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<https://www.csnrdc.net/>**OPEN ACCESS****REVUE
CONGOLAISE
DES SCIENCES
ET TECHNOLOGIES****Participation in hunting activities and other human behaviors in an area enzootic for the *Monkeypox virus* and hypothesis on zoonotic risk factors in Tshuapa Province, Democratic Republic of Congo (DRC)****[Participation à des activités de chasse et autres comportements humains dans une zone enzootique pour le *Monkeypox virus* et hypothèses sur les facteurs de risque zoonotiques en Province de Tshuapa en République Démocratique du Congo (RDC)]****Lem's Ndimba Kalembe^{1*}, Jesse Bonwitt² & Jean Mukulire Malekani¹**¹Department of Sciences of Life, Faculty of Science and Technology, University of Kinshasa, Kinshasa, DR of Congo²Department of Anthropology, DH1 3LE, University of Durham, UK**Abstract**

Mpox is an endemic zoonosis in West and Central Africa. Despite significant research efforts, there is still too little information available on the specific interactions that lead to the transmission of the mpox. Qualitative studies therefore make it possible to collect information that could not be obtained by other methods. Thus, we used a qualitative method to determine the hunting techniques that could serve as potential routes of exposure to the *Monkeypox virus*. Fieldwork was conducted over a period of four months in 2021 (March–April and July–August). Thus, a total of 211 participants were interviewed during 23 semi-structured interviews, 10 focus groups discussions, and 15 days of participatory observations. Present results highlighted that only hunting techniques using dogs, bows with nonpoisonous arrows, nets, capture in holes, and a technique used for catching cricetomas (giant pouched rats) increase the risk of bites and scratches as well as contact with blood and other animal bodily fluids. This could be a potential route of exposure to the *Monkeypox virus*. Then, this study has provided us with some additional qualitative information that was missing about hunting on a public health point of view. We therefore hope that our findings will increase the scope of future quantitative research on this topic.

Keywords : Mpox, Human-animal contacts, In-depth interviews, Hunting methods, Way of primary transmission, Democratic Republic of Congo.

Résumé

Le mpox est une zoonose endémique en Afrique occidentale et centrale. De nos jours, malgré de multiples efforts de recherche, il existe trop peu d'informations sur les interactions spécifiques qui mènent à la transmission du virus du mpox. Par conséquent, des études qualitatives auraient facilité l'obtention des informations inaccessibles par d'autres méthodes. Ainsi, nous avons utilisé une méthode qualitative pour déterminer les techniques de chasse pouvant constituer des voies potentielles d'exposition au *Monkeypox virus*. Le travail de terrain s'est déroulé sur une période de quatre mois en 2021 (mars-avril et juillet-août). De ce fait, un total de 211 participants ont été interviewés lors de 23 entretiens individuels, 10 groupes de discussion ainsi que 15 jours d'observations participatives. Nos résultats ont souligné que seule la chasse utilisant des chiens, l'arc avec des flèches non empoisonnées, des filets, la capture dans des trous et la technique utilisée pour attraper des cricétomes accroissent le risque de morsures et égratignures ainsi que le contact avec du sang et autres fluides corporels des animaux. Cela pourrait être des voies potentielles d'exposition au *Monkeypox virus*. Ainsi, la présente étude nous permet d'apporter un peu plus d'informations qualitatives qui manquaient sur la chasse du point de vue de la santé publique. C'est pourquoi nous espérons que nos résultats élargiront la portée des futures recherches quantitatives sur ce sujet.

Mots-clés: Mpox, Contacts homme-animal, Interviews en profondeur, Méthodes de chasse, Voie de transmission primaire, République Démocratique du Congo.

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1. Introduction

Zoonoses are responsible for more than 60% of emerging infectious diseases (EIDs) and pose a major threat to global health (Nii-Trebi, 2017). Among those zoonoses, mpox is endemic in West and Central Africa. It causes the disease in humans (Reynolds & Damon, 2012). Since 1980, mpox has been confined mostly to Central Africa, although some studies have reported the presence of mpox in West Africa (Reynolds et al., 2010). In DRC, mpox has been reported in Tshuapa province since 2010, where it persists to this day (Doty et al., 2017).

Although mpox is a zoonosis, the animal reservoir species are still unknown (Doty et al., 2017). The virus has only been isolated from a rope squirrel (*Funisciurus anerythrus*) in DRC, from a sooty mangabey in Ivory Coast (*Cercocebus atys*) and recently from a fire-footed rope squirrels in DRC and in Cameroon (*Funisciurus pyrropus*) and Duikers (*Cephalophus weynsi* and *Sylvicapra grimmia*) in DRC (Khodakevich et al., 1986; Leendertz et al., 2026; Leendertz et al., 2025; Radonić et al., 2014; Riutord-Fe et al., 2026). Although it is unclear if those animals were infected from a spillover event as opposed to be reservoir hosts, there is some evidence that African squirrels species and cricetomas may play a very important role in maintaining the *Monkeypox virus* in the wild (Falandysz et al., 2017).

Our understanding of behavioral risk factors for zoonotic transmission of *Monkeypox virus* are sparse (Reynolds & Damon, 2012), especially in endemic settings. Understanding the human and animal behaviors that facilitate physical human-animal contacts, requires the involvement of social sciences (Bonwitt et al., 2016, 2017). Hunting, as a social activity, is mostly practiced in rural areas and is a key topic for in-depth social scientific analysis to understand zoonotic transmission (Bonwitt et al., 2017). Indeed, it is reported (Wolfe et al., 2005) that hunting and game butchering pose a significant risk of transmission, as they expose humans to animal secretions and body fluids from bites, scratches, and tissue handling.

Describing human-animal interactions necessitates a mix-method approach to both quantity and qualify the types and nature of such interactions (Bonwitt et al., 2017). However, the diverse nature of these interactions poses significant methodological

challenges for research, as these hunting practices remain secret (Bonwitt et al., 2017). This is why quantitative surveys on these topics can compromise data reliability and the validity of conclusions (Razafimanahaka et al., 2012; St. John et al., 2010). Children, for example, are among the groups that are extremely difficult to study using quantitative surveys. Such obstacles can only be overcome by using open-ended qualitative studies conducted by establishing long-term relationships of trust. Qualitative studies, however, aim to make research more accessible to researchers, allowing them to obtain sensitive data that is difficult to access through other methods, thanks to the trusting relationships established with informants.

Thus, anthropological studies related to hunting seek to provide more information on the evolution and interaction of factors that facilitate the transmission of diseases from animals to humans (Fuentes, 2006). Therefore, we chose to conduct long-term qualitative research to determine the hunting techniques practiced in Tshuapa Province that may present potential routes for zoonotic exposure to the *Monkeypox virus*.

Tshuapa Province was chosen because it is one of the main historical foci and epicenters of mpox in the Democratic Republic of Congo. The disease is endemic there due to the local forest ecology and the frequent proximity between populations and animal reservoirs. In this province, transmission regularly occurs through direct contact with infected animals during hunting or the handling of game meat, as the majority of the population practices subsistence farming. The inhabitants of the region often depend on wildlife for their protein intake and livelihoods, which can increase the risk of zoonotic diseases (Doty et al., 2017).

Animal species that could be potential zoonotic sources of the *Monkeypox virus* were the focus of this investigation: squirrels, cricetomas (giant pouched rats), elephant shrews, forest rats/mice and monkeys, because sero-surveillance data in Central Africa confirmed the circulation of the virus in these rodents and non-human primates, and also because these animals are regularly in contact with humans for consumption (Doty et al., 2017; Khodakevich et al., 1988; Monroe et al., 2015; Nolen et al., 2015). So as a research question, we'll like to know what techniques of hunting expose humans to animal secretions and body fluids? As a research hypothesis, we believe that hunting with dogs, arrows, nets, uprooting nests, and

other methods expose humans to animal secretions and body fluids from bites and scratches.

2. Material and methods

2.1. Study sites

This study was conducted in the province of Tshuapa in the Democratic Republic of Congo (DRC). That province is located in the northwest of the DRC and covers an area of 132,957 km².

Two health zones (HZs) (Boende and Bokungu) were selected for the present study. We chose those two HZs based on the number of confirmed cases of mpox and accessibility. In those two HZs, villages were carefully selected to be representative using simple random sampling; that is, all villages that had reported at least one confirmed or suspected case of mpox in those two health zones were included. To enable rapid and secure access to key informants, four villages were selected (two villages in each HZ) (figure 1). The investigator chose those villages because he was familiar with them from having worked there in the past. Since the people of the region are a closed community that do not easily trust strangers, the

number of reported confirmed and suspected cases of mpox (three months before to the present study), the prevalence of hunting, and the accessibility of hunting roads are the criteria that led the investigator to select those four villages. Being able to understand, listen and speak the local language (Lingala) and live in the study villages were criteria for participant selection. Since literacy was not a requirement, participants (children and illiterate adults) who met the inclusion criteria were recruited. In addition, the exclusion criteria for participants were an inability to understand, listen, or speak Lingala, and not living in the study village.

The interviews targeted children and parents until data saturation was reached. That is to say until the interviewer had no further questions to ask and the participants had nothing more to add or began repeating what they had already said. Snowball sampling was used to identify other informants.

Fieldwork was conducted over a period of four months in 2021 (March-April and July-August), spanning the rainy season (March-April) and dry season (July-August).

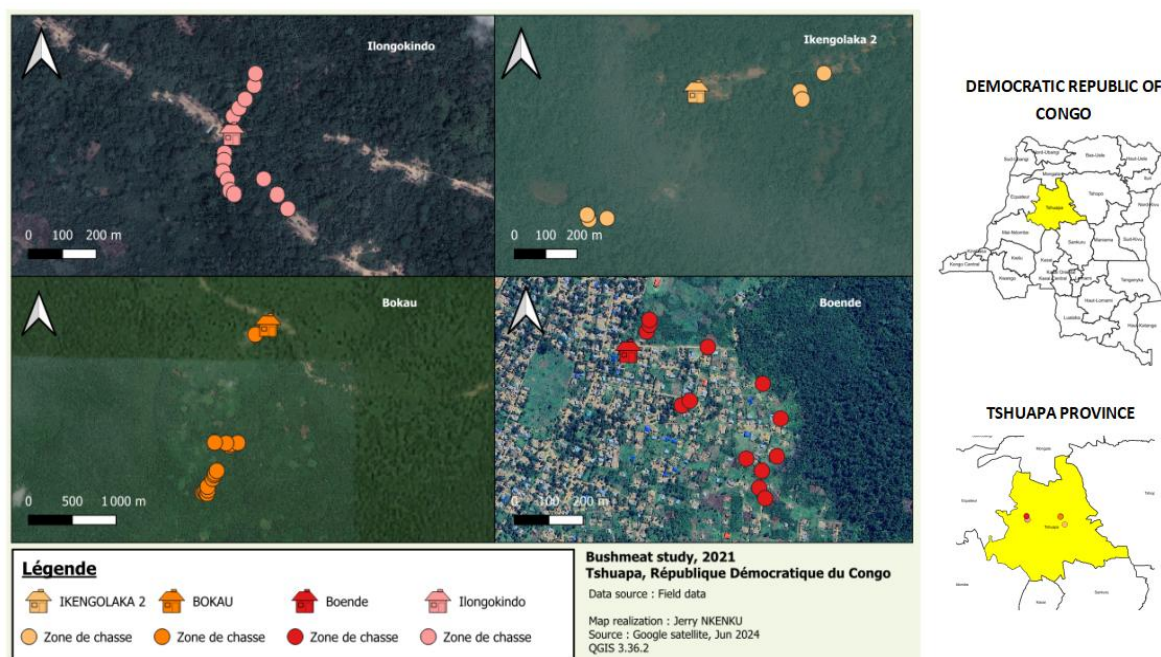


Figure 1. Survey villages represented using Google Maps satellite 2024

2.2. Interviews and discussions

Semi-structured interviews and informal discussions were conducted. The discussions took place in Lingala (the national language and the most widely spoken language in the study area). Questions and answers included basic demographic information and techniques used to catch animal species. Questions were open-ended to uncover specific types of behavior

of interest that were previously unknown or unaccounted for during the preparatory literature search. Focus group discussions were conducted either among school-aged children or among adults to allow the different groups to express themselves more freely. The number of participants per group ranged from 5 to 10. These interviews were also conducted in Lingala, using the same study themes.

Photos of wild animal species and the “Guide to African Mammals” (Kingdon, 2015) were used to determine vernacular names and ensure the accuracy of the names.

The interviewer also provided contextual and reflective notes for each interview. The recordings and field notes were immediately transcribed into French by the investigator and his assistant (LKN and LLD) using Word 2013 (Microsoft Corp., Redmond, WA). The data were anonymized from the outset and shared online with the research team. Analysis was performed on an ongoing basis, and the interview and observation guides were modified iteratively. Triangulation was achieved through two field researchers (LKN and LLD) and one supervisor (JB). Coding was performed in MS Word 2013 using thematic analysis. A priori themes included human-animal contacts, and methods used to catch animal species.

After reviewing all the transcripts and notes, we conducted inductive coding (identifying themes, codes, and categories that emerged directly from the raw data) and initial deductive coding (applying predefined codes to the collected data based on existing theories or hypotheses), line by line. We then reorganized the codes to synthesize and compare larger segments of data, and subsequently recoded our qualitative data to determine the relationships between the data, codes, and analytical categories under development. A qualitative thematic analysis of the transcripts was then conducted. The themes were predefined (human-animal contacts, methods used to catch animal species and participating in hunting activities), extracted, and grouped retrospectively in the research protocol. Researchers from the University of Kinshasa, the Kinshasa School of Public Health, and Durham University translated and transcribed the discussions, then interpreted the qualitative results by selecting relevant quotes. All researchers discussed and reviewed the themes and quotes to ensure they represented the full range of perspectives expressed during the interviews.

2.3. Observation guides

The observation guides used for direct and participatory observations covered direct and indirect forms of contact between humans and wild animals (all species). Direct contact was defined as people who have been in direct contact with animals' blood, organs, fur, or other body fluids. We observed people's daily behaviors in their environment in order to compare

their behaviors with those reported during the discussions? (Interviews). Participatory observations were carried out mainly with trusted informants and only with their permission.

3. Results

A total of 23 semi-structured interviews and 10 Focus group discussions were conducted, and 15 days of participatory observations were carried out. Informants included health workers, teachers, housewives, farmers, women traders, and children (aged 7 and above) (table 1). No informant was interviewed twice. There were 151 (72%) men and 60 (28%) women. All from the Mongo tribe. In total, 26 (12%) participants were aged group of 7-9 years, 85 (40%) were aged group of 10-19 years, 38 (18%) were aged group of 20-29 and 62 (29%) were aged group of ≥ 30 years (table 1).

Tableau I. Socio-demographic characteristics for qualitative survey participants

	IDIs	FGDs	POs	Total (%)
Participants	23	130	58	211 (100.0%)
Sex				
Male	19	79	53	151 (71.6%)
Female	4	51	5	60 (28.4%)
Age range (year)				
0–9	0	19	7	26 (12.3%)
10–19	6	53	26	85 (40.3%)
20–29	5	26	7	38 (18.0%)
≥ 30	12	32	18	62 (29.4%)
Occupation				
Health agent	2	1	0	3 (1.4%)
Agriculture	3	4	2	9 (4.3%)
Hunting	7	32	23	62 (29.4%)
Fishing	0	25	0	25 (11.8%)
Household worker	2	13	0	15 (7.1%)
Student	5	55	27	87 (41.2%)
Office work	3	0	3	6 (2.8%)
Sales person	0	0	3	3 (1.4%)
Other	1	0	0	1 (0.5%)

IDIs: In-depth interviews; FGDs: Focus group discussions; POs: Participatory observations. No participant was interviewed twice.

3.1. Human-animal contacts

According to participants, several methods are used to catch animals, especially those suspected of being potential reservoirs of MPXV, such as squirrels, cricetomas, elephant shrews, small rodents, and monkeys.

3.1.1. Methods for catching squirrels

Several techniques are used to catch squirrels, according to participants (IDIs and FGDs). In addition to traps, participants hunt with arrows (Misongo in Lingala) (figure 2) and with dogs. Another method is to search for holes inhabited by squirrels in trees (figure 2). If the animal is not present when the nest is

discovered, the hunters return in the evening. Once the animal is present, they either set fire at the entrance of the hole and let the smoke drives the animal out, then catch it with their hands as it emerges. Also, hunters can dislodge the animal with sticks by pinching it, and then catch it with their hands as it emerges. If the animal is not yet dead, they kill it by strangulation or dislocation. During strangulation, we observed during the participatory observations (POs) that the animal excretes blood and saliva from its mouth, as well as urine and feces, which come into direct contact with the hunters.

When hunting with arrows, they search for squirrels or attract them by imitating their distress calls. Sometimes, they use baby squirrels taken from another nest to attract adult squirrels in the wild according to participants (IDIs and FGDs). Unfortunately, during

this study, the research team did not get a chance to observe this because no baby squirrels were found. In Ilongonkindo village, during the participatory observations (POs), we observed two hunters, aged 13 and 17, imitating the cries of a squirrel. The 17-year-old managed to attract a squirrel and then wounded it with an arrow.

When set upon by dogs, squirrels take refuge in burrows or tree holes. The hunters then dig with their machetes, and one of them reaches into the burrow to catch the animal and kill it by strangulation. If squirrels take refuge in a tree hole, hunters use one of the techniques listed above to extract them. This was reported during in-depth interviews (IDIs) and Focus group discussions (FGDs) and observed during participant observations (POs).

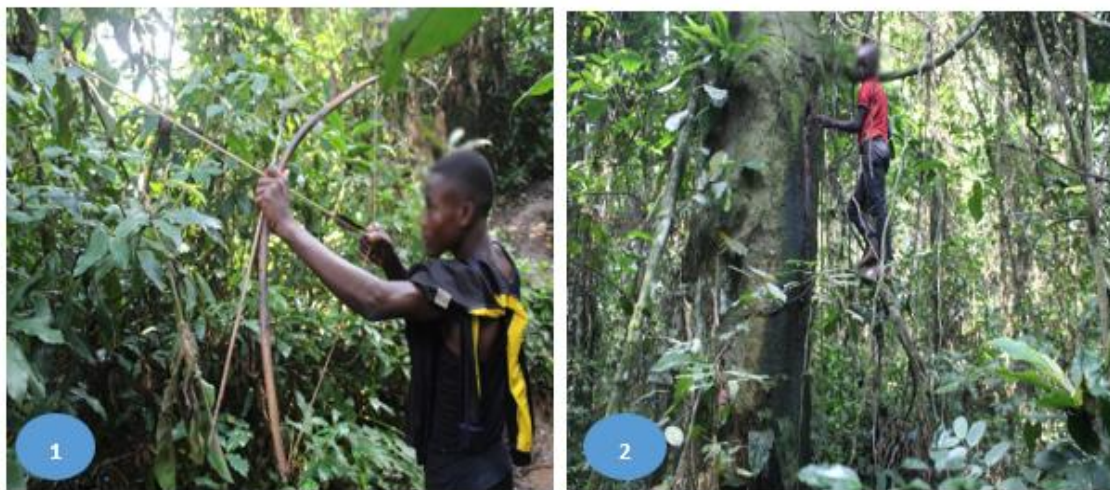


Figure 2. 1: A 17-year-old boy hunting squirrels with his bow and arrow in the village of Ilongonkindo. 2: A 10-year-old child searching for squirrel nests in a tree hole in the village of Ilongonkindo.

3.1.2. Methods for catching cricetomas

To catch cricetomas, we observed during POs that participants use another technique, which involves forcing animals out of their burrow. The first step is to check a burrow to see if it is inhabited or not by an animal. For that, hunter will cut a circular piece of bark from a tree with a diameter equal to that of the burrow entrance. In the middle of this piece of bark, they make a small hole 5 to 10 mm in diameter (figure 3) and place the bark over the entrance of the burrow.

They then cut a strand from an old piece of clothing and set fire to one end to produce smoke (figure 3). After that, they place the end of the strand that is producing smoke in the small hole in the bark. Some of the smoke enters into the burrow and some comes out. If the animal is in the burrow, the smoke coming out of the hole in the bark will be sinusoidal in

shape due to the animal's breathing. However while, if the animal is absent, the smoke coming out will rise in a straight line. If animal is insight, they begin to look for emergency exits and then, they place a rope or wire with a knot slightly inside each emergency exit, with the end of the knot rising to the surface. They then block these existing with dead leaves and post a hunter at each emergency exit. Each hunter places their foot on these leaves to prevent the animal from escaping.

At the main exit, he removes the bark and places another rope or wire with a knot slightly inside. Another hunter prepares a pointed stick measuring 1 to 2 m maximum and begins to threaten the animal by pushing the stick into the ground from the main exit towards the other exits. The animal, feeling threatened, will try to escape. One of the hunters, whose foot is blocking an exit, will feel the pressure of the animal

under his foot and will be forced to pull the end of the cable or wire. The animal will then be caught at the thorax (figure 3). The hunter will introduce his hand

into the hole to catch the animal and kill it directly by strangulation (figure 3).

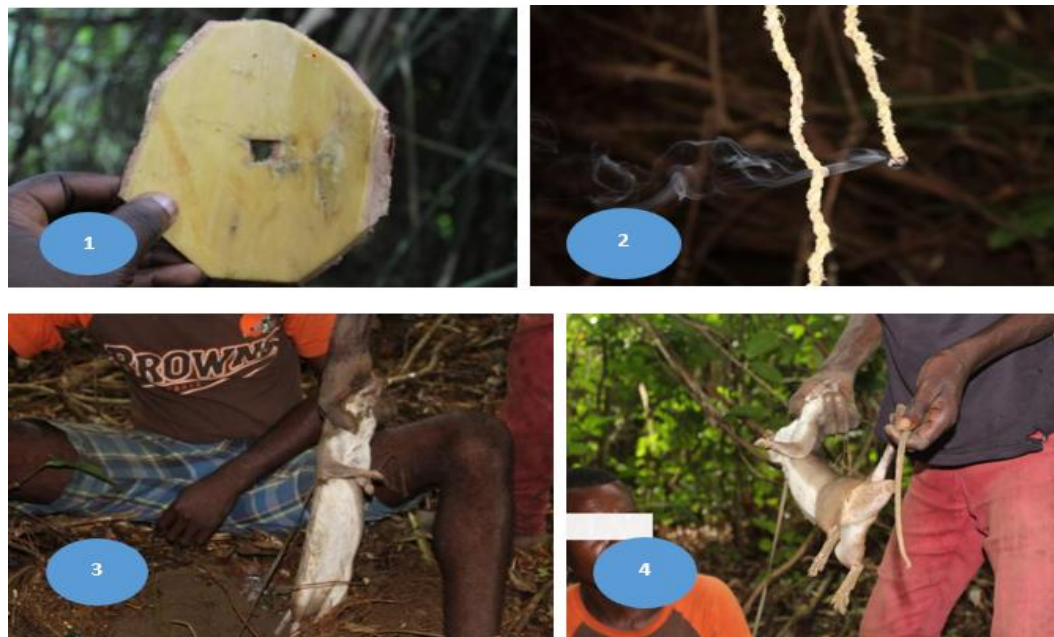


Figure 3. 1: Bark model used by hunters to block the main entrance to the cricetoma's burrow. 2: Filament from an old garment used by hunters to make smoke. 3: A hunter catching the animal into the burrow and grabbing it by the neck in the village of Boende 2 Kimbangu. 4: The animal is strangled.

3.1.3. Methods for catching elephant shrews

According to the participants (IDIs and FGDs), in addition to traps for catching elephant shrews, they also use nets. First, they find the best place to hunt, i.e., a place where they notice spoor, such as their tracks, paths, or evidence of feeding. Second, they determine in which direction or on which side they can set up a net. To set up a net, two people hold the net at both ends and block the animal's path. Third, once this is done, a team moves upstream to drive the animal toward the net. Fourth, at some point, the two people will notice that the animal or animals are on the net and they will throw the upper part of the net over the animal or animals. Fifth, they can then remove the animal or animals from the net by hand. Sixth, they will then kill them by strangulation or using a machete.

3.1.4. Methods for catching monkeys

According to the participants (IDIs and FGDs), it is difficult to catch an adult or even a juvenile monkey alive. This is because they bite very hard and can inflict wounds on the hunter. Therefore, they usually use firearms or dogs. If they don't have a firearm or ammunition, they can use poisoned arrows.

3.1.5. Trapping (all species)

According to the participants (IDIs and FGDs) also observed during POs, several types of traps are used to catch wild animals. Depending on the names given to them in the different dialects in the region, those include cable traps (Bokoka in Kimongo) and Besanjo traps, which are used to catch squirrels. Those traps are not baited. Cable traps are made with a steel cable attached to sticks and form a knot placed on animal passages with a trigger. This cable is designed to catch an animal (squirrel) by surprise, injuring or killing it immediately after it is caught.

Besanjo traps are placed at a height of approximately three meters above the ground. Participatory observations (POs) in the village of Boende 2 Kimbangu allowed us to observe the installation of that trap: a path is cleared in the forest in the form of a two-meter-wide linear transect to prevent arboreal animals, particularly squirrels, from crossing from one side to the other. They placed a stick approximately three meters above the ground connecting the two ends of the forest to entice arboreal animals to use. They then place the trap in the middle of that stick. During one PO, two Besanjo traps were set up on the same transect, and one captured a male

squirrel (*Heliosciurus rufobrachium*, Waterhouse 1842) (figure 4).

To catch cricetomas and other ground-dwelling animals, trappers use different traps: the first one is the cable trap that is set up alone or across diversion dams (Lokombo in Kimongo) (figure 4). This trap is bait-free.

A diversion dams (Lokombo in Kimongo) contains several cable traps. In Ilongonkindo, young people (aged 10–19) built a dam over 100 m long. They chose a flat, swampy area just 20 m behind the village. They placed cable traps every 5 m along the dam. The traps are set up in such a way as to make it easy for the animal to pass through the knot in the cable where the trigger is located. Once the animal places its paw on the trigger, it will be caught by the neck and killed within seconds.

The second kind of trap is the nylon trap which is also placed in the animal's path. To set this trap, they dig a hole in the ground where the animal is likely to pass. Above this hole, they place pieces of sticks stuck into the ground from one side to the other. Then they attach a nylon string to a long stick stuck in the ground one meter from the hole (which will serve as a bow) and tie a knot at the other end, then place it above the sticks over the hole. They then cover the hole with dead leaves. Once the animal places its paw or hand in the hole, it will be caught. The trapped paw or hand will be lifted so that the animal cannot cut the string and will remain suspended. This type of trap is set for any game (depending on its size). In the village of Bokau, we observed during POs a female of *Civettictis civetta* (Pocock, 1915) (Djo or Bolia in Kimongo) caught with this kind of trap. The animals are always caught alive and can spend several days in that state. To remove them, hunters strike them with machetes to kill them. This prevents bites but exposes hunters to blood.

Finally, the simokilo trap is named after as the bait. Simokilo is a fruit from the wonderful kola tree (*Buchholzia coriacea*, Engler 1886) that is collected from the ground (figure 5). To obtain it, they have to dig the ground in places where animals have been grazing, such as porcupines. They also use this method to catch duikers. According to the participants, even nonhuman primates (bonobos, gorillas, and others) and bush pigs consume it. This bait only lasts four days in the traps, after that they are replaced. To set this trap, trappers dig a small 20 cm hole in the ground to make animals believe that the bait is naturally found in that location. In the hole, they place the bait on a trigger

with a ring. This ring is supported at the surface by three sticks stuck in the ground in a triangle shape. Animals that come to graze on the bait will also tend to move the trigger and get caught by the neck.

To catch small forest rodents (e.g., *Praomys jacksoni*, De Winton 1897), the investigator observed during POs that participants set traps called Ilonga (singular) or Tolonga (plural) in Kimongo (figure 5) and "box traps." Those traps are set only on the ground through the passages used by small rodents, slightly towards the right or the left of the passage. Those traps are baited with pieces of cassava. Ten forest rats/mice of the genus *Lophuromys flavopunctatus* (Thomas, 1888) were captured between 9 a.m. and 10 a.m. with these traps. They kill those rats within a minute of their capture, reducing the risk of bites.

Box traps work much like Sherman traps, but with this type of trap, the bait is attached to the lid with a string. Once the animal starts gnawing on the nut inside the box, it will also cut the string and the lid will close, trapping the animal inside the box (figure 5). The advantage of these box traps is that the animal remains alive, as with the nylon trap. These traps can also catch squirrels and can be placed on the ground or in trees. To avoid being bitten, once a rat is caught in the box, they shake the box until the animal loses consciousness. Then, they take it out and strangle it until to death.



Figure 4. 1: A squirrel (*Heliosciurus rufobrachium*, Waterhouse 1842) caught in a Besanjo trap in the village of Boende 2 Kimbangu. 2: A diversion fence with cable traps in the village of Ilongonkindo.

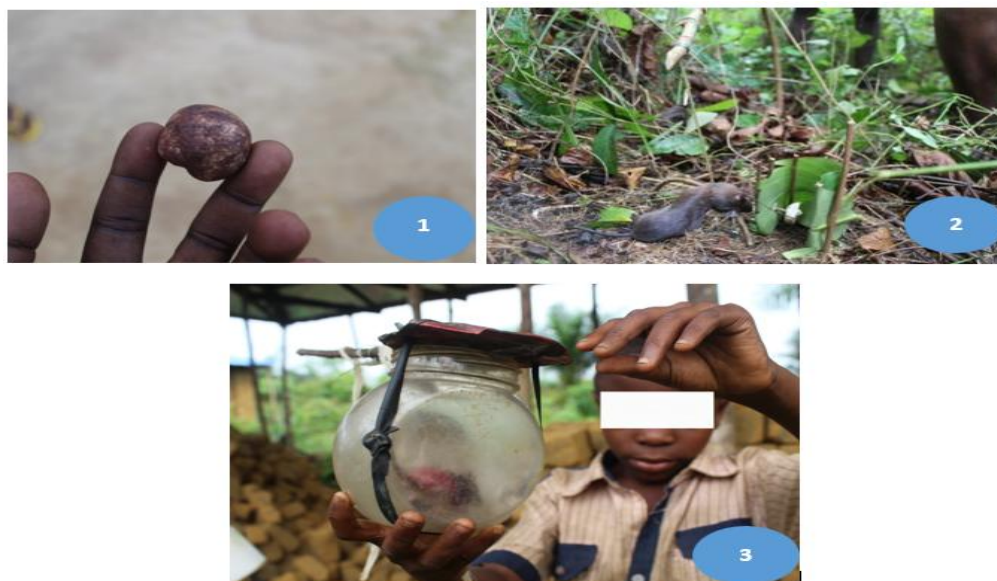


Figure 5. 1: The bait (wonderful kola) that hunters use in simokilo traps. 2: The species *Lophuromys flavopunctatus* (Thomas, 1888) caught in an Ilonga trap in the village of Boende 2 Kimbangu. 3: An 11-year-old hunter caught the species *Lemniscomys striatus* (Linnaeus, 1758) in a box trap in the village of Boende 2 Kimbangu.

3.2. Participation in hunting activities

According to participants in the IDIs and FGDs, people in the 10–19 age group hunt small animals and rarely medium-sized ones such as cricetomas, porcupines, civets, squirrels, galagos, and others. These findings were observed during our participatory observations. Those aged 20–29 may also hunt animals similar to those hunted by the 10–19 age group, but they also seek out larger arboreal animals (such as monkeys) and terrestrial animals (such as bush pigs and others). Those over 30 years old focus exclusively on hunting large game (duikers, antelopes, primates, and others). They venture deep into the forest, where they stay in camps for several days or even months to hunt large animals. Upon leaving the forest, they return to the village with smoked meat for their families and to sell. While in the villages, they may also hunt squirrels, ground squirrels, civets, and other small or medium-sized animals to provide food for their households. Nowadays, it is very difficult to find large game near the villages. To catch large animals, they have to travel several kilometers (10 km on average). As a result, only adults cover these distances in search of large game.

4. Discussion

The use of social science methodology has provided insight into the interactions between human and animal factors that could serve as potential routes

of zoonotic Monkeypox virus exposure. Several studies on hunting and butchering wild animals have been carried out using social science methods (Bonwitt et al., 2016, 2017; Friant et al., 2015; Rimoin et al., 2017; Wolfe et al., 2005).

According to Law No. 82-002 of May 28, 1982 on the regulation of hunting in the DRC, hunting is defined as any astuteness used to capture or kill game. Thus, to search for or pursue it with a view to capturing or killing it, in particular to collect its eggs, nests, broods, or young are activities for hunting. The data from this study showed that several methods are used in Tshuapa province to catch game, including trapping, hunting with firearms, hunting with dogs, bow hunting, net hunting, and other new techniques identified in the region. This is due to the human population explosion in villages between 2015 and 2026, the population of the Tshuapa Province experienced significant growth, in line with the national trend, with a population approaching the 2-million mark for an area of 135,548 km² that has led to the evolution of hunting techniques.

Physical contact between villagers and small mammals during hunting exposes villagers to the animals' body fluids, which present potential routes for zoonotic exposure (Radonić et al., 2014; Reynolds et al., 2010). Hunting, which includes tracking, capturing, handling, and transporting game, offers multiple routes of exposure of zoonotic pathogens

through direct contacts with body fluids, bites, and scratches (Gessain et al., 2013; Wolfe et al., 2004). The present study shows that catching squirrels by reaching into burrows or tree holes or picking up a squirrel wounded by an arrow with unprotected hands increases the risk of bites and scratches hunters, which can lead to potential routes of exposure (Reynolds & Damon, 2012).

In addition to catching squirrels, cricetomas, elephant shrews alive and killing them by strangulation, this study indicates that these strangled animals excrete blood and other fluids from their mouths, noses, and eyes, as well as feces and urine, which come into direct contact with hunters. This could be one of the potential routes of exposure to the Monkeypox virus as demonstrated by Falendysz et al. (2017) in squirrels.

On the other hand, there is less or almost no risk of bites and scratches when hunting non-human primates with rifle or poisoned arrow. Because, the poison on the arrow kills the animal within five minutes of being struck by causing the blood to clot. Whereas a rifle kills the animal the moment it hits it. This way, the hunter simply picks up a dead animal with less risk of bites and scratches. However, there is still contact with the animal's blood.

One advantage is that many studies of this kind on exposure to wild animals do not focus on school-age children (Friant et al., 2015; Subramanian, 2013), unlike the present study and that of Bonwitt et al. (2017), which enrolled school-age children.

According to participation in hunting activities, this study indicates that in Tshuapa Province, both adults and children are involved in hunting. Among the Mongo people, we found that the type of contact with game during hunting, particularly with animal species that may serve as reservoirs for the Monkeypox virus, differed according to demographic characteristics such as age. Adults are more involved in hunting non-human primates and other large game than children, which is consistent with the data from (Mossoun et al., 2015). In contrast, school-age children are more involved in hunting small rodents than adults. Among small rodents, Mongo adults are increasingly less interested in small game. Even if they bring it home, they leave it for the children to consume. A Mongo adult does not spend their time searching for small game. This is not the case in Sankuru, DRC, where there is no difference across age groups in the consumption or use of game (Rimoin et al., 2017). This study also shows that children's hunting is autonomous and beyond parental

control. They may hunt in groups with children from neighboring villages with different cultures. This is considered an important aspect of children's socialization. This finding corroborates with the data from Bonwitt et al. (2016).

We can not forget that in West Africa, the Ebola virus disease outbreak began during a children's hunting expedition (Marí Saéz et al., 2015). Thus, it is children who hunt with dogs, use bows and arrows, set nets, and employ other methods to catch squirrels and elephant shrews. Consequently, they are more exposed to bites and scratches and come into greater contact with the blood and other body fluids of those animals than adults. This means they may be at greater risk than adults. That supports the description by Nolen et al. (2015) with children who brought a squirrel at home and played with it before eating it. Then, one of them contracted mpox five days after the animal's death. It also supports the assertion that school-age boys are the primary source of *Monkeypox virus* transmission into households, rather than adult hunters of the same study (Nolen et al., 2015).

Although this study focuses on a zoonosis (Monkeypox virus), the findings can be extrapolated to other zoonoses within the One Health framework, as the data from this study on exposure to health risks from zoonotic pathogens throughout activities related to game capture in Tshuapa Province have shown that hunters constitute a group of individuals in the province who are more likely to contract a zoonotic pathogen. These findings corroborate those reported by Rimoin et al. (2017) in Sankuru Province, also in the Democratic Republic of the Congo. Thus, the present data also show that hunting (which includes capturing, handling, and transporting) game may cause a number of opportunities of exposure to zoonoses through direct contact with feces, blood, and other body fluids. This corroborates the data from Gessain et al. (2013), Peeters et al. (2002) and Wolfe et al. (2004).

As a limitation, the present study did not retrospectively interview confirmed human cases of mpox. In addition, the small sample size precludes any generalization to the wider population. However, a follow-up quantitative study has been undertaken to assess whether the described behaviors are commonly placed over a larger geographic and populational level.

Related to social desirability bias, in this study we found that participants did not exhibit any unconscious or deliberate tendency to alter their responses or behaviors, since they were familiar with the investigator and his assistant. They have worked

together for several years in the past in those villages. They were all happy and open for participating in the study, and the same behaviors reported during the IDIs and FGDs were observed during the POs.

As an ethnological study, we sought to focus on routine behaviors during hunting or capturing game that could constitute potential routes of exposure to zoonotic diseases, such as mpox.

5. Conclusion

The results of the in-depth interviews and observational work indicated that hunting with dogs, bows with non-poisoned arrows, nets, digging up burrows, and technique for catching cricetomas provoke contacts with animal secretions and blood through bites and scratches, as well as during strangulation, which could be a potential route of exposure of the *Monkeypox virus*. Similarly, our results showed again that during trapping, if the animal is not dead, there is also a risk of contact with blood. This could also be a potential route of exposure for the virus. The present study sheds light on human-animal interactions with a view to understand behaviors that may serve as potential exposure routes for the *Monkeypox virus* in a human society living in a region endemic for mpox. By providing a detailed description of hunting practices, we hope that our results will broaden the scope of future quantitative research on this subject.

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Conflict of Interest

No competing interests exist for the present study.

Ethical Considerations

The study was approved by the Ethics Committee of the Kinshasa School of Public Health and the CDC, Atlanta. Participants received information sheets that were read aloud. We emphasized that participants were not required to answer questions and could withdraw from the study at any time without consequences. Written and verbal consent was obtained from the respondent or a parent for participants under the age of 18.

Author Contributions

J.B., L.N.K. and J.M.M.: Conceptualization.

J.B. and L.N.K.: Data curation.

J.B. and L.N.K.: Formal analysis.

Y.J.N.: Acquisition funding.

L.N.K.: Survey.

J.B., L.N.K. and J.M.M.: Methodology.

J.B., L.N.K. and J.M.M.: Project administration.

Y.J.N.: Resources.

J.B. and J.M.M.: Supervision.

J.B. and J.M.M.: Validation.

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