:118-120.

05. Hussain S. A. 1991. Ecology of gharial (*Gavialis gangeticus*) in National Chambal Sanctuary, India. MPhil dissertation. Center for Wildlife and Ornithology. Aligarh Muslim University. Aligarh.

06. Hussain S. A. 1999. National Chambal Sanctuary. India. *Biol.Cons*.87: 261-268.

07. Hussain S. A. 2009. Basking site and water depth selection by Gharial Gavialis gangeticus Gmelin 1789 (Crocodylia, Reptilia) in national Chambal sanctuary, India and its implication for the conservation. Aquatic conservation marine and freshwater ecosystem.

08. Lang, J. W., and S. Whitaker, (2010). Spatial ecology of Gavialis gangeticus in the Chambal River, India. Paper submitted to 20th CSG Meeting, 12-17 September, Manaus, Brazil.

09. Maskey T. M., Percival H. F., Abercrombie N.D.C.L. (1995). Gharial habitat use in Nepal. *J. of Herpetol*. 29: 463-464.

10. Rao, R. J., and L. A. K. Singh (1987). Notes on ecological relationship in basking and nesting site utilization of Kachuga spp. (Reptilia, chelonian) and *Gavialis gangeticus* (Reptilia, crocodilia) in national Chambal Sanctuary. *J. Bombay Nat. Hist. Soc*. 94(3): 599-604.

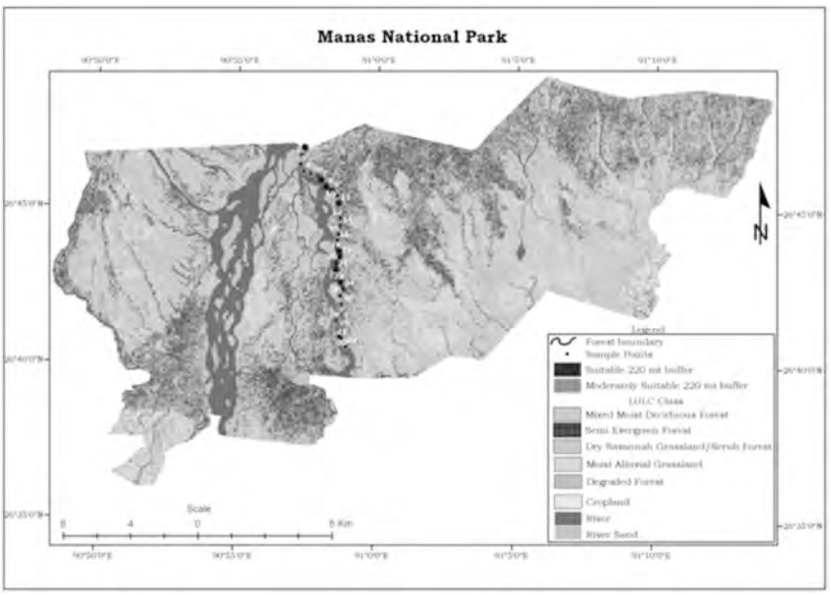
11. Saikia, B. P., B. J. Saud, M. K. Saikia and P. K. Saikia (2010). Present distribution status and conservation of Indian Gharial in Assam, India. *Int. J. Biodiv. & Cons*. 21(12): 382-387.

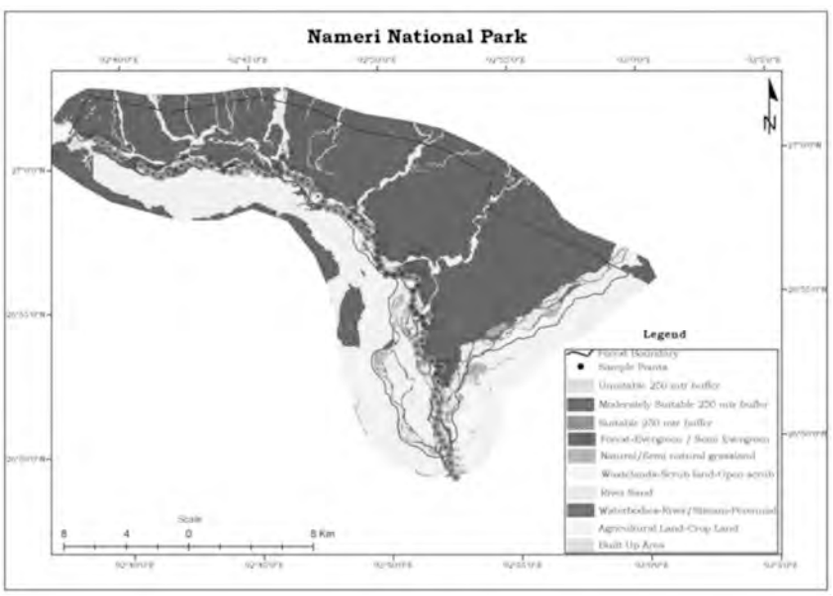
12. Whitaker R. and Basu D. (1983). The Gharial (*Gavialis gangeticus*): a review. *J. Bombay Nat. Hist. Soc*. 79: 531-548.

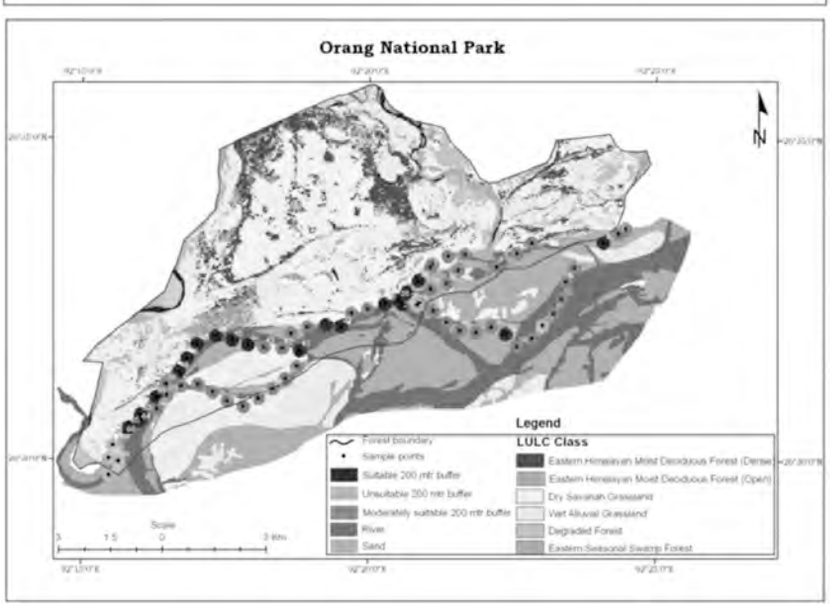
13. Whitaker, R., Rajamani, V., Basu, D., & V. Balakrishnan. (1974). Preliminary survey of the gharial, *Gavialis gangeticus*. Madras Snake Park Trust Report, pp 1 16.

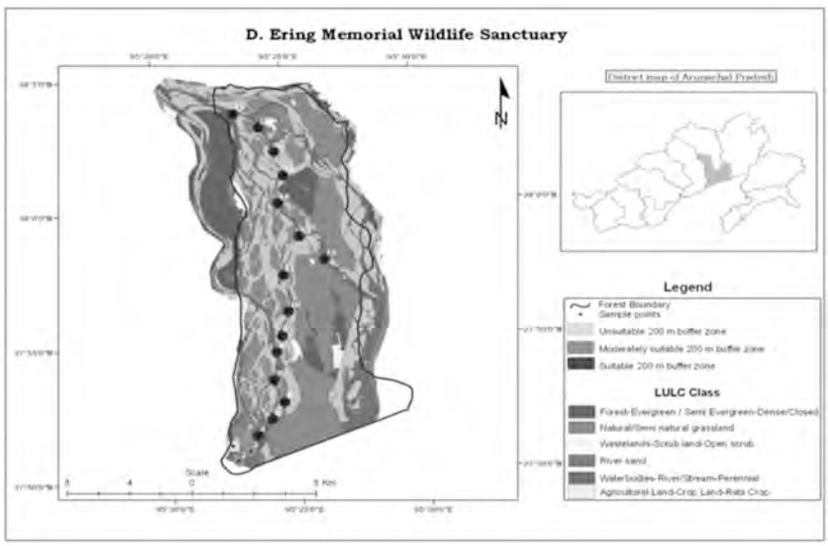
14. Whitaker, R. (2007). The Gharial: going extinct again. *Iguana*. 14(1): 25-33.

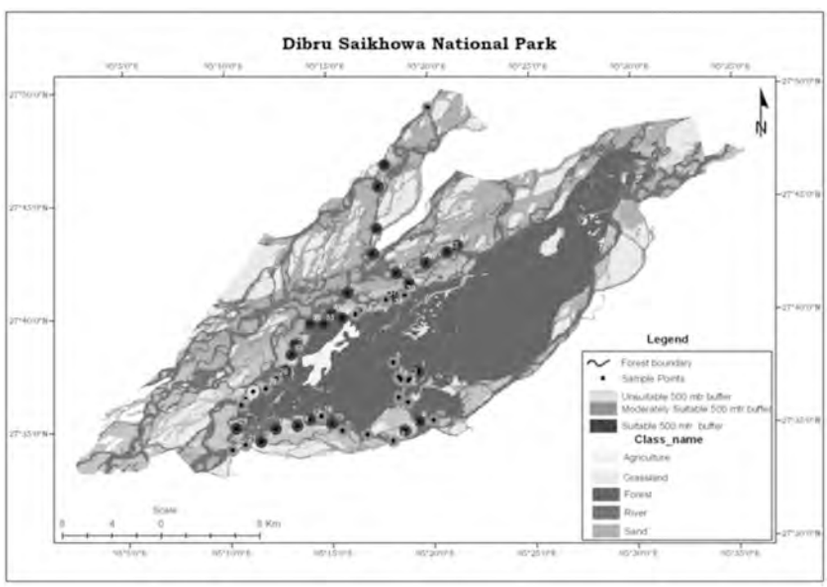
15. Wakid, A. (2009). Status and distribution of endangered gangetic dolphin (*Platinista gangetica*) in Brahmaputra River within India in 2005. *Curr. Sci*. 98 (8): 1143-1151.


Manas National Park
N
Legend
Forest boundary
Sample Points
Suitable 220 mtr buffer
Moderately Suitable 220 mtr buffer
LULC Class
Mixed Moist Deciduous Forest
Semi Evergreen Forest
Dry Savannah Grassland/Scrub Forest
Moist Alluvial Grassland
Degraded Forest
Cropland
River
River Sand
Scale
0 4 0 8 Km


Nameri National Park
N
Legend
Forest Boundary
Sample Points
Unsuitable 250 mtr buffer
Moderately Suitable 250 mtr buffer
Suitable 250 mtr buffer
Forest-Evergreen / Semi Evergreen
Natural/Semi natural grassland
Waterbodies-River/Stream-Perennial
Agricultural Land-Crop Land
Built Up Area
Scale
8 4 0 8 Km


Orang National Park
N
Legend
Forest boundary
Sample points
Suitable 200 mtr buffer
Unsuitable 200 mtr buffer
Moderately suitable 200 mtr buffer
River
Sand
LULC Class
Eastern Himalayan Moist Deciduous Forest (Dense)
Eastern Himalayan Moist Deciduous Forest (Open)
Dry Savanah Grassland
Wet Alluvial Grassland
Degraded Forest
Eastern Sebsonal Swamp Forest
Scale
3 1.5 0 3 Km


D. Ering Memorial Wildlife Sanctuary
District map of Arunachal Pradesh
N
Legend
Forest Boundary
Sample points
Unsuitable 200 m buffer zone
Moderately suitable 200 m buffer zone
Suitable 200 m buffer zone
LULC Class
Forest-Evergreen / Semi Evergreen-Dense/Closed
Natural/Semi natural grassland
Wastelands-Scrub land-Open scrub
River sand
Waterbodies-River/Stream-Perennial
Agricultural-Land-Crop Land-Rabi Crop
Scale
0 4 0 8 Km


Dibru Saikhowa National Park
N
Legend
Forest boundary
Sample Points
Unsuitable 500 mtr buffer
Moderately Suitable 500 mtr buffer
Suitable 500 mtr buffer
Class_name
Agriculture
Grassland
Forest
River
Sand
Scale
8 4 0 8 Km


Kaziranga National Park
N
Legend
Forest boundary
Survey Point
Moderately Suitable 500 mtr buffer
Suitable 500 mtr buffer
Agricultural Land
Forest-Deciduous
Forest-Evergreen / Semi Evergreen
Natural/Semi natural grassland
Tree Clad Area-Open
Wastelands-Scrub land
River Sand
Waterbodies-River/Stream-Perennial
Wetlands-Inland Natural
Scale
8 4 0 8 Km

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 36 - 40

Captive/ Semi-Captive Gharial management & husbandry techniques in Chitwan National Park, Nepal

Bed Bahadur Khadka [1], Kamal P. Gairhe [2] Fanindra Kharel [2], and Sabita Malla [1, 2]
Chitwan National Park, Chitwan, Nepal | [1] WWF Nepal, Baluwatar, Kathmandu, Nepal

Abstract

The Gharial (*Gavialis gangeticus*) belonging to the family Gavialidae is one of the most threatened of all crocodilians. The Gharial population in Chitwan National Park (CNP) crashed down to 57 in the late 1970s. In response to this critical situation of gharial, Gharial Conservation Breeding Center (GCBC) was established in Kasara in 1978. Since, 1981 GCBC has played a crucial role in egg collection, rearing and release of gharials in major river systems of Nepal. Presently, GCBC houses 605 gharials of all age-size classes (hatchlings 244, juveniles 338, sub-adult 18 and adult 15). A total of 891 gharials have been released to supplement the wild population. Several structures are built and upgraded in GCBC for better captive management while improving the survival rates of the new born hatchlings in the breeding center.

Key words: Gharial (*Gavialis gangeticus*), Chitwan National Park, Captive Breeding, Husbandry, Nepal

Introduction

The Gharial (*Gavialis gangeticus*) belonging to the family Gavialidae is one of the most threatened of all crocodilians species (GCA, 2011). Abundant in most of the major river systems in the Indian subcontinents in the past, gharial is now believed to be extinct from Bangladesh, Bhutan, Myanmar and Pakistan. Presently, wild population is confined to a few river systems of Nepal and India (Maskey, 1989). Its distribution is limited only to 2% of their historical range with as low as 200 breeding adults remaining in the wild (Whitaker *et al.,* 1974). This represents almost 96% decline in gharial population (Whitaker et. al 1974). Realizing its critical situation, it was recently upgraded to IUCN Red list of endangered species as "critical endangered" in 2007 and is under appendix I of CITES. Gharial is a protected reptile of Nepal, under the National Parks and Wildlife Conservation Act of 1973.

The Gharial population was estimated to be around 57 during 1980 (CNP, 1998). Realizing this situation, the Gharial conservation center was established in 1978 with the aim to maintain viable wild Gharial population through re-introduction program.

Captive/Semi-captive Management Procedure

Nesting and Hatching process

Generally, Gharial lay eggs between last week of March and 1st week of April. Nests are monitored by the experienced nest watchers who keep a track of breeding females all the time. Once the nest are located, all the records and measurements(count, weight, viability) are taken, eggs are placed in plastic pot and transported via boat to Gharial Monitoring Center exactly in the same orientation as was in the nest. Eggs are re-buried in the same orientation by digging nest in natural sand bank of Narayani River at Gharial Monitoring Center and are guarded by Gharial keepers until they are hatched. Captive-laid eggs are left as such in Gharial Conservation Breeding Center (GCBC) since each of the female guard their nest and do not allow any interventions.

During 2013, we found 13 nests in the wild (Fig 1) 7 in Rapti and 6 in Narayani (Map 1). Eggs from the 4 nests from Narayani were transported to GMC, Amaltari while 2 nests were left in the wild. In Rapti river, out of 7 located nests; eggs from 3 nests were left in the wild, 2 nests were transported to GCBC and 1 nests got destroyed due to the fights between two females during nesting.

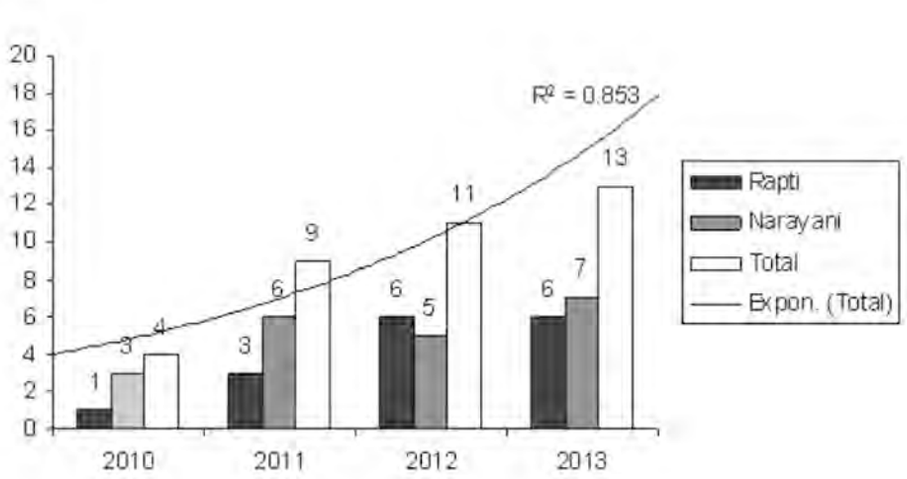


Figure 1. Trend in Gharial Nest in Chitwan National park, 2010-2013

Hatching

During hatching period as soon as hatching calls are made by hatchlings inside the nest, gharial keepers help them come out of nests. Hatching takes place during first to last week of June.

In captivity nests are mainly protected by females, although males are sometimes involved. Interestingly, males are found to take a leading role in taking care of hatchlings, producing hissing sounds when keepers or even female Gharials approach. Hatchlings also respond to the hissing vocalizations of males by going towards them rather than to females. After one week, hatchlings are relocated to separate hatchling nursery ponds (Khadka, 2010).

Captive Rearing and Management

Hatchlings begin eating small fresh fish at night after 1 week. They begin to eat during day time after one month of age. Hand feeding is done for those hatchlings that donot feed. They are fed every second day and are separated from those who feed on their own. Comparison shows that gharials that are hand fed are lesser in weight and size than those feeding on their own. At this stage, animals are graded into different pens on the basis of their size.

Photos 1,2 and 3 (Left: Hand feeding, Middle: Vitamin feeding and Right: Teeth cleaning at GCBC)

Vitamin supplement (0.2 ml or 1-2 drops per hatchling) is also provided by syringe into the mouth every second day until 6 months. During winter, the hatchling pools are covered with plastic sheets to maintain necessary heat. It helps reduce hatchling mortality during this period. Every day, the pools are cleaned up with wire brushes and all left over fish feed are removed. Similarly, for the control of bacterial growth in the water, potassium permanganate is added into the pools.

During rainy season (June-September) the hatchlings teeth is brushed up and body washed twice a month using potassium permanganate. It helps control teeth and skin fungal diseases. The Gharial grows up to or >150 cm in length after 5 years of proper rearing in captivity. This is the age at which it can survive in natural habitat.

Table 1: Gharial Survival Percentage in GCBC

Year	No. of Egg Collection	No. of Hatchlings	% of Hatchling	No. of Hatchling survival after 1 year	% of Hatchling survival after 1 year
1977	592	438	73.99	NA	NA
1978	310	162	52.26	NA	NA
1979	543	294	54.14	NA	NA
1980	264	187	70.83	NA	NA
1981	259	64	24.71	NA	NA
1982	90	38	42.22	NA	NA
1983	296	124	41.89	NA	NA
1984	40	33	82.5	NA	NA
1985	158	116	73.42	NA	NA
1989	253	144	56.92	NA	NA
1990	395	237	60	NA	NA
1991	359	281	78.27	NA	NA
1992	490	230	46.94	NA	NA
1993	428	280	65.42	11	3.93
1994	437	144	32.95	10	6.94
1995	221	97	43.89	17	17.53
1996	577	276	47.83	17	6.16
1997	311	106	34.08	20	18.87
1998	302	19	6.29	2	10.53
1999	408	101	24.75	10	9.9
2000	244	141	57.79	30	21.28
2001	291	81	27.84	27	33.33
2002	466	229	49.14	32	13.97
2003	347	169	48.7	3	1.78
2004	521	298	57.2	157	52.68
2005	510	333	65.29	80	24.02
2006	382	262	68.59	95	36.26
2007	343	117	34.11	53	45.3
2008	369	133	36.04	32	24.06
2009	101	71	70.3	41	57.75
2010	508	355	69.88	133	37.46
2011	634	256	40.38	141	55.08
2012	658	262	39.82	88	33.59
Average	366.88	184.18	50.86	49.95	25.521

Gharial Release

Gharial release is carried out almost every year in Rapti River. For this, gharials are loaded in a specially designated ventilated wooden box of size (20 x 30 x 180) cm and are transported to the soft enclosure built in an area close to GCBC with low water current. These enclosures are made up of elephant grass. Gharials remain in the soft enclosure for a week's period until they break open the enclosure and are finally released into the wild. This allows them to get adapted to the natural conditions. Till the reporting period, May, 2013 a total of 891 gharials have been released into different river systems of Nepal (Figure 2).

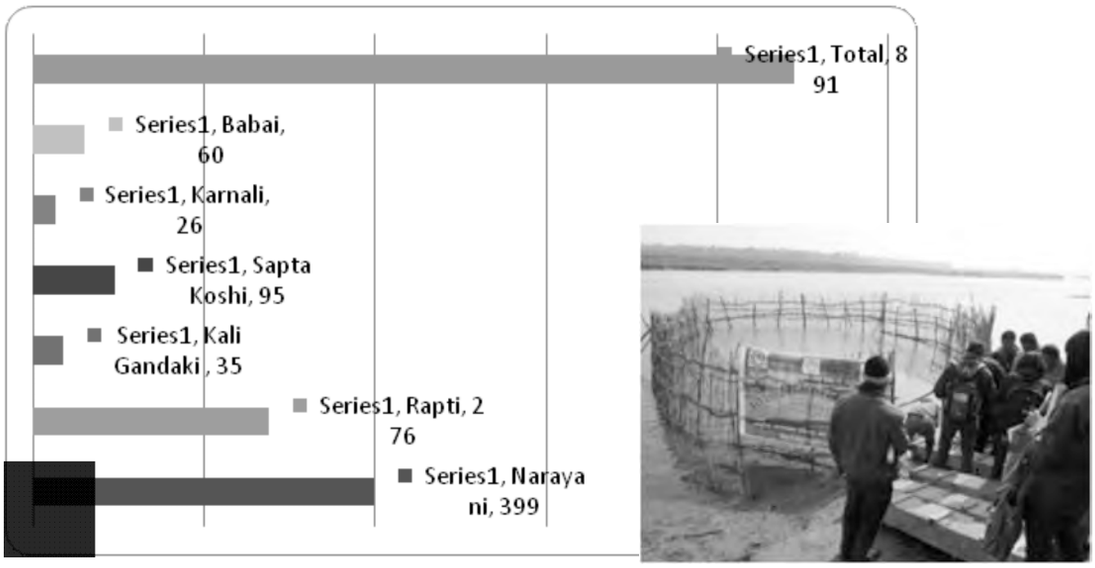


Figure 2. Gharial released in different river systems of Nepal (1981-2013)

Current Status of Gharial in GCBC, CNP

All together, GCBC has 32 smaller to large size concrete ponds/pools with sand bank available all around the pool. Water quality is maintained by replacing water every 3-4 days and cleaning the ponds. All together there are 605 small to breeding sized gharials (hatchlings 244, juveniles 328, sub-adult 18 and adult 15) at GCBC (Figure 3). Age-size classification is done on the basis of size, as hatchlings (<90 cm), juveniles (90-180 cm), sub-adults (181-300 cm) or adults (>300 cm).

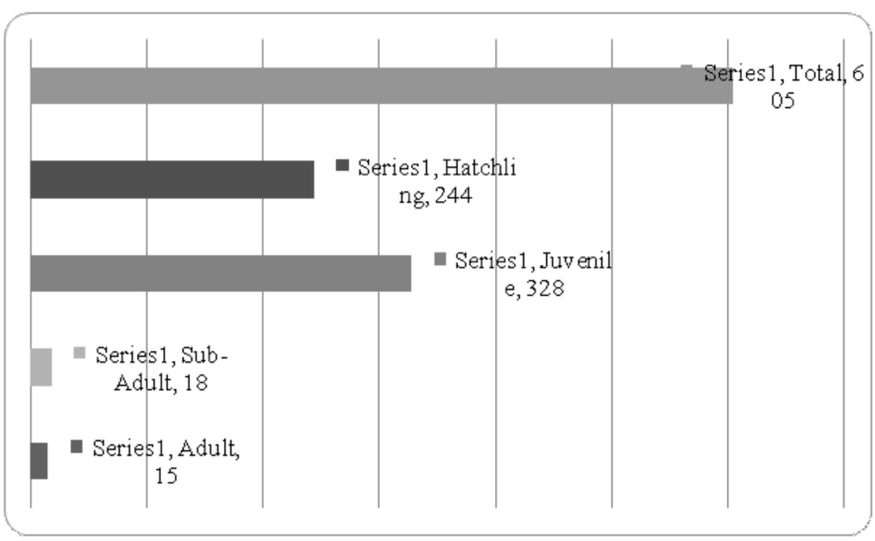


Figure 3. Current Status of Captive Gharial in GCBC, Chitwan National Park

Fish farming in GCBC

GCBC is managing live fish farming in an area of 0.15 ha nearby Gharial ponds. Water from the gharial pools are flushed into fish farm along with droppings during pool cleaning. GCBC is now practicing live fish feeding to the Gharials before releasing them into the wild. Currently, a controlled study on "Live Vs Dead Fish Feeding to gharial" is been undertaken at the center.

Revenue Collection by GCBC

GCBC initiated the collection of entry fee at the center since 2006. Entry fee of Rs 20 and Rs 100 is charged to Nepalese and International visitors respectively. This has helped in supporting the salary of 12 staff that are hired by GCBC on contractual basis.

Table 2. Revenue collection by GCBC (2006-2013)

S.N	Fiscal Year	No of Visitor Vs Revenue collected by GCBC				Total visitors	Total revenue	Remarks
		Nepalese Visitors	Revenue Collected	Foreigner	Revenue collected			
1	2006			3085	302500	3085	302500	
2	2007			6675	667500	6675	667500	
3	2008			6680	668000	6680	668000	
4	2009	908	18160	8485	848500	9393	866660	
5	2010	20124	402480	10634	1063400	30758	1465880	
6	2011	28538	570760	11947	1194700	40485	1765460	
7	2012	23395	467900	12995	1299500	36390	1767400	
8	2013	6916	138320	16550	1655000	23466	1793320	Till the end of April

Recommendations

Gharial Conservation Breeding Center was established with an aim to maintain viable population of Gharials in the wild; through head starting program. Though, this program has halted the complete extinction of the species; has not been able to meet the visionary goal. Since the year 1981, a total of 891 Gharials have been released to different river systems of Nepal but the latest study of 2013 showed 124 gharials in 4 rivers of Nepal (Rapti, Narayani, Babai and Karnali). Head starting program needs to be supported by strong governmental policies to act upon the immediate threats of sand mining, boulder mining, gill netting, excessive human pressure and pollution in gharial dwelling rivers.

In the recent years, there has been major development in GCBC such as the construction of new breeding pools, fish farm, visitor center and health laboratory through the support of WWF Nepal including LACOSTE and FDB, French NGO. For better captive management and to increase the moral of the contractual staff, they need to be hired on a permanent basis with similar benefits of governmental staff.

Literature Cited

01. Khadka B.B. (2011). Gharial and Mugger monitoring in the Narayani and Rapti Rivers of Chitwan National Park, November 2010. Crocodile Specialist Group Newsletter 30(1): 11-14, January-March IUCN-SSC.

02. Khadka, B.B. (2010). Gharial hatching status in 2010, Chitwan National Park, Nepal. Crocodile Specialist Group Newsletter 29(3): 16-17. July-September IUCN-SSC.

03. Chitwan National Park/Gharial Conservation Breeding Centre). (1998). Information Leaflet.

04. GRSP, 2011. Gharial Species Recovery plan, January 2011. Workshop Convened by the Gharial Conservation alliance, Delhi, 22-24 June 2009.

05. Maskey, T.M.1989. " Status and Conservation of Gharial in Nepal" Paper Submitted to XIIth Working meetings of Crocodile Specialist Group, Pattaya, Thailand.

06. Whitaker, R. Rajamani, V.,Basu, D.& Balakrishnan. 1974. Preliminary survey of the Gharials (*Gavialis gangeticus*). Madras Snake Park trust Report, PP 1-16.

Physical evaluation of Gharials

Himanshu R. Joshi[1] , Avadh Bihari Shrivastav[1] and R.K.Sharma[2]
[1] Centre for Wildlife Forensic and Health, Jabalpur, Madhya Pradesh, India | [1] Nanaji DeshmukhVeterinary Science University, Jabalpur- 482001, Madhya Pradesh, India | [2] Research Officer, Gharial Rearing Centre, National Chambal Sanctuary, Morena, Madhya Pradesh.

Gharial *(Gavialis gangeticus)* is a critically endangered (IUCN, 2009) riverine species inhabiting the Gangetic and Mahanadi river systems. To save the species various programs have been launched. However, the scientific rearing and conservation still needs some improvements. During the study period at, Gharial Rearing Centre, National Chambal Sanctuary, Dewari, Morena, Madhya Pradesh juvenile and hatchling gharials were restrained manually with precautions to avoid undue stress. The different body measurements i.e. total length, head length and body weights were recorded along with sex determination. The hatchling and juvenile measurements were taken from different pools at Gharial Rearing Centre. The difference in their measurements and body condition was use to determine the health of the animals. Signs like sunken super temporal fossa, drawn in neck condition and diaphanous teeth indicate poor body condition.

Leukocyte morphology of Gharials

Himanshu R. Joshi[1] , Avadh Bihari Shrivastav[1] and K.P.Singh[1]
[1] Centre for Wildlife Forensic and Health, Jabalpur, Madhya Pradesh, India | [1]Nanaji DeshmukhVeterinary Science University, Jabalpur - 482001,Madhya Pradesh, India

The blood smears were prepared on grease free clean micro slides. Each direct smear was stained with Wright Giemsa's staining solution and leukocyte morphology was studied under oil immersion. However, it was observed that the morphology of leukocytes (heterophils, lymphocytes, eosinophils, monocytes and basophils) gharial recorded did not differ much with that of the other reptiles.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 42 - 52

Behavioral ecology of Gharial on the Chambal River, India

Jeffrey W. Lang and Pankaj Kumar
Madras Crocodile Bank Trust&Gharial Conservation Alliance,
Vadanemelli Village, Post Bag 4, Mahabalipuram 603104 INDIA
(jeff.w.lang@gmail.com; 1385 Brompton, St Paul, MN 55108 USA)

Abstract

The Gharial Ecology Project, also known as the Gharial Telemetry Project, was initiated in June 2008 to investigate the circumstances of the 2007-08 mass die-off of gharials in the 2-4m size class, totaling 110+ individuals in the lower Chambal River. To date, 20 radio-tagged gharials have been tracked successfully throughout the annual seasonal cycle, monsoon and dry periods, for an average of 2+ years per animal, since June 2008 through May 2013. Individual gharials show different patterns of seasonal movement and residency, primarily dependent on size/age. Adult females move as far as 80-120 km each seasonal cycle to join dry season basking-breeding aggregations (>60 adults), and to locate suitable nesting areas. In contrast, sub-adult gharials exhibit restricted movements, typically 10-30 km seasonally, and occupy seasonal residencies only 5-15 km in extent. Some sedentary sub-adults showed virtually no movements, either upstream or downstream.

Gharial feed primarily during the monsoonal months of June through September, and bask daily for long periods during the winter months of November through February. Large basking aggregations form in December and January. Mixed basking groups of all age/size classes shift to primarily groups of large sub-adults and adults by mid-February when courting and mating commence. Nesting follows in late March/early April when smaller groups of reproductive females assemble near sandbanks adjacent to deep water. Yearlings (9 months old) from the previous years' hatch often remain close to the dominant male, rather than nesting females, and the male responds to nearby yearlings with specific displays. Colonial nesting sitesare located in areas of minimal disturbance, but locations shift from year to year, depending on local restructuring of the nesting sites. Females open the nests, but do not transport the young to water. Adult females and a singular dominant male remain with hatchlings for 1-2 months, attend the young, and guard them against potential predaors. Large male gharials, with well-developed and prominent gharas, remain individually associated with large groups of young (200-1000+). Large crèches remain together, and young have been observed feeding regularly on small fish.

These results are directly relevant to conservation and management. First, the long distance movements of adult reproductive females, and likely adult males responsible for breeding, indicate that an open, dynamic, free-flowing river is critical. Second, illegal fishing, sand removal, and/or riverside cultivation anywhere along the river constitutes disturbance to which wide-ranging gharials are exposed, consequently would have adverse effects on their well-being and survival. Third, the detailed behavioral observations of social and reproductive activities indicate that the gharial population inhabiting the lower Chambal is healthy and thriving, and that annual recruitment is high. Fourth, egg removal to exsitu artificial incubation facilities, and the subsequent captive rearing of young (=head starting) is not necessary for the Chambal population presently, and should be discouraged/prohibited. Fifth, any reintroduction or translocation schemes to move gharials into new habitats should take into account the proclivity for sub-adult gharials to move 10-20+ km, and for adults to move 80-100+km. Lastly, this study sheds new light on the mass die-off of 2007-08. The event was specific to gharials, rapid in its effects and restricted to 12 weeks (from early December through February), and very local in its geographic extent, extending from 12 km above the Yamuna-Chambal confluence in the lower Chambal River to 75 km upriver.

Introduction: background, rationale for project, and study objectives

The Gharial Ecology Project, also known as the Gharial Telemetry Project, was initiated in June 2008 to investigate the circumstances of the 2007-08 mass die-off of gharials in the 2-4m size class, totaling 110+ individuals in the lower Chambal River. The project was conceived and initiated by D. Basu, Rom Whitaker, and Jeff Lang to provide new ecological information about the gharial population inhabiting the National Chambal Sanctuary (NCS). In particular, the emphases were on spatial data about gharial movements, and related behavioral observations relevant to all phases of gharial life and natural history.

The general questions were: 1) how far do gharials move seasonally throughout the year, and during a lifetime?, 2) how do gharials respond to the annual monsoon, and consequent high water?, 3) how do gharials use the river habitats throughout the seasonal high water and low water periods?, 4) when and where do gharials feed?, 5) how does social behavior influence their distribution on the river?, 6) when and where do they court and mate, nest, incubate eggs, and guard hatchlings? Prior to this study, partial or incomplete information about all of the above questions was conjectured from notes recorded in captivity and/or from anecdotal observations in wild populations. Answers to these questions are necessary in order to formulate management and conservation-related strategies for the continued well-being, health, and survival of wild gharials in the Chambal which is still an open and dynamic river.

In late June 2008, with assistance from WWF-India, the Madras Crocodile Bank Trust and the Gharial Conservation Alliance received Ministry of Environment and Forests and state government permissions to capture, radio-tag, and monitor up to 30 wild gharials in the size range of 2-4m, the die-off size range, in three episodes of 10 animals/tagging operation. A rapidly advancing monsoon in June 2008 cut short the tagging effort, and only one individual was tagged, and intermittently tracked. A subsequent tagging in March 2009 resulted in 10 animals tagged, and another 10 were tagged in November 2010.

Results: New Spatial and Behavioral Findings

To date, 20 radio-tagged gharials have been tracked successfully throughout the annual seasonal cycle, monsoon and dry periods, for an average of 2+ years per animal, since June 2008 through May 2013. At present, five gharials are still being tracked into the 2013 monsoon from the 2010 group. A total of 2300+ animal-specific locations were recorded for the 2009 group, and more than 1500+ locations, 1-3 x weekly, have been logged for the 2010 group. These findings are summarized in Tables 1 and 2. Preliminary results have been published in the Wildlife Telemetry Issue of the ENVIS Bulletin, and numerous reports summarize the results to date for government departments and funding agencies (see reference list).

In brief, these ecological studies, based on detailed observations of the radio-tagged, wild gharials resident in the lower Chambal, have indicated that the population is spatially-structured. Individual gharials show different patterns of seasonal movement and residency, primarily dependent on size/age. The most remarkable finding is that adult reproductive females routinely move as far as 80-120 km each seasonal cycle to join dry season basking-breeding aggregations (>60 adults), and to locate suitable nesting areas where they nest communally and remain with eggs/young until monsoon floods arrive. Then, adults move rapidly downstream, in 30-50 km trips within days/few weeks to the lower stretches of river near the Yamuna-Chambal confluence. Then, as water levels subside, they regularly return upstream long distances to the same localities, over weeks/several months during the post-monsoon period (Figure 1)
In contrast, sub-adult gharials exhibit restricted patterns of movement, typically 10-30 km seasonally, and occupy seasonal residencies only 5-15 km in extent. Monsoon residences are located downstream, and these gharials make short upstream movements to dry season residences. Some sedentary sub-adults showed virtually no movements, either upstream or downstream. Instead, they occupied very restricted sections of river, only totaling 12-18 km in extent, regardless of season (Figure 2).

In addition to this new information on the spatial ecology of gharials living in the lower Chambal River, this study has provided, for the first time, a picture of the behavioral ecology of this population. Specifically, data have been recorded for the seasonal cycles of maintenance, social, and reproductive behaviors (Table 3). Gharial feed primarily during the monsoonal months of June through September, and bask daily for long periods during the winter months of November through February. Large basking aggregations form in December and January. Mixed basking groups of all age/size classes shift to primarily groups of large sub-adults and adults by mid-February when courting and mating commence. Nesting follows in late March/early April when smaller groups of reproductive females assemble near sandbanks adjacent to deep water. At these colonial sites, eggs incubate for 2 months, and hatch in early-mid June.

Colonial nesting sites, typically with 5-15+ nests, are located in areas of minimal disturbance, but locations shift from year to year, depending on local restructuring of the nesting sites (Figure 3). Females open the nests, but do not transport the young to water. Instead, the young move from the nest to water nearby where other hatchlings have assembled in groups. Adult females and a singular dominant male remain with hatchlings for 1-2 months, attend the young, and guard them against potential predaors. Large male gharials, with well-developed and prominent gharas, remain individually associated with large groups of young (200-1000+). Up to12 males have been observed in one season, and 16 different male-young groups are recorded over three nesting seasons, 2010 through 2012 (Table 4). Multiple females are present as well with these groups, and routinely attend/guard hatchling groups until water levels rise. Large crèches remain together, and young have been observed feeding regularly on small fish (Figure 4).

In addition, detailed behavioral observations have been made on social inteactions primarily associated with breeding. Males tolerate other males initially as large basking groups form in January and early February, but then begin to establish social hierarchies, with a dominant, large ghara male engaging in most courtship and mating at specific localities, often associated with nesting areas. In late February and early March, the dominant male patrols an area where

reproductive females congregate, and courtship and mating were observed with multiple females over periods of several weeks. Then, females select nesting sites, often frequented by dominant males following breeding, but prior to nesting. At these times, yearlings (9 months old) from the previous years' hatch often remain close to the dominant male, rather than nesting females, and the male responds to nearby yearlings with specific displays.(Figure 5).

Relevance of Ecology Study Results to Management and Conservation

The results of the Gharial Ecology Project are directly relevant to the conservation and management of the gharial population inhabiting the lower Chambal River, National Chambal Sanctuary. First, the long distance movements of adult reproductive females, and likely adult males responsible for breeding, indicate that an open, dynamic, free-flowing river is critical. The lower Chambal should be maintained without obstructions and with sufficient water flow throughout the year for continued successful breeding and recruitment. Individual gharials live in 100+km of river. They inhabit downstream sections during 2-4 months of high water, and return each year to upstream segments for the remaining 8-10 months. The river is an important corridor between their widely-spaced seasonal residences, and adequate water flow connecting these areas is vital year-round, especially in the post monsoon when upstream movements take weeks to months. Likewise, any major disturbances or obstructions that would inhibit or prevent such seasonal movements would be detrimental and adversely affect the gharial population.
Second, illegal fishing, sand removal, and/or riverside cultivation anywhere along the river constitutes disturbance to which wide-ranging gharials are exposed, consequently would have adverse effects on their well-being and survival. Restriction, and eventually elimination of these activities, especially fishing and sand mining, should be viewed as necessary enhancements to riverine habitats.

Third, the detailed behavioral observations of social and reproductive activities indicate that the gharial population inhabiting the lower Chambal is healthy and thriving, and that annual recruitment is high. During the three year period from 2010 through 2012, the total nests counted were 38, 76, and 80, respectively. Hatched nests totaled 31, 48, and 69 respectively in 2010, 2011, and 2012. Using an average hatchlings per nest of 40, hatchlings during these years totaled 1240, 1920, and 2760 respectively. Furthermore, loss of eggs/hatchlings was highest among nests that were not located at colonial sites; these nests were typically lost by predation/disturbance. Usually, few if any guarding adults were present at these nests, and no guarding males were in association with these.

A possible insitu strategy would be to relocate these isolated/few nests to nearby colonial nesting areas where the probability of successful hatching would be greater, and predation loss minimized. This approach has the additional benefit of re-focusing management efforts on intact, natural nesting areas, and could be augmented with increased monitoring and protection from disturbance at these sites. This could be initiated on an experimental basis for a few years and based on the results, a decision can be taken to adopt it as the official policy.
Fourth, egg removal to exsitu artificial incubation facilities, and the subsequent captive rearing of young (=head starting) is not necessary for the Chambal population presently, and should be discouraged/prohibited. Survival of captive hatchlings has been low (mortalities over 50%) at most rearing facilities. Behavioral observations of wild hatchlings indicates that they benefit from very high pre-monsoon ambient temperatures, and begin feeding on live fish almost immediately after hatching. Adults, both attending females and guarding males, protect hatchlings from most predators until monsoon waters rise and the adults move back downstream.
Fifth, any reintroduction or translocation schemes to move gharials into new habitats should take into account the proclivity for sub-adult gharials to move 10-20+ km, and for adults to move 80-100+km. Relocations or re-introductions within restricted areas of protected riverine habitat would likely result in gharials moving into unprotected nearby sites where net fishing and/or sand mining may pose serious threats to their continued survival.

The five points enumerated above regarding the relevance of this study to management concerns are only some examples of how knowing more about gharial ecology is directly applicable to the conservation of this critically endangered species.

Undoubtedly, other management decisions/actions will be informed by accurate knowledge of gharial ecology.

Relevance of Ecology Study Results to Mass Mortality Event of 2007-08

Lastly, this study sheds new light on previous explanations/interpretations of the causes and consequences of the mass die-off of 2007-08. In fact, at present, all indications are that the event was specific to gharials, rapid in its effects and restricted to 12 weeks (from early December through February), and very local in its geographic extent, extending from 12 km above the Yamuna-Chambal confluence in the lower Chambal River to 75 km upriver (Figure 6). More than half (56/104=54%) of the deaths were located at 40-62 km upriver from the confluence, and 77% (80/104) occurred within the 29 km stretch from KheraAjab Singh (62 km upriver) to Barchouli (33 km upriver). Likewise, 77% (80/104) of deaths occurred between 8 December and 19 January, a 42 day period of unusually cold weather during the winter months.

The spatial patterns of the sub-adult gharials in this study living close to the die-off epicenter suggest that the victims of the die-off were most likely similar resident sub-adults that resided year-round in the area and did not move seasonally. Four sub-adult male gharials in the 2010 tagged group were sedentary during the 2-3 years of this study, and moved only maximum distances of 12, 17, 17, and 18 km in total extent while being monitored (Figure 2). None of these sedentary, tagged gharials were ever observed within 30 km of the confluence, and subsequent to the die-off have lived presumably unharmed in the immediate area of the maximum die-off deaths. In addition, at least one other sub-adult that was tracked in this study lived during an entire dry season in the lower reaches of the Yamuna during 2012, but subsequently has moved back into the Chambal close to where it was captured.

These observations demand a re-examination of the previous explanation for the die-off. The prevailing explanation was that gharials living in the Chambal traveled to the confluence of the Yamuna-Chambal where they fed on tainted fish from the polluted Yamuna outflow and/or moved into the lower reaches of the Yamuna where pollution is sometimes heavy and widespread. Thus, it was surmised that exposure to toxins was due to eating polluted fish sourced from the Yamuna. In light of the findings from the present study, it is more likely that there was a point source for toxins in the lower Chambal well upstream from the confluence, and presumably located in the stretch of river between the Udi and Sashon bridges. Based on the concentration of deaths in the immediate localities between KheraAjab Singh (62 km) and Chikni Tower (47 km), the epicenter of exposure was probably in this 15 km section of the river.

If so, the gharials resident in this area, particularly the sedentary sub-adult population with restricted movement patterns, were vulnerable and accounted for most of the deaths. A point source with local and rapid effects might have produced sub-lethal effects on certain sized fishes, incapacitating them so they could be easily caught by resident gharials. The gross finding of visible articular and visceral gout in the few specimens necropsied is consistent with this conjecture, but why only gharials were affected, and not muggers or other species is not known. Unusually cold weather has been implicated as an accessory condition that would have limited the capacity of affected individuals to clear the toxin fast enough to prevent lethal effects. Metabolism is well known in crocodilians to be strongly temperature dependent, and low ambient temperatures would have the effect of slowing any metabolic response to clear or otherwise neutralize an ingested toxin. The movement study results also suggest that most adult gharials would have already moved upstream prior to the period of deaths in the winter months. A re-analysis of the die-off mortality data is presently being prepared by the international team of veterinarians who produced the Final Report on Gharial Mass Mortality Event in 2007-08, with special reference to the findings of this study summarized here.

Current and Future Plans for Continuance of Ecology Study of Gharial in NCS

The current group of taggedgharial willbemonitored during the remainder of 2013 untilthe radios cease tofunction.Representative staff and advisors atMCBTwillbethe primary project staff, in addition to thetrackers, andwill visit theproject sitesperiodicallyandbe resident at Garhaita, Sashon, and Etawah,andcontinue to accessthe river habitatswithinthe NCSbyjeep, on motorbike, and on foot.

Continuance of the GharialTelemetry Project is pending,depending on availablefinancial support, operationaland logistic planning,and the necessary permissions tocontinue.A tentative schedule for 2013 is to conduct a capture-taggingof another group ofgharials to fit tracking devices for October-November when disturbance tosocial and breeding activities is low.The numberand sizes of gharialtotargetremains tobedetermined, as wellas specific locations where gharial will be tagged.

Monitoringofgharialsintheuppersegmentsofthisstretch,aswellasaselectgroupoflargeradults,includingoneormorelarge,breedingmaleswillshedadditionallightongharialecology,andprovidebaselinedataonthehealthandstatusoftheresidentgharialpopulationintheNational Chambal Sanctuary. In addition, small juveniles presumably remain in the section of river near where they hatched, and may not make appreciable seasonal movements down or up the river, much like subadults, but as yet the spatial ecology of juveniles is not known. Managementandconservationstrategies in NCS, especially those focussed on gharialsshouldbebasedongharialbiology.

There may be benefit in tagging a small number of mugger crocodiles as well. Mugger biology in the NCS is not well understood, and this species is implicated in increased conflicts with humans. Interestingly, mugger crocodiles were not affected by whatever was responsible for the gharial die-off, but the basis for this difference is not known.

Table 1:Summary of Tracking Locations for Gharial tagged with radio transmitters in NCS Abbreviations noted in legend below table.Trackablelocations aretallied for the initial groupoften(49thru75)taggedin2008---09,andforthesecondgroup(21---41)taggedinNovember 2010. During the first half of 2011, as many as 16 gharial were being tracked on a weekly/biweekly basis at Chambal locations ranging from Sashon to aboveNaangoan

ID	sex	tl(m)		2010	2010	2010	2011	2011	2011	2011				
				may-MM jun	july-MM sept	oct-MM dec	jan-MM mar	apr-MM jun	july-MM sept	oct-MM dec		oct-MM 2011	total locat	
49	F	2.9		KH	BD	KH	KH	KH				46	218	
51	F	2.8		DN	CH	DN	DN	DN		***		49	246	
53	F	2.3		DN	NK	DN	DN	DN		***		61	255	
55	M	2.1		CH	CH	CH	CH	CH	CH	***		97	311	
57	F	2.9		BD	BD	BD	**					38	228	
59	M	2.0		KT	CH	KT	KT	KT	CH	***		62	174	
61	F	2.9		CH	CH	CH		***		***		67	308	
63	F	3.3		?	CH	CH						33	152	
69	F	3.0		DN	CH			***		***		21	213	
75	F	2.5		DN	NK	DN	DN	***		***		35	216	
												=509	=2321	
21	F	2.9				(PN)	GH	GH	SG	GH		70		
23	F	3.6				(PN)	GH	KH*	CF	SG		64		
25	M	2.6				(PN)	GD	GD	CF	SG		17		
27	M	2.2				(PN)	PN	PN	PN	PN		59		
29	M	2.2				(PN)	PN	PN	SG	PN		64		
31	M	2.3				(KH)	KH	KH	KH	KH		63		
35	M	2.3				(KS)	GD	GD	CF	SG		56		
37	M	2.1				(KS)	KS	KS	KS	KS		53		
39	M	2.3				(PN)	KH	KH	SG	KH		34		
41	F	3.1				(BR)	GH	GH	CF	GH		68	= 495	

ID=gharialtaggedwith radio, e.g., 49 is151.49MHz, 51 is151.51MHz, etc sex: F=female, M=maletl (m)is total length in meters

Chambal location abbreviations KH=KheraAjab Singh; BD= Badpura; DN=Dinnpura; CH=Chilonga; NK=Nachnoli; KT=Koroth; PN=PituwankaNagla (Philmunnagara); BR= BarchauliGH= Gohera;SG= SashonGhat; CF=confluenceYamuna------Chambal;GD=Godha; KS=Kasaua (PN), (KH), (KS), (BR)=capture/ release sites for gharial tagged in November 2010

***=visualobservation of tagged gharialwithradioattached, butno longer broadcasting

**=visualobservation oftaggedgharial,radiodetached

*=this female was observed to have nested at Chikni Tower, just below Khera in 2011

Table 2.Tracking Summary of ten wild Gharial with radio transmitters in National Chambal Sanctuary Movements are summarized for second group (ID21-41) tagged in late November 2010. Most were tracked weekly/biweekly; 25&37 were lost by end 2011, and 29 by early 2012. Seven were tracked for 26+months; five thru May 2013.Total animal--specificlocations in from Dec 2010 in to March 2013 = 1009 +

)$	≥•∏	¥⊢№	£°∞		≠Æ≥	¨ocs	´≠≥	¨oc toCFL	§≤π	5 km	∑et	$ km	Æ≥¥
□□	&	□ỳ□	0.		X□Ψ	X□□Ψ	□□□	□¥Ø103	' (	د□□	- 3	□□	#4 ,DN,DN
□□	&	□ỳ□	" 2		X□Ψ	X□□Ψ	□□□	□¥Ø103	' (	د□□	0!	□□	¯MÖN,??
□□	&	□ỳ□	0.		□□	□□□	□□	□5 to 105	' (	د□□	3'	□□	¯MÖ?,??
□□	-	□ỳ□	+3		X□Ψ	X□Ψ	□□□	¯-M2--M□□,16	' $ Ö 9 - +(	د□□ د□□ د56	0! 0$ 0!	¯MM □□ □□	
□□	-	□ỳ□	0.		□□	□□	□□□	¯-M¥105	' $	د□□	3'	¯MM	
□□	-	□ỳ□	0.		□□	□□	□□	□5 to 90	0. Ö - '	د□ د□□	- 3	□□ □□	
□□	-	□ỳ□	0.		□□	□□□	□□	□9 to 47	#4	د□□	3'	□□	
□□	-	□ỳ□	0.		X□Ψ	X□□Ψ	□□	□0 to 47	"!	د□	"!	□	
□□	-	□ỳ□	+3		□□	□□	□□	□0 to 47	4+	د□	4+	□	
□□	-	□ỳ□	+(		X□Ψ	X□□Ψ	□□	□4 to 56	#4	¯M	#4	□	

Chambal River loc: GD=Godha; GH=Gohera; MG=Magheraka Pura; DN=Dinnpura; KH=Khera Ajab Singh; KS= Kasaua; CT= Chikni Tower; PN=Pituwanka Nagla (Philmunnagara); BR=Barchouli; SG=Sashon Ghat; Mahua Sunda=MS; PA=Patharra--Bihar; CF=Yamuma -Chambal confluence; YM=Yamuna; PD=Pachnada, belowY--Cconfluence. (PN),(KH),(KS), (BR)=capture/releasesites.

legends:tl--m=totallength, metres; cap=capture location; mns= months tracked; locs= location srecorded; kms= maximum movement distance, in kms; loc to CFL=locationon Chambal, relative to con fluence (CF)=0; dry= dry season location; Ukm= seasonal upstream movement, in km; wet=wet seasonlocation; Dkm= seasonal downs tream movement, in kms.

23 nested in 2011 at CT, in 2012 at DN, and 2013 at DN; 41 nested in 2012 at DN. In 2013, nesting by 41 and 21 stilluncertain.

PUBLICATIONS/TALKS/REFERENCES TO THIS PROJECT (downloadable at academia.edu under "JEFFREY LANG")

Lang, J.W. and Whitaker, S. (2010). Application of telemetry techniques in crocodilian research: Gharial (Gavialis gangeticus) spatial ecology in the Chambal River, India, pp.161-171,in Siva kumar, K. and Habib, B.(Eds.) Telemetry in Wildlife Science, ENVIS Bulletin. Wildlife and Protected Areas, Vol13 No. 1, Wildlife Institute of India, Dehradun 248001. INDIA

Lang,J.W. and Whitaker, S. (2010) Spatial Ecology of Gavialis gangeticus in the Chambal River, India, pp.183-196, in Crocodiles, Proceedings of the 20th Working Meeting of the Crocodile Specialist Group, IUCN, Gland, Switzerlandand Cambridge UK.

Lang, J.W. (2010). Adult-Young Associations of free-living Gharials in the Chambal River, India, p.197, abstract, in Crocodiles, Proceedings of 20th Working Meeting of the Crocodile Specialist Group, IUCN, Gland, Switzerland & Cambridge UK.

Lang, J.W. (2012). Gharial Ecology on the Chambal River in north India, abstract for talk at World Congress of Herpetology(WCH7),8-14 August 2012,University of British Columbia,V ancouver BCCANADA

Lang, J.W. (2013). Behavioral Ecology of Gharial on the Chambal River, India. Project Report to Ministry of Environment & Forests, Government of India, New Delhi, June 2013.

This project is a joint venture of Madras Crocodile Bank Trust (MCBT) and the Gharial Conservation Alliance (GCA), PO 4, Mahabalipuram 603104 INDIA

in collaboration with Ministry of Environments & Forests, Government of India, Uttar Pradesh and Madhya Pradesh Forest Departments, and Garhaita Village, Etawah UP.

We thank the following for their guidance, assistance, and support in various ways: Dr.Anmol Kumar, MoEF; Dr. B.K. Patnaik& Staff, UPFD; Dr. H.S. Pabla& Staff, &R.K. Sharma, MPFD; Ravi Singh, Dr. P. Gautham, & Dr. S. Behra, WWF-India; R.P. Singh, Chambal Safari; Dr. Shailendra Singh & Staff, Turtle Survival Alliance; and to Rick Hudson, Brian Horne, F.Bill Zeigler, Kent Vliet, Perran Ross & Don Boyer.

Romulus Whitaker, Ms. Janaki Lenin, Samir Whitaker, Dr. GowriMallapur, Colin Stevenson, Dr. Ravi Chellam, K. Munuswamy and all staff at MCBT and GCA.Residents of Garhaita, EtawahDt, & Riverside Villages, National Chambal Sanctuary

Thanks to the following sponsors for major project support/logistics:

The Rufford Maurice Laing Foundation, London, Great Britain;Ocean Parks Conservation Foundation, Hong Kong;Crocodile Specialist Group, IUCN, Gland Switzerland; Zoo Praha, Prague, Czech Republic;Cleveland Metro Parks Zoo, Ohio, USA; San Diego Zoo & Wild Animal Park, California USA; SeaArk Boats, Arkansas.

Table3. Summary of Gharial activities and behaviors observed on the lower Chambal River (National Chambal Sanctuary) throughout the annual cycle (shown here bimonthly). In general,gharialof all size classes are most concentrated at late winter basking sites prior to breeding, and are most dispersed at high water levels during monsoonal rains when main channel flow is swift, andresting and baskingsitesalongtheshorelinearelimited. Captureandtaggingshouldberestrictedto October--November when adults move upstream, when social interactions are minimal, and when reproductive activities do not occur.

annualcycle		weather/season	size/age/sex distribution	spatial pattern	group size	dominant activities	riverhabitats
July-– Aug		monsoonhigh water	all sizeclasses	dispersed	l–5 5-–10	feedingbasking	shallows, edges, side channels
Sept-– Oct		post monsoon receding water	all sizeclasses	small, mixed grps	5–10 10–-20	feedingbasking	main channel, shallows, edges
Nov-– Dec		earlywinter cool temps	all sizeclasses	medium, mixedgrps	10–-30	basking	sand bars, river bends
Jan-– Feb		latewinter cooltemps	adults– subadults multiple males >4 juveniles-–s-–adults	largegrps breeding marginal	30–-90 5–15	basking, breeding	mid river bars, bends, rocks
Mar-– April		early summer warm temps low water	nesting females egg incubation attendent male(s)	restricted tonesting locations	10–-30	trial nests, nesting, incubation	river bends, highsandbanks, w/ deep water
May--- June		pre monsoon very high temps lowest water	nesting females hatchlings guarding male=1 juveniles-–s-–adults	restricted tonesting locations marginal	10–-30 5–15	incubation, egg hatch, creches	river bends, highsandbanks, w/ deep water

Table4: Spatial distribution of nest sites on lower Chambal River, referenced to upstream distance from Yamuna confluence (=0 km) Fourteen nest sites were used during three nesting seasons, producing 38, 76, and 80 nests respectively in 2010, 2011, and2012. The number of nests that produced hatchlings in each year are shown for each location in the bottom panel.Predated nests=( );=pd For example, the Rheasite (*RH*) had 11, 20, and 30 total nests,and 11, 19, and 28 nests hatched in 2010, 2011, and 2012, respectively. Bolded, underlinedentryindicatesthatamalewasobservedguardinghatchlingsatnestsite,andoftenresidentpost--hatching.

distance river(km)	38	46	49	54	56	74	79	85	87	93	103	107	133	161			
nesting location	**PN**	**KS**	**CT**	**KHc**	**KHf**	**CH**	**NK**	**DNu**	**DNm**	**NG**	**GH**	**GD**	**KP**	**RH**		total nests	nest sites
2010	1	(3)		4	4	3	3				3	4	(2)	11		38	10
2011	6	7	3	(7)	7	6	6			(4)	(3)	(3)	(4)	20		76	12
2012	7		(3)		20			8	12					30		80	6
nesting location	**PG**	**KS**	**CT**	**KHc**	**KHf**	**CH**	**NK**	**DNu**	**DNm**	**NG**	**GH**	**GD**	**KP**	**RH**		nests hatched	hatch sites
2010	1	pd		**3**	**4**	**3**	2				3	4	pd	**11**		31	8
2011	**6**	**5**	**3**	pd	**3**	**6**	**6**			pd	pd	pd	pd	**19**		48	7
2012	**5**		pd		**17**			**8**	**11**					**28**		69	5

Nesting location abbreviations: PN=PituwankaNagla (Philmunnagara); KS=Kasaua; CT=Chikni Tower; KHc=KheraAjab Singh, back channel; KHf=KheraAjab Singh, main channel; CH=Chilonga; NK=Nachnoli; DNu=Dinnpura, UP side; DNm=Dinnpura, MP side; NG=Naangoan; GH=Gohera; GD=Godha; KP=Kuerapura; RH=Rhea

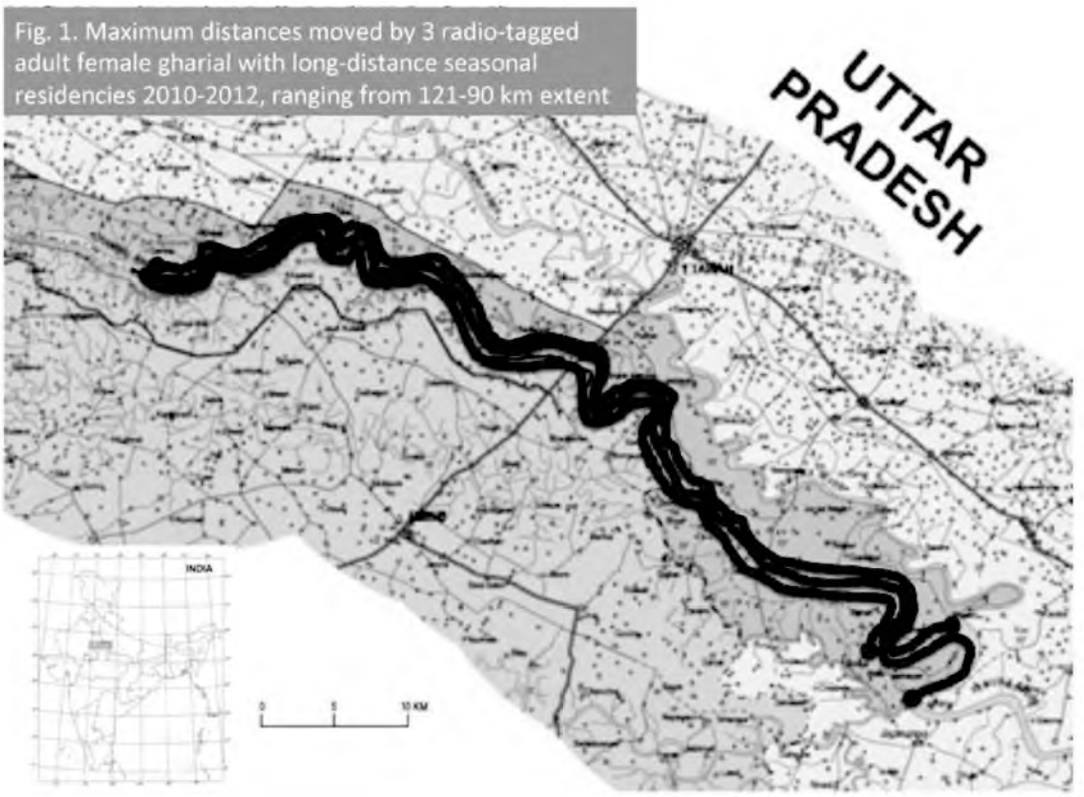


Fig. 1. Maximum distances moved by 3 radio-tagged adult female gharial with long-distance seasonal residencies 2010-2012, ranging from 121-90 km extent

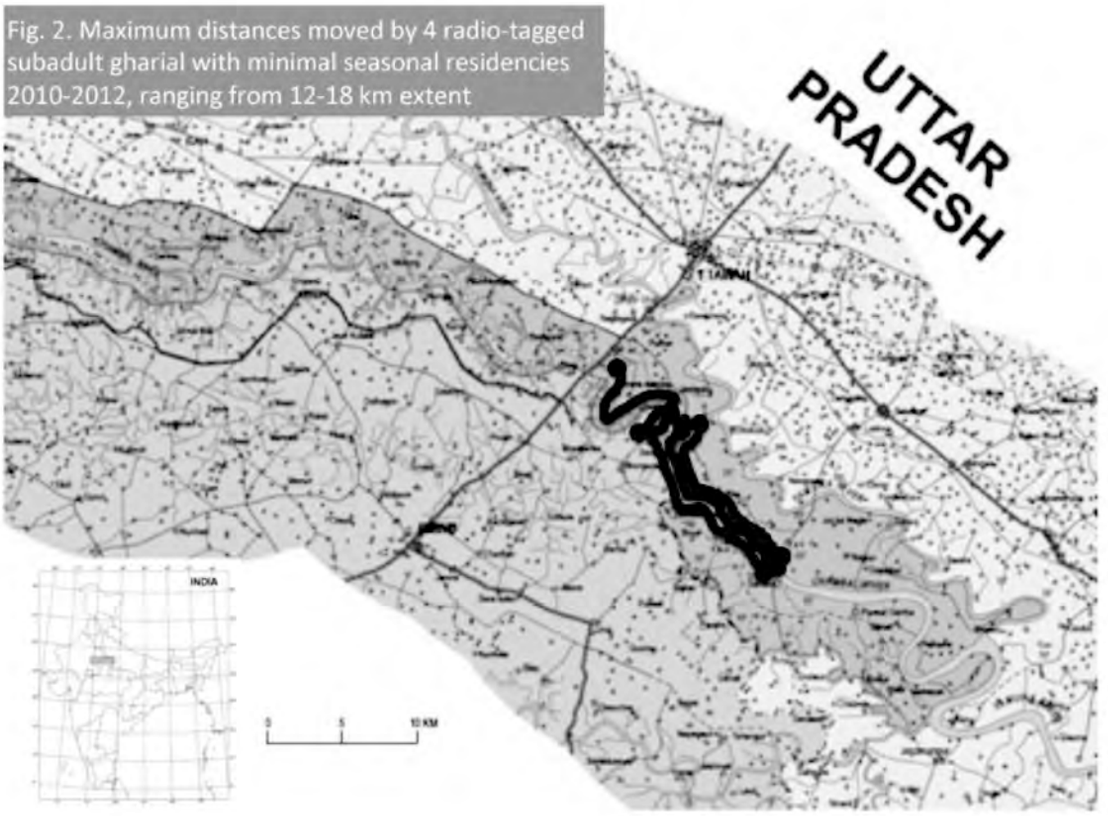
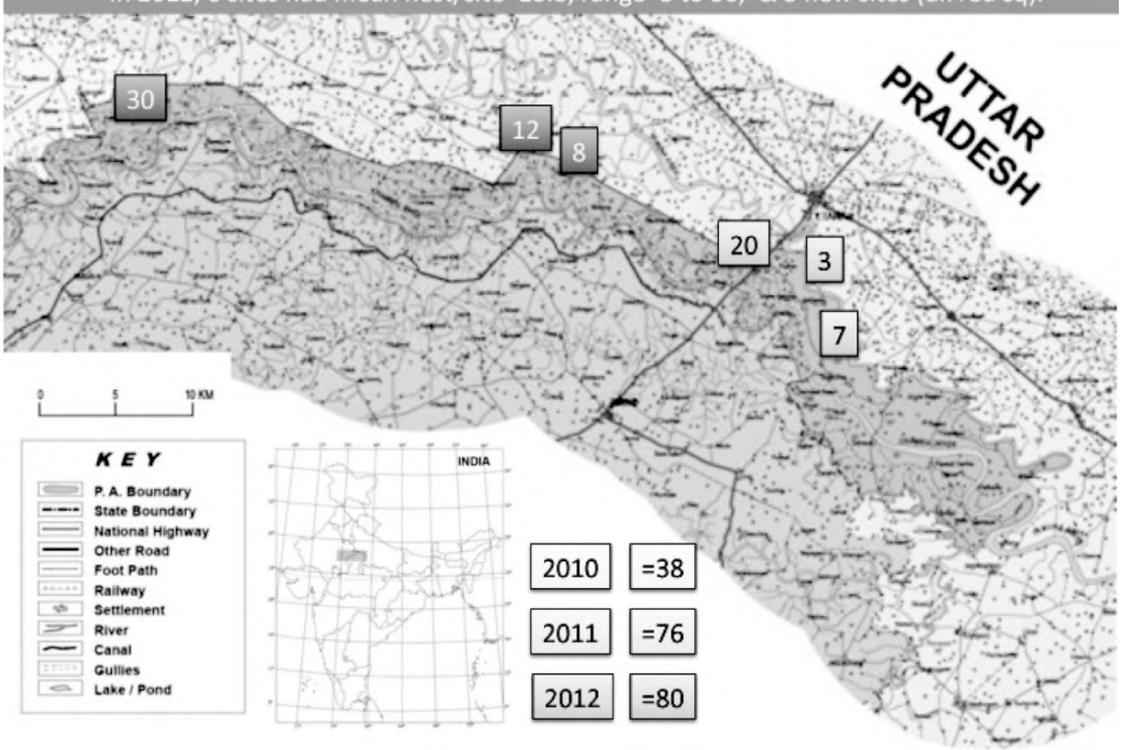
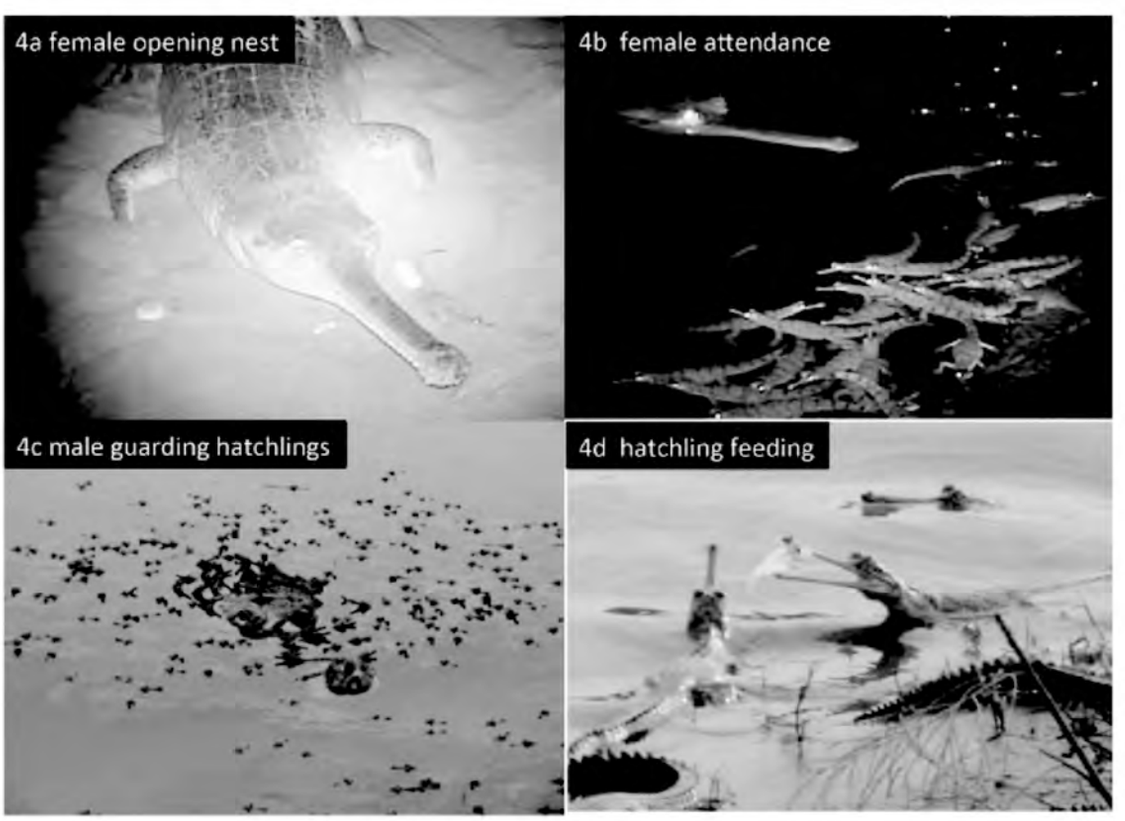
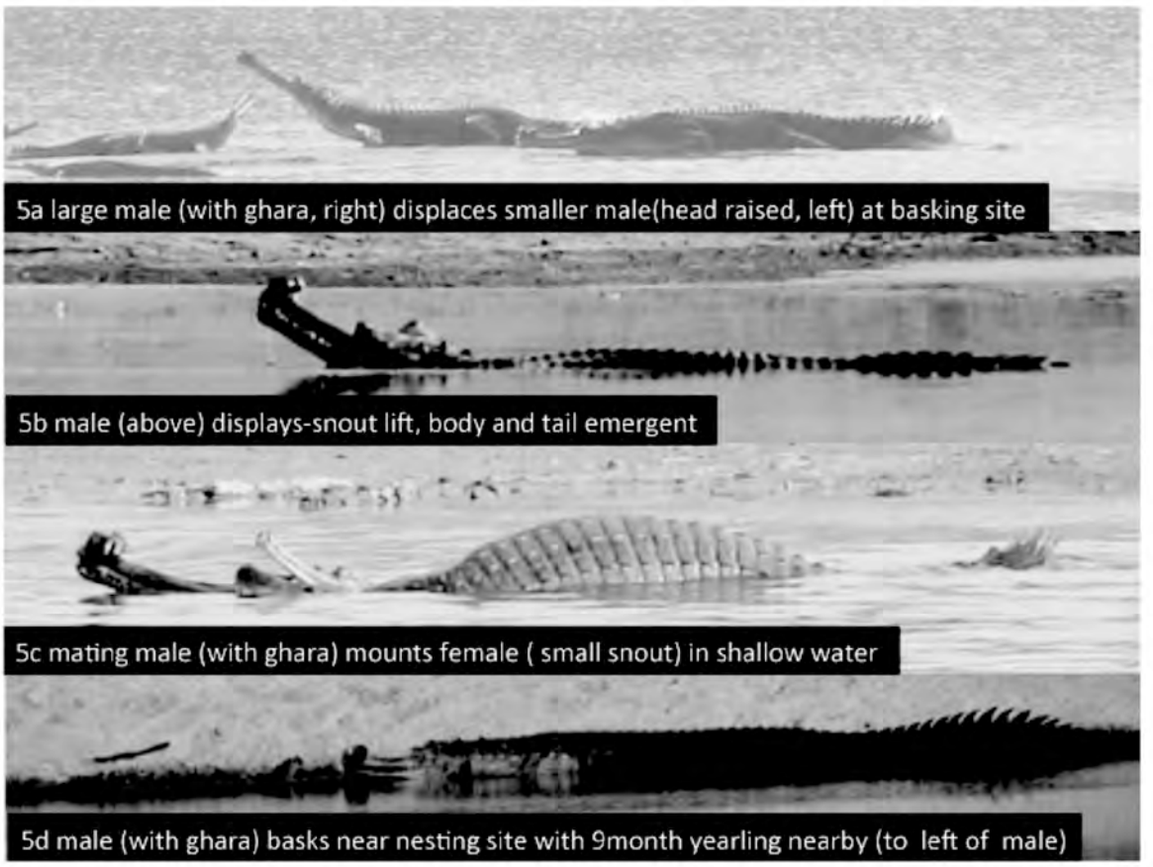


Fig. 2. Maximum distances moved by 4 radio-tagged subadult gharial with minimal seasonal residencies 2010-2012, ranging from 12-18 km extent

Fig. 3. In 2010, 2011, and 2012, nest sites, nest numbers at sites, and nest predation varied. In 2012, 6 sites had mean nest/site=13.3, range=3 to 30, & 3 new sites (dk red sq).







5a large male (with ghara, right) displaces smaller male(head raised, left) at basking site

5b male (above) displays-snout lift, body and tail emergent

5c mating male (with ghara) mounts female (small snout) in shallow water

5d male (with ghara) basks near nesting site with 9month yearling nearby (to left of male)

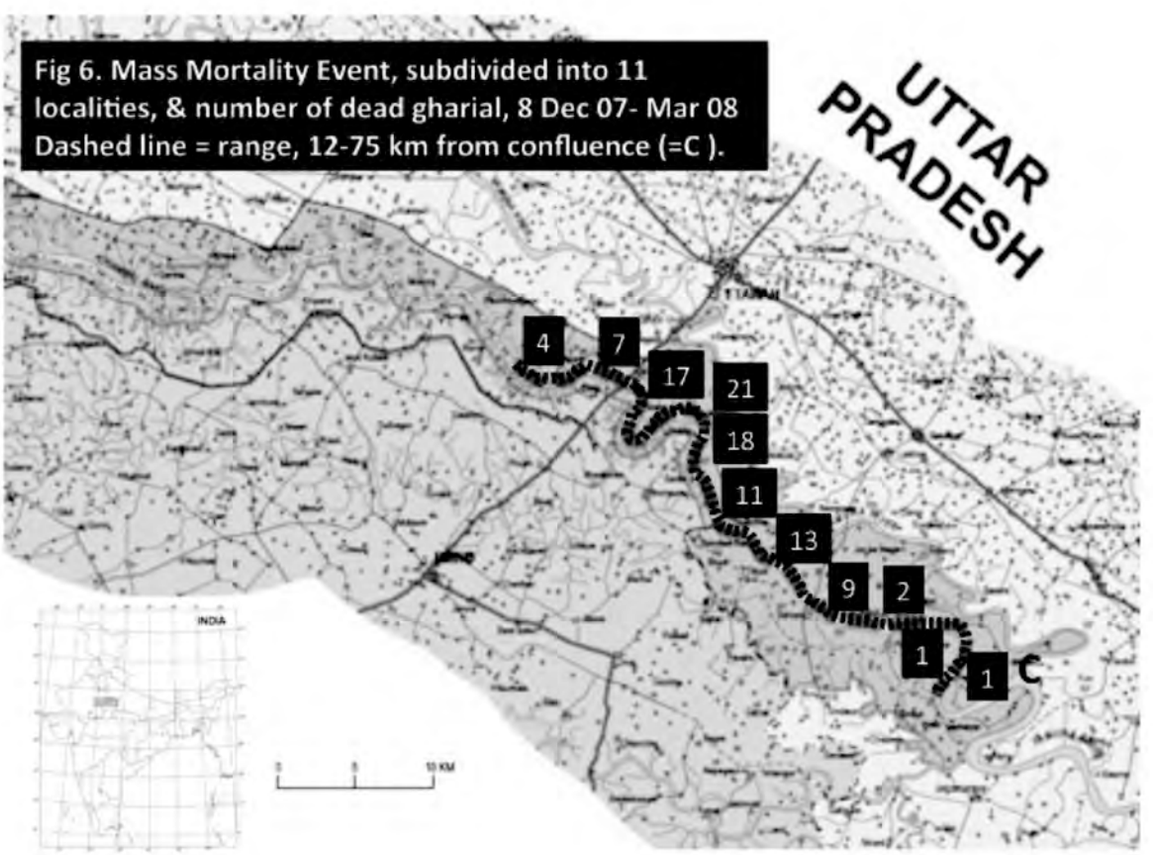


Fig 6. Mass Mortality Event, subdivided into 11 localities, & number of dead gharial, 8 Dec 07- Mar 08
Dashed line = range, 12-75 km from confluence (=C).

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 53 - 65

Dry-season assessment of gharials (*Gavialis gangeticus*) in the Betwa, Ken and Son Rivers, India

Tarun Nair and Suyash Katdare
Gharial Conservation Alliance/Madras Crocodile Bank Trust India
orresponding author: tarunnair1982@gmail.com

Introduction

While gharial (*Gavialis gangeticus*) populations are monitored in the National Chambal Sanctuary (Madhya Pradesh Forest Department annual surveys, Lang 2010, Lang & Whitaker 2010, Nair 2010, Katdare 2011, Nair et al. 2012, Lang & Kumar 2013), Katerniaghat Wildlife Sanctuary (Chaudhari 2008, Converse 2009, Choudhary 2011) and Corbett Tiger Reserve (Chowfin 2013, Chowfin & Leslie 2013), virtually nothing is known from the rest of the gharial's range in India. To address this shortcoming, the Gharial Species Recovery Plan (in prep.), and IUCN's Gharial Status Survey & Conservation Action Plan (Stevenson & Whitaker 2010) suggest an overall assessment of the status of existing gharial populations to be used as a baseline fors measuring the effectiveness of past recovery efforts. As part of this range-wide assessment of gharials in India, and following observations of gharial hatchlings in the Yamuna River, near the Ken - Yamuna confluence, (Nair 2012), we undertook surveys of 3 rivers (Rivers Betwa, Ken & Son) in the Yamuna - Ganga Drainage.

Study Area

a) Betwa River: The Betwa River originates in the Vindhyan Ranges, near Bhopal in Madhya Pradesh, and flows in a north-easterly direction for approximately 590 km to meet the Yamuna River in Uttar Pradesh near the town of Hamirpur. The project area (Figure 1, 4) includes ~100 km of the lower Betwa, between Tikri village (N 25° 53' 53.45", E 79° 31' 24.54") and the Betwa-Yamuna confluence (N 25° 55' 2.60", E 80° 12' 48.66").

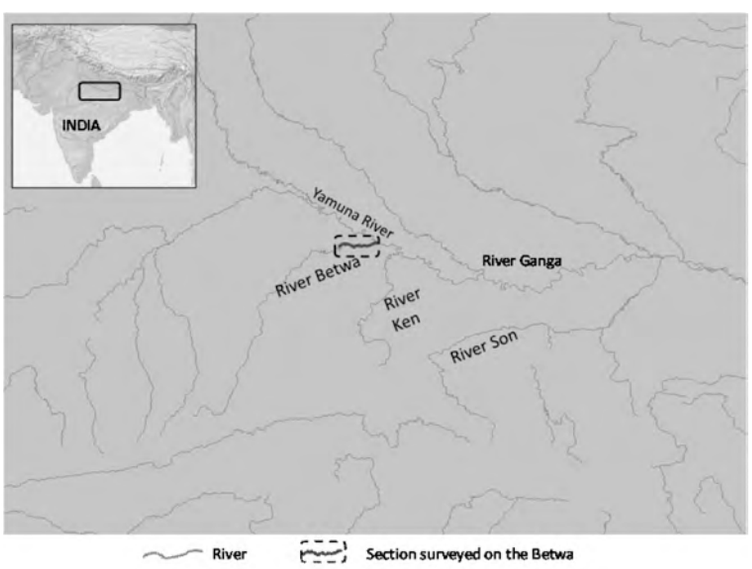


Figure 1. Map of study area (Rivers Betwa, Ken & Son) highlighting the section surveyed on the Betwa River

b) Ken River: The Ken River originates on the north-western slopes of the Kaimur hills in Jabalpur district of Madhya Pradesh (M.P.) at an elevation of about 550 m above mean sea level and joins the Yamuna River near Chilla village in Uttar Pradesh (U.P.) at an elevation of about 95 m. It forms the boundary between Panna and Chhatarpur districts in M.P., and the state boundary between Chhatarpur district (M.P.) and Banda district (U.P.). The river has a total length of 427 km, out of which 292 km lies in M.P., 84 km in U.P. and 51 km forms the common boundary. Its tributaries include Sonar, Shyamari, Kutni and Urmal Rivers among others. The Ken River basin lies between north latitudes 23°20' and 25°20' and east longitudes 78°30' and 80°32'. The total catchment area of the basin is 28,058 sq. km. (Jain et al. 2007).

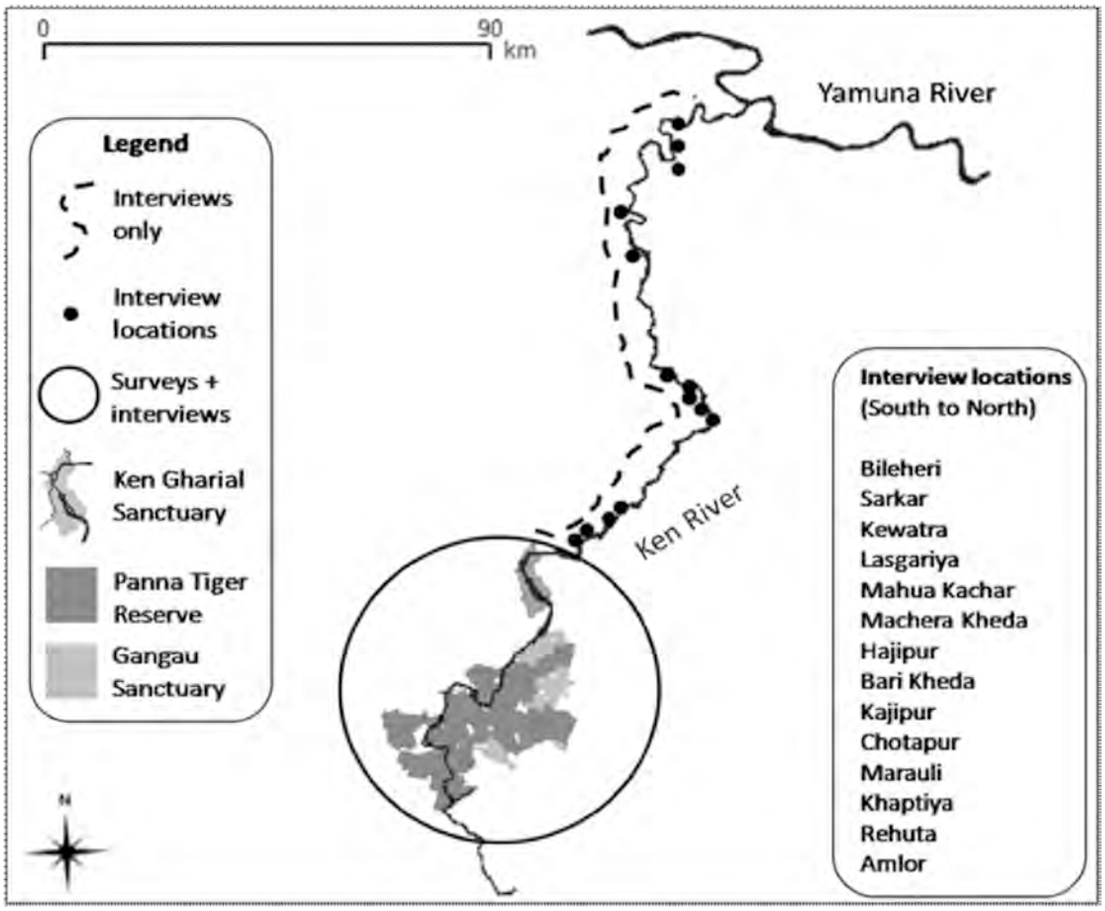


Figure 2. Map of study area, showing surveyed locations in the Ken River.

The Panna Tiger Reserve (PTR) covers 542 km^2 of the Vindhyas in north-central Madhya Pradesh. This landscape consists of two extensive, step-like plateaus separated by 3080 m high escarpments that run parallel to the Ken River (Karanth et al. 2004), and the dominant vegetation type is tropical dry-deciduous forest (Meher-Homji 1990). Approximately 55 km of the Ken River flows though / along PTR. The annual rainfall fluctuates within the range of 6001100 mm (Jayapal et al. 2007) between July and September, which is followed by the cool season between October and February. This is followed by an increasingly dry summer, when the maximum temperature may frequently exceed 45° C (Karanth et al. 2004).

Approximately 16 km, and not 45 km as reported earlier (Rao et al. 1995; Sharma et al. 1999), of the Ken River between the Barriarpur Weir (N 24°50'32.00" E 80°05'18.00") and the Ken - Urmal confluence (N 24°56'20.00" E 80°04'6.00") has been designated as the Ken Gharial Sanctuary (KGS) since 1981.

c) Son / Sone River: The Son River originates in the Maikal Range, near the town of Amarkantak (Madhya Pradesh, India), at an elevation of 600 m (Hunter 1908, Sinha & Sharma 2003). After an initial course running North-Northwest, the Son flows in an East-Northeasterly direction along the Kaimur Range. Its runs for about 784 km till its confluence with the Ganga upstream of Patna, Bihar.

The Son has a steep gradient (3555 cm per km) with quick run-off (Wikipedia 2013) and a recorded monsoonal discharge of up to 830,000 cu ft/s (Hunter 1908). However, being wide and shallow, it leaves disconnected pools of water in the remaining part of the year (Wikipedia 2013). Its tributaries include the rivers Ghaghar, Johilla, Banas, Gopad, Rihand, Kanhar and North Koel River. The total catchment area of the basin is 71,258 sq. km. (Jain et al. 2007). Water impoundments on the Son include the Bansagar Dam, Indrapuri Barrage and Dehri Anicut.

209.21 km of river length [including 160.93 km of the Son River, from the Bansagar Dam to the Singrauli (M.P.) - Sonbhadra (U.P.) border; 22.53 km of the Banas River from the Son - Banas confluence to the bridge on the Sidhi - Shahdol PWD Road; and 25.75 km of the Gopad River from the Son - Gopad confluence to the bridge on the Rewa Waidhan PWD Road] has been declared as the Son Gharial Sanctuary (SGS). It also includes 200 m on either side of the riverbank.

Figure 3: Map of study area, showing surveyed locations in the Son Gharial Sanctuary.

Field Methods, Observations and Discussion

We surveyed 3 rivers (Rivers Betwa, Ken & Son) in the Yamuna - Ganga Drainage between February and May 2013. Surveys were carried out either on foot, by row-boat or through stationary observations depending on local conditions and logistics. Two observers, equipped with binoculars, scanned the river and both banks. All observations were noted in a standardised format and their locations recorded in a Global Positioning System (GPS) unit.

a) Betwa River: Approximately 100 km of the lower Betwa, between the Betwa-Yamuna confluence (N 25° 55' 2.60", E 80° 12' 48.66") and Tikri village (N 25° 53' 53.45", E 79° 31' 24.54") was surveyed from February 02-13, 2013, moving upstream in a row-boat. Local residents were interviewed and shown photographs of gharial and mugger (*Crocodylus palustris*) to inquire the presence of both species from the Betwa River.

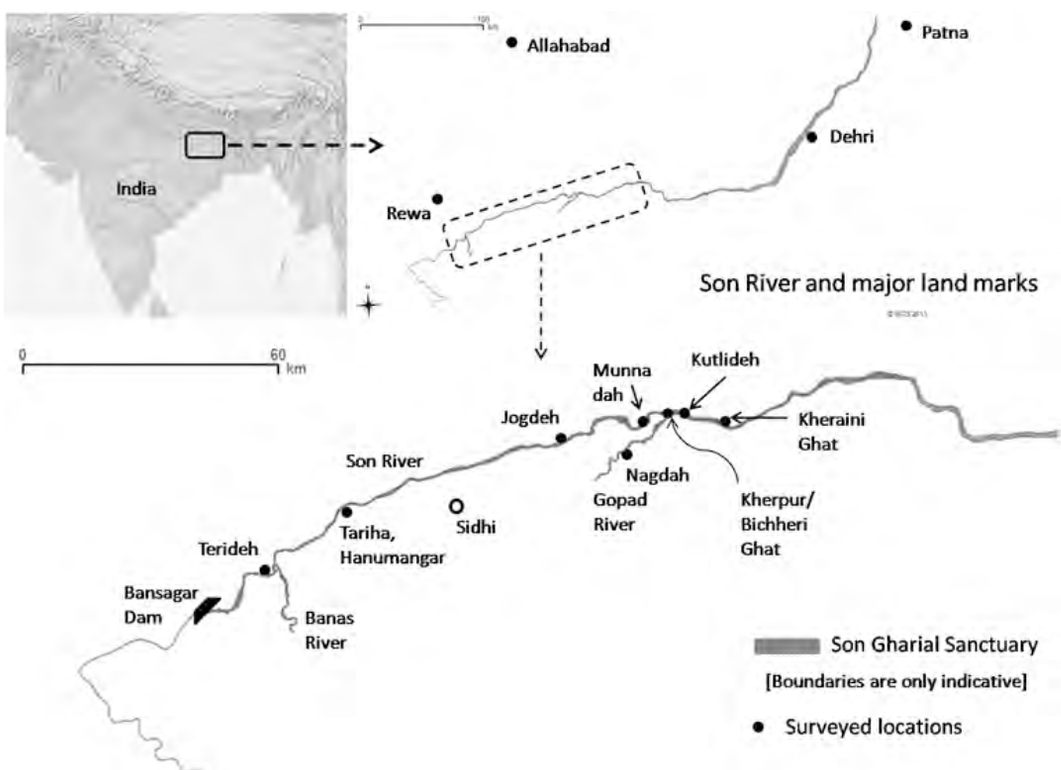


Figure 4. Satellite image of the surveyed area in the Betwa River, showing start and end locations (dark blue pins), mugger observations (light blue pins) and major sand-mining sites (shaded red).

Two muggers were detected during the survey (one each at N 25°54'49.64" E 79°36'33.56" and N 25°53'11.96" E 79°33'13.49").

The surveyed length of river was notably shallow (only observed, not quantified) and fordable at multiple locations (most boatmen simply used bamboo push-poles to navigate the river rather than row or paddle).

A range of intrusive and extractive human activities (the most common being riverside agriculture, sand-mining and fishing), and domestic activities including washing, bathing and cattle herding were observed throughout the surveyed area. Sand was being mined (in-stream and floodplain) at an industrial scale, and several makeshift bridges, to facilitate vehicular movement, had been laid out across the river near every large-scale mining site. A series of concrete pipes at the bottom of these makeshift bridges ensured the flow of water but this arrangement seemed inadequate to ensure functional connectivity for aquatic wildlife. In addition, these sites were also subject to round-the-clock activity of heavy machinery and mine workers.

While fishing was observed frequently (cast-net and gill-net), fishermen indicated poor daily catches of as little as 2-3 kg, and alleged the low-productivity to be a result of falling water levels and siltation caused by sand-mining. Local fishermen reported occasional observations and entangling of small gharial near the Betwa - Yamuna confluence during the monsoonal floods. Hunting was also reported to be widespread in the area.

Historical accounts of gharial in the Betwa are scarce. Singh (1978) notes that the gharial habitat in the Betwa has been badly disturbed and that the gharial population is either extinct or near extinction. Rao et al. (1995) reports the release of 55 gharials in the downstream section (Uttar Pradesh) of the Betwa but we could not gather any evidence to suggest their continued survival. Based on our observations in the dry, low-flow season, we believe that the lower Betwa is unsuitable for the long-term survival of gharials and that it has low conservation potential for the species.

b) Ken River: We assessed ~ 86 km of the Ken River, between where the Ken River enters Panna Tiger Reserve (N24°27'24.89" E79°51'52.16") and exits Ken Gharial Sanctuary (N24°56'18.22" E80° 04'19.33"); and conducted semi-structured, opportunistic interviews (with photographs of the gharial and mugger as visual aids) of local riverside residents to record their observations of these species in the lower ~175 km of the Ken River (Figure 5).

i) Panna Tiger Reserve(PTR): We investigated 55 km of the Ken River flowing through the Panna Tiger Reserve from 09 -17, April 2013. Observations were carried out on foot in daylight, except for a 9 km section upstream of the Gangau Dam which was covered by row-boat.

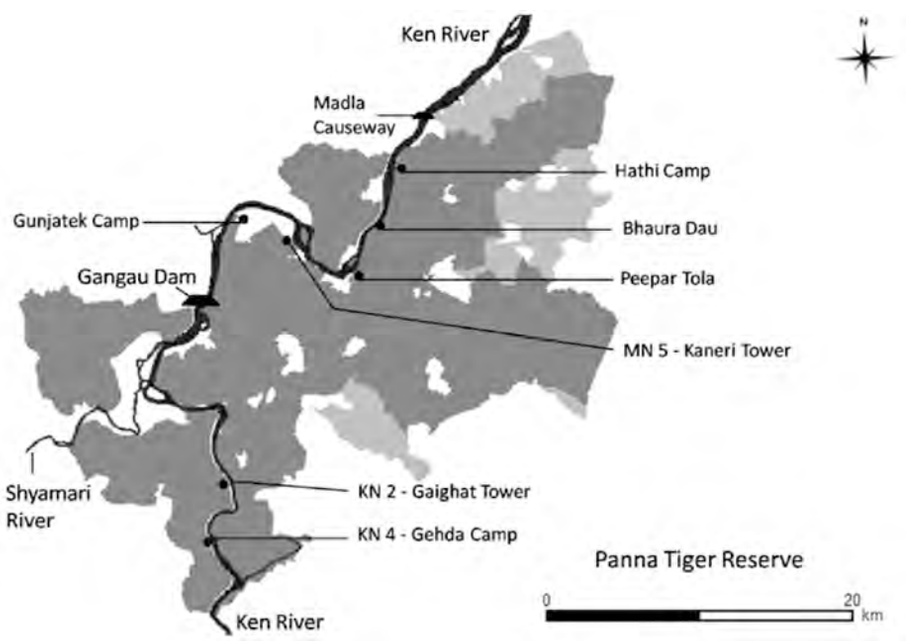


Figure 5. Map of the Ken River, flowing through Panna Tiger Reserve

We detected 56 mugger / marsh crocodiles in this 55 km section (see Table 1). We did not find any evidence (direct or indirect) of gharials in the Panna Tiger Reserve during this survey, in spite of two attempts to introduce the species here (see Table 3). Based on the number of detections (N=56) and effort, in terms of distance surveyed (55 km), we can make coarse estimates of encounter rates at 1.01 individuals / km.

Table 1. Details of mugger observations in the Ken River in Panna Tiger Reserve.

Date	No. of individuals	Location (nearest)
11.04.2013	1 juvenile	N 24°30'24.1'' E 79°51'44.9'' (Near KN 4 - Gehda Camp)
11.04.2013	2 yearlings	N 24°31'31.8'' E 79°52'43.8'' (Near KN 2 - Gaighat Tower)
11.04.2013	1 juvenile	N 24°32'43.1'' E 79°52'17.1'' (Near KN 2 - Gaighat Tower)
14.04.2013	1 juvenile	N 24°41'17.7'' E 79°53'04.4'' (Near Gunjatek Camp)
15.04.2013	1 adult 1 sub-adult	N 24°39'42.0'' E 79°56'03.1'' (Near MN 5 - Kaneri Tower)
15.04.2013	1 juvenile 1 yearling	N 24°39'07.2'' E 79°57'01.9'' (Near Peepar Tola)
16.04.2013	4 adults 5 juveniles	N 24°39'16.7'' E 79°57'11.5'' (Near Peepar Tola)
16.04.2013	1 adult	N 24°39'22.0'' E 79°57'21.0'' (Near Peepar Tola)
16.04.2013	2 juveniles	N 24°39'43.0'' E 79°57'47.5'' (Near Peepar Tola)
16.04.2013	2 adults 2 juveniles	N 24°39'50.3'' E 79°57'59.2'' (Near Peepar Tola)
16.04.2013	1 adult 1 juvenile 1 yearling	N 24°39'42.5'' E 79°58'02.6'' (Near Peepar Tola)
16.04.2013	1 juvenile / sub-adult (?) 1 yearling	N 24°39'24.8'' E 79°57'50.9'' (Near Peepar Tola)
16.04.2013	1 adult 4 juveniles	N 24°40'04.7'' E 79°58'08.6'' (Between Peepar Tola and Bhaura Dau)
16.04.2013	1 adult	N 24°40'30.2'' E 79°58'15.4'' (Near Bhaura Dau)
16.04.2013	1 adult 1 juvenile	N 24°40'45.7'' E 79°58'37.2'' (Near Bhaura Dau)
17.04.2013	3 adults 1 juvenile 1 yearling	N 24°41'12.1'' E 79°59'01.4'' (Near Bhaura Dau)
17.04.2013	3 adults	N 24°41'20.1'' E 79°59'06.2'' (Near Bhaura Dau)
17.04.2013	1 juvenile	N 24°41'28.1'' E 79°59'10.1'' (Near Bhaura Dau)
17.04.2013	1 sub-adult 1 adult	N 24°41'35.1'' E 79°59112.5'' (Near Bhaura Dau)
17.04.2013	1 adult / sub-adult (?) 3 juveniles	N 24°41'54.0'' E 79°59'17.1'' (Near Bhaura Dau)
17.04.2013	1 adult	N 24°42'06.0'' E 79°59'18.5'' (Between Bhaura Dau and Hathi Camp)
17.04.2013	1 juvenile	N 24°42'20.4'' E 79°59'21.8'' (Between Bhaura Dau and Hathi Camp)
17.04.2013	1 adult	N 24°43'35.0'' E 79°59'52.7'' (Between Hathi Camp and Madla Causeway)
TOTAL	**56**	**[21 adults; 2 sub-adults; 25 juveniles; 6 yearlings; 1 juvenile / sub-adult (?); 1 adult / sub-adult (?)]**

ii) Ken Gharial Sanctuary (KGS): We surveyed 16 km of the Ken River flowing through the KGS from 25 - 26, April 2013. Daylight observations were carried out on foot, except for a 5 km section downstream of Raneh Falls which was covered by row-boat.

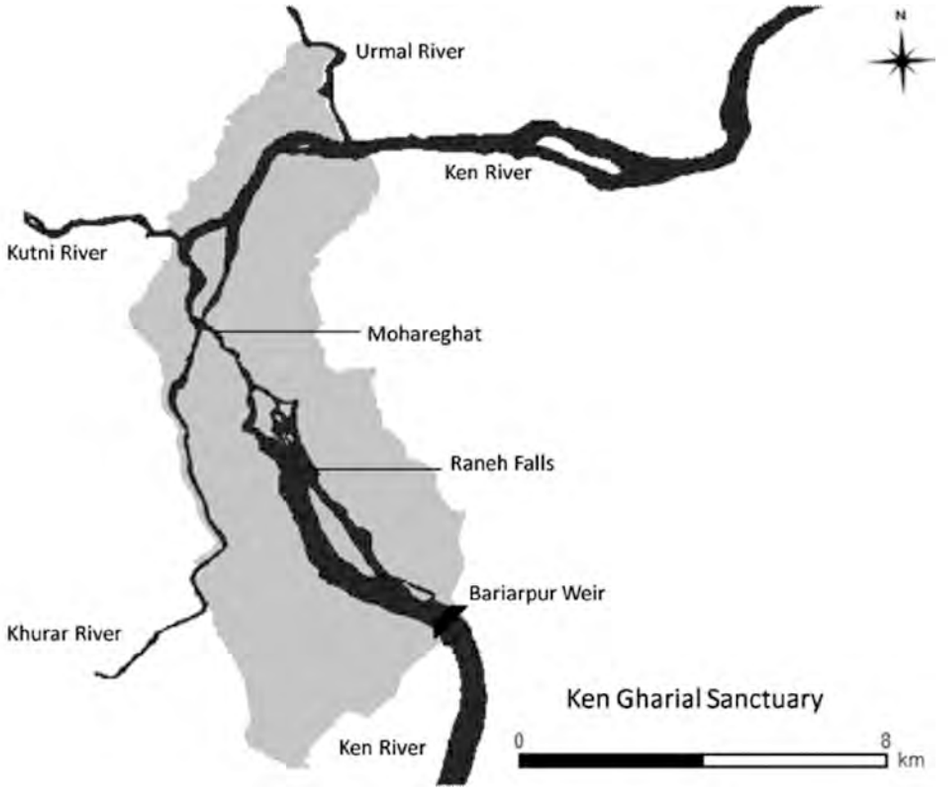


Figure 6. Map of the Ken River, flowing through Ken Gharial Sanctuary.

We detected 4 mugger in this 16 km section of the Ken River (see Table 2), giving us an encounter rate of 0.25 individuals / km. However, we did not find any evidence (direct or indirect) of gharials in the KGS during this survey, in spite of several efforts to (re)introduce the species here (see Table 3).

Table 2. Details of mugger observations in the Ken River in Ken Gharial Sanctuary

Date	No. of individuals	Location (nearest)
26.04.2013	1 adult / sub-adult (?)	N 24°53'45.8'' E 80°02'36.9'' (Near Mohare ghat)
26.04.2013	2 adults	N 24°53'59.2'' E 80°02'29.2'' (Near Mohare ghat)
26.04.2013	1 adult	N 24°54'14.7'' E 80°02'06.2'' (Near Mohare ghat)
TOTAL	**04**	[**3 adults; 1 adult / sub-adult (?)**]

Previous accounts of gharials in the Ken River are ambiguous. Singh (1978) reports gharials as extinct in the Uttar Pradesh (lower) portion of the Ken River, and according to Sharma (2000) the species did not occur in the Ken Gharial Sanctuary prior to the reintroduction of captive-reared animals. However, Whitaker & Mahadev (1976) report sighting an adult gharial, and gather the presence of a few more individuals from local fisherman in the Mandla Sanctuary (we are not aware of the existence of the Mandla Sanctuary and believe this to be the Ken Gharial Sanctuary close to the town of Madla, Madhya Pradesh). Whitaker & Daniel (1978, 1980) also note the presence of a small population of gharials in the Ken River.

The Madhya Pradesh Forest Department considered KGS suitable for the management of gharials based on habitat characteristics and prey availability (Sharma et al. 1999), and as per official records maintained at KGS (Khajuraho, Madhya Pradesh), 109 gharials have been released here since its establishment in 1981 (see Table 3). In addition, 33 gharials (15 in 1996 + 18 in 1998) were released at Bhaurau Dau, PTR (N24°41'0.00" E79°58'45.00") approx. 22 km upstream of Barriarpur Weir (see Table 3).

Table 3. Official record of gharials released in the Ken River (Ken Gharial Sanctuary and Panna Tiger Reserve).

Year	Number of gharials released	Location
1982	8 (sex undetermined)	Ken Gharial Sanctuary - Mohareghat
1985	4 (2 female + 2 male)	Ken Gharial Sanctuary - Mohareghat
1987	10 (sex undetermined)	Ken Gharial Sanctuary - Mohareghat
1989	10 (sex undetermined)	Ken Gharial Sanctuary - Mohareghat
1993	15 (11 female + 4 male)	Ken Gharial Sanctuary - Mohareghat
1994	1 (sex undetermined)	Ken Gharial Sanctuary - Kat Singhar Ghat
1995	15 (all females)	Ken Gharial Sanctuary - Mohareghat
1995	1 (male)	Ken Gharial Sanctuary - Mohareghat
1996	15 (sex undetermined)	Panna Tiger Reserve - Bhaurau Dau
1998	18 (sex undetermined)	Panna Tiger Reserve - Bhaurau Dau
1998	20 (sex undetermined)	Ken Gharial Sanctuary - Mohareghat
2007	25 (20 female + 5 male)	Ken Gharial Sanctuary - Mohareghat
TOTAL	**142 (48 females + 12 males + 82 undetermined)**	

Despite the release of 142 gharials in the study area, there is no evidence to suggest that this effort has helped sustain a breeding population here. No gharials have been observed by local forest staff at Bhaurau Dau, PTR for at least three years (Shankar Verma, pers. comm.). Meanwhile, forest staff at KGS mention of the presence of only 1 female adult gharial near Mohareghat, reportedly seen 2 weeks before this survey (Lalu Kewat and Sunwa Kewat, pers. comm.). Gharial nesting and a pod of 8 hatchlings were reportedly observed in 2003, and the only known adult male has not been seen since a major flood in the Ken River in 2005 (Ibid).

The sections of the Ken River flowing through PTR and KGS are predominantly rocky, and the complementary availability of two critical components of gharial habitat - deep pools and sand deposits, are limited and widely disconnected. Individuals that move downriver in the monsoonal floods or during high water do not have the opportunity to return to the relatively protected confines of the KGS or PTR due to the several man-made barriers and disrupted flow regimes in the Ken River. Water impoundments at Gangau Dam, Ranguwan Dam, Madla Causeway and Barriarpur Weir have diminished river flow, and this is compounded in the dry, summer months. The proposed Ken - Betwa river-linking project will further aggravate the situation by the creation of the Daudhan Dam on the Ken River at a location of about 2.5 km upstream of the existing Gangau Dam and the diversion of 1020 Mm^3 of water from the Ken River (NWDA, undated).

Additionally, activities like dynamite and gill-net fishing and sand-mining on an industrial scale have rendered the non-protected sections of the Ken River too disturbed and hostile to permit gharial populations to establish themselves. Other human activities in the form of bankside agriculture, livestock herding and unrestricted human movement along the river also contribute to habitat loss and disturbances.

The Ken River supports diverse fish fauna of high conservation importance (Johnson et al. 2012, pers. obs.) and significant populations of other associated fauna like muggers and Grey-headed Fish-eagles (*Ichthyophaga ichthyaetus,* pers. obs.). However, based on the current situation and our observations of the Ken River in Panna Tiger Reserve and Ken Gharial Sanctuary in the dry, low-flow season, we are of the opinion that this is, at best, sub-optimal habitat for gharials, and not conducive to the long-term conservation requirements of the species. We suggest that future plans to reintroduce gharials in the Ken River be critically evaluated for its conservation benefits. We also suggest that the Ken Gharial Sanctuary be renamed as '*Ken River Sanctuary*' since the existing name lends a false assurance that the sanctuary provides suitable habitat and sustains a natural gharial population.

We also conducted opportunistic interviews of local riverside residents to record their observations of gharials and muggers in the lower ~175 km of the Ken River (between the downstream end of the Ken Gharial Sanctuary and the Ken-Yamuna confluence). The interviews were semi-structured, and used species' photographs as visual aids. A total of 15 group interviews were conducted across 14 villages (see Table 4). While all respondents recognised muggers from the photographs shown to them, only six recognised gharials, and of these six respondents, only one reported seeing gharials in the last 20 years. Although such interview surveys '*are likely to be subjective, biased and unreplicable*' (Magnusson 1982), our preliminary results suggest that the Ken River does not support resident gharial populations, and that the reported (Lambri Kewat, pers. comm.) and recent (Nair 2012) observations of gharials from the region may likely be monsoonal migrants or dispersing individuals from the National Chambal Sanctuary.

Table 4. Local observations of gharials and muggers in the Ken River

Location	Primary Respondent*/ Age/Gender/ Occupation	Species recognised from photographs	Local observations of gharials and muggers
Bilheri N 24°57'19.90" E 80°08'45.00"	Dhibu Kewat. 41. Male. Boatman.	Gharial: Yes Mugger: Yes	Gharials seen in the distant past. Muggers seen occasionally in monsoonal floods. No incidents of conflict reported with either species.
Sarkar N 24°58'13.90" E 80°10'06.70"	Vijay Kewat. 20. Male. Fisherman/farmer.	Gharial: No Mugger: Yes	Muggers seen occasionally in monsoonal floods. No incidents of conflict reported with muggers.
Sarkar N 24°58'13.90" E 80°10'06.70"	Avadh Bihari Shukhla. 63. Male. Retired Govt. Employee.	Gharial: Yes Mugger: Yes	Not seen either species but believes that both species may be present locally in the monsoonal floods. No incidents of conflict reported with either species.
Kewatra N 24°59'43.80" E 80°12'49.50"	Rajua Kewat. 48. Male. Fisherman.	Gharial: No Mugger: Yes	Muggers seen occasionally in monsoonal floods. No incidents of conflict reported with muggers.
Lasgariya N 25°00'00.80" E 80°13'17.50"	Group interview. All adult males. Fishermen/farmers	Gharial: No Mugger: Yes	Not seen either species. No incidents of conflict reported with either species.
Mahua Kachar N 25°10'33.08" E 80°25'25.99"	Rajua Kewat. 61. Male. Farmer.	Gharial: Yes Mugger: Yes	Reports seeing gharials almost 50 years ago and muggers prior to 2005. No incidents of conflict reported with either species.
Machera Kheda N 25°11‘08.22" E 80°25'10.70"	Babu Kewat. 40. Male. Fisherman.	Gharial: Yes Mugger: Yes	Not seen either species. No incidents of conflict reported with either species.
Hajipur N 25°11'57.40" E 80°24'56.95"	Ramshankar. 32. Male. Fisherman.	Gharial: No Mugger: Yes	Muggers seen occasionally in monsoonal floods. Reports mugger killing cattle (1 calf).
Bari Kheda N 25°13'57.37" E 80°23'43.86"	Phullu Kewat. 60. Male. Farmer.	Gharial: Yes Mugger: Yes	Gharial last seen in 1992. Mugger seen about 3 years ago (~ 2010). No incidents of conflict reported with either species.
YĂ N 25°16'31.03" E 80°21‘04.49"	wA 25. Male. Fisherman.	D Mugger: Yes	a No incidents of conflict reported with either species.
/ N 25°30'19.94" E 80°17'33.64"	ë 30. Male. Farm labour.	D Mugger: Yes	b muggers in the locality from others. No incidents of conflict reported with either species.
a N 25°34'46.88" E 80°16'36.40"	wA 42. Male. Fisherman.	D Mugger: Yes	a floods. No incidents of conflict reported with either species.
Y N 25°40'10.66“ E 80°22'21.64"	wA 38. Male. Sand mining.	D Mugger: Yes	a seen 2-3 years ago (~ 2010). No incidents of conflict reported with either species.
wś N 25°42'39.26" E 80°22'42.23"	[Ă 58. Male. Farming.	D Mugger: Yes	. monsoonal floods. No incidents of conflict reported with either species.
! N 25°44'07.84" E 80°22'49.66"	wA 35. Male. Boatman.	D Mugger: Yes	ws Amlor. More seen in monsoonal floods. No incidents of conflict reported with either species.

* Although the interviews were directed at the primary respondent, each interviewee unit consisted of 3-12 predominantly male respondents.

c) Son River: Based on previous reports of gharial (Sharma et al. 2011, MPFD 2013), we investigated 8 locations (see Figure 3, Table 5) in the SGS from 05 - 11, May 2013. Since daytime temperatures in summer exceed 40°C, crocodilian basking is largely restricted to the morning and evening hours. We, therefore, undertook stationary counts from suitable vantage points on the riverbank, either in the morning (0600 - 1000 hrs) or in the evening (1530 - 1830 hrs) at each of these locations to determine and record the presence, number and size-classes of gharials.

Two observers, equipped with binoculars, scanned the river and both banks. All observations were noted in a standardised format and their locations recorded in a Global Positioning System (GPS) unit. The total numbers of gharials seen during these stationary bank observations, done hourly and sorted by size-class are noted. The maximum number of gharials seen in each size class at each of these hourly counts can be used as the best estimate of the number of animals in that particular size class. Thus, summing the best estimates for each size class would provide a more accurate estimate of the total population.

Size-classes were estimated visually through a 'gestalt combination of size and shape', and categorised into 4 classes - yearlings, juveniles, sub-adults and adults. Since our observations preceded the gharial hatching season, there was no likelihood of encountering hatchlings. So, individuals <90 cm long were considered to be yearlings, those 90180 cm as juveniles, those 180300 cm as sub-adults and those >300 cm as adults. We also recorded the presence of mugger, Indian Skimmer (*Rynchops albicollis)* and freshwater turtles.

Table 5: Details of field observations in the Son Gharial Sanctuary

Date	Location	Observations
05-May-2013 & 10-May-2013	Jogdeh N 24°30'49.7'' E 82°08'33.9''	Relatively well protected (especially north bank), and a large, deep pool bounded by shallow riffles up- and down-stream. 17 gharials (By summing best estimates for each size class. Includes 2 adult males, 4 adults, 1 sub-adult / adult, 9 juveniles and 1 yearling). Known gharial nesting site. 9 muggers (By summing best estimates for each size class. Includes 4 adults, 1 sub-adult, 3 juvenile, 1 yearling). 25 - 35 Narrow-headed soft-shell turtles (*Chitra indica*). 10 - 15 Indian tent turtles (*Pangshura tentoria*); < 5 Indian soft-shell turtles (*Nilssonia gangetica*). 14 Indian skimmers The south bank at Jogdeh was frequently disturbed by livestock. We observed gill-net fishing immediately downstream of the Jogdeh pool. The lower jaw of one of the resident gharial juveniles appeared broken and may have resulted from previous entanglement in a gill-net.
07-May-2013 & 08-May-2013	Kutlideh N 24°33'26.2'' E 82°24'55.3''	Large pool bounded by shallow runs up- and down- stream. Dense aquatic vegetation indicative of eutrophication. 3 gharials (all adults). Potential gharial nesting site. 9 muggers (7 adults, 2 juveniles). 18 - 21 Indian skimmers Moderate levels of human activity observed here. River-crossing zone at the lower end of the Kutlideh pool; fishermen seen approaching the upper section of the pool with gill-nets.

08-May-2013	Kherpur / Bichheri ghat N 24°32'45.80" E 82°22'25.20"	This section was characterised by a shallow run, and did not appear to be suitable gharial habitat. High levels human activity - river-crossing, and livestock herding / wallowing.
08-May-2013	Kheraini ghat N 24°32'4.20" E 82°29'58.00"	This section was characterised by a shallow run, and did not appear to be suitable gharial habitat. We observed 2 mugger burrows nearby, beside a small, isolated pool at N 24°32'20.9" E 82°29'22.3" High levels human activity - river-crossing, and livestock herding / wallowing. 1 tractor sand-mining.
09-May-2013	**Munnadah** **N 24°32'13.9"** **E 82°19'29.6"**	**Large pool bounded by very shallow sections up- and down- stream.** **1 mugger burrow along the southern bank.** **High levels of human activity - river-crossing, firewood collection, livestock herding and miscellaneous domestic activities.**
09-May-2013	Nagdah (Gopad River) N 24°29'00.2" E 82°16'45.2"	This section was characterised by a shallow run, except for a pool at Nagdah. 1 mugger (sub-adult / adult?) Moderate - high levels of human activity - river-crossing, fishing, firewood collection and livestock herding.
11-May-2013	Terideh (near Bhaversen ghat) N 24°16'33.41" E 81°27'9.05"	Large pool (approx. 2 km long) bounded by a rapid upstream and a shallow run downstream of the bridge at Bhaversen ghat. Also site of Son - Banas confluence. Potential gharial nesting site. 4 Indian tent turtles (*Pangshura tentoria*) 2 Indian skimmers. Relatively less disturbed than other sites, but local staff report incidents of dynamite fishing in the past.
11-May-2013	Tariha, Hanumangar N 24°23'56.1" E 81°38'05.8"	This section was characterised by a shallow run, and did not appear to be suitable gharial habitat.

We observed a total of 20 gharials (17 at Jogdeh; 3 at Kutlideh) from the 8 locations we investigated (see Table 5). This included 2 adult males, 7 adults, 1 sub-adult / adult, 9 juveniles and 1 yearling. Local staff reported gharial nesting on the north bank at Jogdah (K.P. Tripathi & Anjaneya Sharma, pers. comm.), and our observations of behaviour indicative of nest attendance and nest guarding suggest the presence of as many as 4 nests (three of them on the same sand-deposit near the Jogdeh watchtower, and one approx. 300 m upstream of this sand-deposit).

Previous records of gharials in the Son River probably date back to the Babur-nama (the 16th century memoirs of Mughal Emperor Babur), which depicts a longirostrine crocodilian, most likely the gharial (Figure 7).

More recently, Whitaker & Mahadev (1976), Rao (1988) and Khan (1993, in Sharma et al. 1999) note the presence of gharials prior to the notification of the SGS in 1981. Andrews (2006) reports observing 3 trial nests and 1 nest in 2006; followed by 2 nests each in 2007 and 2008 (R.K. Sharma pers. comm., in Stevenson & Whitaker 2010). Local field staff have confirmed gharial nesting at Jogdeh every year from 2006 onwards, and 48 hatchlings were observed here in 2012, followed by 79 hatchlings in 2013 (Anjaneya Sharma, pers. comm.). The gharial nesting sites along the north bank at Jogdeh are reportedly maintained by supplementing sand from the south bank and local staff believe that this has aided successful nesting and hatching here since 2006 (ibid).

Figure 7. Babur crossing the River Son. The longirostrine crocodilian at the bottom of the illustration is likely a gharial.Illustration from the Memoirs of Mughal Emperor Babur: the Babur-nama Source: http://en.wikipedia.org/wiki/File:Babur_crossing_the_river_Son.jpg

164 gharials have been released in the SGS between 1981 and 2011 (Sharma et al. 2011) and yet, surveys in 1996, 2003 and 2010 (ibid) present a declining population trend. While we do not attempt to compare the results of our rapid assessment with previous surveys (due to differences in methodology and survey effort), we note that this assessment has detected gharials in only 2 out of 8 locations where gharials have been recorded recently (Sharma et al. 2011, MPFD 2013). While this may well be an artefact of the dry, low-flow season and/or detection biases, we speculate that fluvial action and /or disrupted flows due to the Bansagar Dam have changed the local morphology of sites like Kheraini ghat and Kherpur / Bichheri ghat which are now characterised by shallow runs (we could not locate any pools in the vicinity and adjacent sections) and thus not very optimal gharial habitats.

The Son Gharial Sanctuary represents that second longest riverine sanctuary in the country after the National Chambal Sanctuary, and based on our brief assessment, we believe that it has considerable conservation potential especially for the gharial, mugger, Indian skimmer and a range of fresh-water turtles. Earlier studies (Rao 1988, Sharma et al. 2011) have noted the suitability of the SGS for gharial, and sites like Jogdeh reaffirm that view. However, the rest of SGS does not enjoy the same level of attention and protection as Jogdeh and faces a multitude of threats and disturbances especially from fishing and sand-mining. We suggest the immediate augmentation of staff-strength and capacity to ensure effective patrolling and protection

Sand-mining in the SGS has been a long-standing problem (Vagholikar 2003) and there have been recent demands to de-notify a 31.25 km section of the Son River from the SGS for this purpose. Since sand-mining can severely jeopardise the conservation objectives of the SGS, we strongly recommend that such proposals be rejected. Sand-mining will not only compromise the integrity and lateral connectivity of this river sanctuary, but is capable of altering channel geometry, leading to channel scouring, erosion and head-cutting; undermining bridge piers and other structures; increasing sedimentation and turbidity; and significantly degrading wildlife habitat and threatening aquatic biodiversity (Meador & Layher 1998, Ashraf et al. 2011). Sand-mining also destroys critical nesting habitat for gharials, fresh-water turtles and ground-nesting birds like the Indian skimmer.

Observations of foam near Jogdeh, Munnadah and Kutlideh may be indicative of sewage and/or effluent discharge in the Son River and this needs further investigation. We suggest the establishment and maintenance of ecological-flows from the Bansagar Dam, and that changes and developments in the catchments of the Banas and Gopad rivers which flow into the SGS are monitored.

Acknowledgements

We thank the Madhya Pradesh Forest Department for permissions and support in the field, especially Dr. P.K. Shukla, Principal Chief Conservator of Forest (Wildlife) and Chief Wildlife Warden; Dr. Suhas Kumar, Additional Principal Chief Conservator of Forest (Wildlife); R. Srinivasa Murthy, Field Director - Panna Tiger Reserve; and Mr. K. Raman, the Field Director - Sanjay Tiger Reserve; Mr. Vikram Singh Parihar, Deputy Director, Panna Tiger Reserve; Mr. S. Misra, Sub-Divisional Officer - Madla, Panna Tiger Reserve; Mr. B.R. Gavahde, Superintendent, Ken Gharial Sanctuary; K.P. Tripathi, Sub-Divisional Officer - Son Gharial Sanctuary; Mr. S. Sahu, Ranger - Son Gharial Sanctuary. We also thank R. N. Singh, Santosh Marskole, Ram Singh, Man Singh, Gayadeen Gond, Dinasingh Gond, Lalley, Kallu Gaekwad, Sujan Singh, Prem Lal Yadav, Lakhan Lal Yadav, Susheel Sharma, Balwan Singh, Chatursingh Yadav, Bahadur Singh, Chote Lal Prajapati, Mangal Singh Yadav, Jaipal Singh Yadav, Parvat Singh, Shankar Verma (all Panna Tiger Reserve); Lalu Kewat, Sunwa Kewat, Balli Prajapati, Beta Yadav (all Ken Gharial Sanctuary); Anjaneya Sharma, Lalu Thakur, S. Prajapathi, Tajimul Hussain Ansari, Nizamuddin Ansari, Chandraban Singh, Anjani Sharma, Motilal Yadav, R.N. Bahadur Singh (all Son Gharial Sanctuary); Jaipal Singh, Bhole Singh and Rajesh Patel for assistance in the field. We appreciate Raghu Chundawat & Joanna Van Gruisen's generosity to host us, and help us with logistics and local contacts. This project is supported by the Zoological Society of San Diego, USA.

Literature cited

01. Andrews, H.V. 2006. Status of the Indian gharial, conservation action and assessment of key locations in North India. Unpublished report to Cleveland Metro Park. 8pp.

02. Ashraf, M.A., Maah, M.J., Yusoff, I., Wajid, A. & Mahmood, K. 2011. Sand mining effects, causes and concerns: A case study from Bestari Jaya, Selangor, Peninsular Malaysia. Scientific Research and Essays. 6(6): 1216-1231.

03. Chaudhari, S. 2008. Gharial reproduction and mortality. Iguana. 15(3): 150-153.

04. Choudhary, S. 2011. Seasonal habitat use and resource partitioning between two sympatric crocodilian populations (*Gavialis gangeticus*&*Crocodylus palustris*) in Katerniaghat Wildlife Sanctuary, India. M.Sc. Thesis. 99pp.

05. Chowfin, S. 2013. Trail cameras show promising results in Corbett Tiger Reserve. Crocodile Specialist Group Newsletter. 32(2): 20.

06. Chowfin, S. & Leslie, A. 2013. A preliminary investigation into nesting and nest predation of the critically endangered, gharial (*Gavialis gangeticus*) at Boksar in Corbett Tiger Reserve, Uttarakhand, India. International Journal of Biodiversity and Conservation. 5(2): 54-57.

07. Converse, L. 2009. Katerniaghat Gharial Project 2008-2009. Report of Preliminary Findings. A report to GCA and James Cook University.

08. Hunter, W.W. 1908. Imperial Gazetteer of India. Volume - 23, Singhbhum to Trashi-Chod-Zong. Oxford. 435 pp.

09. Jain, S.K., Agarwal, P.K. & Singh, V.P. 2007. Hydrology and Water Resources of India - Volume 57 of Water Science and Technology Library - Tributaries of Yamuna River. Springer, 350pp.

10. Jayapal, R., Qureshi, Q. & Chellam, R. 2007. Developing a spatial conservation protocol for Central Indian Highlands through a biogeographical analysis of birds and existing Protected Area network: a Geographical Information Systems approach. Research Report No. R.R.07/001, Wildlife Institute of India, Dehradun, 200pp.

11. Johnson, J.A., Parmar, R., Ramesh, K., Sen, S. & Murthy, R.S. 2012. Fish diversity and assemblage structure in Ken River of Panna landscape, central India. Journal of Threatened Taxa. 4(13): 3161-3172.

12. Karanth, K.U., Chundawat, R.S., Nichols, J.D. & Kumar, S.N. 2004. Estimation of tiger densities in the tropical dry forests of Panna, Central India, using photographic capture-recapture sampling. Animal Conservation 7: 285290.

13. Katdare, S., Srivathsa, A., Joshi, A., Panke, P., Pande, R., Khandal, D. & Everard, M. 2011. Gharial (*Gavialis gangeticus*) populations and human influences on habitat on the River Chambal, India. Aquatic Conservation: Marine and Freshwater Ecosystems 21(4): 364-371.

14. Khan, Z. 1993. Son Gharial Sanctuary: Summary Plan & Management. Mimeo. Forest Department, Madhya Pradesh. 16 pp.

15 Lang, J.W. 2010. Adult-young associations of free-living gharials in Chambal River, North India. pp. 142. In: Crocodiles. Proceedings of the 20th Working Meeting of the Crocodile Specialist Group, IUCN, Gland, Switzerland and Cambridge UK.

16. Lang, J.W. & Kumar, P. 2013. Behavioral ecology of gharial on the Chambal River, India. In Crocodiles: Prceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.

17. Lang, J.W. & Whitaker, S. 2010. Application of telemetry techniques in crocodilian research: gharial (*Gavialis gangeticus*) spatial ecology in the Chambal River, India. (IN) Sivakumar K & Habib B (Eds). 2010. Telemetry in Wildlife Science, ENVIS Bulletin: Wildlife and Protected Areas. Vol. 13 No. 1. Wildlife Institute of India, Dehradun. India. 161-170 Pp.

18. Magnusson, W.E. 1982. IUCN-SSC techniques for surveying crocodilians. Crocodiles: Proceedings of the 5th Working Meeting of the Crocodile Specialist Group, pp. 389403. Gainesville, Florida, USA, 1216 August 1980. IUCN, Gland.

19. Meador, M. R. and A. O. Layher. 1998. Instream sand and gravel mining: Environmental issues and regulatory process in the United States. Fisheries 23(11): 6-13.

20. Meher-Homji, V. M. 1990. Vegetation types of India in relation to environmental conditions. In Conservation in developing countries: problems and prospects: 95110. Daniel, J. C. & Serrao, J. S. (Eds). Bombay: Oxford University Press.

21. MPFD. 2013. Madhya Pradesh Forest Department survey of the Son Gharial sanctuary - March, 2013. 1 pp.

22. Nair, T. 2010. Ecological and anthropogenic covariates influencing gharial *Gavialis gangeticus* distribution and habitat use in Chambal River, India. M. Sc. Thesis, National Centre for Biological Sciences, Tata Institute of Fundamental Research.

23. Nair, T, Thorbjarnarson JB, Aust P & Krishnaswamy J. 2012. Rigorous gharial population estimation in the Chambal: implications for conservation and management of a globally threatened crocodilian. Journal of Applied Ecology. 49: 1046-1054. doi: 10.1111/j.1365-2664.2012.02189.x

24. Nair, T. 2012. Gharial hatchlings in the Yamuna. Crocodile Specialist Group Newsletter. 31(4): 17.

25. NWDA. (undated). National Water Development Agency. Accessed from URL:

http://www.nwda.gov.in/index4.asp?ssslid=35&subsubsublinkid=22&langid=1 on 30-April-2013.

26. Rao, R.J. 1988. Gharial rehabilitation in the Son Gharial Sanctuary. Wildlife Institute of India. 14pp.

27. Rao, R.J., Basu, D., Hasan, S.M., Sharma, B.B., Molur, S. & Walker, S. (Eds). 1995. Report of the Population and habitat viability assessment (P.H.V.A.) workshop for Gharial. 99 pp.

28. Sharma, R.K. 2000. Status and distribution of gharials in Madhya Pradesh. Crocodile Specialist Group Newsletter. 19(1): 9.

29. Sharma, R.K, Choudhury PK & Basu D. 1999. Status of gharial in Ken and Son Gharial Sanctuaries, Madhya Pradesh. Indian Crocodilians. ENVIS - Wildlife and Protected Areas. 2(1): 87-90.

30. Sharma, R.K., Singh, H. & Dasgupta, N. 2011. A survey of habitat invetorization and habitat potentiality for sustenance of Gharial in Sone (*Gavialis gangeticus*) Gharial Sanctuary. International Journal of Biodiversity and Conservation. 3(1): 19-23.

31. Singh, V.B. 1978. The status of the gharial (*Gavialis gangeticus*) in UP and its rehabilitation. Journal of the Bombay Natural History Society. 75(3): 668-683.

32. Sinha, R.K. & Sharma, G. 2003. Current status of the Ganges River Dolphin, *Platanista gangetica* in the Rivers Kosi and Son, Bihar, India.

33. Stevenson, C. & Whitaker, R. (010. Indian Gharial *Gavialis gangeticus*. Pp. 139-143 in Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson.

34. Vagholikar, N. (2003). Undermining the Son gharials: a report on the illegal sand mining in the Son Gharial Sanctuary. Association for Species Conservation in India.

35. Whitaker, R. & Daniel, J.C. 1978. The status of Asian crocodilians. Tigerpaper. 5(4): 12-17.

36. Whitaker, R. & Daniel, J.C. 1980. The status of Indian crocodilians. Journal of the Bombay Natural History Society. 75(4): 369.

37. Whitaker, R. & Mahadev, E. 1976. Gharial survey report for the New York Zoological Society. Madras Snake Park Trust. 20pp.

38. Wikipedia. 2013. 'Son River.' Wikipedia, The Free Encyclopedia. Accessed at http://en.wikipedia.org/wiki/Sone_River on 28 May, 2013.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 66 - 73

Monitoring of Gharial (*Gavialis gangeticus)* and its habitat in the National Chambal Sanctuary, India

R.J. Rao, S. Tagor, H. Singh and N. Dasgupta
Conservation Biology Unit, School of Studies in Zoology,Jiwaji University, Gwalior, M.P., India

Abstract

Today, commercial hunting is not the prime factor for the dwindling population of the gharial, but a variety of factors including incidental killing, destruction of habitats by agricultural practices and sand mining, egg collection etc. So, it is necessary to protect such areas where the Gharials nest regularly. From March-April there is a nesting season of the Gharial in the Chambal and it will be very easy to monitor the nesting areas and various threats to the nests of Gharials. A study has been carried out in the National Chambal Sanctuary in a 400 km stretch of the Chambal River borders Rajasthan Madhya Pradesh and Uttar Pradesh. The Chambal River was classified into five habitat types depending on the nature of the bank and the river depth during hot season. The overall topography of the Chambal River indicated that most of the south Chambal River has rocky beds compared to north Chambal River, where extensive sand banks are present. Distribution of gharial is habitat specific. The species prefer sand banks of varied nature like flat peninsulas, mid-river islands for basking and high sand banks for nesting. Information has been collected on gharial population over a period of 25 years. There is a fluctuating population size of gharial in these years. The distribution of gharials showed congregation in particular water depths during various months. During the month of November the River had a very high flow and the lateral connectivity is good. Thus gharials were widely distributed and showed affinity towards the depths of 3-7m and above 9m. Almost 40.6% and 22.2% of the gharials were found in these depth categories. Approximately 85 gharial nests were found during 2012 increasing double the number of 1998. Sighting of hatchlings after around one month of hatching is found to be very rare. When the river is under flood it was not possible to see the hatchlings, which are visible only after the flood recedes in the month of September every year. In the study stretch fishing is a major problem in addition to sand mining at some points and agriculture on the river banks. These human activities have direct and indirect impact on the gharial and its habitat. Due to sand mining activities near gharial nesting sites, the gharials have shifted their nesting activities to other areas. In the National Chambal Sanctuary more than 100 gharials have been found dead during December 2007 February 2008. These causalities occurred downstream between Barhi (Madhya Pradesh/Uttar Pradesh) and Chakranagar (Uttar Pradesh) and the length of the affected river stretch is around 35 km. Water samples from different sites were collected and analysed. It is found that the Chambal River water is pollution free in all sampling sites

Introduction

The Ganges river system in North India includes in its fauna two species of crocodiles - the Indian Gharial *Gavialis gangeticus* and the marsh crocodile *Crocodylus palustris*. The populations of gharial in India were driven to very low levels relative to their earlier abundance. The gharial has been illegally hunted throughout its range for hides, meat and medicine. In addition the loss of habitat from alteration and human settlement, and the use of nylon nets for fishing may have been significant in regulating some local populations (Sitaram and Rao 2012). By the end of 1960's the gharial population was dwindled to less than 150 animals. Information on the status and distribution of Gharial has been reported through many scientific surveys. In the Chambal River Government Organizations have actively participated to develop conservation programmes to protect Gharial from extinction. Under the *Grow and Release Programme* wild gharial eggs are being collected for artificial hatching in different rehabilitation centres. Recovery of gharial population has undoubtedly taken place since protection (Rao, 2008). The gharial rehabilitation programme has been most successful in the Chambal River where approximately 33 per cent of the animals up to age 5 were recorded to have survived within the protected National Chambal Sanctuary. The most significant reason for the higher success rate of the rehabilitation programme for the Chambal river population would; however appear to be the extensive protected river length available to the released gharials. The present study carried out in National Chambal Sanctuary is useful to understand the present status of gharial, major environmental impacts on their habitats, socioeconomic status and biological value of natural resources in the National Chambal Sanctuary.

Methodology

Study Area

The present study has been carried out in National Chambal Sanctuary, Entire area was divided into several zones and stretches for convenience of field surveys (Fig. 1). The studies were conducted while camping at the Crocodile Rearing Centre, Deori, Morena District, Madhya Pradesh and by conducting field studies in the Chambal River.

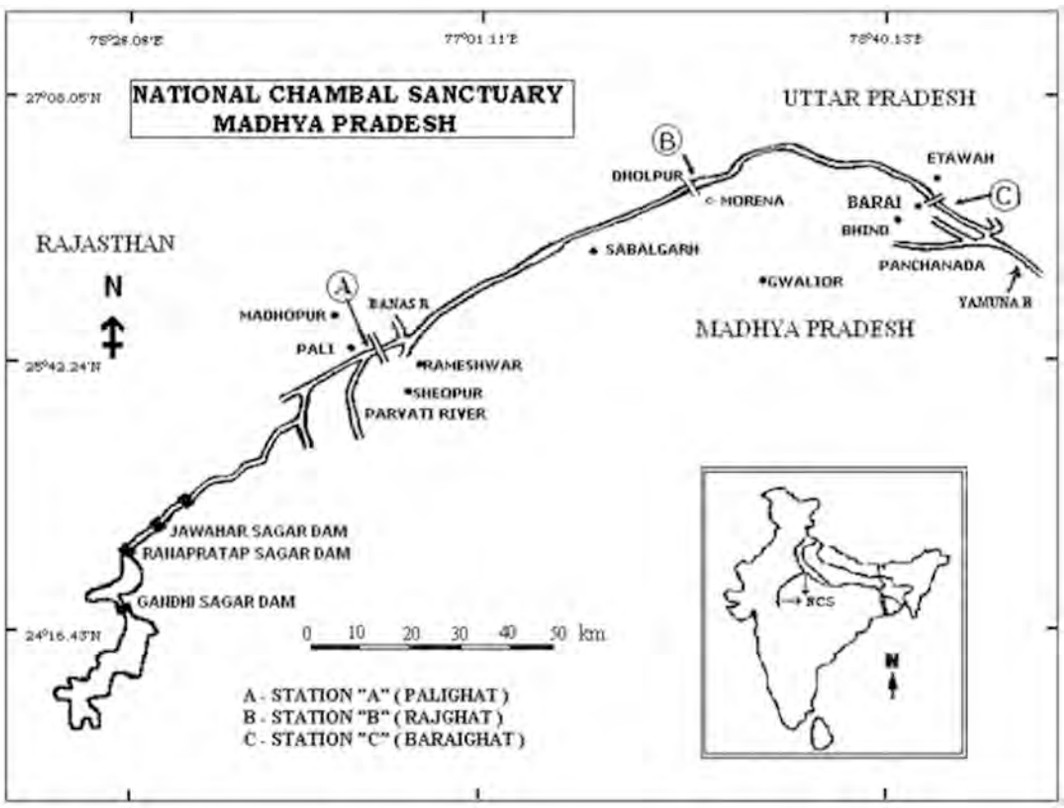


Figure 1. Map of National Chambal Sanctuary

Species location

Data was collected on the occurrence of gharial in the National Chambal Sanctuary. Different maps of the study areas environmental characteristics such as physical, social, ecological, aesthetic etc. were prepared. These maps were overlaid to produce a composite characterisation of the habitat conditions.

Gharial population monitoring

Every year the authorities of the National Chambal Sanctuary, M.P. conduct wildlife census including the gharial nest monitoring in the Sanctuary. The present study was carried along with the census operation of the field staff. Staff and volunteers are supplied with a kit bag containing binoculars, data sheets, field maps of different sections of the river, pen, pencils and writing pads. In addition instruments like thermometer to record ambient and water temperatures, GPS to record the geographical coordinates of habitat features and also to record the location of animals, cameras to take photographs of animals and human activities in the gharial habitats.

We collected information on sightings of crocodiles (both gharial and mugger), turtles (hard shell and soft shell), dolphins, otters and migratory birds with the help of binoculars. We spot gharial, muggers and turtles, mostly as they basked on land or were swimming and dolphins as they surfaced for breathing. Animals seen were recorded along with sighting time, GPS locations and nearest village name etc. on data-map sheets. Surveys were discontinued during overcast and rainy days. At few river sections, in which the survey was interrupted or rendered ineffective due to bad weather or any other reason, were resurveyed and the best count of animals recorded in these sections were used for estimating populations. The survey team also collected additional information on human activities including illegal sand mining, fishing, water extraction and agriculture. All information collected during survey has been recorded on the field map sheets. At the end of the census period reports have been collated for final analysis.

The census continued from 8 am to till 5 pm on all days in the 11 zones of the Chambal River within the National Chambal Sanctuary. During the census gharial and other animals were searched not only on the MP side of the river but also on the opposite side of the river bank on Rajasthan and UP side of the rive bank.

The river stretch, to be surveyed, was delineated on the map for each day. Modern data recorder like GPS was used in the census. The researchers in the teams were well trained on GPS recording at the training period. The longitude and latitude of gharial location, the starting and end point of the surveyed stretch were recorded on GPS. The starting point of each survey stretch was marked and coded using GPS. Subsequently the river stretch was surveyed at a low speed only observing the basking gharial. The end of each survey stretch was again marked and coded using GPS. Information like basking time, ambient and water temperature, river depth, habitat type, presence of other wildlife etc were also recorded on the census card.

Preliminary data entry was done in MS Excel by developing a format following the parameters stated above. Then, normal validation was done using print out data sheets with those of field data sheets. Raw data was downloaded from the GPS receiver to computer using Map Source Software. This raw data was not in a workable format. So the raw data was converted to a workable format like excel format. GPS was used to mark and store coordinates of the locations of gharial and other wildlife from the field.

Gharial population was also monitored every month at different areas identified as best habitats earlier. Gharials of different sizes were recorded with the help of binoculars while walking along the river and also by moving in the boats. The survey was conducted along the river bank approximately 10km distance was covered during the daily survey. The distance of 20 km was covered by vehicle or by foot according to the convenience. We observed main habitat constantly 3-4 hours .GPS location, various other activities on the gharial habitat was noted on the field data sheet. Photographs were taken by using 300 zoom lens cameras where ever possible. Data on threats to gharial and problems to its habitat in the Chambal River was collected. Data on impact of human activities on gharial in the Sanctuary was also collected.

Results and Discussion

Species diversity

The crocodile species present in the National Chambal Sanctuary are the Gharial (*Gavialis gangeticus*), and the Mugger (*Crocodylus palustris*) (Fig. 2).

Figure 2. Sympatric species of gharial and mugger basking on a rocky island

Gharial habitats

The habitat of gharial in the Chambal River is characterized by expanses of open sand which is sparsely covered with a variety of herbs, the most common in the open sand being *Tamarix* dioca (Fig. 3). The overall topography of the Chambal River indicated that most of the south Chambal River has rocky beds compared to north Chambal River, where extensive sand banks are present. Distribution of gharial is habitat specific. The species prefer sand banks of varied nature like flat peninsulas, mid-river islands for basking and high sand banks for nesting. The hydrology of Chambal River indicates that the river is a fast flowing and deep water pools at certain stretches are most suitable for gharial (Table 1). Important sand banks in the study area are mapped in the field maps.

Figure 3. Crocodile habitats in the Chambal River.

Table 1. Maximum and Minimum flows in Chambal River

S.No.	Year Maximum	Date	Level	Discharge (Cusecs)	Year Minimum	Date	Level	Discharge (Cusecs)
1.	1976	10.9.76	140.18	13670.84	1976	2.6.76	118.58	48.98
2.	1977	19.9.77	141.55	45200	1977	10.5.77	118.81	104.04
3.	1978	2.9.78	139.90	25683.53	1978	11.6.78	118.78	84.96
4.	1979	16.7.79	129.18	6160.00	1979	7.6.79	119.55	50.95
5.	1980	7.8.80	135.45	18224.29	1980	5.5.80	119.16	35.35
6.	1981	21.7.81	134.80	19707.00	1981	20.6.81	119.04	30.02
7.	1982	25.8.82	145.37	58552.96	1982	5.3.82	118.96	82.65
8.	1983	22.8.83	130.02	7247.36	1983	4.5.83	119.12	94.38
9.	1984	21.8.84	136.20	20979.00	1984	16.5.84	119.13	72.80
10.	1985	11.8.85	136.15	19950.00	1985	29.4.85	119.09	41.23
11.	1986	29.7.86	141.60	37600.00	1986	31.5.86	119.02	32.43
12.	1987	2.9.87	133.34	16085.34	1987	25.5.87	119.74	68.73
13.	1988	7.8.88	131.75	7717.94	1988	14.6.88	119.52	65.03
14.	1989	29.8.89	127.27	7882.14	1989	17.5.89	119.23	37.70
15.	1990	5.7.90	128.45	9439.82	1990	6.6.90	119.12	57.63
16.	1991	26.8.91	139.66	20079.63	1991	3.6.91	119.41	58.26
17.	1992	19.8.92	131.50	8737.84	1992	4.6.92	120.02	59.56
18.	1993	7.8.93	132.15	9056.73	1993	8.6.93	119.85	20.92
19.	1994	9.9.94	130.08	10320	1994	18.5.94	120.11	63.00
20.	1995	5.9.95	134.22	17205	1995	2.6.95	119.30	32.26
21.	1996	22.8.96	145.54	NA	1996	15.4.96	120.30	94.00
22.	1997	9.8.97	133.66	9785.99	1997	16.5.97	120.30	82.17
23.	1998	16.7.98	129.60	6817.70	1998	15.4.98	120.30	94.00
24.	1999	26.7.99	134.71	16031.04	1999	3.6.99	119.95	57.91
25.	2000	21.7.2000	132.55	12990.77	2000	19.5.2000	119.71	48.74
26.	2001	4.7.2001	135.01	15939.00	2001	16.5.2001	119.50	29.00
27.	2002	11.7.2002	131.22	19313.31	2002	12.5.2002	121.00	32.11
28.	2003	16.7.2003	130.11	17121.11	2003	17.5.2003	118.22	43.11
29.	2004	7.8.2004	132.13	12333.11	2004	13.6.2004	123.11	41.21
30.	2005	9.7.2005	130.15	13221.41	2005	3.06.2005	119.42	45.34
31.	2006	4.09.2006	132.34	14144.61	2006	4.05.2006	135.11	34.41

Source Central Water commission, Dholpur, Rajasthan

Gharial population

Gharial population was monitored during the study period from June 2007 to May 2008 (Table 2). During the 2007 and 2008 annual census of fauna, different sizes of gharial were observed by visual analysis. Sighting of gharial during monsoon season is very difficult. The field conditions are not suitable for movement on the land as well in the high flood waters. The water in Chambal is muddy and sighting of gharial is rare. Due to high floods all basking sites of gharial are submerged and there are no suitable basing sites for gharial. Gharials are sighted rarely floating in the flood water of the river. Sightings of gharial of all sizes during the flood water is not possible due to non availability of basking sites, muddy waters, inaccessibility to river due to bad field conditions and boating is not possible due to high currents.

Table 2. Population estimation of Gharial in NCS between 1978 -2008[+]

S. No.	Year	Gharial Population estimation (as per sightings)
1.	1978	107
2.	1979	*
3.	1980-83	*
4.	1984	451
5.	1985	605
6.	1986	628
7.	1987	-
8.	1988	820
9.	1989	-
10.	1990	982
11.	1991	-
12.	1992	-
13.	1993	898
14.	1994	1108
15.	1995	1214
16.	1996	1242
17.	1997	1289
18.	1998-2002	**
19.	2003	540
20.	2004	552
21.	2005	584
22.	2006	772
23.	2007	865
24.	2008	996

* No data available | ** No surveys | + Certain years data was obtained from Madhya Pradesh Forest Department

Monitoring of gharial population in different stretches is an indication of almost stable population after the monsoon floods in the Chambal River. The situation of gharial was normally same at these localities till next year's floods. The numbers of gharial hatchlings are significantly low in this stretch. As per the nesting data, with an average clutch size of 38 eggs for nest, it is estimated that more than 3000 gharial hatchlings were born during the hatching time ie. June (Fig. 4). However, during the monthly surveys very few hatchlings were sighted. It seems most of the hatchlings were dead during the monsoon floods.

Data on gharial population in different 5 km stretches from Pali to Rajghat during 1988 and 2013 is given in table 2-4. The data shows that the sub adult and female population was increased, but juvenile population was decreased. The young gharials were wondering type and they move downstream until they settle at a suitable place. Population trend of gharial of various sizes during 1998-2008 in the entire sanctuary is shown in table 2. The trend shows that gharial population was increased during 1994 -1997 but the population was again decreased by the year 2003. There were no population estimates during 1998 2002. It is not clear how the population was drastically decreased in the year 2003 to only 540 animals. The large number of gharial during 1995-1997 may be the addition of any released gharial in these years. Due to non availability of data on size classes of gharial in these years, the data could not be analysed systematically.

Figure 4. Gharial nesting, hatching, hatchlings and captive rearing at rehabilitation centre

Impact of Human activities

Threats to the fauna of Chambal River including Gharial recorded during the study period were fishing, cultivation, ferry services and sand mining (Fig. 5). In the study stretch fishing is a major problem in addition to sand mining at some points and agriculture on the river banks. There are more than 150 families of fishermen at Shaympur and Birpur in Sheopur District. The fishermen catch fish illegally and sell them at local as well as fish market at Sabalgadh, Morena District. Although large scale sand mining is not reported this activity of sand mining is also a major problem for habitat destruction. These human activities have direct and indirect impact on the gharial and its habitat. Due to sand mining activities near gharial nesting sites, the gharial have shifted their nesting activities to other areas. Due to this number of gharial nesting sites during 2008 were less than 2007 and new sites were not identified, inspite of vigorous searches to locate new nesting sites. Vegetable cultivation on the gharial nesting sites observed at Bagdia Sand, Baroli and Nadigaon has also shown considerable impact on the nesting of gharial during 2008.

Table 3. Gharial Population from 2009-2013

Year	River stretch	Male with *Ghara*	Adults*	Sub-adults	Juvenile	Yearlings	Hatchlings	Total
2009	Pali to Pachnada	26	281	155	210	126	136	934
2010	Pali to Pachnada	30	297	130	191	113	109	870
2011	Pali to Bharreh	36	349	127	170	125	102	909
2012	Pali to Chakarnagar	32	322	147	275	79	50	905
2013	Pali to Chakarnagar	36	393	153	216	82	68	948

* Female/ Male without *ghara*

Table 4. Distribution and size class of Gharial observed during 2013

Area Covered	Approx. Dist. (kms)	Adults		Sub Adults (2-2.8m)	Juvenile (0.9-2m)	Yearlings (0.62-0.9m)	Hatchlings (0.3-0.6m)	Total of zone
		Male with ghara (>3.5m)	Male/ Female (>2.8m)					
Pali-Rameshwar	22	01	08	03	04	02	01	**19**
Rameshwar-Baroli	36	02	09	02	02	01	-	**16**
Baroli-Atar	51	03	31	10	12	04	05	**65**
Atar-Sarseni	64	04	17	05	01	-	02	**29**
Sarseni-Rajghat	30	02	14	13	10	11	12	**62**
Rajghat-Babusinghgher	36	02	26	09	16	10	05	**68**
Babusinghgher-Usedghat	40	05	58	24	20	14	08	**129**
Usedghat-Ater	40	06	102	29	31	15	11	**194**
Ater-Barhi	41	05	60	32	54	09	10	**170**
Barhi-Chakarnagar	35	06	68	26	66	16	14	**196**
TOTAL	**395**	**36**	**393**	**153**	**216**	**82**	**68**	**948**

Figure 5. Different threats to gharial like fishing, sand mining, cattle washing and water extraction in the Chambal River

Acknowledgements

We are thankful to Madhya Pradesh Forest Department for permission to conduct research activities in the National Chambal Sanctuary. We are also thankful to the Administration of Jiwaji University, Gwalior for necessary support. Different funding agencies like UGC, MOEF and GCA supported the research. We are extremely thankful to the field staff in the Sanctuary particularly Dr. R.K. Sharma and Mr. Sukhdev for local support in the field and also sharing information on gharial population.

Literature cited

01. Rao, R.J. 2008. Reintroduction Programmes of Endangered Species in North Madhya Pradesh. Paper presented in the First Wildlife

02. Reintroduction Conference: Applying science to conservation 15-16 April 2008, Chicago, USA

03. Sitaram T. and R. J. Rao 2012. Biodiversity and anthropogenic threats: Aquatic biodiversity and threats assessment in the Chambal River, Madhya Pradesh, India. Publisher: *LAP LAMBERT Academic Publishing GmbH & Co., Germany pp: 1-122*

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 74 - 77

Status and population trends of gharial in Chambal River, National Chambal Sanctuary

R. K. Sharma[1] and Niladri Dasgupta[2]
National Chambal Sanctuary, Morena, Madhya Pradesh, India |
[2]Conservation Biology Unit, School of Studies in Zoology,
Jiwaji University, Gwalior, Madhya Pradesh, India

Abstract

Gharial, a critically endangered species has its last stronghold in Chambal River, National Chambal Sanctuary. The population trend of this animal has been assessed during the years 2003 to 2013. The surveys had been conducted within Pali to Pachnada. The total population has increased from 514 to 948 individuals with major increment in adult, sub-adult and juvenile populations. The density of the total population from 2003 to 2013 has increased by 84.4%. The density of adults, sub-adults and Juveniles; and yearlings and hatchlings were increased by 186.0%, 39.2% and 51.5%, respectively. Though population of gharial increased from 2003 to 2013, the populations between the years were very fluctuating and have not shown any trend. There will always be need to continuously monitor and control all the illegal activities in the Sanctuary area to safeguard this species.

Introduction

Crocodilians in present world are represented by order Crocodylia, within class Reptilia. The order includes only 23 living species. Gharial (*Gavialis gangeticus*) is the only surviving member of the family Gavialidae (Janke et al., 2005). Specialized habitat requirements and feeding habit make this animal vulnerable to any changes in the environmental conditions. Once widely distributed, gharial is now extinct in its former range of Pakistan, Bhutan, and Myanmar, and most likely in Bangladesh (Aufray, 2010). A few nests were recorded in Nepal. The largest remaining populations found in India at the four locations along the Son River, Katerniaghat, Girwa and Chambal River (Choudhury et al., 2007). The Chambal River, the last stronghold of 429 breeding adult gharials, is also under tremendous anthropogenic pressure (MPFD, 2013).

The Chambal River is one of the last surviving rivers in the greater Ganges River system that has significant conservation value in terms of biodiversity as it harbors the largest population of the Gharial (*Gavialis gangeticus*), in the world. Extensive studies have been done in the past at Chambal River for status, population trends, distribution, habitat, ecology, behavior (Sharma et. al., 2013; Hussain, 2009; Sharma 2006; Sharma and Basu, 2004; Sharma 2000; Hussain, 1999; Rao, 1999; Sharma 1999; Sharma et al., 1995; Rao and Singh, 1993; Sharma, 1993; Hussain, 1991; Rao, 1987; Rao and Sharma, 1986a, b; Rao, 1986; Sharma, 1985; Bustard, 1982; Bustard and Choudhury, 1982) and radio tracking of Gharial (Singh, 1985). As the River is being exploited for its natural resources like water, sand and fish; the gharials, by the mid-1970's was on the verge of extinction due to loss of habitat, mortality in fishing nets (Hussain, 1999; Whitaker, 1987) and poaching (Whitaker and Basu, 1983; Bustard, 1979). These anthropogenic threats have increased and continue to negotiate the survival of the species at present time.

Study Area

The National Chambal Sanctuary (N 25° 24' 33" E 76° 36' 20" to N 26° 33' 57" E 79° 00' 45") was created on the River Chambal during early 1979 primarily for the conservation management of gharial by the states of Madhya Pradesh, Uttar Pradesh and Rajasthan. The Sanctuary includes a stretch from Jawahar Sagar Dam to Kota barrage, then after a free zone of about 18 km, the Sanctuary again begins from Keshoraipatan and extends to Pachhnada where Kuwari Pahuj and Sindh rivers form a confluence with river Yamuna. The length of the Sanctuary from Keshoraipatan to Pachhnada is 572 km that includes about 15 km of Yamuna after Chambal-Yamuna confluence. The width of the river that is included inside the Sanctuary is 1000 m from either bank.

The upper Chambal basin is marked by hilly terrain belonging to the Vindhyan chain; the alluvial plains have developed into extensive ravines, which are often 10-15 km wide from either banks of the river. The area is semi-arid. The temperature in the region varies from 20°C to 48°C during winter and summer respectively. The southwest monsoon is

the major source of rainfall. The mean annual rainfall over the Chambal basin was computed as 797 mm, of which about 93% falls during the four monsoon months (Hussain, 1993).

Methodology

Surveys were conducted in the stretch from Pali (25.85° N, 76. 57° E) to Pachnada (26.44° N, 79.21° E), the confluence with River Yamuna, Kunwari, Pahuj and Sindh; in the month of February during 2003 to 2013. The spatio-temporal distribution of gharials were determined by Visual Encounter Survey (VES) method (Crump and Scott, 1994) to gathered data on direct sightings of the species was used while traversing through boat in the mid-stream of the river. Survey started daily on 09:00 hrs till 17:00 hrs. The survey was conducted using motor boat and with the help of GPS device (GARMIN 12), Binoculars (12X50), Data Sheet, Field Map, Camera and Range Finder (BUSHNEL X900). The survey is generally conducted according to the weather condition prevailing at the designated time. Sunny conditions are preferred more than cloudy or foggy conditions. Thus, survey, sometimes may got postponed according to the weather condition.

The sightings of gharials were noted by two individual observers and were added to get data from either side of the river. The age and sex classes were determined according to Singh and Bustard (1982). Individuals >2.8m were considered as Adults, 2-2.8m as Sub-adults, 90cm-2m as Juveniles, 60-90 cm as Yearlings and 30-60 cm as Hatchlings. Adult males are recognized by the bulging structure (*Ghara*) above their snout.

Results & Discussions

The surveys during 2003 to 2006 were conducted within Pali to Chakarnager (26.55° N, 79.09° E). The total population during 2003 was 514 individuals with 150 adults; 265 sub-adults and Juveniles and 99 yearlings and hatchlings. During 2004 the total population increased slightly with increase in all the size classes. There were 158 adults, 276 sub-adults and Juveniles and 118 yearlings and hatchlings. During 2005 there were 169 adults, 280 sub-adults and Juveniles and 135 yearlings and hatchlings. In the year 2006 major increase in yearlings and hatchlings were observed. The total population was 772 with 178 adults, 272 sub-adults and Juveniles and 322 yearlings and hatchlings. From the year 2007 to 2010 the survey was conducted within Pali to Pachnada. During 2007, significant increase in gharial population, especially in adults, sub-adults and juveniles were observed. Total population was 865 with 208 adults, 445 sub-adults and Juveniles and 212 yearlings and hatchlings. In the year 2008, the adult population increased significantly. There were a total of 996 individuals with 326 adults, 398 sub-adults and Juveniles and 272 yearlings and hatchlings.

Population declined during 2009 with 934 animals. There were 307 adults, 365 sub-adults and Juveniles and 262 yearlings and hatchlings. During 2010, the adult population increased significantly, though total population decreased. The total population was 870 with 327 adults, 321 sub-adults and Juveniles and 222 yearlings and hatchlings. During 2011 the survey was conducted from Pali to Bhareh (26.49° N, 79.25° E). A rapid increase in the total population was observed during this period. The total population was 928 animals with 385 adults, 316 sub-adults and Juveniles and 227 yearlings and hatchlings. During the years 2012 and 2013 the survey was conducted between Pali to Chakarnagar. In the year 2012, the total population was 905 with 354 adults, 422 sub-adults and Juveniles and 129 yearlings and hatchlings. The adult population has declined though increase in the Sub-adults and juveniles provide for addition of more adults in coming years. The scenario observed during 2013 as the adult population increased to 429 animals with an increase in the total population, which was 948. There were 369 sub-adults and Juveniles and 150 yearlings and hatchlings. The population density of individual size classes and total population are presented in Table 1 and figures 1 and 2.

During 2012 and 2013, the survey was restricted to Chakarnagar as no major gharial population is observed in the stretch of Chakarnagar to Pachnada. The density of the total population from 2003 to 2013 has increased by 84.4%. The density of adults, sub-adults and Juveniles; and yearlings and hatchlings were increased by 186.0%, 39.2% and 51.5%, respectively.

Though population of gharial increased from 2003 to 2013, the populations between the years were very fluctuating and have not shown any trend. The fluctuations may be correlated with increasing anthropogenic pressure in terms of fishing, sand mining, agriculture and low water availability. There will always be need to continuously monitor and control all the illegal activities in the Sanctuary area to safeguard this species.

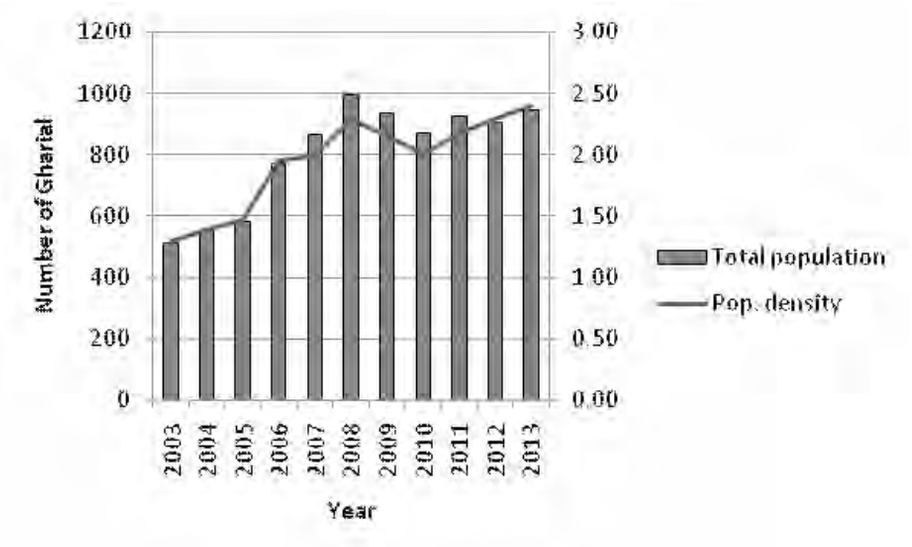


Figure 1.Total population and density of gharial during 2003 - 2013.

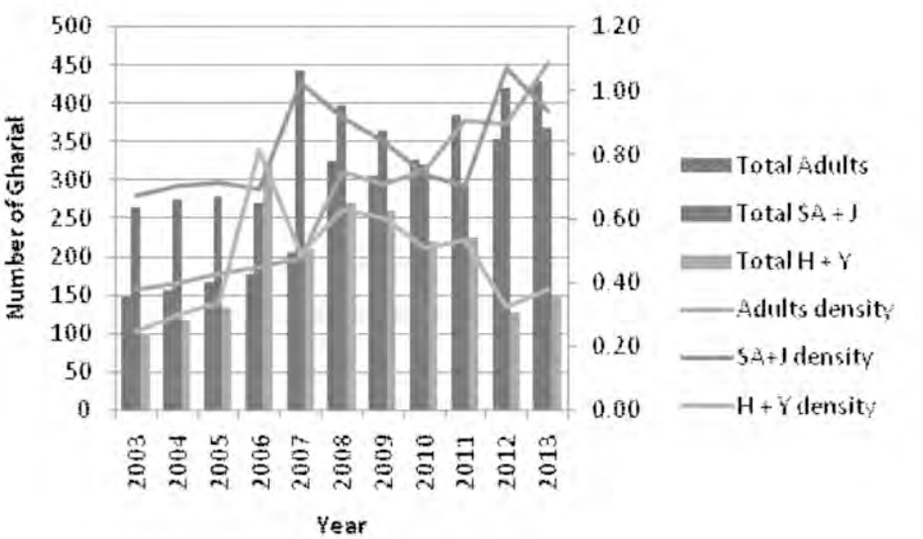


Figure 2.Population and density of individual size classes of gharial during 2003 - 2013.

Table 1. Survey years, area and density of gharial population during 2003 - 2013

Year	Section of river	Length of river	Adults density	Sub-adult+Juvenile density	Yearling+Hatchling density	Total Population density
2003	Pali- Chakarnagar	395	0.38	0.67	0.25	1.30
2004	Pali- Chakarnagar	395	0.40	0.70	0.30	1.40
2005	Pali- Chakarnagar	395	0.43	0.71	0.34	1.48
2006	Pali-Chakarnagar	395	0.45	0.69	0.82	1.95
2007	Pali-Pachnada	435	0.48	1.02	0.49	1.99
2008	Pali-Pachnada	435	0.75	0.91	0.63	2.29
2009	Pali-Pachnada	435	0.71	0.84	0.60	2.15
2010	Pali-Pachnada	435	0.75	0.74	0.51	2.00
2011	Pali-Bharreh	425	0.91	0.70	0.53	2.18
2012	Pali- Chakarnagar	395	0.90	1.07	0.33	2.29
2013	Pali- Chakarnagar	395	1.09	0.93	0.38	2.40

Acknowledgement

We would like to acknowledge PCCF Wildlife, Bhopal; DFO, Morena; Superintendent, NCS, Morena, for providing infrastructure and logistics to carry out the survey works. We would also like to thank the efforts of the field staffs of respective Forest Departments for helping in the field works. It is our pleasure to acknowledge the contribution of NGOs, and Government bodies who participated in the surveys and provided guidance and support.

Literature cited

01. Aufray R. 2010. Gangetic Gharial (Gavialis gangeticus) situation in the world, population and conservation measures in Nepal. Unpublished report.10 pp.

02. Bustard HR & Basu D. 1982.A record of gharial clutch.Journal of the Bombay Natural History Society. 79(1): 207-208.

03. Bustard HR & Choudhury BC. 1982. The distribution of the gharial. Journal of the Bombay Natural History Society. 79(2): 427-429.

04. Bustard HR. 1979.Conservation of the gharial.British Journal of Herpetology. 5: 747-748.

05. Choudhury BC, Singh LAK, Rao RJ, Basu D, Sharma RK, Hussain SA, Andrews HV, Whitaker, N, Whitaker R, Lenin J, Maskey, T, Cadi A, Rashid SMA, Choudhury AA, Dahal B, Win Ko Ko U, Thorbjarnarson J & Ross JP. 2007. Gavialis gangeticus. In: IUCN 2012. IUCN Red List of Threatened Species.Version 2012.2.<www.iucnredlist.org>.

06. Crump, M.L. and N.J. Scott, Jr. 1994. Visual encounter surveys. In: Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, M.S. Foster (Eds.). Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington.

07. Hussain SA. 1991. Ecology of gharial Gavialis gangeticus, Gmelin in National Chambal Sanctuary. Study Report, Wildlife Institute of India, Dehradun. 59pp.

08. Hussain SA. 1999. Reproductive success, hatchling survival and rate of increase of gharial Gavialis gangeticus in National Chambal Sanctuary, India. Biological Conservation. 87: 261-268. doi: 10.1016/S0006-3207(98)00065-2

09 Hussain SA. 2009. Basking site and water depth selection by gharial Gavialis gangeticus Gmelin 1789 (Crocodilia, Reptilia) in National Chambal Sanctuary, India and its implication for river conservation. Aquatic Conservation: Marine and Freshwater Ecosystems. 19(2): 127-133. DOI: 10.1002/aqc.960

10. Hussain, S. A. (1993). Aspects of the ecology of smoothcoated otter (Lutra perspicillata) in National Chambal Sanctuary.PhD thesis, Centre for Wildlife and Ornithology, Aligarh Muslim University, Aligarh.

11. MPFD (Madhya Pradesh Forest Department). 2013. Annual survey report on gharial, mugger and migratory birds in National Chambal Sanctuary, Madhya Pradesh.

12. Rao RJ & Sharma RK.1986a. Annual gharial census in south National Chambal Sanctuary. Provisional report submitted to Madhya Pradesh Forest Department (Wildlife). 11pp.

13. Rao RJ & Sharma RK.1986b. Gharial rehabilitation in Madhya Pradesh, India.Tigerpaper. 13(1): 2-4.

14. Rao RJ & Singh LAK. 1993. Communal nesting by gharial Gavialis gangeticus (Gmelin) (Reptilia, Crocodilia) in National Chambal Sanctuary. Journal of the Bombay Natural History Society. 90(1): 17-22.

15. Rao RJ. 1986. Gharial Conservation in the National Chambal Sanctuary. Hamadryad. 11(3): 16-17.

16. Rao RJ. 1987. India (Gharial in National Chambal Sanctuary). Crocodile Specialist Group Newsletter.6: 5.

17. Rao RJ. 1999. Status and conservation of crocodiles in Madhya Pradesh- An update. Indian Crocodilians.ENVIS - Wildlife and Protected Areas. 2(1): 80-83.

18. Sharma R & Basu D. 2004.Recent reversals in the population trends in the population of Gharial in National Chambal Sanctuary in North India; Implications and a suggested strategy for the conservation of one the world's most endangered crocodilians.Proceedings of the 17th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - the World Conservation Union, Darwin, Australia. p. 180-186.

19. Sharma RK, Mathur R & Sharma S. 1995.Status and distribution of fauna in National Chambal Sanctuary, Madhya Pradesh. Indian Forester 121(10): 912-916.

20. Sharma RK. 1985. Results of 1981 survey for gharial (Gavialis gangeticus) in North National Chambal Sanctuary. Journal of the Bombay Natural History Society. 82(1): 215-218.

21. Sharma RK. 1993. Annual gharial census in National Chambal Sanctuary. Journal of Tropical Forestry. 9(1): 90-93.

22. Sharma RK 1999. Survey of Gharial in National Chambal Sanctuary 1993-97. ENVIS Wildlife and Protected areas Vol. 2(1): 84-86

23. Sharma RK 2000. Status and Distribution of Gharial in Madhya Pradesh. Crocodile Specialist Group Newsletter Vol. 19(1): 9

24. Sharma RK 2006. Status of Mugger (*Crocodylus palustris*) in protected areas of Madhya Pradesh. Herpinstance Vol.4(1): 2-7

25. Sharma RK, Bhadoria SC, Rathore BS and Dasgupta N 2013.Diversity of Aquatic animals in National Chambal Sanctuary Madhya Pradesh. In: B.S. Rathor , Vijay Singh Rathor (Eds.) Management of Natural Resource for Sustainable Development. Daya Publishing House, Astral International Pvt. Ltd., New Delhi. 246-261.

26. Singh LAK & Bustard HR. 1982.The snout of the gharial Gavialis gangeticus (Gmelin).British Journal of Herpetology. 6(7): 253-258.

27. Singh LAK. 1985. Gharial population trend in National Chambal Sanctuary with notes on radio-tracking. Study Report Dec. 1985. Crocodile Research Centre, Wildlife Institute of India, Hyderabad. 178pp.

28. Whitaker R & Basu D. 1983. The gharial (Gavialis gangeticus): A review. Journal of the Bombay Natural History Society. 79(3): 531-548.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 78 - 82

Conserving the Critically Endangered Gharial *Gavialis gangeticus* in Hastinapur Wildlife Sanctuary, Uttar Pradesh: Promoting better coexistence for conservation

[1]Sanjeev Kumar Yadav, [1]*Asghar Nawab and [2]Afifullah Khan
*[1]River Basins & Water Policy, WWF India, New Delhi (India) | [2]Department of Wildlife Sciences, Aligarh Muslim University, Aligarh (India) | *Corresponding author: anawab@wwfindia.net*

Abstract

Gharial *Gavialis gangeticus* is perhaps the largest living crocodilian; is the most unique in its morphology, but sadly over the last decade has become Critically Endangered. Gharial was first recognized as an endangered species in the 1970s. Populations rebounded in the 1980s and 1990s as a result of large-scale captive rearing and head-starting programs in protected areas of India and Nepal. However, in 2008, mass death of 111 Gharial in National Chambal Sanctuary demonstrated the extreme vulnerability of the species to extinction. In order to address the conservation needs of this species, it was necessary to locate viable alternative habitats to supplement the extremely few habitats where the species currently occurs. Between 2009-2012, WWF-India in collaboration with the Uttar Pradesh Forest Department has released 494 Gharial in the River Ganga in Hastinapur Wildlife Sanctuary. Ongoing monthly surveys to document habitat use and dispersal pattern have revealed of almost 40% survival of these animals. Alongside the research, the programme integrates work with local community groups to help understand in building a striking harmonious synergy between cause of conservation and the aspiration of locals. This will help in ending unsustainable dependency on natural freshwater resources ensuring a sense of ownership and desire for stewardship towards biodiversity conservation and river health in particular.

Key words: *Gharial, re-introduction programme, River Ganga, Ecology, Conservation.*

Introduction

The Gharial is a Critically Endangered crocodilian (IUCN 2007) with fewer than 200 breeding adults estimated to survive in the wild, about half of them in one protected area: the National Chambal Sanctuary, in the states Uttar Pradesh, Rajasthan and Madhya Pradesh, India (GCA 2009). Between December 2007 and March 2008, deaths of 111 Gharial were recorded, mostly from a 40-km long segment of the river, extending from Barahi of district Bhind, Madhya Pradesh, to Udi (downstream Sahson) in district Etawah, Uttar Pradesh. Preliminary veterinary findings point out to toxicants as the cause of deaths; however, their nature, composition, source and pathway to the affected Gharial are not clear. However, these incidents demonstrated the extreme vulnerability of the species to extinction and in order to address the conservation needs of the species, it was necessary to locate viable alternative habitats to supplement the extremely few habitats where the species currently occurs. In December 2008 WWF-India in collaboration with the Uttar Pradesh Forest Department conducted exhaustive evaluation of habitat viability for the re-introduction of Gharial in the River Ganga within the Hastinapur Wildlife Sanctuary limits, following the IUCN re-introduction protocols. *Mukhdumpur village* (26°08'84.2"N Lat. and 78°04'70.0"E Long.) was found to be the most suitable site. Between February 2009 - February 2012; 419 Gharial have been released and field monitoring is continuing. Alongside the research, the study integrates work with riparian communities to help understand in building a striking harmonious synergy between cause of conservation and the aspiration of locals. This will help in ending unsustainable dependency on natural freshwater resources ensuring a sense of ownership and desire for stewardship towards species conservation and river health in particular.

Study area

Hastinapur Wildlife Sanctuary (28°46´ and 29°35´N Latitude and 77°43´ and 78°30´E Longitude) was established in 1986 in the Indo-Gangetic plains (Fig. 1). The Sanctuary encompasses an area of 2073 km^2 representing about 0.2% of the total geographical area of the Gangetic grasslands. The area of the Sanctuary mainly falls under five districts of Uttar Pradesh namely Muzzaffarnagar, Bijnor, Meerut, Ghaziabad and Jyotibafuley Nagar (Noida). Altitude of the area ranges between 130 and 150m above sea level. Three distinct seasons are recorded; winter from October to mid March, followed by summer from mid March to mid June and monsoon starts in mid June and continues till September. May and June are the hottest months when the temperature reaches about 45°C; December and January are coldest and the temperature can fall near to 0°C. The annual precipitation is about 1200mm. The vegetation of the Sanctuary can be classified into three

main types - tall wet grasslands in low-lying areas that remain inundated for most parts of the year; the short wet grasslands remain dry from mid winter to the onset of the monsoon, and the dry scrub grasslands on raised grounds amidst the Ganga and on highland, also known as 'Khola' (Nawab 2000). A diverse fauna exists in the Sanctuary which makes this area a biodiversity hotspot in the Gangetic plains.

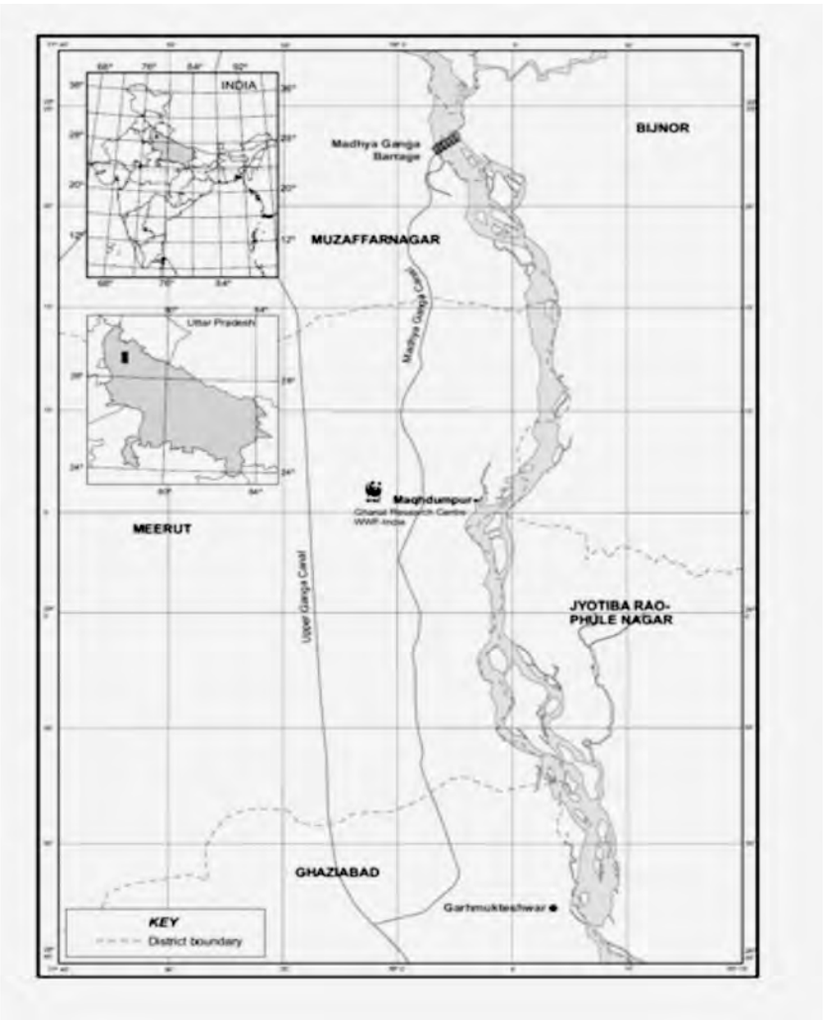


Figure 1. Map of the study area.

Methodology

Pre release survey

Protocols as outlined by Rao (1998) in the Re-introduction Specialist Group of IUCN's Species Survival Commission were followed to assess habitat viability for Gharial re-introduction in Hastinapur Wildlife Sanctuary. Intensive monitoring was conducted between 26 and 28 December 2008 along a 173 km stretch (*i.e.* from Shukhartal to Garhmukteshwar) of River Ganga within the limits of the Sanctuary. The entire stretch was surveyed by boat and distance measurements were guided by a 1:100.000 map (Topo Sheet Survey of India) and GPS. On identification of suitable habitat, data on Physical parameters, Chemical parameters and Disturbance parameters were collected.

Post release survey

Surveys were conducted from upstream to downstream covering approx. 100 km stretch (*i.e.* from Madhya Ganga Barrage to Garhmukteshwar) of River Ganga. Distance measurements were guided by a 1:100.000 map (Topo sheet survey of India) and GPS. For winter survey were conducted from 0900 to 1500 and summer survey were conducted from 0800 to 1200 and 1500 to 1730. *Ad-libitum* records were maintained during monsoon. Gharials were counted from a motor boat driven by a 25 HP Mercury engine. The motor boat moved at 710 kmh^{-1} down mid-river. Usually, two observers were stationed at the front seat of the motor boat, each searching for Gharial on either bank with 8_40mm prismatic binoculars. Ecological parameters and human activities affecting occurrence of Gharial were recorded.

Results and Discussion

Gharial release site selection

The total extent of favorable habitat recorded during the assessment of viable habitat for Gharial re-introduction was 6 km; from *Mukhdumpur village* (26°08'84.2"N and 78°04'70.0"E) till *Jalalpur Zohra village* (29°03'39.9"N and 78°04'25.4"E). A maximum of 3 sandy Islands (sand banks) free from anthropogenic pressure were recorded. Other optimum features included shallow water and deep pools, abundant prey base, moderate water current, large river width and presence of shelter in the form of shoreline vegetation. Water quality recorded was also favorable.

Gharial release, sighting frequency and relative abundance

Till February 2012, a total of 419 captive-reared Gharial have been released (Table 1). This constitutes 300 females which were 1.9 3.8 years, their total length ranged from 96 cm 167 cm and body weight ranged from 2.0 kg 12.0 kg. Males were 119 in number and were 1.9 3.8 years, their total length ranged from 120 cm 180 cm and body weight ranged from 2.0 kg 16.0 kg.

Table 1. Physical condition of captive-reared Gharial released in River Ganga at Hastinapur Wildlife Sanctuary, Uttar Pradesh.

Year	Female				Male			
	Total #	Age (Yr) (Mean±S.E)	Body Wt. (kg) (Mean±S.E)	T.B.L (cm) (Mean±S.E)	Total #	Age (Yr) (Mean±S.E)	Body Wt. (kg) (Mean±S.E)	T.B.L (cm) (Mean±S.E)
2009 N = 131	95	3.49±0.04 (2.8 – 3.8)	7.94±0.10 (6.5 – 12)	139.13±1.23 (120 – 167)	36	3.66±0.06 (2.8 – 3.8)	8.77±0.31 (6.5 – 16)	146.6±2.16 (127 – 180)
2010 N = 63	50	3.8±0.0	3.88±0.11 (2.5 – 5)	122.51±0.78 (96 – 133)	13	3.8±1.91	4.18±0.15 (3.4 – 5)	124.78±1.16 (120 – 131)
2011 N = 150	99	2.82±0.03 (1.9 – 2.9)	2.79±0.08 (2.0 – 7.5)	124.32±0.45 (120 -139)	51	2.70±0.06 (1.9 – 2.9)	2.90±0.15 (2 – 8)	124.67±0.67 (120 – 141)
2012 N = 75	56	3.51±0.06 (2.8 – 3.8)	6.28±0.13 (4.2 – 7.9)	134.55±1.07 (120 – 157)	19	3.54±0.10 (2.8 – 3.8)	6.16±0.18 (4.3 – 7.6)	133.47±1.57 (120 – 144)
419	**300**	**1.9 – 3.8**	**2.0 – 12.0**	**96 – 167**	**119**	**1.9 – 3.8**	**2.0 – 16.0**	**120 - 180**

During the course of the study overall sighting frequency of Gharial recorded was 1764 (range = 305 612). Mean sighting frequency was recorded maximum (152.5 ± 4.5) during 2012 which also relates to high encounter rate (1.5 Gharial sighted/km) (Fig. 2 & Fig. 3).

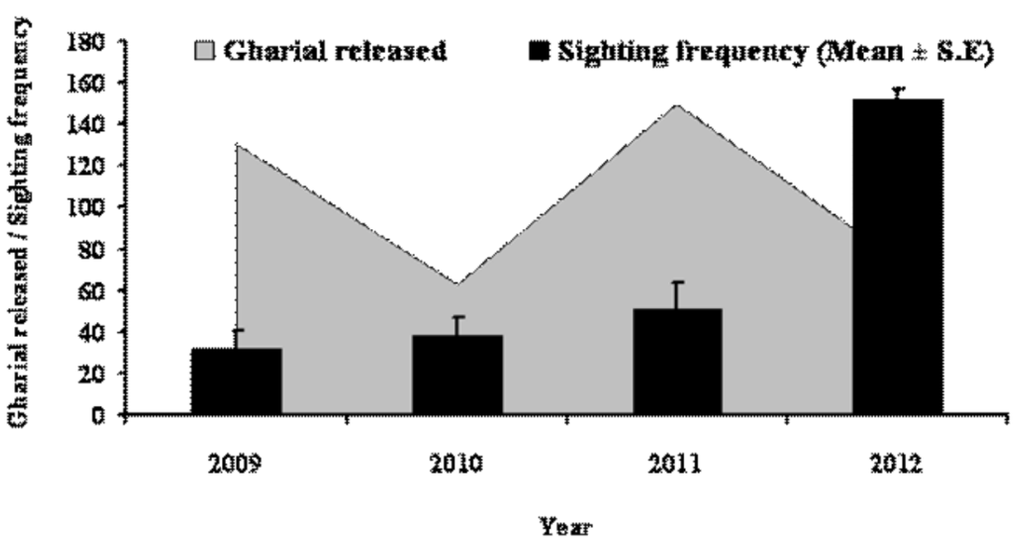


Figure 2. Sighting frequency of Gharial released in River Ganga during the course of the study.

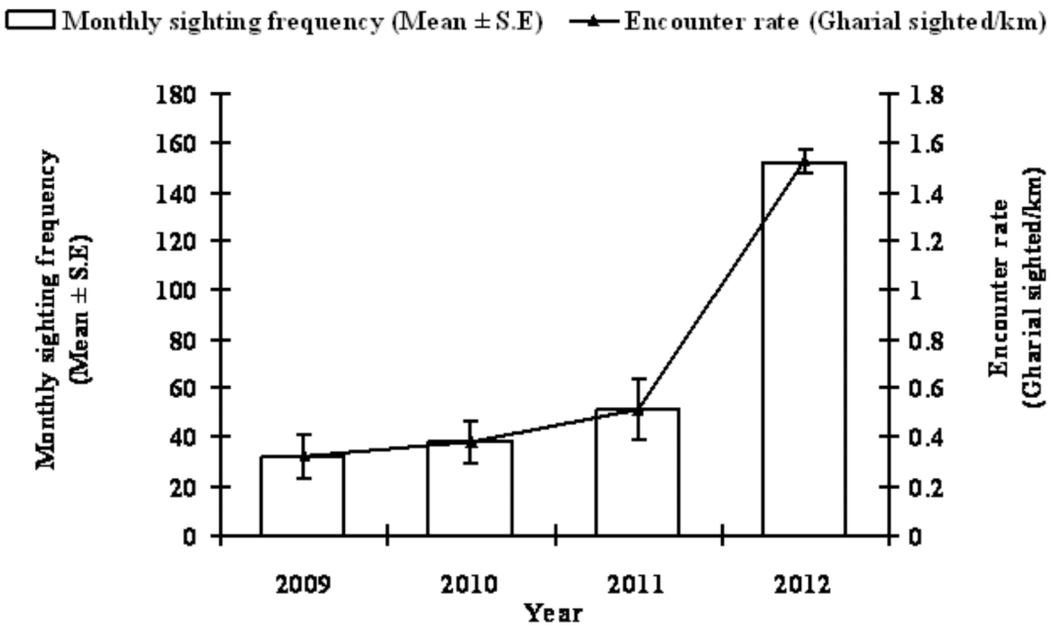


Figure 3. Encounter rate of Gharial (animal/ km) in River Ganga during the course of the study.

Biometrics of released Gharial

Between 17 December 2010 15 January 2011 biometric study was conducted. Physical (medical) examination was conducted and biometric changes of the re-captured animals were recorded. Of the 13 animals captured, 8 belonged to 2009 and 5 belonged to 2010 release respectively. The animals released in 2009 and recaptured in December 2010 showed a significant increase of 17.68kg body weight and an increase of 56cm in Total Body Length over a period of 1 year and 11 months. The animals released in January/February 2010 and recaptured in December 2010 showed increase of 10.40kg body weight and an increase of 40cm over a period of 11 months.

Threats and conservation prospects

In landscapes where natural habitats have been severely degraded through anthropogenic pressures, conservation of biodiversity is a growing issue, and the establishment of protected areas (PAs) often forms the cornerstone of conservation strategies. These PAs offer opportunities to examine the natural distribution pattern of species of conservation significance and their use of resources for planning effective restoration measures (Nawab & Hussain 2012). It is paramount to identify the nature of the threats to the species in question and is crucial in diagnosing the processes threatening the species as accurately and comprehensively as possible to ensure long term survival of the species. As detailed below, fishing, *palage* (riparian seasonal agriculture) and ferrying were recorded as major forms of disturbance to Gharial (Fig. 4) during the course of the study.

Fishing is prohibited within the Sanctuary; though it is rampant in some areas. It is more likely that Gharial can get entangled in fine mesh monofilament nets than traditional large mesh natural fiber nets. Entangled Gharial that do not drown are generally killed or have their rostrums chopped off to disentangle nets and perhaps, in retaliation for damaging nets. Gharial of all sizes are vulnerable to this threat; the impact on populations is particularly severe when mature adults are killed. Indirectly, fishing also affects Gharial by reducing fish stocks and changing prey size and species composition.

Palage or riparian seasonal agriculture

(melons, gourds, mustard and wheat) was recorded as the major form of disturbance to Gharial. This activity encroaches upon the basking and nesting sites and may also disrupt the behaviour of the animal and may even force local populations to desert the area. Disturbance and disruption of basking sites reduces habitat quality for the Gharial and may compromise their thermoregulatory behaviour, further affecting feeding, growth and reproduction. Ferrying may not directly affect the survival of the Gharial though it may indirectly contribute to the problem.

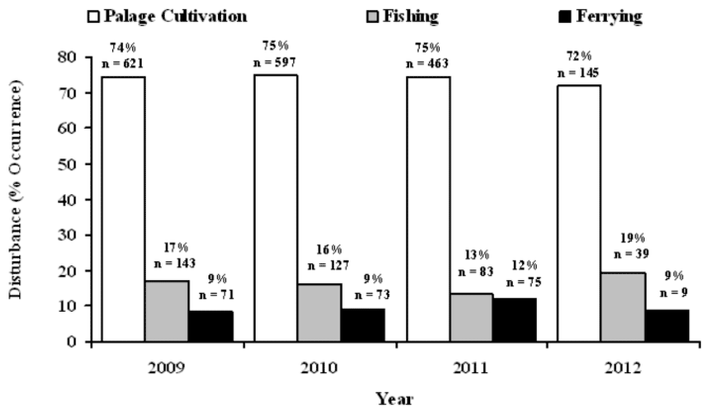


Figure 4. Disturbance activities recorded across different sampling sites in Hastinapur Wildlife Sanctuary, Uttar Pradesh.

The Uttar Pradesh Forest Department (UPFD) in 1991-92 had released a batch of 300 Gharial into River Ganga at Garhmukteshwar. However due to lack of monitoring no further records were maintained. Though the area is known to have been inhabited by wild Gharial until fairly recent times. A female Gharial (3.63 m) is known to have inhabited this area as late as 1994 (*Unpbd.*UPFD Data). Another Gharial was rescued here in 2006-2007 and later released into the Ganges at a spot further upstream. Apart from being a favorable habitat site for Gharial, the area being located in the Hastinapur Wildlife Sanctuary enjoys legal protection. Immediately below the limits of the Wildlife Sanctuary, the Ganges River and its environs downstream to the Ganga Irrigation Barrage to Narora, have been declared as a Ramsar Site with its own conservation implications. The area is currently the focus of a dolphin conservation programme of WWF-India which would concurrently benefit Gharial conservation, monitoring and protection. The findings of this *ongoing* study would help develop a Species Conservation Management Plan for Gharial in Hastinapur Wildlife Sanctuary that would inform the development of a range-wide Species Recovery Plan (SRP) for Gharial by the Ministry of Environment & Forests (MoEF), Government of India. The local communities (like fishermen and farmers) dependent on the river for their livelihoods are the important stakeholders and their participation will play a significant role in the long-term conservation of the species and their habitat. The plight of the Gharial is symbolic of the serious problems facing all river fauna in the subcontinent and unless the continuing deterioration of the region's major rivers is addressed we stand to not only lose these endangered taxa but also the use of these waters for human consumption (GCA 2009).

Acknowledgements

We express our gratitude to the Ministry of Environment & Forests (MoEF), Govt. of India and the Uttar Pradesh Forest Department for granting us permission to conduct this study. We thank Mr. Ravi Singh (Secretary General & CEO-WWF India) and Dr. Sejal Worah (Programme Director-WWF India) for providing infrastructural support for this study. This study was supported by the Living Ganga Programme funded by the HSBC Climate Partnership. Additional funding support was from Thames Rivers Trust, UK. We thank Prof. B. C Choudhury for his suggestions on improving the study. We express our gratitude to the organizers of the World Crocodile Conference 2013, in particular Anslem De Silva, Aasim Mukthar and Mariesz Abdul-Cader for giving us the opportunity to present the research findings and to publish the same. We thank the anonymous referee(s) for reviewing the manuscript.

Literature cited

01. IUCN. 2007. IUCN Red List of Threatened Species. [Online].

02. Available at: http://www.iucn.org/themes/ssc/redlist2007/ docs/05_gharial_en_low.pdf.

03. Gharial Conservation Alliance (GCA). 2009.Gharial Species Recovery Plan (Draft: October 2009). From a Workshop Sponsored and Convened by the Gharial Conservation Alliance, Delhi, 22-24 June 2009.

04. Nawab, A. 2000.Plant species composition and structure of Hastinapur Wildlife Sanctuary, Uttar Pradesh, India.M.Sc. Dissertation.Aligarh Muslim University, Aligarh., India.

05. Nawab, A and Hussain, S.A. 2012.Factors affecting the occurrence of Smooth-coated Otter *Lutrogale perspicillata* in aquatic systems of the Upper Gangetic Plains, India.*Aquatic Conserv: Mar. freshw. Ecosyst.*Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/aqc. 2253.

06. Rao, R.J. 1998. Gharial *Gavialis gangeticus* re-introduction in India. RE-INTRODUCTION NEWS No. 16 September: 17-18.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 83 - 89

Manobo-Crocodile co-existence in Agusan Marsh, Philippines: A cultural legacy of mutual benefit

Marcos "Makahinlo Gubat" Gonzales, Jr.[1], Rainier I. Manalo[2], Van Leeah B. Alibo[3], Vicente P. Mercado[2], William T. Belo[2] and Daniel C. Barlis[2]

[1]Provincial Tribal Chieftain, Agusan Del Sur, Mindanao, Philippines | [2] Crocodylus Porosus Philippines Inc., Pag-asa Farms, Kapalong, Davao Del Norte | [3] Professor, Caraga State University, Ampayon, Butuan City

Abstract

There is mutual, yet fragile co-existence between the Manobos and the crocodiles in Agusan Marsh. Regarded as river people, the Manobo tribes of Agusan Marsh possess powers based on their cultural beliefs and values that essentially contribute in protecting their inherited lands and waterways. Their indigenous knowledge systems and practices (IKSPs) reveal that their understanding of the wetland ecosystem they belong to is holistic; that their lives' sustenance is a function of their interrelationships and interdependence with the rest of the other components in the marsh. More specifically, their IKSPs unravel their mutual co-existence with even the apex predator in the area, the crocodiles. The longevity of their co-existence that dates back since 14th century displays a relationship that is mutually beneficial to one another. It has only been in the recent years when this relationship has been threatened. Alongside the weakening protection and conservation initiatives towards the crocodiles in the marsh is the slowly eroding Agusanon Manobo culture. Reconsidering these IKSPs that are in danger of adulteration, its documentation is but imperative. Anchored to this premise, this paper presents an account of Manobo-crocodilian relations in the marsh by way of their mythical beliefs, religious rituals, cultural practices and anecdotal accounts. Focus Group Discussions and Key Informant Interviews with the chieftains of the different provinces and municipalities within and surrounding the marsh was conducted. The results from these meetings and discussions were then verified to existing literatures as well as to local historians.

Introduction

The Agusan Marsh is the home of the Agusanon Manobo that adapt to the harsh living conditions in the flood plains along Agusan Rivers that annually becomes a vast inland lake. The Agusan Marsh is an extensive flood plain of about 60 lakes and ponds that lies at the confluence of several Agusan River tributaries, a catch basin located in eastern Mindanao, Philippines (Davies 1993). This belongs to the Agusan River Basin (ARB), third largest river basin of the Philippines (river length of 350 kms. and total drainage area of 10,921 square kilometers). It was declared Protected Area by virtue of Presidential Proclamation No. 913 in 1996 under the National Integrated Protected Areas System (NIPAS) and being conferred as a RAMSAR Site in 1999 as Wetlands of International Importance.

Manobo basically means "people" or "person" a localized form of Spanish word Manuvu. The term may have originated from "Mansuba," a combination of man (people) and suba (river) meaning river people. They are among the first inhabitant of the Island of Mindanao, Philippines. According to De Jong (2010), the first Manobo settlers lived in northern Mindanao, at present Manobo tribes can be found at the hillsides and river valleys of the northeastern part of Cotabato. The Manobo appears to be a remnant of the first Austronesian invasion from Taiwan, pre-dating people like the Ifugao of Luzon while ancestors of the New Zealand Maori were a Polynesian people originating from Southeast Asia (Serrano 2008). The Agusan Manobo is one of 8 tribal groups that comprise a cluster of tribes known generally as Manobo (MCN 2012).

According to an oral tradition, the Manobos in general were lead by two brothers: Mumalu and Tabunaway, who lived by the Banobo creek, which flowed into the Mindanao River near the present site of Cotabato City. In the 14th century Sharif Kabungsuan, a muslim missionary, arrived from Johore, to convert the people of Mindanao. Tabunaway did not want to convert to Islam but told his younger brother not to reject the Muslim Faith. Tabunaway and his followers moved up the Pulangi River to the interior of Cotabato. They decided to part ways and from then on established their own tribes. These groups retained their indigenous beliefs, practices and the name of their original site, Banobo, which eventually became Manobo; the descendants of Mamalu became the Maguindanao.

Despite the fact that the various Manobo communities have been separated, there is one common thread that binds them together. The culture of each tribal group believes in one Great Spirit, usually viewed as the creator figure, or the Magbabaja. The Manobos also believe that there are many unseen spirits who can intrude in the lives of humans to accomplish their desires. These spirits are both good and evil in nature and can raise anger and pleasure. The

Manobo's reverence to these spirits dwelling in nature is the very driver of its respect towards it.

Most importantly, long before the Agusan Marsh was first recorded by Spanish Augustinian Recollects in 1622 as well as French and German anthropologists in 1880-1881 (Hontiveros 2008), the Manobo have already shared a place to live with the crocodiles. Crocodiles play an essential role in their mythic beliefs, culture and rituals. It is also a symbol of power, courage, strength and indigenous beliefs which enabled the modern day inhabitants of the marsh to live in peace and respect with the crocodiles.

Operational definition of terms

The Agusanon Manobo tribe embodies different aspects of cultural expressions such as its mythical beliefs, religious rituals, cultural practices and anecdotal accounts.

Mythical beliefs The word myth is derived from the Greek word *muthos* which is *mythus* in modern Latin (http://oxforddictionaries.com/definition/english/myth). Myths are traditional stories, especially one concerning the early history of a people or explaining a natural or social phenomenon, and typically involving supernatural beings or events. Although generally considered as false beliefs by the greater public, the Manobos adhere to its firm hold of it being true.

Religious rituals Ritual comes from the Latin word *ritualis* which means a religious or solemn ceremony consisting of a series of actions performed according to a prescribed order http://oxforddictionaries.com/definition/english/ritual. Rituals are oftentimes confused with ceremonies. The word "ceremony" comes from *caeremonia* which means "sacredness". Unlike ritual, ceremony includes the sacred -- it's a total experience, involving our bodies, minds, emotions, and our spirits. Intention is also very important in ceremony, just as it is in business. When intention is lostwhich can sometimes happen the ceremony can feel empty and becomes a “meaningless ritual”, (Neale, 2011).

Cultural practices Practices refer to sets of activities performed often, customarily or habitually (http://www.merriam-webster.com/dictionary/practice). These practices are most often unique to every indigenous peoples group which identifies them from the rest.

Anecdotal accounts The word anecdote is derived from the Greek *anekdota* which means short narratives of an interesting, amusing or biographical incident http://www.merriam-webster.com/dictionary/anecdote.

Materials and methods

This study employed Focus Group Discussions and Key Informant Interviews. A semi-structured survey questionnaire was prepared. Data derived from observations, testimonies, personal accounts, were juxtaposed to that of existing written literatures and expert judgment (local historians) for the examination of information gaps. All the chieftains with jurisdiction in the marsh were the respondents.

Conceptual framework of the study

Figure 1 represents the conceptual framework of the study. It basically resembles a two-set Venn diagram; two circles overlapping each other with a well-defined area of union and intersection. The overlapping area is the area where the Manobos and the crocodiles, though as separate entities of the marshland ecosystem, share a common space of existence. This union or co-existence of two top predators is made possible by its mutually benefiting relationships. The Agusanon Manobo's mythical beliefs, religious rituals and ceremonies, cultural practices and anecdotal accounts are the tribe's expression of its mutually benefiting relationship with the crocodiles. The harmonious co-existence of both is predicted to be in peril if this space of union gets narrower and narrower; through the erosion of this indigenous culture.

Results and Discussions

Mythical Beliefs The beliefs of the Agusanon Manobos involve the mythical world through their belief in guardian spirits that they too, worship and revere. This act of worship to the spirits puts their mythical beliefs in one of the many facets of their indigenous religion. Religious beliefs of the Agusan Manobo are related to Maguindanaon Manobo where there are many unseen spirits who interfere in the lives of humans. They believe that these spirits can intrude on human activities to

accomplish their desires. The spirits are also believed to have human characteristics. They are both good and evil in nature and can be evoked to both anger and pleasure. The Manobos' beliefs and values are inherent to their strong regard for land as the source of life. They believed in the presence of spiritual unseen beings residing in their forests, rivers and animals.

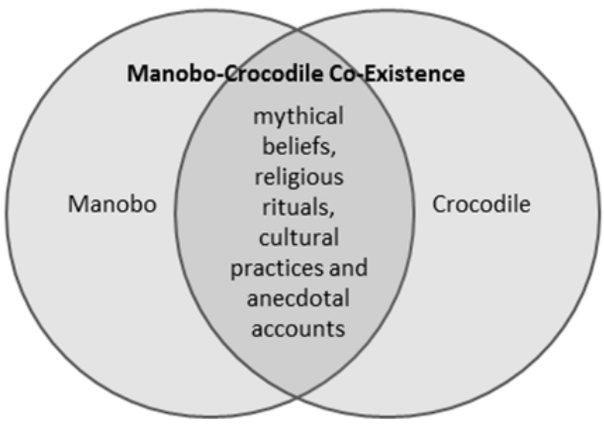


Figure 1. **Conceptual framework of the study**

The wise utilization and proper care of their resources reflects their unwavering respect to the nature's spirit, since these spirits are the guardians of these resources. An example of the exhibition of these practices is when they gather wood and their interactions with wildlife (e.g. hunting). More specifically, the Manobos do not cut hard wood, this is because they believe that the cutting of hardwood would bring about a calamity that shall devastate their homeland.

Furthermore, the Agusan Marsh Manobo, consider their people as born with a crocodile twin spirit. A person's twin spirit is literally considered a relative which also serves as a guardian to its human twin. This mythical belief is common to both the Agusanon and the Maguindanaon Manobo of the Ligawasan Marsh in Cotabato which is implicative that the Manobo Indigenous communities are intimately related to crocodiles having started a relationship with crocodiles upon birth. There have been existing literatures that narrate mythical and legendary accounts of past chieftains having connections with crocodiles upon birth:

> *"After the datu (male royal or chieftains) was born a small crocodile emerged from the mother's womb to the surprises of the couple. Believing that the creature was their son's twin, they kept it in a separate cradle besides that of the infant datu. As the datu grew so did the crocodile. The couple showered it with the same care as they did with their son. When the datu was an adolescent, the crocodile was so enormous it could no longer fit in a cage in the house. After much thought, the couple decided to free the crocodile in the river. But before that, they placed a yellow band in its neck so that they could distinguish it from other crocodiles. Many years passed. The datu now a fully-grown man developed into an incorrigible gambler. Slowly yet steadily, he squandered away his family's wealth to support his vice. His parents were worried that if he continued with his gambling activities, in time the family's wealth will be lost. While the datu was away on one of his gambling sorties, they devised a plan to save what was left of their precious gold. The next morning they ordered their servants to bring the gold to the riverbank. The couple stood at the bank and called their crocodile-child. A few minutes later, the crocodile emerged. They set all the gold onto the crocodile's back and instructed it to keep the property safe."(Mangansakan II 2008).*

Other accounts are reflected on the immoral acts and how these acts are to be dealt with by the spirits. Spirits, believed by the Manobos to be part of nature, are the ones who punish those who do immoral acts. An example of this is that a person who committed an immoral act will be punished through a lightning struck and then will be transformed into a crocodile:

> *"A male warrior named Dagye-an and his old wife Dehunajen, committed incest relationships. After committing such acts, they were struck by the anit (a supernatural lightning that was concerned with such acts) after being struck by the anit, the couple became crocodiles."*

Another version of the story above is shown below, in this story, there is a place where Dagye-an fought crocodiles after he, himself was turned into a crocodile by the strike of a lightning.

> *"There is a place called Tikgon, where actual crocodiles reside further downstream from the Sabang Kawayanan, a juncture where bamboos grow. Here Dagye-an fought a crocodile and during their fight, as the crocodile fighters splashed their tails to the river, it created the many rivers and creeks in the Middle Agusan Valley. Dagye-an was proven to be stronger than the other crocodiles who reside in Tikgon."*

Mangansakan II (2008) also cited that anthropologists Margarita Cojuangco wrote that the origin of this belief "involves two brothers and two versions". One, the datu who stole his brother's wife; the other, of the intense rivalry and drowning of a brother with his family and entourage at sea in vengeance for ill-treatment. Eventually, the adversaries all became crocodiles."

Based in the FGD conducted, the Agusanon Manobo datus expressed their belief that their forefathers and ancestors have passed on to them the belief that the crocodiles belong not to them, but to the environment. This drives them as a people respectful and considerate to the crocodiles in the wild. As recipients of the environmental services provided by the crocodiles in the wetland ecosystem, their actions toward this animal should be in harmony with its existence.

Furthermore, the Agusanon Manobos are familiar with the behavior of the crocodiles. As a community, they believe that the disturbance of the crocodiles' natural habitat through clearance of marsh vegetation, electro-fishing and any other harmful activities are detrimental to the life stages and processes of these animals. If these activities are not stopped, the co-existence of the Manobos and the crocodiles are believed to be in danger. This is because crocodiles can become aggressive when provoked, which to some extent will result to crocodiles attacking humans. There are also instances that fishing gears set-up within a known crocodile habitat is torn by crocodiles themselves.

The Agusanon Manobos further believe that the crocodiles are able to recognize a person's pure intention. When the person is identified by the crocodile to have good intentions, they voluntarily reveal themselves, allowing for them to be seen by the person, independent to either dry or rainy season. These crocodiles surface during any season depending on the intentions of those it encounters. Moreover, the Agusan Manobos articulated that once a person is granted by a crocodile to catch a sight of them, the person must only look at it, so that no harm will be done to them by the crocodile.

Some chieftains recall that in the past, ancestor fishermen tap the side of their canoes using their paddle to produce a distinct sound to convey to the crocodiles their presence and their intention to safely navigate the rivers. This activity signals the crocodiles to move away for their boats to cross safely. The respondents added that when they are aboard their canoes and they see a crocodile from a distance, they just make this sound and the crocodile sinks or leads to the opposite direction. According to them, this belief is an expression of giving respect to the crocodiles as vital members of the wetland ecosystem.

Religious rituals

Manobo religious rituals are specifically called *panawagtawag* which is a general form of ritual intended to call the spirits. This is performed by a *baylan* for a specific purpose, such as crocodile hunting, healing of the sick, and thanks giving for an abundant harvest among others. Here, the *Baylan* (the priest) calls for the *Magbabaja*, the GOD the father, creator of heaven and earth and other *Tawagon*, the spirit in-charge in a certain area. Below is the list of some identified Manobo deities. Agusanon Manobos manifest religion in their own way such as attending rituals as a form of worship to the unseen spirits that protects nature. It is believed that *Tagbanua* (spirits) are present in the area to safeguard the crocodiles. A *Baylan*(priest) offers prayer to the spirit sentinel of crocodiles, for them not to harm their community and recognized the humans. Only the *Baylan* are allowed to mention the names of unseen spirits living in the marsh. The *Tagbanua* is the general term for the overall caretaker of a certain sector or place such as:

Yumud/Lumud/Alimugkat - These are spirits taking care of those living in the water.

Sugujon - This spirit is in command order for hunting, capture and/or removal of an animal from their area.

Taegbusow - This spirit is associated with the color red (blood) and death. It usually pertains to a witch which feed on blood (human blood). According to Garvan (1931) and Montillo-Burton (1985), the Tagbusau

(Taegbusow)- are the diwata of bloodshed and revenge and, in the past, used to incite the bagani to wage war in order to appease their craving for human blood.

Inajow - The Inadyaw/Inaiyu is an example of a nonchanting celestial diwata who dwells on a lakeshore in heaven. He is the god of thunderbolt and lightning; and of wind, rain, and storm. He punishes breakers of taboos with the anit, i.e., a curse which causes physical deformities or skin diseases.

Umli - This is a collective term for beneficent deities of which little is known because they hold themselves aloof from the human race.

During rituals, there are things that must be prepared for offering. It is believed that by doing more and giving more items during the offering, more will be provided in return. Some of the items brought during offerings including the blades, weapon or swords of the male royal (Datu) or chieftains and are placed in the *Angkawan* (altar) to show respect.

Some of the items being offered and their purpose of offering during the conduct of *Panawagtawag* are presented in the table below:

Table 1. List of items used during the conduct of the *Panawagtawag*

Materials	Purpose
Live pig (40kgs. up)	Offered food for the spirits, a large animal sacrifice is offered to the spirits in exchange for big favors (e.g. hunting a crocodile).
Mallorca (wine)	The scent of a Mallorca provides a heavenly sensation for the spirits.
Biscuits	Staple partner for wine.
Apog	Staple partner for wine.
Egg	Staple partner for wine.
Candies	Sweet food offering.
Buyo/Mam-on (betel nut)	It is used for chewing during the *panawagtawag*.
Rice	Essential food offering that will be cooked afterwards.
Coins	The coins symbolize material wealth offering.
Plate	Contains the dry food offerings.
Spear (*Bangkaw*)	It is used to slaughter the offered pig.
Binuka	container of blood in which to be smelled by the Taegbusow.
Altar (Angkawan)	Serves as special and sacred platform wherein the materials and items for ritual are placed.
Mayonhow	

The first part of the ritual starts with stating the purpose and paying respect for the spirits. Here, the *Hakyad* is performed wherein live pig and other material items are offered to the unseen spirits. The liver, meat, fats and skin (formed from an image of *Binuaja* or crocodile) are grilled and served to the *Tagbanua* together with other cooked and prepared food. After which, it is considered that the unseen spirits are finished eating, offertory foods are then distributed to those who are present in the ritual. It is customary to Manobos to share to the participating visitors (dayos) these goods. It comes with a warning that the spirits will definitely know whether a person's intentions are yielding to their beliefs or not.

A ritual for thanksgiving is normally offered whenever a Manobo fisherman catches more fish in a crocodile inhabited area.

It is noted that religious rituals are performed once in a while for a specific purpose. Some are performed to call the *Tagbanua* to request permission for activities proposed to be performed in the marsh. In cases of crocodile related activities, the *yumud* or *alimugkat,*is considered as the rightful caretaker or the spirit-owner of the crocodiles. This provides a peaceful conduct of activities prior to entering the marsh.

> *"Before the capture of the largest crocodile in the marsh named lolong, a ritual was performed to call Sugujon, spirit in-charge of hunting to request the capture of an alleged nuisance crocodile in exchange to live animal offering. However, it is believed that Sugujon asks for a human life as an offer instead". Datu Cabanbanan*

This was believed to be true when a lead crocodile trapper, Mr. Ernesto *"Lolong"* Goloran Coñate, Sr, who have an Agusanon Manobo ancestry died of cardiac arrest a week before the of capture. Thus, in honor of Mr. Coñate's courage, strength and to the lives of Manobo community in the marsh, the captured crocodile was named after him. This is the etymology of the now 2012 Guinness record holder (world's largest crocodile in captivity) "*lolong*" stationed in Bunawan Nature Park, Agusan del Sur.

Cultural practices

The way of life among Agusanon Manobos is sharing the same place with the crocodiles; thus living together in one ecosystem. Low impact activity and respect to environment characterize their cultural practices as an indigenous group. Respect to life is one very clear attribute of the Agusanon Manobo cultural practices. The Spanish people that came to the Island of Mindanao have referred indigenous people of Agusan as self-righteous. They observed Agusanon natives live side by side with crocodiles and still swim in the waters inhabited by crocodiles. The response lies in the perception of the indigenous people about their knowledge on the behavior of crocodiles as well as their understanding of feeding habit and aggressiveness when aggravated. Offerings of pig during village rituals also provide food for the crocodiles and they believed that all things happened for a reason. The Manobo Tribal leader of the Lake Panlabuhan floating community revealed stories from his grandfather that in order to live and survive in their settlement, one must have an amulet (like crocodile tooth) for safety and protection.

The Manobos in the marsh are primarily fishermen. Their lives have been attached to this livelihood in a way that they have been identified with it; without fishing, there would be no Agusanon Manobos. Their fishing practices reveal that they associate the abundance of fish catch to the presence of crocodiles. According to them, crocodiles are indicators of a healthy fish population. The presence of crocodiles in the marsh means that there are still secluded and relatively undisturbed portions of the marsh where crocodiles find its refuge and establish territory. It is in these serene areas in the marsh where crocodiles breed and nurse its young. These kinds of areas are also believed by the Manobos to be breeding and spawning grounds for fishes. It has surfaced during the interviews that they perceive these areas as fish sanctuaries; an assurance of healthy fish stocks to sustain their fishing practices.

To elaborate their fishing practices further, the Manobos do fishing in a conservative and a traditional way. Largely comprised of fishermen, the floating community of Sitio Panlabuhan uses local materials and only target mature fishes. Their fish traps (bobo) are established in strategic places during the twilight of day. They then rise up early in the morning and sail on in their canoes to check these traps. The large nets are intentional for the purposes of catching only those that are mature enough for harvest. The conduct of direct fishing practices within crocodile habitats are considered as a restricted activity. Due to large area of Agusan Marsh, there are certain areas intended for crocodiles, fish nurseries, and other activities to prevent resource use conflicts. Thus, fishing areas are carefully delineated.

Furthermore, the Manobos insist that crocodile habitats are supposed to be free from disturbances. One of their main objectives is to maintain the presence of crocodiles in their natural habitat through the habitat protection. The removal of vegetation should be avoided if possible if not to be totally avoided. It is their practice to not get close to the crocodile habitat especially during the breeding month of March. It is known that crocodiles are more aggressive during this time and pose a large probability of inflicting harm to humans. Utmost care is exhibited when crossing a crocodile habitat as a sign of respect to the animal in the area. When possible, engine boats are turned off when inside a crocodile area.

In addition, the Manobos perceive that crocodiles help in maintaining the depth of river and creeks that lessens silt accumulation. This is done through the natural movements of the animal.

On the other hand, in a news article of Jeffrey Tupas (2010), he interviewed an Agusanon ethnic Manobo named Rey Calderon about their life with the crocodiles. Calderon states that "*We need to recognize them and respect their presence in the marshland. That is very important. They have to be understood and given their own space. Their territory is their territory*. *What is necessary is that we lessen our encounters with them. They are just there, living with us. They have their sanctuary and so we give them that*. He also told stories of close encounters with the crocodiles and the mysterious forces at play in the marsh.

> *"I was about 6 years old then, fishing with my father at dawn, when I first saw one. The crocodile's mouth was wide open, waiting for the prey, perhaps waiting for any of us. It was scared, but now, I realized that they were playing their role in protecting the marshjust like we do."*

A small floodplain Lake Tagsubon known as the crocodile nesting site in the vicinity of Bunawan has been declared local strict protection zone by Lake Mihaba Fisheries Association (LaMiFA), a grassroots organization, in order to limit disturbance infused by the villagers to the crocodiles.

However, an isolated case of fatal crocodile attack to a twelve-year old girl happened in 2009 at Lake Mihaba. Stories about supernatural reptiles containing spirits of tribal ancestors slightly change from reverence to fear and hysteria even though they once peacefully coexisted with the crocodiles, the top predators in the area. But according to Calderon (Tupas 2010), "*the baylanon told us that the gods were enraged over the desecration of the place. A villager somewhere far from the floating community built a house and used a galvanized iron sheet as roof. The iron sheet disturbs the water with its bizarre reflectionthat enraged the gods. The attack was a warning, a very scary warning. Some things are too difficult to explain to others but that's how things are here. Ultimately, I believe that we are being taught to show respect to people, nature and those we cannot see or explain*." The people only returned to the floating village after holding a religious ritual called *manubad-tubad* to appease the gods.

Respect for crocodiles among the Manobos also manifest in their craftsmanship and artworks. There have been known crocodile inspired designs and symbolism an Agusanon Manobo community. Some are seen inscribed in the *Kampilan* (sword) of the *Bagani* (warrior) while some are incorporated in an architectural design. Signs inscribed in these armaments are known to be symbols of courage, power and high regard for the crocodile reputation.

> *"Being an IP and an observant of the customs, traditions and practices of the Manobo tribe, the frontage design of my house is called Binuaja, a design inspired by the crocodile because long time ago, true crocodiles are considered as life of our forefathers. The existence of crocodiles are the same as the existence of our ancestors, they believe that there are no IP's if there are no crocodiles". Hawudon Mabayow-Manunuyat*

Anecdotal accounts

In the past, there are no reports of human-crocodile conflict. This may be attributed to the low human population density in the marsh, and high crocodile population. Crocodiles are likewise then observed to be scared of humans. Contrary to the present situation, humans are now the ones scared of the crocodiles. These reported human-crocodile conflicts are believed to be a result of the disturbance of known crocodile habitats. On the other hand, scarcities of fishes in the marsh may have prompted the crocodile to find more available food sources, lead to attract on livestock in the community.

> *"There were two people seen with rifle guns riding a raft made of logs, they saw a crocodile afar and wanted to shoot. However, when they are close enough to the crocodile, they got scared and made use of their rifle as a paddle to get away from the animal. This shows that that in the past there are no encounter between crocodiles and man". Datu Makahinlo Gubat*

Another story happened during one flood season in Sitio Panlabuhan, a lake floating community of the Manobo tribe. At that time, a crocodile was seen entangled in one of the fishing nets installed in Lake Bukogon.

"For five hours we thought that the crocodile was dead. I dove into the water and checked the crocodile; we were surprised to see that the crocodile is still alive. Then after about ten minutes, the animal surfaced and we saw that it was almost as big as our motorboat. We are about 30 persons then who witnessed the crocodile floating in the waters. The crocodile swam freely and did not harm us because we do not do anything to harm the animal". Hawudon Kanimbaylan

Furthermore, personal communications of Alcantara (2011) to Tribal Leader Boyet Reyes convey anecdotal evidence about the lone tourists who dropped in unannounced and unaccompanied have experienced unexplained mishaps (near drowning, injury, body pains and other misfortune). A mysterious ailment would seize an unlucky visitor, prompting him to come back and beg for healing with tribal leaders. All they wanted was respect for their forefathers and ancestral domain.

Protection Efforts

After a couple of years since an isolated crocodile fatal attack to humans, the local government of Bunawan town has organized the capture of the alleged problem crocodile in response to the growing anxiety. Since then, reports on the sighting and alleged activities as nuisance crocodiles have spread in the communities of Agusan River Basins. Other inhabitants and local authorities had gained interest to capture crocodiles to address the assumed fear of river communities. As a result, series of Protected Area Management Board (PAMB) meetings are conducted to determine specific actions and concerted efforts to address issue about crocodiles that pose threat in their respective areas. But based on the excerpts on the minutes of PAMB Executive Committee meeting on August 2011, the Agusanon Manobo agreed to take out only one crocodile from their natural habitat. In an event when mistaken individuals had been caught, no replacement will be granted from the residing Agusan Manobo.

Additionally, influx of migrants coming into the marsh, has been alarmingly observed in the recent years. These migrants come from different provinces such as Davao del Norte, Davao del Sur and as far as in the Province of Iloilo, Island of Panay. They come to the marsh in search for better living conditions as compared to the dry lands. Several others have been brought to the marsh by intermarriages with the lumads. These people come from different areas with different microcultures of their own, thereby influencing their perception and eventually their practices. This mixture of different cultures, unless resolved at first hand, poses as in imminent threat the once solid Agusanon Manobo culture. It is alarming in a sense that most of the time, only the elders in the Manobo communities in the marsh remain to be well-versed with their IKSPs. The external influences and the clashes of migrants or *dayo* as that of the lumad culture must have caused some confusions among the younger generation.

Synthesis and Conclusion

The mythical beliefs, religious rituals, cultural practices and anecdotal accounts of the Agusanon Manobos pertaining to crocodiles in Agusan Marsh altogether display their mutually benefiting co-existence. All the four components of their indigenous culture that is focused on in this study stand complementary to each other; and are reflective to crocodile protection and conservation. Their IKSPs reveal that they perceive crocodiles as co-equals. This explains their high regard to these animals. Furthermore, their IKSPs acknowledge the ferocity of crocodiles; as an animal capable of fatal attacks. This understanding, however, has not seen to create a feeling of hatred among the Manobos towards the crocodiles. Rather than taking offenses to defend themselves for possible attacks, the Manobos, fully aware of its wild tendencies and animalistic behavior, instead pay respect to these creatures. Crocodiles are therefore not considered villains in the marsh, which is contrary to popular beliefs. The continued persistence of the Manobos in the marsh will only be assured if the integrity of the wetland is maintained. It is embedded in their culture that crocodiles are indicators of a healthy wetland ecosystem. Compromising their beliefs in the importance of crocodiles in the marsh would only jeopardize their existence as a riverine community. This study furthermore sees the urgency and the need for the older Agusanon Manobo generation to impart all their IKSPs to the younger generation.

This study therefore concludes that the Agusanon Manobo culture is in one with the protection and conservation efforts currently in place. Their culture is an essential management tool to further push local and national initiatives for the said cause. Inasmuch as crocodiles are the target entities for these programs, people and communities of direct contact to these animalswhich are the Agusanon Manobos, are as equally important in designing and implementing protection and conservation approaches.

REFERENCES

01. Davies J. 1993. Agusan Marsh in the Philippines. Asian Wetland News 6 (2): 20-21.
02. De Jong, Ronald. 2010. The Last Tribes of Mindanao, Munting Nayon News Magazine.<www.mnnetherlands.com>. Downloaded: April 15, 2012.
03. *Mangansakan II, Gutierrez. (2008). "Crocodile symbolism in Maguindanaon culture." National Museum Papers 14: 133-139.*
04. Serrano, Ben. 2008. New Zealand envoy backs Agusan Sur Manobo-Maori cultural ties. The Philippine Star.Updated June 10, 2008.<www.philstar.com/Article>. Downloaded: April 11, 2012.

http://oxforddictionaries.com. Accessed November 10, 2012.
http://www.merriam-webster.com. Accessed November 10, 2012.
http://mcni.org/Manobo.html. Accessed February 18, 2012.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 90 - 95

Crocodiles in western of Sarawak, Malaysia

Ruhana Hassan * and Mohd Izwan Zulaini Abdul Gani
AquaticScience Department, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia | *Corresponding author: hruhana@frst.unimas.my

Abstract

Saltwater crocodile *Crocodylus porosus* is the most common crocodile species found in Sarawak. Humans and crocodiles have been living in harmony for centuries, peacefully sharing the same landscape. However, in the past three decades, reports on human-crocodile conflicts are on the rise, bringing the assumption that the crocodile populations are bigger in size now and expanding to all rivers. This study is designed to assess the relative density of crocodile in three different rivers located in the western part of Sarawak namely Batang Samarahan, Sibu Laut River and Bako River, using the standard census survey method. For the year 2011, relative densities of crocodile were 0.53 non-hatchling/km, 1.04 non-hatchling/km, 1.8 non-hatchling/km for Batang Samarahan, Sibu Laut River and Bako River, respectively. There is no previous record on crocodile density for Batang Samarahan. For Sibu Laut River, there is a 40% decrease in density compared to year 2003 survey data. Previous survey data for Bako River are available for year 2003 and 2008. Bako River has experienced fluctuation of crocodile density, as systematic culling had been carried out as a response to fatal crocodile attack which happened in year 2006. Findings reported in this study are limited to small number of surveys conducted within the year 2011, therefore more studies should be carried out in future to get a more comprehensive picture of crocodile populations in these rivers. This paper also examined the socio-economy profile of local people living along the three rivers and reports on their perspectives towards human-crocodile conflicts.

Keywords: saltwater crocodile, density, socio-economic profile, human-crocodile conflict

Introduction

There are two species of crocodiles in Sarawak namely, *Crocodylus porosus,* the saltwater crocodile and *Tomistoma schlegelii,* the Malayan gharial. *C. porosus* is the most common crocodile which could be found in most of the major rivers and swamps in the state, whereas *T. schlegeliiis* less common, inhabiting only swampy area of Batang Lupar, Batang Sadong and freshwater wetland Loagan Bunut (Cox and Gombek, 1985). Coastal communities in Sarawak and crocodiles have been living in harmony for centuries because crocodiles play important roles in their culture. For example, folk stories associated with the legend of ferocious crocodile named "Bujang Senang" who had attacked people but could not be killed and will live forever (Ritchie and Jong, 2002). Besides that, people also believe in the aphrodisiac properties of crocodiles' reproductive organs, and the ability of the crocodile meat and other body parts to cure asthma and other sickness.

In late 80s, *C. porosus* in Sarawak was in the brink of extinction due to extensive hunting by local people. This species was hunt primarily for their skin and meat, while farm owners aim for their eggs and hatchlings to boost their farm production. *C. porosus* currently is listed under Appendix I in the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). On the other hand, it is categorized as Lower Risk / least concerned by the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threaten Species 2012. In Peninsular Malaysia*, C. porosus* is under Wildlife Conservation Act 2010 and listed as protected animals in the Sarawak Wild Life Protection Ordinance, 1998.Hence, any hunting, killing or selling of wild crocodiles in the state are prohibited. However, after a few decades protected by law, the crocodiles population in Sarawak is on the road to recovery. There are many reports regarding cases of crocodile attack on human which had concern communities living along the rivers and they assume that the population of this species is on the rise. Field survey by Sarawak Forestry Corporation (SFC) reported that there have been marked increased in the density of this species in most rivers (Tisen and Ahmad, 2010).With the recent efforts by SFC to down listing this species from CITES Appendix I to Appendix II, substantial data on crocodile's population in Sarawak is needed. Down listing *C. porosus* is important so that this resource can be utilized more openly by local communities, which can also contribute to the state economy. Moreover, lowering the number of crocodiles in the rivers may be one of the most suitable approaches to deal with human-crocodile conflicts happening along the rivers.

This paper describes findings of our survey on density of crocodiles in three different rivers in the western part of Sarawak namely Bako River, Batang Samarahan and Sibu Laut River. In addition, local communities' views related to crocodiles especially on the increasing human- crocodile conflicts in Sarawak are also highlighted in this paper.

Materials and Methods

Census survey of crocodiles had been conducted in three different rivers namely Bako River, Batang Samarahan, and Sibu Laut River in 2012 (Figure 1). Night spotting techniques following Cox and Gombek (1985), Games and Severre (1999) and Sullivan *et al.* (2010) were used during the survey where spotter (on the boat) scans shorelines or middle of the river for eyeshines using spotlight. During the survey, recordings of the location were made for all individual crocodile sighting using GlobalPositioning System (GPS). All crocodiles were categorized according to size class (hatchling, yearling, sub-adult and adult). On occasions when observers were unable to accurately estimate size class, the sighting was recorded as eyes only (EO). The commencement location andend point of a survey were also recorded using GPS as a waypoint for the calculation of linear survey distance. For density and distribution of crocodiles, data was recorded as relative density (non-hatchling/km river) as suggested by Games and Severre (1999).

Socio-economic profile and human-crocodile conflict survey had been carried out using face-to-face interview with the local people living along the rivers. Correspondents were selected randomly and subjected to standard questionnaires. The questionnaires were divided into 5 sections namely personal details, socio-economic profile, dependency on water body, crocodile awareness and human crocodile conflict. Results of the interviews were analysed in qualitative manner as well as summarizing the data in graph forms.

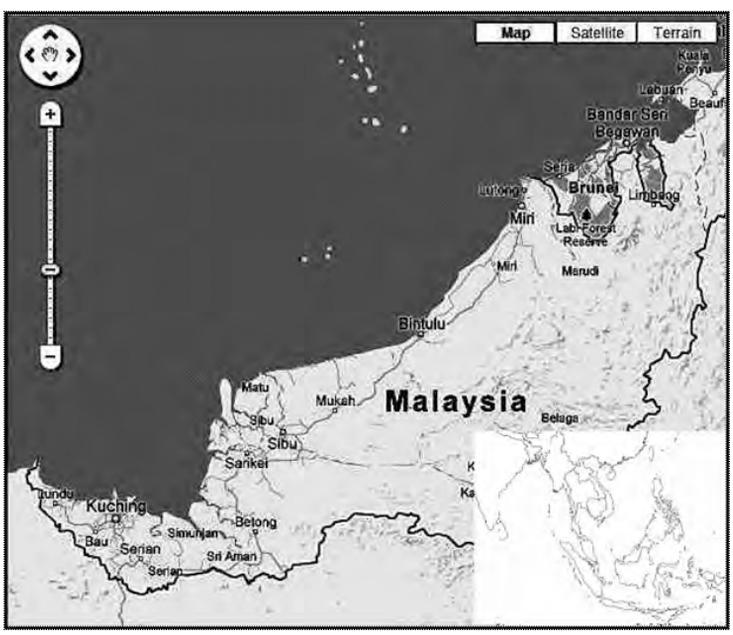


Figure 1. Locations of field samplings. 1- Batang Samarahan (N 01° 30.570', E 110° 29.364'), 2 - Bako River (N 01° 39.514', E 110° 25.946') and 3 - Sibu Laut River (N 01° 41.473', E 110° 12.299')

Results and Discussion

This section will be divided into (i) crocodile density survey and (ii) local people perspectives on crocodiles.

Crocodile Density Survey

During 2011 census survey, Bako River recorded relative density of crocodile of 1.8 non-hatchling/km, Sibu Laut River has 1.04 non-hatchling/km whereas Batang Samarahan recorded 0.53 non-hatchling/km (Table 1). For comparison, Sullivan *et al*. (2010) reported that the density of crocodiles in Queensland, Australia was 0.49 ± 0.72 (non-hatchling/km).

Table 1: **The relative density of non-hatchling *C. porosus* for surveys conducted in Batang Samarahan, Sibu Laut River and Bako River.**

River	Total number of crocodile	Distance (km) of the river surveyed	Mean relative density (non-hatchlings/km)
Batang Samarahan	112	140	0.53
Sibu Laut	15	14.4	1.04
Bako	22	12.2	1.8

Table 2. Comparison of relative density of C. porosus (non-hatchling) for Batang Samarahan, Sibu Laut River and Bako River

River	2003	2008	2011
Batang Samarahan	NA	NA	0.53
Sibu Laut	1.73*	NA	1.04
Bako	2.76*	1.03*	1.8

* Data from surveys by Sarawak Forestry Corporation (Tisen & Ahmad, 2010), NA = not available

During this survey, relative density for *C. porosus* in Sungai Sibu Laut was 1.04 non-hatchling/km (Table 1). This density was decreased almost 40 % compared to the result of survey in the year 2003 (Tisen & Ahmad, 2010) where they reported that the relative density were 1.73 non-hatchling/km (Table 2). There are several reasons that could have caused the decreasing number of crocodiles sighted in the river, such as increasing fishing activities along this river, and expanding human settlement and populations, which contribute to more rubbish and snags into the river. Furthermore, the local authority is carrying out some river bank development including building a more sophisticated jetty and other amenities near the river mouth to support ecotourism activities, for example transporting tourists to Talang-Satang National Park and Kuching Wetland National Park as well as deep sea recreational fishing. These river bank improvements may have destroyed crocodile habitats along this river due to erosion and other changes to the river ecology. There is no report on crocodile attack along Sibu Laut River in 2011, but between late 2012 and early 2013, local people complained about missing pets (cats, dogs) and live stocks, which they feared were being eaten by crocodile. As the complaints intensified, relevant state agencies and local people had joint effort to hunt the crocodile. Finally, on 28th January 2013, one male crocodile of approximately 5 meters long and 650 kg, were captured and re-located to Matang Wild Life Centre, Kuching. This centre has facilities to house many types of wild animals including crocodiles. The animal enclosures here are *ex-situ* conservation, and have been used to raise awareness among the public on issues related to wild animals.

Bako River recorded relative density of 2.76 non-hatchling/km, 1.03 non-hatchling/km, and 1.80 non-hatchling/km in the year 2003, 2008 and 2011, respectively (Table 2). Density of crocodile fluctuation in Bako River is influenced by sequence of events happening in this river, over the nine years period. Many human-crocodile conflicts were reported, one of them involved fatality in 2006, resulting chaos and high sentiments among local people. After a long commotion between local people, non-governmental agency (NGO) pro-animal rights and the state agencies, culling and relocations of crocodiles in this river had been carried out, with the aim to control the population, and the result had been reflected in the year 2008 survey as the density decreased to 1.03 non-hatchling/km. However recent survey in 2011 showed that the density of crocodile is on the rise as data recorded 1.80 non-hatchling/km, and high number of hatchlings and yearlings were recorded (Figure 2), an indication of recovery populations (Sullivan *et al*., 2010). From 2007 to 2012, there was no report on human-crocodile conflict in Bako River although crocodile attacks did happen in nearby rivers. Additionally, SFC staff had been organizing regular meetings with local community and had carried out pilot project on engaging them in ecotourism activity of firefly and crocodile watching along Bako River, with the hope that local people will benefit from the presence of crocodiles in the river rather than solely inculcate negative perception on these animals.

Based on preliminary findings during this study, no adult crocodile was spotted in Bako River and Sibu Laut River. In addition to that, no sub-adult was found in Bako River (Figure 2). Nevertheless, those rivers recorded EO, which most likely were sub-adult and adult crocodiles. Spotting of sub-adult or adults crocodiles is a challenge as they usually swims in the middle of the river and also very sensitive to disturbance (Games and Severre, 1999). The high number of hatchlings observed in the rivers during these surveys, especially towards the upstream areas suggested that successful nesting occurs in these parts of the rivers because of fewer disturbances by human. The population bias to hatchlings and yearlings is an indication of a recovering population (Sullivan *et al*., 2010).

For Batang Samarahan, high number of hatchlings (34%) and relatively high number of EO (28%) were recorded (Figure 2). EO is most likely sub-adult and adult crocodiles, inhabiting mid-river, and usually submerge when the boat tried to approach them. Almost 10 % of the total numbers of *C. porosus* observed were sub-adult while 11% were adult. Based on this preliminary finding, Batang Samarahan supports a balanced crocodile population in terms of size. The high number of hatchlings observed in this study suggests that successful nesting occurs along Batang Samarahan, the bias in the population is an indication of a recovering population (Sullivan *et al*., 2010).

High numbers of yearlings (42%) were recorded in Sibu Laut River (Figure 2). Almost 21 % of the total numbers of *C. porosus* observed in this river were hatchlings. While for survey of *C. porosus* in Sungai Bako, the highest number of cohort size recorded was yearlings (38%) where it was a relatively higher compared to hatchlings which recorded 35% from total number of crocodiles spotted. The presence of EO of 27% and 15.7 % in Bako and Sibu Laut River, respectively, indicated that the populations may also comprise adults and sub-adult crocodiles.

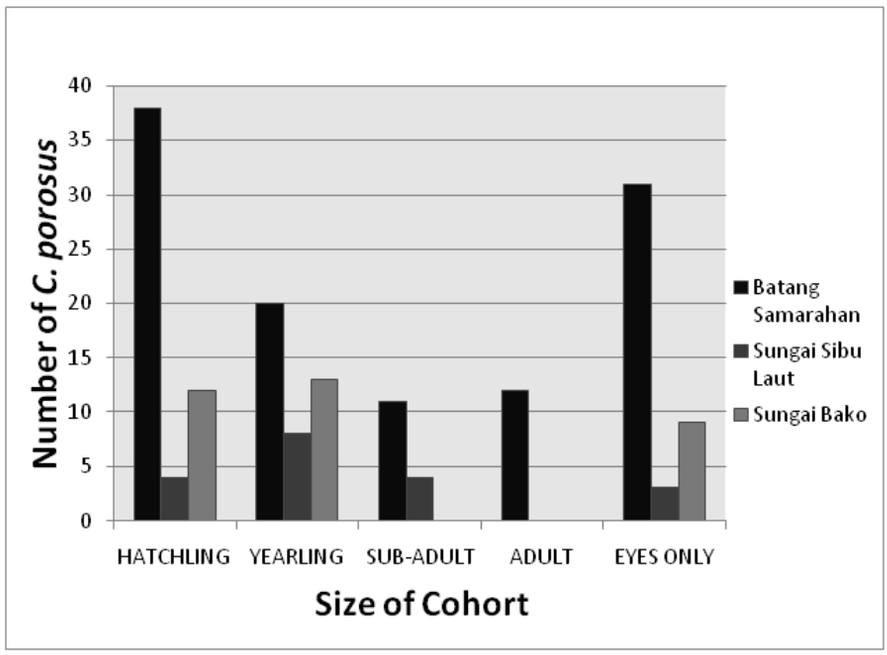


Figure 2: Number of *C. porosus* according to size of cohort recorded during the surveys in Batang Samarahan, Sungai Sibu laut and Sungai Bako.

Local People Perspectives on Crocodiles

In this study, a total of 44 people who are living in the villages along the three rivers had been interviewed, whose age range between 15 to 65 years old. Out of this pool of respondents, 43% were between 40-65 years old. For older generation (60 years old and above), most of them only received formal education up to primary school level or only educated informally on necessary life-survival skills. In contrast, 18% of the overall respondents (who are between 20 to 40 years old) were graduates from universities or colleges, reflecting the current trend of democratization of education in Malaysia, besides relatively cheap tertiary education compared to neighbouring countries

Majority of the respondents are subsistence fishermen, whereby fishing activities are carried out within the estuary river basins as well as within the coastal areas. Other respondents were civil servants, students, small-scale farmers tending small agricultural plots and self-employed entrepreneurs (Table 3).

Table 3. Summary of socio-economic profile of people interviewed during this study, whom living along Batang Samarahan, Sibu Laut River and Bako River

River	No of people interviewed	Educational Background	Occupation
Batang Samarahan	11	Tertiary level: 18% Secondary School: 55% Primary school: 9% Informal education : 18%	Fishermen: 36% Government servant: 19% Students: 9% Others: 36%
Sibu Laut River	24	Tertiary level: 5% Secondary School: 38% Primary school: 48% Informal education: 9%	Fishermen: 52% Government servant: 10% Students: 5 % Others: 33%
Bako River	9	Tertiary level: 23% Secondary School: 33% Primary school: 11% Informal education: 33%	Fishermen: 11% Government servant: 33% Students: 33 % Others: 23%

Many areas in Sarawak are experiencing rapid physical infrastructure development. For local people living near Batang Samarahan, Bako River and Sibu Laut River, tap water is now available to almost all residents, for drinking purposes and other domestic usage. Only 9% of the respondents are still depending on rain water as source of drinking water and water

from rivers for other domestic use. Rivers in Sarawak have many functions including as source of water for domestic use, irrigation of agricultural plots, transportation, recreational and fishing activities (Khairudin, 2008).

Although local people do not depend on rivers as a source of water for domestic use, majority of people interviewed (61%) used rivers as a mean of transportation, to go to other villages and their agriculture plots. Therefore, the peak time people use these rivers depend on tide table, meaning that elevated rate of usage will be during the high tide in the day time. Almost 73% of the respondents do fishing, either categorized as subsistence fishing or fishing as a hobby. Among the common fishing methods mentioned by respondents are fishing rods, nets and traditional fishing traps. In general, fishing activities increased during giant prawn season in these rivers (Stuebing *et al*. 1985) and human-crocodile conflicts incidents also reported to be high during this time of the year. This could be probably due to increase in the usage of the rivers as people put more effort in their fishing activities to increase prawn catch, which will also lead to the increase of income.

As crocodiles could be easily found in almost all rivers in Sarawak (Abdullah and Hassan, 2011), 94% of the respondents claimed that they have seen crocodiles in the wild, with the range between 1 to 5 meters. They reported seeing either partially submerged crocodiles in the water column, in between the mangrove trees or those who sun-basking on the mudflat adjacent to the river mouth or on the riverbank. Almost all respondents said they will try to avoid crocodiles when using the river. However, if they encounter these animals, they will just carry on with their activities as normal, without disturbing the animals. Within river vicinity all around Sarawak, people and crocodiles had already adapted living in harmony for centuries (Ritchie and Jong, 2002), and respect for each other continues until today.

As urbanization and large scale plantation replacing the old-day serene landscape in most parts of Sarawak, increased pressure to crocodile populations is unavoidable due to destruction of habitats, decrease in food sources as well as water pollution. Coincidently, there is also an increase in human population; hence more human activities are happening along the rivers, during night, day, dusks and dawns. Increased pressure to crocodiles and humans alike, may have contributed to the increase number of reports on human-crocodile conflicts. During this study, all respondents never had any personal experience in human-crocodile conflicts; however majority of them had met or heard of people who have had the experience of being attacked by crocodiles. When respondents were asked on suggestions to handle such conflict, 49% said culling should be carried out accordingly to control the number of crocodiles in the river, 27% suggested relevant agencies should monitor crocodile behaviour and population continuously whereas 24% said aggressive ones should be transferred to crocodile sanctuaries and zoos (Figure 3).

As the leading higher learning institution in Sarawak, Universiti Malaysia Sarawak (UNIMAS) is actively involved in research related to crocodiles. Among them are: (i) assessing the genetic diversity and population structure of crocodiles using multiple molecular markers, and (ii) ecological studies on crocodiles. These scientific findings are hoped to help relevant agencies to further formulate sustainable management strategies for this valuable resource as well as help in dealing with the increasing human-crocodiles conflicts in Sarawak.

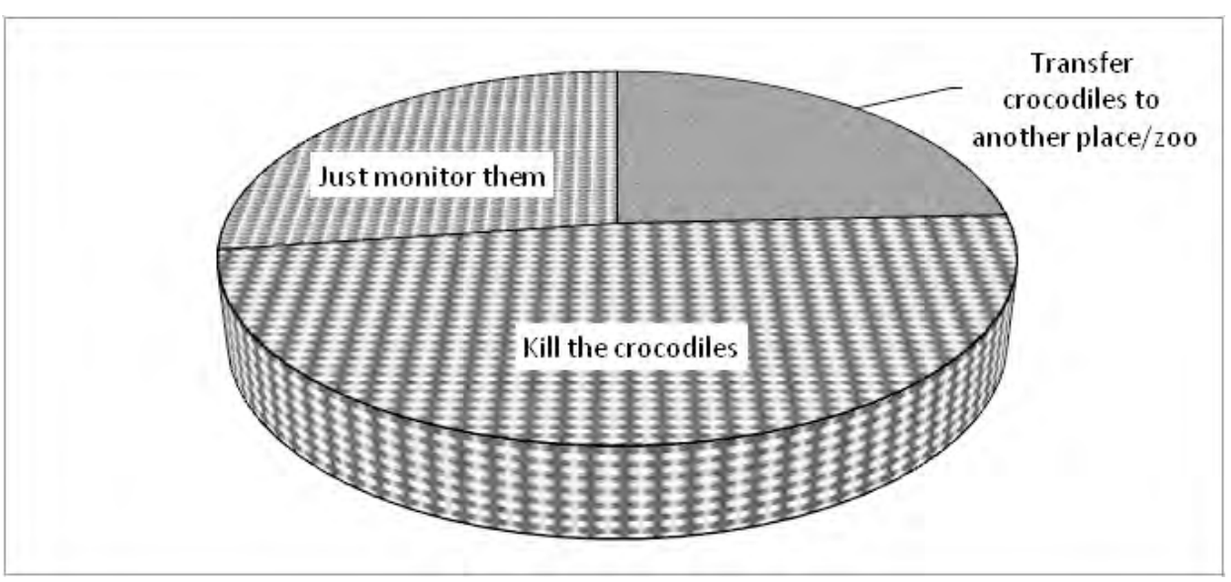


Figure 3: For human-crocodile conflicts, respondents suggested aggressive crocodiles to undergo systematic culling exercise, re-location and a more soft approach of continuous monitoring program by relevant agencies.

Conclusion

During 2011 census survey, mean relative density of 1.8, 1.04 and 0.53 non-hatchling/km were recorded for Bako River, Sibu Laut River and Batang Samarahan, respectively. Compared to previous data available, density of crocodiles in these rivers is showing decreasing trend. However, this data is considered as preliminary data, more surveys in these rivers as well as other rivers are needed to shed lights on the overall picture of density and population of crocodile in Sarawak. Pilot survey on socio-economic of local people living along the rivers revealed that (i) rivers are used heavily on daily basis, (ii) human and crocodiles continue to live in harmony, and (iii) awareness on current crocodile issues is high, but they are very concerned on the safety issues especially for their children.

Acknowledgement

This work was supported by Ministry of Higher Education through FRGS/06(17)/726/2010 (12), awarded to the first author. Mr Mohd Izwan, the co-author, is a Masters candidate supported by MyBrain15 Program. The authors would like to thank Sarawak Forestry Department for granting permit NCCD.907.4.4(jld.VI)-176 and Park Permit No. 94/2011. Thank you to Sarawak Forestry Corporation Bhd. for advice on locations of crocodile sampling sites and other technical aspects during this study. Thank you to Universiti Malaysia Sarawak (UNIMAS) for providing transportation and research facilities. The authors are grateful to English Language Editor, Assoc. Prof. Dr. Soubakeavathi Rethinasamy, Centre of Language Study, UNIMAS for reading the manuscript.

References

01. Abdullah, N. S. S. & Hassan, R. (2011). Phylogenetic relationships of *Crocodylus porosus* in Sarawak based on 12S rRNA Gene Sequences. UNIMAS Aquatic Science Colloquium 2010: Experiences Sharing in Aquatic Science Research (Nyanti, L. Ismail, N. & Mohamad, S., eds.). Monograph.pp104-109.

02. Cox, J., & Gombek, F. (1985).A Preliminary Survey of the Crocodile Resource in Sarawak, East Malaysia.World Wildlife Fund Project No. MAL 74/85, Kuala Lumpur.

03. Games, I. & Severre, E.L.M. (1999).Tanzanian Crocodile Survey. A report to the Director of Wildlife, Tanzania.

04. Khairuddin, D.B.O. (2008). A Journey Through Sarawak's Rivers A Human Development Perspective. UNDP report, Kuala Lumpur

05. Ritchie, J. & Jong, J. (2002).*Man-eating Crocodiles of Borneo.* Kota Kinabalu, Sabah: Natural History Publications (Borneo), Kota Kinabalu.

06. Sullivan S., Holden J. & Williams C. (2010). Report on the distribution and abundance of the estuarine crocodile, *Crocodylus porosus*, in Queensland. Department of Environment and Resource Management, Queensland.

07. Stuebing, R., Ismail, G. & Salih, K. (1985).The Ecology of Crocodile Attack in Batang Lupar Sarawak.*Sarawak Museum Journal*34 (55): 195-214

08. Tisen, O. B. & Ahmad, R. (2010).*Crocodylus porosus* in Sarawak: status and management. Paper presented during IUCN-Crocodile

09. Specialist Group (CSG) Workshop on Human-Crocodile Conflict, 23th-25th June 2010, Sabah, Malaysia.

Crocodile attacks in Sarawak

Engkamat Lading
Nature Conservation & Constitution Division, Forest Department Headquarters, Kuching, Sarawak, Malaysia

In Sarawak human and crocodiles have shared the same environment for many millenniums, and for most parts have coexisted peacefully. Relatively, few humans fell victim to the predators in the past but of lately the number of crocodile attacks have increased dramatically. Statistic has shown that a total of 118 attacks have taken place since 1941 until end of March 2013 where 64 of it were fatal while another 54 cases were reported to have caused various degrees of injuries ranging from just minor scratches to a level that have caused the victims to be bed-ridden for life. The above figure has given an average of 1.66 attacks occurring per year with a rate of 0.90 victims were killed annually by the predators. Two more attacks were just occurred in early April, 2013 where a body of one of the victims is yet to be found to this date. The increase in crocodile attacks of lately, was due to drastic increase in the population of estuarine crocodiles throughout Sarawak. Rivers that have never been inhabited by crocodiles in the past 30 years have now been infested by the man-eaters even up to its upper reaches not affected by daily tidal cycles. The enforcement of the Wild Life Protection Ordinance, 1998 is thought to be one of major factors contributing to the increase of the species. The clearings of vegetations along river banks are another factor as it promotes growth of grassy vegetations favorable for the crocodile nesting sites. Apart from various awareness programs on the species among local communities culling of dangerous individual crocodiles are part of the ongoing management program for the species in Sarawak, and some public places such as beaches have been declared as Crocodile-Free Zones.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 97 - 104

Assessment of saltwater crocodile (*Crocodylus porosus*) attacks in Australia (1971-2013): implications for management

S. Charlie Manolis and Grahame J.W. Webb
Wildlife Management International, P.O. Box 530, Karama, N.T. 0812, Australia

Abstract

When Saltwater Crocodiles (*Crocodylus porosus*) were protected in Australia (1969-1974) after some 25 years of unregulated hunting, the population had been reduced to less than 5% of its former abundance and comprised mainly young (small) crocodiles. In the Northern Territory (NT), which holds the majority of the Australian population of Saltwater crocodiles, the population is considered to have recovered to pristine levels of abundance, but the average size of crocodile continues to increase. The frequency of crocodile attacks (102 since 1971) is increasing over time. Here, we analyse crocodile attack data and assess future management of Saltwater crocodiles in the NT within the context of reducing human-crocodile conflict, without jeopardizing conservation goals.

Introduction

Saltwater Crocodiles (*Crocodylus porosus*) are distributed within three States/Territories in Australia: Northern Territory (NT), Western Australia (WA) and Queensland (QLD). Human-Crocodile Conflict (HCC) has no doubt been occurring since the arrival of Aboriginal people some 40,000 years ago. However, reliable and comprehensive data on attacks have only been available since the species was protected after some 25 years of unregulated hunting (WA 1969; NT 1971; QLD 1974). The last Australia-wide review of crocodile attacks assessed the available data up to 2004 (Caldicott *et al.* 2004); here we analyse data up to mid-2013, and include some additional information for the period 1855-1971.

Methods

Information on attacks by Saltwater Crocodiles was obtained from various sources, including newspaper reports, journals and other publications (general literature, books, etc.). WMI has maintained a detailed database on attacks since 1971, derived from similar sources, and including victim accounts and Government reports. Attacks on people working with crocodiles in the wild (eg researchers, crocodile farmers, crocodile hunters, wildlife rangers) were excluded from the analysis, and only attacks resulting in injury or death of the victim were considered to be "attacks".

Results

Pre-1946

Prior to 1946, Saltwater Crocodiles were mainly hunted for sport or as pests, although in the mid-1930s there was some interest in the commercial hunting for skins. The earliest report of a Saltwater Crocodile attack on a human in Australia was around 1855 (Victoria River, NT). At the time of writing, 214 *C. porosus* attacks were identified from the 1855-1945 period. This is considered an underestimate of the real number of attacks, as details are scarce, many historical attacks on indigenous people are known only from oral history, and the review of historical sources is ongoing.

A high proportion (39%) of the attacks involved indigenous people (Table 1).That most (69.2%) attacks occurred in QLD (Table 1) is considered to reflect the larger human population there relative to the sparsely populated Top End of the NT and WA at the time, although lack of reporting may also be implicated. Attacks were biased towards males (86.0% of victims; N= 207), and a most (61.7%) were fatal (Table 1).

1946-1970

Between 1946 and 1971/74, commercial unregulated hunting of Saltwater Crocodiles took place in northern Australia. The peak in hunting occurred in the first 10 years after 1945 (Webb *et al*. 1984), and a lack of Saltwater Crocodile skins in the late 1950s and early 1960s led to hunting of the less valuable Australian Freshwater Crocodile [*C. johnstoni*; protected in 1962 (WA), 1964 (NT) and 1974 (QLD)]. By the time of protection the Australian Saltwater Crocodile population had been greatly reduced. In the NT, it had been reduced to <5% of its historical abundance and <1% of its

historical biomass (Fig. 1). This trend is also considered to reflect the situation in WA and QLD, except that the levels of recovery in those States is not the same as the NT, where the population is considered to have reached pre-1946 abundance, but biomass (and mean size of crocodile) continues to increase (Fukuda *et al.* 2011).

Only 18 attacks were identified in the 1946-70 period (NT 8, QLD 6, WA 4). Details for 5 attacks could not be confirmed or assigned to a year, and so could not be assigned to either the pre-1946 or 1946-71 periods. Nonetheless, the frequency of attacks during 1946-71 (0.7/y) was significantly lower than that prior to 1946 (2.4/y), which reflects the greatly reduced *C. porosus* populations (Fig. 1), increased wariness of crocodiles towards humans, and improved modes of transport and road infrastructure during the hunting period. Most attacks (72%) involved indigenous people (Table 1) and males (77.3%).

Table 1. Saltwater Crocodile attacks in northern Australia, 1855-June 2013 (information sourced mainly from newspaper reports, as well as journals and other publications). Details for 5 "attacks", including year, could not be confirmed, and they are not included here (Biddell and Stringer 1988).

State/Territory	Fatal	Non-Fatal	Total	% Fatal	Indigenous (%)
1855-1945 (90 years)	**132**	**82**	**214**	**61.7%**	**84 (39%)**
Western Australia	9	9	18	50.0%	6 (33%)
Northern Territory	39	19	58	67.2%	32 (55%)
Queensland	94	54	148	63.5%	46 (31%)
1946-1970 (25 years)	**6**	**13**	**19**	**31.6%**	**13 (74%)**
Western Australia	4	0	4	100.0%	3 (75%)
Northern Territory	2	7	9	12.5%	7 (78%)
Queensland	0	6	6	0.0%	4 (67%)
1971-June 2013 (42.5 years)	**29**	**73**	**102**	**28.4%**	**35 (34%)**
Western Australia	2	11	13	15.4%	2 (15%)
Northern Territory	18	45	63	28.6%	27 (43%)
Queensland	9	17	26	34.6%	6 (23%)

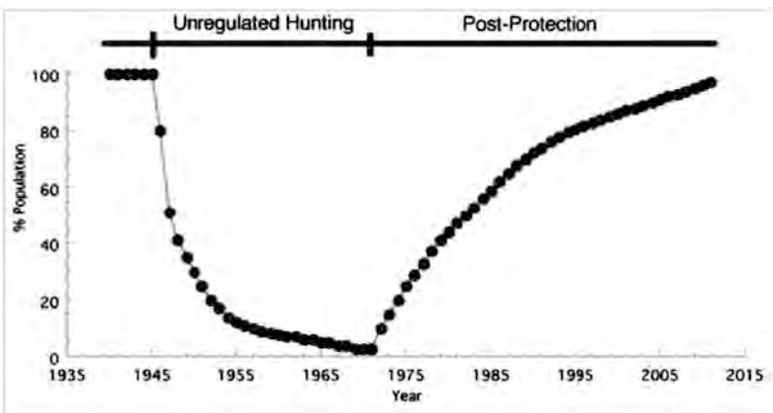


Figure 1. Estimated population trends for Saltwater Crocodiles in the NT following unregulated hunting (1946-70) and protection (1971 onwards).

1971-2013

Since protection in the NT (1971), more detailed information has been available on crocodile attacks in Australia. Since 1971 there have been 102 *C. porosus* attacks, most of which occurred in the NT (62%); QLD accounted for 25% and WA for 13%) (Table 1). Ninety-eight attacks involved one person being injured or killed, and four attacks involved two people being killed/injured - a total of 106 victims.

1. Reason for Attacks

For the 102 attacks occurring between 1971 and June 2013, the primary motivation behind the attacks by crocodiles was considered to be:

a. **Nest defence**: Two attacks involved adult female Saltwater Crocodiles at/near their nest site: one non-fatal attack occurred when a hunter accidently entered a nesting site, and a fatal was considered to be a case of nest defence.

b. Mistaken Identity/Self Defence: Eight attacks were considered to be a case of self defence or mistaken identity by relatively small crocodiles. Two of these attacks involved crocodiles (1.5-1.8 m TL) that had escaped from farms - the behaviour of these animals may have reflected time in captivity.

c. Food/Territoriality: Most of the remaining 92 attacks are considered to be cases of crocodiles preying on humans for food. However, territoriality cannot be ruled out as the motivation in some cases, particularly where the size of the victim was much greater than the size of the crocodile.

Notwithstanding the lack of details for many attacks prior to 1971 (Table 1), one attack was definitely a case of nest defence, but most appear to have been cases of crocodiles seeking food.

2. Fatality Rate

Around one-third (28.4%) of Saltwater Crocodile attacks in Australia since 1971 have been fatal (Table 1), and at least four the non-fatal attacks are likely to have resulted in death of the victim had it not been for the assistance of other people at the scene. Despite the relatively small number of attacks between 1946 and 1971, fatality rate (31.6%) was similar to that in post-1971 period. The assessment of pre-1946 records indicated a higher fatality rate (61.7%), which may reflect the degree of reporting of attacks that resulted in minor injuries, but it may also be indicative of the size structure of the *C. porosus* population at that time, which is considered to have been strongly biased towards large individuals.

The current (post-1970) fatality rate is similar to that reported for *C. porosus* in Sri Lanka (23.7%; De Silva 2010), but lower than that reported for Malaysian Borneo (43.7-61%; Tisen *et al.* 2011; Ambu 2011) and India (45.5%; Gopi and Pandav 2009). Similar fatality rates were recorded for *C. acutus* in Costa Rica (27.5%; Barrantes 2010) and *C. palustris* in India (22.2-42.1%; Vyas 2010; Whitaker 2008). The relatively high fatality rate (63%) for *C. niloticus* on mainland Africa (Fergusson 2004) is probably overestimated, as many non-fatal attacks in remote rural areas go unreported. This is also likely to be the case in specific countries where data are available [eg Madagascar 40.7% (Behra 1996); Zambia 67.8% (Wallace 2011)]. In comparison, only 7.6% of unprovoked American Alligator (*Alligator mississippiensis*) attacks in the USA have been fatal (Conover and Dubow 1997; A. Woodward, pers. comm.), which almost certainly reflects the smaller size and more docile nature of this crocodilian species.

3. Alcohol

Using only 75 cases where adults (>18 y; minimum age for legal alcohol consumption) were attacked since 1971, 21% of attacks are known to have involved the consumption of alcohol by the victim around the time of the attack. This rate is much higher for the 22 fatal attacks (45.5%) and lower for the 53 non-fatal attacks (11.3%). Alcohol is considered to affect the behaviour of victims, in particularly risk taking, and increases the probability of attacks.

4. Age and Sex of Victims

The majority of people attacked since 1971 were males (74.5%). Mean age of victims was 33.7 years for males (N= 69, SD= 15.01, range 5 to 75 y), 25.6 years for females (N= 23, SD= 17.09, range 5 to 60 y), and 32.0 years overall (N= 92, SD= 15.86, range 5 to 75 y).

5. Biases toward Indigenous People

A disproportionate number (34.3%; Table 1) of attacks since 1971 involved indigenous people. In the NT, at least 27 of the 63 attacks involved people of Aboriginal descent: 42.9% of all attacks; 50.0% of fatal attacks; and, 40.0% of non-fatal attacks. This bias cannot be explained by demographics alone (around 28-29% of the NT Top End population are indigenous), but it can be explained by traditional lifestyles involving hunting, fishing and gathering, and the disproportionate number of indigenous people who live in remote, traditional homelands: around 60% of Saltwater Crocodile habitat in the NT is on indigenous lands.

6. Residents versus Tourists/Visitors

Since 1971, a high proportion of Saltwater Crocodile attacks in the NT (92.1%; N= 63) and QLD (87.0%; N= 23) have involved "locals" - long-time residents aware of the risks associated with crocodiles. In contrast, in WA locals made up the minority of attacks (36.4%; N= 11). At least two of the attacks on visitors could have been avoided if normal precautions had been taken.

7. Size of Crocodiles Involved in Attacks

The smallest wild Saltwater Crocodile reportedly involved in an attack was estimated to be 0.8 m long, and the largest was 5.1 m (mean= 3.2 m, N= 87, SD= 1.03; Fig. 2). The average total length (TL) of crocodile involved in fatal attacks was 4.2 m (N= 25, SD= 0.82, range 2.1 to 5.1 m), and for non-fatal attacks it was 2.8 m (N= 62, SD= 0.83, range 0.8 to 4.5 m). There is no doubt that the majority of fatal attacks are disproportionately caused by large male crocodiles (>4 m TL) (Fig. 2), that throughout the period of assessment (1971-June 2013) have comprised an increasing proportion of the total population of crocodiles (see Fukuda *et al.* 2011).

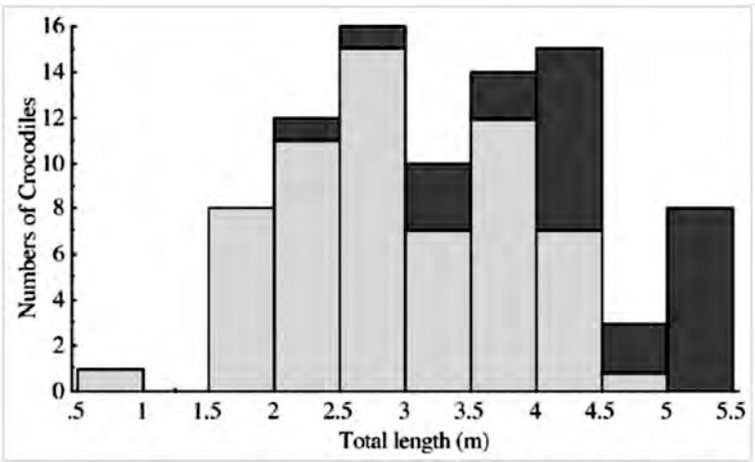


Figure 2. Size distribution of 87 Saltwater Crocodiles involved in attacks, 1971-June 2013). light = non-fatal; dark = fatal.

8. Probability of Surviving a Crocodile Attack by Different Sized Crocodiles

The bodyweight of a crocodile increases exponentially with increasing length, hence longer and heavier crocodiles are more able to attack and overpower humans than smaller ones. The probability of a crocodile attack being fatal increases markedly as size increases (Fig. 3). Indeed, all known attacks by crocodiles over 4.5 m in length across Australia have resulted in the death of the victim.

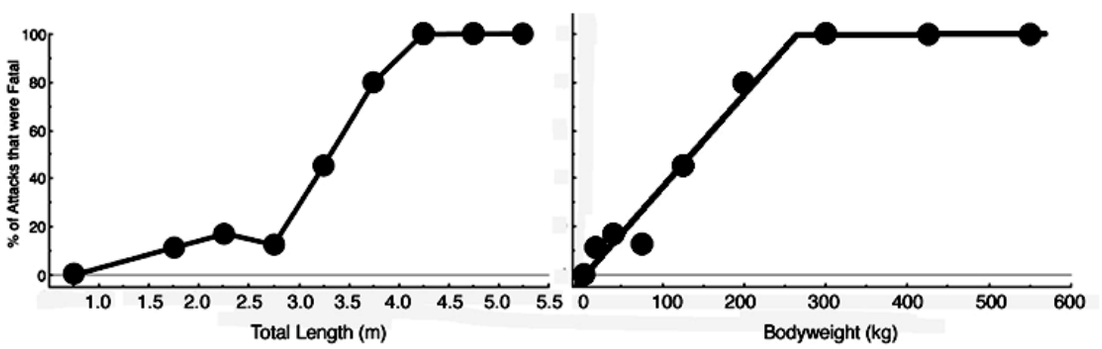


Figure 3. Proportion of Saltwater Crocodile attacks (Australia) as a function of: (left) actual/estimated total length of crocodile (in 0.5 m categories; 1.0-1.49, 1.50-1.99, etc.) and (right)estimated bodyweight of crocodile [mean derived from 0.5 m TL categories; the linear regression relationship between 0 and 300 kg was significant (r^2= 0.96, p = 0.0001)]. Seven attacks where victims received assistance were excluded.

9. Day or Night?

Most attacks by Saltwater Crocodiles have occurred during the day (all attacks 78.0%, fatal 81.4%, non-fatal 70.0%). However, this reflects the timing of activities by victims, rather than any specific preference by crocodiles. We strongly suspect that the rate of attacks would be higher during the night if the same activities were undertaken at the same frequency.

10. Effects of Season on Probability of Attack

Attacks have taken place in every month (Fig. 3), but the majority [92.4% for pre-1971 (N= 119); 85.3% for 1971-2013 (N= 102)] have occurred in the warmer months of the year (August-April), which encompasses the late dry season and wet season. Although this period is correlated with the annual courtship and breeding season (October-April), when crocodiles are thought to be more active generally, there is no real evidence that reproduction is involved. A far more plausible explanation is that the physiological maintenance costs of crocodiles increase exponentially with increasing body temperature. So when the cooler conditions of winter pass by, and water temperatures start to increase, the amount of food required to sustain a crocodile during the warmer months is much, much greater than that in the cooler months. Hence they need to consume much more food to maintain body condition when it is warmer. Recent experiments indicated that of 10 kg of food fed to captive crocodiles in warmer months, 6-7 kg were used for maintenance alone (WMI, unpublished).

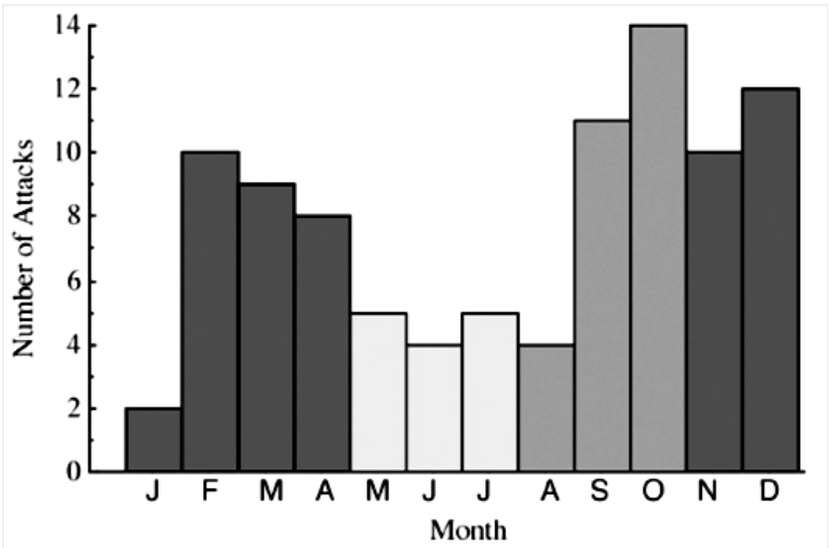


Figure 4. Saltwater Crocodile attacks in each month, 1971-June 2013. November-April= hot, wet; May-July= cool, dry; August-October= hot, dry (see Table 3).

11. Effects of Season on Frequency of Attacks

Three broad seasons can be recognised in the Top End of the NT: cool-dry (May-July); hot-dry (August-October); and, hot-wet (November-April) (Webb 1991). The frequency of attacks in Australia was highest in the hot-dry and hot-wet periods of the year (9.7/mth and 9.3/mth respectively), and lowest in the cool-dry (5.0/mth). Access to many areas is constrained during the wet season (hot-wet), when wetlands are greatly expanded. The cool-dry season encompasses the peak period of tourist visitation in northern Australia.

12. Location of Victims at Time of Attack

Not surprising, the majority (86%) of *C. porosus* attacks have occurred whilst people have been in the water (eg swimming, wading, snorkelling, scuba-diving) or on land at the water's edge (Table 2). That five attacks have occurred on land confirms that large crocodiles will leave the water in search of prey.

Table 2. Location/activity of victims during attacks in Australia (1971-June 2013).

Location (% of all attacks)	Non-Fatal	Fatal	All
Water (86.0%)			
Swimming	18	17	35
In shallow water (eg wading)	20	5	25
Shallow water (getting into boat)	2	-	2
Shallow water/water's edge	-	2	2
Snorkelling, scuba-diving	8	4	12
At water's edge (on bank)	12	-	12
Subtotals	***60***	***28***	***88***
	(82.2%)	(96.6%)	(86.3%)
Boats/Canoes (9.0%)			
In canoe	1	1	2
In boat	7	-	7
Subtotals	***8***	***1***	***9***
	(11.0%)	(3.4%)	(8.8%)
Land (5.0%)			
Asleep in tent near water	2	-	2
Asleep near water	1	-	1
Asleep on beach	1	-	1
Near crocodile nest	1	-	1
Subtotals	**5**	**-**	**5**
	(6.9%)	(0%)	(4.9%)
All	**73**	**29**	**102**

13. Activity of Victims at Time of Attack

Most (90.2%) attacks occurred while people were involved in recreational activities, including fishing and hunting. People working (non-crocodile related; eg commercial divers, researchers) at the time of the attack accounted for 7.8% of attacks, and unknown/miscellaneous attacks (eg escaping from Police) for 2.0%.

14. Canoes

Eight cases of attacks on occupants of canoes prior to 1971 were located, and all involved indigenous people. Since 1971, two attacks have involved people in canoes; a fatal attack in QLD (Normanby River, 2005) considered to have been motivated by feeding, and a non-fatal attack in the NT (East Alligator River, 1985) that may have been territorial/nest defence. These statistics do not reflect attacks that have been directed at canoes by Saltwater Crocodiles, but which have not resulted in injury to the occupants.

It is unclear why crocodiles attack canoes, but the long thin shape may appear like another crocodile, particularly from underwater, and result in behaviour associated with territoriality. Against this, people in canoes are commonly taken by Saltwater Crocodiles in Sarawak and Sabah (Malaysia), and these attacks appear to be crocodiles preying on humans for food.

15. People in Boats

Prior to 1971, 5 attacks directed at people in boats, and which led to injury/death, were identified. A further three cases did not result in injury to the boat occupants.

Since 1971, there have been 7 attacks directed at people on boats. Four of these occurred in the NT; two attacks involved relatively small crocodiles (1.8 and 2.0 m TL) and two attacks involved large (4.0 and 4.5 m TL) crocodiles, and attacks occurred during the day (N= 2) and night (N= 2). In WA, three similar attacks directed at occupants of boats involved 2.0, 2.5 and 3.0 m long crocodiles; all attacks occurred during the day.

Considering the number of boats involved in recreational activities in northern Australian rivers over the last four decades, there have been very few directed attacks on people in boats.

16. Boats

Three cases of crocodiles trying to climb into boats, attracted by dead fish (1930s) or dead crocodiles (1951) in the boats were reported. The reasons for another crocodile climbing onto a ferry (1952) were unclear.

Some cases of Saltwater Crocodiles directing attacks at boats and/or outboard motors merit particular mention:

a. "Sweetheart", a 5.1 m *C. porosus*, made numerous attacks on the propellers of outboard motors in the Finniss River in 1978-79 (Stringer and Jakku 1986). Attacks were not directed at boat occupants. The propellers may have sounded like another large crocodile, and elicited a behavioural response from "Sweetheart" (Webb and Manolis 1989).

b. In 1984 a 5.1 m long *C. porosus* attacked the outboard motor cowlings of a number of boats in the Wildman River, when the boats were tied up at the water's edge, suggesting the crocodile was "attracted" to the warmth of the motors. At night the outboard cowlings may have been mistaken for the warm head of a large mammal at the water's edge (Webb and Manolis 1989).

c. In 2012, 6 attacks on boats by *C. porosus* occurred in the South Alligator River (5) and Wildman River (1) in Kakadu National Park [Jan, Mar (2), Sep, Oct (2)], all of which occurred at night (G. Lindner, pers. comm.). Occupants were woken by crocodiles attacking the outboard motors (N= 5; 2.0, 3.5, 3.5, 4.0 and 4.0-4.5 m long crocodiles) or the boat hull (N= 1; crocodile size unknown, but large judging by puncture marks in the hull).

With respect to the attacks on boats in 2012, park staff reported a changing trend with respect to fishing activities, with more and more fishermen now fishing at night, and sleeping in their boats overnight. Although not permitted, these activities are difficult to enforce. In all 6 cases, none of the boats had peripheral lighting, which is considered to contribute to safety at night, by illuminating the boat and allowing a better view of the surrounding water (G. Lindner, pers. comm.). Interestingly, a 1934 newspaper article referred to Aboriginals maintaining fires throughout the night to "ward off crocodiles" (Thompson 1934). In areas close to Darwin (eg Adelaide, Mary), fishermen are more likely to undertake day trips, and few fishing boats tend to remain on the river at night.

There is no evidence to suggest that there is a general change in crocodile behaviour towards boats. In areas where tours involve crocodile viewing and feeding (eg Adelaide River), crocodiles respond to the large tour boats, and will generally not approach other boats closely (Lyons 1999).

17. Trends in Attacks over Time

No attacks on people were recorded in the NT in the first 8 years of protection (1971-1978), but the number of attacks has increased significantly between 1979 and 2012 (linear regression; $r^2 = 0.26$, $p = 0.002$). This trend is largely due to a significant increase in the number of non-fatal attacks over time ($r^2 = 0.14$, $p = 0.027$); the relationship between numbers of fatal attacks and time was not significant ($r^2 = 0.08$, $p = 0.11$). Given the high variability in these trends, data within 5- and 10-year periods were lumped (eg 1971-75, 1976-80, etc.) to provide more realistic representation of trends (Fig. 5).

On this basis, the average frequency of non-fatal attacks in the NT has increased from 0.0/y in 1971-80 to 1.8/y in 2001-12, for fatal attacks it has increased from 0.2/y in 1971-80 to 0.8/y in 2001-12, and for all attacks it has increased from 0.2/y in 1971-80 to 2.6/y in 2001-12. These data are depicted on Figure 5

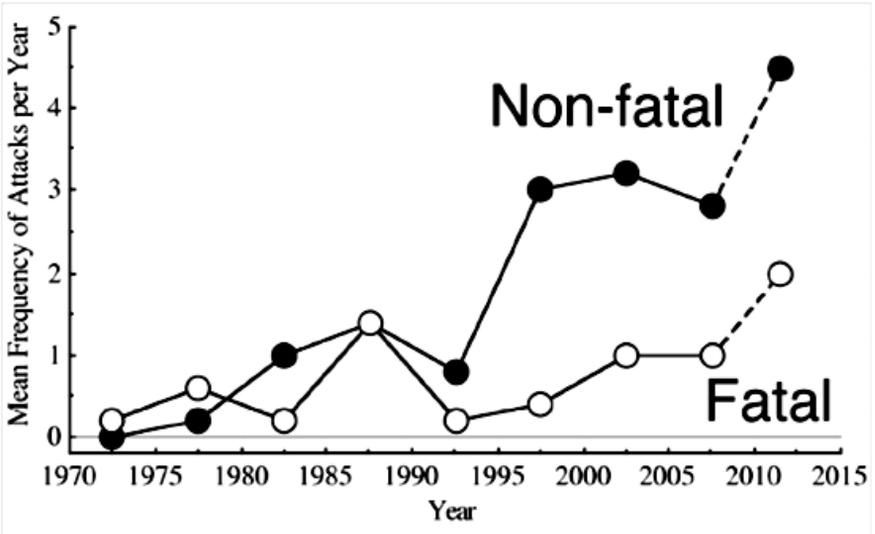


Figure 5. Frequency of Saltwater Crocodile attacks in 5-year periods (1971-2012). Data for 2011-2015 are restricted to two years (2011 and 2012; two attacks in 2013 are not included).

Discussion

The NT's ability to recover its *C. porosus* population back to the level of historical abundance is largely due to the creation of incentives to ensure that crocodiles have a positive value in the eyes of landowners and the public. Nonetheless, the increasing frequency of attacks by *C. porosus* in recent years has resulted in "calls" from the public to reduce HCC, perhaps through widespread culling.

The analysis of attacks since 1971 confirms that public education remains a critical element of management. That the majority of *C. porosus* attacks in Australia have involved locals indicates that public education programs may need to focus more on this segment of the population. That a high proportion of attacks have involved indigenous people also suggests that particular attention needs to be paid to this sector, perhaps delivered in a more culturally appropriate manner. Although traditional indigenous knowledge is important (eg where it is "safe" to swim), few indigenous people today have lived through periods of high crocodile abundance, as is the case now.

Crocodile farms in the NT rely mainly on the ranching of Saltwater Crocodile eggs, and indigenous landowners derive financial benefits through involvement in this program. In the mid-1990s, the CITES Appendix-II listing of Saltwater Crocodiles in Australia was changed from the purposes "ranching" to an "unqualified" listing. This now allowed other forms of use, such as wild harvest, to be implemented. Wild harvesting in WA was undertaken in the 1990s to provide stock for crocodile farms, and data on the impact of sub-adult/adult harvesting were generated (WMI, pers. comm.). In the NT, a trial wild harvest of adult Saltwater Crocodiles in the late 1990s was not extended into a formal program, and remains an option for future management, particularly for landowners who have limited/no nesting habitat and who are thus unable to participate in the egg ranching program. The Australian Government has previously rejected trophy hunting of Saltwater Crocodiles in the NT, although it is now considering an application from the NT which would allow a trial trophy hunting program, involving a low number of animals, to be undertaken. The proposed harvest of trophy animals is well within sustainable limits (<0.03% of the non-hatchling population), and is consistent with IUCN initiatives on trophy hunting (IUCN 2012).

Tourism is one of the main industries for northern Australia, and the ability to see crocodiles in the wild is a expectation for many visitors. Problem crocodile programs in each State/Territory deal with animals that pose a threat to humans or livestock, and some areas are maintained as crocodile-free as possible (eg Darwin Harbour), and in some cases allow for recreational purposes.

The frequency of attacks was lowest during the 1950s and 1960s, when the wild Saltwater Crocodile populations were greatly reduced due to hunting. With recovery of the populations since protection, the frequency of attacks has increased. The increasing movement of Saltwater Crocodiles into upstream freshwater areas, which are often used for recreation, is now a key management issue being addressed in the NT. The use of barriers to prevent entry of crocodiles into swimming areas, and the application of new methods to capture crocodiles being they reach such areas, are options currently under consideration. The use of Crocodile Exclusion Enclosures (CEEs) as used in Sri Lanka and India (see www.iucncsg.org/pages/ Human%252dCrocodile-Conflict.html) also merit consideration.

Literature Cited

01. Ambu, L. (2011). Current status of crocodiles in Sabah.*In* Proceedings of the International Crocodile Conference, Kuching, Sarawak, Malaysia, 19-21 October 2011. (in press).

02. Barrantes, L.D.B. (2010). Analysis of crocodile attacks in Costa Rica, 1990-2009. Crocodile Specialist Group Newsletter 29(2): 14.

03. Behra, O. (1996). Reports of crocodile attacks on people in Madagascar 1990 to 1996. Crocodile Specialist Group Newsletter 15(3): 4-5.

04. Biddell, G. and Stringer, C. (1988).Crocodiles of Australia. Adventure Publications: Casuarina.

05. Caldicott, D.G.E., Croser, D., Manolis, C., Webb, G. and Britton, A. (2005). Crocodile attack in Australia. An analysis of its incidence, and review of the pathology and management of crocodilian attacks in general.Wilderness and Environmental Medicine 16(3): 143-159.

06 Conover, M.R. and Dubow, T.J. (1997). Alligator attacks on humans in the United States. HerpetologicalReview 28: 120-124.

07. De Silva, A. (2010). Crocodiles of Sri Lanka: Preliminary Assessment of their Status and the Human Crocodile Conflict Situation. Project No. 0905271, Mohamed Zayed Species Conservation Fund.

08. Fergusson, R. (2004). Preliminary analysis of data in the African Human-Crocodile Conflict database. Crocodile Specialist Group Newsletter 23(4): 21.

09. Fukuda, Y., Webb, G., Manolis, C., Delaney, R., Letnic, M., Lindner, G. and Whitehead, P. (2011).Recovery of saltwater crocodiles following unregulated hunting in tidal rivers of the Northern Territory, Australia. Journal of Wildlife Management 75(6): 1253-1266.

10. Gopi, G.V. and Pandav, B. (2009). Humans sharing space with *Crocodylus porosus* in Bhitarkanika Wildlife Sanctuary: conflicts and options. Current Science 96(4): 459-460.

11. IUCN SSC (2012).IUCN SSC Guiding Principles on Trophy Hunting as a Tool for Creating Conservation Incentives.Ver. 1.0. IUCN: Gland, Switzerland.

12. Lyons, A.R.C. (1999). Are Interactive Crocodile Tours on the Adelaide River Leading to Measurable Changes in Saltwater Crocodile(*Crocodylus porosus*)Behaviour?Unpublished Honours Thesis, Northern Territory University, Darwin.

13. Stringer, C. and Jakku, E. (1986).The Saga of Sweetheart. Adventure Publications, JB Books: Adelaide.

14. Tisen.O.B., Ahmad, R., Kwan, S., Robi, N. and Osaka, V. (2011).Promoting awareness on human-crocodile conflict in Sarawak.*In* Proceedings of the International Crocodile Conference, Kuching, Sarawak, Malaysia, 19-21 October 2011. (in press).

15. Vyas, R. (2010). The Muggers (*Crocodylus palustris*) of Vishwamitri River: Past and Present. Herpetology& Environmental Research Project (HERP): Vadodara.

16. Webb, G.J.W. (1991). The influence of season on Australian crocodiles. Pp. 125-131 *in* Monsoonal Australia - Landscape, Ecology and Man in the Northern Lowlands, ed. by M.G. Ridpath, C.D. Haynes and M.J.D. Williams. A.A. Balkema: Rotterdam.

17. Webb, G. and Manolis, C. (1989).Crocodiles of Australia. Reed Books: Sydney.

18. Whitaker, N. (2008). Visit to Champa District, Chattisgarh: An Analysis of Findings Relative to Crocodilian Husbandry, Capture, and Human-Crocodile Conflict. Unpublished Report, Madras Crocodile Bank Trust, Madras, India.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 105 - 109

Crocodile human conflict in National Chambal Sanctuary, India

R.J. Rao and Rajesh K. Gurjwar
Conservation Biology Unit, School of Studies in ZoologyJiwaji University, Gwalior, M.P., India,
rjrao09@gmail.com

Abstract

In the National Chambal Sanctuary in India human crocodile conflict does not in itself appear to be a major problem with *Gavialis gangeticus*, but the mugger crocodile *Crocodylus palustris* is considered a threat to man because the wild populations are increasing in the Chambal River and there are cases of mugger attacking human and their livestock.. The degree to which *C. palustris* can and will attack people is largely a matter of theoretical discussion, but the recent increase in their population due to crocodile conservation and management programmes in the sanctuary, it is hard to accept that they would not pose a problem to people in the Chambal area where people were exposed to crocodiles, by using the river for washing, drinking water extraction, swimming and cattle use. Such conflicts are also highlighted by the media, it is likely that the public do fear crocodile attacks and that these fears may turn out to be serious impediments to reintroducing *G. gangeticus* into the Chambal River and other water bodies in neighbouring protected areas. Though local people receive compensation from the Government for every case of crocodile attacks they are more reluctant to agree for reintroduction of crocodiles as they feel that crocodile conservation programme is against human poverty alleviation programme. A study conducted in the Chambal River indicated that major crocodile habitats are under severe pressure due to increase in human activities, Locals use crocodile habitats for water extraction for drinking, irrigation including riverside agriculture, sand mining, and livestock grazing and washing. Due to lack of education and awareness about crocodile behavior and the basic purpose of Government run crocodile conservation programmes the locals are against the crocodile reintroduction programme. In this paper mitigation strategies to be adopted to reduce Human Crocodile Conflict are discussed.

Introduction

Conflicts between humans and animals are a serious problem in many parts of the world. The damage and destruction caused by a variety of animals to human property-and sometimes to human life-is a real and significant danger to many human communities and with the animals often killed, captured, or otherwise harmed in retaliation, these conflicts are one of the main threats to the continued survival of many species. Crocodile attacks on people are common in places where large crocodiles are native and human populations live. Only six of the 23 crocodilian species are considered dangerous to adult humans and only individuals 2 meters (6.6 ft) in length or more represent a serious danger to humans, as smaller crocodiles are considered incapable of killing a person. Frequent encounters with humans and their livestock have caused human-crocodile conflicts which result in retaliation killings (Deutsch and Coleman, 2000). Human-crocodile conflicts have been reported from different parts of the country (Whitaker, 2007, 2008), indicating possible increases in population and/or Mugger reaching larger sizes. Human-crocodile conflict studies have been carried out extensively in many parts of the world (Langley, 2005; Whitaker, 2007, 2008; Aust, 2009; Dunham *et al*, 2010; Fergusson, 2010; Udgata, 2011; Mendis, 2012, Webb, 2012; Chomba *et. al*. 2012).

Crocodiles use the riverine ecosystem for their life propagation and also use the sand bank and marshlands for basking, egg-laying and hiding place. People use the river for various purposes including fishing, sand mining, drinking water collection, washing, extraction of water for irrigation, livestock use and also use the bank for agricultural purposes. The crocodiles have to compete for water, fish stock and bank availability with humans. There is also high rate of conflict due to entanglement and death in fishing nets.

Due to Crocodile Rehabilitation programme initiated during late 1970s under Indian Crocodile Project the populations of crocodiles have been increased. The increasing mugger populations pose a potential threat to human and their livestock living in villages along the banks of Chambal River. The present study has been undertaken to assess the mugger population in the study area, causes and occurrence of conflicts, people's mentality towards the animals and to suggest measures to avoid conflicts.

An assessment of human-crocodile conflict in National Chambal Sanctuary, Madhya Pradesh was carried out from March October, 2012 at regular intervals to collect data on crocodile population in the study site, socio-economic status of the adjoining villages and human-crocodile conflict**.** Primary data were collected through field surveys and secondary data were collected from Madhya Pradesh Forest Department. This study aimed at exploring the human-crocodile conflict in terms of livestock depredation, human casualties, retaliation killing, asses the habitat sharing of crocodiles, asses the anthropogenic pressure on the river ecosystem and determine the crocodile-human conflict to suggest mitigation measures.

Methods

Study area

The Chambal River in India has the single largest contiguous population of gharial reportedly between 48% and 85% of the global population. The gharial is threatened by riverbank land-use changes, reduction in river flows, modification of river morphology, loss of nesting and basking sites, increased mortality in fishing nets and egg-collection for consumption.Few crocodiles reach maturity. Eggs drown sometimes as nests are submerged during wet season flooding and small crocodiles are eaten by jackal, mongoose, goannas, birds, fish, other crocodiles. Anthropogenic processes have physically, chemically and biologically modified India's great river ecosystems. Major part of the Chambal River has been declared as Wildlife Sanctuary during 1978 (Fig. 1). The sanctuary is protected under India's Wildlife Protection Act of (1972). Parts of the sanctuary are threatened by extensive illegal sand mining, which is endangering the fragile lotic ecosystem critical for Gharial breeding. *National Tri-State Chambal Sanctuary Management and Coordination Committee* have been formed for the management of NCS.

The present study was conducted in the National Chambal Sanctuary, Madhya Pradesh in an area of around 50 km from village Bilpur/Kuthiyana to Nayapura (Pinahatghat). Geographically, the study site lies between latitude 26°40'N - 26°51'N and longitude 78°5'E - 78°22'E (Fig. 2). There are about 15 villages along the river bank in the study area. The 15 villages selected in the present study have a population of about 6400, with overall male female ratio of 1.07. The literacy rate of the selected villages as per the census 2011 is 49.6. The average temperature of 36^0C was recorded in the study area. The minimum temperature was 15.8^0C in the month of March, however, the maximum temperature was 42.2^0c in the month of May.

The field surveys were carried out during MarchOctober 2012. For the collection of primary data regular site visits were made. The field surveys were classified into two sections, river survey and questionnaire survey for the villages.Secondary data on human-crocodile conflict was collected from records available in the Forest Department. Literature survey was also carried out by consulting different journals, newspapers, and unpublished thesis/dissertations and other study material from the libraries.

Results and Discussion

National Chambal Sanctuary is at the borders of three districts, Sheopur, Morena and Bhind in the state of Madhya Pradesh in North India. In this part of the National Chambal Sanctuary two species of crocodiles *Gavialis gangeticus* (gharial) and *Crocodylus palustris* (mugger) are present (Fig. 3). Most of the crocodiles that are present in the study area were adults and only a few among them were juvenile. 14 gharial and 19 mugger sub adults were also seen in the study area (Table 1).

Table 1. **Data on occurrence of crocodiles in the study area**

Category of crocodiles	No. of crocodiles			
	Gharial	%	Mugger	%
Adult	51	68.9	27	43.6
Sub Adult	14	18.9	19	30.7
Juvenile	9	12.2	16	25.7
Total	**74**	**100**	**62**	

In the 50 km River stretch, there are only 8 important basking areas of crocodiles at Kuthiyana, Babusingh ke gher, Kisrouli, Daljeet ka pura, Barsala, Sukhdhyan ka pura, Holapura and Usedghat.In the 50 km River stretch, there are 6 important nesting areas of crocodiles in the study area like Babusingh ki gher, Kisrouli, Daljeet ka pura, Barsala, Sukhdhyan ka pura and Holapura. Approximately 2 km of sand bank on small stretches are used by the Gharial for nesting.

The Gharial bask on the sand bank and mugger also use sand banks for basking, although they prefer hard soil and rocks

for basking for long hours. Both crocodiles nest on sand banks at many sites. They use sand banks throughout the sanctuary wherever suitable habitats are available. Sand mining is one of the major human activities in the NCS. Sand is continually extracted in the important nesting and basking site, this is reducing the space of nesting and basking habitat and drastically changing the population trends in aquatic biodiversity.

Conservation of aquatic biodiversity in the National Chambal Sanctuary is major subject of research since 1983 (Singh, 1985; Rao, 1989; Sharma, 1991; Hussain, 2009). There are direct conflicts like injury and death of human and indirect conflicts like crocodile destroying the fishing nets, damage to fish population, predate domestic livestock. The present study is mainly focused on the crocodile-human conflict in the National Chambal Sanctuary. Large numbers of people residing in the riverside villages are directly dependent on the Chambal River. They collect sand, grow agriculture along the river banks and collect fish from the river.

Although fishing is totally banned in the Chambal River to avoid incidental mortality of aquatic animal in the gills nets, occasional illegal fishing is continuing. There are many reports of crocodile and turtles mortalities by drawing in fishing nets. Two dolphins were recorded to be killed in the fishing nets and the fishermen extracted oil from the dolphins in April 1987. Because of the fishing activities in the Chambal River the animals are facing a lot of disturbance.

People use the river for various purposes including drinking water collection, cloth washing etc (Fig. 4). People also cross the river by means of a temporary bridge, cross the river using the boats and Camelsand also the river bank is used for burial of dead bodies and extraction of water for irrigation, livestock use etc. Most of the crocodiles that are present in the study area were adults and only a few among them were juvenile. 14 gharials and 19 sub adult mugger were also seen in the study area.

Although there are reports of human crocodile conflict in the National Chambal Sanctuary, the present studies revealed that in the study area human beings are not attacked by crocodiles but livestock is attacked by the mugger crocodiles (Table 2). In several villages it is reported that 5-6 accidents have been occurred during 2011-2012. Mostly buffaloes, cows, and goats have been attacked by the mugger crocodile when they visit the river for drinking purpose.

Table 2: Percentage of injury and death to live stock by mugger crocodile

Fatalities	Cows	Goats	Buffalos	Dogs	Total
Injury	2	-	1	-	3
Death	7	15	13	2	37
Total	9	15	14	2	40

It was found that most of the people who are the residents of the sampled villages were farmers followed by fishermen and labourers. Buffalos, goats, dogs and cows are the prime victim of the crocodile in the study area. It was found that timing has a direct relationship with accidents rate in the evening hours when people are mostly indoors, however, certain accidents have occurred early in the morning. It has been calculated that 37 casualties of animals viz, cows, goats, buffalos and dogs have occurs in the area due to the conflict with crocodiles and 2 cows and 1 buffalos have become injured during the study period. 29% of the people reported that they are negatively affected by the presence of crocodile and 54% told that they do not have any affect due to presence of crocodile in the area.

Residents living close to the victim of the sampling area believed that their children fear to go to river due to the presence of crocodiles. Grazing, bathing, fishing, drinking and watering have become different for the residents in the area. The opinion of the residents regarding the discomfort of people is listed below. It was found that most of the people are aware of the crocodile behavior in these villages and 80% of the people have seen crocodile once in their life and to escape from clutches of crocodiles and 75% people think to construct alternate source for drinking water, due to the presence of crocodiles and only 9% people prefer to go for fishing.

The information revealed that most of the people who were affected by human crocodile conflict received compensation amount of Rs 5000- 10,000 as a relief from Deori Range. In the Chambal River human activities are increasing slowly. In the past the local people collected and utilized the fish for themselves, but gradually people outside the Chambal region are collecting the fish and turtles for sale in different states particularly West Bengal. Wildlife habitats were considerably altered and there are disturbances along the river by wood collectors, poachers, farmers and sand miners. Such human activities have increased instances of human-crocodile conflict. There are many reports in the sanctuary regarding killing of cattle and human by mugger crocodile in the Chambal River. It is the responsibility of the wildlife managers and researchers to take suitable measures for controlling such human-crocodile conflict in the National Chambal Sanctuary. There is a need to take education and awareness programme to the local human population, which depends totally on the river.

For over four decades the crocodile population in the Northern Territory in Australia has been increasing, crocodile attacks have been occurring, and calls for culling have been raised (Webb, 2012). It is not a simple issue to culls the problem crocodiles. A refined public education programme ensures residents and visitors are well-informed about 'crocodile safety'. Due to the negligence of people, there has been a spike in the number of crocodile attacks on humans in

recent years. The growing human toll, deaths and injuries, have had a far more detrimental consequence on the crocodiles, with the villagers being provoked into poisoning, trapping and killing the crocodiles (Mendis, 2012). Local people in Mozambique are poor and regularly venture into the crocodile areas for collecting fish and are sometimes being attacked by crocodiles. Against crocodile attacks the locals opportunistically killed crocodiles and destroyed their nests because of the danger they posed and the damage they caused to fishing nets. It is suggested that good land-use planning, a long-term solution to many conflicts, is particularly relevant in Mozambique, where crocodile populations of protected areas are often in rivers that boarder these areas, and cause conflicts outside them, and where people commonly live within protected areas. Poverty may prompt fishermen to risk crocodile attack by entering rivers or lakes.

In the Chambal River indigenous crocodiles are once again abundant due to conservation and management programmes. In addition human population in different riverside villages has been increased and they and their livestock depend heavily on the river. The recovery of crocodile population and increase in human population has resulted in substantial levels of human-crocodile conflict. Conflicts between humans and wild animals are as old as the co-existence between them. They occur in all continents only varying in typology and circumstances. When human-wildlife conflicts occur, negative media reporting often exacerbates negative perceptions of the general public towards those species which cause the most conflict such as the crocodile (Chomba, *et. al.* 2012). The increased and progression loss of natural habitats and biodiversity have probably exacerbated human-wildlife conflicts and may continue in future as communities continue to ignore the need to comply with the provisions of General Management Plans in regulating human settlements. The ignorance on the general behavior of crocodiles coupled with the inability to detect crocodiles in water aggravate the conflicts. According to Chomba *et. al.* (2012) crocodiles live very close to humans without being detected. This factor together with the inability to detect crocodiles by people may be responsible for high incidences of crocodile attacks on humans and livestock. Many crocodile attacks may additionally go unnoticed and unreported, since at times, human or livestock may be stealthily taken when a person is alone or livestock is not accompanied by a person.

The findings of this study indicate that major habitats of crocodiles are under pressure due to increase in human activities. The major threat at present is habitat loss due to human encroachment, and disruption of populations through fishing and other hunting activities. In the present study it is observed that due to Crocodile-human conflict relationships between local communities and wildlife authorities is not cordial. Locals consider that crocodile programmes in the Chambal River are major obstacles for poverty alleviation as they depend primarily on the river for livelihood and Government restricts use of resources for crocodile conservation.

Acknowledgements

We are thankful to Madhya Pradesh Forest Department for permission to conduct research activities in the National Chambal Sanctuary. We are also thankful to the Administration of Jiwaji University, Gwalior for necessary support. Different funding agencies like UGC, MOEF and GCA supported the research. We are extremely thankful to the field staff in the Sanctuary particularly Dr. R.K. Sharma and Mr. Sukhdev for local support in the field and also sharing information on gharial population.

Literature cited

01. Aust, P. (2009). The crocdile conflict in north estern Namibia.www.news-namibia.org/april 2009/ crocodiles.

02. Chomba,C.; Senzota, R.; Chabwela,H.; Mwitwa, J.; and Nyirenda, V. (2012). Patterns of human wildlife conflicts in Zambia, causes, consequences and management responses. *J. Ecol. and the Nat. Env*. 4(12): 303-313

03. Deutsch, M. and Coleman, P. (eds.) (2000). The handbook of conflict resolution: Theory and practice. San Francisco: Jossey-Bass.

04. Dunham, K.M.; Ghiurghi, A.; Cumbi, R. and Urbano, F. (2010). Human- wildlife conflict in Mozambique: a National perspective, with emphasis on wildlife attacks on humans. *Oryx*, 44:185-193.

05. Fergusson, R.A. (2010). Nile crocodile *Crocodylus niloticus* in crocodiles.*Status Survey and conservation Action Plan.* Third Ed. S.C. Manolis and C. Stevenson pp 84-89.

06. Hussain, S.A. (2009). Basking site and water depth selection by gharial *Gavialis gangeticus*Gmelin, 1789 (Crocodylia, Reptilia) in National Chambal Sanctuary, India and its implication for river conservation.

07. Langley, R.L. (2005). Alligator Attacks on Humans in the United States.*Wilderness and Environmental Medicine,* 16, 119 124.

08. Mendis, R. (2012). Coping with Human Crocodile Conflict and Hosting Global Crocs Confab. http://dbsjeyaraj. com/dbsj/ archives/ 10974.

09. Rao, R.J. (1989). India (Gharials, National Chambal Sanctuary*). Crocodile Specialist Group Newsletter*. 8: 3-5.

10. Sharma, R.K. (1991). Detailed chemical study on the egg of Gharial (*Gavialis gangeticus*) (Gmelin) (Reptilia, Crocodilia) with reference to environment**.**Ph.D. thesis, Jiwaji University, Gwalior.

11. Singh, L.A.K. (1985). Gharial Population Trend in National Chambal Sanctuary with notes on radio-tracking. Study Report. Crocodile Research Centre, *Wildlife Instituteof India*, Hyderabad.167 vii pp with 3 plates, 10 Figs., 21 tables.

12. Udgata, H.B. (2011). Man-Wild Animal Conflict in Orissa. Orissa River: February-March: 59-63.

13. Webb, G. (2012). Crocodile culls won't solve crocodile attacks.http://theconversation.edu.au. December 2012.

14. Whitaker, N. (2007). Survey of Human/Crocodile Conflict in India, Maharashtra State, December 2007. Available at:www.iucn.org//ph1/modules/Publications/reports.html.

15. Whitaker, N. (2008). Survey of Human-Crocodile Conflict in Gujarat and Rajasthan: Trial of Conflict Mitigation Education Materials and Further Information on Conflicts. Available at: www.iucncsg.org/ph1/modules/Publications/ reports.html.

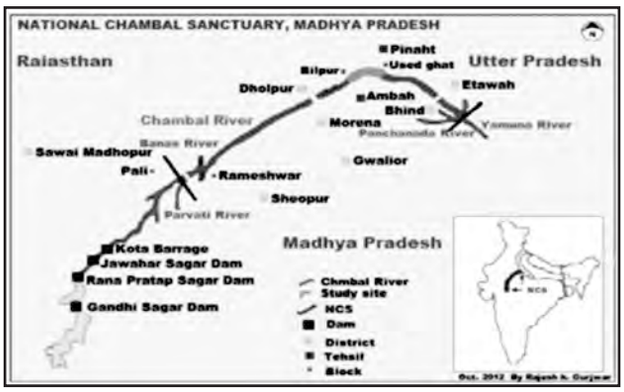


Fig.1. Map of National Chambal Sanctuary showing multipurpose dam on the upper stream, Tributaries and study sites in the present study.

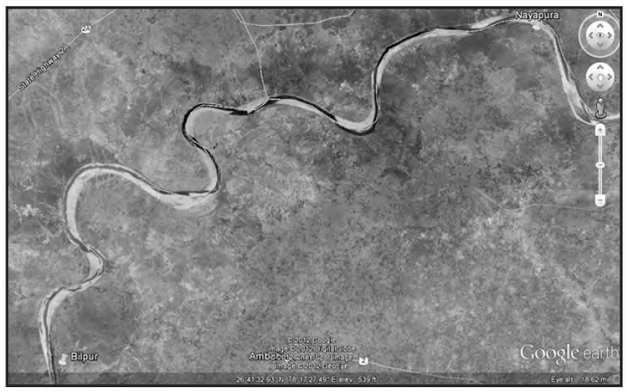


Fig. 2. Map of study area in the National Chambal Sanctuary

Fig. 3. Crocodiles (Gharial and mugger) basking in the Chambal River

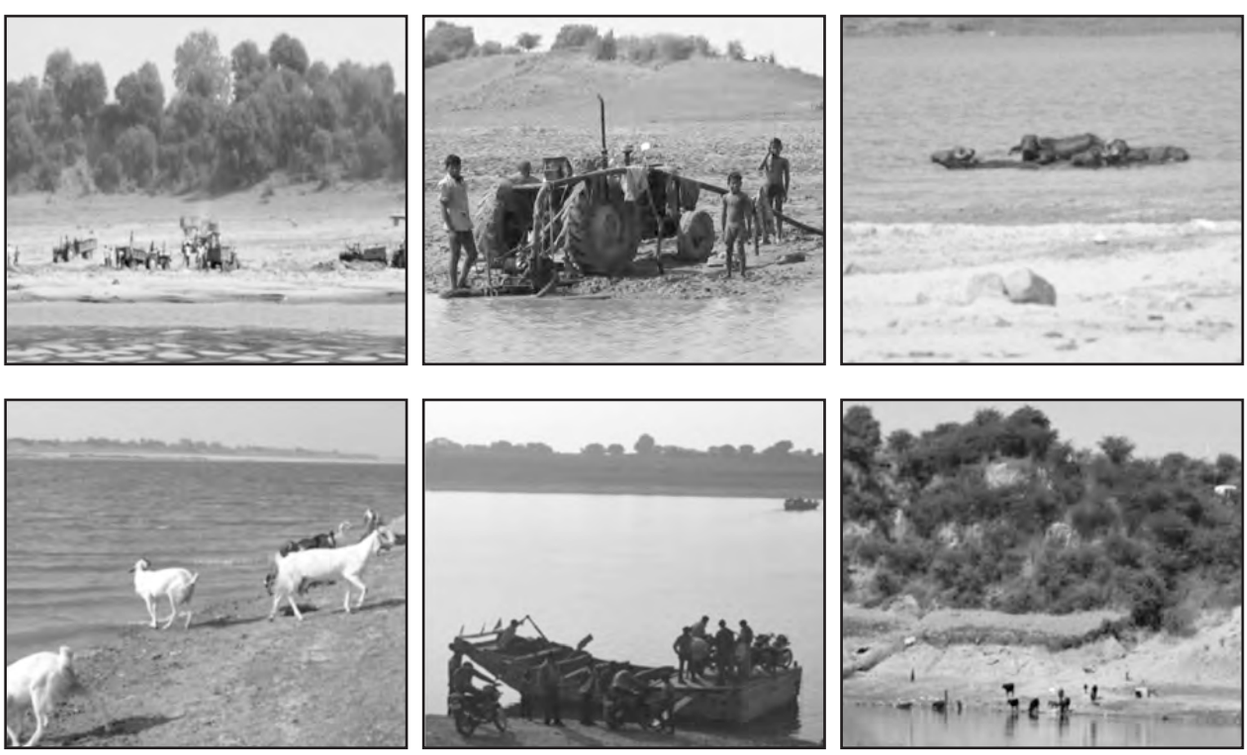


Fig. 4. Human activities (sand mining and water extraction) on the river banks

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 110 - 113

An analysis of crocodilian attacks worldwide for the period of 2008 - July 2013

Brandon M. Sideleau[1,2] and Adam R.C. Britton[3]

[1] 2900 Bayham Circle, Thousand Oaks, California | [2]Corresponding Author, Email: BSideleau@gmail.com | [3]Big Gecko Crocodilian Research, McMinns Lagoon, Northern Territory, Australia

Abstract

Attacks on humans by crocodilians have been documented reasonably well in developed countries in the last few decades. Conversely, attacks in developing countries are typically poorly documented despite those countries holding the highest frequencies of crocodilian attacks. Here we present the results of an analysis of 1237 crocodilian attacks resulting in 674 fatalities worldwide for the period of January 2008 through July 8th, 2013. Attacks were recorded from 15 crocodilian species and fatal attacks were recorded from 7 of those 15 crocodilian species. 494 attacks resulting in 285 fatalities were recorded for *Crocodylus porosus* (problem areas identified for the species include East Timor, Sumatra and East Kalimantan of Indonesia, Sarawak of Malaysia, Orissa of India, and coastal Sri Lanka), 428 attacks resulting in 309 fatalities for *C. niloticus*, 98 attacks resulting in 50 fatalities for *C. palustris* (mostly from India, particularly within Gujarat state), 69 attacks resulting in 13 fatalities for *C. acutus* (problem areas were the Pacific Coast of Mexico, Costa Rica and Panama), 36 attacks resulting in 9 fatalities for *Melanosuchus niger* (mostly from the Amazonas state of Brazil), 8 attacks resulting in 4 fatalities for *Tomistoma schlegelii*, 16 attacks resulting in 2 fatalities for *C. moreletii* (with the most severe cases coming from the Tamaulipas state of Mexico), 47 attacks resulting in no fatalities for *Alligator mississippiensis*, and 33 non-fatal attacks for 7 other species (*C. johnstoni*, *C. siamensis*, *C. mindorensis*, *C. intermedius*, *Caiman yacare*, *C. latirostris*, and *C. crocodilus*); in 8 attacks (2 of them fatal) the species responsible was undetermined (could have been either of two species present in the area). Issues encountered included a paucity of attack data being available from much the *C. niloticus* range and some of the *C. porosus* range (e.g. New Guinea, Solomon Islands), as well as information disappearing from online news archives over time resulting in a loss of records prior to when we began compiling the database. We began compiling our data in 2010, thus there is a slightly less amount of data available for 2008 and 2009 due to this loss of online reports. Attack data were compiled from a number of sources including online media reports, local wildlife officials, crocodilian experts, and relevant recent publications.

Species Reports

Crocodylus porosus

494 attacks resulting in 285 fatalities were attributed to *C. porosus* during the study period; *C. porosus* was responsible for 39.9% of all reported crocodilian attacks and 42.3% of all reported crocodilian fatalities. Indonesia was the location of the highest amount of conflict with 211 attacks resulting in 107 fatalities. Provinces with the highest numbers of attacks were East Kalimantan (35 attacks, 22 fatal), South Sumatra (22 attacks, 16 fatal), Bangka-Belitung (26 attacks, 8 fatal), East Nusa Tenggara (22 attacks, 11 fatal), and Riau (16 attacks, 8 fatal). Other countries with a high level of *C. porosus* - human conflict were East Timor (31 attacks, 26 fatal), Malaysia (57 attacks, 32 fatal), India (54 attacks, 31 fatal), Papua New Guinea (50 attacks, 40 fatal), and Sri Lanka (21 attacks, 12 fatal); it is important to note that in some areas (particularly the entire island of New Guinea) data regarding attacks is very limited and thus the number of attacks reported is likely much lower than the number that have occurred. In Papua New Guinea the vast majority of our data has been provided by Dr. Valerie Archer of Kikori District Hospital in Gulf Province; according to Dr. Archer, attacks are just as frequent in the Western province (Fly River region) and likely other areas (such as the Sepik/Ramu River regions) but that no data were available from these regions. It also appears to be highly likely the attacks within the Solomon Islands are underrepresented in our database due to a lack of reporting to the media. Australia, although home to one of the largest existing *C. porosus* populations, has a fairly low fatality rate (29 attacks, 8 fatal; 27.6%) compared to the rest of the *C. porosus* range (59.6%); the reason for this is unknown, although it may be related to better access to medical care and perhaps the smaller size of the attacking crocodiles. We also cannot discount the possibility that the media is biased towards reporting fatal attacks, and thus many non-fatal attacks may go unreported within developing regions.

Crocodylus niloticus

428 attacks resulting in 309 fatalities were attributed to *C. niloticus* during the study period; *C. niloticus* was responsible for 34.6% of all reported crocodilian attacks and 45.8% of all reported crocodilian fatalities. Collecting attack data for *C. niloticus* is problematic since most attacks occur in areas with little or no reporting occurring; in areas like Malawi attacks frequently occur along Lake Malawi and the Shire River and they are very rarely reported (Bruce Carruthers *pers. comm.*). Getting an estimate for the number of people killed by *C. niloticus* every year is very difficult; we know that at the very least dozens of people are killed in Mozambique and Uganda every year and the situation could be similar in

other areas that have little reporting (such as Somalia, Ethiopia, Burundi, etc.). The small amount of data available suggests that the species is responsible for far more attacks on humans than all other species, but little else is known.

Crocodylus palustris

98 attacks resulting in 50 fatalities were attributed to *C. palustris* during the study period; *C. palustris* was responsible for 7.9% of all reported crocodilian attacks and 7.4% of all reported crocodilian fatalities. The majority of these attacks occurred within India (83 attacks, 43 fatal) followed by Sri Lanka (11 attacks, 4 fatal) and Nepal (4 attacks, 3 fatal); no attacks were reported from Iran or Pakistan. Problem areas within India included Gujarat state (particularly around Vadodara city) (21 attacks, 14 fatal), Uttar Pradesh state (16 attacks, 4 fatal), Karnataka state (7 attacks, 5 fatal), and Madhya Pradesh state (9 attacks, 4 fatal). It is unknown if more *C. palustris* attacks occurred in Nepal but went unreported to the media.

Crocodylus acutus

69 attacks resulting in 13 fatalities were attributed to *C. acutus* during the study period; this makes *C. acutus* responsible for the highest percent of reported attacks (46.6%) and fatalities (54.2%) within Latin America, but still a fairly low fatality rate (18.8%) compared with four of the Old World species. The highest number of *C. acutus* attacks were reported from Mexico (37 attacks, 2 fatal), Costa Rica (14 attacks, 5 fatal) and Panama (8 attacks, 3 fatal). Problem locations in Mexico include Jalisco state (particularly around Puerto Vallarta) (9 attacks, 1 fatal), Quintana Roo (particularly around Nichupte Lagoon in Cancun) (7 attacks, all non-fatal), and Oaxaca (4 attacks, 1 fatal). Although the site of the most fatal attacks, the frequency of attacks within Costa Rica has dropped significantly in recent years; 71.4% of attacks and all fatalities occurred between 2008 and 2010.

Crocodylus moreletii

16 attacks resulting in 2 fatalities were attributed to *C. moreletii* during the study period. Attacks for this species were reported from Mexico (11 attacks, 2 fatal), Guatemala (3 attacks, all non-fatal) and Belize (2 attacks, both non-fatal). The majority of the Mexican attacks (8 of the attacks and both fatalities) were reported from extreme southern Tamaulipas state (Altamira, Tampico and Madero City municipalities). The first fatal attack occurred in 2008 at Contadero Lagoon in Altamira; it involved a fisherman bleeding to death after being bitten in the leg. The second fatal attack also occurred in 2008, this time at Carpintero Lagoon in Tampico city; in this incident an intoxicated man was reportedly dragged into the lake by multiple crocodiles in front of a crowd of onlookers after attempting to "pet" one of them. His body was later recovered intact without any sign of consumption by the crocodiles.

Crocodylus johnstoni

Six attacks, all of them non-fatal, were attributed to *C. johnstoni* during the study period; four of the attacks were reported from Western Australia and two of the attacks from the Northern Territory. The first WA incident occurred in 2009 when a woman was attacked while swimming within the Throssel River (Hines and Skroblin 2010) and the second WA incident also occurred in 2009, this time at Lake Argyle which is known to have one of the largest *C. johnstoni* populations in existence; this incident involved a man swimming in the lake and was apparently unprovoked (Somaweera 2011). The third WA incident occurred in 2012 at Ivanhoe Crossing on the Ord River; a teenage boy was attacked while in waist-deep water, this incident was initially logged as a *C. porosus* attack, but it has since been confirmed to have been C. *johnstoni* (Ruchira Somaweera *pers. comm.*). The fourth and final WA incident occurred in 2013 at Slatey Creek Gorge; a woman was attacked by the crocodile while swimming within a waterhole. The first NT incident occurred in 2009 in an upstream portion of the Adelaide River populated by *C. johnstoni* (rather than *C. porosus*, which is abundant along much of the Adelaide River) (Charlie Manolis *pers. comm.*); only minor injuries were inflicted on the victim. The second NT incident occurred in 2012 along the Daly River, the female victim had been hunting for turtles and may have unintentionally provoked the crocodile; she sustained severe injuries to one of her hands during the attack, nearly resulting in the loss of one of her fingers.

Crocodylus siamensis

Two non-fatal attacks were attributed to *C. siamensis* during the study period and in both cases it appears as though the attacks were defensive in nature and may have involved provocation. The first incident took place within Cat Tien National Park of Vietnam in 2008; apparently a man had been illegally fishing within the park and was attacked by a crocodile that may have been defending her hatchlings (Heng Sovanarra *pers. comm.*). The second incident took place in 2012 at Lake Mesangat in East Kalimantan of Indonesian Borneo; in this incident a fisherman may have unintentionally provoked the crocodile into attacking him while attempting to retrieve a stuck fishing line from a log. Both *T. schlegelii* and *C. siamensis* are present within the waters of Lake Mesangat, but the crocodile responsible in this case is believed to have been *C. siamensis* (Agata Staniewicz *pers. comm.*).

Crocodylus mindorensis

Two attacks, both of them non-fatal, were attributed to *C. mindorensis* during the study period; both attacks occurred within the San Mariano municipality on the island of Luzon in 2010. The first incident involved a pregnant woman bathing at Dinang Creek in barangay Cadsalan; she sustained severe leg wounds during the attack but recovered. The second incident involved a man fishing within the Catalangan River of barangay Dibuluan; it is has been suggested that he may have been "electro-fishing" and that the crocodile attacked him in response, but this has not been confirmed (van der Ploeg*et al.* 2012).

Crocodylus intermedius

Only one non-fatal attack was detailed for *C. intermedius* during the study period, although one other non-fatal attack is reported to have occurred within the same area. The report comes from the La Palmita town along the Cojedes River in 2009; the attack was quite severe, involving a fisherman losing his lower right leg to a large crocodile during the attack (Barrio-Amoros 2012).

Tomistoma schlegelii

Eight attacks resulting in four fatalities were attributed to *T. schlegelii* during the study period, all of them occurring within Indonesia; since this species is sympatric with *C. porosus* in many areas, attacks were only attributed to it when the species was specifically mentioned as the attacking crocodilian or when expert advice suggested the species was more likely to be responsible than the more dangerous *C. porosus*.

Two fatal attacks occurred within Central Kalimantan province of Indonesian Borneo, both in late 2008; in one of these incidents a large (4 meter +) *T. schlegelii* was killed and the remains of the victim were retrieved from its stomach. Two attacks, one of them fatal, occurred within the East Kalimantan province; the non-fatal incident took place in 2011 along the upper reaches of a river typically known for *C. porosus* attacks (the Sangatta River), but the victim specifically identified the attacking crocodilian as "buaya supit" (one of the local names for *T. schlegelii*, translates as "chopstick crocodile"). The fatal East Kalimantan attack occurred along the upper reaches of the Belayan River in 2010 and it has been stated that the species responsible was *T. schlegelii* (Rob Stuebing *pers. comm.*).

Within the Jambi province of Sumatra one non-fatal attack was attributed to the species in 2012; while *T. schlegelii* was not specifically mentioned in the attack article, the circumstances and location of the attack are more suggestive of that species, rather than *C. porosus*. The incident began when a man accidentally speared the crocodilian, which had been lying at the floor of a swamp, mistaking it for "labi-labi" (a soft-shelled turtle that often shares habitat with *T. schlegelii*) (Rob Stuebing *pers. comm.*). The crocodilian attacked in retaliation, seriously injuring the man. Within the Riau province of Sumatra two non-fatal attacks were reported from along the Air Hitam River of Rokan Hulu Regency in 2010 and 2013; in these cases the species was identified as *T. schlegelii* by the victims and witnesses. A single fatal attack was reported from the Rokan River near Rimba Melintang in 2010; initially we attributed this attack to *C. porosus* since both of the species inhabit this area, but following the attack a large *T. schlegelii* was killed (the reports claimed 5.5 meters in length) and "human-like" bones were recovered from its stomach.

Alligator mississippiensis

47 attacks, all of them non-fatal, were attributed to *A. mississippiensis* during the study period; all bites, even very minor and provoked incidents, are reliably recorded throughout the range of *A. mississippiensis*, so the reported number of non-fatal attacks is much higher. Many attacks by the species are provoked or defensive in nature and unprovoked attacks are fairly rare. Fatal attacks by *A. mississippiensis* are very rare, with none occurring since prior to the study period in 2007.

Melanosuchus niger

36 attacks, resulting in 9 fatalities, were attributed to *M. niger* during the study period; Brazil held the highest number of reported attacks (29) and all of the reported fatalities, but non-fatal attacks were also reported from Peru (3 attacks), Ecuador (3 attacks) and Guyana (1 attack). More attacks, including some fatalities, have also occurred within Guyana, but no details have been made available (Peter Taylor *pers. comm.*); officials within French Guiana state that no attacks by *M. niger* have occurred there (Beniot de Thoisy *pers. comm.*). Within Brazil the highest number of attack reports came from Amazonas state (24 attacks, 6 fatal), followed by Acre state (2 attacks, 1 fatal), Rondonia state (2 attacks, 1 fatal), and Amapa state (1 fatal attack). It is possible that attacks have gone unreported within remote portions of Brazil or in other parts of the range of *M. niger* (e.g. Bolivia).

Caiman crocodilus

15 attacks, all of them non-fatal, were attributed to *C. crocodilus* during the study period; attacks were reported from Brazil (8 attacks), Colombia (5 attacks), Suriname (1 attack), and Trinidad (1 attack). Four of the attacks were reported to have been provoked by the victim, although it is possible that some of the other attacks may have as well. In 2013 two attacks occurred at Campo Maior Dam of Piaui state within a 2 month period.

Caiman yacare

Five non-fatal attacks were attributed to *C. yacare* during the study period, two in Argentina and three in Brazil. The first and most severe attack occurred in 2008 at a dam in Ingeniero Juarez in the Formosa province of Argentina; in this incident a young boy lost one of his feet to the caiman. The second Argentinean incident took place along the Paraguay River in 2012; very little detail is available for this attack but it involved a fisherman being bitten. The first Brazilian incident occurred in 2011 along the Paraguay River within the Pantanal; a fisherman was attacked by a 1.5 meter caiman while cleaning fish along the edge of the river (Neto, Stolf and Haddad 2013). The second Brazilian incident took place in 2012 along a river within the Pantanal of Mato Grosso do Sul; a man was attacked by a caiman while walking along the Taquari River in the Pantanal. The third Brazilian incident occurred in 2013 along the Cuiaba River of Mato Grosso state; a man was attacked by a caiman estimated to be around 1.5 meters in length while attempting to retrieve his stuck fishing line from the river.

Caiman latirostris

Two non-fatal attacks were attributed to *C. latirostris* during the study period; both attacks occurred in Brazil and in both cases the caiman was unintentionally provoked by the victim. The first incident took place in 2009 within the Jaguaribe River of Paraiba state; a man accidentally stepped on the caiman while net-fishing. The second incident took place in 2011 within the coastal waters of Illha do Mel (Honey Island) in Parana state; a fisherman accidentally stepped onto a caiman mistaking it for a log.

Literature Cited

01. Barrio-Amoros, C.L. (2012).Orinoco Croc Encounters. Reptiles Magazine February 2013: 48-53.

02. de Campos Neto, M.F., Stolf, H.O. and Haddad Jr., V. (2013). Ataque de jacare a pescador no Pantanal de Mato Grasso (Brasil): relato de caso. Diagn Tratamento 18 (1): 21-23.

03. Hines, K.N. and Skroblin, A. (2010). Australian Freshwater Crocodile (*Crocodylus johnstoni*) Attacks on Humans. Herpetological Review 41 (4): 430-433.

04. Somaweera, R. (2011). A report of a probable unprovoked attack by an Australian freshwater crocodile at Lake Argyle in Western Australia. Zoologist Vol. 35 (4): 973-976.

05. van der Ploeg, J. Cauilan-Cureg, M., Koopmans, F., Balbas, M., van Weerd, M., and Arano, R. (2012). Philippine crocodile attacks on humans in the Northern Sierra Madre. Crocodile Specialist Group Newsletter Vol. 31 (2): 20-23.

Human-Crocodile conflicts in Andaman and Nicobar Islands - a case study

C. Sivaperuman[1] and S. Senthil Kumar[2]
[1] Zoological Survey of India, Andaman & Nicobar Regional Centre, Port Blair - 744 102, A & N Islands
(c_sivaperuman@yahoo.co.in) |[2]Department of Environment and Forest, Andaman & Nicobar Administration, Port Blair - 744 102, A & N Islands

The Andaman and Nicobar Islands comprises of 572 islands, islets and rocky outcrops and is located between 06º and 14º N Latitudes and 92º and 94º E Longitudes in the Bay of Bengal. The archipelago has a total land area of 8293 km^2 and a coastline of 1962 km. The Saltwater Crocodile *Crocodylus porosus* (Schneider) is a common species throughout the Andaman and Nicobar Islands. It can be encountered in the open sea, near the shore, mangrove creeks, freshwater rivers and swamps. Human-crocodile conflicts have been reported since early 1970s in these islands. About 26 crocodile attacks including 8 casualties have been reported between 1986 till date in the Andaman and Nicobar Islands. Recently, two people were killed at the famous Radha Nagar Beach in Havelock and Bakultala in Middle Andaman. The Department of Environment and Forests captured both the problem crocodiles and released into the mini zoo at Port Blair. In such a situation, removal of the problem crocodile might provide a temporary fix, but another male will eventually dominate the creek and may again be a threat to local people and tourists. Possible reasons for crocodile attack on humans include defending individual territories, attractive food-sources such as livestock and other domestic animals and dumping of high-protein waste food materials on banks or beach areas. Proper management of the crocodile populations to reduce human crocodile conflicts include training field staff in field survey techniques and capturing crocodiles, creation of awareness among local people and tourists by providing brochures, pamphlets, posters, through newspaper write ups on crocodile biology, behavior, ecology and organizing awareness workshops. The indigenous methods developed for capturing these crocodiles are discussed in detail in this paper.

An assessment of human-crocodile conflicts in Neyyar Wildlife Sanctuary, India

C. Sivaperuman[1] and E.A. Jayson[2]
[1] Zoological Survey of India, Andaman & Nicobar Regional Centre, Port Blair - 744 102, A & N Islands (c_sivaperuman@yahoo.co.in) | [2] Department of Wildlife Biology, Kerala Forest Research Institute Peechi, Thrissur, Kerala - 680 653, India

Human-crocodile conflict involving the Mugger crocodile *Crocodylus palustris (*Lesson) was studied in the Neyyar Wildlife Sanctuary, Southern India after 18 years of reintroduction. The Neyyar Dam was built in the Neyyar River in the early 1940s for the purpose of irrigation in the States of Tamil Nadu and Kerala with an extent of 8.45 km^2. The Neyyar Wildlife Sanctuary, declared in 1958, is situated in the Kerala State, southern India. The extent of the Sanctuary is 128 km^2 and lies between 8^o 17' and 8^o 53' North latitudes and between 76^o 40' and 77^o 17' East longitudes. The survey was carried out by structured questionnaire survey, interviewing the victims and also visiting the sites of attack.

Twenty-nine Mugger crocodiles were reintroduced into the reservoir in the year 1983 and crocodile attacks on livestock were reported from 1985 onwards. During the initial period of the study, 21 to 25 Mugger crocodiles were estimated but only 10 to 16 crocodiles were recorded towards the end of the study period as nine animals were removed from the reservoir to reduce the conflict. Twenty-nine crocodile attacks on humans were reported prior to the study and six occurred during the study period, including two fatalities. The attacks occurred over 26 km along the banks of the reservoir and followed previous patterns of attack behaviour. It was estimated that 2,808 houses exist in a 26 km long and 400 m wide belt on the bank of the reservoir. As local people utilise the reservoir for various purposes such as collection of drinking water, bathing, washing clothes, washing cattle, fishing and retting of coconut leaves, these communities have significant negative impacts on the crocodile population. It was suggested to monitor the crocodile population in the reservoir annually by conducting census during the months of April-May, which will assist in the proper management of crocodiles in future. Public awareness programmes may be initiated to educate the people on the precautionary measures required to live safely with crocodiles.

Human-Crocodile issues: Sarawak Report

Oswald Braken Tisen, Francis Gombek, Rambli Ahmad and Christopher Kri
Protected Areas & Biodiversity Conservation Division, Sarawak Forestry Corporation, Kuching Sarawak, Malaysia

Sarawak, the Malaysian state of Borneo, has 22 river basins. These river systems provide local communities with mode of transportation, water and food resources as well as being bastions to huge diversity of flora and fauna including estuarine crocodiles (*Crocodylus prorosus*). For most of the time crocodiles and humans co-exist peacefully but there had been instances of serious consequences when crocodiles and humans crossed paths. Sarawak records the highest crocodile attacks in the world with an average of 10 per year. These had resulted in repeated and emotional public and political outcries for the management authority in Sarawak to take swift actions. The Sarawak State Cabinet in an effort to pacify the populace had directed the crocodile management authority to carry out state-wide culling of the crocodiles. This paper presents the human-crocodile issues and highlights efforts to formulate the Strategic Crocodiles Conservation Plan for Sarawak.

Proceedings: **World Crocodile Conference**
22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group
pp 116 - 122

Study on *Crocodylus palustris* : co-existence of men, animal and population survey at Kheda Anand district in Gujarat, India

Jigar N Upadhyay[1] and Dr R K Sahu[2]
[1]B 1 Shreeji Baug Society, Nigam Soc. Rd, Nr Smruti Mandir,Ghodasar,Ahmedabad, Gujarat India.pincode:- 380050. jigarupadhyay@hotmail.com | [2]Zoo Superintendent(Now Director), Ahmedabad Zoo, Kankaria, Ahmedabad ,Gujarat, India pin code :-380022. rksahu63@gmail.com

Abstract

Present study is based on Population survey of *Crocodylus Palustris* and coexistence of men and animal in and around ten villages and 18 village ponds in Kheda and Anand District of Gujarat, India. Total 157 Mugger *Crocodylus palustris* were counted using day count method. The population comprised of 11 juveniles, 50 Sub Adults, 71 Adults and 25 Big size Mugger. The study was conducted during December 2011 to June 2012. Two instances of Human Crocodile conflict were recorded and people's approach towards coexistence was observed by interacting with them. The observations also include the basis of coexistence between men & animal, instances of man-animal conflicts, threats to Mugger and recommendations to reduce man animal conflict.

Introduction

The study area was 10 villages of Kheda and Anand District of Gujarat State in India and 18 village lakes were been observed for the population survey of *Crocodylus palustris.* These *Crocodylus palustris* population has been coexisting with men in these villages since times immemorial and their basis of Coexistence was the prime observation. The study also focuses awareness spread among people, Instances of man animal conflicts, suggestions to reduce man animal conflict (De silva 2011).

Conservation Status

Crocodylus palustris is also known as Mugger or Marsh Crocodile is in the Appendix I of CITES also listed a Vulnerable in IUCN Red list 2012.2.In Indian perspective *C.palustris* is protected under Schedule I in wildlife protection Act 1972.

Management Objective

Crocodylus Palustris has been always remained on the top list of attraction as along with its other peers. Mugger crocodile is principally restricted to the Indian subcontinent where it may be found in various freshwater habitat types including rivers, lakes, and marshes (Whitaker 1987, Whitaker & Whitaker 1989) So far in India a great amount of conservation work has been implemented by Government, various Zoos, and Other specialist Groups. Now Mugger population are increasing in many states of India and credit for this success lies with ex-situ conservation programme "Indian Crocodile Conservation Project (Singh 1999) and so does it flourishes in Gujarat State (Vijay Kumar 1997; Vijay Kumar et al. 1999a,b; Vyas 2008). The Management objective (Bayliss 1987) of this survey was to understand distribution of the *Crocodylus palustris* in the village lakes and the basis of Human Croc Conflict (Whitaker N 2008) as well as the approach of the people for co existence and suggestions for prevention of possible conflicts (De Silva 2008, 2010,2011).

Study Area

Study was done in two Talukas Matar & Sojitra belonging to Kheda & Anand district respectively. Where in Taluka is subdivision of a district and comprises several villages organized for revenue purposes.

Study area comprised of *Six*villages and 10 village lakes of Matar Taluka out of 10 talukas of Kheda District (http://nadiyaddp.gujarat.gov.in 2013). The district is situated between North22°.30' to 23°.18 latitude and East 72°.32 to 73°.37 longitude .The villages under study were Traj, Heranj, Nagrama, Marala, Tranja, Kathoda. Also *four* villages with 8 village lakes were studied from Sojitra Taluka one of eight Talukas of Anand District (http://ananddp.gujarat.gov.in 2013). The district is situated between 22° 6' to 22° 43' north latitude and 72° 2' to 73° 12' East longitude. Anand district is popularly known as *"Charotar".* In Gujarati, the word "Charutar" literally means a pot full of gold coins. The villages under study were Deva, Malataj, Dabhou and Maghrol of Sojitra Taluka. (Study area map Fig.1)

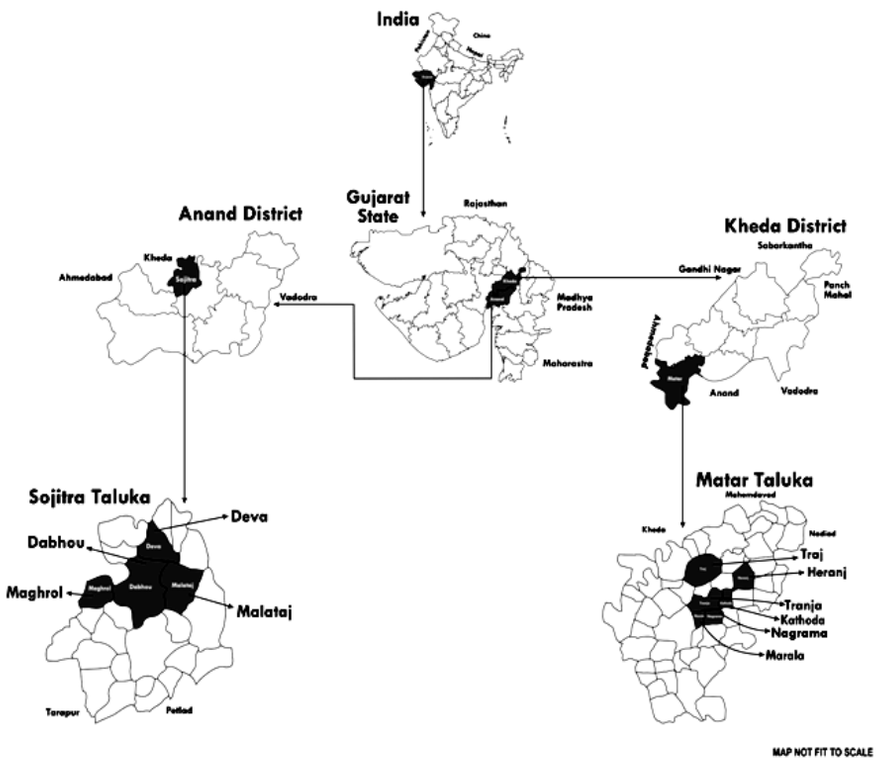


Figure 1. Study area map

Study Period

The study was conducted between December 2011 to June 2012. Each village study was divided into 10 days spread during the study period. Winter months, and pre summer seasons were selected as they are good times for counting crocodiles as in day time, they tend to bask in groups (Choudhary & Roy 1982)**(Fig.2)**

Figure 2. Group Basking Mugger Deva Village (Photo Jigar N Upadhyay)

Method

A reconnaissance of the entire area was done during the study period and Direct as well as indirect method were used for determining population of Mugger. From December 2011 till June 2012 the sites were observed by keeping a safe distance so as to avoid disturbance to the animals. A) Direct Method included day count observations done from 0600 hrs. to 1900 hrs. and basking(P. Dilip Venugopal &K. V. Devi Prasad 2007)observations were classified into Surface

bask, when the crocodile observed was on the surface of the water without any movement. Prebask, when half to two-thirds of the body was still in water and, Basking, when the crocodile was completely out on land, exposing the entire body .The sizes of crocodiles were estimated visually. B) Indirect method included observations of faecal pellets, den (Fig.3) or tunnel, tracks or tails and egg shells. With the periodical interactions with local people basking sites and human animal conflicts were been identified.

Figure 3. Presence of Mugger in Den or tunnel in Heranj Village. (Photo Jigar N Upadhyay)

Results

Total 157 Mugger *Crocodylus palustris* were counted .The population comprised of 11 juveniles, 50 Sub Adults, 71 Adults and 25 Big size *Crocodylus palustris.* During the study it was observed that Population of Mugger was highest in Deva Village (58) followed by Heranj village (41).Population count is categorised as:- juvenile <1>meters, Sub Adult <1 to2> meters, Adult <2 to 3> meters, Big Size >3 meters. Also Villages Nagrama-Marala has one common lake and Tranja-Kathoda also has one common lake. The result of the population count is mentioned Taluka wise i.e. Matar Taluka Villages (Table 1) Sojitra Taluka Villages (Table 2). Population count consolidated is mentioned for both Talukas (Table 3)

Table 1. Mugger Population Count at Matar Taluka. Kheda District

Name of Village	Lake & Coordinates	Size of Lake (In Hectares) 1 hectare=2.471 Acre	Number of Animals				Total
			Juvenile <1> Mtrs	Sub Adult <1 to 2> Mtrs	Adult <2 to 3> Mtrs	Big Size 3>Mtrs	
Traj	Gaam Talav 22°40'23"N 72°38'26"E	7.8 ha	2	5	4	1	12
	Irrigation Talav 22°40'22"N 72°38'52"E	14.2 ha	0	0	0	0	0
	Salaa Talav 22°39'29"N 72°37'51"E	64.15 ha	0	0	0	0	0
Total Count Traj (a)							**12**
Heranj	Chokadiya Talav 22°40'6"N 72°41'36"E	64 ha	0	5	14	4	23
	Gaam Talav 22°40'23"N 72°38'26"E	0.90 ha	3	4	3	2	12
	Lake 2 22°39'44"N 72°41'45"E	0.28 ha	0	2	0	0	2
	Lake 3 22°39'35"N 72°41'31"E	0.30 ha	0	4	0	0	4
	Paani Talavdi 22°39'46"N 72°41'32"E	0.30 ha	0	0	0	0	0
Total Count Heranj (b)							**41**
Tranja-Kathoda	Gaam Talav 22°40'23"N 72°38'26"E	93.5 ha	0	2	4	2	8
Nagrama-Marala	Gaam Talav 22°40'23"N 72°38'26"E	114.4 ha	2	4	6	3	15
Total Count (c)							**23**
Taluka Total (a+b+c)			**7**	**26**	**31**	**12**	**76**

Table 2. Mugger Population Count at Sojitra Taluka, Anand, District

Name of Village	Lake & Coordinates	Size of Lake (In Hectares) 1 Hectare=2.471 Acre	Number of Animals				Total
			Juvenile <1> Mtrs	Sub Adult <1 to 2> Mtrs	Adult <2 to 3> Mtrs	Big Size 3>Mtrs	
Deva	Kumbharyu Talav 22°37'16"N 72°44'33"E	1.1ha	0	0	0	0	0
	Andhariyu Talav 22°37'13"N 72°44'5"E	3.5ha	2	11	9	7	29
	Malav Talav 22°37'6"N 72°43'56"E	2.5ha	0	9	10	4	23
	Kana Talav22°36'45"N 72°43'54"E	1.6ha	2	0	4	0	6
Total (a)							**58**
Malataj	Gaam Talav 22°34'52"N 72°44'58"E	1.5ha	0	4	9	2	15
Dabhou	Mandirvalu Talav 22°34'56"N 72°42'59"E	5.23ha	0	0	4	0	4
	Gaam Talav 22°35'0."N 72°43'4"E	4.27 ha	0	0	2	0	2
Maghrol	Shakti Mata Talav 22°34'32"N 72°40'56"E	3 ha	0	0	2	0	2
Total (b)							**23**
Taluka Total (a+b)			4	24	40	13	**81**

Table 3 .Human Crocodile Population Details Matar & Sojitra Taluka

b Ã▒ ś h ź Taluka	b ĵ ▒ Lš'n¤ź Lakes	I ĵ ▒ Ă▬ Population of villages in study	bĵ ▒ Lš'nh ź ! ▪-▒ Ă▄				Ç¤ĊĂ▄ Mugger Count
			Ỿõś▪▟ <1> Mtrs	{ĵ L'! ŕĵ▄ <1 to 2> Mtrs	! ŕĵ▄ ▭و Ċ¤ 3> Mtrs	. ▟ {▟ŧś 3> Mtrs	
a ĂCĂn	ھو	ھي يو و	ي	ي و	وى	و و	ي ي
{▪▟ĊnĂ	ي	ھھولآو	ى	ى و	ھى	ى و	و ي
Ç¤ĊĂ▄	يو	ھيلآ ھى	و و	ھي	و ي	ي و	بيو

Detailed observations

C*rocodylus palustris* has adapted well to reservoirs, irrigation canals and man-made ponds (De silva and Lenin 2010) .Village lakes mentioned above are used by the villages for the day today activities . These lakes are also connected with the irrigation canals which may provide passage routes to the *Crocodylus palustris* to migrate during different situations(Vyas 2008).However the presence of *C.palustris* clearly defines the strength of the ecosystem with regards to the survival and breeding in the wild. A vivid range of water birds were also sighted .During the day hours when the village lakes waters are used by village people for their daily routine the crocodiles remain on distant shores of the lakes .All these lakes are used for the purpose of washing clothes (Fig.4), bathing ,and livestock movements as well as fishing. Generally these lakes are occupied by humans between 0900 hours to 1700 hours of the day. Nesting sites were been located in around almost each lake Which was a clear indicator of their successful breeding and hatchlings were also observed. positions of these nests and their distance from the water varied from one another (Bayani et.al. 2011). However the hatchlings have multiple threats for survival since these lakes are not monitored on periodical basis. Also most of the nests were found quiet nearer to the locations with human interactions.

Human Animal Conflict

There have been few instances of crocodile's attacks on livestock and stray dogs in theses villages but most of them unrecorded. While in Village Traj. Prior to study period One incident occurred on August 2009 first week when an adult crocodile attacked a 9 year old girl named Hetal Ode who was standing on the shore of village lake along with few geese. When people shouted the crocodile that caught the girl from the waist region got frightened and started swimming back and took the girl on the small island in the lake. By that time the girl lost her life, although immediately villagers came chasing the crocodile that had left the dead body on the land and flee away. Girl was taken to hospital and declared dead.

This aroused people's anger for the first time and some 7 to 8 crocodiles were removed from the lake with the Help of NGOs and Forest department. The crocodiles were shifted to Kevadiya colony dam a protected area for crocodiles. On discussion with locals and the family of the deceased girl, I was informed that the attack was mere an instance of mistaken identity or mis-predation. (Whitaker & Whitaker 1989) where the crocodile was actually preying on the Geese.

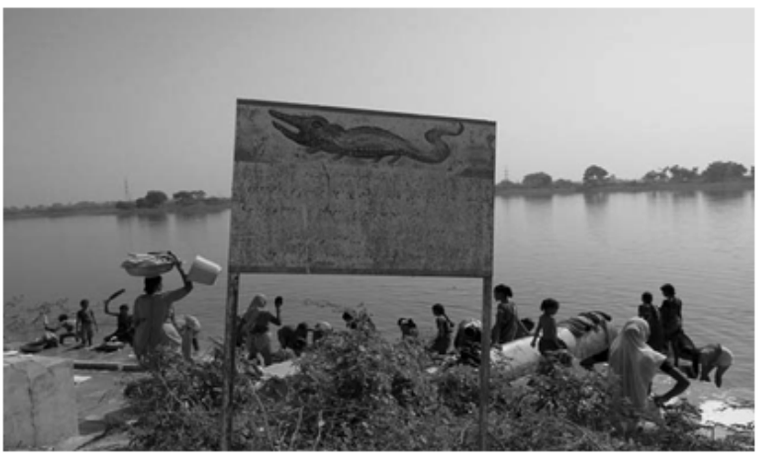


Figure 4. Use of Village Lake for daily routine activities Village Traj (Photo Jigar N Upadhyay)

Second instance took pretty three years too occur it was 3rd march 2012 when a Sub adult crocodile was caught in the fishing net of fishermen .And they tied the crocodile on the lake side so as to release it after removing the fishing nets. However few kids playing nearby got little more closure to the small crocodile and in that moment the animal attacked an 11 year old boy and injured him to 25 stiches on the leg. However with timely rescue the boy was saved and shifted to hospital.

Apart of above mentioned instances of Village Traj no other incidents were recorded at any other lake. Interestingly there had been no sign boards which were found informing about crocodiles presence in the lakes except few villages .All attacks occurred whereas there were no crocodile exclusion enclosures (De Silva 2008).

Major reasons for very few man animal conflicts revealed the fact that the villagers consider Crocodiles to be associated with their religious beliefs (Vyas R[8] 2003) and also the existence is been positively accepted. Another observation was that crocodiles were not provided any kind of offerings from villagers which was purely a reason for crocodiles remaining in their territories. Lakes being large enough can sustain families of crocodiles with sufficient food. Any kind of poaching or disturbance to *C Palustris* is strictly prohibited and this act is done voluntarily by the villagers. During the research it was clearly evident that human negligence leads to crocodile attack (De silva 2010). Awareness campaigns for the importance of crocodiles in the ecosystem were been conducted in small groups during this research.

Threat: Although the existence of *C.Palustris* is accepted by the villagers and as of now there seems to be no major threat of encroachments or poaching. Major threats that were identified during this study were related to possibility of accidental attacks on humans by *C. Palustris* since there are no safety measures kept. (Fig 5)

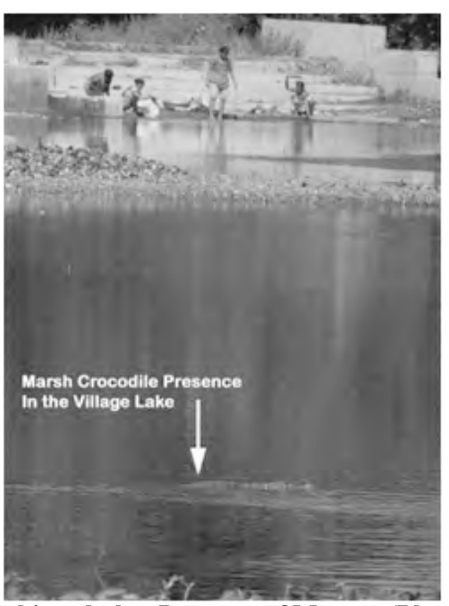


Figure 5. Women washing clothes Presence of Mugger (Photo Jigar N Upadhyay)

Apart of threats to humans, *C. palustris* in these lakes face following threats:-

a) Attacks on humans has resulted into low tolerance by people for coexistence with crocodiles.(Vyas R 2008)

b) Capturing and Reallocation of adult crocodiles to different locations. This might result into removing the breeding male or female and which can pose a threat on juveniles and hatchlings.

c) Fishing activities leading to trapping of the crocodiles i.e hatchlings, juveniles or sub adults which can also pose a threat of drowning in fishing nets (De Silva, 2008).

d) Since these lakes are connected with irrigation a major threat prevails for reduction in water levels. This leads to Crocodiles burrowing for maintaining temperature but simultaneously this can also pose a threat as chance of attacks might increase. Crocodiles might also move from these lakes and their migration might be hazardous for humans or animals.

e) Some of the lakes were observed with presence of Common Water Hyacinth (*E. crassipes*) along with other aquatic vegetation (Fig 6).

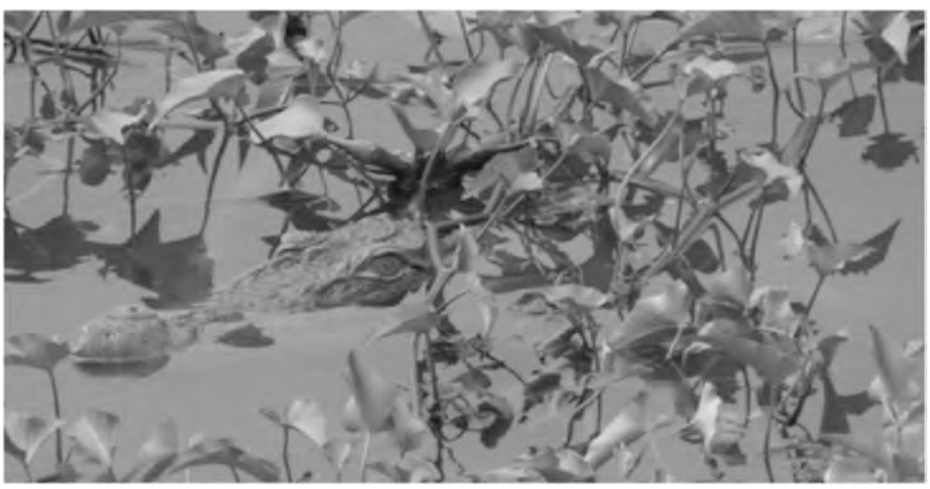


Figure 6. Aquatic Vegetation Village Malataj (Photo Jigar N Upadhyay)

Since their presence imposes a threat on many fishes also it might effect on the mobility of the *C palustris.*

Corrective measures required for eradication of above mentioned threats as this will effect a dignified presence of *C.palustris* in these lakes.

Recommendations

During the study following recommendations be proposed so as to conserve the Existence of C.palustris.

Implementation of an intense and detailed plan for the awareness of Importance of C.palustris to be conducted at villages.

1) Survey for the population Census to be conducted every year.

2) Village Lakes to be provided with properly designed Crocodile Exclusion Enclosures so as to eradicate future man animal conflicts.

3) Village lakes to be protected from encroachments.

4) Presence of Common Water Hyacinth (*E. crassipes*) and other aquatic vegetations to be controlled.

5) Fishing activities to be monitored and care should be taken to avoid entanglement of C.palustris in fishing nets by restricting areas with heavy mobility of C.palustris.

6) Ensuring proper water management in the village lakes during summer days so as to reduce migration of C.palustris in various nearby locations.

7) Strong coordinating approach to be implemented between Local wildlife enthusiasts, NGOs and Forest department.

8) Measures to ensure restriction on future possibility of poaching should be implemented.

The recommendations here are made with the due respect to the enormous efforts and understandings been displayed by the local villagers for conservation of C.palustris in their village lakes. The recommendations proposed here will create a benchmark in the field of conservation of C.palustris and will enhance the understandings of villagers in scientific manner. So as to strengthen their approach of "dignified Coexistence" with C.palustris.

Acknowledgement

We are very much thankful to the Villagers of all the villages mentioned above along with a special thanks to respective Gram Panchayats and their members for supporting us in this detailed observation. We thank Chief Conservator of Forests Social Forestry Circle Ahmedabad and entire forest department staff for their support .We are also thankful to Mr Anslem de silva for providing us guidance during different stages of this paper. A word of gratitude for Raju Vyas who provided his valuable inputs and insight for completion of the study.

Literature cited

01. Bayani,A.S.,Trivedi,J.N., and Suresh,B.(2011) Nesting Behaviour Of *Crocodylus Palustris* (Lesson) And Probable Survival Benefits Due To The Varied Nest Structures. *Electronic Journal of Environmental Sciences Vol. 4, 85-90 (2011)*

02. ISSN: 0973-9505 *(Available online at www.tcrjournals.com)*

03. Bayliss.P (1987) Survey Methods and Monitoring within Crocodile Management Programmes. Wildlife Management Crocodiles and Alligators.(Eds.Webb, G.J.W; S.C. Manoli & P.J. Whitehead).Surrey Beatty and Sons, Sydney. Pp. 157-175

04. Choudhary, B.C. and R.K. Roy.(1982). *Status survey of the crocodile population*. A field guide, Central Crocodile Breeding and Management Training Institute, Hyderabad, Andhrapardesh, India

05. De Silva, A (December 2011) Crocodiles in Sri Lanka: Historical Aspects, Threats and the Recent Re-awakening in Research, Awareness and Conservation. Wildlife December 2011 Vol. 7

06. De Silva, A (January 2011) Prevention of Crocodile Attacks In Sri Lanka some traditional methods. Crocodile Specialist Group News Letter Vol 30 No.1

07. De Silva, A. and Lenin, J. (2010). Mugger Crocodile *Crocodylus palustris.*Pp. 94-98 *in* Crocodiles.Status Survey and Conservation Action Plan.Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.

08. De Silva, A. (2010)**.** Crocodiles of Sri Lanka: Preliminary Assessment of their Status and the Human Crocodile Conflict Situation. (Report submitted after fulfilment of the project to Mohamed Bin Zeyed Species Conservation Fund) Author, Gampola: 49

09. *http://nadiyaddp.gujarat.gov.in/nadiyad/english/jillavishe/jilla-ni-samanay-ruprekha.htm Latest Access 9th May 2013*

10. *http://ananddp.gujarat.gov.in/anand/english/index.htm Latest Access 9th May 2013*

11. P. Dilip Venugopal & K. V. Devi Prasad (2003),Basking Behaviour of Marsh Crocodiles, *Crocodylus palustris* (lesson,1831) In Ranganthittu Bird sanctuary, Karnataka, India. *Hamadryad Vol 27 No 2 Copyright of Madras Crocodile Bank Trust 2003.*

12. Singh,L.A.K. (1999).Significance and achievements of the Indian Crocodile Conservation Project.*ENVIS (Wildlife and Protected Area). 2(1): 10-16*

13. Vijay Kumar, V. (1997).Evaluation of restocked mugger crocodiles and its implication in long-term conservation and management of the species in Gujarat, India.July, 1997.VII.Gujarat Institute of Desert Ecology, Patwadi Naka, Bhuj-Kachchh, Gujarat (Unpublished Report).

14. Vijaya Kumar, V., Vyas, R. and Choudhury, B.C. (1999a).Status of mugger in Gujarat state. Crocodile Specialist Group Newsletter 18(2): 7-8.

15. Vijaya Kumar,V., Vyas, R. and Choudhury, B.C. (1999b).Status of mugger and its conservation problems in Gujarat. Indian Crocodile Conservation Project; ENVIS (Wildlife & Protected Area) 2 (1): Wildlife Institute of India, Dehradun, June 1999: 69-76.

16. Vyas, R. (2008). Why muggers (Crocodylus palustris) are found at some of water bodies of Gujarat State? Crocodile Specialist Group Newsletter 27(1): 14-16.

17. Vyas, R (2008) Mugger (Crocodylus palustris) population in and around Vadodara city, Gujarat State India. Published in *Russian Journal of Herpetology Vol 17, No. 1 2010*

18. Whitaker, N. (2008)**.** Survey of Human-Crocodile Conflict in Gujarat and Rajasthan: Trial of Conflict Mitigation Education Materials and Further Information on Conflicts .Available at: www.iucncsg.org/ph1/modules/Publications/reports.html.

19. Whitaker, R. (1987). The management of crocodilians in India.In: *Wildlife Management: Crocodiles and Alligators* (Eds.Webb, G.J.W; S.C. Manoli & P.J. Whitehead). Surrey Beatty and Sons, Sydney. Pp. 63-72.

20. Whitaker, R. and Z. Whitaker.(1989). Ecology of Mugger crocodile. In: *Crocodiles: Their Ecology, Management and Conservation*. A special publication of the Crocodile Specialist Group.IUCN, Gland, Switzerland. Pp. 276-297.