

A Survey of the Abundance, Population Structure, and Distribution of Mugger Crocodiles (*Crocodylus palustris*) using day Ground Surveys in District Bhopal and its impact on Community



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Abstract

Mugger crocodile (*Crocodylus palustris*) are one of the planets oldest living creatures, thought to be around 200 million years old which means that crocodiles were around in dinosaur times. The Indian Maggar crocodile is a critically endangered species of freshwater Crocodylians were once abundant in many tropical waters around the world. The dangerous levels of exploitation came with the rise in demand for crocodile leather throughout the world especially in the European countries. Crocodiles were killed illegally every year to make wallets, shoes, handbags, and belts. With rising demand, hunters turned to more lethal methods. Using high-powered rifles, spotlights, and power boats, hide-hunters have pushed many species to the edge of extinction.

Mugger is common in many parts of India and is reported over 12 states. Presently the mugger population is estimated over 4,500+ in the wild, excluding 5000+ in captivity [1]. In the Pre-historic period only seven species resided in India, and the number has decreased to Due to hunting and habitat destruction, the Maggar population was reduced significantly. Now only three primary species: Mugger crocodile (*Crocodylus palustris*), estuarine (coast) crocodile (*Crocodylus porosus*) and Gharial (*Gavialis gangeticus*).

The reptile fauna of India consists of about 460 species; with 244 snakes, 178 lizards, three crocodiles, and 35 turtles. In the previously research study regarding Madhya Pradesh Publish in zoo print journal there are 01 crocodile, 01 Ghariyal, 11 turtle & tortoise, 32 lizard/Gecko/Agama/Skink 19 frog and 38 species, of snake [2]. In Madhya Pradesh first time preliminary assessment (survey) to know the population and habitat distribution of Maggar Crocodile was conducted in the aquatic bodies of the Bhopal city. Result of this study reported 1 Ghariyal & 12 Crocodile species The population of crocodile Estimated by interview method & Direct Day count, method in winter of 2017- 2018.

The area under Biotic pressure due to urbanization, tourism development project and local community. All aquatic bodies are traditionally used by local people for fishing, bathing, washing of cloths. activities resulted in shrinkage, degradation and destruction of natural habitat. Conclusion of study is given develop a method to estimated population, recognized the habitat for conserve the mugger Crocodile species in future and helpful to draw effective management plan.

Aims & Objective: The main objective of the proposed study is to conduct an assessment and determine the status/distribution of mugger crocodile (*Crocodylus palustris*) inhabiting the Bhopal region, investigate human-mugger crocodile interaction situation, promote activities for crocodile conservation and ultimately propose actions that should be taken to conserve the species in this region.

- a) To update the status of Mugger Crocodile through surveys, Study of habitat features and population structure behavioral biology including reproduction, thermo-regulation, feeding, water-orientation, locomotion etc.
- b) To protect and conserve the remaining population of crocodylians in their natural habitat and identify habitat that would be suitable for restoration.
- c) To identify the causes of declining Species status, To take-up research and
- d) use Finding for future Best and effective management.
- e) To build up Awareness among local people for conservation of Maggar Crocodile.

Status/Threats: The Mugger Crocodile is classified as Vulnerable (VU A1 a₂a) on IUCN Red Data list 2004 and is listed on Appendix I of Cites. The mugger crocodile greatly decreased in number until the early 1970s. Killing of the species for skins was the primary cause of their decline in India [3]. It was most vulnerable to this during years of drought when hunters could track and kill the animals more easily. Habitat

destruction and alteration was another primary cause of species loss. Many dam construction projects that occurred during the 1900s to the 1950s destroyed habitat by removing areas of deep water that provided good cover. Timber operations also destroyed habitat during this same time, by damaging forest ponds and rivers. Egg collection, hunting of crocodiles for meat and medicine, and death from fishing nets also have contributed to their decline [4] (Britton A, 1995). Throughout the 1960s, surveys indicated that numbers of the mugger crocodile were on a swift decline. However, conservation and restoration did not begin in earnest until 1972, when three crocodile species, including the mugger, the saltwater crocodile, (*Crocodylus porosus*) and the Gharial, (*Gavialis gangeticus*) were placed in IUCN's Red Data Book. Also, during this year, the mugger crocodile was included in the schedule for the Indian Wildlife Protection Act of 1972, [5]. This act provided for greater protection of habitat.

Keywords: Reptile; Diversity; Habitat; Endangered Species; Conservation; Protected Area; Population; Monitoring; Faunal diversity

Protection Status

The International union for conservation of Nature & Natural recourses (IUCN) Placed the Maggar Crocodile (*Crocodylis palustris*) as vulnerable under in Red data Book of endangered species in 1972 in Schedule - I given high degree protection.

Mugger Crocodiles (*Crocodylus palustris*)

Mugger are in some report Largest modern reptile back bone (vertebrate) cold blooded (depends on outside source for its body temp) lay shelled egg breath air (well develop long) four chamber hearts teeth filmy set in long flat jaws with their extraordinary range of body size. Due to Four chambered heart & well develop lungs they can also stay underwater for extended time because they can slow their heart rate; allowing them to hold their breath for longer. Crocodiles can see underwater due to a transparent lid that closes over their eye to protect it. They also have excellent night vision; due to a specialized retina; as well as a good sense of smell. Small sensory buds around the top and bottom jaws allow crocodiles to detect vibrations-crucial when hunting in murky water.

Crocodiles are large and skillful predators that hunt by stealth. Their muscular tail propels them through water and allows them to lunge forward with great power and speed. It can also be used to thrust them vertically to capture a bat or bird in mid-flight or in foliage. However; they cannot maintain strenuous activity for long periods and can easily become exhausted while capturing prey or fighting other crocodiles. Extreme exertion is done an aerobically (without oxygen) and must be followed by a period of rest so that the 'oxygen debt' can be repaid to their muscles. The result of anaerobic activity is a build-up of lactic acid in the blood. Although crocodiles can withstand higher levels of blood acidity than other animals; sometimes it can be fatal.

Mugger Crocodiles (*Crocodylus palustris*) scenario in India

Madhya Pradesh the land of diversity is one of the most exiting wild life destinations of India. The protected area (included National Park; Project Tiger and Sanctuary) in Madhya Pradesh is 14324.844 (in Sq. Kms). The reptile fauna of India consists of about 460 species with 244 species of snakes; 178 lizards; three crocodiles; and 35 turtles.

The mugger crocodile is a freshwater (Vulnerable) species found sparsely in various lakes; rivers and marshes in the Indian

subcontinent. They have also been found in reservoir irrigation cannels and other human made fresh water bodies [6]. Presence of crocodile is recorded in most parts of the India Mugger crocodile. The notable mugger population is recorded in Tamil Nadu; Kerala; Maharashtra; Goa; Uttaranchal; Uttar Pradesh; Orissa; Gujarat and Rajasthan. but presently in 12 states of India; the total population of crocodile population is estimated at 4000+ in Natural habitat as per inventory of Central Zoo Authority for the year 2016-17 in 23 states the captive population of 185 Males; 186 female and 2121 unknown i.e. total 2492 in captivity. [7] Central zoo authority of India; inventory; 2017-2018. The average mortality is 23.333 % and birth rate is 43.598 birthrate and mortality are show the draw the effective management to multiply pollution program.

Mugger Crocodiles (*Crocodylus palustris*) scenario in Madhya Pradesh

Three Crocodilians Species is a home many parts of India Mugger crocodile (*Crocodylus palustris*); Salt water crocodile (*Crocodylus palustris*) & Gharial (*Ganvialis gangeticus*) in which 1 species of Maggar crocodile (*Crocodylus Polustris*) and Ghariyal (*Ganvialis gangeticus*) are found in Madhya Pradesh. The Crocodile population in protected areas Management plan in Madhya Pradesh are very less in number Population & status data is not available in others working plan aquatic bodies eg. lake river pond lakes; dam nala; Nala stops dam of nearest local residents have direct and indirect evidence regarding presence of mugger different part of state in revenue area however; at present there is no effective management plan prepare for conservation of Mugger.

Apart from this there is 3 medium zoos in Madhya Pradesh. As per the central zoo authority inventory of zoo animals' analysis the data from 2011-2015 which reported there is 3 male; 4 female and 36 unknown gender crocodile in captivity (Table 1). The birth rate is 0.692% and the mortality is 3.889% due to which the mortality is greater than the birth rate shows that the management is not proper.

Table 1: Direct Sighting of Crocodile in Day basking Survey 2016 -2017.

Approximate in length (in meter)	Observed No.	%
< 02	1	0.14
3-Feb	4	0.56
> 03 above	2	0.42
	7	100

Ghariyal population scenario in Madhya Pradesh

Ghariyal (*Gavialis gangeticus*) the only survivor of the Gavialidae family is one of the most endangered crocodile in the world. The Madhya Pradesh Government has declared three sanctuaries for the conservation of crocodiles. They are:

- a) National Chambal Sanctuary
- b) Son Ghariyal Sanctuary
- c) Ken Ghariyal Sanctuary

In National Chambal Sanctuary sanctuaries habitat area (length x river width) is 128 Sq. kms with small patches of Ghriyal Habitat and as per survey of 2007 the total population is 208 adults. Son Ghariyal Sanctuary is 13.5 sq.km and the population is (survey 2006) more than 38 adults. With the best management practice the population of ghariyal will be increase.

In Van Vihar National Park/Zoo since from the year 1995-96 to 2017-18. According to table; the Captive population of the crocodiles (Mugger) in the Van Vihar National Park Zoo is declining. It is found that efforts have been taken up by bringing male dominant species for increasing the population in year 2012-13. This effort made by the Forest Officials is appreciated and fruitful but the causes behind the declination may be the proper site suitability; lack of management or environment for habitation of crocodiles in the zoo. It is also observed that the ratio of the male dominant is very less to negligible compare to female crocodiles. The present scenario states that only 10 male crocodiles were brought compare to female numbers 149 in total of past 23 years where the ratio is almost 1:15. To increase the population of crocodiles and conserve the life of the endangered species; it is suggested that the ratio of the dominant male compare to female must be 2:5 for the production in numbers. Training programs must be provided by introducing crocodile experts and

proper management has to be taken up by the National Park Zoo Authorities.

Material Method Study Area

The study area selected was aquatic bodies located in Bhopal city the state capital of Madhya Pradesh lay down between Latitude: 23° 15' 35.7588" N & Longitude: 77° 24' 45.4068" E; the total area of Bhopal is 285.9 km² & the population is 1,79,82,18.8 (As per India census 2011) The terrain of Bhopal is undulating and sildly hilly. The city was the capital of the former Bhopal State. Bhopal is known as the City of Lakes for its various natural as well as artificial lakes and is also one of the greenest cities in India. The Upper lake is a large lake which lies on the western side of the city have been built by the Paramara Raja Bhoj during his tenure as a king of Malwa (1005-1055). It is a major source of drinking water for the residents of the city; serving around 40% of the residents with nearly 30 million imperial gallons (140,000 m³) of water per day and Lower Lake is located to the east of the Upper Lake. An earthen dam separates the two lakes. 10 other aquatic bodies (Total areas is 43468863.95 selected for the Assessment of crocodile population status & distribution.

Equipment

- a. GPS (Garmin)
- b. Map of study area 1:50,000 with 30 second interval
- c. DCLR Camera (Nikon D-90)
- d. Binocular (7×10)
- e. Survey sheet (Questionnaire)
- f. Scale; Pen; Pencil with Nate book
- g. Vernier caliper (for dunk measurement)
- h. First aid kit

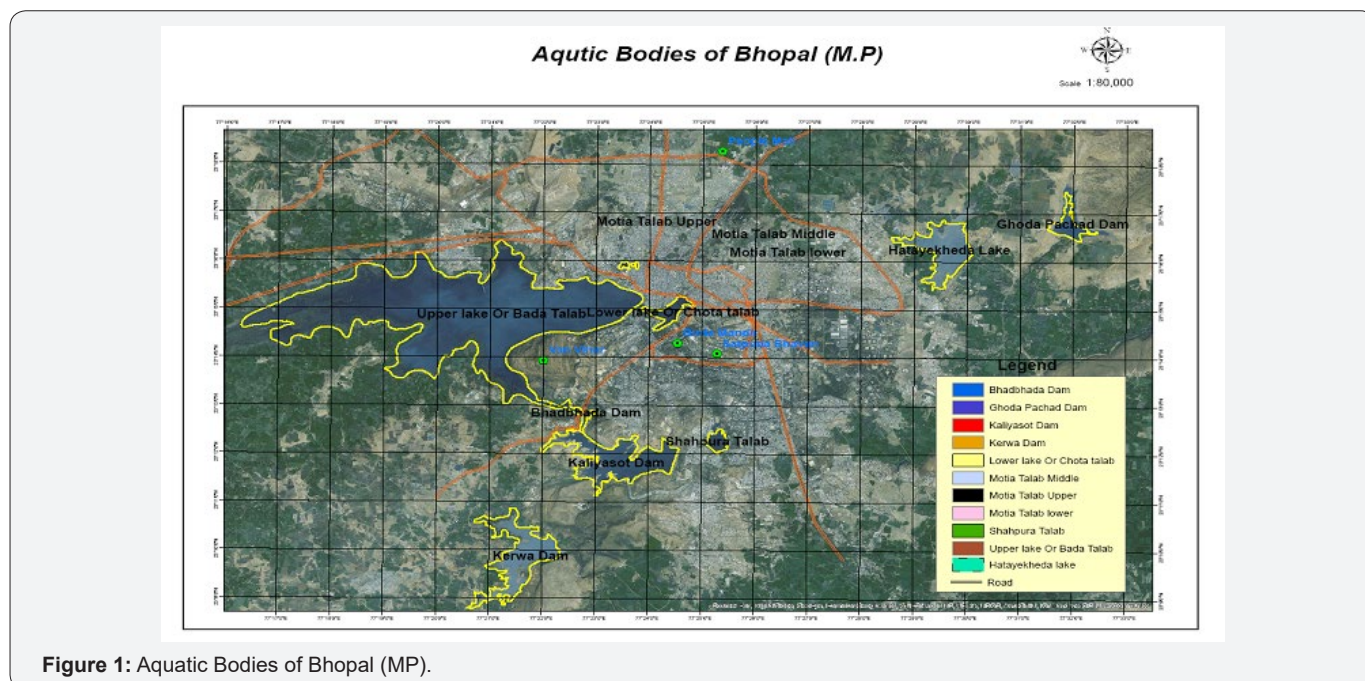


Figure 1: Aquatic Bodies of Bhopal (MP).

Based on Daily Newspaper and Media news Reporting crocodile rescue from aquatic body of Bhopal in first survey was carried out from 10 January to 13 January 2016 in result only 7 crocodile and 1 ghariyal is spotted. In year 2017 -2018 final survey

was carried out from 2 December to 31 December 2017 in the potential area by boat during the day time (10.AM to 1 .00 PM). for estimating Population of crocodile & their distribution by direct count method (Sun Basking Count Method) (Figure 1).

Primary Data Collection

Questionnaire survey

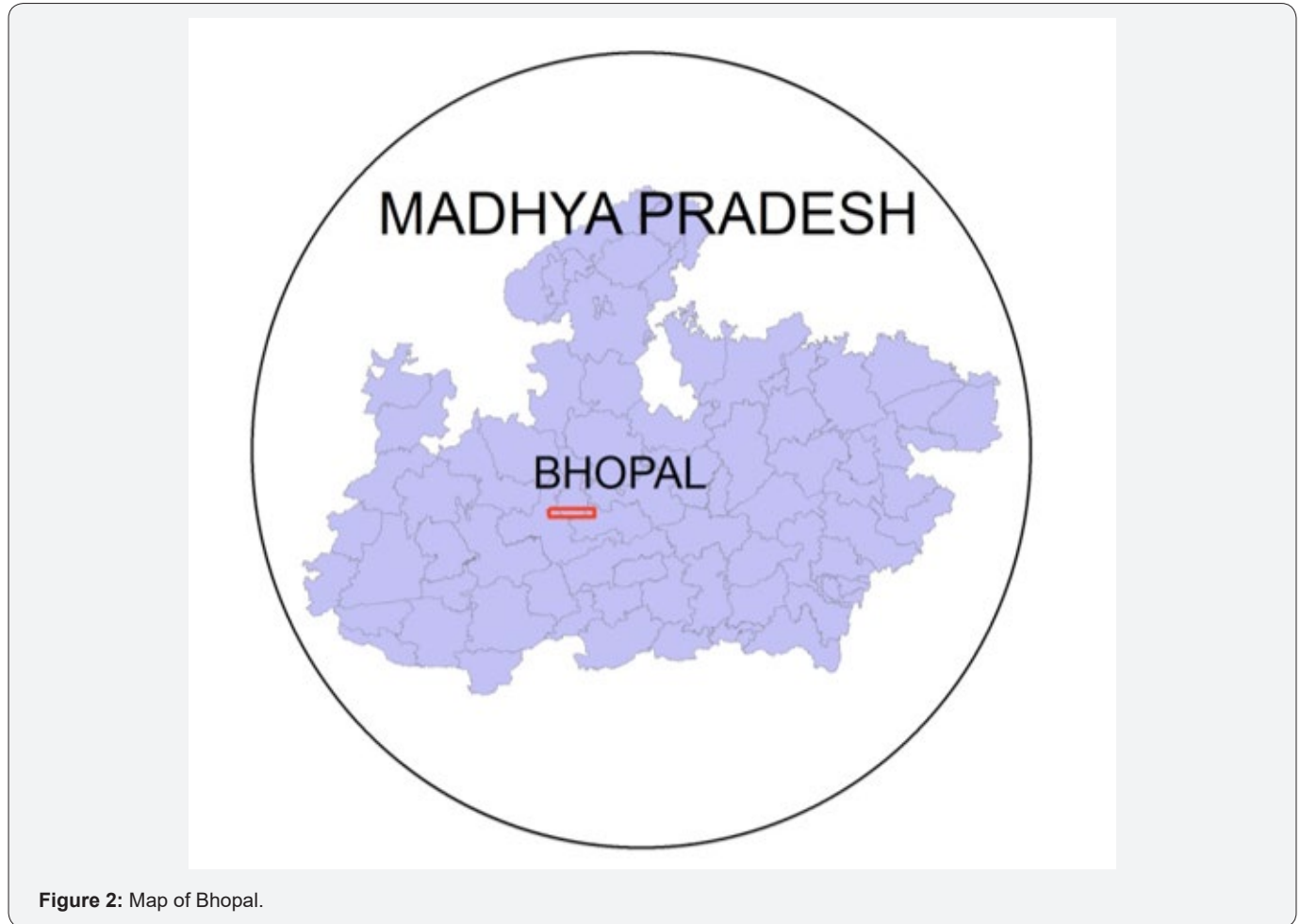


Figure 2: Map of Bhopal.

The primary data collected is based on the information collected through different sources like preparing questionnaire; interviewed of people & group discussion. The questionnaire included question on topography of Area; presence of crocodile and their habitat (Direct and Indirect sighting); Evidence of presence; habitat (Nesting & barrow); Men & Crocodile conflicts; local people knowledge of mugger crocodile; local people dependency on water bodies; in study area population of Mugger Crocodile increase/decrease in past year; poaching and trading activities etc. (Figure 2).

Interviews and previous data can be helpful for the initial visit to a site as a method to obtain background information or in determining current research needs [8] (Thorbjarnarson 1988; Thorbjarnarson and Hernandez 1988). Questionnaire survey with 237 local resident people. Fishermen; public & tourist in the month of September & October 2017 in which only (28 questionnaire reports 14% of people interviewed have seen crocodile.

Day light ground method; direct sighting

Day time Ground Count is nice method in which least equipment required day time can be done by foot or boat as per size of water body area some time reducing transport & logistic Cost Magansson 1982 [9]. Crocodiles use the water; sun and shade to maintain their preferred body temperature of 30-33°C. When basking; they orientate their bodies to ensure the maximum surface area is exposed to the sun. Crocodiles cannot sweat. To avoid over-heating; they may return to the water or lie with their jaws a gape; allowing cool air to circulate over the skin in their mouths. This process of heating and cooling their bodies is called thermoregulation and is crucial for many bodily functions including digestion and movement. Often observed basking on the banks of watercourses where they are generally inactive; crocodiles are less likely to be seen when they are in the water. Livelier in the water; crocodiles can swim just below the surface; with only their eyes and nostrils visible (Figure 3).

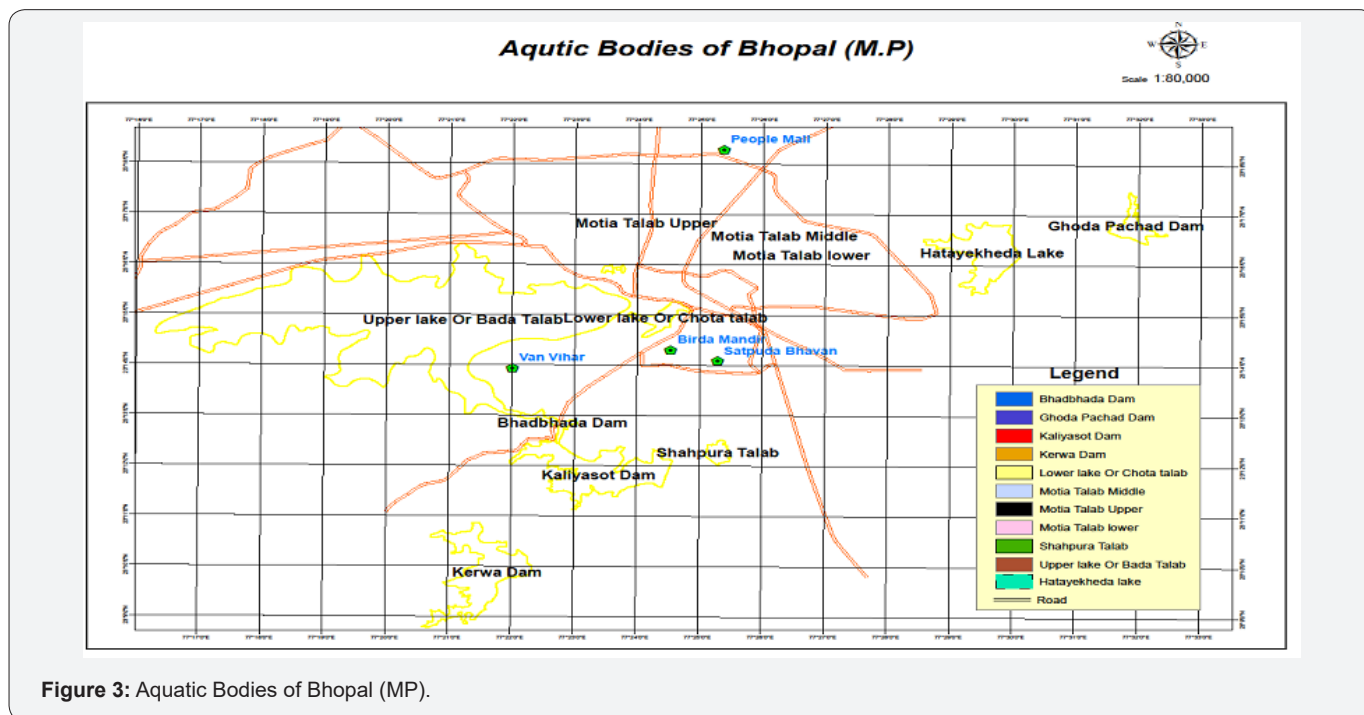


Figure 3: Aquatic Bodies of Bhopal (MP).

As per collect survey local resident people in the Questionnaire where crocodile was observed in previously & potential areas selected three water bodies out of ten; (1. Upper Lake 2. Kalyasot Dam; and 3 Bhdbhada Dam + Smiriti Van Bhadbhada). For counting crocodile; a team of 2-4 local people depending on the size of Aquatic body to be surveyed in the day time 10-AM to 1.00 Noon. Day light count Required the least equipment and area the most easily arrange however many zero count have been associated with day light ground given the crocodile refrain from basking with cloudy weather or when the optimal body temperature is reached [10].

Result

Day time survey

The Population & their distribution of crocodile are estimated by direct count method (Sun Basking Count Method) survey was carried out from 10 January to 13 January 2016 in the potential area by boat during the day time (10.AM to 1.00 PM) [11]. The survey revealed a total of only destroys nests of the Crocodile and 07 species found in direct sighting. The Total Count report is given in given below (Table 2).

Table 3: Final survey 2017-18.

Date	Name of Aquatic bodies	Observed Number			Total
		<2 mt	1-2 mt.	>1 mt. Less then	
02 Dec. 2017	Sewage treatment plant Bhadbhada	02 + 1	1	0	03 + 01
03 Dec.2017	Bhadbhada	-	2	0	2
09, 10 Dec. 2017	Kalyasot Dam + Smriti Van Bhadbhada	03 + 01	5	1	09 + 01
16, 17 Dec. 2017	Upper lake	3	3	0	6
		06 + 02	11	1	20 + 02

Distribution of Crocodile Observed (Day light Ground method). (02 December to 07 December 2017) First Round.

Table 2: Final survey 2017-18

Approximate in length (in Meter)	Observed No.	%
< 02	0	0
3-Feb	2	0
>03 above	3	0
	5	100

Distribution of Crocodile Observed (Day light Ground method).

Discussion

Interview survey

Interview with the residents were conducted to understand attitudes towards muggers and to assess the human-mugger interactions. Interviews and previous data can be helpful upon the initial visit to a site as a method to obtain background information or in determining current research needs10 (Thorbjarnarson 1988; Thorbjarnarson and Hernandez 1988). Figure 4 Questionnaire survey with 237 local resident fishermen; public & tourist in the month of September & October 2017 in which only (28 questionnaire reports 14% of people interview have seen crocodile [12-15] (Table 3).



Figure 4: Mugger Crocodiles (*Crocodylus palustris*) scenario in India.

Indirect sighting/evidence of presence:

Crocodile tracks; dung; trails; dens; footprints and nest are not found in study area.

Night time survey

Night spot light survey is preferred method of crocodile survey (Magnusson 1982) because of their versatility in habitat and nocturnal nature of the animal. But in night time Survey required special skill and manpower so night survey is not done [16-19].

Mortality

Natural mortality and accidental death of crocodile is not reported in study area.

Human and Crocodile conflict

The incidence of crocodile attack on human is none in study area because the population of crocodile is less in compare to large aquatic body; so, food available and habitat area is enough; so, the territorial difference not seen in wide range of prey so with increasing body size Figure 4a. Crocodile not took a big size prey from body size. Causes for attacking behavior of crocodile are in defense for their nest and siblings; mistakenly identifying animal accompanying with people or Human are considered to have been case of mistaken identifying type of incidence or attack are not recorded in this area [20-23].



Figure 4(a): Mugger Crocodiles (*Crocodylus palustris*) scenario in Madhya Pradesh.

Water quality

Table 4: Distribution of approximate length of Crocodile observed.

Date	Name of Aquatic bodies	Observed Number			Total
		<2 mt	1-2 mt.	>1 mt. Less then	
12 January 2018	Sewage treatment plant Bhadbhada	1	2	0	3
12 January 2018	Bhadbhada	0	0	0	0
13 January 2018	Kaliyasot Dam + Smriti Van Bhadbhada	02 + 01	3	0	05 + 01
14-Jan-18	Upper lake	0	3	0	3
		03+ 01	8	0	11 + 01

Water quality of aquatic bodies gets contaminated every year by accumulation of sediments; human waste; and House hold waste organic material (Table 4).

All identified site location faces due to direct and indirect activity Water sports and similar activities can all have negative impacts on habitat of crocodile (Table 5).

Population & habitat Assessment Survey

Table 5: Aquatic bodies where Muggar Crocodile were observed.

Approximate length (in meter)	Number	%
> 2 mt greater then	3	25
1- 2 mt.	8	66.6
< 1 mt. Less then	1	8.33
	12	100

Wildlife habitat for Crocodile in year 2017-18 estimate Crocodile wild population is 21. As well as other wildlife (Birds & Reptile) are very good. Encroachments in the habitat or in its fringes is continues process; None Crocodile and men conflicts found in Study area no none people repotted from crocodile attached by minor Injuries or death cattle of human and Domestic animal. Natural mortality of crocodile is not repotted in study area.

Security

4 No Forest staff engaged or depute to report their status and Protection.

Festival

People generally ignore environmental impact of pollution on Air; Water; Noise; solid Waste; etc Figure 4b. While celebrating Ganesh; Durga Pooja and Muharram; with a Tazia festival water pollution caused by Visarjan i.e. The immersion of lord Ganesh and goddess Durga; Tazia Pop; Cloths; Bamboo stick; wood part paper thermocol jute & poisonous colours Synthetic Non-dissolving paints; Iron.4 in lakes; rivers and Sea which are made from Plaster of Paris (PoP) i.e. calcium sulphate hemi-hydrate. It takes several months to totally dissolve Ganesh Idols made up of PoP into water [24-26].



Figure 4(b): Muggar Crocodiles (*Crocodylus palustris*) scenario in Madhya Pradesh.

Ecotourism

The boat club or Zoo road side without consideration use for tourism one Cruse boat and other motor boats activities are responsible for cause of disturbance of habitat of reptiles and their movements. It is an ideal place to enjoy water sport activities

like kayaking; canoeing; parasailing; and water-skiing Figure 4c. In winters many migratory birds come from distance of 1000 km of mile but due to human activity; noise & Disturbance causes decreasing of population of migratory birds' day by day (Table 6-7).



Figure 4(c): Mugger Crocodiles (*Crocodylus palustris*) scenario in Madhya Pradesh.

Table 6: Aquatic bodies where Muggar Crocodile were observed.

Name of Aquatic bodies	Number	%
Sewage treatment plant Bhadbhada	3	25
Bhabbhada	1	8.33
Kaliyasot Dam + Smriti Van Bhadbhada	6	50
Upper lake	2	16.66
	12	100

Table 7: Captive Maggar in different Zoo of Madhya Pradesh.

S. No.	Financial		Name of zoo		Opening stock		Births		Acquisitions			Disposals			Deaths			Closing stock					
	Year		M	F	U	T	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	T	
1	2012-13	Van Vihar National Park Zoo	2	4	11	17	0	0	2	0	0	0	0	0	0	0	0	0	0	2	4	13	19
2	2013-14	---	2	4	13	19	0	0	0	0	0	0	0	0	0	0	0	0	2	4	13	19	
3	2014-15	---	2	6	11	19	0	0	0	0	0	0	0	6	3	2	0	0	0	0	8	8	
4	2015-16	---	0	0	8	8	0	0	0	0	0	4	0	0	0	0	0	0	0	0	12	12	
5	2016-17	---	0	0	12	12	0	0	0	1	0	0	0	0	0	0	0	1	1	0	11	12	
6	2012-13	Gandhi Zoological Park	1	2	14	17	0	0	0	0	0	0	0	0	0	0	0	0	1	2	14	17	
7	2013-14	---	1	2	14	17	0	0	0	0	0	0	0	0	4	0	0	0	1	2	10	13	
8	2015-16	---	1	2	10	13	0	0	0	0	0	0	0	0	0	0	0	0	1	2	10	13	
9	2016-17	---	1	2	10	13	0	0	0	0	0	0	0	0	0	0	0	0	1	2	10	13	
10	2012-13	Kamla Nehru Prani Sanghralaya Zoo	2	2	16	20	0	0	0	0	0	0	0	0	0	0	0	0	3	3	16	20	
11	2013-14	---	2	2	16	20	0	0	0	0	0	0	0	0	0	0	0	0	2	2	16	20	
12	2014-15	---	2	2	16	20	0	0	0	0	0	0	0	0	0	0	0	2	2	2	14	18	
13	2015-16	---	2	2	14	18	0	0	0	0	0	0	0	0	0	0	0	0	2	2	14	18	
14	2016-17	---	2	2	14	18	0	0	0	0	0	0	0	0	0	0	0	2	2	2	12	16	
Total			20	32	179	231	0	0	2	1	0	4	0	6	7	2	0	5	20	27	173	218	

Waste

House hold waste & Impurities are drawn in coming from colony Hotel farm house and Resort.

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