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Evaluation of Habitat Suitability Index Model of Indian Gharial in National Chambal Sanctuary, M.P. India

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Abstract: Almost all animals use their habitats in a non-random manner. But the cost and benefits of using specific habitat types remain unknown for many types of organisms. Habitat suitability models aim to assess the relationship between species and their habitat and accurately predict the species response to habitat changes. We developed a riverine habitat model for Gharial (*Gavialis gangeticus*), a critically endangered species, in the National Chambal Sanctuary in India after reviewing and synthesizing existing information. Based on the model, an index of habitat suitability is produced, ranging from 0 (unsuitable habitat) to 1 (optimal habitat). The results of the present study indicate that the Gharial prefer deep pools in water bodies. The deep waters serve as feeding and breeding grounds for Gharial. They prefer water with a velocity ranging from 20–70 $cm.sec^{-1}$. Sandy banks are preferred as basking sites, mainly because they provide moisture during the warm months and because it seems that they find it easier to crawl on sandy surfaces than on rocky or clay surfaces. Insects, tadpoles, tiny fish, and frogs are preferred by young Gharial. A habitat suitability model for Gharial can be used as a decision support system in order to improve conservation efforts at different landscape scales.

Key words: Gharial • National Chambal Sanctuary • HSI

Introduction

The Gharial, *Gavialis gangeticus* (Gmelin, 1789), is an endemic river dwelling crocodilian of the North Indian Sub-Continent, specifically in the river systems of the Indus (Pakistan), the Ganges (Indian and Bangladesh), the Brahmaputra (Bhutan), the Irrawady (Myanmar) and Mahanadi Orissa (Whitaker and Basu, 1982; Neill, 1971; Hornaday, 1885; Shortt, 1921; Smith, 1931; Singh, 1985; Hussain, 1991, 1999, 2009).

The Gharial (*Gavialis gangeticus*), also known as the fish-eating crocodile, inhibits primarily large-bodied, deep, fast-flowing plain rivers (Shah and Tiwari, 2004). The Gharial is considered critically endangered in the IUCN Red Data Book. It is listed in Appendix I of CITES. It is the only surviving member of the family Gavialidae (Maskey, 1989). Gharials are arguably the most thoroughly aquatic of all crocodilians, and adults do not appear to have the ability to walk in a semi-upright stance as other species do (Bustard and Singh, 1978; Whitaker and Basu, 1983; Whitaker, 1987). Like other crocodilians, the reproductive status of Gharial is also determined by size. Females reach sexual maturity when they reach 3 m in length (usually over 16 years old) and males reach sexual maturity at 4 m (Maskey and Mishra, 1981; Bustard, 1984; Singh, 1999a, b; Whitaker, 1987). Species occupy habitats that

are characterized by a range of abiotic and biotic characteristics. Habitat suitability indices (HSI) were originally developed as a part of habitat evaluation procedures to quantify the effects of land management and alternatives on wildlife habitat (United States Fish and Wildlife Service, 1987). Habitat suitability indices have been widely used to assess both the likelihood of species occurring at a specific location as well as the quality of a habitat and its ability to support a species. Habitat suitability index models are based on measurements of physical and chemical habitat variables that are relevant to the target species (Schamberger and Krohn, 1982). Habitat suitability index models involve the collection of a series of individual habitat variables with data that may be based on field measurements, expert opinion, or a literature review. Individual habitat data is used to generate scores that are then combined into a single habitat suitability index. The Habitat suitability index is defined as a value between 0 and 1, with 1 representing the optimal habitat quality for the target species. Habitat suitability indices have been widely used in the development of land use plans, management of protected areas, and mitigation of human wild conflict (Thomas 1982; Balcombe et al., 2005; Scott et al. 1993). The ability of habitat suitability index models to allow land managers to predict likely impacts from potential future management activities is especially powerful (Rickers et al., 1995; Baxely et al. 2011). Efforts to conserve crocodiles in India effectively began in 1972 with the declaration of the Indian Wildlife Protection Act, under which all three species of Indian crocodiles were declared as totally protected fauna. The Government of India initiated a Crocodile Conservation Project in 1975 in collaboration with FAO/UNDP. Under the Crocodile Project, many crocodile habitats were recognized and protected by declaring thirteen of them as crocodile sanctuaries. Among them 7 (54%) sanctuaries with an area of 2986 Sq.km. were specially created for the protection of Gharial (Rao, 1989). Gharial essentially piscivorous is the aquatic crocodile with its long brawny tail, narrow head and long body, its aerodynamics is improved in water. Young Gharials can reach a length of one meter in eighteen months. Female maturity appears around ten years of age at a length of 2.6 meters. Males mature around 13 or 14 years at a length of 3 meters (Whitaker, 1987). During the hot season, just before the monsoon (March-April), females make a hole in a sandbank to lay 15 to 65 eggs. After 71 to 93 days of incubation, young Gharial's hatch in July just before the monsoon (Rao, 1989).

Materials And Methods

Study area: The present study was carried out in the National Chambal Sanctuary (NCS) in India (Figure 1). The sanctuary was initially notified as an NCS in the years 1978–1979 via gazette notification no. 15/5/77/10/2 dated 20 December 1978 and modified by notification no. 15-1–(2)–82 dated 24 December 1982 with the aim of providing a protected habitat for the conservation and propagation of highly endangered crocodilian species and other aquatic animals. Geographically, the study site lies between latitudes of 26°39' N - 26°51' N and longitudes of 78°50' E - 78°22'. The study area lies within the semi-arid zone of Northern Madhya Pradesh (MP) and Southern Rajasthan. The study area has a subtropical climate with moderate to hot temperatures ranging between 7- 45 °C, and relative humidity drops to about 20% during March, April and May. The average rainfall of the area is 850 mm and precipitation largely depends on the Southwestern monsoons.

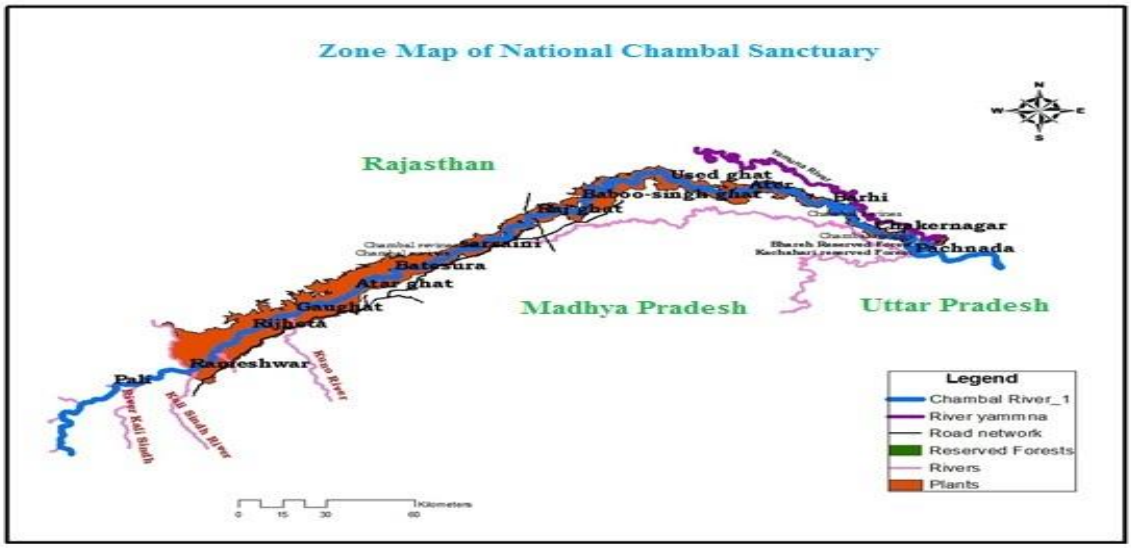

Figure 1. Map of the study area

Method

The present study was conducted from Rajghat to Barhi in the National Chambal Sanctuary, MP, in an area of around 200 km on the Chambal River. For the purpose of data collection, the data collection process was split into Primary and Secondary Data Collection. For primary data collection, regular field surveys were carried out during May–October 2015 by walking along the transects (Burnham et al. 1980). The study sites were surveyed by motorboats by traversing along the river. The Gharials were observed and identified according to their age class by the direct sighting method. The total count of individuals was done with the help of binoculars (Nikon Action 8×40 8.2) and a Nikon Digital Camera (AF-S NIKKOR 18-300 mm). The locations were marked through GPS (GARMIN 60). Secondary data was collected from records available in the Forest Department. A literature survey was also carried out by consulting different journals, newspapers and unpublished dissertations and other study materials from libraries.

Model applicability

Geographic area: The Habitat Suitability Index model for Gharial is applicable in the National Chambal Sanctuary in India. With some modifications, the model should be useful for evaluating habitat in other parts of the species' range.

Season: The model was designed to produce an index of habitat suitability for Gharial nesting and feeding and basking season on a year-round basis.

Cover types: The model was designed for application in the National Chambal Sanctuary as a habitat for basking, feeding and breeding of Gharials. The cover types include sandy banks, clay banks, rocky banks and deep waters.

Minimum habitat area: The minimum amount of contiguous suitable habitat required by a species to fully fulfill all of its life needs is defined as the minimum habitat area**.** Specific information on the minimum breeding and nesting areas required by the Gharials were not included in the literature.

Verification level: The HSI model for Gharial was developed from the existing information on the habitat requirements of the Gharial. The model has not been field tested

Results and Discussion

The HSI model for the Gharial is intended for use in habitat evaluation procedures (HEP) developed according to the standards given by the U.S. Fish and Wildlife Service (1987). The model was prepared from a review and synthesis of existing information and is scaled to produce an index of basking, feeding, and breeding Gharial habitat suitability between 0 (unstable) and 1 (optimally suitable). The model is a hypothesis of species-habitat relationships, not a statement of proven cause and effect. The model has not been field-tested. The present investigation was carried out from Rajghat to Barhi, a 200 km stretch adjoining the boundary of Madhya Pradesh, Uttar Pradesh and Rajasthan. The present study is based on information on population and habitat use by the Gharial in the National Chambal Sanctuary. The number of Gharials were counted during the investigation using both direct sighting methods (sighting habitats, basking spots, swimming in surface water, and catching the reflection of eyes at night) and indirect methods (fecal pellets, tracks, egg shells, and trials), as well as information gathered from various sources such as fisherman, local community, game inspectors, and game watchers.

The Habitat Suitability Index (HSI) for the Gharial is based on the concept of limiting factors. The HSI model provides the suitable habitat characteristics within the geographic range of the Gharials. The HSI model for Gharial enables us to predict the amount of available suitable area.

Model description

Overview: The presence of Gharial is generally related to the abundance of food. A model has been developed to determine the suitability of Gharial in the National Chambal Sanctuary as a habitat for feeding, breeding, basking and nesting. Various parameters of Gharial were used for the preparation of the Habitat Suitability Index (HSI) Model (Figure 2). The model may be applicable in planning the habitat research studies of Gharial and also in estimating the relative suitability of habitats for Gharial.

Three key variables involved in the model are: food/foraging component, water component, and climatic component.

Habitat Suitability Index

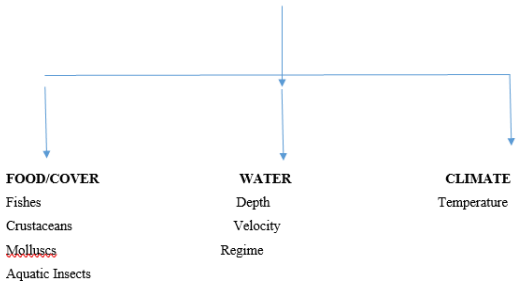

Figure 2. Relationship between the habitat variable, component and HSI

Habitat requirements

Food and foraging components: Fish is the primary constituent of the food consumed by Gharial. Young Gharial prefers insects, tadpoles, small fish and frogs. Uncommon reports of other food items such as soft shell turtles, birds, plant materials, and small mammals have also been reported. Adult Gharials feed on fish and small crustaceans. Their jaws are too thin and delicate to grab large prey.

According to Whitaker (2007), the narrow snout reduces resistance to water when the creature is hunting fish, while the inter-digitated teeth are well adapted to capturing them. It appears that young Gharials hide and forage in shallow water. As they grow, they move to deeper waters. Those up to 120 cm (47 inches) prefer 1-3 m (9.8-9.8 ft) deep water, while those up to 180 cm (70.1 inches) hunt and hide in 2-3 m deep water. The adult Gharial prefers to forage

and hide in depths greater than 4 m (13ft). (Hussain, 2009).

Water component: Hydrological components are important to any aquatic animal. Three key variables were used in the model to quantify the suitability of the water component: water depth, water velocity and water regime.

Gharials prefer water bodies with deep pools. The deep pools provide habitat for both feeding and breeding Gharials. Sometimes the Gharial uses shallow water for feeding. Shallow water does not provide any cover for the Gharial. It is very difficult to distinguish the proximal effects of water depth, since it is directly related to other components of the model (food, cover, and temperature). The model assumes that a percentage of open water with a depth of <1 m and > 8 m is best suited as breeding and feeding habitat for a Gharial and water depths of 0.5-1 m represent marginal habitat and water with a depth approaching > 0.5 m is unstable.

Gharials prefer water with a velocity ranging from 20–70 $cm.sec^{-1}$. For the purpose of habitat suitability analysis, rivers with an average peak velocity of <70 cm/sec and > 20 cm/sec were assumed to have zero suitability for Gharials. Rivers with an average peak velocity of > 70 cm/sec are assumed to contain lower flows suitable for Gharial. Those regions of the river with higher velocity and much lower velocities will be avoided in favor of moderate velocity areas. This assumption is appropriate for a typical river with an average width of 500–1500 m. A wider river or a narrower river will not provide this average velocity, as the wider river may have lower water velocity and the narrow stream has higher water velocity.

Rivers with permanent water will have the highest likelihood of supporting the Gharial throughout the year. Rivers with less water are not suitable for Gharial. Gharials from such stretches immigrate to other areas where large quantities of water are available.

Climatic components: Thermal characteristics of the riverine system are critical for an aquatic animal that is primarily dependent on climatic conditions. The Gharial habitat experiences three distinct seasons: summer, monsoon and winter.

In the Gharial habitat, the maximum air temperature is recorded in the summer months (48°C), while the minimum air temperature is recorded in the winter (8°C). The water temperature ranges between 15 and 31 degrees Celsius. Based on the findings of this study, it was assumed that a water temperature range of 20–30 °C is best suited for Gharial. Gharial prefers temperatures between 15 and 35 degrees Celsius (Adhikari *et al.*, 2019).

Activity

Basking: Gharials prefer to bask near areas of easy escape coverage. Observation during the study showed that Gharials have a strong attachment to a particular basking area to which they return time and again, making it more vulnerable to disturbance. Sandy banks are preferred as basking sites mainly because they provide moisture during the warm months and because it seems that Gharials find it easier to crawl on sandy surfaces than on rocky or clay surfaces. During the winter months, Gharials were sighted to spend most of their time basking throughout the day from 0600 hrs. to 1800 hrs., beyond which basking was rare. During the summer months, the basking activity was observed either early in the morning hours or late in the evening hours. During the mid-day hours, the Gharials were observed to be active, spending most of its time in deep water feeding**.** The basking site was divided into four categories: sandy banks, clay banks, rocky banks and rock outcrops. The Gharials were seen to prefer sandy banks for basking. The rocky banks were preferred when the sandy banks were not available. Small areas of rock outcrops were

used for basking. The clay areas were totally avoided for basking.

Nesting: The nesting period starts from March to May. Gharials prefer sandy banks for nesting. Nesting is done in the dry season in holes excavated in river sandbanks. During the survey, it was observed that "Rajghat", "Kuthiana Ghat" and "Babu Singh ki Gher" are best suited for nesting due to the presence of large sandy banks. Usaid Ghat and Barhi/Bhind were found to be the least suitable for nesting. The nests were excavated at a distance ranging from 1–10 m away from the water's edge, about 50 cm deep.

Co-Existence of Gharial: During the field survey, the Gharials were observed to co-exist with other aquatic animals. In the study areas, the Gharial was found to co-exist with muggers and various species of turtles. In addition, various migratory birds were also observed co-existing with the Gharial (Figure 3).

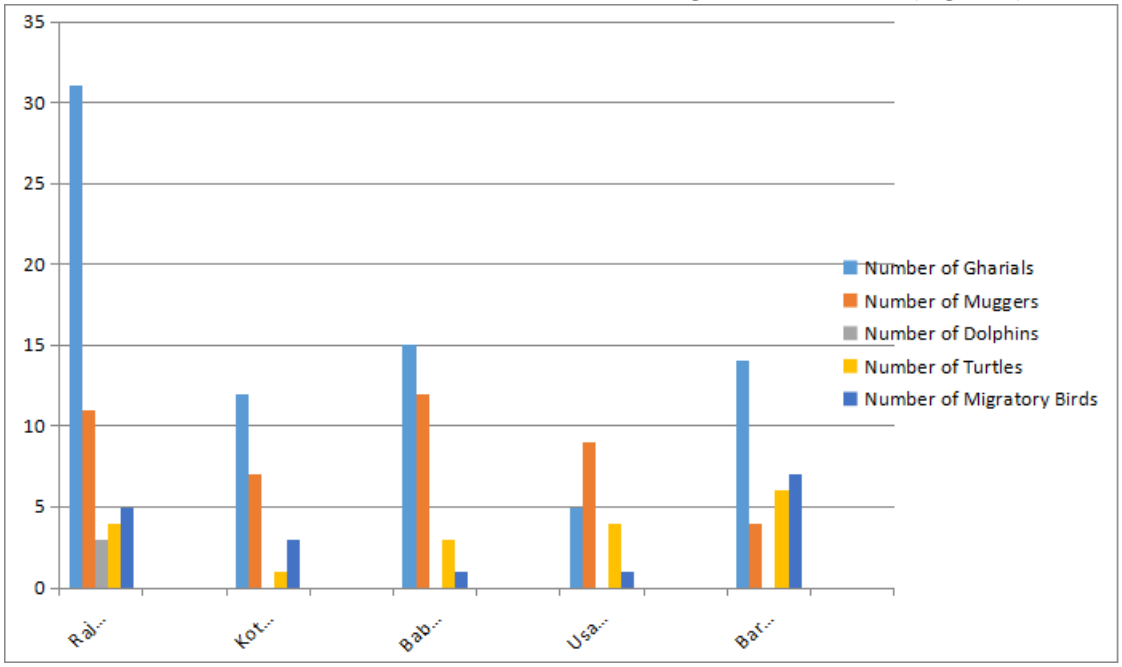

Figure 3. Co-existence of Gharial with different animals.

Conclusion

To establish a stable population of Gharials, high population areas need to be identified and protected in the wild. For conservation implications, a proper survey of the potential habitats should be carried out. Maintaining the sandy island and limiting human activity are two of the most vital priorities for conserving the Gharials in the area. A habitat suitability model for Gharial can be used as a decision support system in order to improve conservation efforts at different landscape scales.

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