Wild Pigs in an Irreplaceable Area for Biodiversity Conservation: Current Situation and Importance of the Local Community in the Population Control

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Abstract: I present here observational and experimental impacts and control activities of wild pigs in the Serra da Mantiqueira, an irreplaceable area for biodiversity conservation in the world, inserted in Atlantic Forest of Brazil. In the Serra da Mantiqueira wild pigs damage streams, vegetation, gardens and crops. Wild pigs also consume seeds and cause the death of endangered trees. Together with the local community my team and I worked out a pilot plan for wild pig control in two protected areas of the Serra da Mantiqueira. Meetings and training activities were held with the volunteer hunters that carried out control of the wild pigs. The pilot plan control reduced the incidence of wild pigs in one of the protected areas. Finally, I suggest a national program to control wild pigs in protected areas to fill in the gaps identified during this present work.

Keywords: feral hogs; feral swine; Sus scrofa; vertebrate vest

Introduction

Wild pigs (Sus scrofa) are one of the 100 worst invasive species in the world. It is native to Eurasia and northwestern Africa, from western Europe to the north coast of Africa, eastern Japan and southern Sri Lanka, Sumatra, Malaysia, and Indonesia. It is one of the oldest species intentionally introduced worldwide and is currently present on all continents except Antarctica[1], making it one of the most widely distributed species worldwide[2].

Wild pigs are classified as ecosystem engineers, which are those species that, directly or indirectly, regulate the resource availability and alter physical and chemical environmental characteristics, resulting in the creation, modification or maintenance of habitats for themselves and other species[3]. In the case of wild pigs, this characteristic has generated numerous social conflicts and impacts on ecosystems. The impact of wild pigs is directly related to their biology and ecology, characteristics such as high reproductive capacity, with a mean of 10 piglets/female/year, high competition capacity, low rates as prey and foraging habits consisting of rooting. They also present opportunistic behavior as to their varied diet, consuming plants, vertebrates and invertebrates[1].

The environmental impacts they generate are nutrient loss and soil leaching, reduction of diversity and plant cover, dispersion of exotic grasses, and alteration and homogenization of the seed bank structure. Wild pigs also compete for and prey upon numerous native vertebrate species and destroy nests and microhabitats of small mammal and birds. In addition, the species is an important reservoir of diseases for humans and domestic animals of economic interest[1].

The main conflict between wild pigs and humans is the use of agricultural crops by wild pigs as a source of food, in some cases destroying entire crops. In addition, the wild pig and the domesticated pig, commonly free-raised in Brazil,
are of the same species, Sus scrofa. Because of this the crossing of wild pigs and domestic pigs generate fertile offspring and is often stimulated by humans due to a preference for the meat of crossbred animals. These actions also increase the success of dispersal, colonization and settlement of wild pig populations\cite{1,4}.

1. **Wild Pig Invasion in Brazil**

In South America wild pig invasion occurred in three major cycles. The first cycle occurred between 1400 and 1900, referring to the exploration and settling of America, with domestic animals being brought from Europe and inserted in several countries on the continent. The second cycle occurred from 1900 to 1990, with the insertion of wild boars of pure lineages for hunting purposes, causing a great miscegenation with domestic individuals. The last cycle occurred from 1990 to 2010, with the involuntary or voluntary release of captive individuals. In all cases the direct or indirect motivation of the introduction of the species is the production of meat and game\cite{4}.

Thus, the arrival of this species in Brazil was inevitable, first 200 years ago in the central west of the Brazilian territory, when on the occasion of the Paraguayan War (1865–1870) farms were abandoned and animals occupied the entire floodplain of the Pantanal. In 1989 wild pigs were recorded in the south of Brazil near the border with Uruguay and later, between 2000 and 2005, many wild pigs were voluntarily released into the wild from breeding sites, mainly in Atlantic Forest of south and southeast Brazil, after the government forbade the establishment of new breeding sites. Currently a new cycle of invasion is occurring in which the causes are still unknown\cite{4}.

Currently, wild pigs have the largest distribution among exotic mammals occurring in Brazil\cite{5}, with population estimates ranging from 0.22\cite{4} to 22.3 individuals per km\cite{6}. With social and environmental impacts increasing in Brazil\cite{7,8}, many people have carried out the control of wild pigs that has been authorized since 2013. In Brazil any citizen can control wild pigs using live traps and hunting techniques (e.g. hunting with or without the use of dogs). Other methods, such snare and poisons are forbidden. Wild pigs can be controlled year-round in Brazilian territory, with no limitation on the number of animals slaughtered, sex or age structure. Currently, to carry out this activity, it is necessary to receive a license from control activities of wild pigs in the Environment and Renewable Natural Resources Institute (in Portuguese, Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, IBAMA), and/or the Army in the case of the use of firearms and authorization from the area manager in the case of control carried out within protected areas. Hunting has been the main form of control of the species in the country, and many hunters are motivated by the opportunity to legally hunt, with a mean of 16.8 wild pigs/year/hunter\cite{8}.

In 2016 the Brazilian government expanded efforts to control the species by bringing together researchers, technicians, farmers' representatives, hunters and animal welfare activists to elaborate the National Action Plan for Wild Pigs Prevention, Control and Monitoring (NAP Wild Pigs), which seeks to reduce environmental and economic damage to the species in the short, medium and long term. Despite being recent, some actions of NAP Wild Pigs are already being put into practice, such as binational meetings with Uruguay, in order to carry out a joint wild pig control strategy among nations.

2. **Serra da Mantiqueira and Wild Pig Invasion**

The Serra da Mantiqueira, or Mantiqueira Range, located in the states of São Paulo, Rio de Janeiro and Minas Gerais, is one of the largest and most important mountain chains in southeastern Brazil and, together with Serra do Mar, forms the largest block of preserved Atlantic Forest\cite{9}. Recently the conserved areas of Serra da Mantiqueira were considered one of the ten irreplaceable areas for biodiversity conservation in the world\cite{10}. The Serra da Mantiqueira has an altitude between 700 and 2,798 m, and a great diversity of ecosystems, with mixed formations of grasslands, swamps and forests.

In the portion within the state of Minas Gerais, wild pigs have occurred in the Serra da Mantiqueira since 2006. For scientific purposes, my work team and I spent two years (2014–2015, around 360 days/man) visiting conserved areas of Itamonte county, Minas Gerais, one of the counties with the highest proportion of the conserved area within the Serra da Mantiqueira. During this time, I observed many wild pig tracks in different types of environments (e.g. forest, grasslands, roads), wild pigs predating seeds of Araucaria angustifolia, and endangered trees protected by law in Brazil.
and feeding on different species of bamboo and bromeliads. I observed streams with their physical structure altered and investigated such in my doctoral thesis showing that wild pigs alter the physical properties of streams[11]. Wild pigs also caused soil disturbance, removal of herbaceous species, destruction of bird nests, ringing of juvenile Araucaria angustifolia individuals, leading to tree death, as well as causing indirect death to other trees present in shallow soil environments through rooting around the roots of the trees, leaving them vulnerable to abiotic factors (e.g. rain, wind) (Figure 1). Residents of local communities also report the destruction of agricultural crops, the predation of livestock, the triggering of erosion processes and, as observed in the field, destruction of small streams and springs[8].

![Figure 1. A) bromeliad removed from soil and consumed by wild pigs; B) soil disturbance due rooting of wild pigs; C) tree tumbled by wind and rain after the rooting of wild pigs near their roots; D) vegetation removed by the rooting of wild pigs; E) dead tree (Araucaria angustifolia) individual after the trunk ringing caused by wild pigs; F) seeds of Araucaria angustifolia predated by wild pigs; G) streams damaged by wild pigs](image)

However, in the Itatiaia National Park, the first protected area of Brazil, I notice that the Melanophryniscus
moreirae, an endemic frog, use the pools created by wild pigs in the high altitude grasslands to reproduce (Figure 2). Wild pigs can trigger negative or neutral effects on the ecosystem, but also they can have a positive effect when replacing ecological functions of extinct native species and kept in low densities\textsuperscript{12,13}. So a great scientific effort is still necessary to try to understand the interactions of this invasive species with the environment and the fauna in the tropical regions, to measure negative relations and economic and environmental damage.

Figure 2. A) Melanophryniscus moreirae in amplexo and B) tadpoles of Melanophryniscus moreirae in the pool created by wild pigs.

The Invasive Species Specialist Group (ISSG-http://www.issg.org) of IUCN recommends that all wild pig populations should be considered as an exotic pest to be controlled, reduced in number or eradicated, even before any environmental, economic and social impacts are detected. So, in response to this problem the “Wild Pigs in Mantiqueira” project was created in 2013, with the main goal of assessing the social, economic and environmental impacts of wild pigs and to include the local community and experts from public and private sectors in the wild pig control actions in the Serra da Mantiqueira.

4. The Inclusion of the Local Community in Wild Pig Control

Hunting has always been a common activity in Brazil, especially in rural areas\textsuperscript{14}. However, the Federal Fauna Protection Act of 1967 prohibits professional hunting and establishes that the Brazilian government needs to regulate the amateur hunting and pest control in Brazil. With the regulation of hunting never being carried out by the Brazilian government, this activity was marginalized, creating the understanding in society that it is entirely prohibited in Brazil. Despite occasional attempts to regulate this activity over the years\textsuperscript{8}, wild pig control is the first hunting experience regulated nationwide since 1967. It is in this context of 50 years of marginalization of hunting that my work of local community inclusion, with the purpose of inciting good management practices for wild pig control, began in the Serra da Mantiqueira.

My work team and I organized a workshop at the beginning of the “Wild Pigs in Mantiqueira” project with the participation of 50 people representing governmental and nongovernmental institutions at all political levels (municipal, state and federal), including researchers, rural technicians, managers and local community, the latter represented especially by farmers and people interested in control of wild pigs. The aim of the workshop was to present the project to interested people, and exchanging experiences to build actions and goals, defining the allocation of financial resources and responsibilities of each collaborator. So, on the first day of the workshop, lectures and roundtables were held, where invited researchers presented the problem of biological invasions and wild pig invasions in a global, national and regional context. My team and I also presented the goals and preliminary results of the “Wild Pigs in Mantiqueira” project. At the end of the first day we divided the participants into six groups within topics chosen by the
participants themselves, which were called thematic blocks: 1) Problems; 2) Control Measures; 3) Public Policies; 4) Communication and Information; 5) Research; and 6) Economic Aspects.

On the second day of the workshop, the participants initially discussed the issues of each block and later the actions proposed by each group were discussed among all workshop participants. All proposed actions that did not have a person or institution responsible for execution were automatically eliminated. The other actions were discussed inserting scope, importance and feasibility within the project. The approved actions were inserted within a conceptual matrix containing the information of (1) Problem; (2) Action; (3) Scope; (4) Expected result; (5) Responsible; (6) Collaborators and (7) Deadline.

Within this dynamic, we planned the follow actions of the project in a participatory way, resulting in a pilot plan to control wild pigs in the Itatiaia National Park (INP) and in a private protected area called RPPN Alto Montana (RPPN), that is located inside a federal protect area, the Environmental Protect Area of Serra da Mantiqueira. The pilot plan was executed between 2014 and 2015 and among the actions proposed were the identification and training of collaborators to execute wild pig control with techniques used by the local community (Rosa et al., 2016), allowed by Brazilian legislation and by the Management Plans of each protected area. The aim of the wild pig control actions was to evaluate the technical and operational feasibility of each technique used, considering the limitations caused by the rugged terrain and unstable climate of the Serra da Mantiqueira in order to, based on the experience gained, support the actions to be adopted in the region, especially in protected areas. Thus, the control activities were performed considering the local topography and signs of use of the area by wild pigs, which determined the location of the installation of the traps and hunting points.

In the INP, control actions were carried out by the park administration, while at the RPPN it was carried out by eight volunteers who are part of the local community of the municipality of Itamonte, Minas Gerais. The volunteer hunters participate in training activities, including aspects such as identification and morphology of wild pig phenotypes, reproduction, collection of morphometric data (e.g. body and ear), collection of blood and tissues for sanitary analysis purposes, evaluation of the carcass for safe consumption of meat, safety in hunting activity and shooting techniques. The courses were given by project collaborators, including the Brazilian Agricultural Research Corporation (in Portuguese, Empresa Brasileira de Pesquisa Agropecuária, Embrapa) and Chico Mendes Institute for Biodiversity Conservation (in Portuguese, Instituto Chico Mendes de Conservação da Biodiversidade, ICMBio), both governmental institutions. One of the main impacts of wild pigs is the transmission of diseases to herds of domestic pigs and even humans[1]. Therefore, all controllers were instructed to notify the official sanitary organs upon suspicion of any type of disease in wild pigs.

During one year, the wild pig control activities were carried out using hunting without dogs (stand), hunting with dogs and live traps. Such actions reduced the incidence of wild pigs by half at the RPPN. We did not notice a difference in wild pig records in the INP due to the low effort employed and due to the continuous action of poachers acting in the INP, making control difficult to evaluate. In the INP the hunting with dogs was the most feasible way to control wild pigs because most of the territory, having almost 30,000 hectares, could only be assessed on foot (Rosa, 2016, Unpublished). From this experience and with the end of the project, my team, project collaborators and I created the “Wild Pigs Work Team” that falls under the advisory board of the Mantiqueira Mosaic of Protected Areas which has the participation of more than 20 protected areas of Serra da Mantiqueira. The councils are made up of representatives of public and private institutions and local community organized in unions, NGOs, etc. Although the council has no decision-making power, it is important for monitoring and assisting management activities that are in the interest of protected areas, as they include experts, local community and decision makers.
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6. Implications for Wild Pigs Control

It should be noted that all control activities conducted in the RPPN were carried out voluntarily by hunters. The creation of groups led by one or more local hunters, i.e. stakeholders, has generated positive results worldwide as they place hunters focused on priority areas and seasons for control actions, benefiting local community by mitigation of wild pig impacts on their properties, as well as increasing the possibility of protein consumption in low-income regions[15,16,17].

All the activities that I described, including meetings, training, etc., were fundamental to the creation of a solid group of volunteer hunters, generating a relationship of trust between the RPPN manager and hunters. One of the goals of including RPPN hunters in the project was to train them for continued control after the project ends. However, after the end of the research project, the hunters had difficulty in renewing their licenses in the Environmental Protected Area of Serra da Mantiqueira administration, so the control activities in the RPPN area stopped. This resulted in the end of the relationship between the RPPN and hunters, impairing the control of wild pigs in the Serra da Mantiqueira since other hunters were afraid to try to obtain the license and be eventually marked as poachers in the Environmental Protected Area of Serra da Mantiqueira. As long as the Brazilian government does not have a national policy with clear rules for wild pig control within protected areas, managers will be vulnerable and the authorization of hunting will be compromised by the individual and personal judgment of government employees.

I recommend that the Brazilian government create a policy that considers the registration of voluntary hunters without environmental criminal records within protected areas. I recommend giving preference to local hunters to avoid further conflict between the local community and the protected areas. Non-local hunters can be included when the manager allows an exchange of experiences among hunters. Hunters able to carry out the activity must undergo a training program that provides theoretical classes with topics that cover biodiversity conservation, wild pig identification, in hunting safety, and practical shooting lessons that can be conducted in
collaborator with the police, and even the army, both of which usually have specific locations for this type of training. The program may provide a provisional authorization where novice hunters must be accompanied by senior hunters. The consolidation of novice hunters could only be performed after the backing of senior hunters. The same hunters can and should be included in activities using traps inside and outside the protected areas where they may be responsible for maintaining the trap and slaughtering the animals. We recommend that each protected area, with wild pig occurrence, have pre-determined hunting zones- which can be dynamic in time- that can be accessed by hunters in periods determined by the manager, who can close access to tourists in the wild pig control period, if necessary. In addition, a national program can bring direct and indirect benefits to protected areas. The direct benefits are the execution of wild pig control within the protected areas with a low cost to the state, and the indirect benefits relate to inhibiting the entry of poachers. Another benefit is one of knowledge improvement, since hunters also can collaborate collecting blood and tissue samples for sanitary analysis, the stomach for studies of the wild pig’s diet, collecting data on reproduction and population structure, etc. Finally, this will also create a database of hunters who may be activated for wild pig control throughout the national territory in case of outbreaks of sanitary diseases caused by wild pigs, for example.

No invasive species control program will be effective if the source of introduction is not addressed together with population control. In this sense, it is not enough to have control of wild pigs in protected areas without inserting the surrounding community that has a direct interest in such control, since it is also harmed by wild pigs through the destruction of gardens and agricultural crops. For this purpose, specific guidelines can be created together with the community using capture traps that can be incorporated into daily activities on the private property. In case of capture of individuals, the local hunter’s collaborators of the protected area can carry out the slaughters, since often, farmers do not want to participate. The transparency of control activities, within and around the protected areas, is fundamental for a good relationship between managers and the surrounding community.

Wild pig invasion comes to break the paradigm of untouched nature still so common within the Brazilian environment policy, especially considering that currently no Brazilian protected area is able to carry out any effective wild pig control without the inclusion of society (e.g. hunters and rural producers in the surrounding area). I believe that a national program involving society will bring the community closer to the protected area, creating a relationship of trust between managers and community which can bring benefits in reducing other conflicts, such as poaching and criminal fires.

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