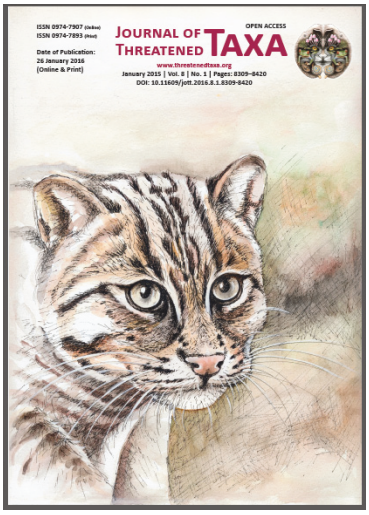

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COMMUNICATION

THE CONSERVATION STATUS OF THE FISHING CAT *PRIONAILURUS VIVERRINUS* BENNETT, 1833 (CARNIVORA: FELIDAE) IN KOSHI TAPPU WILDLIFE RESERVE, NEPAL

Iain Rothie Taylor, Hem Sagar Baral, Prava Pandey & Prativa Kaspal

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The conservation status of the Fishing Cat *Prionailurus viverrinus* Bennett, 1833 (Carnivora: Felidae) In Koshi Tappu Wildlife Reserve, Nepal

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Abstract: The status of the Fishing Cat *Prionailurus viverrinus* in Koshi Tappu Wildlife Reserve, Nepal was assessed by camera trapping and pugmark searches from 2011 to 2014. The reserve is a highly dynamic and unstable snow-fed braided river system with many anabranches and islands. Evidence of Fishing Cats was found throughout most of the reserve. They were probably more abundant on the eastern side, among the islands of the main river channel, and in the adjacent buffer zone where there was a chain of fishponds and marsh areas fed by seepage from the main river channel. Evidence of Fishing Cats was found up to 6km north of the reserve on the Koshi River but not beyond this. The population is probably small and may be isolated but given the endangered status of the species, is significant. The main likely threats identified are wetland and riparian habitat deterioration caused by over exploitation and illegal grazing by villagers, overfishing of wetlands and rivers within the reserve, and direct persecution arising from perceived conflicts with fish farming and poultry husbandry. Required conservation actions are discussed.

Keywords: Conservation strategy, Fishing Cat, Koshi Tappu Wildlife Reserve, survey, threats.

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INTRODUCTION

The wetland dependent endangered Fishing Cat *Prionailurus viverrinus* (Bennett, 1833), once widespread throughout Southeast and southern Asia, now has a discontinuous distribution in Java, Thailand, Cambodia, Sri Lanka, India, Pakistan, Bangladesh and Nepal (Pocock 1939; Cutter & Cutter 2010; Duckworth et al. 2010; Mukherjee et al. 2010, 2012; Royan 2010). Available evidence suggests a recent widespread and continuing decrease in range and abundance, with loss of wetland area and quality, overfishing and direct human persecution most often cited as causes (Nowell & Jackson 1996; Mukherjee et al. 2010, 2012).

In India the species' distribution includes the eastern states of West Bengal, Assam, Odisha, Andhra Pradesh and the northern Terai wetlands bordering Nepal (Sunquist & Sunquist 2002; Mukherjee et al. 2012; Sadhu & Reddy 2013; Janardhanan et al. 2014). Information is absent for most other areas but recent research failed to find any evidence of the species in coastal Kerala in southwestern India where it had been believed to occur (Janardhanan et al. 2014). Within Nepal, although the Fishing Cat is known to occur within all the protected areas of the Terai (Dahal & Dahal 2011; Jnawali et al. 2011; Mishra 2013), there have been no systematic surveys to assess abundance. There is no quantitative information on population trends or threatening processes in either India or Nepal.

The objective of this study was to assess the current status of the species in Koshi Tappu Wildlife Reserve, Nepal and by conducting an intensive standardised sampling programme, an attempt to establish a baseline against which future changes may be assessed. The species' habitat was examined to determine likely threatening processes or factors that may determine future population viability. In addition, information was gathered on local villagers' knowledge and perceptions of Fishing Cats, particularly those aspects that might relate to the species' population viability.

STUDY AREA

Koshi Tappu Wildlife Reserve, established in 1976, extends between 86^{0}55'–87^{0}05'E & 26^{0}34'–26^{0}45'N on the flood plain of the Koshi River in the Terai of southeast Nepal and consists of a core area of 175km² with an additional buffer zone of 173km². Between 1958 and 1964, a barrage was constructed across the Koshi River at the Indian/ Nepal border 5km south of the reserve and embankments were constructed on both sides upstream of the barrage to contain and channel floodwater through the barrage. The current core area of the reserve, about 17km long and 9km wide now lies within these embankments. The rise in elevation between the most southerly and northerly edges of the reserve is only 20m. The entire area is a highly active snow-fed braided river system, comprising mostly river and stream courses, sandbanks, grasslands, swamps, and some areas of forest, representing newly colonising woodland and eroding old established forest. In the 1960s the main channel was on the western side of the reserve but this shifted and now lies at the extreme eastern edge. This shift has been associated with profound habitat changes across most of the reserve; between 1976 and 2010 the total area comprising wetland habitats declined by 17% whereas grassland increased by 45%. In 2010, 10% of the reserve core area was rivers and streams and only 6% swamps and marshland, whereas 56% was grassland and the remainder mainly sandbanks and forest (Chettri et al. 2013; Fig. 1).

Prior to its establishment as a reserve, Koshi Tappu was used extensively by local villagers for livestock grazing, fishing and collection of grasses and firewood. This use has continued and has resulted in severe habitat degradation including a loss of riparian vegetation. Although there has been no objective assessment of fish stocks local fishermen are clear from their catch in relation to effort that stocks have declined considerably (CSUWN 2009; DNPWC 2009).

At the time of the present study the eastern side of the reserve was least affected by overgrazing. Immediately to the west of the main river channel a series of islands were in an essentially natural condition with intact vegetation of long grasslands, swampland and forest offering cover for Fishing Cats. To the west of this, there was a zone of braided river channels most of which had either lightly or non-vegetated sand banks and islands among them offering little cover. West of this there was a mixed habitat of short and long grassland and open woodland. Much of the western side of the reserve was easily accessible to villages and overgrazing by domestic livestock was intense.

The buffer zone includes areas of the river course to the north and south of the reserve core area and areas beyond the embankments on the east and west banks sides, which are now mostly settled and cultivated. On the east side many areas of wetland that resulted from seepage through the embankment during the monsoon floods have progressively been replaced by fishponds since the 1990s (CSUWN 2009). There is a

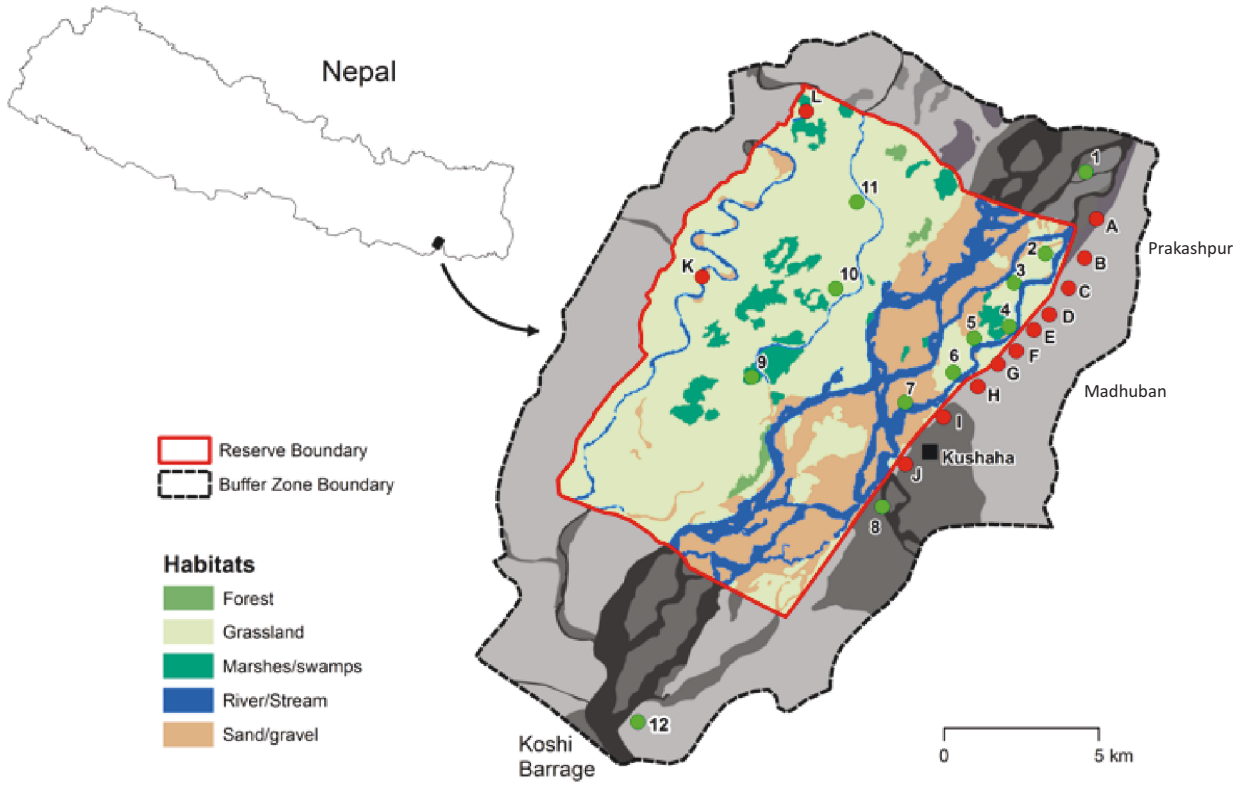

Figure 1. Map of Koshi Tappu Wildlife Reserve and buffer zone showing habitats and sampling sites for Fishing Cat surveys. Red spots show camera trapping sample sites and green spots show pugmark sample sites.

semi-continuous chain of fishponds along this edge from about the level of Kushaha (the reserve headquarters) northwards. The ponds are mostly small (about 1,000–2,000 m²) and have been dug into the substrate, with earth banks and no fencing. Some are no longer in use and are being colonised by wetland vegetation, and there remain many small areas of swampland among the ponds that support populations of small fish, amphibians, molluscs and crustaceans, but they are intensively harvested by villagers for all of these species, regardless of size. On the western side of the reserve there are only minor anabranches of the Koshi River and small tributaries such as the Trijuga River, which are insufficient to maintain fishponds or significant areas of swampland. Potential habitat for Fishing Cats is more restricted.

In 2008 an exceptionally large flood broke through the embankment in the south eastern sector of the reserve, depositing large amounts of sand over wetlands, fish ponds and villages and farmland about 1 km south of Kushaha (Khatri et al. 2013). Consequently, the habitat for Fishing Cat in this area has been reduced.

During the 1950s, prior to the establishment of the barrage, the area around Koshi Tappu retained original forest and grassland supporting populations of large predators such as Tiger *Panthera tigris* and Leopard *P. pardus*. However, following a programme of resettlement of people from the mid hill areas to the north starting in the 1950s, these large carnivores were exterminated. The exact dates are unrecorded (Chhetri & Pal 2010).

METHODS

Camera trapping

During 2011 an initial study was conducted to gain general information on the species' distribution along the eastern side of the reserve, within the buffer zone (Image 1). Camera traps were set up in wetland habitats between 19 April 2011 and 19 June 2011 in the Prakashpur, Madhuban, Kushaha and Jabdi areas, covering all of the eastern side of the reserve from north to south. Six cameras were used over 10–12 nights in each area.

From February to December 2013 an intensive programme of camera trapping was undertaken at 12 wetland sites in the eastern and western sectors of the

Table 1. Location and habitat characteristics of camera trap sampling sites

Site	Grid reference of centre point	Main wetland type	Habitat
A	26°41.4'N & 87°04.6'E	Active fish ponds	Farmland with active fish ponds, patches of scrub and marsh, clumps of bamboo and banana, scattered trees
B	26°41.4'N & 87°04.8'E	Active fish pond & remnant marshland	Farmland with active and abandoned and overgrown fishponds, clumps of bamboo and banana, scattered trees.
C	26°41.2'N & 87°04.5E	Abandoned fish ponds, & marshland,	Active and overgrown abandoned fish ponds, marshland, clumps of bamboo and banana and trees
D	26°41.1'N & 87°03.4'E	Active fish ponds	Active and overgrown abandoned fish ponds, clumps of bamboo and banana and trees
E	26°40.4'N & 87°03.5'E	Active & abandoned fish ponds	Active and overgrown abandoned fish ponds, clumps of bamboo and banana and trees
F	26°40.2'N & 87°04.2'E	Active and abandoned fish ponds	Active and overgrown abandoned fish ponds, clumps of bamboo and banana, scrub and trees
G	26°39.3'N & 87°03.4'E	Abandoned fish ponds & marsh	Riverine forest with adjacent abandoned fishponds and marshland. No cultivated land
H	26°39.1'N & 87°03.3'E	Active fish ponds	Farmland with active fish ponds and a few scattered trees
I	26°39.1'N & 87°03.4'E	Swampland and abandoned fish ponds	Riverine forest with abandoned fish ponds and swampland
J	26°37.3'N & 87°01.7'E	Koshi River	Scrubland with scattered trees and extensive areas of bare sand
K	26°38.4'N & 86°56.7'E	Trijuga River	Open grazed land with scattered bushes, sandbanks and river
L	26°43.5'N & 87°00.2'E	Overgrown oxbow lake	Open grazed land with oxbow lake overgrown with *Ipomea carnea*

Image 1. Fishing Cat *Prionailurus viverrinus* captured by camera trap in the buffer zone of Koshi Tappu Wildlife Reserve, Nepal - 2011

buffer zone. On the eastern side ten sample sites were spaced approximately evenly throughout its length from Kushaha northwards (Fig. 1). Wetland areas were more restricted on the western side and cameras were sited at the two largest wetland areas. In addition, cameras were placed at the Koshi Tappu Bird Observatory 12km north of the reserve; an area that retained undisturbed scrub vegetation within 300m of wetland habitat and potentially a refuge for Fishing Cats. At each site cameras were placed 50–100 m apart along the edges of wetland habitats and the trails connecting them. The number of cameras deployed at each site ranged from five to 13, depending on the extent of potentially suitable habitat. The grid references of each site, to enable precise future comparisons, and their habitat characteristics are given in Table 1.

Searches were also made for evidence of Fishing Cats using pugmarks. All of the camera-trapping sample areas were searched for pugmarks on areas of soft substrate around wetlands or fish ponds on the days when the cameras were in operation. Within the reserve during February 2014, searches were made on the islands on the western bank of the main branch of the Koshi River. At approximately 1km intervals southwards from the northern edge of the reserve, sample stretches of 100m of extensive exposed soft mud on the riverbank were searched. In the central area of the reserve a similar procedure was used on one of the main anabranches wherever access was possible from a track. Pugmarks were also used to search for evidence of the presence of the cats northwards from the reserve boundary. On the eastern bank of the main river, for a total of 12km northwards, at 2km intervals, sample lengths of 300m of soft substrate were searched. A sample area immediately north of the Koshi barrage, to the south of the reserve, and another area 2km south of Kushaha in the buffer zone were also searched.

Diurnal activity patterns

Data on activity patterns were taken from the programme of camera trapping described above, but to increase sample size, camera trapping was extended by a further 330 camera trap nights at 46 stations during November and December of 2013. This gave a total effort of 808 camera trap nights. As all areas were

utilised by the local human population there was a problem of camera theft, which required cameras to be set up each day one hour before sunset and retrieved one hour after sunrise.

Villagers' perceptions of Fishing Cats

To assess local knowledge and perceptions of the species a sample of 208 adult villagers living within the buffer zones were interviewed in 2011. They were asked if they had seen Fishing Cats, where and when, what the species' habitat and diet were, and also what their attitudes were towards conserving the species. Attitudes towards Fishing Cats and fishpond production were also explored by interviewing the owners or managers of a sample of 55 fish farms.

RESULTS

Distribution of Fishing Cats

Camera trapping: The presence of Fishing Cats was confirmed by camera trapping along all of the eastern buffer zone, from Kushaha northwards, and across the western buffer zone (Fig. 2). Variations in the intricate pelage patterns of Fishing Cats were used to identify individuals from the photographs where possible, but most of the images obtained were of cats moving quickly and their patterns were not adequately clear for identification. In the 2011 survey, nine separate Fishing Cats were recognised, three in the Prakashpur area, three in Madhuban, one in Kushaha and none in Jadbi. In the latter case, no images of Fishing Cats were captured.

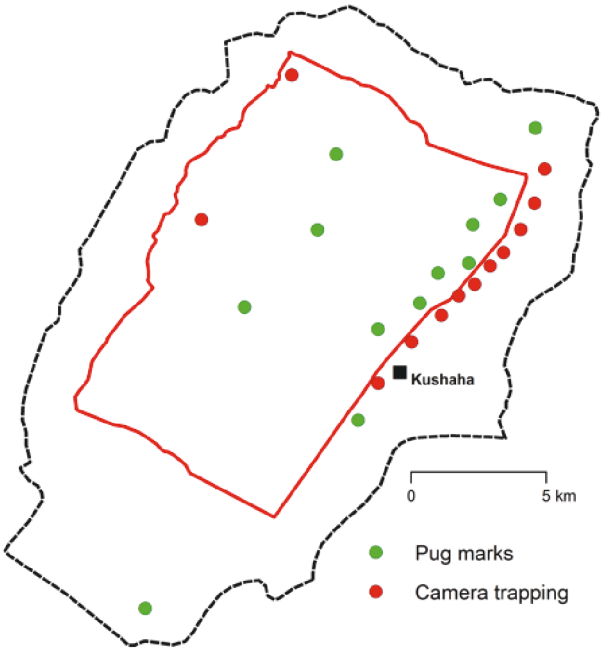

Figure 2. Map of Koshi Tappu Wildlife Reserve and Buffer Zone showing positive sites at which evidence of Fishing Cats were found. Red spots show sites for camera trapping evidence and green spots show pugmark evidence.

In the intensive study of 2013/14, images of Fishing Cats were captured at nine (75%) of the 12 sites sampled (Table 2). In the majority of cases (80.4%) where Fishing Cats were photographed at a camera station only a single image was obtained per night. In three cases (5.9%) two images were obtained of cats travelling in opposite directions within 10 minutes. Although it was not know

Table 2. Camera trapping effort at each sample site and numbers of independent Fishing Cat images obtained, 2013.

Site	Month	N Cameras	N Nights	N Camera/ Nights	Fishing Cat images	Images/10 camera nights	Pug marks found
A	November	8	5	40	2	0.5	Yes
B	November	13	10	100	1	0.1	Yes
C	March	5	5	25	2	0.8	Yes
D	March	7	5	35	2	0.57	Yes
E	March	5	5	24	0	0	Yes
F	December	8	5	36	7	1.94	Yes
G	February	8	6	41	8	1.95	Yes
H	December	13	4	52	11	2.12	Yes
I	February	9	6	45	0	0	Yes
J	March	5	5	25	0	0	No
K	March	5	5	25	2	0.8	No
L	March	6	5	30	13	4.33	Yes

Table 3. The total numbers of all other predatory mammals photographed in camera traps

Fishing Cat	Jungle Cat	Small Indian Civet	Jackal	Indian Fox
48	9	7	23	1

for certain that these represented the same individual it was assumed they did and these cases recorded as only a single event. The remainder of cases (13.7%) involved apparently independent events, with more than a single individual. The number of images captured ranged from zero to 18 at different sites but there was no significant correlation between the number of images captured per 10 camera trap nights and the total number of trap nights at each site (r = -0.14, P = 0.66). Thus the number of images obtained was not related to trapping effort. In total, 10 different cats were identified but most images were too blurred for individual identification so it is not known how this number relates to the true number of individuals. The cameras captured images of all other mammals that used the tracks. Other predatory species this included the Jungle Cat *Felis chaus*, Small Indian Civet *Viverricula indica*, Jackal *Canis aureus*, and the Indian Fox *Vulpes bengalensis* (Table 3).

Pug marks: Fishing Cat pug marks were found around all camera trapping sites where photographs were obtained but were also found at one site where no photographs were obtained. At the remaining two sites where no photographs of the cats were obtained there were also no pugmarks (Table 2). Pugmarks were found at all of the sample sites within the reserve (Fig 2). On the eastern side of the reserve along the western bank of the main river course, the density of prints at all sites was exceptionally high suggesting frequent use, but elsewhere only a few prints were found in each sample suggesting much lower use. Pugmarks were found north of the reserve on the main river bank at sites 2, 4 and 6 km beyond the reserve boundary but not at sites farther north. In all cases they were single tracks with a much lower density of prints than farther south within the reserve. Pugmarks were also found at the sample site just north of the Koshi barrage, but none were found at the site 2km south of Kushaha.

Diurnal activity patterns

Cameras could not be left in position during daylight hours because of the threat of theft so the information obtained relates to the period from one hour before sunset to one hour after sunrise. Only two images (4.2%

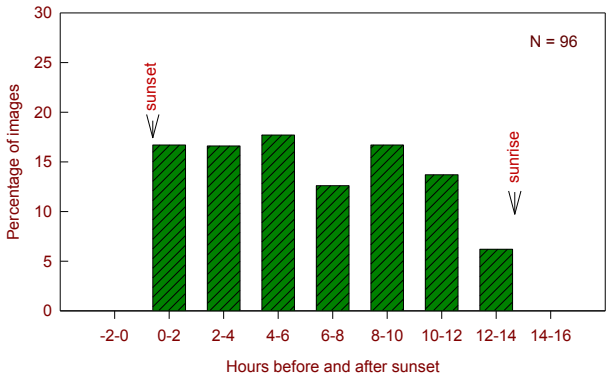

Figure 3. Activity pattern of Fishing Cats at Koshi Tappu Wildlife Reserve from one hour before sunset to one hour after sunrise. Data from camera trapping in 2013.

of the total) were obtained in the short period of low light of dawn immediately after sunrise and none in the hour before sunset. At these times on all cameras images of villagers were captured on all the trails as they returned home or started their daily activity. In the intervening period of darkness, there was little evidence of any pattern: the cats seemed to be equally active throughout the entire night with perhaps slightly lower activity immediately before sunrise (Fig. 3).

Villagers' knowledge of Fishing Cats

Seventy eight percent (78%) of the 208 villagers interviewed stated they had seen Fishing Cats, and 66% stated they had seen them around their farms, either at fishponds or at poultry cages. Of those that reported seeing the cats, 83% stated they had seen them in the first light of morning and 17% during darkness. No one reported seeing the cats during daylight hours. All of those interviewed stated that Fishing Cats feed on fish, crustaceans and snails and all of them also stated that their habitat was wetlands. Half (50%) of those interviewed believed that the Fishing Cat population in the area was declining, 16.5% believed the population to be increasing, 16.5% suggested no recent change and the remainder had no opinion. Sixty-seven percent (67%) were in favour of conserving the species and 33% wanted them killed because of perceived problems as predators of fish in ponds or of poultry. Only 8% knew that the Fishing Cat was an endangered species. Some suggested that Fishing Cats were already persecuted in retaliation for taking chickens and fish and that attempts were made by some to kill them by either electrocution or poisoning around fish ponds. Two authenticated cases of this were established during the course of the 2013/14 study period, one of which involved a cat

intercepted while trying to raid a poultry house.

Aquaculture methods and interactions of Fishing Cats with fish farms

All fishpond owners reared a mixture of species of Carp (Family Cyprinidae), including Rohu *Labeo* spp., Naini *Cirrhinus mrigala*, Bighead Carp (Thul Tauke) *Aristichthys nobilis*, Commom Carp *Cyprinus carpio*, Grass Carp (Ghase Machha) *Ctenopharyngodon idellus* and Silver Carp (Chade Machha) *Hypophthalmichthys molitrix.* The ponds were stocked with fry each year, usually from April to May but sometimes also in March depending on the amount of water in the ponds and temperatures. Fry were purchased either from a local hatchery or from dealers from India. The price of local fry in 2014 was 300–500 Nepali rupees per kilo for locally produced fry and 500 Nepali rupees for Indian fry. Fish were fed mainly with pellets made by the owners from local produce, mostly cornflour, ground cereal husks and mustard oil. The growth period before harvesting was 6–8 months with harvesting mainly during December and February when the fish were from 0.5–1.0 kg in weight. Selling prices in 2014 were between 150 and 250 Nepali rupees per kg depending on the species. Common Carp, Rohu and Nairi fetched the highest prices. Fish were harvested by netting progressively during the harvesting period whenever dealers arrived to purchase the fish.

Of 55 fish pond owners or managers interviewed, nine (16.4%) stated they believed Fishing Cats to take fish from their ponds, while only three (5.5%) reported they had actually seen the cats doing so. Fifteen (27.3%) stated they believed Jungle Cats took fish and 12 (21.8%) stated they had seen them eating their fish. Forty (72.7%) reported they thought "Otters" (the Smooth-coated Otter *Lutra perspicillata*) took fish from ponds and 37 (67.3%) stated they had actually seen otters doing so. Other species were reported taking fish including Jackal (9.1%), Monitor Lizard *Varanus bengalensis* (7.3%), and Mugger Crocodile *Crocodylus palustris* (20%). Asked if Fishing Cats should be conserved, 40 fish farm owners (72.7%) declined to express an opinion, Seven (12.7%) stated they were in favour of conservation while five (9.1%) gave negative responses. Three believed Fishing Cats to have a significantly adverse effect on their business and one of these stated that he knew other pond owners who had killed Fishing Cats in retaliation for taking fish. In comparison, 67.3% of owners believed that otters reduced their profits and wanted action taken to protect their ponds from them.

DISCUSSION

Status of the Fishing Cat

From a combination of camera trapping and pugmarks, Fishing Cats were shown to occur across most of Koshi Tappu Wildlife Reserve and buffer zones. They seemed to be more concentrated in the eastern edge and buffer zone than in the drier western side. Pugmarks were found along the stream in the centre of the reserve but much of this central area was mostly shallow river channels with sandbanks offering no cover for Fishing Cats and may have had a lower carrying capacity for the cats. The southern part of the buffer zone on the eastern side south of Kushaha may also have a lower density of the cats: neither the camera trapping nor searches for pug marks in this area succeeded in finding evidence of them.

Although it is not possible to estimate total population size from this preliminary study the indications were of a significant population, given the globally endangered status of the species. The habitats in Koshi Tappu Reserve are highly modified but it is possible the density of Fishing Cats might actually be higher there than in more natural habitats. In the eastern buffer zone, in an area of only about 24km², a minimum of nine individual adults was identified in 2011. By comparison, an intensive camera trapping study in the more natural Chitwan National Park (CNP) wetlands, involving 868 camera trap days over an area of 160km² identified only five individual Fishing Cats with an estimated density of 4.4 cats per 100km² (Mishra 2013). The study area in CNP retained all potential predators and competitors of the Fishing Cats, whereas in Koshi Tappu, both tigers and leopards were absent and the range of potentially competing smaller carnivores was much less. It is possible that the apparently higher density in Koshi Tappu may have been an example of meso-predator release in the absence of the larger predators. There is growing evidence that larger predatory species prey on and compete with smaller species and that in their absence changes can occur in the trophic niches, numbers and distribution of the smaller species (Ritchie & Johnson 2009; Brashares et al. 2010; Ripple et al. 2013; LaPoint et al. 2014). However, at Koshi Tappu it is also possible the high density of fishponds may have supported higher populations of Fishing Cats.

The number of separate images obtained per 10 camera nights' effort varied greatly among the sites sampled from zero to 18 but it would be imprudent to assume that these represented real differences in either abundance or intensity of use of different areas.

Without detailed knowledge of range use there was probably a considerable level of chance in the siting of cameras in relation to the animals' activity.

Diurnal activity patterns

There is limited information on the diurnal activity patterns of wild cats. Lynam et al. (2013), using camera trapping in several protected areas in Thailand, found that small to medium-sized species were highly variable: species such as the Leopard Cat *Prionailurus bengalensis* and Clouded Leopard *Neofelis nebulosa* were mostly nocturnal whereas the Asiatic Golden Cat *Catopuma temminckii* was mostly diurnal and the Marbled Cat *Pardofelis marmorata*, completely diurnal. They secured only six images of Fishing Cat and all were nocturnal. Other than this there is no published information for Fishing Cats. At Koshi Tappu, because of the threat of theft, the cameras were in the field only for one hour before sunset and one hour after dawn so even though almost all the images obtained were in hours of darkness, it cannot be stated for certain that the species was entirely nocturnal. Nevertheless, the lack of records for the two hours of daylight before sunset and after sunrise that the cameras were in position suggests that they probably were, and this was supported by the observations of the villagers. It is not known if the pattern at Koshi Tappu was typical of the species or to what extent it was an adaptation to prey availability or a response to the high human use of the area. Most of the Fishing Cat's prey species are probably more available at night: most amphibians are more active at night and many freshwater fish tend to undergo diel vertical migration (DVM), occurring more commonly near the water surface at night (Mehner 2012). Most rodents such as members of the family Muridae tend to be nocturnal (Roll et al. 2006).

Threats and conservation strategy

From this study it is possible to identify only potential threats rather than known, established threats and to suggest elements of a provisional conservation strategy. Within the core area of the reserve, the main threats were probably depletion of fish stocks through overharvesting by villagers and removal of vegetation, especially riparian vegetation, by the large numbers of livestock grazed within the reserve. Removal of vegetation could have severe effects on fish populations, potential alternative prey species such as rodents, birds and reptiles, and also on cover for denning sites. The use, legal or otherwise, of the reserve by local villagers to extract a wide range of resources and to graze livestock is intensive (CSUWN 2009); reducing the extent of illegal grazing should be a priority.

The demographic viability of this population is unknown. It is likely the population is small and may be isolated. Outside the reserve and buffer zone there is limited potential habitat. Upstream, the river quickly moves into steep sided and deep upland valleys and our pug mark survey suggested no animals farther north than about 6km. Downstream, the river immediately passes into India and into very intensively farmed and heavily populated areas. On the western side of the reserve there is some limited potential habitat in the tributaries of the Koshi River such as the Tijuga River but on the eastern side most land is intensively farmed. Added to the limited extent of suitable habitat the current carrying capacity of the reserve is probably well below its potential because of the human overexploitation of resources. In this context, the only feasible conservation strategy may be to ensure that the reserve and buffer zone achieved their maximum carrying capacity by reducing the level of overexploitation.

Local villagers around Koshi Tappu clearly knew Fishing Cats well. Most had seen them and knew, in general terms, the food and habitat of the species. However, few were aware that the Fishing Cat is endangered and even though the majority stated they were in favour of conserving the species, a third considered they should be killed. It seems clear that ignorance of the species' status may also be a threat and that an important preliminary conservation action should be to improve the villagers' appreciation of the species' conservation status.

The desire among the general community to have Fishing Cats killed was a consequence of their perceived or known knowledge of the cats' predation on poultry and fish. Most fishpond owners refused to comment on this point so their general attitude cannot be gauged but some also stated that they wanted Fishing Cats to be killed. Two instances of retaliatory killing were confirmed during the study. Only a minority of fishpond owners stated that they believed Fishing Cats took fish from their ponds. The results of interviews always need to be interpreted with caution as, without testing, the motives and accuracy of the respondents are unknown. It is possible there may have been some confused identification as a much higher percentage of owners also stated they had seen Jungle Cats taking fish from ponds. Images of Jungle Cats were captured by the camera traps only nine times at three of the camera trapping sample sites compared with 48 images of Fishing Cats at nine of the sites, suggesting they were

much scarcer than Fishing Cats. Also Jungle Cats are not generally known to catch fish (Sunquist & Sunquist 2002; Mukherjee et al. 2004; Majumder et al. 2011). Most probably they would have been seen under low light conditions and it is possible that Fishing Cats were misidentified as Jungle Cats so that the occurrence of Fishing Cats at fish ponds may have been higher than suggested by the owners. Also the nocturnal activity of the Fishing Cats would have reduced the fish pond owners' ability to detect them.

The effect of mortality from retaliatory killing on the population of Fishing Cats depends on the extent of the mortality, the size and productivity of their population and whether the mortality is additive or compensatory in overall population limitation. If mortality from humans merely replaces density-dependent mortality that would occur for other reasons (compensatory) the effect could be minimal (see Newton 1998). At present the total population size of Fishing Cats in Koshi Tappu is unknown and also nothing is known of the dynamics or regulation of the population so the effect of human persecution cannot be assessed and it would take many years of research before this could be achieved. Thus it is wise to assume at present that human predation is a threat and act to accordingly. Human persecution of Fishing Cats seems to be widespread throughout the Fishing Cat's range and conflict with fisheries and poultry husbandry seems a common cause. In some areas of India, villagers believe they may have exterminated the species by such action (Mukherjee et al. 2012).

It is clear that the perceived direct conflict between Fishing Cats and humans around Koshi Tappu, especially relating to predation at fish ponds, needs to be resolved as part of the overall conservation strategy. However, the situation is likely to be complex. In addition to quantifying the possible pest status of Fishing Cats at fishponds it is important to understand the extent to which Fishing Cats currently depend on fishponds for food. For most of the year the fishponds are probably the main concentration of medium-sized fish in the area, and being Cyprinids, would be relatively easy for the cats to catch. Any actions to exclude Fishing Cats from ponds could remove an essential food source and hence be a significant threat to them. Although most fishpond owners did not identify Fishing Cats as a major problem, the great majority believed the Smooth-coated Otters to be serious pests and wanted to exclude them from fish ponds by fencing, an action that would also exclude Fishing Cats.

Should fishponds prove to be a significant food source for the Fishing Cats, as seems likely, there would be important seasonal changes in the profitability of the ponds as a feeding habitat for the cats. By March most of the fish are harvested from the ponds and restocking with fry occurs mainly during April to May. There would thus be a period of several months in spring, before the monsoon, when the ponds are less profitable as feeding sites and the cats would have to rely on other sources.

The extent to which Fishing Cats depend on food other than fish at Koshi Tappu is unknown but could have a significant effect on the population's survival. In addition to fish, the species is known to prey upon birds, small mammals, amphibians, reptiles, molluscs, crustacea and insects (Haque & Vijayan 1993) as well as scavenging livestock carcasses (Nowell & Kackson 1996). In Koshi Tappu the Fishing Cats may have be able to compensate partially for reduced fish stocks generally in the rivers and wetlands and seasonally in the fish ponds by diversifying their diet. This may have been facilitated by reduced competition in the absence of Leopards and several other small carnivores in Koshi Tappu. Competitive release of this kind has been suggested for other similar systems (Moreno et al. 2006). From the limited information collected at Koshi Tappu, Fishing Cats seemed able to associate with human environments, taking poultry from farms. The cultivated environment in the buffer zones had high populations of commensal rodents, especially around farm buildings and storage areas (Authors pers. obs. 2013) that could provide an alternative food source. If Fishing Cats could be perceived as important agents of rodent pest control, human perceptions might become more favourable. There is a strong argument for an in-depth investigation of all aspects of the Fishing Cat's trophic relations at Koshi Tappu to be included as a priority in a conservation strategy.

In the longer term, the Fishing Cat population will be susceptible to any change in the main river course. In a short period of time after the 1960s the main course of the river shifted from the western edge of the reserve to the eastern edge and presumably similar changes could happen again. At present all of the fishponds and marshland in the eastern buffer zone rely on water seepage through the embankment from the immediately adjacent river as well as an irrigation canal that takes water from above the reserve. The fishponds might survive with the canal water but most of the remnant wetlands would dry out if the river channel moved westwards. New wetland habitats would form but the time taken for these to become productive feeding habitats for the cats would be crucial.

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