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Human-wildlife conflicts assessment in the Alexander Skutch Biological Corridor, Costa Rica

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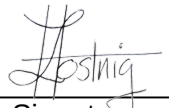
Declaration in lieu of oath

I herewith declare in lieu of oath that this thesis has been composed by myself without any inadmissible help and without the use of sources other than those given due reference in the text and listed in the list of references. I further declare that all persons and institutions that have directly or indirectly helped me with the preparation of the thesis have been acknowledged and that this thesis has not been submitted, wholly or substantially, as an examination document at any other institution.

01.11.2019	
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Abstract

Human-wildlife conflicts are predicted to increase, mainly due to human population growth and due to the pressure their activities exert on natural resources. To address these problems management measures are needed, principally to prevent conflicts from escalating and from affecting the survival of wildlife as well as the welfare of human communities.

Costa Rica through the establishment of biological corridors, expects to reduce human pressures and improve the conservation and management of its natural resources by considering the participation of local communities. In addition, Costa Rica with this strategy aims to provide connection between protected areas, promote the sustainable use of the natural resources and offer alternative livelihoods for local populations.

As part of this strategy, the Alexander Skutch Biological Corridor was established. Consequently and with the participation of the local population, this has led to the recuperation of forest cover in this corridor. Further, community awareness, local protection and law enforcement regarding wildlife seem to have helped wildlife populations to recuperate. All these efforts may be allowing the transit of wildlife within the corridor; however, this may also lead to an increase of positive or negative human-wildlife interactions, or even given rise to new ones.

Although the biological corridors have become one of the most important conservation initiatives of the country, human-wildlife conflicts have been scarcely researched within these areas, and are still not considered enough in the strategic and action plans.

In order to provide information that could help to ensure the coexistence of wildlife populations and rural communities inside the Alexander Skutch Biological Corridor, this study has assessed the existence of human-wildlife conflicts through interviews with seventy-three local residents of seven communities located within the biological corridor. The perception of local residents towards wildlife involved in these conflicts and towards the biological corridor was assessed as well.

The results show eight wildlife species belonging to different taxonomic groups as the main species causing damages to livelihoods and welfare of surveyed people. Five mammals (e.g. tayra *Eira barbara*, white-tailed deer *Odocoileus virginianus*, coyote *Canis latrans*), two reptiles (e.g. fer-de-lance *Bothrops asper*), and one group of birds (parrots Arini tribe). Most of these species have opportunistic and generalists habits, and adapted easily to human-disturbed environments. Interviewees' perception regarding the frequency in which the events of damage occur, as well as their perception and attitudes towards wildlife species involved in conflicts, seem to be influenced principally by personal experiences and the severity of the damage caused, or the potential damage that some of these species could cause. However, notwithstanding local people's perception towards all species that cause them harm is mainly of dislike, respondents do not seem to be against their presence, with exception of the fer-de-lance viper, which is the only species perceived with fear.

To prevent HWC from escalating, or that new ones emerge, continuous programs with local residents regarding management and prevention measures should be considered. Finally more information campaigns regarding the significance, importance and objectives of the biological corridor, involving more residents should also be considered.

Zusammenfassung

Aufgrund des Bevölkerungswachstums und des daraus resultierenden Drucks, den menschliche Aktivitäten auf die natürlichen Ressourcen ausüben, ist zu erwarten, dass Konflikte zwischen Mensch und Tier zunehmen werden. Um zu verhindern, dass diese Konflikte das Überleben von wild lebenden Tieren gefährden und sich dabei auf das Wohlergehen von menschlichen Gemeinschaften auswirken, sind Maßnahmen erforderlich, die diese Probleme angehen.
Durch die Strategie der Errichtung von biologischen Korridoren in denen die Beteiligung lokaler Gemeinschaften berücksichtigt wird, erhofft sich Costa Rica den Druck der Menschen auf die natürlichen Ressourcen zu verringern und deren Erhaltung und Bewirtschaftung zu verbessern. Costa Rica will mit diesen Korridoren zudem den Austausch zwischen Schutzgebieten sicherstellen, die nachhaltige Nutzung der natürlichen Ressourcen fördern und alternative Lebensgrundlagen für die lokale Bevölkerung bieten.
Im Rahmen dieser Strategie wurde auch der biologische Korridor Alexander-Skutch eingerichtet. Infolgedessen hat dies unter Beteiligung der lokalen Bevölkerung zur Wiederherstellung der Waldbedeckung in diesem Korridor geführt. Darüber hinaus scheint das gesetzliche Jagdverbot geholfen zu haben, dass sich die Wildtierpopulation erholt und der Transit von Wildtieren innerhalb des Korridors ermöglicht wird. Dies kann jedoch auch zu einer Zunahme positiver oder negativer Interaktionen zwischen Mensch und Tier führen oder sogar neue hervorrufen
Obwohl die biologischen Korridore zu einer der wichtigsten Naturschutzinitiativen des Landes geworden sind, wurden Konflikte zwischen Mensch und Tier in diesen Gebieten kaum erforscht und werden in den Strategie- und Aktionsplänen immer noch nicht ausreichend berücksichtigt.
Um Informationen bereitzustellen, die dazu beitragen, die Koexistenz von Wildtierpopulationen und ländlichen Gemeinden im biologischen Korridor Alexander Skutch zu gewährleisten, hat diese Studie die Existenz von Konflikten zwischen Menschen und Wildtieren sowie die Einstellung der Anwohner zu diesen Konflikten und dem Korridor anhand von Interviews mit dreiundsiebzig Personen bewertet, die in sieben Gemeinden innerhalb des biologischen Korridors durchgeführt wurden.
Die Ergebnisse zeigen, dass acht Wildtierarten aus verschiedenen taxonomischen Gruppen, die Haupttierarten sind, die die Lebensgrundlage und das Wohlergehen der befragten Personen beeinträchtigen. Fünf Säugetiere (u.a. Tayra *Eira barbara*, Weißwedelhirsch *Odocoileus virginianus*, Kojote *Canis latrans*), zwei Reptilien (u.a. Lanzenotter *Bothrops asper*) und eine Vogelgruppe (Papageien Arini Tribus). Viele diese Arten haben opportunistische und generalistische Gewohnheiten und passen sich leicht an vom Menschen gestörte Umgebungen an. Die Wahrnehmung der Befragten in Bezug auf die Häufigkeit des Auftretens der Ereignisse und der in die Konflikte verwickelten Wildtierarten sowie ihre Einstellung zu diesen Arten scheint von der Schwere des verursachten Schadens oder dem potenziellen Schaden, den einige dieser Arten verursachen könnten, beeinflusst zu werden. Auch wenn die meisten Befragten die Meinung vertreten, dass diese Wildtierarten überwiegend unangenehm sind, scheinen sie nicht gegen deren Anwesenheit zu sein - mit Ausnahme der Lanzenotter, der einzigen Spezies, die mit Angst wahrgenommen wird.
Um die Eskalation dieser Konflikte mit wild lebenden Tieren oder das Entstehen neuer Konflikte zu verhindern, sollten kontinuierliche Programme zu deren Aufarbeitung mit Anwohnern durchgeführt werden. Schließlich sollten auch Informationsprogramme in Bezug auf die Bedeutung, Wichtigkeit und Ziele des biologischen Korridors in Betracht gezogen werden, und eine größere Anzahl an Einwohnern beteiligen.

Resumen

Se predice un aumento de conflictos humano-fauna silvestre, principalmente debido al crecimiento de la población humana y la presión que sus actividades ejercen sobre los recursos naturales. Para abordar estos problemas, se necesitan medidas de gestión, principalmente para evitar que los conflictos se intensifiquen y afecten la supervivencia de la fauna silvestre y el bienestar de las comunidades humanas.

Costa Rica mediante el establecimiento de corredores biológicos espera reducir las presiones humanas y mejorar la conservación y el manejo de sus recursos naturales considerando la participación de las comunidades locales. Además, tiene como objetivo proporcionar conectividad entre áreas protegidas, promover el uso sostenible de los recursos naturales y ofrecer medios de vida alternativos para las poblaciones locales. El Corredor Biológico Alexander Skutch se estableció como parte de esta estrategia. Como consecuencia y con la participación de la población local, esto ha permitido la recuperación de la cubierta forestal dentro del corredor. Asimismo, la conciencia de la comunidad, la protección local y la aplicación de la ley con respecto a la fauna silvestre parecen haber ayudado en la recuperación de sus poblaciones. Todos estos esfuerzos pueden estar permitiendo que transiten dentro del corredor; sin embargo, esto también puede conducir a un aumento de las interacciones positivas o negativas entre humanos y fauna silvestre, o incluso dar lugar a nuevas. Aunque los corredores biológicos se han convertido en una de las iniciativas de conservación más importantes del país, los conflictos entre humanos y fauna silvestre apenas se han investigado en estas áreas, y todavía no se consideran lo suficiente dentro de los planes estratégicos y de acción.

Con el fin de proporcionar información que pueda ayudar a garantizar la coexistencia de las poblaciones de fauna silvestre y de las comunidades rurales dentro del Corredor Biológico Alexander Skutch, este estudio ha evaluado la existencia de conflictos humano-fauna silvestre, a través de entrevistas con setenta y tres residentes locales en siete comunidades dentro del corredor. Así como la percepción de los residentes locales hacía las especies silvestres involucradas en los conflictos y su percepción con respecto al corredor biológico.

Los resultados muestran ocho especies de fauna silvestre pertenecientes a diferentes grupos taxonómicos como las principales responsables de daños a los medios de vida y al bienestar de las personas encuestadas. Cinco mamíferos (e.g. tolomuco *Eira barbara*, venado cola-blanca *Odocoileus virginianus*, coyote *Canis latran*), dos reptiles (e.g. terciopelo *Bothrops asper*) y un grupo de aves (loros tribu Arini). Muchas de estas especies tienen hábitos oportunistas y generalistas y se adaptan fácilmente a los ambientes perturbados. La percepción de los entrevistados con respecto a la frecuencia en que ocurren los eventos de daño, así como su percepción y actitudes hacia las especies de fauna silvestre involucradas en los conflictos parecen estar influenciadas por experiencias personales y por la severidad del daño causado o el daño potencial que algunas de estas especies podrían causar. Sin embargo, los encuestados no parecen estar en contra de su presencia, a pesar de que su percepción hacia la mayoría de estas especies de fauna silvestre es principalmente de disgusto. Con la excepción de la terciopelo, que es la única especie percibida con miedo.

Para evitar que los conflictos con la fauna silvestre escalen o surjan nuevos, se deben considerar programas de capacitación continuos sobre mediadas de manejo y prevención con los residentes locales. Finalmente, también se deben considerar más campañas de información sobre la importancia, significancia y objetivos del corredor biológico, involucrando a más residentes.

1. Introduction

The accelerated growth of human populations and their daily activities have increased the pressure on natural resources around the world and have provoked an increase of socio-environmental conflicts, including conflicts between human communities and wildlife (Diestefano 2005, Madden 2008, Anand and Radhakrishna 2017). Costa Rica despite being a country recognized for its efforts in nature conservation is not oblivious to these conflicts.

In this regard, one of the strategies used by Costa Rica has been the establishment of biological corridors to reduce human pressures and to improve the conservation and management of its natural resources by considering the participation of local communities. With this strategy Costa Rica aims to provide connection between protected areas, promote the sustainable use of the natural resources and offer alternative livelihoods for local populations (SINAC 2008). This initiative began with the creation of the Mesoamerican Biological Corridor (CBM by its Spanish acronym: *Corredor Biológico Mesoamericano*) in the nineties, which is a large habitat corridor that connects a number of national parks, wild land and nature reserves from southern Mexico through all of Central America. The CBM aims at maintaining biological diversity, reducing fragmentation and improving the connectivity of the landscapes and ecosystems, as well as encouraging the sustainable use of natural resources improving the quality of life of local human populations (CCAD-PNUD/GEF 2002).

In this context, the Alexander Skutch Biological Corridor (COBAS by its Spanish acronym: *Corredor Biológico Alexander Skutch*) was officially established in 2005 covering an area of approximately 6 027 hectares between an altitude range from 700 to 1 800 meters above sea level (Acuña Prado *et al.* 2017). It represents one of the 43 biological corridors of Costa Rica, and where the present study has been taken place.

The COBAS started as a conservation initiative by members of seven local communities, the Tropical Science Center (CCT by its Spanish acronym: *Centro Científico Tropical*), and the York University of Canada (Canet-Desanti 2005). The purpose of the corridor is to improve the livelihoods of human populations and the ecological integrity within its limits through conservation initiatives, such as reforestation, environmental education, and ecotourism (Montoya and Martinez 2015). As well as promoting, recovering and maintaining the connection among forest patches from the Chirripó National Park and the Biological Reserve Las Nubes to the Neotropical Bird Sanctuary Los Cusingos.

Although the creation of biological corridors with the participation of local stakeholders has become one of the most important initiatives in the conservation of Costa Rican biodiversity, the functioning of these corridors (among them the COBAS) faces several challenges such as climate change and socio-environmental problems (SINAC 2018a). Problems mainly caused by forest fragmentation, pollution, land degradation, and the decline of wild animal populations due to habitat loss and hunting, that came with the arrival and establishment of rural communities in these areas (Acuña Prado *et al.* 2017, Maguire 2017, SINAC 2018b). Most of these problems are still present today, while new ones have probably been added.

Regarding COBAS, Rapson *et al.* (2008) assessed the forest cover and land uses between 1998 and 2008, and found that the corridor lost 19 % of its forest cover since 1998 empathizing the need to restore the key areas for the protection of biodiversity. In a recently publication by Acuña Prado *et al.* (2017), concluded that there has been a constant process of regeneration and recovery of forest-covered spaces increasing gradually in area and amount of fragments between the years 2005, 2012 and 2016. In addition, the same authors (Acuña Prado *et al.* 2017), based on local people perceptions and trap cameras (located in forest fragments within the corridor) confirmed the presence of wild species such as the puma (*Puma concolor*) and the ocelot (*Leopardus pardalis*) that require large extensions of dense forest and abundance of prey species. This may suggest that the establishment of the biological corridor has allowed the recovery of the forest cover, and as a result this may be offering conditions in terms of refuge and food for wildlife.

The recuperation of forest cover in COBAS added to the effort of the institutions to involve the local population in the sustainable development of the area might have favored the transit of wildlife within the corridor. Further, community awareness, local protection and law enforcement regarding wildlife might have allowed the recuperation of wildlife populations, of species that were absent or at low densities. However, this may also have led to an increase of positive or negative human-wildlife interactions, or even given rise to new ones.

Concerning negative interactions, here refer as human-wildlife conflicts (HWC), have been scarcely researched in biological corridors in Costa Rica. One of these few publications by Corrales-Gutiérrez *et al.* (2016), deals with the implementation of anti-predatory strategies in livestock farms located within two biological corridors of Costa Rica as part of the project "*Reducing conflicts between people and big wild cats*". However, HWC are still not considered enough in the strategic and action plans of biological corridors in Costa Rica.

Several authors highlight the importance of collecting baseline information as a first step in managing HWC, and coincide that understanding the timing and locations of conflicts, the socioeconomic practices, perceptions, as well as the behaviors of the involved individuals (wildlife and human) is essential to planning management measures (Treves *et al.* 2006, Treves 2008, Dickman 2010, Nyhus 2016). Therefore, if these aspects are considered, it could help to find management alternatives to reduce or prevent these conflicts and thus improve the functioning of the biological corridors and reach their objectives.

1.1 Purpose and significance of the study

In order to provide baseline information for future research and for strengthening the management objectives of the COBAS, this study has assessed human-wildlife interactions within the corridor through interviews with local residents. The main purpose of this study is to identify if HWC are taking place, as well as to evaluate the perception of local people towards wildlife involved in these conflicts. The information obtained through this research is expected to contribute to the initiatives which aim to achieve the harmonious coexistence of wildlife populations and rural communities within COBAS.

1.2 Research questions

In order to achieve the objective of the study the following questions were addressed:

1) Are there any problems between wildlife and human populations within COBAS?

   In case problems have been detected:

   i. What are the causes and frequency of these problems?
   ii. What are the consequences of these problems, for humans and wildlife?
   iii. What is the conservation status of these wildlife species at a national and international level?
   iv. Are there harmonious coexistence relationships between wildlife and human populations?
   v. Are wildlife species still hunted in the corridor?

2) What is the perception of local residents about wildlife involved in HWC?

3) What is the perception of local residents about the COBAS?

2. Background

2.1 Human-wildlife conflicts (HWC)

Definition

HWC are mostly defined as the negative result of interactions between humans and wildlife, but perhaps the most accurate definition is the one in WWF-SARPO (2005) which defines HWC as "*Any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, on the conservation of wildlife population, or on the environment*". HWC are not restricted to geographical regions or climatic conditions; they occur in all continents and in different socio-economic contexts and have occurred since humans and wildlife have shared the same landscapes and limited resources (Woodroffe *et al.* 2005, Zimmermann *et al.* 2010, Nyhus 2016). However, agreeing with Lamarque *et al.* (2009), the conflicts vary according to the particular environment and people's way of life.

Causes

HWC may arise and escalate for several reasons as many authors have described through different case studies worldwide (e.g. Woodroffe *et al.* 2005, Distefano 2005, Madden 2008, Lamarque *et al.* 2009, Zimmermann *et al.* 2010). Authors like Distefano 2005 (2005) and Lamarque *et al.* (2009) state that human population growth and land transformation constitute the main driving forces that lead to HWC, together with other related global trends that contribute to the escalation of these conflicts, e.g. species habitat loss, degradation and fragmentation, increase of wildlife population as a result of conservation programs, natural characteristics of wildlife, abundance and distribution of wild prey, natural factors such as climatic changes and stochastic events, among others.

Consequences

According to the International Union for the Conservation of Nature (IUCN) (2005), *"HWC occurs when wildlife´s requirements overlap with those of human populations, creating costs to residents and wild animals"*. Woodroffe *et al.* (2005) refer to these costs as for example, when wildlife prey on livestock, damage crops, injure or even kill humans, as well as cases where people who experience or perceive actual or potential threats to themselves, their family and livelihoods, intentionally capture, injure or kill wildlife. These cases can usually be more severe in developing countries, where many people still depend on agriculture and livestock, and where the laws and policies do not always contribute to the mitigations of HWC (Madden 2008, Lamarque *et al.* 2009, Gemeda and Meles 2018). Regarding wildlife, the impacts can be higher for species who have large spatial requirements, specialist habits or a restricted distribution, causing not only the decline of its populations but also environmental impacts on ecosystem equilibrium and biodiversity preservation (Woodroffe *et al.* 2005, Lamarque *et al.* 2009, Zimmermann *et al.* 2010). Additionally, in many cases the conflicts increase when human populations are close to protected areas, where wildlife population density is higher as it has been confirmed in different studies (e.g. Treves 2008, Musimbi 2013, Makindi *et al.* 2014, Anaya-Zamora *et al.* 2017, Banikoi *et al.* 2017).

2.2 Costa Rica

Biodiversity

Costa Rica is a country located in Central America that covers approximately 51 100 Km^2 of land surface (MIDEPLAN 2018), that is to say only 0.03% of the world's land surface. However, belongs to one of the 25 world hotspots (Myers *et al.* 2000). According to Obando (2007), Costa Rica possesses approximately 4.5% of the total expected world diversity, placing it between the 20 first most diverse countries worldwide, although what most stands out Costa Rica is the number of species per unit of area (species density).

However, many human activities threat biodiversity. According to Dirzo *et al.* (2014), animal loss represents a major change in biodiversity, and it is likely to have important effects on ecosystem functioning (e.g. pest control, pollination, seed dispersal, nutrient cycles, among others). Furthermore the same authors (Dirzo *et al.* 2014), highlight the main threats for wildlife populations worldwide including habitat destruction, invasive species, climate change, human introduced pathogens, and overexploitation. In Costa Rica the decline of wildlife has been principally attributed to the practices of hunt and trade, combined with habitat loss (Maguire 2017).

Institutional and legal framework

In order to improve the protection and management of natural resources, the Ministry of Environment and Energy of Costa Rica (MINAE by its Spanish acronym: *Ministerio del Ambiente y Energía*) created in 1998 the National System of Conservation Areas (SINAC by its Spanish acronym: *Sistema Nacional de Áreas de Conservación*). SINAC is an institutional, decentralized, participatory management and coordination system that integrates the departments of the MINAE in forestry, wildlife, protected areas, hydrographic basins and water systems (SINAC 2019). This system divides the national territory into eleven *Conservation Areas*, which are *"Territorial units, governed by the same development and administration strategy, in which both, private and state activities interact for the management and conservation of natural resources"* (SINAC 2019). Within these Conservation Areas are the *Protected Wild Areas* (ASP by its Spanish acronym: *Áreas Silvestres Protegidas*), which are defined as *"Delimited geographical spaces, officially declared and designated to a management category by virtue of its natural, cultural and/or economic importance, to fulfill with certain objectives of conservation and management"* (SINAC 2019). Furthermore, in 2006, the SINAC established the National Program of Biological Corridors (PNCB by its Spanish acronym: *Programa Nacional de Corredores Biológicos*), as part of the CBM created in 1998 (that extends from Mexico through Central America), and defined *biological corridors* as: *"Continental, marine-coastal and island delimited territories whose primary purpose is to provide connectivity between ASP, as well as between landscapes, ecosystems and habitats, natural or modified, being rural or urban. Their goals are to ensure the maintenance of biodiversity and ecological and evolutionary processes; to provide spaces of social agreement and to promote investment in the conservation and sustainable use of biodiversity in those spaces"* (SINAC 2019). Currently there are 43 biological corridors inside the PNCB of Costa Rica, which represent about 31 % of the country's continental territory (SINAC 2019). See Appendix 1 for map of the previously defined conservations systems in Costa Rica.

According to SINAC (2008), a biological corridor must be integrated by the following natural areas under special management regimes: (i) *Core areas:* ASP or private protection areas, where usually human activities are strictly prohibited, although scientific research and ecotourism might be allowed to a certain degree. (ii) *Connectivity routes:* facilitate the movement and migration of wildlife between core areas. (iii) *Matrix or area for multiple uses***:** area where the human settlements are located and where activities such as agriculture, livestock raising, forest exploitation, and/or ecotourism are practiced. Although generally, this area is dominated by open habitats, the presence of small patches of forest may serve as temporary shelters and may facilitate the movement of species through the biological corridor. (iv) *Buffer zones:* help to reduce the impacts of the matrix on core areas.

Moreover, parallel to the ASP of the State, there is also private protection initiatives of forests and natural ecosystems, which include ecotourism reserves, wildlife refuges, biological stations, and reserves of absolute protection, among others. These conservation initiatives are supported by the government through payments to landowners for the environmental services provided by forested ecosystems, such as carbon storage, erosion control, soil fertility, maintenance of water quality and quantity, protection of biodiversity. These protected areas strengthen and strategically complement public conservation of nature.

Adding the aforementioned efforts, numerous regulatory bodies have been implemented, e.g. the Organic Environment Law Nr. 7554 (1995), the Forestry Law Nr. 7575 (1996), and the Biodiversity Law Nr. 7788 (1998). Moreover, for the discussion and elaboration of laws, and for the elaboration of plans and programs on these subjects, citizens, universities, and non-governmental Organizations (NGO) are frequently summoned (SINAC-JICA 2017). As for example, the Wildlife Conservation Law Nr. 7317 which was established due to a popular initiative in 2012; this Law forbids the hunting, capture, extraction, and trade of wildlife (Asamblea Legislativa de la República de Costa Rica 2012). Wildlife hunting is now only permitted in cases of scientific research, population control, and subsistence hunting, all of which needs to be previously approved by the MINAE. In regard to subsistence hunting, it is defined as “Use of wildlife for personal or family consumption of people of very low economic resources” (previously verified by the norms that dictate the regulation of the law); still, subsistence hunting cannot include species at risk or occur in protected areas (Asamblea Legislativa de la República de Costa Rica 2012). However, this Law is not applied to indigenous people within their territories.

Furthermore, Costa Rica has signed and ratified most of the major international conventions on the environment, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, the World Heritage Convention, Convention on Wetlands of International Importance, and the Biodiversity Convention (USAID 2010).

Hunting

In Costa Rica as well as in many other tropical regions, hunting has been traditionally practiced since ancient times by indigenous peoples as a subsistence resource. However, in Bennett and Robison (2000), the authors state that through the colonization

of tropical forests by new residents mostly farmers, the hunting levels have increased and have led it to an unsustainable practice, resulting in the decline of many wildlife populations. A situation that has been described for Costa Rica in several publications (e.g. Oduber 2008, Hewitt 2011, Wong 2014). In the case of COBAS, the immigration and settlement of people at the beginning and through the 20th century in the area, brought with it the transformation of the forest to other land uses, and wildlife hunting to meet their economic needs (Ortiz 2014, Maguire 2017). However, according to Maguire (2017), in recent years hunting has declined. Although, despite the prohibition of hunting by law in Costa Rica (Wildlife Conservation Law No. 7317), hunting is still practiced, as a tradition, as a sport, as a source of income, or when considering wildlife as "agricultural pests" (Wong 2014, Maguire 2017).

Research on HWC in Costa Rica

In Latin America and in Costa Rica in particular, research in HWC have mostly focused on conflicts with large carnivores such as jaguars (*Panthera onca*), pumas (*Puma concolor*) and coyotes (*Canis latrans*), mostly due to the economic losses they cause to livestock farmers (Morazán Fernández *et al.* 2010, Amit *et al.* 2013, Castaño-Uribe *et al.* 2016) However, little attention has been paid to other wildlife species, that may also being persecuted for causing damages to livelihoods or wellbeing of people, and whose role in the ecosystem is important as well. Marchini (2014), states that the concept of HWC has generally been applied to cases that include charismatic mega-fauna such as large herbivores and top predators, whereas non-charismatic nuisance animals continue to be handled through the traditional animal damage control approach (i.e. as pests).

Authors such as Hilje and Monge (1988) published a list of harmful wildlife species in Costa Rica responsible for crop damage and livestock predation which includes mammals, birds and reptiles. Monge (2012) published an updated list of harmful species but only focusing on birds. The same author in a recently publication (Monge 2018) review different researches on the same topic dating from the early nineties to the present, where one of the most mentioned species given the damage they cause to crop plantations are gophers (*Orthogeomys* spp.). However the publications cited above, pay more attention on the damages these species cause to human livelihoods, and in some degree on the control measures applied, while they do not discuss the causes for the increase of its populations in areas where they have been reported as harmful or pest species. Further, none of these works deal with the potential consequences for the ecosystem equilibrium if lethal controls are applied or not.

On the other hand, Alvarado-Barboza and Gutiérrez-Espeleta (2013) reported HWC with raccoons (*Procyon lotor*) in urban areas in Costa Rica due to the lack of planning in urban growth, and due to the ability of this species to adapt to human spaces, resulting in damages to crops and public areas, and invasion of houses which also represents a risk for humans and pets health. In SINAC (2009) conflicts related to the increase of raccoons and coatis (*Nasua nasua*) in urban areas and plantations in Costa Rica are reported as well. This last publication (SINAC 2009) also mentions the increase in the number of snakes in agricultural areas, and of other species such as opossums, gophers, bats, birds among others; however, the conflicts are not discussed in detailed and the authors indicate that the causes have not been well studied. Although they suggest that the increase of the populations may be related to the greater availability of food (e.g. exposed dumps, crops), the displacement of wildlife populations due to the

destruction of their habitats and/or the invasion of humans in the territories of the species.

A list of wildlife species mentioned in all the previously cited documents can be seen in Appendix 2.

2.3 Study area: Alexander Skutch Biological Corridor

2.3.1 Location

The COBAS is located on the Pacific side of south-central Costa Rica on the foothills of the Talamanca mountain range (Figure 1). This area corresponds to the Pérez Zeledón region in the province of San Jose, and it is considered within La Amistad Pacífico Conservation Area (ACLA-P by its Spanish acronym: *Area de Conservación La Amistad-Pacífico*). The biological corridor is also located at the east of San Isidro de El General, capital of Pérez Zeledón region and largest city near the corridor.

Due to its location, COBAS represents an important buffer zone for the Chirripó National Park and therefore for the biodiversity present in the Talamanca mountain range. The Talamanca mountains concentrate approximately 80 % of the total endemic species of Costa Rica and they represent an important habitat for many large mammals and birds that are now threatened in much of their range (SINAC 2018b).

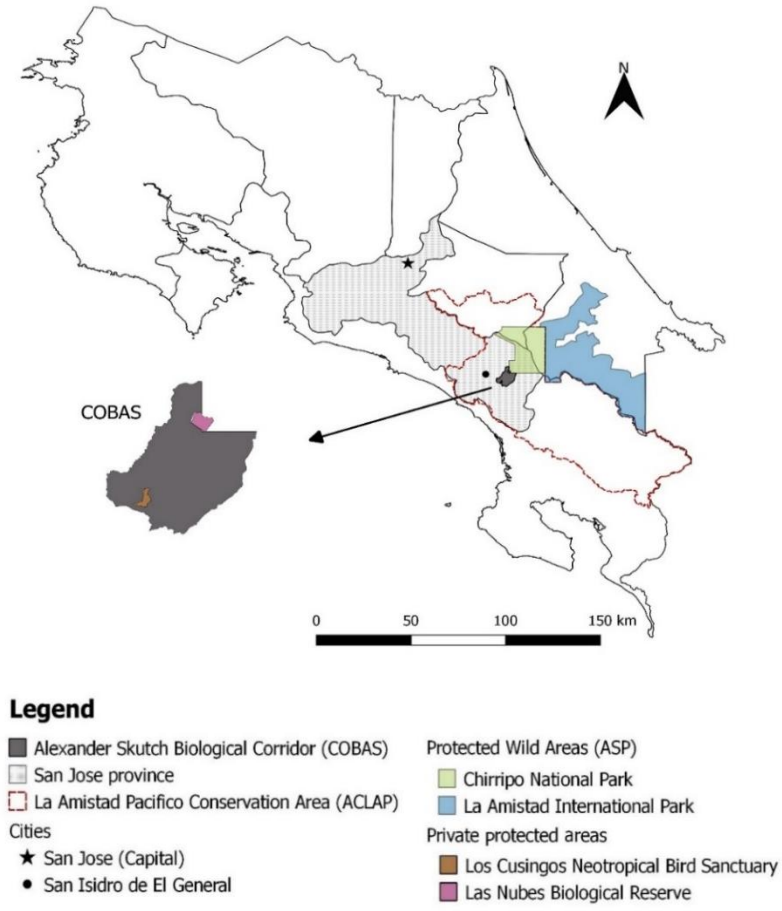

Figure 1. Location of COBAS in Costa Rica (Source: own illustration using information obtained from the National System of Territorial Information of Costa Rica http://www.snitcr.go.cr/)

2.3.2 Climate, flora and fauna

The region has an equatorial climate characterized by precipitations throughout the year; however, two distinct rainy seasons can be observed, short rains from December to April, and long rains starting in May and reaching its maximum between September and October (Canet-Desanti 2005). Additionally, due to the marked altitudinal gradient of COBAS, it possesses varied climatic conditions. The mean annual rainfall is 3 237 mm, but it increases at higher altitudes (Acuña Prado *et al.* 2017). Further, the average maximum temperature is 24 ºC and the minimum is 18 ºC, whereas in higher parts of COBAS the temperature may drop below 10 °C (SINAC 2018b).

Acuña Prado *et al.* (2017), describe three different life zones in COBAS, based on the Classification of Holdridge Life Zones System (Holdridge 1967):

- *Low montane rainforest:* it is found in the upper part of the biological corridor and where Las Nubes Biological Reserve is located. This rainforest on mountain slopes is distinctly different from the lowland rainforest that covers the flatlands, and low hills, and it is represented by a dense forest with the presence of tree ferns. According to Kohlmann (2011) it is also one of the areas of highest endemism in Costa Rica.
- *Pre-montane rainforest*: according to the authors is the predominant life zone in COBAS. It is located in the central part of the corridor and is characterized by pastures and forest patches.
- *Premontane wet forest:* It is found in the lower part of the corridor where the Neotropical Bird Sanctuary Los Cusingos is located, and where the greater density of human population occurs. Therefore, in this low part there is a reduced forest cover due to pressure of extensive crops like sugarcane and coffee being Los Cusingos one of the latest remaining forests in this area. According to Kohlmann (2011) it is one of the areas of highest species richness in Costa Rica.

In Appendix 3 photos of the different landscapes within COBAS can be seen.

Moreover, the region is rich in wildlife species, some of them listed by SINAC (2017) as endangered species or with reduced populations. Species such as the jaguar (*Panthera onca*), puma (*Puma concolor*), ocelot (*Leopardus pardalis*), jaguarondi (*Herpailurus yagouaroundi*), oncilla (*Leopardus tigrinus*), margay (*Leopardus wiedii*), tapir (*Tapirus bairdii*), neotropical otter (*Lontra longicaudis*), black-handed spider monkey (*Ateles geoffroyi*), white-lipped peccary (*Tayassu pecari*), collared peccary (*Tayassu tajacu*), red brocket deer (*Mazama temama*), fiery-billed aracari (*Pteroglossus frantzii*), among others. However, some of these species (e.g. ocelot, jaguarondi, collared peccary) are considered within the Least Concern category by the IUCN Red List of Threatened Species (IUCN 2019), because of its wide distribution range.

Furthermore, over 300 bird species have been identified to be present in COBAS some of them endemic to the region (Montoya and Martinez 2015), 30 species of amphibians have been recorded of which at least two frogs and two salamanders are endemic (for Costa Rica and Panama, SINAC 2018b), as well as 120 species of orchids of which some are also endemic to the region (SINAC2018b).

2.3.3 Human settlements

Within COBAS there are seven main communities: Santa Elena, Quizarrá, Montecarlo, San Francisco, San Ignacio, Santa Maria and Santa Marta (Figure 2). Although Santa Marta is located geographically outside the limits of the corridor, it decided to join COBAS voluntarily after the delimitation of the corridor (Felipe Montoya pers. comm.).

For the year 2011, the population within COBAS was approximately of 3 093 inhabitants, most of which were concentrated in the two largest communities of Santa Elena and Quizarrá (Acuña Prado *et al.* 2017).

According to Ortiz (2014), the communities settled in the area at the beginning of the 20th century due to the international financial crisis of 1930 that triggered internal migrations within the country. The same author (Ortiz 2014) also states that most people in COBAS are small-scale farming families, whose main income stems from agricultural activities that include coffee, sugarcane cultivation and cattle grazing; although people also supplement their income with wage labor, and small-scale ecotourism. In addition, many people usually have a small garden for self-consumption during the year. As well, people exchange with neighbors or relatives the products of its small gardens such as vegetables and fruits (Canet-Desanti 2005).

In addition, none of the villages has a defined form; all of them are mainly distributed along the roads. Further, almost all houses are surrounded by forest patches or agricultural fields. There are no paved roads, and the only public transport is a bus line that connects the communities of Santa Elena and Quizarrá with the communities outside the limits of the corridor, as well as with the city San Isidro de El General. Most of the communities are equipped with basic infrastructure, such as a primary education center, a health center, drinking water and sewer services, electricity and public lighting, and a few small grocery stores. See Appendix 4 for photos of the infrastructures within COBAS.

2.3.4 Stakeholders

The main actors in the management of COBAS are the MINAE through the PNCB, the Faculty of Environmental Studies of York University in Canada, the CCT, and local committees (Montoya and Martinez 2015).

York University-Las Nubes Biological Reserve

The Faculty of Environmental Studies of York University is in charge of Las Nubes Biological Reserve. It is a private protected area of 124 ha of montane rainforest, located in the northeast and upper part of the corridor between 1 200-1 500 m asl, which the York University acquired through a private donation in 1998 (Ortiz 2014). Las Nubes is also located next to Chirripó National Park, a 50 150 ha ASP that reaches 3 820 m asl (Canet-Desanti 2005). The Chirripó National Park continues into La Amistad International Biosphere Reserve (also an ASP) that Costa Rica shares with Panama, forming part of one of the largest contiguous tropical forest ecosystems in Central America (Cante-Desanti 2005). These areas refuge a great number of species of fauna and flora, some endemic, in danger of extinction or with reduced populations (Cante-

Desanti 2005). The location of the three protected areas previously mentioned can be seen in Figure 2.

CCT-Neotropical Bird Sanctuary Los Cusingos

The CCT is a non-profit ecological research and conservation NGO in Costa Rica. The CCT acquired the Neotropical Bird Sanctuary Los Cusingos through the ornithologist Alexander Skutch in 1996 (Canet-Desanti 2005). It is a 78 ha private protected area which comprises a lowland tropical forest, located in the southern end of the biological corridor at approximately 600-700 masl (Canet-Desanti 2005) (Figure 2). It is one of the few remaining forests in the low lands on the Pacific side of the Talamanca mountain range.

Local committees

The local committees are formed by inhabitants of different communities within the corridor. Through these committees, people participate in community development at an environmental, tourism and labor level, which in turn is also related to the objectives of the corridor (Acuña Prado *et al.* 2017). Some of these committees are the following:

- Group of Active Women of the COBAS (AMACOBAS by its Spanish acronym: *Asociación de Mujeres Activas del Corredor Biológico Alexander Skutch*), focused on community management, local community tourism and environmental education;
- Association of Women Entrepreneurs of Santa Elena (AMESE by its Spanish acronym: *Asociación de Mujeres Emprendedoras de Santa Elena*);
- Association of Producers for the Integral Development of the Peñas Blancas river Microbasin - Farmers Union (ASOCUENCA by its Spanish acronym: *Asociación de Productores para el Desarrollo Integral de la Microcuenta del Río de Peñas Blancas*).

2.3.5 Structure and components of the biological corridor

COBAS is integrated principally by:

a) Core areas:
   - Chirripó National Park.
   - Las Nubes Biological Reserve.
   - Los Cusingos Neotropical Bird Sanctuary.

b) Connectivity routes:
   - Peñas Blancas river and margins.
   - Forest patches within the matrix.

c) Buffer zones:
   - Area next to the core zones.
   - Area along and next to Peñas Blancas river margins.

d) Biological corridor matrix:
   - Human settlements: Santa Elena, Quizarrá, Montecarlo, San Francisco, Santa María, Santa Marta and San Ignacio.
   - Agricultural fields, pastures, forest patches of various sizes and family gardens.

Figure 2 shows the previously described components.

The Peñas Blancas river watershed, born inside the Chirripó National Park and crosses the main protected areas of the corridor: Las Nubes and Los Cusingos. The main river (Peñas Blancas) is joined by tributaries such as Peña Blanquita river and Caliente river, and it joins the El General river in the lowlands (Canet-Desanti 2005, Figure 2). In this regard, rivers can play an important role in the biological corridor as connection routs that wildlife can use to move across the area. In Costa Rica, the margins of rivers are protected under the Forest Law Nr. 7575, which determines as protection areas the banks of rivers or streams by prohibiting the elimination or felling of trees in a strip of 15 meters in rural areas and 10 meters in urban areas (measured horizontally to both sides) (Asamblea Legislativa de la República de Costa Rica 1995).

According to Arauz-Beita *et al.* (2016), the COBAS is a fluvial corridor, since it incorporates the basin of the Peñas Blancas river, and altitudinal because it goes from low elevations (Los Cusingos 600-750 m asl) to high elevations (Chirripó mountain 3820 m asl), favoring the altitudinal migration of different wildlife species.

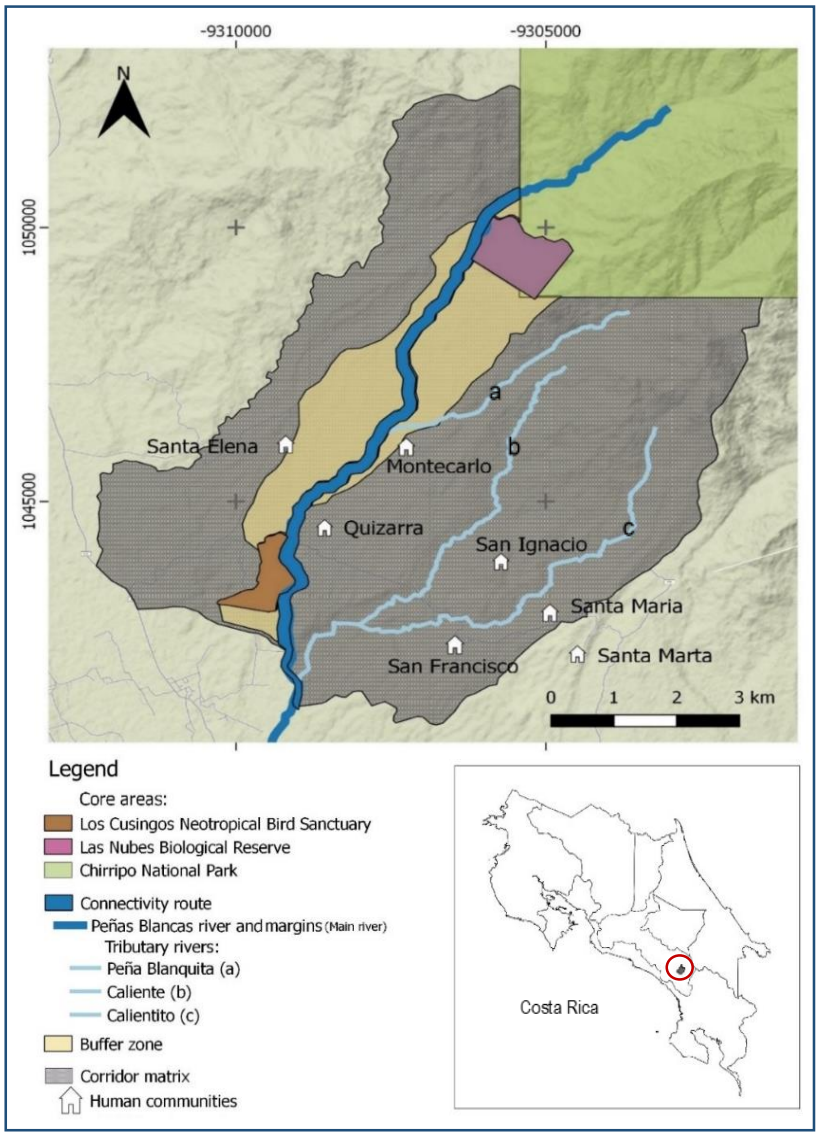

Figure 2. COBAS structural components (Source: own illustration using information obtained from the National System of Territorial Information of Costa Rica http://www.snitcr.go.cr/).

3. Research methodology

3.1 Data collection

The data collection was conducted in September 2017 through qualitative semi-structured interviews with 73 local residents of the seven communities located within the COBAS (Santa Elena, Quizarrá, Montecarlo, San Ignacio, San Francisco, Santa Maria and Santa Marta). Qualitative interviews are a useful tool to identify HWC, as well as for exploring the opinions, experiences, beliefs, etc., of individuals regarding wildlife (e.g factors influencing the perceptions and attitude of local residents toward wildlife) (Torkar *et al.* 2011).
Local people were interviewed according to their availability when being visited in their homes. The houses were reached by foot or by private transport provided by York University. Prior to the commencement of interviews, the purpose and importance of the research was explained, in order to obtain verbal consent from each participating respondent to use the information for this study.
The interviews were semi-structured, designed with both closed and open-end questions. Closed-ended questions are used to gather quantitative data from respondents and are those, which can be answered by a simple "yes" or "no", with numbers, or select among a set of choices. While the open-ended questions (i.e. required more than a yes/no answer), are used to gather qualitative data giving respondents an opportunity to express their opinions and experiences.
All the information obtained from the interviews was recorded using a digital voice recorder and transcribed afterwards into a database. To support the data analysis process, additional notes based on personal observations, behavior of the interviewee, and of the surrounding environment were also taken during the interview development.

3.1.1 Interview structure

The scheme in Figure 3 represents the main topics and the key questions used for the interviews with local residents. The key questions helped to define the topics to be explored and allowed interviewees to express their answers in more detail.
As shown in Figure 3 the interview included questions regarding (i) the *socio-demographic characteristics* of the respondents (community, age, gender, occupation), (ii) questions regarding their *livelihoods* (divided into three main groups: crops, livestock, and pets), like the type of crops and animals the interviewees had, and for what purpose (e.g. for market or family consumption), as well as the amount of animals and type of enclosure they use for their livestock. The objective of these last questions was to give an overview of the importance of potential impacts wildlife can cause over the livelihoods of the families. (iii) Questions regarding negative experiences with *wildlife*, which included the type of wild animal that caused them problems, the frequency of those events and what measures respondents took in response. In this regard, the study focused only on vertebrate wild species; therefore, invertebrate species mentioned by the interviewees were excluded. Information about positive experience with wild animals was also taken during the interviews as additional notes. (iv) Further, information regarding to *hunting* in the area and their understanding about what *COBAS* means was asked. (v) Finally, the perception based on the expressions and attitudes respondents used during the interviews to manifest their position regarding wildlife and the COBAS was assessed.

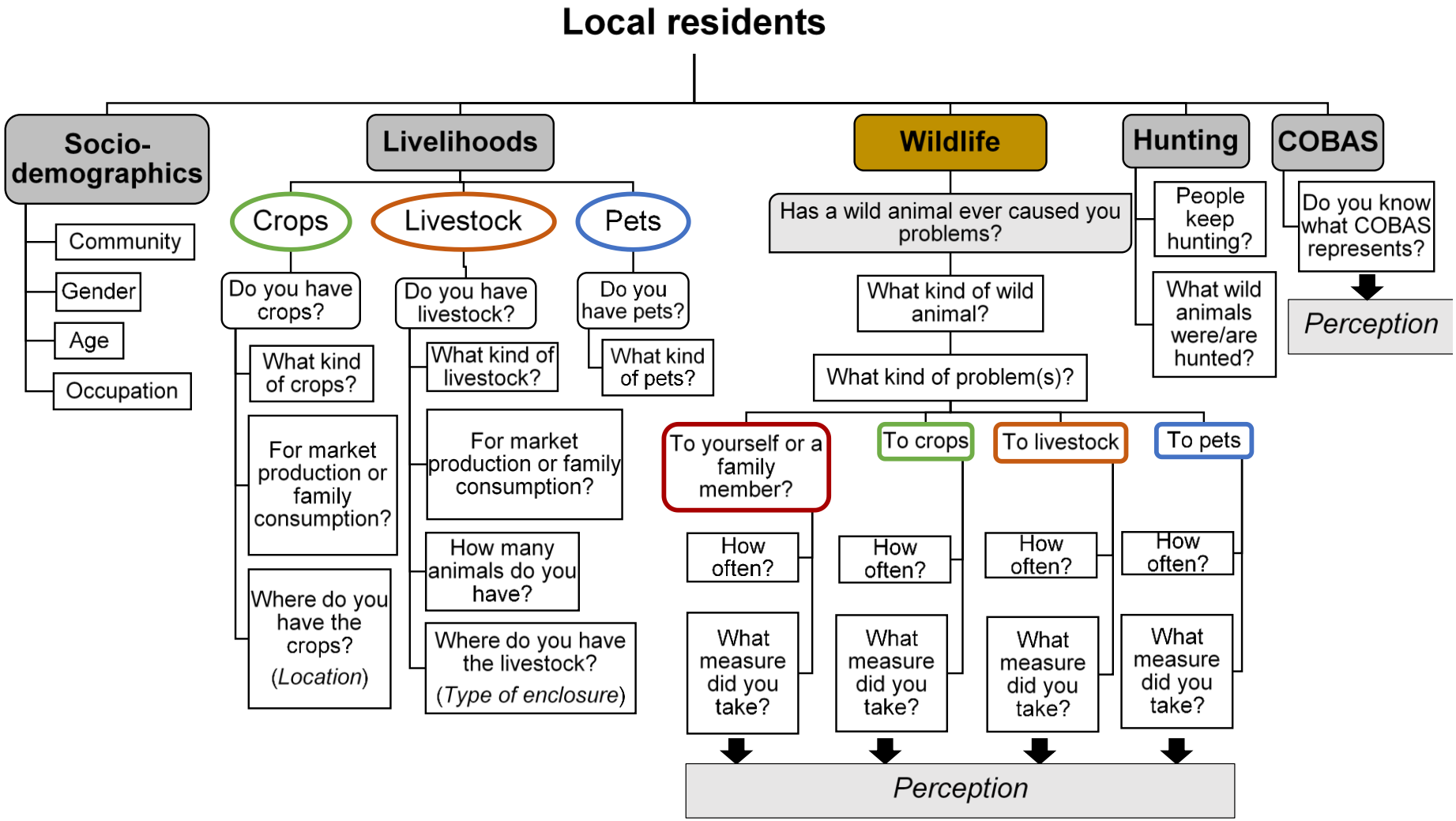

Figure 3. Scheme of questions used for the interviews. (Source: own illustration)

3.2 Data analysis

To prepare the data for the analysis, the transcripts were read carefully several times and the information was organized according to the main topics and key questions.

Once the information was organized, the answers to closed-ended questions were codified (e.g. 1/0) and counted (e.g. how many people grew coffee, had poultry, or how many respondents have been affected by wild animals).
To facilitate the organization of the information, lists were made with the kind of crops, livestock, and pets that respondents mentioned having. Furthermore, a list of wildlife species reported having caused some type of damage was made. From the latter, the animals mentioned by more than 10 % (i.e. n=73) of the interviewees were selected for the subsequent analysis.

For the analysis to open-ended questions, categories based on words used by the respondents in their answers were defined; this has been done in order to maintain the transparency on the interpretation of the information. In addition, notes taken during the interviews based on personal observations of the situation were used to support the classification of categories. Answers to open-ended questions such as the *type of enclosure*, varied between the respondents. Therefore, categories based on the main types of enclosures used by respondents to keep their livestock were made (e.g. if some respondents mentioned to keep their livestock outside a pen or fence, this answers were categorized as "outdoors"). The same was repeated for the categorization of the *type of measure* respondents took in response to the damages caused by wildlife, which also varied between the interviewees and between the wildlife species (e.g. depending on the species and the type of damage it caused, it was scared away or killed). The *type of damage* or problem caused by wildlife was categorized according to the livelihood affected. For example, if the wild animal caused damages or ate any type of crop this was classified as “crops” (the same was repeated for “livestock” and “pets”). If the damage affected the welfare of respondents this was classified to the category of “humans”. Furthermore, local people usually have another way for expressing the temporality of facts. Therefore, the categorization of the *frequency* in which the damage events took place was defined based on the words used by interviewees to describe when and how often an event took place (e.g. respondents were talking in present when the event happened many years before, reason why it was classified as "not often"). This method was also used to evaluate the *perception of the respondents about the wild animals* that caused them some kind of damage (to their welfare or to their livelihoods): categories were defined based on the words respondents used to express feelings while they were telling their experience, such as fear, rejection, dislike or sympathy. Finally, the *perception of the respondents about COBAS* was classified and defined based on their expressions when they were asked if they know what COBAS represents. Once the categories were defined, the data for these categories was simplified, codified and counted (e.g. 1/0). The results are finally presented in percentages with bar charts and pie charts using Microsoft Excel (Microsoft Excel version 2013).

Table 1 summarized and describes in detail the information previously described.

Table 1. Definition of categories to open-ended questions. (Source: own illustration)

Open-ended questions	Categories and definitions
Type of enclosure (for livestock)	• **Outdoors:** animals kept outside pens, fences or barns. • **Closed pen:** animals kept inside a barn or pen with roof, usually all covered with metal mesh. • **Open pen:** animals kept inside a fence or pen with/without roof, without being all covered with metal mesh. • **Mixed:** animals kept part of the day outdoors and inside a pen (usually closed). • **Covered pound:** fishpond covered with metal mesh. • **Uncovered pound:** fishpond not covered with metal mesh. • **Unspecified:** no specification on the type of enclosure or location of the animals.
Type of damage	• **Humans:** wild animal attacked, injured or directly threatened a person or a close relative of the person. • **Crops:** wild animal ate or damaged crops. • **Livestock:** wild animal killed or injured livestock. • **Pets:** wild animal killed or injured pets. • **Unspecified**: expression used “everything was affected” • **No answer:** question was not responded.
Frequency	• **Not often:** expressions used “years ago”, “once”, “it does not happen often”, “only by seasons”. • **Often:** expressions used "they eat the fruits / chickens", “they are eating”. “it happens recently”. • **Very often:** expression used “it happens all the time”. • **No answer:** question was not responded
Type of measure	• **Construction of structures**: fences or pens. • **Crop improvement/fumigation:** cultivation of resistant plants (e.g. fruits with harder peel), use of chemical substances. • **Scare away:** wild animal scared away (e.g. making noises). • **Remove:** wild animal captured, transported and released. • **Kill:** wild animal killed. • **No answer:** question was not responded.
Perception about wildlife	• **Sympathy:** expressions used “it is not a problem”, “but I like to see them”, “we all have to eat”. • **Dislike:** expression used “they are harmful”, “it is harmful” • **Fear:** expressions used “they are very harmful", “they are dangerous” • **Rejection:** expressions used, "they eat everything and leave nothing", “they do a lot of damage”
Perception about COBAS	• **Disagree:** expression used “I don’t get any benefited from it”. • **Agree:** expressions used “it is good”, “it helps”, "it is nice". • **Interest:** expressions used "it's interesting", "it's important". • **Support:** expressions used "it's very good", "I love it", "it's very important", "I'm involved" or "we belong to it". • **No opinion**: no comment.

3.3 Literature review

A variety of sources of information in English language as well as in Spanish language has been consulted throughout all stages of the research, e.g. scientific articles, reports, academic thesis, books, and strategic plans, among others. This literature mostly related to the topics of HWC, human-wildlife interactions, biological corridors, Costa Rica, and wildlife. Further, information related to the study area (COBAS) has been reviewed covering the reduction/recovery of the natural forests within time, wild animals that inhabit the region, its natural requirements and its conservation status, human activities and livelihoods. This allowed me to establish the required definitions, found in section 2, and the understanding of necessary concepts during the development of the work, as well as information for the discussion of the results.

4. Results

The current section presents in detail the research results based on the 73 interviews conducted during the data collection phase in Costa Rica. First, there is a focus on the identification of the socio-demographic characteristics and the livelihoods of the interviewees. Subsequently, the results on the interviewees' responses to human-wildlife interactions are presented, as well as the assessment of hunting activities. Finally, this section finalizes with the interviewees recognition of COBAS.

4.1 Socio-demographic characteristics

Surveyed local people (n=73) were aged between 26 to 80 years, of which 69.9% were men and 30.1% women. Most of them belonged to the communities of Santa Elena (35.6%) and Quizarrá (20.5%), followed by Montecarlo (13.7%), San Ignacio (9.6%), San Francisco (8.2%), Santa Maria (6.8%) and Santa Marta (5.5%) (Table 2). Farmer was the most common occupation (45.2%), usually performed by men, while most women interviewees take care of domestic activities (20.5%). Table 2 shows the previously results.

Table 2. Demographic characteristics of surveyed people (n=73).

Demographic parameter	Category	Number (%) of respondents
AGE	Min	26
	Median	54
	Max	80
GENDER	Male	51 (69.9)
	Female	22 (30.1)
COMMUNITY	Santa Elena	26 (35.6)
	Quizarrá	15 (20.5)
	Montecarlo	10 (13.7)
	San Ignacio	7 (9.6)
	San Francisco	6 (8.2)
	Santa Maria	5 (6.8)
	Santa Marta	4 (5.5)
OCCUPATION	Farmer	33 (45.2)
	Housewife	15 (20.5)
	Merchant	7 (9.6)
	Retired	6 (8.2)
	Livestock keeper	5 (6.8)
	Carpenter	2 (2.7)
	Other (e.g. craftsman, gardener),	5 (6.8)

4.2 Livelihoods

All interviewees (n=73) have at least one of the three evaluated livelihoods (crops, livestock, pets), whereas others have two of them or even all three.

Figure 4 shows the percentages of respondents growing crops, raising livestock and holding pets. Of the total of respondents (n=73), 93% were growing crops at the time of the interview, 66% raised livestock and 62% held pets. While 4% responded not having any type of crop, 27% did not have any type of livestock and 38% did not have any type of pets. Figure 4 also shows that 3% of the respondents did not answer when they were asked about growing crops as well as 7% did not answer the question about raising livestock.

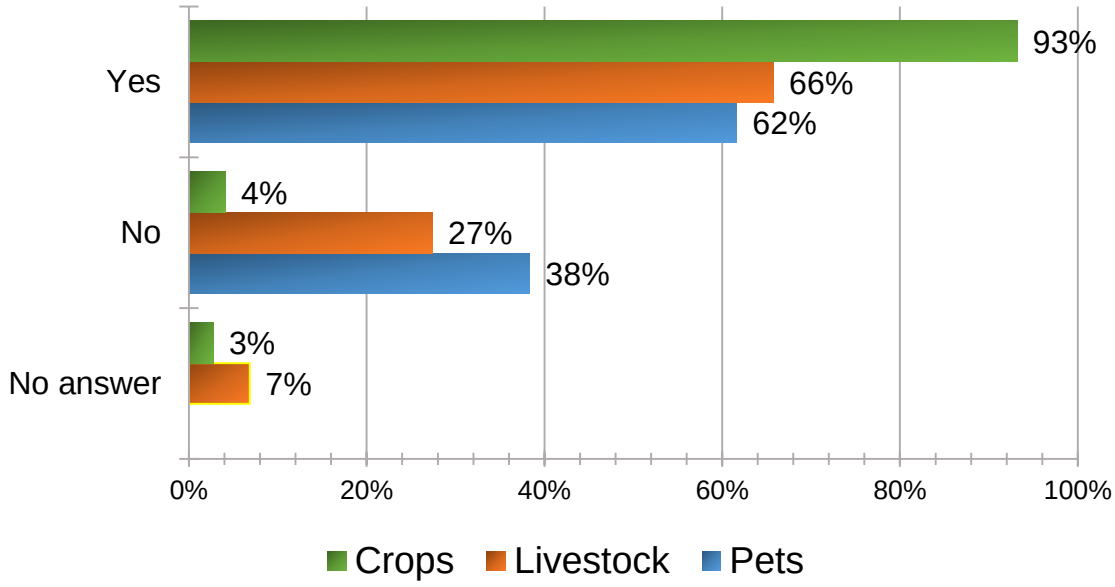

Figure 4. Percentages of respondents growing crops, raising livestock and holding pets (n=73).

Crops

Almost all respondents having crops (n=68), cultivate more than one type (e.g. some grow coffee and at the same time they have fruit trees, and/or fruit trees of different types of fruits). The main types of crop respondents cultivate are fruits (48%), followed by coffee (24%), vegetables (13%), sugarcane (7%), root vegetables (6%) and corn in smaller percentage (2%) (Figure 5). Many of the respondents did not specify the type of fruit crops they grow, but among the fruits that some respondents mentioned and coinciding with personal observations, the most common are bananas, rambutan, and orange. Also mangoes, cocoa, avocados, tangerine, peach palm, soursop, pineapple, guayaba, mangosteen, coconut, loquat, star fruit and blackberries were mentioned. Although, respondents did not always specify the type of vegetables and root vegetables they grow, some of them mentioned beans, coriander, chayote, celery, squash, yucca, and sweet potato, which coincided with personal observations as well. See Appendix 5 for photos of the agricultural activities within COBAS.

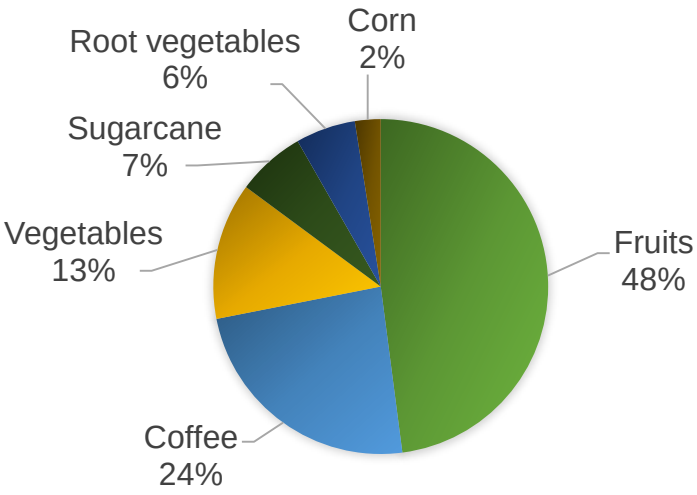

Figure 5. Type of crops grown by respondents.

Of the total of respondents growing crops (n=68), 43% do it for family consumption and 44% for both market production and family consumption, while 12% grow crops only for market production (Figure 6). Only 1% did not answer the question (Figure 6).

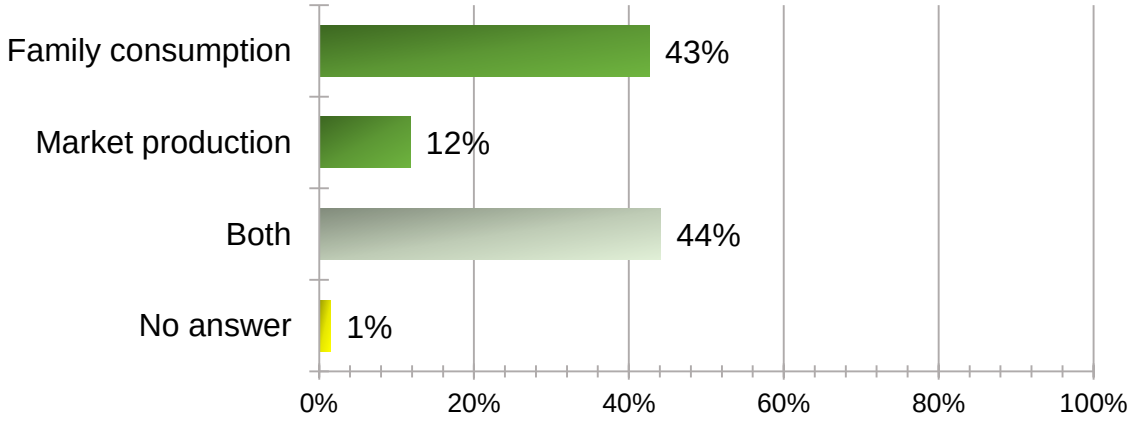

Figure 6. Purpose of respondents for cultivating crops (n=68).

None of the respondents mentioned how many plots of crops they cultivate. However, of all respondents raising crops (n=68), 99% mentioned to have their crops around their houses (see Appendix 5 for photos).

Livestock

Some respondents (42%) having livestock (n=48), raise more than one type (e.g. some people have fish in ponds and at the same time they breed laying hens). Poultry (e.g. laying hens, broilers, turkeys) is the main type of livestock that people raise (51%), followed by cattle (19%) and pigs (14%), while horses (5%), goats (5%), fish (4%) and ornamental birds (3%) in less percentages (Figure 7). Tilapia is the only fish species that people breed in ponds, and the budgerigar, or also called Australian parakeet, is the

only ornamental bird species people breeds (which according to the law is not forbidden to hold in captivity since it is considered a non-native species).

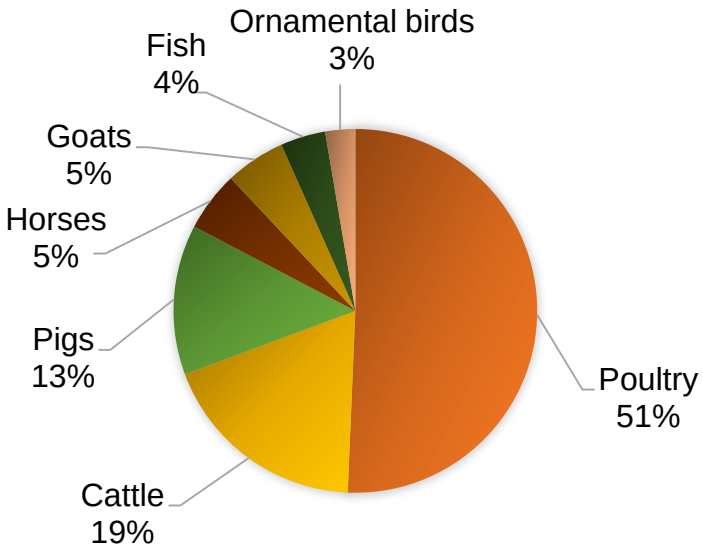

Figure 7. Type of livestock raised by the respondents.

Of the total of respondents raising livestock (n=48), 48% raise it for both family consumption and market production, and 42% for family consumption only, while 10% had livestock specifically for market production (e.g. ornamental birds) (Figure 8).

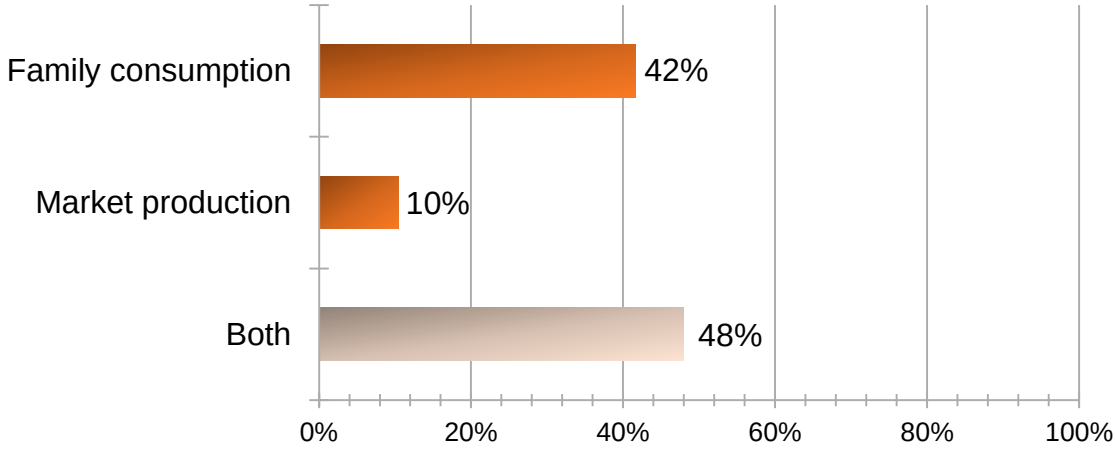

Figure 8. Purpose of respondents for raising livestock (n=48).

Figure 9 shows the percentages of respondents raising different types of livestock in different quantities. Of the total of respondents that acknowledged having livestock (n=48), most of them raise from 1 to 15 animals, 52% have 1 up to 5 animals and 58% from 5 up to 15 depending on the type of livestock. For example, respondents who mention having 1 up to 5 animals (n=25), breed horses (75%) and goats (75%) followed by cattle (50%), and pigs (50%), while only 18% of them breed poultry in such quantities. Of the total of respondents having 5 up to 15 animals (n=28), 55% breed poultry, 29%

cattle, and 10% pigs. Only a few people keep poultry in larger numbers (>15). As well, only some respondents have horses (8%) and pigs (10%) in higher numbers (>16). In the case of people breeding ornamental birds, all keep from 6 up to 15 birds, while respondents producing fish did not specify the number of tilapias they keep in the ponds. Figure 9 also shows that 21% of the respondents raising livestock did not specify the number of animals they possessed.

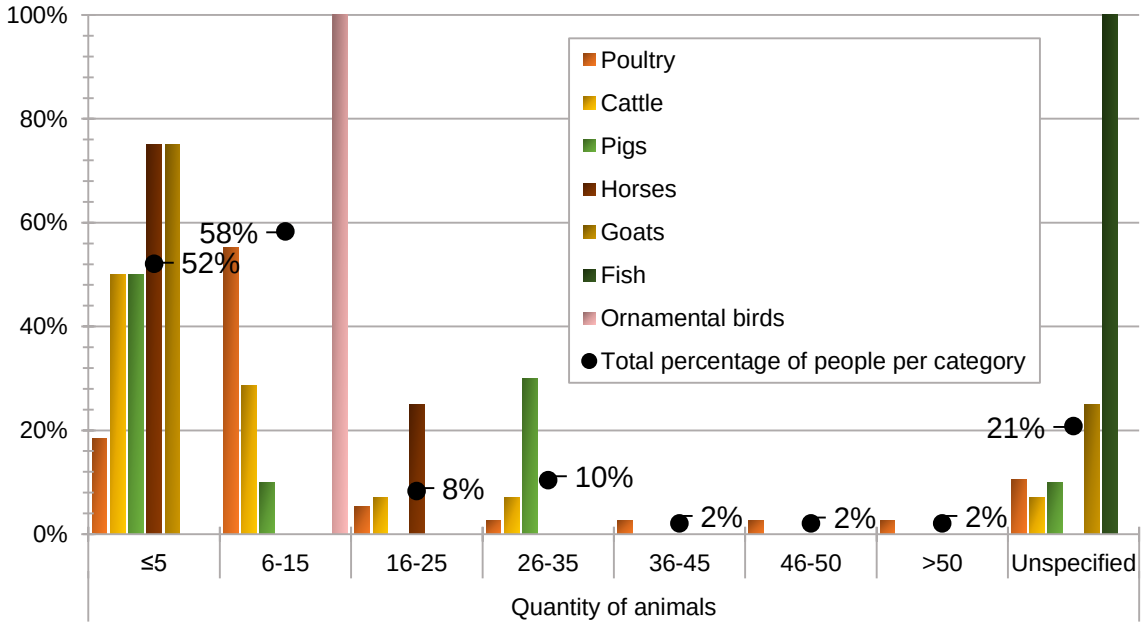

Figure 9. Quantity of animals per type of livestock raised by the respondents (n=48

The location or type of enclosure where respondents have their animals is variable; however 77% of respondents have their animals in closed pens, 33% outdoors, 17% mixed, 17% in open pens (Figure 10). Usually, it differs between the types of livestock they raise. This is shown in Figure 10, where 66% of the respondents who have poultry, keep them inside closed pens, 16% of them outdoors, and 8% keep their poultry inside open pens or mixed (5%). On the other hand, 43% of the respondents that breed cattle held them free, 21% keep them inside closed pens and only a few respondents inside open pens (14%) or mixed (14%). Half of the people breeding horses have them free while the other half varied the type of enclosure (mixed). Most people breeding goats (75%) held them in closed pens while the rest in mixed enclosures. In the case of respondents breeding pigs 40% used closed pens, 30% open pens, 20% leave them outdoors and only 10% of them keep their pigs in mixed enclosures. Figure 10 also shows that ornamental birds are only held inside closed pens. Further, 67% of the respondents that farm fish, reported to have their fish inside covered ponds, while 33% have their fish in an uncovered pond. Only a few respondents breeding poultry and cattle did not specify what kind of enclosure they used for their animals (Figure 10).

Photos of the type of enclosures and livestock of the interviewees can be seen in Appendix 6.

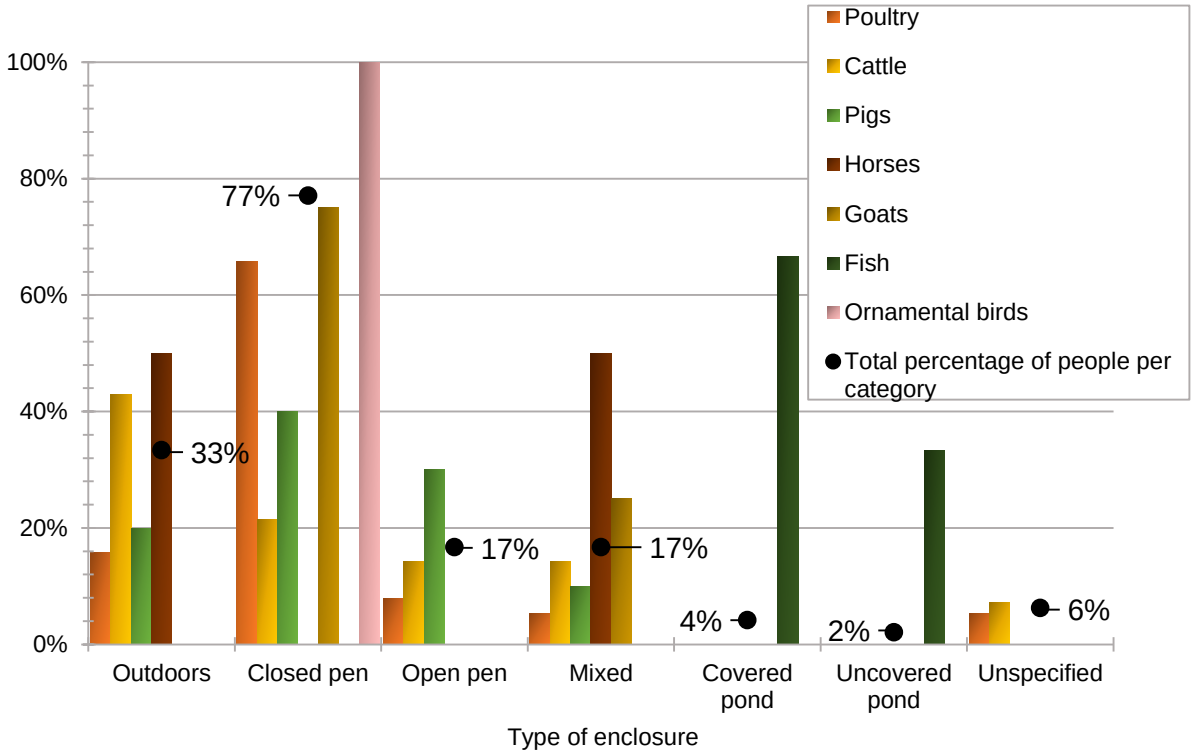

Figure 10. Type of enclosure per type of livestock used by respondents (n=48).

Pets

Many respondents (60%) who have pets (n=45), have more than one type of pet or more of the same type. With regard to the type of pets kept by the respondents, 75% are dogs, 11% cats, 9% budgerigars, while 5% represent other animals (e.g. turtle, rabbit, parrot) (Figure 11).

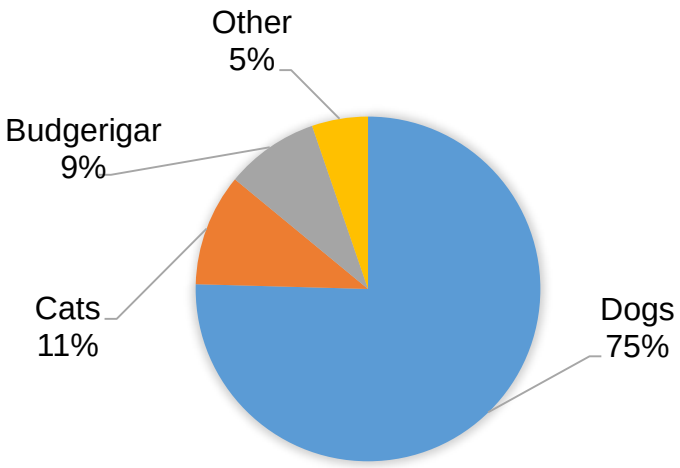

Figure 11. Type of pet respondents held.

Pets such as dogs are usually held to take care of the houses or livestock, and cats to control other animal species such as rats, mice and others (personal observation).

Additionally, it was observed that some respondents keep their dogs free and others have them tied up or even locked up.

4.3 Human-wildlife interactions

Of the total of respondents (n=73), 85% mentioned at least one wild animal species as responsible for some kind of damage to their livelihoods or personal welfare, while 7% answered to have not suffered any kind of damage caused by wildlife, and 8% did not answer the question (Figure 12).

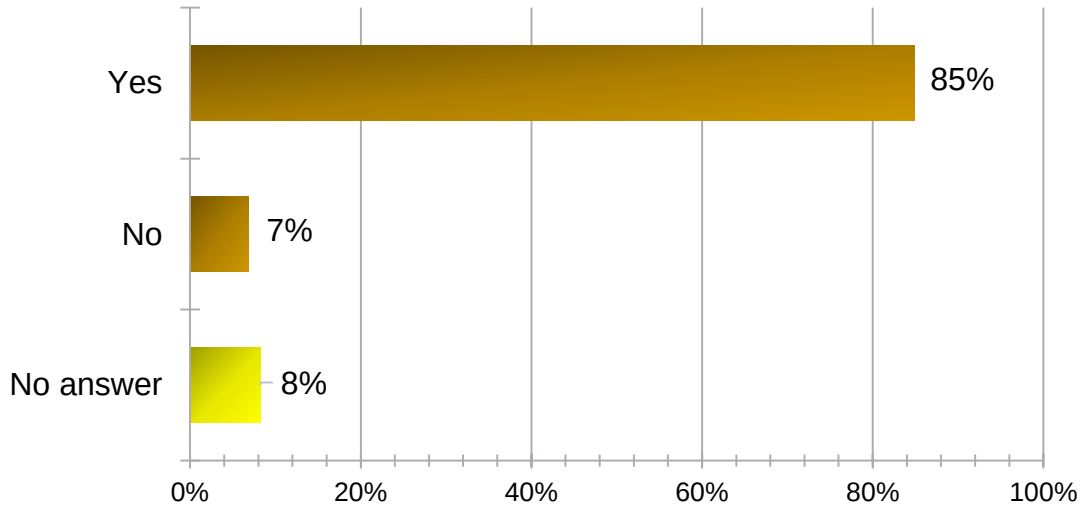

Figure 12. Percentages of respondents that mentioned having suffered some kind of damage by wild animals (n=73).

Figure 13 shows the percentage of respondents that mentioned having suffered damages caused by different wildlife species (n=62). The species described by respondents belong to three large groups of vertebrates: mammals (17 species), birds (5 species) and reptiles (5 species). Among the most mentioned mammals are squirrels (by 39% of respondents), tayra (24%), white-tailed deer (16%), coyote (16%) and opossums (13%). Regarding the birds group, 21% of respondents mentioned parrots. The only group mentioned between the reptiles are snakes, being the fer-de-lance a venomous snake the most mentioned by 42% of respondents, followed by the boa a non-venomous snake by 13% of interviewees. Whereas the remaining animals presented in Figure 13 were mentioned by less than 10% of the respondents.

The type of damage respondents reported for each wildlife species is also shown in Figure 13. According to the respondents, the white-tailed deer and the squirrels cause damage to crops, such as beans and fruits. The coyote and the tayra prey on their livestock, principally poultry, while in the case of opossums 88% of the respondents reported damages to their livestock by preying on poultry, and 13% reported damage to their crops. The parrots were responsible of crop damage, principally coffee. In the case of the fer-de lance, 50% of respondents reported damages (e.g. snakebites) to livestock, 42% reported direct threats or attacks to their self-welfare or to close relative, while 8%

reported damages to their pets. The boa is responsible for preying on livestock, principally poultry, and for preying on pets according to 75% of the respondents, usually small pets like rabbits or budgerigars.

Another 6% of the respondents reported damages to their livestock and pets by wildlife; however, they claim that they could not specify the animal that caused the damage (Figure 13).

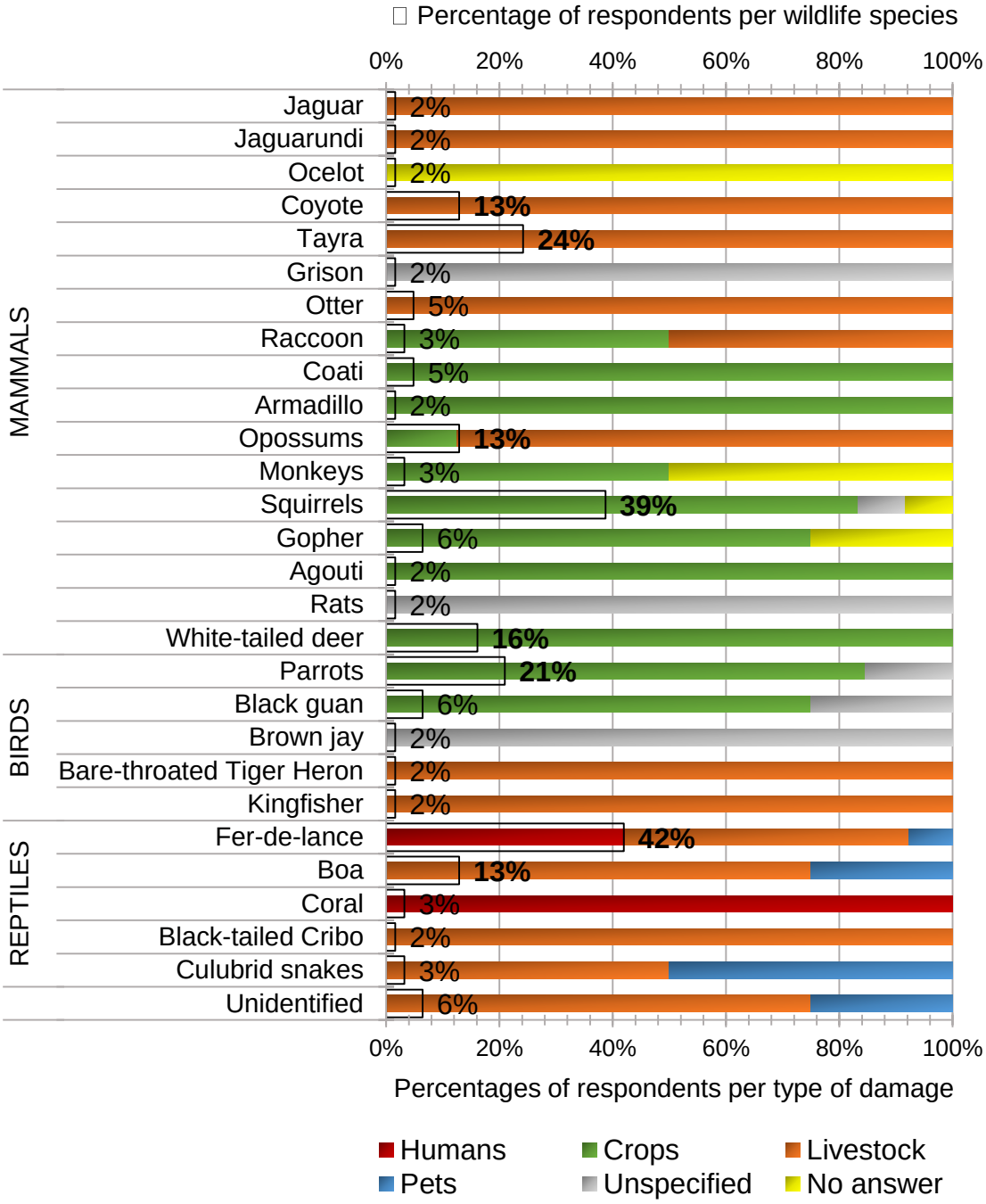

Figure 13. Percentages of respondents per wildlife species responsible of causing damage (bars without color), percentage of respondents per wildlife species per type of damage (bars in color) (n=62).

Figure 14 shows the frequency with which the most mentioned wildlife species causes damages. According to 44% of respondents damages occur often, 37% said they do not occur often, and a 3% reported damages occur very often. While a 17% of respondents did not answer the question. The frequency of damages reported by the respondents varies for each species and between species. However, only in the case of the fer-de-lance snake, 12% of respondents confirmed this snake affected them frequently.

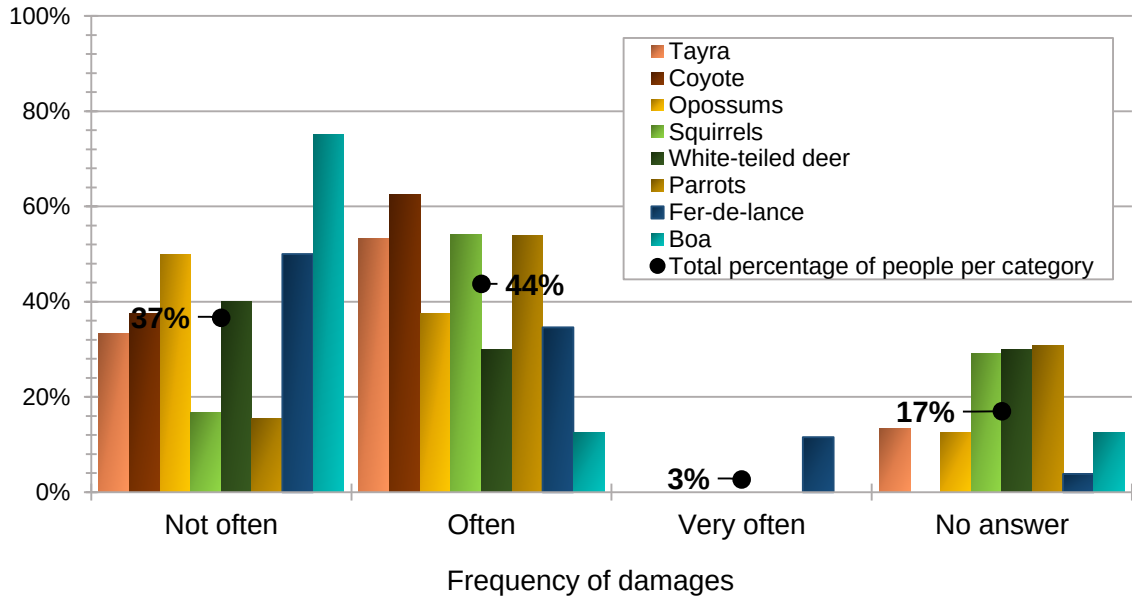

Figure 14. Frequency of damage per wildlife species according to respondents.

Figure 15 shows the type of measures respondents take when they find the mentioned species causing problems. In this case 65% of respondents did not answer the question. A few respondents mentioned that after having experienced a problem with the tayra, white-tailed deer or opossums, they decided to lock their animals in closed pens, or mentioned having scared away the squirrels and deer, or in the case of the boa and opossums respondents take them to other place after catching them. Only in the case of the snakes, respondents mentioned to have killed the animal in retaliation or as a prevention measure, 81% affirmed to have killed the fer-de-lance snake, and 38% the boa.

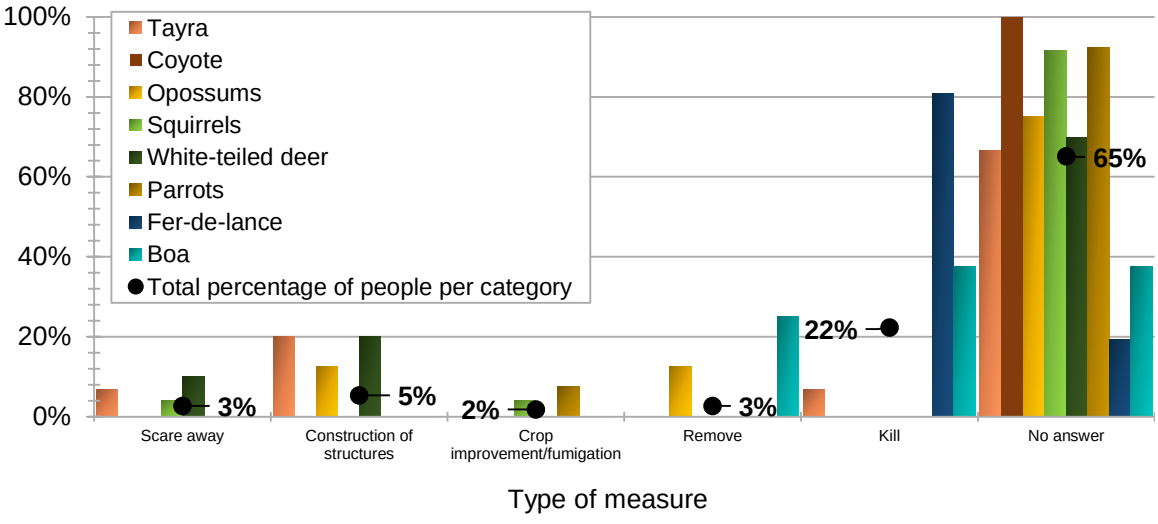

Figure 15. Type of measure respondents take per wildlife species.

Figure 16 shows the perception of respondents towards wildlife who caused them damage. Most of the species are perceived with dislike per 57% of the respondents, 20% of respondents express fear, 15% rejection and 8% sympathy. In the case of the fer-de-lance snake, it is perceived with fear by 85% of respondents. Respecting the tayra and opossums, all respondents who mentioned them express dislike. Other species also perceived with dislike by more than the half of respondents who mentioned them are, the white-tailed-deer by 70%, the coyote (63%), the boa (88%), and the squirrels (58%). While people who express rejection do it for species such as the coyote (38%), squirrels (21%), white-tailed deer (20%), parrots (46%) and the boa (4%). Species who are perceived with sympathy for some of the respondents even if they were affected by them are squirrels (21%), white-tailed deer (10%), the parrots (15%) and the boa (13%).

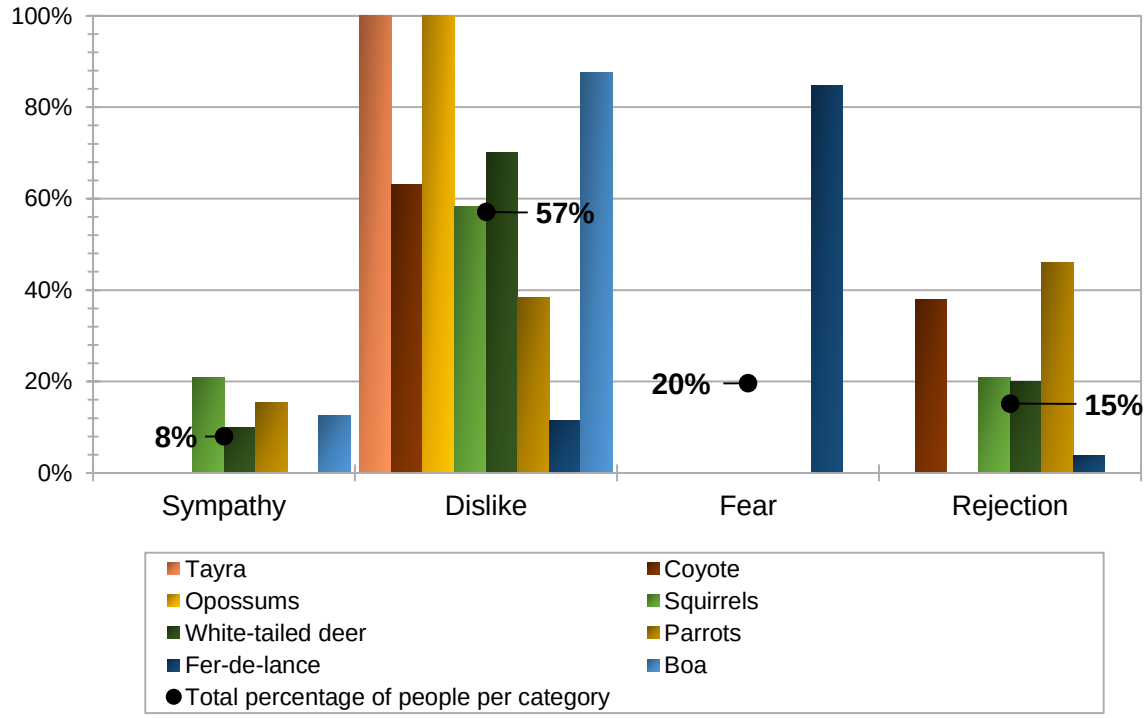

Figure 16. Perception of respondent toward wildlife species.

4.4 Hunting

When surveyed people were asked about the situation of hunting in the area, of the total of respondents (n=73), 56% affirm there are people that still hunt, while 15% said it is no longer practiced (Figure 17). Another 8% respond not to know about it and 21% did not answer the question (Figure 17)

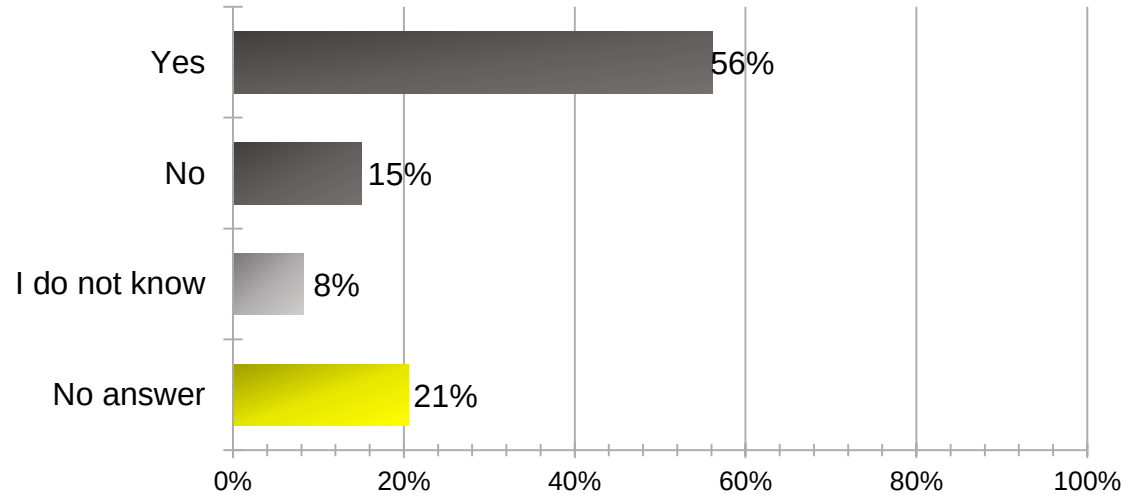

Figure 17. Percentages of respondents responding about hunting in COBAS (n=73).

Of the total of respondents who confirmed there is still hunting in the area (n=41), 41% mentioned the white-tailed deer to be the most hunted species and 22% mentioned the paca (*Cuniculus paca*), while other species were mentioned by less than the 10% of the respondents (Figure 18). The 39% of respondents did no answer the question and 2% did not specify the wildlife species that still is hunted (Figure 18).

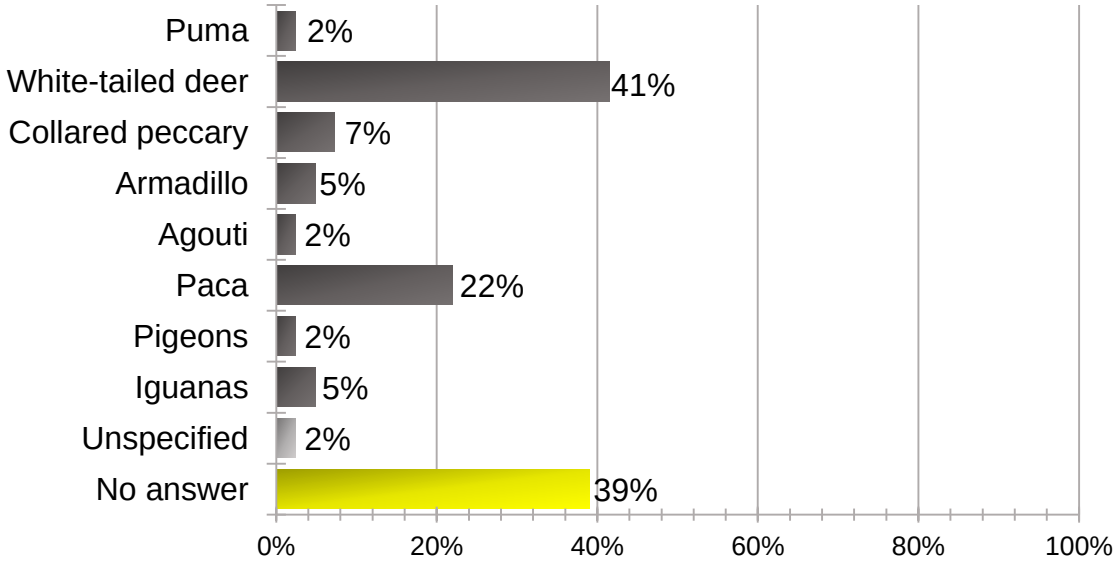

Figure 18. Wildlife species hunted mentioned by respondents

4.5 COBAS

Figure 19 shows the percentages of respondents answering the question about COBAS. Of the total of interviewees (n=73), 48% confirm to know what COBAS represents, while 14% mentioned not to know much about it, 30% said they do not know what it is, and 8% did not answer the question.

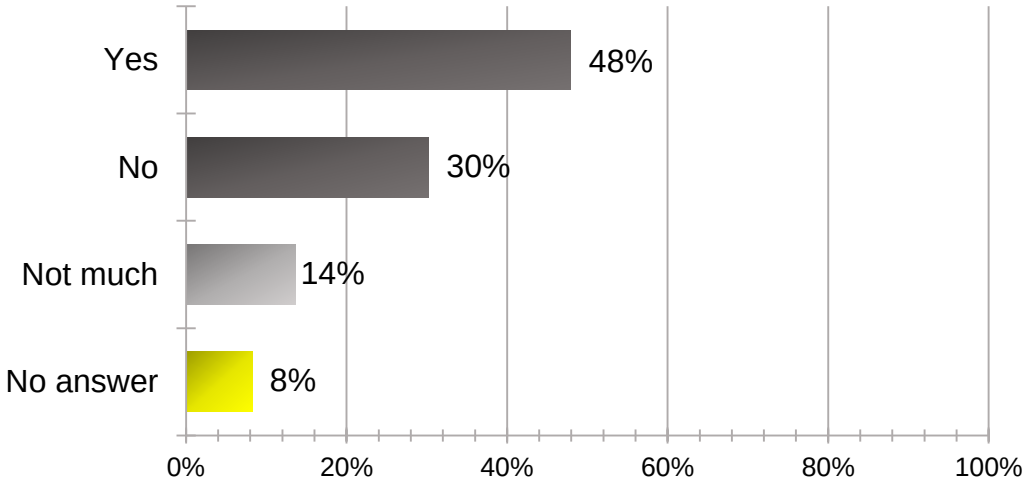

Figure 19. Percentages of respondents confirming if they know about COBAS (n=73).

The perception of respondents about COBAS is shown in Figure 20, 46% are agree, 11% support it, 6% think it is interesting, while 3% of the respondents disagree. The 34% of them did not manifest their position. However, it is important to highlight that approximately 20% of the total of respondents who confirmed knowing what COBAS is (n=35), referred to Los Cusingos Neotropical Bird Sanctuary since they related the name of the corridor with the ornithologist Alexander Skutch who was the owner of those lands before his death in 2004.

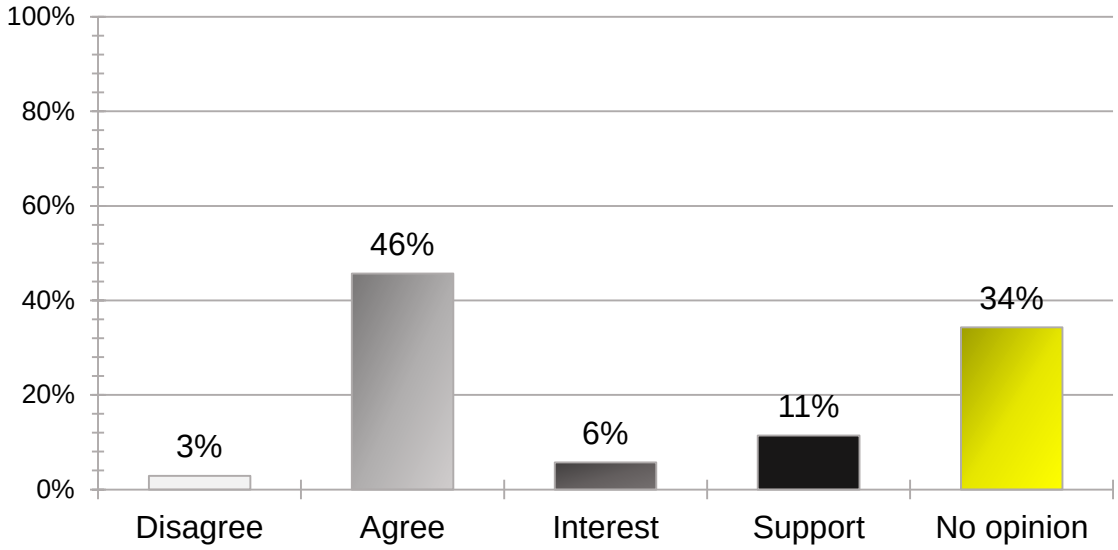

Figure 20. Percentages of respondents per opinion about COBAS.

5. Discussion

A total of 73 adult people were interviewed in seven communities within COBAS, most of these people live in Santa Elena and Quizarrá, which are the largest villages within the corridor. Between the survey people, farming was the most common activity; usually performed by men, while mostly women take care of domestic activities, although also support some agricultural activities (e.g. coffee harvest). About their livelihoods, fruit trees are the most common crop cultivated by the respondents, followed by coffee and vegetables, which are in almost all of the cases located near the houses. Further, the most common type of livestock is poultry followed by cattle and pigs, which are usually kept in quantities of 1 to 15 animals, and in the case of poultry mostly inside closed pens, although pigs are also kept inside open pens, while cattle is usually kept outdoors. These livelihoods are often for the families' own consumption and not exclusively for the trade, although they mostly have both purposes. Furthermore, many respondents also have pets, mostly dogs, which are also kept for protective purposes. These results confirm that survey people are mostly small-scale farmers, whose livelihoods are principally part of their subsistence economy while they also get a monetary gain from some of them, which agrees with was identified by Ortiz (2014) in her research concerning peasants in COBAS.

5.1 HWC in COBAS

A total of eight species belonging to different taxonomic groups are the most reported for causing damage to livelihoods and to welfare of survey people, five of them are mammals of different species (tayra, white-tailed deer, coyote, squirrels, and opossums), followed by two different species of snakes (fer-de-lance and boa) and one group of bird species (parrots). All these species are present in the corridor according to the list of SINAC (2018b), in the case of the squirrels, opossums, and parrots with more than one species.

Parrots

In this study, parrots were mentioned by 18% of respondents for causing damages to crops (mostly to coffee). In COBAS there are two different species of birds called by the respondents as "*chucuyos*", the crimson-fronted parakeet (*Psittacara finschi*) and the white-crowned parrot (*Pionus senilis*) (SINAC 2018b), both belonging to the *Psittacidae* Family. These two species have been listed in Hilje and Monge (1988) and in Monge (2012) as harmful species in Costa Rica for causing damages to crops (e.g. corn and fruits). In Mexico, the species *Pionus senilis* has been attributed to corn damages (Romero-Baldera -Baldera *et al.* 2006), while in Honduras and Colombia has been listed as a pest species in agricultural areas (Monge 2012).

Ramírez-Fernández *et al.* (2019) state that the diet of *Pionus senilis* is poorly documented, but mainly consists of fruits, seeds, and acorns. While *Psittacara finschi* feeds on flowers, fruits, wild figs, and wood (Collar *et al.* 2019, Ramírez-Fernández *et al.* 2019).

In regard to the conservation status of these species, both are listed as Least Concern on the UICN Red List (BirdLife International 2016a, BirdLife International 2016b).

BirdLife International (2016a) reported that the population of *Pionus senilis* is suspected to be in decline due to ongoing habitat destruction through its distribution rang that extends from Mexico through Central America. In contrast, *Psittacara finschi* populations are suspected to be increasing, due to ongoing habitat degradation which seems to be offering new areas of suitable habitat (BirdLife International 2016b). Further, while its distribution was restricted to Nicaragua, Costa Rica and Panama, a recent research (Portillo-Reyes *et al.* 2017) establish *Psittacara finschi*, as a new species for Honduras. In addition, both species are listed in Appendix II of CITES, which includes species that are not necessarily endangered, but whose trade must be controlled (CITES 2017).

Squirrels

Squirrels were mentioned by 33% of interviewed people in this research for causing crop damage (e.g. to fruits trees, vegetables such as chayote, and coffee). There are two different species of squirrels present in COBAS belonging to the *Sciuridae* Family, the variegated squirrel (*Sciurus variegatoides*), and the red-tailed squirrel (*Sciurus granatensis*), both locally known as "*ardillas*" or "*chizas*" (SINAC 2018b).

According to the literature, these two species are opportunistic omnivores given their ability to adapt to different habitats and food availability (Monge and Hilje 2006). Both species feed principally on fruits and grains, but depending on the situation, they can also feed on insects (Thorington *et al.* 2012). Heaney and Thorington (1978) affirm that an increase in crop production in areas where *S. granatensis* is present could lead them to reach high densities, while Monge (2009) described a similar situation in the case of *S. variegatoides*, suggesting that if its populations in Costa Rica reach important densities this may lead to considered them as agricultural pests, as it has been reported in Honduras. An increase in crop production seems not be the case in COBAS, since according to Acuña Prado *et al.* (2017) between the years 2005-2016 the forest cover within the corridor has increased approximately 6 %, while the permanent crops (e.g. coffee) have decreased and the semi-permanent crops (e.g. sugarcane) have remained constant. This may suggest that there has not been an increase in crop production in the area; however, the authors do not mention fruit tree production within the corridor. Furthermore, some respondents mentioned during the interviews that before the Wildlife Conservation Law (N° 7317) was passed in 2012, they used to hunt squirrels but they did not specify the reason (e.g. for food, sport or to reduce the damage on crops). This may suggest that the new law might have allowed squirrels to grow in number by decreasing the hunting frequency, and as a consequence, this might have led to an increase in crop damage by squirrels in the corridor, although this should be verified.

In addition, both species (*S. variegatoides* and *S. granatensis*) are known to be indicators of the state of conservation of the ecosystem. Many publications highlight the ecological role these squirrels play due to their close relationship with particular plant associations, as seed dispersers, and as a prey species for birds, reptiles as well as for other lesser carnivores (Heaney and Thorington 1978, Carvajal and Adler 2008, Rojas-Robles *et al.* 2012, Thorington *et al.* 2012, Henn *et al.* 2014, Dittel *et al.* 2015). As well, Thorington *et al.* (2012) suggest that squirrels may benefit humans by consuming insects that could become pests and create severe problems in crop production.

Regarding the conservation status of *S. variegatoides* and *S. granatensis*, both are listed on the IUCN Red List as Least Concern with a stable population trend because of its

wide distribution and its tolerance of a broad range of habitats (Reid 2016, Koprowski *et al.* 2016).

Opossums

Damages caused by opossums have been reported in this study by 13 % of the respondents, 88 % mentioned damages to their livestock (principally poultry), and 11 % to their crops. Respondents did not specify which species of opossums cased them damage. In COBAS there are three species of opossums called locally as "*zorros*", the common opossum "*zorro pelón*" (*Didelphis marsupialis*), the four-eyed opossum "*zorro cuatro ojos*" (*Philander opossum*) and the water opossum "*zorro de agua*" (*Chironectes minimus*), all three belong to the Didelphidae Family (SINAC 2018b).

Didelphis marsupialis and *Philander opossum* are opportunistic omnivores, their diet consists on insects, fruit, seeds and small vertebrates, but they can also become predators of poultry when available (Castro-Arellano *et al.* 2000). While *Chironectes minimus* is carnivorous and feeds on small fish, crabs, crustaceans, insects that it catches in the water, and occasionally frogs (Pérez-Hernandez *et al.* 2016, Souza Leite *et al.* 2016).

In Mexico, the *Didelphis* genus is known to prey on poultry (Amador-Alcalá *et al.* 2013, Rodríguez-Calderón *et al.* 2018). In Costa Rica, *Didelphis marsupialis* has been listed as a harmful species since they usually prey on poultry, cause crop damage, or cause disgust due to its presences in residential areas (Hilje and Monge 1988, Monge 2018, SINAC 2009). With respect to *Philander opossum*, it has not been reported as a harmful species in Costa Rica, although Castro-Arellano *et al.* (2000) suggest that can invade croplands, and Monge-Meza and Linares-Orozco (2010) have confirmed their presence in pineapple plantations in Costa Rica, while in El Salvador, it has been reported that it preys on small and medium poultry . No literature was found regarding damages to human livelihoods by *Chironectes minimus*, possibly because this species usually occurs in areas of permanent water courses such as streams and rivers with forest cover (Pérez-Hernandez *et al.* 2016) and due to its specialized diet.

Moreover, according to Castro-Arellano *et al.* (2000) *Didelphis marsupialis* and *Philander opossum* are important seed dispersers and prey of larger predators as well.

The three opossum species mentioned above are listed on the UICN Red List as Least Concern because of its wide distribution ranges that go from Mexico to Argentina (Astua de Moraes *et al.* 2016, de la Sancha *et al.* 2016, Perez-Hernandez *et al.* 2016). The populations of *Didelphis marsupialis* and *Philander opossum* are considered stable due to its tolerance to habitat modification (Astua de Moraes *et al.* 2016, de la Sancha *et al.* 2016), while the population of *Chironectes minimus puplations* seems to be decreasing due to its vulnerability to deforestation, contamination and deterioration of freshwater ecosystems (Perez-Hernandez *et al.* 2016).

White-tailed deer

The results of this research show that 14 % of respondents reported damage to crops by white-tailed deer (e.g. predation of beans and damage to fruit trees with their antlers).

The white-tailed deer (*Odocoileus virginianus* – *Cervidae* Family) known locally as "*venado cola blanca*", is an opportunistic generalist herbivore, it can adapt to a variety of habitats, and its diet includes many different types of vegetation (e.g. forbs, fruits, grasses, flowers and fungi, as well as twigs, shoots, and leaves) (Hewitt 2011), which varies greatly with the seasons and the region in which it inhabits (Trani and Chapman 2007). In agricultural regions, it also may feed heavily upon crops, which can lead to important economic losses for farmers if its populations become too high (Hilje and Monge 1988, Hewitt 2011, Adams 2016). Weber and Gonzales (2003) also state that high number individuals of this species can cause serious damage to forest vegetation due to over-browsing, which has led to managing their populations in several regions of North America (Hewitt 2011, Adams 2016).

The white-tailed deer is also commonly hunted by humans for its meat and as a sport through its distribution range (from Canada to South America) (Gallina and López-Arevalo 2016). In Costa Rica, it was intensely hunted until it became a rare species in the sixties (Maguire 2017). Respondents in this research mentioned during the interviews that there was a time where it was difficult to see a deer in the area, while in the present it is more common to see them within the corridor. However, 23 % of the respondents affirm that there are people who still hunt white-tailed deer in the corridor despite the Wildlife Conservation Law (N° 7317). This information coincides with Maguire (2017), who concludes that white-tailed deer still being one of the principal game species in COBAS. On the other hand, there are no research works about the population status of the white-tailed deer in COBAS. In this regard, the recovery of forest cover within the corridor in recent years (Acuña Prado *et al.* 2017) may be offering to the deer shelter and food opportunities that they did not have before, added to the law enforcement and the absence of predators (e.g. jaguars and pumas), all this together may be allowing the species to increase in number.

Additionally, this species represents an important prey animal for a number of large predators throughout its wide distribution range (from Canada to South America) (Gallina and López-Arevalo 2016).

The white-tailed deer is listed as Least Concern species in the IUCN Red List with a stable current population (Gallina and López-Arevalo 2016), however, this is based on its adaptability to a wide range of human-dominated and natural habitats. Gallina and López-Arevalo (2016) reported that deer herds in Canada and mainly in the United States are overabundant, while in Mexico, Central America, and South America most of the populations of the species are declining. In Guatemala it is considered inside Appendix III of CITES (2017).

Tayra

The tayra (*Eira barbara* – *Mustelidae* Family) known locally as "*tolomuco*", was mentioned by 21 % of the respondents in this study. It is responsible for livestock predation, principally poultry.

Publications like SINAC (2009) in Costa Rica and Amador-Alcalá-Alcalá *et al.* (2013) in Mexico have reported poultry predation by tayra, while Cuarón *et al.* (2016) state that the tayra has been persecuted in some areas of its distribution range due to the problems they cause to livestock.

Presley (2000) describes the tayra as an opportunistic omnivore whose diet usually includes fruits, carrion, small vertebrates, insects, and honey. Although the tayra inhabits a variety of natural habitats along its distribution range, which goes from southern Mexico to northern Argentina (Cuarón *et al.* 2016), it can also live near human habitations, crops, and other human-disturbed habitats (Presley 2000, Cuarón *et al.* 2016). However, Presley (2000) and Cuarón *et al.* (2016) highlight the lack of information regarding several aspects of this species ecology, their role in the ecosystem and their toleration to human intervention.

In addition, Presley (2000) considers the tayra as one of the most common medium-size predators throughout its range, while Gonzáles-Maya *et al.* (2015) affirm that its adaptability and role within the ecosystem can be influenced by the presence or absence of large predators such as jaguars and pumas. Nevertheless, Cuarón *et al.* (2016) suggest that besides their persecution due to the damages they cause to livestock, its populations may primarily be threatened by the loss and degradation of ecosystems.

In Mexico, the tayra is listed as endangered (Ruiz-Gutiérrez *et al.* 2017), in Honduras is consider inside Appendix III of CITES, while on the IUCN Red List is listed as Least Concern species with a decreasing current population trend (Cuarón *et al.* 2016).

Coyote

The coyote (*Canis latrans* – *Canidae* Family) is another livestock predator according to 11 % of the respondents. Predation of calves and poultry by coyotes in Costa Rica has also been reported in other publications (Hilje and Monge 1988, Morazán Fernández Fernández *et al.* 2010), as well as predation of corn and melon plantations (Cove *et al.* 2014). However, conflicts with coyotes due to livestock and game species predation, and damages to crop plantations have been more frequently reported in other countries such as Mexico, Canada and the United States, which added to the fur trade have been the greatest motives for their lethal control and persecuting (Philipp and Armstrong 1993, Sillero-Zubiri *et al*. 2004, Rodriguez-Calderón *et al.* 2018).

Respondents in this study mentioned that these problems with coyotes are relatively new. Sillero-Zubiri *et al.* (2004) and Cove *et al.* (2014) suggest that the reduction or eradication of larger predators (e.g. jaguars and pumas) and the modification of landscapes by human activities have facilitated the expansion of the coyote from Mexico to Central America and inside Costa Rica; on the other hand, Hidalgo-Mihart *et al.* (2004) indicated that coyotes were probably already present in these areas and did not recently disperse from the north of Mexico to the south, where it used to be an uncommon species. Whereas, Kays (2018) suggest that livestock introduction and climate change are the reason for its expansion.

The coyote is an opportunistic and generalist predator that eat a variety of food items ranging from fruit and insects to livestock (Sillero-Zubiri *et al.* 2004), even large ungulates like the white-tailed deer (Mastro *et al.* 2011), it also has the facility to adapt to a variety of habitats even those modified by humans.

According to Sillero-Zubiri *et al.* (2004), *"their plasticity in behaviour, social ecology, and diet allows coyotes to not only exploit, but to thrive, in almost all environments modified by humans"*, therefore the authors state that there are no current threats to coyote

populations throughout their range (from Canada to Central America). In addition, the species is listed in the IUNC Red List as a species of Minor Concern due to their plasticity and wide distribution with an increasing population trend (Kays 2018).

Fer-de-lance

The fer-de-lance (*Bothrops asper*– *Viperidae* Family), locally known as "*terciopelo*", was mentioned by 42 % of the interviewees in this research, 50 % of them for biting livestock (mostly cattle), 42 % reported attacks or threats to themselves or their close relatives, while 8 % mentioned that their pets were bitten by the snake (see Appendix 7 for photos).

The fer-de-lance is a large body size venomous viper, it is an opportunistic carnivorous that consumes a variety of prey types (e.g. rodents, birds, and anurans), and it can inhabit a variety of habitats including human-disturbed environments (Cisneros-Heredia and Touzet 2004, Sasa *et al.* 2009).

Gutiérrez (2011) in its review about snakebites poisoning in Latin America and the Caribbean, conclude that the fer-de-lance is responsible for most of the snakebites incidents in humans and livestock in Costa Rica, and in other countries where the species is present (from Mexico throughout Central America to Colombia, Ecuador, and northern Peru). In this regard and within the framework of this research, additional data of snakebite poisoning of the last ten years were obtained from the Escalante Pradilla Hospital in the city of San Isidro de El General (the closest to the study area). The data indicate that between the years 2007 and 2016 eleven cases of snakebites were attended within the region where COBAS is located (the data belongs to the provinces of Cajon and General), but they do not specify the exactly area where the patient was bitten as well as they do not specify the snake species responsible for the attack. Moreover, among the interviewees, two of them mentioned to have been bitten by a fer-de-lance, one of them 40 years ago and the other one in 2012. Whereas the other respondents who mentioned the fer-de-lance, referred to attacks to close relatives (e.g. brother, daughter, wife), or to self-encounters with the snake considering that they were damage by the snake because of the threat and fear they felt in its presence.

However, according to 50 % of the respondents the damages caused by fer-de-lance do not occur often, a 35 % said it occurs often, whereas a 12 % affirm this happens very often. On this subject Sasa *et al.* (2009) and González-Andrade and Chippaux (2010) suggest that a high frequency of damages may be related to the relative abundance of the species in some areas due to its high reproductive capacity, as well as to its capacity to live near human residences or due its presence in agricultural areas. On the other hand, authors like Chaves et al (2015) suggest that snakebites may vary as a result of climate change, since they found that snakebites are more likely to occur at high temperatures and may be significantly reduced after the rainy season in Costa Rica, whereas in other countries like Ecuador, González-Andrade and Chippaux (2010) affirm that snake bite incidence by fer-de-lance increased during the rainy season and El Niño phenomenon. Nevertheless, the perception of respondents towards the frequency in which snakebites occur might be also influenced by the perception of people towards the fer-de-lance.

Between fer-de-lance individuals may be a great variation in their external characters, such as the size, color pattern and sexual dimorphism (Sasa *et al.* 2009). These external variations in some cases leads local people to confuse the fer-de-lance with other species of snakes, such as the boa, or to consider them according to their characteristics as separate species using a variety of common names for the same species. For example, some interviewees mentioned the "*barba amarilla*", "*rabo amarillo*" or "*tiznada*" as other dangerous snake species in the area, however they all are the fer-de-lance (personal comm. Aarón Gómez-Coordinator in the Serpentarium of the Clodomiro Picado Institute). These lack of information on the identification of snakes by local people may lead to the killing of other species of snakes that do not pose a real threat to them. In addition, it is important to highlight that the fer-de-lance is an important species for the ecosystem balance, as well as other snakes species, since they control other species populations that can become pests (Sasa *et al.* 2009), and represent a food source for other predators such as raptors, mammals, snakes, among others.

Sasa *et al.* (2009) states that the species has a conservation status of Least Concern despite human persecution and considerable habitat modification. Nevertheless, there is no data about its conservation status on the IUCN Red List.

Boa

The boa (*Boa constrictor* – *Boidae* Family) is mentioned by 11 % of respondents for casing damages; 75 % of them reported predation of livestock (mostly poultry), and 25 % predation of pets.

Hilje and Monge (1988) listed the boa as a harmful species in Costa Rica due the depredation of poultry (e.g. ducks, chickens) and pets (e.g. dogs), and in Mexico Amador-Alcalá-Alcalá *et al.* (2013) have also reported poultry predation by this species.

The boa is non-venomous snake, it is a carnivorous generalist which feeds on a wide variety of prey including mammals, reptiles, and birds (Boback *et al.* 2000, Gondim *et al.* 2012), and it can inhabit a variety of habitats within its distribution range (from northern Mexico to South America) (Gondim *et al.* 2012, Montgomery and da Cunha 2018).

As in the case of the fer-de-lance, there is no data about its conservation status on the IUCN Red List. However, it is listed inside the Appendix II of CITES (2017), and in Costa Rica, due to its reduced population, it is considered threatened (SINAC 2017).

Table 3 summarizes the previously analysis on wildlife species mentioned by the respondents in this study, and those present in COBAS, as well as the results of the literature review.

Table 3. Summary of the analysis on the wildlife species mentioned by respondents and present in COBAS.

Vertebrate group	Common name in local Spanish used by respondents in COBAS	Species present in COBASaccordingto SINAC (2018b)	Common name in English[1]	Related problems mentioned by respondents[2,]	Related problems according to literature[3,*]	Diet according to literature[4]	IUCN Red list category, global conservation status (2019)	CITES (2017)	Costa Rican conservation status according to SINAC (2017)
MAMMALS	Ardillas	*Sciurus variegatoides* (Ogilby, 1839)	Variegated squirrel	Crop damage	Crop damage	Omnivorous	LC-Stable	-	-
		Sciurus granatensis (Humboldt, 1811)	Red-tailed squirrel		Crop damage	Omnivorous	LC-Stable	-	-
	Tolomuco	*Eira barbara* (Linnaeus, 1758)	Tayra	Livestock damage	Livestock predation	Omnivorous	LC-Decreasing	III (Honduras)	-
	Venado cola blanca	*Odocoileus virginianus* (Zimmermann, 1780)	White-tailed deer	Crop damage	Crop damage	Herbivorous	LC-Stable	III (Guatemala)	-
	Coyote	*Canis latrans* (Say, 1823)	Coyote	Livestock damage	Livestock predation	Omnivorous	LC-Increasing	-	-
	Zorros	*Didelphis marsupialis* (Linnaeus, 1758)	Common opossum	Livestock and crop damage	Livestock predation, crop damage	Omnivorous	LC-Stable	-	-
		Chironectes minimus (Zimmermann, 1780)	Water opossum			Carnivorous	LC-Decreasing	-	-
		Philander opossum (Linnaeus, 1758)	Gray four-eyed opossum			Omnivorous	LC-Stable	-	-
BIRDS	Chucuyo	*Pionus senilis* (Spix, 1824)	White-crowned Parrot	Crop damage	Crop damage	Herbivorous	LC-Decreasing	II	-
		Psittacara finschi (Salvin, 1871)	Crimson-fronted Parakeet		Crop damage	Herbivorous	LC-Increasing	II	-
REPTILES	Terciopelo	*Bothrops asper* (Garman, 1884)	Fer-de-lance	Humans, livestock and pets damage	Humans and livestock damage	Carnivorous	Not Evaluated	-	-
	Bécquer	*Boa constrictor* (Linnaeus, 1758)	Boa	Livestock and pets damage	Livestock predation	Carnivorous	Not Evaluated	II	Reduced or threatened population

[1]English names based on those found on the IUCN Red List (https://www.iucnredlist.org), Mammals of the world (Mammal Species of the World: a taxonomic and geographic reference)

[2]See Figure 13.

[3]See cited literature regarding related problems for each species on the text.

[4]See cited literature regarding diet specifications for each species on the text.

The results on the frequency in which damages occur differ between interviewees' responses and among the wildlife species they mentioned, usually between "not often" and "often". Only in the case of the fer-de-lance, 4 % of respondents mentioned that damages occur "very often". According to Treves (2007), human perceptions towards the frequency of damages by wildlife *"are shaped by catastrophic events more than frequent, small-scale losses, notwithstanding the higher cumulative costs of the latter"*. Therefore, the perception of the respondents about the frequency at which the damages occur might be subject to the severity of the damage caused. This may explain why in the case of the fer-de-lance, some respondents mentioned the damages occur very often since the damage this species can cause can be lethal, not only to their livestock but also to themselves.

Furthermore, the variation in interviewee's responses about the frequency in which the damages occur may be subject not only to the severity of the damage but also to the fact that local people have a different perception of the temporality of the events. Therefore, they might be reporting damages caused by wildlife as a recent event, when it actually happened many years ago and only once. Cases like this in this study have been considered in the "not often" category if at any time during the interview the respondents implied that in fact, it happened many years ago. In this regard, Treves (2007), claims that the time scale and spatial scale from *"human perception may be distilled from long memories and stories from distant associates".*

Concerning the measures respondents take after having experienced damages by wildlife, 65 % of the respondents did not answer the question. While 22 % of the respondents admitted to taking lethal action against some of species, mostly snakes, for example 81 % of respondents admitted having killed fer-de-lance snakes mostly by fear, prevention or retaliation, for having injured/killed their livestock/pets, or for threatening their own safety or their family safety, as well 38 % of the respondents admitted to having killed boas because they eat their poultry. The results are consistent with Maguire (2017), the author found that local people in COBAS kill all the snakes they encounter as a protection measure and sometimes some people have killed accidentally or deliberately non-venomous snakes.

The lack of answers regarding the measures respondents take against problematic wildlife species may suggest: (i) Respondents have built or have improved the enclosures/fences where they keep their livestock or crops after have being affected and most of them did not mention it; since only 5 % of the respondents admitted to having built enclosures as a result of the damage caused the tayra, white-tailed deer, and opossums. (ii) Respondents do not take any direct actions against wildlife (e.g. lethal measures) nor any preventive measures. Or, (iii) In case respondents took, or are taking lethal measures they are afraid to mention it since they are aware of the Law in force (with exception of snakes). If this latter is the reason, this may suggest that depending on people's perception towards each wildlife species their attitude varies with respect to each one of them. Maguire (2017) states that some species in COBAS are killed out of conflict, either because they instill fear or because they do damage. In addition, it seems that although the law protects all species of wildlife including snakes, the direct action of killing snakes, in particular, the fer-de-lance, seems to be justified by the damage they can cause to its own welfare and that of its family. Nonga and Haruna (2015) registered a similar behavior of people towards snakes in Tanzania, where most respondents

reported to kill snakes, even if people were not attacked, but for the fact that they are venomous.

Regarding hunting in the corridor, the results in this study show that notwithstanding local people are aware of the Wildlife Conservation Law, the hunting of wildlife continues. Being the white-tailed deer and the paca (*Cuniculus paca*) the favorite species to hunt in the corridor according to the respondents. These results appear to be consistent with the results presented by Maguire (2017), the author also adds that the motivations of people within the corridor to hunt appears to be mainly sport, the taste for bushmeat, tradition, among others. However, the same author concludes that hunting in COBAS has declined due to the establishment of the biological corridor, local awareness, law enforcement, among other reasons.

5.2 Perception of respondents

Perception towards HWC in COBAS

Several authors emphasize the importance of understanding people's perceptions towards interactions with wildlife because it can influence human behaviors (Mascia *et al.* 2003, Dickman 2010, Kansky and Knight 2014, Nyhus 2016), such as tolerance or killing specific species (Kahler and Gore 2015). Nyhus (2016) states that besides "*managing wildlife or building barriers*", "*efforts to change human behavior can be as more important than simply reducing damage caused by wildlife*".

The results show that 57 % of the affected respondents report dislike towards problematic wildlife. In the case of the tayra and the group of the opossums, the perception of all respondents who mentioned them is of dislike. In the case of the coyote, 63 % of the respondents express dislike towards the coyote, and 34 % of them show rejection. The negative human perceptions towards some species of canids including the coyote (e.g. red fox *Vulpes vulpes*, golden jackal *Canis aureus*, gray wolf *Canis lupus*) are known to be related to human-canids conflicts. Sillero-Zubiri *et al.* (2004), mention some reasons such as *"competition between man and canids for the depredation on game species and domestic stock, or canids as victims or vectors of several zoonoses, of direct and indirect concern to man".* In addition, according to Sillero-Zubiri *et al*. (2004) *"the traditional response to perceived problems of predation and disease has been to attempt to reduce canid numbers by killing them"*, which also agrees with what Philipp and Armstrong (1993) found.

In contrast, the perception of respondents towards the other conflict species varies. For example, 46 % express rejection towards parrots and 38 % report dislike, while 15 % show sympathy towards them. These results indicate that the perception of the respondents may change according to the severity of the damage the species can cause, since some of the respondents mentioned that the harm to coffee plantations occur when parrots eat the pulp of the coffee fruit and drop seeds to the ground, giving them more work when harvesting; although the product and the plant are not damaged. Similarly occurs with the squirrels, 58 % of the respondents express dislike towards them and 21 % indicate rejection due to the damages they cause mostly to their fruit trees, while 21 % of the respondents show sympathy towards the squirrels, of which some even expressed their desire to plant more fruit trees so that there is enough food for everyone (respondents and squirrels). With respect to the white-tailed deer, although in

this case, the perception of 70 % of respondents is of dislike and 20 % of rejection, 10 % also express sympathy towards them notwithstanding the damage it causes. During the interviews, some respondents mentioned that when the deer reach a bean plot they depredate and leave nothing, whereas other respondents stated that they would like to sow more beans so that the deer can eat because they considered them charismatic animals. Regarding the boa, the perception of 88 % of the affected respondents is of dislike, which may due to the damages this species causes to their livestock and pets and for being a snake, while the 12 % feel sympathy for boas, which may due to the fact that it is a non-venomous snake.

The fer-de-lance was the only species perceived with fear by 85 % of the respondents. This result show that the perception of local people towards the fer-de-lance is mainly influenced for being a poisonous snake, and therefore the damage it may cause can be lethal. However, religion, popular beliefs, and the natural fear that people feel for snakes in general may also have an influence on local people's perception towards snakes. Nonga and Haruna (2015), affirm that most snakes "*will not attack humans unless they feel threatened, trodden or injured, or provoked*"; however, although many respondents are aware of this, it does not change the fear they feel for snakes.

In summary, the perception of respondents towards problematic wildlife seems to be mostly influenced by personal experiences. Those experiences can be negative or positive and seem to be related to the frequency in which the damages occurred, the type of damage, the harm intensity, or the potential damage the species may cause to their livelihoods or to their personal well-being. The appearance of some wildlife species may also affect the human perception, i.e. charismatic species might be seen with sympathy, whereas the damage to their livelihoods not become too severe. For example, respondents expressed sympathy for some of the wildlife species despite the damage they cause, such as squirrels, parrots, and the white-tailed deer and even the boa for being a non-venomous snake.

On the other hand, based on the observations most respondents seem to be happy to see wildlife in the corridor and shown interest in protecting wildlife. However, this may change if they are affected constantly by wildlife.

Perception towards COBAS

Regarding the perception of the respondents towards the corridor, the results were also variable, since 46 % of the respondents expressed to be agree with COBAS, while a 34 % of the respondents did not answer the question. Furthermore, some respondents confused the name of the corridor with the *Neotropical Bird Sanctuary Los Cusingos* during the interviews, while other respondents not only confused the name, but they also assume that the corridor is *Los Cusingos*. This suggests that the name of the corridor has brought confusion within the population in the recognition of the biological corridor. This confusion has been also identified in a previous publication carried out in COBAS by Guilcapi-Luna (2013). However, respondents seem to agree with the protection of wildlife.

6. Conclusion

Eight species belonging to different taxonomic groups are the main species involved in HWC in COBAS according to interviewed local residents, most of them have opportunistic and generalist habits and easily adapt to disturbed environments. These wildlife species mainly cause damages to livelihoods (crops, livestock and pets), which in this case correspond to the subsistence farming and the monetary income of respondents. Whereas, the viper fer-de-lance, besides causing damages to livestock and pets also poses a threat to their safety.

Consequently, local people's perceptions regarding the frequency in which the events of damage occur, as well as their perception and attitudes towards wildlife species involved in conflicts, seem to be influenced principally by personal experiences and the severity of the damage caused or the potential damage that some of these species could cause. In addition, the increased percentage of “no answers” regarding the actions they take when trying to deal with problematic wildlife also indicates a strong level of distrust, which may be related to their awareness of the laws that protect wildlife. However, notwithstanding local people's perception towards all species that cause them harm is mainly of dislike, respondents do not seem to be against their presence, with exception of the fer-de-lance viper, which is the only species perceived with fear.

Although, besides the boa none of the wildlife species involved in HWC in COBAS is listed as threatened at the international and regional level. There is no information available about the current population status of these species in COBAS. Hence, more information in this regard is needed, as well as more information about their population dynamics. St. John *et al*. 2014, conclude that ecological information together with local people's perceptions toward a species and management are important considerations in species conservation.

Therefore, the results of this study show the importance of considering the ecological characteristics of all species that commonly come into conflict with local people, local people’s perceptions and attitudes in the understanding of HWC, since comprehending them can have significant implications for the success of management actions, especially within biological corridors where one of the objectives is to achieve a harmonious coexistence between local populations and wildlife.

Regarding local people’s perception towards COBAS, they still confuse about what COBAS really represents; on the other hand, people seem to agree with the protection of wildlife.

Finally, to prevent HWC from escalating, or emerging conflicts between humans and the consequences to become more serious for both parties (wildlife and humans), stakeholders should involve the needs of local people or included them to address HWC adequately. Agreeing with Madden (2008), HWC may escalate when local people feel that the needs or values of wildlife are given priority over their own needs, or when local institutions and people are inadequately empowered to deal with the conflict. As well, agreeing with Woodroffe *et al.* (2005), resolving HWC will be crucial to the success of conservation development plans that require the coexistence of people with wildlife such as in the case of biological corridors. This confirms the importance of integrating HWC

assessment (involving different types of wildlife species), in the strategic and action plan of COBAS.

To conclude, training workshops on mitigation, management and prevention actions with the local population is recommended, to ensure the coexistence of people and wildlife within the corridor. Additionally, more information campaigns regarding the significance, importance, and objectives of the COBAS, involving more residents should be considered.

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Acronyms

ACLAP	La Amistad Pacifico Conservation Area
AMACOBAS	Group of Active Women of the COBAS
AMESE	Association of Women Entrepreneurs of Santa Elena
ASOCUENCA	Association of Producers for the Integral Development of the Peñas Blancas River Micro-basin - Farmers Union
CBM	Mesoamerican Biological Corridor
CCT	Tropical Science Centre
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COBAS	Alexander Skutch Biological Corridor
HWC	Human Wildlife Conflicts
IUCN	International Union for the Conservation of Nature
MINAE	Ministry of Environment and Energy
NGO	Non-governmental organization
PNCB	National Program of Biological Corridors
SINAC	National System of Conservation Areas

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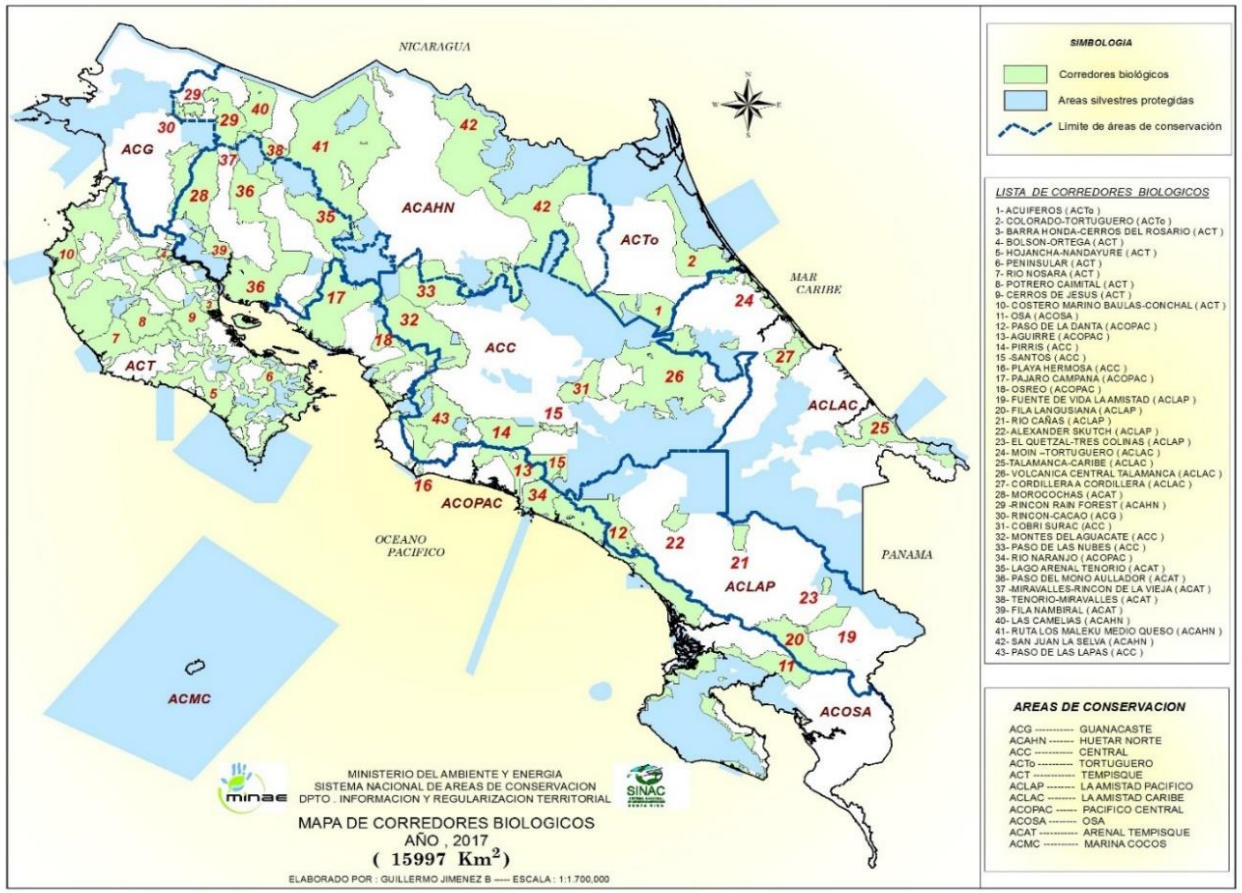
Appendix

Appendix 1. Map of biological corridors in Costa Rica.

The biological corridors are represented in green, the protected areas in light blue and the limits of the conservation areas are represented by the dotted lines in blue. The COBAS correspond to the number 22 in red on the map. (Source SINAC 2018, Available online: http://www.sinac.go.cr/EN-US/correbiolo/Pages/default.aspx)



Appendix 2. Compilation of wildlife species involved in HWC in Costa Rica.

(Source: own illustration)

Vertebrate group	*Family*	*Species*			*Type of damage*				*Literature**	*Present in COBAS*
		Scientific name	Local common name (Spanish)	English name	Crops	Livestock	Humans	Houses		
MAMMALS	Felidae	*Panthera onca*	jaguar	jaguar		x	x		1, 3, 5, 7 8	x
		Puma concolor	puma	puma		x	x		3, 5, 7, 8	x
	Canidae	*Canis latrans*	coyote	coyote	x	x			1, 3, 8	x
		Urocyon cinereoargenteus	zorra gris	gray fox	x				1	
	Atelidae	*Alouatta palliata*	mono congo	mantled howler	x				1	
	Mustelidae	*Eira barbara*	tolomuco	tayra		x			1	x
		Mustela frenata	comadreja	long-tailed weasel		x			1	
	Didelphidae	*Didelphis virginiana*	zorro pelón	virginia opossum	x	x		x	1, 8	
		Didelphis marsupialis	zorro pelón	common opossum		x		x	8	x
		Philander opossum	zorro de cuatro ojos	four eye opossum					8	x
	Procyonidae	*Nasua narica*	pizote	coati	x				1, 2	x
		Potos flavus	martilla	kinkajou	x				1	x
		Procyon lotor	mapache	raccoon	x				1, 2, 6	x
	Erethizontidae	*Coendou mexicanum*	puercoespin	mexican tree porcupine	x				1	x
	Dasypodidae	*Dasypus novemcinctus*	armadillo	nine-banded armadillo	x				1	x
	Tayassuidae	*Tayassu tajacu*	zaino	collared peccary	x		x		1, 8	x
	Cervidae	*Odocoileus virginianus*	venado cola blanca	white-tailed deer	x				1, 8	x
	Phyllostomidae	*Desmodus rotundus*	vampiro	common vampire		x			1	x
		Diphylla ecaudata	vampiro	hairy-legged vampire bat		x			1	

		Glossophaga soricina	murcielago	pallas's long-tongued bat	x				1	x
	Geomyidae*	*Orthogeomys cavator*	taltuza	chiriqui pocket gopher	x				1, 8	
		Orthogeomys cherriei	taltuza	chiriqui pocket gopher	x				1, 8	
		Orthogeomys heterodus	taltuza	variable pocket gopher	x				8	
	Muridae	*Sigmodon hispidus*	rata algodonera	hispid cotton rat	x				1, 8	
		Rattus norvegicus	rata de caño	brown rat				x	1, 8	
		Rattus rattus	rata negra o domestica	black rat	x			x	1, 8	
		Mus musculus	raton casero	house mouse				x	1	
	Sciuridae	*Sciurus granatensis*	chiza, ardilla	red-tailed squirrel	x				1, 8	x
		Sciurus variegatoides	chiza, ardilla	variegated squirrel	x				1, 8	x
	Leporidae	*Sylvilagus brasiliensis*	conejo	tapeti	x				1	x
BIRDS	Anatidae	*Dendrocygna viduata*	piche careto	white-faced whistling duck	x				1, 4	
		Dendrocygna autumnalis	piche o pijije	black-bellied whistling-duck	x				1, 4	
		Dendrocygna bicolor	piche	fulvous whistling duck	x				1, 4	
		Cairina moschata	Pato real	muscovy duck	x				1, 4	
		Anas discors	zarceta	blue-winged teal	x				1, 4	
	Phalacrocoracidae	*Phalacrocorax brasilianus*	cormoran	cormorant		x			1, 4	
	Ardeidae	*Ardea alba*	garceta grande	great egret		x			1, 4	
		Egretta caerulea	garceta azul	blue heron		x			1, 4	x
		Bubulcus ibis	garza bueyera	cattle egret	x				1, 4	x
	Cathartidae	*Coragyps atratus*	zopilote o zoncho	black vulture	x	x			1, 4	x
		Cathartes aura	zopilote de cabeza roja o zoncho	turkey vulture	x				1, 4	x
	Pandionidae	*Pandion haliaetus*	águila pescadora	osprey		x			1, 4	x
	Accipitridae	*Buteo platypterus*	gavilán pollero	broad-winged hawk		x			1, 4	x

	Rallidae	*Porphyrio martinico*	gallina de agua	purple gallinule	x		1, 4	
	Jacanidae	*Jacana jacana*	jacana	wattled jacana	x		1, 4	
	Columbidae	*Patagioenas fasciata*	paloma collareja	band-tailed pigeon	x		4	
		Patagioenas flavirostris	paloma morada	red-billed pigeon	x		1, 4	
		Columbina minuta	tortolita	plain-breasted ground dove	x		1, 4	
		Columbina passerina	tortolita	common ground dove	x		1, 4	
		Columbina talpacoti	tortolita	ruddy ground dove	x		1, 4	x
	Psittacidae	*Psittacara finschi*	cotorra, perico frenti-rojo, chucuyo	crimson-fronted Parakeet	x		1, 4	x
		Aratinga canicularis	catano, zapoyol, perico frenti-anaranjado	orange-fronted Parakeet	x		1, 4	
		Aratinga pertinax	perico carasucio	brown-throated parakeet	x		1, 4	
		Brotogeris jugularis	catano, perico barba-anaranjado	orange-chinned parakeet	x		1, 4, 8	
		Pionus senilis	chucuyo, loro coroniblanco	white-crowned parrot	x		1, 4	x
		Pionus menstruus	chucuyo	blue-headed parrot	x		1, 4, 8	
		Amazona autumnalis	lora, loro frenti-rojo	red-lored amazon	x		1, 4, 8	x
		Amazona albifrons	lora, loro frenti-blanco	white-fronted amazon	x		1, 4 , 8	
	Alcedinidae	*Chloroceryle amazona*	martín pescador	amazon kingfisher	x		1, 4	x
	Picidae	*Melanerpes formicivorus*	carpintero	acorn woodpecker	x		1, 4	
		Melanerpes chrysauchen	carpintero nuquidorado	golden-naped woodpecker	x		1, 4	x
	Thamnophilidae	*Thamnophilus doliatus*	cacareona	barred antshrike	x		1, 4	
	Tyrannidae	*Pitangus sulphuratus*	cristofué, pecho amarillo	great kiskadee	x		1, 4	x

	Corvidae	*Psilorhinus morio*	piapia	*brown jay*	x		1, 4, 8	x
	Thraupidae	*Thraupis episcopus*	viuda	blue-gray tanager	x		1, 4	x
	Emberizidae	*Sporophila torqueola*	semillero, espiguero collarejo	*cinnamon-rumped seedeater*	x		1, 4	
		Spiza americana	pius, sabanero	dickcissel	x		1, 4, 8	
		Sporophila minuta	espiguero pigmeo	ruddy-breasted seedeater	x		1, 4	
		Zonotrichia capensis	comemaíz	rufous-collared sparrow	x		1, 4	
	Cardinalidae	*Piranga flava*	tangara veranera	hepatic tanager	x		1, 4	
	Icteridae	*Dolichonyx oryzivorus*	tordo arrocero	bobolink	x		1, 4	
		Agelaius phoeniceus	sargento	red-winged blackbird	x		1, 4	
		Dives dives	tordo cantor	melodious blackbird	x		1, 4	
		Quiscalus mexicanus	zanate	great-tailed grackle	x		1, 4, 8	
		Leistes militaris	tordo petirrojo	Red-breasted Blackbird)			1	
		Icterus galbula	cacique veranero	baltimore oriole	x		1, 4	
		Psarocolius montezuma	oropéndola de Montezuma	Montezuma oropendola	x		1, 4	
REPTILES	Boidae	*Boa constrictor*	boa, béquer	Boa		x	1, 4	x
	Corytophanidae	*Basiliscus basiliscus*	garrobo, cherepo	common basilisk	x		1	x
	Iguanidae	*Ctenosaura similis*	garrobo, iguana negra	black iguana	x	x	1	
		Iguana iguana	iguana	green iguana		x	1	x
	Phrynosomatidae	*Sceloporus malachiticus*	lagartija espinosa	green spiny lizard	x		1	
	Crocodylidae	*Crocodylus acutus*	cocodrilo	Crocodilian			1, 8	

*(1) Hilje and Monge 1988, (2) SINAC 2009, (3) Morazán Fernández *et al.* 2010, (4) Monge 2012, (5) Amit *et al.* 2013, (6) Alvarado-Barboza and Gutiérrez 2013, (7) Corrales-Gutiérrez *et al.* 2016, (8) Monge 2018

Appendix 3. Different landscapes within COBAS.

(Source: own photos)

Montane forest in the upper part of COBAS, Las Nubes Biological Reserve.

Tree ferns, characteristic of montane forests.

Peñas Blancas river in Las Nubes Biological Reserve.

Pastures for cattle on the edge of the montane forest in Montecarlo.

Forest patches and pastures in the middle part of COBAS.

Pastures and forest patches in Santa Elena.

Pastures and forest patches in San Ignacio.

Premontane forest in the lower part of COBAS, Neotropical Bird Sancuary Los Cusingos.

Cultivated land in the lower part of the corridor.

Appendix 4. Infrastructure within COBAS.

(Source: own photos)

„La Casita Azul" the blue house, is a resource center for education and learning. Santa Elena.

Primary school, Santa Elena.

San Ignacio.

Santa Elena.

Santa Elena.

Santa Elena.

Appendix 5 . Agricultural activities within COBAS.

(Source: own photos)

Banana plantation.

Pastures for cattle.

Sugarcane plantation.

Plant nursery.

Mixed cultivation of banana and coffee.

Family vegetable garden.

Coffee plantations.

Appendix 6. Types of enclosures for livestock used in COBAS.

(Source: own photos)

Cattle grazing on the edge of the forest, outside fences "outdoors".

Cattle inside a wire fence "open pen".

Cattle inside a barn "closed pen".

Hens between crops, outside fences "outdoors".

Hens and rooster inside a fence (concrete and wood) with roof (calamine) "open pen".

Hens inside a hen-coop "closed pen".

Pigs inside a fence (wood) with roof (plastic) "open pen".

Goats inside a shed "closed pen".

Tilapias in a pool covered with wire mesh "covered pond".

Appendix 7. Presence of fer-de-lance (*Bothrops asper*) in COBAS.

Fer-de-lance vipers killed by local residents and a dog bitten by a fer-de-lance (to the right below) within the biological corridor (Source: Diego Valverde, María Zuñiga and Gabriel Barbosa).