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Original Contribution

Hunting Bats for Human Consumption in Bangladesh

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Abstract: Bats are important wildlife to their ecologic system, but they are also a zoonotic disease reservoir. Close bat–human interaction can lead to pathogen spillover. We conducted a qualitative study in two districts of Bangladesh and interviewed 30 bat hunters who hunt bats primarily for consumption, to understand the process and their reasons for hunting bats and their perceptions about bats and bat-borne disease. Most hunters catch bats during winter nights, using a net. Bat meat is used for household consumption, and the surplus is sold to cover household expenditures. They prepare the bat meat at home to sell it in their own and in neighboring communities. They also sell live bats to traditional healers. They report that the bat population has declined compared with 5 or 10 years ago, a decline they attribute to hunting and deforestation. Many have heard of a disease from bat-contaminated date palm sap but do not believe that bats can spread such disease to humans. Close bat–human interaction reported in this study pose a risk of pathogen spillover. Conservation initiatives have the potential to reduce such interaction and so both reduce disease risk and support the ecology.

Keywords: Bats, Nipah virus infection, Hunting, Zoonosis, Qualitative research, Bangladesh

Introduction

Bats contribute to restoring the environment, ecologically and economically, through seed dispersal, pollination and the reduction of insects that damage plants (Muscarella and Fleming 2007; Kunz et al. 2011). Bats are also the reservoir of several infectious diseases that can affect both humans and animals (Calisher et al. 2006; Wong et al. 2007).

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Interaction with infectious bats can cause outbreaks and disease emergences (Coltart et al. 2017). In Bangladesh, human outbreaks of bat-borne fatal Nipah virus infection (NiV) have occurred almost every year, mostly associated with consumption of bat-contaminated raw date palm sap (Luby 2013). Pteropus bats are the reservoir hosts for NiV (Halpin et al. 2011).

A review published in 2001, summarizing data from the prior three decades, suggests that in Bangladesh there were 31 species of bats, including three species of fruit bats, though many of these populations have been declining in size (Khan 2001). One factor likely contributing to this decline is deforestation (Khan 2001), which has been rapidly occurring in Bangladesh (The World Bank 2018). Cutting trees with bat roosts or where bats prefer to roost, and trees that provide food for bats leads to habitat destruction (Khan 2001). Continuous deforestation increases contact between humans and wildlife and may increase the health risk for people (Wolfe et al. 2005).

In Bangladeshi villages, people observe bats flying over their household, visiting their fruit trees and sometimes roosting in and around their households (Openshaw et al. 2017). Some indigenous communities in Bangladesh occasionally hunt Pteropus medius, the largest bat in Bangladesh, for consumption (Mickleburgh et al. 2009). While hunting and using bats as medicine or food, people are directly exposed to bats (Openshaw et al. 2017). Close bat–human interaction might cause zoonotic virus spillover (Smith and Wang 2013). Reducing bat hunting may reduce such interaction and improve bat conservation. Understanding why and how people hunt bats can help to develop conservation strategies and limit bat–human interaction to reduce the risk of zoonosis. In this study, we aimed to understand the process and reasons for bat hunting and bat hunters' perceptions of changes in the bat population and bat-borne disease.

Methods

We conducted an exploratory qualitative study among people who hunt bats for human consumption in NiV-affected Faridpur and Rajbari districts. This study was part of an NiV prevention study in Bangladesh (Nahar et al. 2017).

Identifying Study Population

Since hunting bats for consumption is uncommon, our data collection team asked local residents of Faridpur and Rajbari to identify bat hunters. Following the leads provided, the team met with some bat hunters, explained the aim of the study and responded to their questions. As the team built rapport with the initial study participants, these bat hunters provided names and addresses and introduced the team to other bat hunters who, in turn, helped the team to identify and communicate with additional hunters.

Study Sites

The team established contact with hunters and identified seven areas where they lived. Based on the availability and willingness of hunters to participate in the study, the team purposively selected one village in Faridpur, three in Rajbari, and one semi-urban area in Faridpur where hunters live among many non-hunters. The houses of hunters were built close to each other because of the scarcity of land, creating congested living spaces. Few hunters owned the land and the house where they lived, and several built their houses on government's or someone else's land.

Sampling

Team members spent time at the selected study sites, for hunters to get to know them and to build rapport before starting the interviews. The team selected experienced hunters currently hunting bats and interviewed those who were available and willing to share their knowledge. They continued to interview until they repeatedly received similar information to ensure data saturation. In total, they purposely selected and interviewed 30 hunters.

Data Collection

Three trained qualitative interviewers conducted in-depth interviews in Bengali, for an average of 53 min, between February 19 and March 11, 2014. They used interview guide with open-ended questions and recorded the interviews with voice recorders. They asked hunters about their occupation, hunting practices, reasons for hunting, use of bats, their perception of changes in bat populations and perception of diseases transmitted from bats to humans.

Data Analysis

The recorded interviews were transcribed in Bengali verbatim. Two team members separately read the transcripts to identify emerging themes and then developed a code list together. They coded the interviews manually and reviewed each other's codings. They looked for similarities, differences and connections between and among codes to group the data into categories, and then, they grouped these categories in central themes (Supplementary Table 1).

Results

Demographic Information

All our informants were male belonging to a Hindu minority group. Only six informants had formal education (2–5 years). Most explained that, because of poverty, they started working at an early age and could not attend school or continue their education. All held multiple seasonal jobs, mostly as a daily laborer and/or catching swamp eels (Table 1), earning an average of US$ 4 per day (one US$ = 82 Bangladeshi taka). However, securing this income was sometimes difficult since it depends on the availability of work or swamp eels, and their physical ability to perform these labor-intensive activities. Many hunt a range of animals (Table 1), and some raise poultry, cattle and pigs at home. They have dogs and cats as pets.

Learning Bat Hunting

Most informants learned to hunt bats as little boys or young teenagers accompanying the hunting team, mostly from family members (Table 2). Many consider hunting a special skill, a privilege that makes it easy to provide meat for their families. Not everyone knows how to hunt unless they had someone in their family or neighborhood to teach them.

Reason for Hunting

Most informants reported that they hunt mainly for household consumption and sometimes to sell the surplus (either meat or living bats) to generate income (Box 1)

Table 1. Demographic Information of Bat Hunters from Faridpur and Rajbari Districts, Bangladesh, 2014.

	Faridpur $N = 10$ (%)	Rajbari $N = 20$ (%)	Total $N = 30$ (%)
Gender (male)	10 (100)	20 (100)	30 (100)
Age mean (range)	32 (19–55)	39 (20–70)	37 (19–70)
Household member: median (range)	5 (4–8)	4 (3–10)	5 (3–10)
Education: years of schooling (range)	(0–5)	(0–5)	(0–5)
Number of informants that attended school	3 (30)	3 (15)	6 (20)
Religion (Hindu)	10 (100)	20 (100)	30 (100)
Income-generating activities to maintain livelihood (involved in multiple activities)			
Daily labor to carry loads	9 (90)	13 (65)	22 (73)
Daily labor others	3 (30)	13 (65)	16 (53)
Artist (making Hindu God figures and singing religious songs)	1 (10)	1 (5)	2 (7)
Catching swamp eel	7 (70)	16 (80)	23 (77)
Catching fish	0	5 (25)	5 (17)
Seasonally catching bats	1 (10)	1 (5)	2 (7)
Catching snakes	0	1 (5)	1 (3)
Animals they hunt mainly for consumption (excluding bats)			
Rabbits	8 (80)	9 (45)	17 (57)
Turtles	5 (50)	2 (10)	7 (23)
Squirrels, foxes, wild cats, mongoose/weasels, hedgehogs, birds	1 (10)	7 (35)	8 (27)
Pigs	2 (20)	0	2 (7)

Table 2. Information on Learning Bat Hunting, Reasons and Season of Bat Hunting and Selection of Hunting Places from Faridpur and Rajbari Districts, Bangladesh, 2014.

	Faridpur $N = 10$ (%)	Rajbari $N = 20$ (%)	Total $N = 30$ (%)
Learn hunting bats from			
Family: grandfather, father, brother, father in law, cousin, uncle	6 (60)	12 (60)	18 (60)
Neighbors and friends	3 (30)	3 (15)	6 (20)
Can't remember	1 (10)	5 (25)	6 (20)
Reason for hunting bats (multiple responses)			
For household consumption	8 (80)	16 (80)	24 (80)
Can sell the surplus catch	7 (70)	14 (70)	21 (70)
Can earn money when there is no other work available to pay the daily need	4 (40)	4 (20)	8 (27)
Like to hunt bats/hobby/happily join when others asked to join	3 (30)	2 (10)	5 (17)
Tradition, hunting and consuming for generations	2 (20)	2 (10)	4 (13)
Other people ask them/because of high demand during winter	2 (20)	0	2 (7)
Muslim people and traditional healer (Kabiraj) ask for alive bats	0	2 (10)	2 (7)
A business	0	1 (5)	1 (3)
Bat hunting season			
During winter/cold months/one to 3 months somewhere between Vadro and Falgun (mid-August to mid-March) based on the coolness of months	5 (50)	14 (57)	19 (63)
Six to eight months somewhere between Ashar and Magh (mid-June to mid-February)	2 (20)	6 (30)	8 (27)
Stop hunting when bats get pregnant and keep babies under the wings (mid-February to mid-June)	9 (90)	18 (90)	27 (90)
Reasons for not hunting pregnant bats and bats host babies under the wings (multiple responses)			
Don't want to kill three bats instead of one/babies will die too (each mother bat conceives and gives birth to two babies)	5 (50)	17 (85)	22 (73)
Let babies grow for future, otherwise, no bats would live/bat population will decline (when babies leave their mother, they weighted 250 gm and are edible)	5 (50)	8 (40)	13 (43)
Don't eat pregnant bats (meat is not tasty, and it is smelly, do not feel like eating when seeing babies inside)	2 (20)	5 (25)	7 (23)
Bat babies (that lives under the wings of mothers) are not big enough to eat	2 (20)	2 (10)	4 (13)
God can see and punish for killing pregnant bats or bats with babies under the wings/something bad can happen to the wife and children if they hunt pregnant bats	1 (10)	2 (10)	3 (10)
No one will eat it after seeing that the bat was pregnant	0	1 (5)	1 (3)
Selection of hunting place			
Close to date palm trees/fruits and flower of certain trees that attract bats	3 (30)	10 (50)	13 (43)
Sap harvesters and fruit tree owners invite to come and catch bats	2 (20)	11 (55)	13 (43)
Saw bats flying around a tree or saw signs of bats presence (when they go hunting swamp eel)	3 (30)	6 (30)	9 (30)
Hunt from roost	1 (10)	1 (5)	2 (7)

(Table 2). They are accustomed to eating bat meat, and hunting is an enjoyable tradition practiced for generations. Hunters like meat, but it is expensive (US$ 1.2–5 per kg) given their daily income. Therefore, they prefer hunting bats and other animals over buying meat. One hunter reported that he occasionally bought bat meat, when he was too busy catching swamp eel but felt enjoyed eating it. Several hunt bats when there was no other income-generating work available. Sometimes they feel like eating bat meat and go hunting if they have free time.

Box 1. Quotations from bat hunter interviews on reasons for hunting bats from Faridpur and Rajbari Districts, Bangladesh.

Reasons for hunting bats

Bat meat tastes better than chicken and mutton. There is a high demand for bat meat during winter. I can't afford to buy meat. We follow in the footsteps of our father and grandfather, they hunted and now we hunt. Sometimes I hunt more to buy food for my family, however, bat hunting alone doesn't give us enough to live. Working as a laborer is my main income source. [Age 28 years, Faridpur]

We are Adivashi (indigenous people), we are poor, we can't buy meat. So, when we feel like eating meat or when we don't have enough to eat, we hunt bats and other animals. If we want to eat goat meat, it is US$5 per kg. We can't afford it. We can only afford broiler chicken which is cheaper than other meat, we buy it when we have relatives or guests at home. Otherwise, we hunt bats and rabbit to eat. [Age 37 years, Faridpur]

I hunt during winter to earn a living. When I got children, I needed more money to support my family and I started to hunt. If I hunt 10 bats, we can eat 5 and, after selling the rest, we can buy 2 kg of rice. Now the kg of rice is US$ 0.6, it is very difficult to feed 4–5 people in the family and pay the rent. As a daily laborer, I also don't have a regular income. That makes me hunt bats. During the winter season, there is not much work "loading and unloading" the trucks (the work of a daily laborer). I don't earn enough to feed my family, so I prefer to hunt bats. [Age 37 years, Rajbari]

Hunting Season

All informants hunt bats 3 months during the cold season when demand for bat meat is high as bats get fatter, tastier and less smelly than during warmer months. It coincides with the time when date palm sap is harvested. However, eight informants said that they hunt bats 6–8 months a year (Table 2).

Almost all hunters reported that they do not hunt bats during the 4 months when bats are pregnant and carry newborns under their wings, between February and May (Table 2). When the buds are seen in *Erythrina variegata* and *Bombax ceiba* trees, hunters know that bats are pregnant and avoid hunting them.

Selection of Hunting Place

Most hunters provided a similar description about finding a hunting place. They said that from experience, they know how to find bats. They observe flowers blooming or fruits ripening on trees that attract bats, like *Erythrina variegata*, *Polyalthia longifolia*, *Ficus benghalensis* and *Diospyros discolor*. To confirm the bats' nightly visits, they search for signs such as partially eaten fruits and bat feces close to the trees or places where they see bats flying. Hunters know that bats are attracted to clusters of harvested date palm trees where they come to drink the sap. When they go hunting for swamp eel or other animals, they look for signs of bats or see them flying around trees and decide where to hunt. Sometimes fruit tree owners, sap harvesters, and villagers inform them about the bats' presence, asking hunters to catch them (Table 2). Some avoid hunting from the roosts because that could scare bats to leave forever. Most prefer a known location that can be reached from home, on foot or on a rickshaw van (2–6 km) or by bus (40 km or more). Four informants said that they travel outside their home district to a place where there are more bats.

Hunting Process

While hunters hunt bats when it is dark, between dusk to dawn, they prefer to arrive at the bat hunting place when there is still sunlight to complete their preparations. The supplies used for hunting include two long bamboo poles, a net, a rope to attach the net to the poles, a pulley to move the net up and down like a flag, and a knife to stick into the bat's mouth in case it bites them. A hunting team requires at least two, but preferably three people: one who can climb trees, one to pass the bamboo poles to the tree climber, and one to hold the end of the rope. First, they identify two big trees, and then, the climber ties the bamboo poles to those trees and hangs the net across the bats' flying route. Then, they attach the net to the rope and use a pulley to hoist the net up after sunset.

Once one or two bats are caught and make sounds, they bring the net down using the rope. They beat the bat with a stick on the back of the neck, sometimes killing it, to avoid being bitten. Several hunters preferred to break their wings so they cannot fly away, keeping them alive for later consumption or to sell freshly slaughtered bats for a good price. Once removed from the net, they keep the bats in a

sack. Since hunting requires being awake for most of the night, they prefer not to hunt every night (Box 2).

Slaughtering and Selling Meat

Once at home with their prey, all hunters reported severing the throat of the surviving bats, removing the skin, and throwing it away along with the head, intestines, claws, and wings. One said that he typically feeds the waste to a dog or buries it in the ground. Some keep a few live bats hanging from a tree to slaughter and consume them within the next few days.

The prepared meat is divided equally among the team members. The net owner may get an extra share. Female household members take the meat, wash it, and cook it into a meat curry until it is soft enough to eat. After meeting the household needs, they sell the surplus at US$1.2 to US$3.6 per kg within their community or to similar communities nearby. Muslim people do not buy bat meat though some Muslim people and traditional healers ask for live bats caught on a Saturday or Tuesday night, under the belief that bats caught on those days have special healing value. Many hunters charge more per live bat, about US$6 since they consider it an urgent need for that buyer.

Problems Related to Hunting Bats

Many informants (53%) reported being bitten by bats at least once. Perceived problems of hunting bats included several physical, physiological and security issues (Table 3, Box 3). They believe that ghosts can scare people in the dark, resulting in catching a fever and being killed. Being awake for the night makes them too tired to work as a laborer the next day, missing the opportunity to earn their daily income. Climbing trees causes body aches, along with the potential risk of dying from falling from the tree. Some also described problems such as bat and insect bites, encountering snakes, getting colds, constipation, and some security issues. Although most people support their practice, sometimes hunters faced resistance from people when they want to hunt bats from roosts in a graveyard, shrine or temple. Some mentioned social rejection because they hunt bats, and reported that people looked down on them (Box 3, Table 3).

Box 2. Quotations from bat hunter interviews on bat hunting process from Faridpur and Rajbari Districts, Bangladesh.

Hunting process

First, we observe in which direction the bats fly. We also search on the ground, we see bat excreta. Then we know which direction they are flying. If there are several date palm trees being harvested, we know that bats visit those trees. We start at home. Based on the distance to the hunting place, we try to reach the place by the afternoon. Then we select two trees, climb them and tie two bamboo poles, then add a pulley to bring the net up or down with a rope. In our team, we need a good tree climber. We place the net in the evening. When bats get trapped, we bring the net down and beat the bats, sometimes to death, to remove them. They have nails and sharp teeth. It's difficult to remove them without beating them. We don't slaughter them because it causes bleeding and is difficult to carry them back home. When people see blood, they want to see what we have in our bag. Often, we do not carry bamboo poles. We try to collect or borrow them locally. We know when bats are trapped in the net because the rope from the pulley shakes. We hunt the whole night and stop in the morning. [Age 30 years, Faridpur]

We start at home after lunch to reach the place where we will hunt bats. We need a net, a rope, and two bamboo poles to hunt bats. We need a very long rope because you never know how high these two trees to hang the nets would be. The net can be 12 m wide and 18–23 m long. Bats fly to fruit trees and we see them. We know they will come here. If there are other trees around, we select two trees to hang the net in the area where bats fly. We will climb the trees, tie bamboo poles, hang the net (where they fly) and attach a rope to the net with a pulley. We prepare everything before evening but place the net in the evening when it gets dark because if bats see the net they will avoid it. A few bats get stuck in the net during the evening, though most bats would be captured just before morning when they are on their way back home (to the roost). We can't sleep while we work. We need to be awake all night. Who knows when bats will come and get stuck in the net, we need to bring the net down to remove them and put it back. We grab the bat by the neck to remove it from the net, to avoid getting bitten. We also brake the wings to keep bats alive, we beat it, so it makes a sound. When bats get stuck or are in pain, they call in a way that other bats hear and understand and come back to see what is going on. Hunters also make a special sound to attract bats. After the night we come back home in the morning, sometimes we reach home by 10 am. [Age 43 years, Rajbari]

Table 3. Reported Problems Related to Hunting Bats and Local People's Reaction to Hunting Bats from Faridpur and Rajbari Districts, Bangladesh, 2014.

Risks and difficulties	Faridpur $N = 10$ (%)	Rajbari $N = 20$ (%)	Total $N = 30$ (%)
Informants bitten by bats	7 (70)	9 (45)	16 (53)
Perceived physical and psychological health issues related to hunting bats			
Ghosts (scare people and people get a fever, ghosts can kill people)	4 (40)	8 (40)	12 (40)
Get tired being awake all night, placing nets, climbing trees	2 (20)	6 (30)	8 (27)
Snake and insects can bite	2 (20)	5 (25)	7 (23)
Bats bite	1 (10)	3 (15)	4 (13)
Fall from the tree	3 (30)	1 (5)	4 (13)
Feel cold–get cold	1 (10)	0	1 (3)
Get constipation	1 (10)	0	1 (3)
"Committing a sin by hunting bats" and feel guilty	1 (10)	0	1 (3)
Perceived security issues related to hunting bats			
Criminal/bandits/robber/terrorist/political party people can beat them	3 (30)	1 (5)	4 (13)
Local people confuse them with robbers/thief and beat them	1 (10)	1 (5)	2 (7)
Darkness	1 (10)	0	1 (3)
Police can catch them and put them in jail	1 (10)	0	1 (3)
Local peoples' reaction to hunting bats			
When bats disturb people (eat fruits, date palm sap, sometimes make noise or make the place dirty) people invite hunters to come and catch bats/when people see hunters hunting bats they encourage them, come and talk to them, support hunters	8 (80)	11 (55)	19 (63)
Local people do not allow to hunt bats from a roost in graveyard and shrine and temple/from a roost in general (bats bring fruits)/because it is not legal/because hunter makes a mess, break the branches of trees, affect their cultivation (crops)	4 (40)	11 (55)	15 (50)
Ask for money if they hunt bats from peoples' land/destroy net/take bats forcefully/police ask for a bribe to let them carry the hunt	3 (30)	2 (10)	5 (17)
Local people look down on them, do not drink tea from the same cup in the tea stall if they know that they hunt bats	0	4 (20)	4 (13)

Hunting Past and Present

Many (60%) said that, although fewer people hunt bats now compared to 5–10 years ago, more people can afford bat meat now (Table 4). However, some other hunters (37%) believed that more people hunt bats now than 5–10 years ago. Several hunters reported that earlier, only bat hunters and members of their community consumed bats. Now, some low-income population that do not hunt bats have started buying bat meat for its taste and affordability. Six informants who did not sell meat earlier started selling it due to high demand during the cold season. A few hunters reported knowing that bat hunting is illegal, indicating that now they rarely hunt bats.

Many hunters reported that they see and catch fewer bats than five to 10 years ago (Table 4) when they would easily catch around 50 bats per night in their locality. Now they get 2–5 bats, sometimes none. When they travel to "far and remote places," they may get 10–20 bats. If they travel 50 km or more, or to other districts, they may catch 50–100 or more. In addition, earlier they often got bats weighing over 750 grams. Now, most weigh 200 grams and sometimes 500 grams; therefore, they need to hunt many bats for it to be a rewarding business. Hunting is becoming economically less beneficial for most of them than working as a daily laborer.

Many believed that the bat population declined because of hunting and destruction of their habitat. Previ-

Box 3. Quotation from bat hunter interviews on bat bites and problems related to hunting bats and local people's reaction to hunting bats from Faridpur and Rajbari Districts, Bangladesh.

Bat Bites

When it [the bat] bites, you get a very high fever. The bat's bite on my finger made it swell up and caused severe pain and high fever. When it bites, it doesn't let you go because its jaw gets locked. It requires putting a knife in the bat's mouth to free your hand. I had a fever for a day or two. [Age 37 years, Faridpur]

[When a bat bites] You need to put a knife in its mouth or a stick on the nose to make it stop biting you since its jaw gets locked. I was bleeding and it was painful, but I was fine in a few days. [Age 66 years, Rajbari]

Problems related to hunting bats

There are snakes (that can bite) and ghosts. One person even died from a ghost attack. They hanged the (bat catching) net on a big tree. When they loosened the rope, the net was not going down. The person climbed the tree to check and the ghost held him and did not let him go. Consequently, he died. That's why I always pee on the net before hunting, to keep ghosts away. It gets contaminated by pee and no magic can harm us. We hunt during the winter season and we catch a cough and colds. However, if we see a bat, we go hunting, we do not think about these problems, our mind says to hunt it and eat it. It's like catching fish, if you don't get any fish, you still go fishing, it is like an addiction. [Age 43 years, Faridpur]

It is difficult to climb and get down from trees. It is also difficult to be awake at night. That's why, when we don't have enough work to do (income generating work during daytime) we go hunting. We are working every day as labours, suddenly, one day there is no work. On that day we say, "let's go and catch some bats." [Age 37 years, Rajbari]

Local people's reaction to hunting

Local people encourage us to hunt bats. They say, bats make a lot of noise, they make the place dirty, they eat fruit. Catch them, take them away. They say they (bat hunters) are indigenous people, they eat bats, let them hunt. [Age 55 years, Faridpur]

There is a big banyan tree (with bat roost) close to a shrine, there lives a caretaker, he never allows to catch bats. He says bats are very useful. Every fruit that the bat eats, it brings it to the owner of the land where they roost. This way they pay a tax to people, so they (people) can eat fruits. It doesn't matter if people are eating those fruits or not, bats fulfill their responsibility. [Age 43 years, Rajbari]

In the beginning, I felt ashamed about bat hunting. Day by day I got used to hunting bats. Sometimes other community people (even some Muslims) pay in advance for bats to heal pain from health problems…Although people invite us to catch bats, in my locality, it remains a lower caste job. Some people react like "You people are living well now, then why do you still hunt bat?" Some people avoid having a close relationship with us. Sometimes, we don't tell that we hunt bats because in bazar/marketplace people may not drink tea with us or will not allow us to drink from the same cup. In my work (daily laborer at the marketplace) a man said, "Stop bat hunting, support your sister to complete her education. I will support her to get a job [to have a better living]." [Age 22 years, Rajbari]

ously, there were more large trees for bats to roost in and feed on. Since people cut down big trees and cleared forest areas, bats and other wild animals are not commonly seen anymore. Some said that bats might have moved to other places because of hunting.

Perceived Usefulness of Bats

When asked about the usefulness of bats, most informants said that bats are neither useful nor harmful. Several hunters indicated that bats are harmful because they have a negative financial impact on fruit tree owners, they make noise and they make a place dirty. They reported that the "gas" produced from bat's excreta can kill the tree hosting a bat roost. Some hunters believed that consuming bat meat can cure disease, but others did not believe this (Box 4). Some hunters proposed that, because bats eat the best fruits on a tree, their meat may have special healing properties. Some believe that bats are useful to those who have roosts in their trees. When bats return to the roost after foraging, they drop fruits that the tree owners' can consume. The fruits dropped by the bats can also help people grow new plants and trees.

Perception of a Disease Transmitted from Bats to Humans

Four informants from Faridpur and eight from Rajbari reported hearing about a disease from bat-contaminated date palm sap, and one specifically mentioned "Nipah virus." They heard about it over the last 7 months to 5 years, through television, word of mouth, and in one

Table 4. Comparing Past with the Present: bat hunting and Bat Population reported by Bat Hunters from Faridpur and Rajbari Districts, Bangladesh, 2014.

	Faridpur $N = 10$ (%)	Rajbari $N = 20$ (%)	Total $N = 30$ (%)
Bat hunting now			
More people hunt bats now than 5–10 years back	3 (30)	8 (40)	11 (37)
Less number of people hunt bats now than five to 10 years back	6 (60)	12 (60)	18 (60)
Less number of people hunt bats now because			
In the past, more people hunted more frequently because of poverty and less income-generating work than now	0	8 (40)	8 (27)
Have to go far to find bats	2 (20)	4 (20)	6 (20)
Several hunters grew old to hunt	2 (20)	2 (10)	4 (13)
Because non-bat hunters look down on those who hunt bats	0	4 (20)	4 (13)
Less number of bats	0	1 (5)	1 (3)
Many people stopped (since hunting is not legal)/government banned hunting birds	2 (20)	1 (5)	3 (10)
Number of bats			
Earlier there were more bats and now fewer bats	7 (70)	20 (100)	27 (90)
The number of bats did not decline	1 (10)	0	1 (3)
Reason for having fewer bats			
Hunting			
Now more people hunt bats than earlier since human population increased/now other people (not traditional bat hunters) also hunt bats	3 (30)	8 (40)	11 (37)
Because of continuous hunting/killing	0	3 (15)	3 (10)
Consumption and selling			
More people consume bats than earlier/income increased so more people can afford to buy meat than earlier	2 (20)	0	2 (7)
Earlier hunter for consumption and now for selling	1 (10)	1 (5)	2 (7)
Environmental change			
Trees declined, thus, no food for bats/less big trees and jungle-like areas to make bat roost/now fewer fruit trees for bats and date palm trees	3 (30)	5 (25)	8 (27)
People cover the fruit trees with a net so bats can't access	1 (10)	0	1 (3)
Used gun to kill bats that frighten bats/people chased bats	2 (20)	0	2 (7)
Bat conservation (suggestions)			
Stop hunting/killing/consuming bat/stop hunting for 3–4 years/if not killed bat population will increase a lot	3 (10)	4 (20)	7 (23)
No way to conserve/can't do anything if number declines	0	3 (15)	3 (10)
If the government makes a rule	0	1 (5)	1 (3)
Selling bats			
Earlier never sold bats but now I do, since people outside their community also consume bats/sell to a neighbor/to non-bat hunting population	4 (40)	4 (20)	8 (27)
Stopped selling, catch only for household consumption	1 (10)	1 (5)	2 (7)
Now more people buy bats (since they have other income-generating activities and have money to buy)	0	2 (10)	2 (7)

instance, by working with a team catching bats for a scientific study. Sometimes when they go hunting in other districts, people warn them about a disease from bats. They do not believe that bats could spread a disease to humans (Box 4) because they have been hunting and consuming

Box 4. Quotation from bat hunter interviews on the perceived usefulness of bats and perception of a disease that people can get from bats, from Faridpur and Rajbari Districts Bangladesh.

Perceived usefulness of bats

Bats can heal asthma and arthritis. That's why many Muslims come to us to buy bats. We consume bats and none of us, even the very old people, suffer from asthma or arthritis. By observing this, we understand that bats have something inside, it has a quality. That is because bats eat fruits. Medicines are made from fruits. You don't know when the fruit will become ripe in your tree, but a bat knows much earlier than you. Some small children get a fever at night. The wing bone of the bat can be used to treat the fever. It can be hanged from their throat. [Age 50 years, Faridpur]

I don't believe that bats can heal asthma. My father has asthma and he has been eating bats his whole life. My uncle is having arthritis. [Age 25 years, Rajbari]

Bats are not useful, rather, they cause harm to the crops. I have heard that bats can cure asthma and arthritis. It needs to be cooked and consumed. Bat bones can prevent fever in small children. I don't know if it is correct or false. [Age 32 years, Rajbari]

Perception about a disease from bats to humans

Bats do not cause any disease. We have been consuming bats for many years. If it carried any disease that affects people, we would have gotten it. [Age 21 years, Faridpur]

I heard 2 years ago, that it is not allowed to drink date palm sap that bats drank from, or fruits eaten by bats. People can get sick and die, and many people died from it. That's why I also thought that we need to be careful by avoiding any risk. When I first heard, I asked our people not to hunt bats. Who knows, you can risk your life by hunting and eating bats. But, after a while, I thought, whatever happens, I continue. Nothing can stand fire and we cook the meat nicely using fire. [Age 43 years, Rajbari]

bats for generations and nobody from their community caught any disease from bats.

Discussion

Our informants hunt bats and a range of other wild animals. The activity includes handling, killing, and butchering bats, as well as preparing meat for cooking and selling. Hunters are exposed to body fluids, bites, body tissue, urine and feces of wild animals that may contribute to disease transmission and zoonotic pathogen emergence (Wolfe et al. 2005). Bat hunters raise domestic animals at home, where they also butcher and prepare bat meat, sometimes keep bats alive and throw leftover bat body parts or feed it to pets, increasing the risk of disease transmission from bats to animals and humans. For example, a human NiV outbreak in Malaysia occurred when bats infected pigs and pigs infected humans (Yob et al. 2001). So far, we are not aware of evidence that hunting and butchering bats, and interacting with bats and animals in the bat hunters' households resulted in NiV infection. However, NiV is able to infect a wide range of animal species (Eaton et al. 2006). Therefore, it seems prudent to limit such interactions.

Bat hunters have hunted and consumed bats for generations. To them, bat meat is a delicious seasonal food that helps them increase their income. They are poor and often unable to buy meat or meet their basic household needs. A multi-country study from Africa found that high bushmeat hunting and consumption occurred locally among hunters' households, in settlements isolated from economic opportunities (Brashares et al. 2011). When people have low labor productivity, and alternative livelihoods are seasonally unavailable, people turn to wildlife hunting to generate income and food (Brashares et al. 2011). Although our informants were not isolated from the labor market, they earn minimal wages by working as daily laborers and have few other employment opportunities. They prefer not to hunt bats when other income-generating work is available since hunting is hard work and not always sufficiently lucrative to meet their everyday household needs. Creating work opportunities might reduce the number of hunters but may not reduce demand. Bat meat is still a less expensive alternative, similar to some other settings where bushmeat consumption was found to be high and consistent among poor households located close to wildlife because bushmeat is noticeably cheaper than other alternatives (Brashares et al. 2011). However, we did not find the massive hunting and trading of bat meat reported in studies from Thailand, Indonesia and Ghana (Struebig et al. 2007; Kamins et al. 2011; Suwannarong and Schuler 2016). Most bat hunters do not know that bat hunting is

illegal, and those who knew about it reported reducing hunting. An intervention engaging hunters in other work to improve their livelihood, and providing conservation information may reduce hunting.

Our data suggest that the number of bats has declined in the study area. Our informants indicated two main factors: hunting and loss of habitat. We do not know the volume of bats they hunt each year, or if the decline in bat populations has been primarily driven by hunting or by bat migration away from the area. These could be explored in future studies to define bat conservation strategies. Globally, many bat species are extinct and endangered (Mickleburgh et al. 2002). Because of the loss of forest habitat, bat populations in Singapore have dramatically declined (Lane et al. 2006). Increasing deforestation in Southeast Asia might lead to the extinction of many bat species (Lane et al. 2006). The bat population might have declined all over Bangladesh because of deforestation. From 1930 to 2014, the forest-covered areas declined 39%; from 2006 to 2014, the annual rate of gross deforestation was 0.77% (Reddy et al. 2016). Increasing population and economic development initiatives that convert forests into agricultural land, and exploitation of resources, contribute to this deforestation (Salam and Noguchi 1998).

Because of deforestation, bats might have increased interaction with humans, as they do not have any other place to go. When food becomes insufficient because their natural sources of forest foods have been removed, bats look for alternative sources and visit trees close to human settlements, potentially increasing the spillover risk between bats and livestock or humans (Plowright et al. 2015). Conservation measures such as rebuilding and preserving bat habitats may decrease contact between bats and humans and reduce the risk of spillover (Schneeberger and Voigt 2016). Finding strategies to protect forests, such as including local people in co-managed protected forests (Chowdhury et al. 2009, 2014), or combining forestry and agriculture can be financially beneficial to the poor while ecologically beneficial to the country (Ahammad et al. 2014). Since bat hunters often encounter resistance to catching bats from the trees located at temples, shrines, and graveyards, bat hosting trees (Khan 2001) can be planted in those places and in protected forests. Growing bat hosting and feeding trees may contribute to bat conservation.

Many informants did not believe bats can carry diseases that infect humans, although some of them heard about NiV. They are often bitten by bats during hunting and did not link bat bites with rabies or other infections. Informing people about disease risk might generate hostility toward bats and adversely impact conservation efforts. Bat hunters belonging to a minority group might be blamed and marginalized for transmitting bat-borne diseases to people. Pig-raising minority communities from Indonesia and Egypt were blamed and stigmatized, though they were not the reason for transmission and emergence of the ''swine flu'' (Padmawati and Nichter 2008; Leach and Tadros 2014). Therefore, informing people about the usefulness of bats might be the first step of an intervention.

Some bat hunters reported that other people look down on them and it is unlikely that they will trust health information and intervention from a majority group who marginalizes them. Marginalized and stigmatized communities are difficult to reach with interventions (Barrett and Brown 2008; Nahar et al. 2013). However, when people are respected, they are open to access health services, behavioral recommendations and to accept interventions (Gustafsson et al. 2004; Lyons et al. 2015; Jones et al. 2017). Working with bat hunters to design practical conservation intervention materials could produce more credible and effective communication.

Our study has limitations. Our data represent the thoughts and perceptions of bat hunters; we did not conduct any observations to confirm their reports. We interviewed only hunters and not their clients. Although those who buy bat meat from hunters are from similar low-income communities, we do not know how frequently they buy it. Interviewing them would give us an idea about the demand, the volume of meat they buy and their interaction with bats. Similar to other countries, in Bangladesh, bats have been used for medicinal purposes (Mildenstein et al. 2016). Some hunters sell live bats outside of the hunting community to those who use bats for the treatment of illness. We did not collect information on where these bats were taken and their interaction with humans and animals. We can assume these bats were taken to neighboring places where bat hunters live. Bat hunters live in densely populated rural and semi-urban areas and work as laborers in busy marketplaces. The high density of human population in urban centers close to wildlife (bushmeat) hunting areas and increasing movement of people from urban to rural areas may increase the risk of new epidemic zoonoses (Wolfe et al. 2005). Thus, interactions with live bats and the medicinal use of bats can be future research topics.

This study provides insight on bat hunters' behaviors and their perception of bats. The close interaction between bats and humans can pose a risk of zoonotic spillover. If the

zoonotic pathogen is capable of person-to-person transmission, dense, highly mobile populations in Bangladesh create a broader risk. Future studies in a larger geographic area can explore the diversity and intensity of bat–human interaction and advance strategies to prevent spillover. Fruit bats are crucial pollinators and seed disbursers in tropical forests so a declining bat population undermines tropical forest ecology (Muscarella and Fleming 2007). Interventions to improve bat habitats hold the potential for contributing to bat conservation and limiting bat–human interactions.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The interviewers obtained written informed consent prior to conducting the interviews. The team did not record information that can identify the particular informant and labeled each interview with a number. Human subject review committees at icddr,b and FHI 360 approved the study protocol.

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