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Impact of agroforestry systems on bird diversity in Peruvian Amazon

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DECLARATION

I, Pavla Slavíčková, hereby declare that this thesis, submitted in partial fulfilment of requirements for the master degree in Faculty of Tropical AgriSciences of the Czech University of Life Sciences Prague, is wholly my own work written exclusively with the use of the quoted sources.

In Prague 2017

Pavla Slavíčková

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Abstract

Deforestation and unsustainable land management (not only) in the Amazon cause many problems, mainly to environment, as well as to local people. Agroforestry system could have a great potential for sustainability from economic, social, environmental and ecological point of view. This study focuses on potential of agroforestry systems as tool for biodiversity conservation. The objective of this study was to assess, if the habitat types influence occurrence and abundance of selected bird species. Birds occupy all kind of habitat and the Ucayali region count 1012 bird species. Therefore birds as bio-indicators were selected. For the aim of this study were five flag bird species selected (russet-backed oropendola *(Psarocolius angistifrons),* violaceous jay *(Cyanocorax violaceus),* yellow-rumped cacique (*Cacicus cela),* dusky-headed parakeet (*Aratinga weddellii)* and speckled chachalaca (*Ortalis guttata))* and their abundances within various habitats as agroforestry systems (AF), secondary forest (SF) and primary forest (PF) were surveyed. Comparison of three different habitats (AF, SF, PF) in surrounding of San Alejandro and Von Humboldt in Ucayali region- Peruvian Amazon was carried out between September and December 2016. In total 1,135 individuals of all selected species were recorded. Most (544) of the individuals were recorded in agroforestry systems, then in secondary forest (366) and the least in primary forest (225). *A. weddellii* is the species with the highest abundance. The analysis proofed, that there is an influence of habitat type on abundance of selected species. The most significant influence of habitat has been shown in case of *A. weddellii*, most abundant in AF and *O. guttata* most abundant in SF. In the case of selected species were agroforests considered as suitable habitats. The success of AF could be caused mainly by low presence of predators of selected species, discontinuous structure of agroforests and easily assessable food sources. In this form, the study forms a good scientific background for further monitoring of ecological changes in human modified landscape in the Peruvian Amazon region.

Keywords: agroforestry, biodiversity, bird abundance, Corvidae, Cracidae, habitat influence, Icteridae, Peruvian Amazon, Psittacidae

Souhrn

Soustavné odlesňování a neudržitelné využívání půdy má negativní dopad jak na životní prostředí Amazonie, tak i na život místních lidí. Z ekonomického, sociálního a ekologického pohledu by mohli mít agrolesnické systémy dobrý potenciál v případě udržitelnosti. Tato studie se zaměřuje na potenciál agrolesnictví v rámci ochrany biologické rozmanitosti. Cílem této studio bylo zhodnotit, zdali má typ habitatu vliv na přítomnost a četnost jednotlivých druhů. V regionu Ucayali se nachází 1012 druhů ptáků, jež obývají téměř všechny typy habitatů, což bylo stěžejní při určení ptactva jako bioindikátor. Výběr jednotlivých druhů závisel především na ekologii druhů a na možnosti jejich identifikace. Pro účel této studie bylo vybráno pět vlajkových druhů (*Psarocolius angistifrons, Cyanocorax violaceus, Cacicus cela, Aratinga weddellii, Ortalis guttata),* jejichž četnosti byli zaznamenávány v habitatech, jako jsou agrolesy, primární a sekundární lesy. Porovnávání těchto tří habitů vyskytujících se v blízkosti San Alejandra a Von Humboldtu, městech ležících v regionu Ucayali v Peruánské Amazonii probíhal od září do prosince v roce 2016.

Celkem jsem zaznamenala 1135 příslušníků všech vybraných druhů. S 544 jedinci vykazovaly agrolesnické systémy nejvyšší četnost ptactva, následované sekundárními lesy s 366 ti jedinci a primárními lesy s 225 zaznamenanými jedinci. Nejčastěji zaznamenaným druhem byl *A. weddellii*. Výsledky analýz dokazují. Že typ habitatu má bezprostřední vliv na četnost jedinců vybraných ptačích druhů. Nejznatelnější vliv habitatu vykazoval agrolesnický systém na přítomnost druhu *A. weddelli* a sekundární les na přítomnost *O. guttata*. V rámci pozorovaných druhů mohou být agrolesy hodnoceny jako vhodný habitat. Úspěch AF může být způsoben především nízkou přítomností predátorů vybraných druhů, nesouvislými lesními porosty a snadno přístupnými potravními zdroji. Studie v této podobě poskytuje dostatečný materiál pro navazující výzkum ekologických změn v uměle upravené krajině Peruánské Amazonie.

Klíčová slova: agrolesnictví, Corvidae, Cracidae, četnost ptactva, druhová rozmanitost, Icteridae, Peruánská Amazonie, Psittacidae, vliv habitatu

Content

LIST OF FIGURES

LIST OF TABLES

1. Introduction

Amazon rainforest covers roughly half of remaining rainforest on the world. This territory is shared by nine nations and its major portion (60%) lies within Brazil. On the Peruvian territory is located second largest part (13%) of Amazon rainforest; however it covers about 60% of the country (Piu and Menton, 2014; Charity et al., 2016, Malhi et al., 2008). However, there are many different estimates of Peruvian Amazon´s rainforest cover. Peruvian Ministry of Agriculture (2010) asserts, that Peruvian rainforest covered 78.8 million ha in 2010, while FAO referred to 67.9 million ha in 2011. The most recent estimates of Peruvian forest cover derived from National Forest Heritage Map made by Landsat 2009 images is 73.3 million ha in 2011 (Piu and Menton, 2014; Charity et al., 2016).

The Amazon as a whole represents world´s greatest concentration of biodiversity. Bird diversity in Neotropics is very high and the most recent species count totals 3,751 species within 90 families (Douglas et al., 1996). Peru has the largest diversity of the bird species on the World with 1,817 known bird species, out of them 1,012 living in the Ucayali region. This fact was one of the reasons for choosing birds as a biodiversity indicator for this study. (Charity et al., 2016, Piu and Menton, 2014).

Deforestation and forest degradation causes many problems not only in Peruvian Amazon. The major causes of deforestation are agriculture, mining, energy sector (Hydrocarbon and hydraulic power) and illegal logging. The poverty plays important role in this vicious circle. Population growth and poverty cause demand of agriculture land, energy production and sources of livelihood (Cornelius 2010). Compared to the relatively low deforestation rate (0.2% per year) it is the largest source of GHG (greengas houses emissions) (Piu and Menton, 2014).

Habitat fragmentation, caused mainly by deforestation and land use changes, is the major cause of biodiversity loss. One of the major tasks on nowadays is to decrease negative influence of land use management on biodiversity (Charity et al., 2016).

Many worldwide, even local organizations tend to involve and implement agroforestry systems as a tool to diminish deforestation and forest degradation, as well as to improve farmers’ livelihood. Besides that benefits, many studies focusing on function of agroforestry systems highlighted their potential for biodiversity conservation (McNeely et al., 2006). In the case of Peruvian Amazon, Cornelius (2010) claims that well-established cacao or coffee agroforestry with shade trees and other crops has a great contribution to livelihood and for biodiversity conservation (Cornelius, 2010).The objective of this study was to assess the potential of cocoa agroforestry systems for maintenance of bird diversity. Specifically we wanted to recognize the influence of certain habitats (primary forest (PF), secondary forest (SF) and agroforestry system (AF)) on occurrence and abundance of selected bird species. Couple of studies proofed, that birds are great bioindicators, because they occupy all kind of habitats and their observation does not need an expensive material. Moreover, many observation are done by volunteers (Douglas et al., 1996, Järvninen and Väsiänen, 1979). Birds were selected regarding to their ecology and relatively easy identification. Evaluation of collected data shows differences in abundance of selected bird species within habitats and influence of certain habitats itself.

2. Biodiversity in Peruvian Amazon

2.1. Biodiversity

The Convention on Biological Diversity (CBD) is one of the most important international conventions relating to the environment. It entered in force 29 December 1993 and the main goals of the convention are the conservation of biological diversity, the sustainable use of the components of biological diversity and the last, but not least is the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. In CBD is biological diversity expressed as the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems (CBD 2005).

There are commonly discussed three levels of biodiversity included genetic, species and ecosystem diversity (DeLong- IUCN, 1996). The challenge comes in measuring such a broad concept in ways that are useful. In the frame of biodiversity there are different approaches for measuring it. For understanding of approaches is shown subsequent example. There are two islands with different organisms. Island A host 6 reptiles, 2 birds and 2 mammals on the Island B there are 5 reptiles and 5 mammals. One point of view says that Island A is more diverse with 3 different taxa whilst island B host only 2. However, Island B has a more even spread of the taxa. Neither measure is wrong as richness and evenness are both aspects of biodiversity and underestimating one or other can cause loss of information (Purvis and Hector, 2000).

The first official effort Peruvian of biodiversity protection is stated in Nation Biodiversity Strategy, established in 2001. The primary achievements consisted of environmental management tools as development of regional strategies, strengthening in situ conservation strategies, enforcement of national legal framework, improvement of mechanisms for information exchange, development of regional biodiversity strategies and last, but not least increased sectorial initiatives in biodiversity and trade of food (CBD, 2016).

Biodiversity loss

According to Gaston and Spicer (2004) biodiversity directly or indirectly influence human being in daily life. It provides goods as medicines, food, fibres, biological control and also ecosystem services as nutrient cycling (decomposition, biomass production, etc.), atmospheric regulation, pollination and many others. The relationship between biodiversity, goods providing and ecosystem services is consequently clear, however constantly underestimated. Obviously the ecosystem works as an independent entity, which involves its every functioning component/ force. Therefore the biodiversity loss, thus functioning component loss, lies in disruption of ecosystem functioning (Purvis and Hector, 2000). According to Mahli et al (2008) deforestation of million hectares annually caused most of decimation of plant and animal diversity. Fragmentation and degradation of habitats has a crucial impact on biodiversity and ecosystem functioning. Next to deforestation there are many other drivers of biodiversity loss. Drivers are closely related and influence each other. Deforestation, habitat change, population growth, overexploitation (over-hunting, over-collecting, over-extracting, water pollution), water pollution and many other drivers influence each other and as a whole causes not only biodiversity loss (Charity et al 2016; IUCN, 2016).

2.2.Peruvian Amazon

Food and Agricultural Organization´s (FAO) referred that Amazonian forest is spread on total of 540 million ha of land, of which approximately 73.3 million ha lies on Peruvian territory (Asner et al., 2008; Piu and Menton, 2014). The most common forest types in Peru are lowland forest (*selva baja*) covering 53.4 million ha and highland forest (*selva alta*) covering 14.7 million ha of Peru. Remaining 5.2 million ha of forested land is covered by Northwestern mountain forest, Andean forest, Marańón dry forest and Northern dry forest (MINAM, 2010). According to FAO (2010) the primary forest is spread on 6.1 million ha, secondary forest count 6.82 million ha and remaining 993,000 ha are planted forest. The Amazon basin host about 20-30% of the biodiversity of the entire planet, that is to say four to third of all terrestrial species are found right there in Amazon. Wetlands keep a large fraction of Amazonian biodiversity also including many endemic animal and plant species, and provide multiple ecosystem services to humans (Wittmann and Wolfgang, 2016).

Amazon basin is mainly specified by rainforest cover and by Amazon River and its tributaries. The Amazon River, considered as the second largest river and by discharge as the greatest river on the World, rises in the Andes Mountains. The main tributaries in Peru are called Marañon River. In fact, there are many discussions about the river length. During the wet season the river caused flooding and in its consequence new meanders with distinct length are created. Its flow, discharge and all included processes as evapotranspiration, evaporation, etc. have significant influence on climate, weather, precipitation and in fact on overall ecology of basin linked with biodiversity. Amazonian wetlands consist of many types of wetlands, which vary in water and soil fertility, productivity and in hydrology itself (Wittmann and Wolfgang, 2016).

There in the Amazon basin are two main seasons- wet season and dry season, which are determined by precipitation, temperature and rate of evaporation (Malhi et al., 2008, Goulding et al., 2003). One of the main tributaries of Amazon River is called Ucayali River, which is main source of water in Ucayali region. During the wet season water pours from the riverbed and floods adjacent areas and creates new tributaries. Not all of the Amazon's tributaries flood at the same time of the year (Voeroesmarty et al., 1989). All processes linked with flooding are important for human, faunal and floral life in the territory. Wild floral species are adapted on flooding and most of them need it for their survival. Even local people adopted agricultural techniques to annual flooding, which consequent in soil enrichment, and due it they are fully dependent on seasonality and alternation of drought and wet season. (Kricher, 1997)

Amazon River does not influence only climate, but also significantly influence the diversity of the Amazon basin. Peruvian forests are mainly tropical and subtropical wet forest, where can be found one fourth up to one third of total faunal terrestrial species (McNeely et al., 2006, FAO 2010).

Peru is one of megadiverse countries and thanks to presence of Amazon basin, Andean mountains and coastal region (Pacific) there is a surprising variety of terrestrial, coastal marine and aquatic ecosystems. Within the Peruvian Amazon there are many different ecosystems creating a single functioning entities, requiring integrity of the whole

(McNeely and Schroth, 2006). Knowledge about biodiversity in Peruvian Amazon is still not hundred percent sufficient. According to CDB (2016) and MINAM (2014) there are 20.585 floral and 5.585 faunal species as 2-10% known insect species, 1.847 of birds, 523 of mammals, 446 of reptiles and 1.070 fish species currently found in Peru. The IUCN (2016) states that the trend of biodiversity rate is currently increasing, however even number of threatened species significantly increased. The major threats linked with biodiversity are habitat loss, caused by induced human pressures on land, and over-exploitation of natural resources as over-hunting, over-fishing or over-collecting (DeLong, 1996).

2.2.1. Deforestation and forest degradation in Peruvian Amazon

According to Llanos and Feather (2011) under REDD+ (Reducing emissions from deforestation and forest degradation) in Peru, there is not sufficient amount of data on current and historic deforestation rates and their drivers and causes. (According to MINAM (Ministerio del Ambiente) proposal the level of deforestation was 150,000 ha annually (0.2%) between 1990 and 2000. However, the most recent data delivered by use of Landsat Multispectral Scanner images indicates the deforested area in Peru covers approximately 6.9 million hectares and the annual rate of deforestation is estimated on 261,158 hectares (MINAM 2009). Drivers and causes of deforestation and land degradation in Peruvian Amazon are ascribed to impact of road construction, infrastructure projects, artisanal mining, oil and gas exploitation, mega hydroelectric projects, but mainly the slash and burn cultivation of small scale farmers and overall conversion of forest into agricultural and pasture land (Llanos and Feather, 2011).

There are many underlying drivers of above-mentioned causes such as the growth of the economy, Andean migration and increased demand for resources. Indirect drivers of deforestation were determined by MINAM (2010) and divide into five categories- demographic, economic, political, institutional and legal. However all drivers and factors are closely related. Summary of the most important drivers from all categories are population growth (births, migration), increased demand for agricultural and extractive products, national policy growth and expansion (agriculture expansion, investment in road infrastructure, support for oil and mining companies), weak institutions without adequate enforcement capacity and implementation and the last but not least unclear laws and legal system for land-use exploitation rights (above mentioned overlapping land- use rights, lack of recognition of indigenous lands, unclear regulations) (Llanos and Feather, 2011; Piu and Menton, 2014). Direct drivers of forest degradation implies from the indirect ones. They are mainly constituted by expanding agriculture, illegal logging, firewood extraction and frequent artificial setting fires (Piu and Menton, 2014).

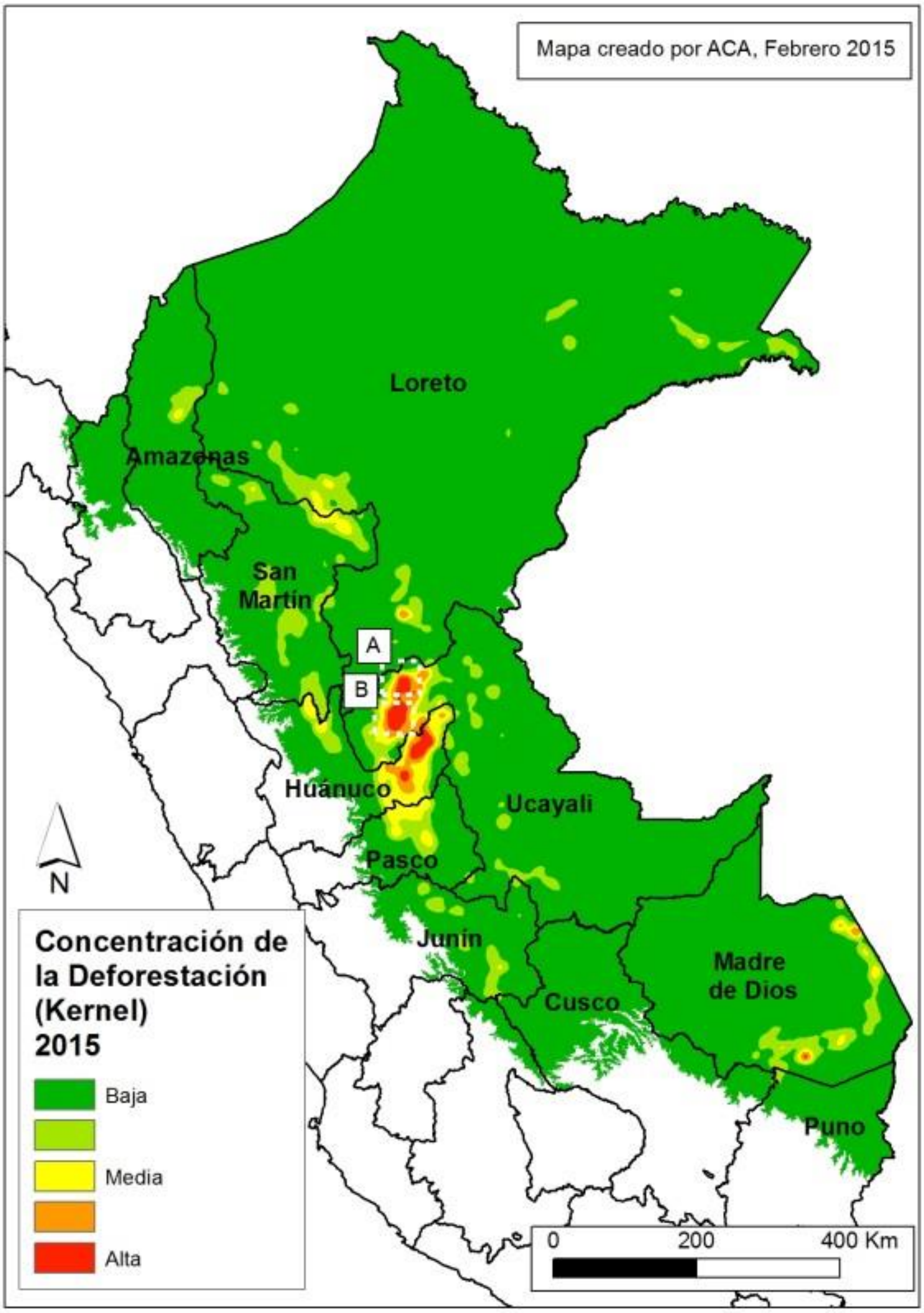


Figure 1 Deforestation rate of Peru (Monitoring of the Andean Amazon Project), explained: Concentration of deforestation (Baja- low, Media- middle, Alta- high)

According to MINAM (2011) two-thirds of forested area in Peru is under forest management involving forest concessions and reserves (forest in permanent production) with the area of 20 million hectares, protected areas with 16.3 million hectares, rainforest belonging to native communities count approximately 10.9 million hectares and 6 million hectares fall within other categories. Almost one third of Peruvian forest do not belong to any category. Rural people work this land for their daily needs, however, it does not usually have land-use classifications (FAO 2010, Nebel and Baluarte, 2001). Unfortunately, there are overlapping rights of tenure. Earlier rights of indigenous peoples and right established in colonial era coincide additionally even with other rights which leads to bad land use management and questioning about land tenure. It led to competition in territories occupation and exploitation of natural resources, nevertheless during such a competition was political and economic concern focused on sectors like oil, agriculture and mining (Piu and Menton, 2014). Majority of deforestation and degradation (64%) in the Peruvian Amazon took place right in Ucayali region (Figure1) (Armas et al., 2009).

2.2.2. Slash and burn agriculture vs. Agroforestry

Traditional slash and burn agriculture (Figure 2) seems to be no more suitable for tropics and is responsible for approximately 30% of the deforestation in Latin America (Palm et al., 2005). This farming management has a big influence on environment and lead to depletion of large areas and their slow recovery. The point of slash and burn agriculture is in clearing of forested areas, usually with use of axe and machete, in low rainy season it is burnt and field is use for crops cultivation. After couple of years (2-5 yrs) the land is abandoned to forest regrowth and other forested part is cut down. Naturally reforested become under this process again after 10-20 years. This traditional system is ecologically and environmentally great only in very low population densities. However, with increased population also increased demand on food, thus environment begun to be overburdened, degraded and heavily deforested (Bandy 1992, ICRAF 1994).

As a possible solution for decrease deforestation and make a sustainable land use with sufficient production shows to be an agroforestry system (Figure 3). These systems are based on long term sustainable land use with maximization of ecological, economic and social benefits (FAO 2010). According to ICRAF (2000) agroforestry is system, which combines two or more species of plants, at least one of which is a woody perennial, or plant and animals. It is a complex of practices involving integration of tree species or other woody perennials, with traditional agricultural practices as crop production, or animal husbandry, or combination of all. AF systems are set to be ecologically and economically more complex than a monocropping system and provide various benefits in a form of multiple outputs. Therefore, decrease necessity of farmer continuing in traditional slash and burn agriculture. Agroforestry systems can be silvopastoral system combining animals and trees, or agrisilviculture combining crops and trees including shrubs and trees, or agrosilvopastoral which combines two systems above mentioned (Nair 1993).

Well managed agroforestry systems play a role in many ways. It has a chance to provide ecosystem services in frame of water regime, soil conditions, habitat improvement, etc.) Environment is enriched by nutrients, which are provided by various species of woody and non woody plants. Due to presence of woody species stable carbon stock is ensure. Trees in AFS provide contribute into water regime by capturing, filtering and storing water. Many shrubs, smaller trees, crops or animals need a shade, which is provided by taller trees. In comparison with monocultures, AFS provides habitats and food for various animal species and thus improves biodiversity. Of course, from economic point of view AFS brings various benefits in the form of wood, but even more in non-wood forest product (fruits, nuts, leaves, mushrooms, medicinal plants, etc.) (FAO 2007; Nebel and Baluarte, 2001; Voeroesmarty et al., 1989).

Figure 2 Slash and burn agriculture, San Alejandro, 2016

Figure 3 Cacao based agroforestry system in San Alejandro, Peruvian Amazon

2.2.3. Biodiversity and agroforestry

Negative influence of land-use change and other factors on biodiversity may be mitigated by several actions (Robiglio et al., 2014). The problem of the biodiversity loss in tropics can be mitigated by an expansion of plantation forestry, agroforestry and secondary forests (Barlow et al., 2007). AF provides wide range of environmental services and well-managed agroforestry system have a greater precondition to conserve biodiversity than purely agricultural landscape. However, survival and spread of floral and faunal species closely depend on type of agroforestry system, which consist of planned and unplanned components. Random species, which consider system as a habitat, belongs to group of unplanned components and are important part of biodiversity. For example, traditional coffee plantation usually consists of coffee, one crop and typically only a single tree species, or live fences is consisted of only a few tree species. In these types of AF systems, which are not planned as a species rich system has unplanned components (forest-dependent native plant and animal species) lower opportunity to find a habitat (Schroth et al., 2011). E.g. Cocoa based agroforestry systems, often with diverse tree species and multiple strata serves as suitable habitat for many bird, insect and mammal species (Rice and Greenberg, 2000).

Management of agroforestry systems closely relate with occurrence of faunal species, however in general, with the many levels of strata and great high canopy is habitat suitable for many species of birds, insects and mammals (Izac and Sanchez, 2001). According to Rice and Greenberg (2000) capacity of cocoa agroforestry systems in Latin America has a greater capacity to conserve birds and ants than any other anthropogenic land use system.

Traditional cocoa agroforestry system in Amazon is established under a tall trees, which provide a needed shade for cocoa (*Theobroma cacao*) (Griffith, 2000). Initially, the forest is cleared by machetes and fire thereafter the canopy of remnant trees which retain provide a necessary shade. The further establishment and maintenance vary throughout the Amazon, however, with an establishment of species rich system, there is apparent spatial distribution and abundance of habitats, suitable for various animal species (Schroth et al., 2011, Rice and Greenberg, 2000).

Despite the fact, that well managed agroforestry system can positively contribute to the biodiversity conservation, there is still significant difference between primary, secondary forest and agroforestry systems. It is important to keep in mind that it has the greatest potential in biodiversity conservation within the agricultural systems (Gascon et al., 2004).

2.3. Bird as bio-indicators

According to Järvninen and Väsiänen (1979) and Järvinen (1983) birds are considered as a useful biodiversity indicator, due to their occupation of all kind of habitats. Moreover, the bird monitoring is relatively inexpensive and volunteer birdwatchers can gather the data (Gregory et al., 2003; Koskimies 1989). The great bio-indicators has to be easily to understood, quantitative, simplifying, realistic to collect and policy relevant. Choice of bird as bio-indicator has to be supported by sufficient ecology knowledge, about a chosen taxa (Gregory et al., 2003). Birds play important role in seed dispersion due to consumption of fruit/seeds and subsequent exclusion of fertilized. In the frame of ecosystem services birds plays crucial role in pollination of various plant species (Clouth and Hay, 1989).

Study held in northern Greece focused on examination of six groups of taxa showed their efficiency as bio indicators of biodiversity. There were found a significant relationship between woody plants and birds, and between birds and aquatic herpetofauna (Kati et al., 2004).

According to the research of Mikusinski et al (2001) there is direct link between abundance of woodpecker species with other bird species. Study has shown, if there in the forest is presence of great abundance of woodpecker species, even abundance of other bird species is significantly higher. It was resulting in consideration, that woodpecker species in other forest ecosystems of the same type, could give approximate estimation of abundance of other birds species. Similar concept suggested Blair (1999) about correlation of bird abundance with abundance of butterfly species in small patches of habitat.

2.3.1. Birds of Peru

With more than 1,800 bird species, Peru can boasts the highest bird diversity in the World (Charity et al., 2016). According to Lepage (2017) the Ucayali region hosts 1012 bird species. From the topographical point of view has Peru enormous variable country, thus the bulk of ecosystems and different habitats are presented there (Puhakka et al., 2011, Rull and Bush, 2013, Terborgh, 1997). The highest elevation can be reached in the Andean Cordillera, which run north/south down the country along its entire length. The Andes breaks the wind form the west and defend the Amazon basin, thus the lowlands and east of the Andes keep being very humid. Therefore these areas are covered by humid evergreen forest, rich in species. However, soil influenced by fires can produce less diverse forest, or even scrub of savanna (Marin and Hedges, 2016; Schulenberg et al., 2010).

Wide, flat and large floodplain of the Amazon and its main tributaries (Napo, Maranon, Huallaga, Ucayali, Yavarí and Madre de Dios) constantly create new channels and leaving behind the old ones, gives a rise to islands or even consume them. This action contributes to formation of additional habitats important for bird diversity, such as river-edge forests, scrub, marshes in the lakes oxbow, or secondary vegetation of vanished tributaries and channels. Much of the Peruvian basin area is located a little around 300 m a.s.l. (Rull and Bush, 2013; Schulenberg et al., 2010).

The most of the Peruvian avifauna are permanent resident (birds usually stay, where they breed). However, still many species are breeding residents i.e. they breed in Peru, but then they depart or leaving Peru, or they breed elsewhere and vacating in Peru. The most common migrant residents are Australian migrants, who breed in temperate latitudes, and their stay on Peruvian territory tales a place between March and October (Cook, 1996; Parler et al, 1985).

Unfortunately, birds has to face an increase of threat, caused by expanding urbanization and associated agriculture, logging, mining, fishing and exploitation of natural resources. Many bird species, especially endemic (e.g. sira curassow, white-winged guan, junin grebe, waved albatross, and white-bellied cinclodes), became to be critically endangered due to overhunting and habitat destruction (Beirne et al., 2017; IUCN, 2015). Identification by vocalization of hundreds species in dense ecosystem as tropical rainforest by one person is hardly possible. The difficulties with observation of all bird species in Peruvian Amazon were diminish by selection of five flag bird species.

2.3.2. Selected bird species

Five selected species were selected regarding to their ecology and species identification, to find out, if habitats has influence on presence of these species. Selected species of birds belonged to families Icteridae, Corvidae, Cracidae and Psittacidae.

One of the selected bird species belong into the family Cracidae (Cracids), which are typical inhabitants of evergreen forests in the Neotropics. Their diet consist mostly of fruit. Cracids are the most endangered avian family in the region (Brook and Fuller, 2006) and abundances varies within disturbed and undisturbed forest, due to change of land use management and hunting pressure and it has been widely used as indicator of impacts of deforestation and hunting practices (Barrio, 2011). Therefore Speckled Chachalaca (*Ortalis guttata*) belonging to cracids was chosen as one species for evaluating agroforestry system as a possible tool for their conservation.

Russet-backed oropendola *(Psarocolius angistifrons),* Violaceous jay *(Cyanocorax violaceus),* Yellow-rumped cacique (*Cacicus cela),* Dusky-headed Parakeet (*Aratinga weddellii)* and Speckled Chachalaca (*Ortalis guttata*) are species consuming mainly fruit, insects or its larvae, seeds and some of them even bird and reptile eggs (Hatchwell, 2009). Despite the wide range of distribution, the trend appears to be decreasing (IUCN, 2016). By presence of these species it can be suggested, that the land-use system by its complexity provide wide range of food resources and thus provide suitable habitat for them.

Moreover, *P. angustifrons* is a nest pirate and within the competition of food resources use to pirate nest of *C. cela* and destroy its eggs and young, or just destroy eggs and kill young, which are close to the nest of *P. angustifrons* (Payne, 1977; Robinson, 1985).

An interaction in case of brood parasitism and evaluating abundance of both species can help evaluate succession of land-use systems to host both species.

Psarocolius angustifrons (Russet- backed oropendola)

Psarocolius angustifrons (Figure 4) is one of the most common and widespread oropendolas. This species belongs to the family Icteridae together with *Cacicus cela.* Oropendolas are large bird species, which colonially breed. They establish long hanging nest, usually in high canopy or in the mid story, across most of habitats in Amazon (IUCN, 2016).

P. angustifrons most commonly forage in a family flocks, or with other species a caciques or jays. In mid or upper story of the canopy. There is a significant sexual dimorphism regarding to body size. With a size ranging 44-48 cm are males considerably bigger than females, whose size range between 24.5- 38 cm (Collar et al., 1992; Hatchwell; 2009). Typical body features are ruffus-brown plumage with the russet rump and relatively long yellowish tail with brown central feathers. The color of bill is inconspicuous, dark or olive-brown. Diet consists mainly of fruit, insects and eggs of birds and lizards (Diamond and Terborgh, 1967).

There is known brood parasitism by *P. angustifrons,* when they attack nests of *C. cela* and damage their eggs or kill their young, to decrease competitors of food resources (Payne, 1977; Robinson, 1985). This fact can be considered at least strange, taking in consideration, that both species belong into the same family Icteridae (Price et al., 2002).

This species is well detectable, especially by vocalization, however, the size and coloring also plays its roles. The sound of russet-backed oropendola is not interchangeable with anything else. The gurgle song followed by a liquid trill varies, but the root is basically the same. The most common sound can be expressed as gurgling “gluglu-TZZZZ´CHUI”. In the frame of this sound the bird falls forward in perch and rise the wings. Some other sounds can be heard, however, all of them precede the typical gurgling sound (Schulenberg et al., 2007; Stotz, 1996).

Figure 4 *Psarocolius angustifrons*, Palmarí Natural Reserve, Amazonas, Brazil; photo by: Juan José Arango (2015)

Cyanocorax violaceus (Violaceous jay)

Violaceous jay (Figure 5) is in Amazonia uncommon, but widespread. The natural habitat of this bird species is varzea, lowland evergreen forest near margins and rivers, even second growth found in elevation up to 900m (IUCN, 2016). *C. violaceus* usually occupy the mid-story or canopy of certain habitats. Across the most of Amazonia is *C. violaceus* belonging to the family Corvidae only jay, which can be found there (Potter and Brandeth, 2010; Schulenberg et al., 2010). This bird species usually flocking in smaller groups, which can be family groups, or with other species- the most commonly are these groups represented by oropendolas and caciques (Collar et al., 1992).

Body size is uniform around 36.5 cm for female and male. Typical features of this bird are predominant dark violet-blue plumage of body and wings, black facial mask and lightly purple nuchal collar (Collar et al., 1992; Schulenberg et al., 2010).

C. violaceus is omnivorous species consuming mostly insects, fruit, birds and reptile eggs and even small lizards (Potter and Brandeth, 2010). Individuals of these species are very well detectable due to their appearance, size, and even vocalization, due to fairly small repertoire for a jay. *C. violaceus* is noisy and the sound could be expressed as a loud, rough, ringing, garrulous "*JEER*", repeated once or twice in row (Schulenberg et al., 2010).

Figure 5 *Cyanocorax violaceus* in agroforestry system, San Alejandro, Ucayali region, 2016

Cacicus cela (yellow-rumped cacique)

Caciques remain by the body type their relatives' oropendolas, however caciques are in general smaller and the sexual dimorphism is not that significant. The nesting strategy is also pretty similar. *C. cela* (Figure 6) use to establish long hanging nest in midstory or in upper canopy across the most habitats of Amazon and Andes up to altitude to 1300 m (IUCN, 2016). One tree can be occupied by up to 100 cup nests of widespread and fairly common *C. cela*, usually associated by *Polistine* wasp nest (Cuervo et al., 2007).

Diet of this species consist mostly of large insects and fruit. The yellow-rumped cacique is a slim bird and differ in the body size within the sex. The males range the size between 27-29 cm and females are smaller with 23-25cm. The plumage covering whole body, head and part of wings is intense black. Wing epaulets, lower belly and base of the tail bright by yellow color. Eyes are lightly, brightly blue. (Stotz et al., 1996; Hilty, 2003).

The vocalization of *C. cela* is brilliant mixture of wheezes, cackles and fluting notes, which even varies within the colonies. However, the most frequent phrase we can recognize individuals by, longer higher call of "*dJEERu dJEEERu-wer"* or varied calls include a "*ju-RIK*," often interspersed with muted "*chack*". Recognition of this species by vocalization is more difficult, however, hanging nests associated by wasp nests and flitting birds in flocks help the recognition (Hilty, 2003; Schulenberg et al., 2010).

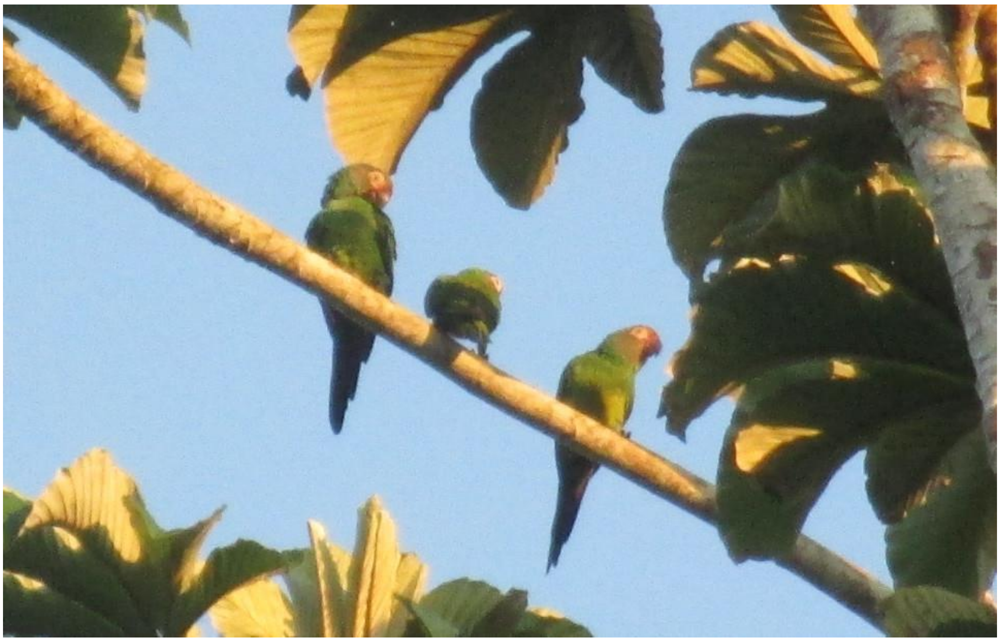
Figure 6 *Cacicus cela* in primary forest Macuya, Ucayali region, 2016; photo by: Zdeněk Jeřábek

Aratinga Weddellii (Dusky-headed parakeet)

A. Weddellii (Figure 7) is small green neotropical parrot with body size of 23.5 - 27 cm belonging to family Psittacidae. Its typical features are dusky grey head and broad bare white eye-ring and black bill. Most of the time they occur in flocks of 6-10 individuals (in the case of wide range of food resources may be flocks formed by 50-70 members)

(Juniper, 1988). The major part of their diet consists of fruits, seeds, nuts, flowers and insects of larvae (Schulenberg, 2010). This species can be commonly found in eastern lowlands bellow 700 m in the western Amazon basin. According to Gilardi (2012) *A. weddellii* inhabit várzea forest (seasonally flooded forest), terra firme forest and riparian, however it seems to have adapted to some degree of habitat degradation and fragmentation. They establish nests in woodpecker holes in trees or arboreal termite nests (Gilardi and Munn, 1988).

This well detectable species can be recognized especially due to conspicuous coloring of head (feature to distinguish him from other species), range of occurrence and especially due to vocalization. Very high and pitched calls sound like rusty "*kree-kree*"



(Schulenberg, 2010).

Figure 7 *Aratinga weddellii* in agroforestry systems, San Alejandro, Ucayali region, 2016

Ortalis guttata (Speckled chachalaca)

Speckled chachalaca (Figure 8) belongs into family Cracideae. It is widely distributed among Amazonia and successfully colonized all ages of second growth up to 1,700 m a.s.l. The population has not been quantifies, but the population trend appears to be decreasing (IUCN, 2016). *O. guttata* has drabber plumage creating brown body with white spots on lower neck and chest. Smaller red dewlap and long tale are very characteristics for this species. Chachalacas have smaller body size, dewlap and shorter tail, than very similar species Guan Spix´s. The body size is around 49.5-52 cm. In general they can be found in small family flocks, or as individuals. Usually they are well recognizable by loud calls. The food consist mostly of fruit and seeds. Commonly mature fallen fruits is consumed. (Barrio J., 2011; Kattan et al., 2016; Schulenberg et al., 2010).

This species is very well recognizable by loud calls, usually heard as duet or chorus, which has typical 4-notes character. Mostly could be described as "*rah-KA´DUK-kah!*" or "cha-cha´LAH-kah!" (it is probably the reason for given name). Other sounds include purrs, cackles, rattles and other sounds (Schulenberg et al., 2010).


Figure 8 *Ortalis guttata* in agroforestry systems, San Alejandro, Ucayali region, 2016

3. Objectives

The main objective of this study was to find out, if the habitat type has an influence on selected bird species abundance.

The study has following specific objectives:

- Document the occurrence and abundance of *Cacicus cela*, *Cyanocoray violaceus*, *Psarocolius angustifrons*, *Aratinga weddellii* and *Ortalis guttata* within agroforestry systems, secondary and primary forest in Peruvian Amazon
- Compare agroforestry systems, secondary and primary forest in Peruvian Amazon considering bird species abundance and their distribution.
- Collect all possible information about ecology and habits of target species.
- Explore mechanisms of bird's distribution considering their daily activity, habitat structure, weather conditions, elevation of plots, presence of predators, etc.
- Observe and record other species, which can affect occurrence and distribution of target species. Describe mechanism of influence.

Based on our objectives we have set following research questions:

- Does the habitat type (agroforestry system, primary forest and secondary forest) influence the abundance of selected bird species?
- Does the bird abundance varies among selected species?
- Does the localities within habitat types influence selected bird occurrence?

4. Materials and methods

4.1. Study sites

This research was a part of long term study done in Peruvian Amazon, in Ucayali Region, which aim is to evaluate feasibility of agroforestry systems as possible biodiversity conservation tool. All previous studies were focused on agroforestry systems, secondary forest, primary forest and traditional slash and burn agriculture fields. For the aim of this study I have excluded I did not include very common slush-and-burn, due to missing tree canopy, which is indispensable for survival of selected bird species. Selected localities (36 in total; 12 in each habitat) included the same plots, which were evaluated (plant composition, small mammals' diversity, dragonflies' diversity, etc.) in frame of long term study. However, previous studies included only four or five localities and for purpose of my research I have selected additional localities in surrounding of these surveyed plots.

Characteristic features of primary forests are full ceiling canopy and several strata (layers of understory) (Figure 10). Its composition and structure is usually very complicated and diverse, poorly affected by human. On the other hand, secondary forests are usually established after clearings. Its composition depends on species succession. Hardly assessable terrain was one of difficulties during data collection. Structure of agroforest closely related with its establishment. Amount of trees, shrubs and crops varies among the farms (Figure 9).

Figure 9 Secondary forest- locality no. 18 (left) San Alejandro, 2016; Agroforestry system- locality no. 11 (right), San Alejandro 2016

Figure 10 Primary forest- locality No. 29, CICFOR Macuya, 2016

Localities of agroforestry systems and secondary forests are found in surrounding of San Alejandro town (S08°49'; W75°13'), which lies in Pucallpa region (Figure 9, 10). San Alejandro town is located 120 km far from Pucallpa city being the capital of Ucayali department. Ucayali region is one of the 25 Peruvian regions, consisted of four districts. Its name was delivered from the Ucayali River (one of the main Amazon tributaries). There in Ucayali region lives 462,159 inhabitants (2007 Census), from more than half lives in the regional capital- the city of Pucallpa (MINAM, 2016). The primary forest sites were located in Forest Experimental Station (CICFOR Macuya - Center for Forest Research and Training (S08°52'; W75°00')) of the National University of Ucayali near the town of Von Humboldt, located 86 kilometers far from Pucallpa and it is the nearest city of primary forest.

Figure 11 Ucayali region in Peruvian Amazon- left, study sites- right

Figure 12 San Alejandro (left circle) and CICFOR Macuya (right circle)

The local climate is characterized by high temperatures throughout the year and variation of dry and wet season. The heavy rains occur mostly in wet season, which takes place from November to March. However, even in dry season typically occur at least little rains (Figure 11). The average annual precipitation in surrounding of San Alejandro town is approximately 3,330 mm and the average temperature range 26.1 °C. Torrential rains and floods cause main problems to local people, especially in the recent year heavy floods in this region occur. This has plagued the area and hinder the livelihood of local residents living in already difficult conditions. Frequent heavy rains and floods negatively affect the crop production, which is a local source of livelihood and lives of local people depends on it.

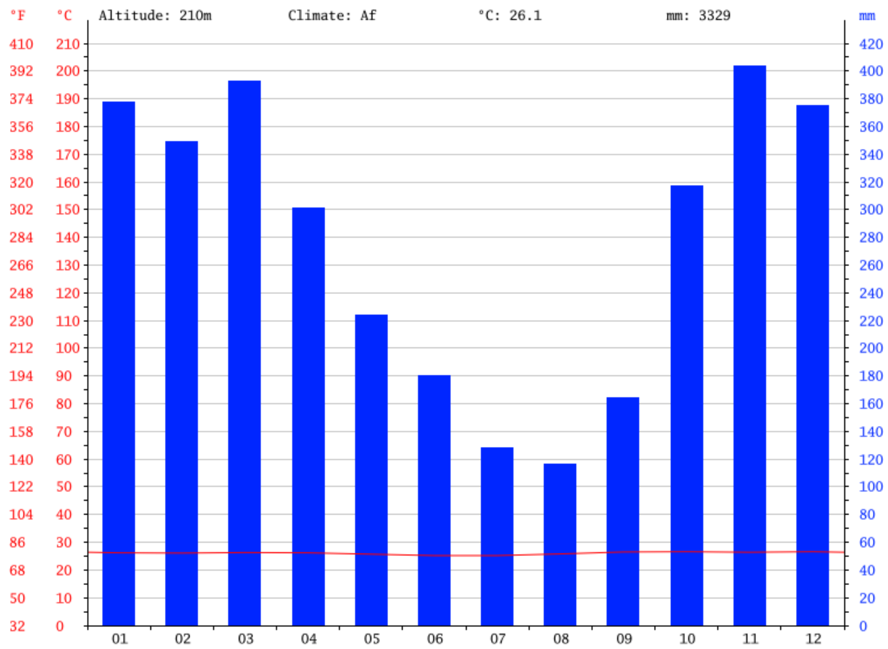


Figure 13 Climatic characteristics of San Alejandro, 2016 (source: www.climate-data.org)

The farmers usually cutlivate rice (*Oryza sativa* L.), maize (*Zea mays L.*), cassava (*Manihot esculenta)*, citruses (*Rutaceae*), pineapple (*Ananas comosus)*, papaya (*Carica papaya*), banana (*Musa*) and cacao *(Theobroma cacao*). Some of these products are commonly cultivated in agroforestry systems with valuable tree species. Cocoa is usually grown under the planted shade of various local multipurpose tree species.

4.2.Data collection

Bird´s observation within the different forest systems was done at the turn of dry and rainy season during three months, between beginning of October and the beginning of December 2016. I have focused on observation of abundance of the following species: Russet-backed oropendola *(Psarocolius angistifrons),* Violaceous jay *(Cyanocoray violaceus),* Yellow-rumped cacique (*Cacicus cela),* Dusky-headed Parakeet (*Aratinga weddellii)* and Speckled Chachalaca (*Ortalis guttata*). These species were selected regarding to their ecology- all species lives in midstory and upper story canopy. Their diet consists mainly of fruits, insect, larvae, lizards´ or birds´ eggs and nuts. All of them are species of forests, however, some of them prefers less dense canopy or secondary growth. Collected data give an overview, if agroforests fulfill various needs of selected bird species and provide them good enough place to live. Well visible nests, loud or characteristic calls and sounds, distinct colors and size were main indicators for their recognition in terrain.

All these species spend most of their lives in higher canopy- nest establishing, feeding, breeding, resting, etc. The most feasible method for these "high canopy species´´ is transect method- point counting (Figure 12) (Betts et al., 2005; Pagen et al., 2002). This method is suitable for patchy habitats and for hardly accessible terrain. Observer, when reached the point, stand in the middle of notional circle- its size is usually up to 50m. Duration of observation mostly depends of number of observed species, their scarcity and vegetation density. The most common observing period last 5-10 min (Betts et al., 2005). Within this method certain quantity of observation points is set in distances 150-250m far from each other to decrease the risk of double counting (count same individual twice). Day time of observation depends on bird activity, which is early on the morning or late evening- in this study morning periods were chosen Data are recorded (paper notebook, videotaping, camera, etc.) and evaluated (Sutherland at al., 2004).

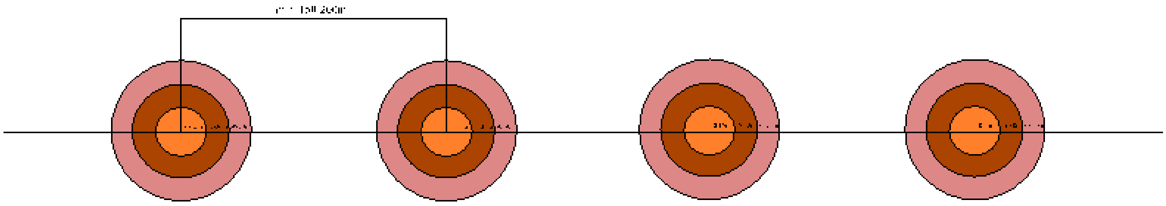


Figure 14 Point counting method for bird abundance estimation.

First two weeks of research were dedicated for setting and marking the points within agroforestry systems, secondary and primary forests. Each point was set at least 150 m from each other and every habitat type totaled 12 observing points. Noise disturbance in surrounding of forests caused by different factors was eliminated by setting the points deeper in the habitats. Each point was set at least 30 m behind the forest border. Collected data as vegetation cover density, altitude, temperature, slope orientation and geographic position by GPS were marked on every observation point.

Repeated observations of every habitat were done once a week for a six-week period. I have developed two procedures of observations, which were rotated each week. First week I have been observing points from first to twelve and the following week I have started on twelfth point, continuing to the first one. These procedures were practiced to decrease influence of varying time and temperature during the day.

Reaching the point I could cause bird disturbance, therefore 1-2 minutes before initiation of observation was needed for bird sedation (Sutherland at al., 2004). Observation on every point took seven minutes and within this time individuals of all above listed species were identified and recorded. Moreover daytime, temperature, weather type, distance of bird from observer and other species presence was recorded on every point during each observation. In total 192 visits of all observation points were done during the six weeks period, however, due to the frequent rainy days, causing zero occurrences of chosen species, only 144 of visits were successful to spot some individuals of selected bird species.

During the observation I recorded also other bird and mammal species, which were mostly seen and heard, captured on camera and lately identified. The other species were considered as a factor, which could influence the occurrence of target bird species.

All recorded information were needed for data analysis, for accurate estimate of bird´s population in certain habitats and their relations.

4.2.1. Bird identification

The bird identification was one the most important action within data collection. The clue for bird identification lied in many factors. Each of the selected species has different foraging behavior, which means that each of them prefers different strata of habitat. Known foraging behavior of every species made evaluation of habitat easier. Due to the similarity of many species, the knowledge about other confusable species or varieties is crucial. To avoid this problem, the selected species are very specific and can be easily identified by calls or nesting habits (Schuleberg et al, 2007).

Selected species has similar relatives, however none of them occur in surveyed areas. The most important clues in bird identification were length and voice. By the length it is possible to distinguish many similar species (in my case *P. jacquacu* is very similar to *Ortalis guttata*, however the length of *P. jacquacu* is almost twice as big). The voice is crucial, because in the dense canopy are birds more heard than seen. Awareness about selected species call expressions are pivotal. There are available library of bird song collection and phonetic descriptions by many authors and volunteers. In overall the identification itself, while having selected species clues mainly in ecology of selected species.

Each species has a characteristic feature for its recognition. *O. guttata* is large bird with very characteristic calls ("*rah-KA´DUK-kah!*"). They do not move so fast and they show high resistant against disturbance, caused by approaching observer. On the other hand *A.* weddellii is easily frightened bird, however its specific very call loud and accelerated motion, often in flocks, make this species easy to observe (easy to hear even seen). *P. angustifrons* has the most typical unchangeable gurgling call ("gluglu-TZZZZ´CHUI"), associated with the forward movement of all body. This species usually stays in one place for a while and though the observation is easy. *C. cela* usually occurs in flocks and their nest are very well visible. The call are wide scale of sounds, however the fast movement from the nest to nest helps to recognize them. The most typical feature of them is black plumage on body and brightly yellowish plumage on lower body and lower wings. The ultimate species *C. violaceus* is well recognizable by body size and color- black plumage on head and upper body and purplish plumage on the rest of body. The typical sound of jay is very distinctive from the other calls.

4.3. Data evaluation and statistical analysis

The number of individuals of each species has been calculated for each habitat. Resulted overview gave a brief notion about species distribution and abundance. Apart of evaluation of abundances of selected species, I have listed other recorded species, which have added predictive ability about monitored habitats. The differences of abundance of each of the selected species between different habitats were analyzed for univariate results by one-way nested ANOVA analysis and for multivariate results by Detrended Correspondence Analysis (DCA) and Canonical Correspondence analysis (CCA).

With the regard to data collection were differences in the abundance of each selected species within three habitat types tested by one-way nested (hierarchical) ANOVA. The analysis were done in program STATISTICA. The species abundance was used as an explained variable (as sum of visual and heard contact). This abundance was tested for forest type over visited localities (36 localities) in certain habitat (agroforestry system, secondary forest, primary forest). The locality was set in ANOVA model as a factor with a random effect. The result of this analysis shows habitat preferences for each of five selected bird species and variability in their occurrence within the localities (1-36) and habitats (AFS, SF, PF).

Another goal was to assess common occurrence/non-occurrence of particular species and test influence of forest type on occurrence/non-occurrence. Multivariate analysis was used for this assessment. CCA was used for an identification of two main gradients in common occurrence of surveyed five selected species. Data was not transformed. Frequent common non-presence of particular species cause arch effect, therefore Detrended Correspondence Analysis (DCA) was used. For the visualization was carried out the ordination diagram. The ordination axes are shown (the same amount of selected species minus one). The axis one is the most important, all other axes are mutually orthogonal and perpendicular to the first axis. These axes creates center of presence of every locality and every species in the space created by axes. It means that species and localities, which are in this space mutually closer, have similar behavior.

DCA was followed by canonical correspondence analysis (CCA), which tested, if the forest type, in which were the measurement done, has a significant influence on this structure. Species composition of particular observations was taken as an explained variable and forest type had been used as an explanatory factor. Other environmental conditions as weather type, altitude, time elapsed since the initiation of observation and temperature could possibly influence common presence of selected species. These variables were used as covariates. It means that other environmental conditions were deducted from forest effect on bird occurrence. Finally there is clear effect of forest on bird occurrence. The resulted canonical axis were tested towards itself. Both multivariate analysis were processed in program CANOCO.

5. Results

5.1. Overall abundance of selected species

In total 144 observations successful observations, I have recorded 1,135 individuals of five selected species (*P. angustifrons*, *C. violaceus*, *C. cela*, *A. weddellii*, *O. guttata*) (Table 1 and Figure 13). The results indicate, that the most abundant species is *Aratinga weddellii* with the highest occurrence in agroforestry systems (207 individuals) and secondary forest (106 individuals). Abundance of *Ortalis guttata* was found lowest with the lowest occurrence in primary forest (28 individuals). The result shown that the most individuals within all five selected bird species was in agroforestry system (544 individuals) followed by secondary forest (366 individuals) and the least in primary forest (225 individuals).

Table 1 Collected individuals of selected species within all observations of all forest types (AF- agroforestry systems, SF- secondary forest, PF- primary forest)

	Psarocolius angistifrons	***Cyanocoray violaceus***	***Cacicus cela***	***Aratinga weddellii***	***Ortalis guttata***	**Total**
AF	85	58	145	207	49	**544**
SF	54	40	85	106	81	**366**
PF	57	31	57	52	28	**225**
Total	**196**	**129**	**287**	**365**	**158**	1135

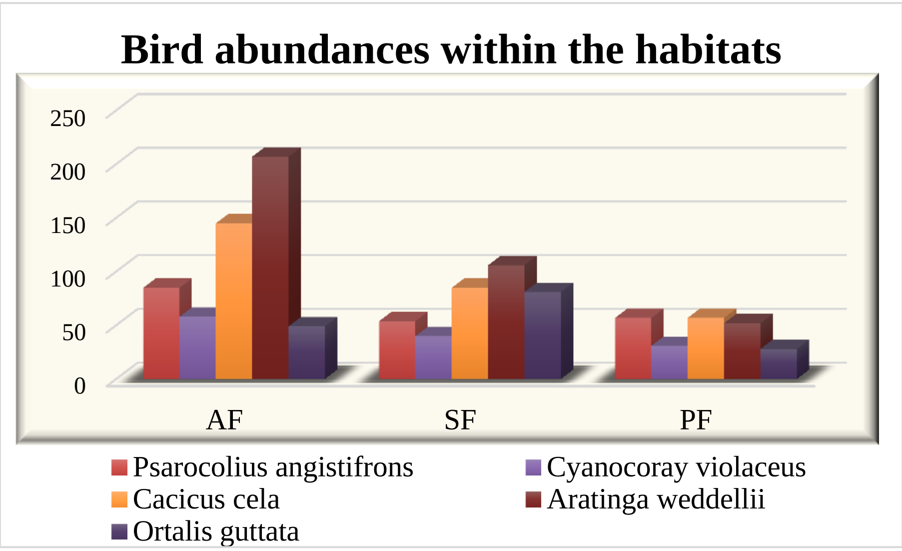


Figure 15 Abundance of selected bird species within three habitats (AF- agroforests, SF- secondary forests, primary forests)

5.2. Observation of Other species

During the 3 months period of observation I have also recorded other bird (table 2) and mammal species (table 3), which could possibly influence the occurrence of selected bird species. Presence of predators could decrease the presence of species, or their vocalization. In the table below are stated only species, which I could determine for 100% (mostly from the captured photos, or by the field encyclopedia of species). The numbers of individuals are not significant in overall view on biodiversity of species, but they can explain some deviations in selected species occurrence. However, from the table it is apparent, that some species occur in a great abundance. On the other hand, some species were seen in low densities, as for example the Harpy eagle, Hoatzin, or Pale-throated sloth. However this species has information capability even in the occurrence of one individual, due to their demands on the quality of the environment.

Data shows, that the highest occurrence of other species and mostly even the highest abundance were recorded in primary forest with 13 species and highest occurrence. Seven other species were found in agroforests and only four other species were noticed in secondary forests. However, the most common mammal species within all forest types is Brown-mantled tamarin (*Saguinus fuscicollis)* with the highest occurrence right in secondary forest.

Table 2 List of non-selected bird species and their abundance within forest types (AF- agroforestry systems, SF- secondary forest, and PF- primary forest)

Latin name	**English name**	**AF**	**SF**	**PF**
Pteroglossus castanotis	Chestnut-eared aracari	5		9
Ramphastos tucanus	White-throated toucan	4		6
Harpia harpyja	Harpy eagle			1
Penelope jacquacu	Guan spix´s			6
Coragyps atratus	Black vulture	16	12	
Buteogallus urubitinga	Great black-hawk	4	3	3
Trogon Curucui	Blue-crowned trogon	2		
Dryocopus lineatus	Lineated woodpecker	6	3	4
Ara severus	Chestnut-fronted macaw			8
Nyctiphrynus ocellatus	Ocellated poorwill			2
Opisthocomus hoazin	Hoatzin			6

Table 3 List of recorded mammal species and their abundance within forest types (AF- agroforestry systems, SF- secondary forest, and PF- primary forest)

Latin name	**English name**	**AF**	**SF**	**PF**
Alouatta seniculus	Venezuelan red howler			4
Cebus albifrons	White-fronted capuchin			9
Ateles chamek	Peruvian spider monkey			8
Saguinus fuscicollis	Brown-mantled tamarin	22	26	24
Bradypus tridactylus	Pale-throated sloth		4	

*Figure 16 Pale-throated sloth (*Bradypus tridactylus*) (left) and Harpy Eagle (Harpia harpyja) on the same tree at the same time, CICFOR Macuya, 2016*

5.3. Abundance of each of selected species within the habitats

5.3.1. Abundance of ***Psarocolius angustifrons***

In total 196 individuals of *Psarocolius angustifrons* were recorded, during the observation period. The highest abundance of this species were in agroforestry system with 85 individuals, however the secondary forest with 54 individuals and primary forest with 57 individuals did not proofed any significant differences in abundance of this species (Figure 14).

From the statistical view *Psarocolius angustifrons* has no significant differences in abundance and spread within the forest type (table 4). However, on some localities significantly higher occurrence of this species was found. Repeatedly highest occurrence of observed individuals was recorded on locality number 11 in agroforest with an average occurrence of 5.5 individuals (Figure 15). This was caused by other environmental conditions. The locality number 11 had significantly higher number of palm species, even their abundance. Furthermore, this locality had the lowest elevation from all selected agroforestry localities. Despite of other localities, 11th locality was flat and not oriented in slope.

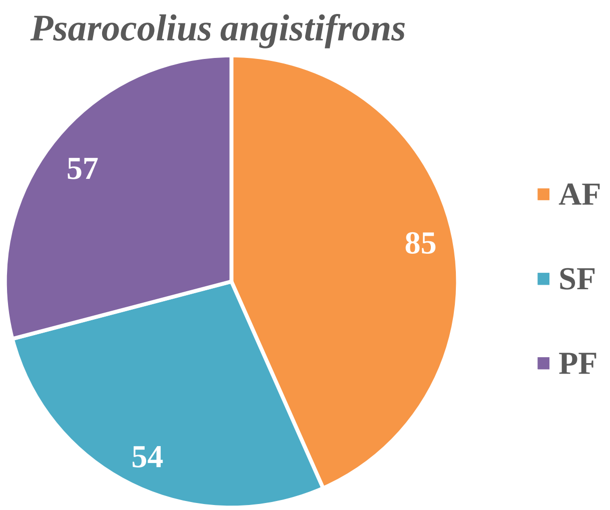


Figure 17 Abundance of *Psarocolius angustifrons* within certain habitats (AF-agroforests, SF- secondary forests, primary forests)

Table 4 Results of nested ANOVA for *Psarocolius angustifrons*

	Effect F/R	Sum of square	Mean square	F	p
Locality (1-36)	Random	100.54	3.047	2.342	0.000546
Habitat type (AF, SF, PF)	Fixed	12.09	6.046	1.989	0.152965
Error		140.5	1.301		

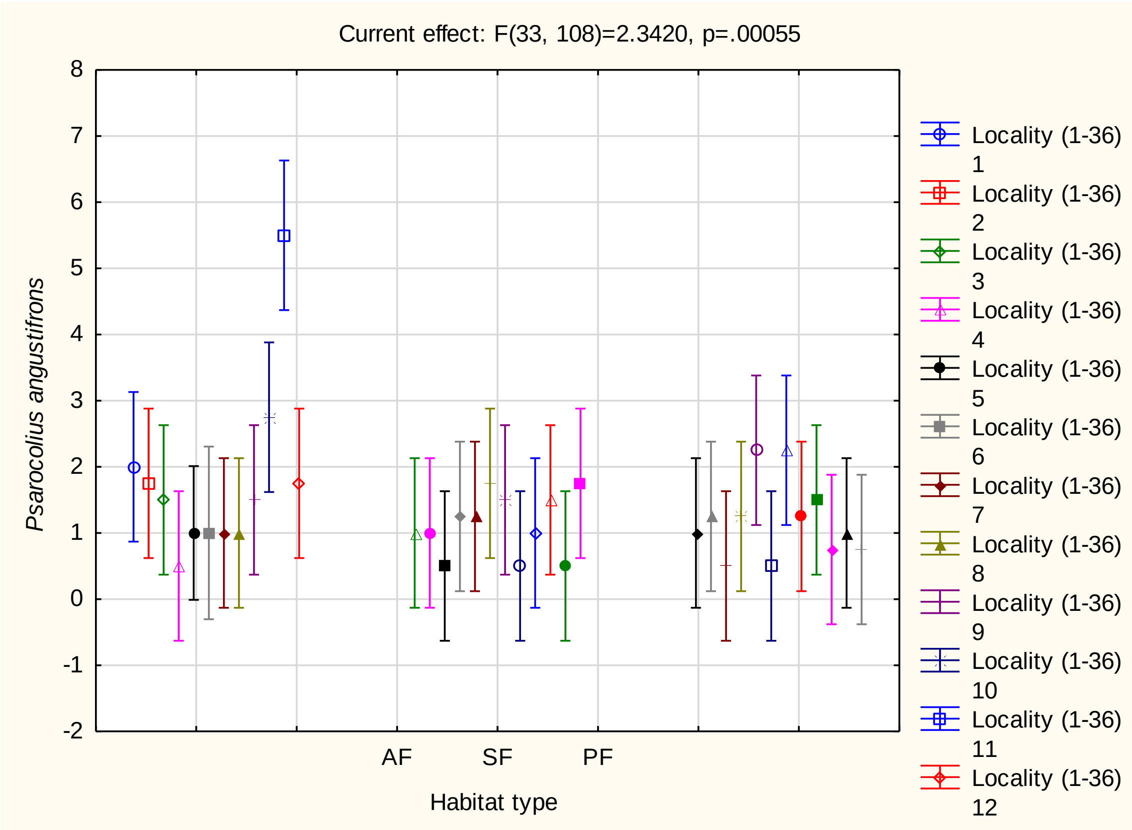


Figure 18 Graphic illustration of an average values of all recorded individuals of *Psarocolius angustifrons* in each locality within all surveyed habitats (1-agroforestry, 2-secondary forest, 3- primary forest)

5.3.2. Abundance of *Cyanocorax violaceus*

I have recorded in total 129 individuals of *C. violaceus*, which is the lowest measured abundance within all selected species. Between the habitats we did not find any significant differences (Table 5). Abundance of species is in general low. However, the highest abundance was measured in agroforests, where I have recorded 58 individuals, the less were recorded in the secondary forests- 40 individuals and only 31 individuals were found in primary forest (Figure 16). We also did not find any significant differences between localities (Figure 17). However, the locality number 18 located in secondary forest has the highest average occurrence of individuals- 2.5.

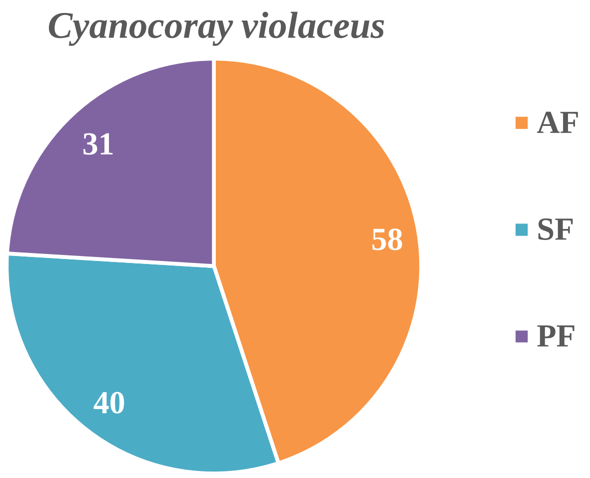


Figure 19 Abundance of *Cyanocorax violaceus* within certain habitats (AF- agroforests, SF- secondary forests, primary forests)

Table 5 Results of nested ANOVA for *Cyanocorax violaceus* do not show the significant differences in case of localities or between habitat types (p>0.05)

	Effect F/R	Sum of square	Mean square	F	p
Locality (1-36)	Random	40.15	1.217	0.985	0.50168
Habitat type (AF, SF, PF)	Fixed	7.021	3.51	2.886	0.06992
Error		133.42	1.236		

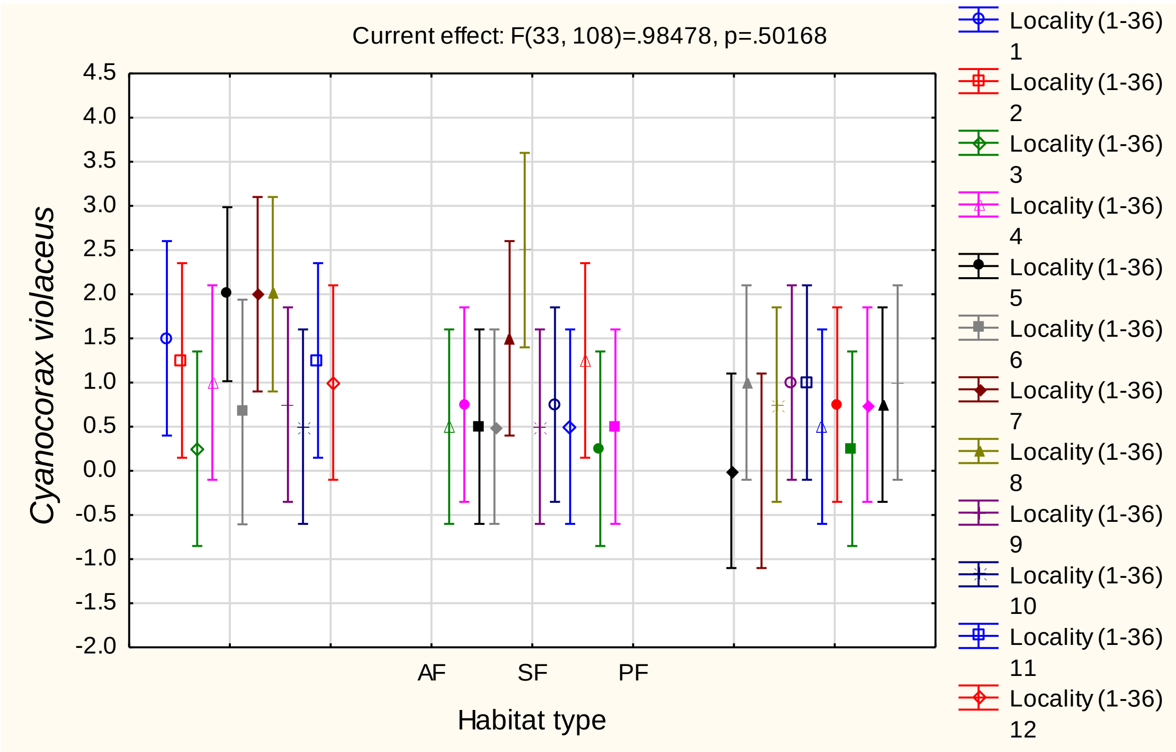


Figure 20 Graphic illustration of an average values of all recorded individuals of *Cyanocorax violaceus* in each locality within all surveyed habitats (1-agroforestry, 2-secondary forest, 3- primary forest)

5.3.3. Abundance of *Cacicus cela*

In total 287 individuals of *C. cela* were recorded within all surveyed habitats. The highest occurrence of this species was recorded in agroforestry systems. I have recorded in total 145 individuals in agroforests, 85 individuals in secondary forest and 57 individuals in primary forest.

For the occurrence of *C. cela*, we have found statistically significant difference within forest types, and even within localities (Table 6 and Figure 18). It means that abundances of birds varies not only in frame of habitats, but they varies even between certain localities. In both cases is *p* value lower than 0.05 (even lower than 0.01). The results show, that there is a significant influence of agroforest on presence and abundance of *C. cela*. However differences between primary and secondary forest are not statistically significant. Moreover the most successful locality number 5 with an average presence of 7.75 individuals was located in agroforests (Figure 19). This statistical result is supported by the fact, that the most nests (16) of *C. cela* were found on this locality.

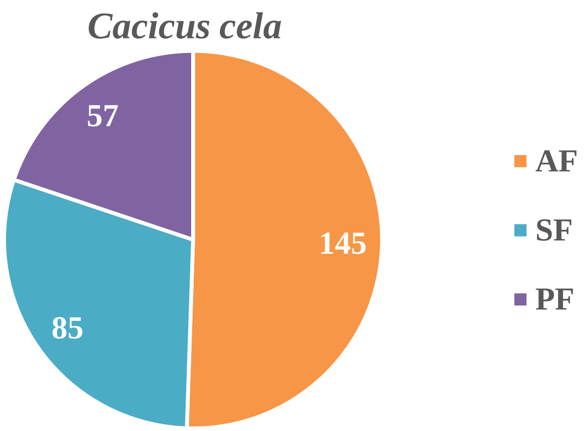


Figure 21 Abundance of *Cacicus cela* within certain habitats (AF- agroforests, SF- secondary forests, primary forests

Table 6 Results of nested ANOVA for *Cacicus cela* shows the significant differences in case of localities even between habitat types (p<0.05)

	Effect F/R	Sum of square	Mean square	F	p
Locality (1-36)	Random	271.9	8.24	2.86	0.000023
Habitat type (AF, SF, PF)	Fixed	73.3	36.65	12.73	0.000011
Error		310.9	2.88		

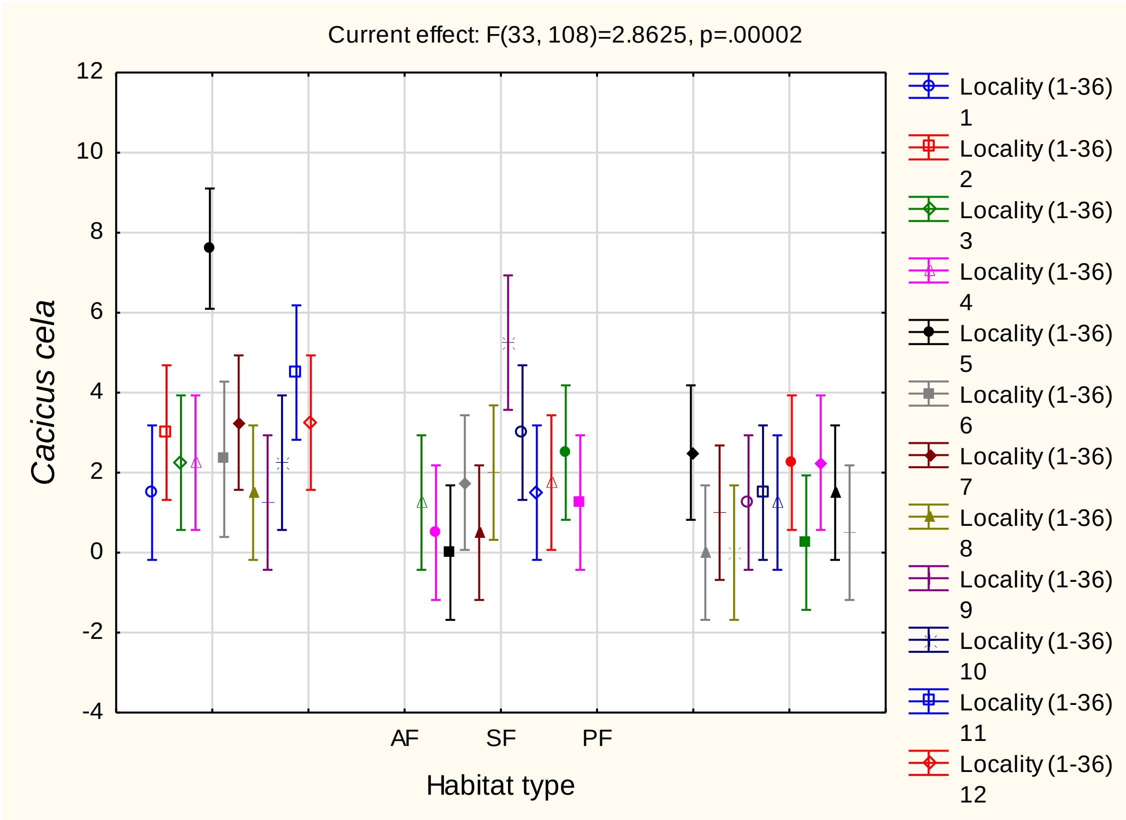


Figure 22 Graphic illustration of an average values of all recorded individuals of *Cacicus cela* in each locality within all surveyed habitats (1-agroforestry, 2- secondary forest, 3- primary forest)

5.3.4. Abundance of *Aratinga weddellii*

A. weddellii is the most abundant species among the surveyed bird species. I have recorded 365 individuals of this species. The majority of them were recorded in agroforests with 207 individuals. In secondary forest were detected 106 individuals and only 52 individuals in primary forest (Figure 20).

The occurrence of *Aratinga weddelli*, resulted from nested ANOVA analysis, is influenced by the habitat type, nevertheless the localities have no significance effect on occurrence of *A. weddellii* (Figure 21; table 7). Agroforestry has the higher influence on *A. weddellii* occurrence than secondary forest and secondary forest has greater influence on presence of species than primary forest. Locality number 1 located in agroforests shown the highest (8) average presence of individuals.

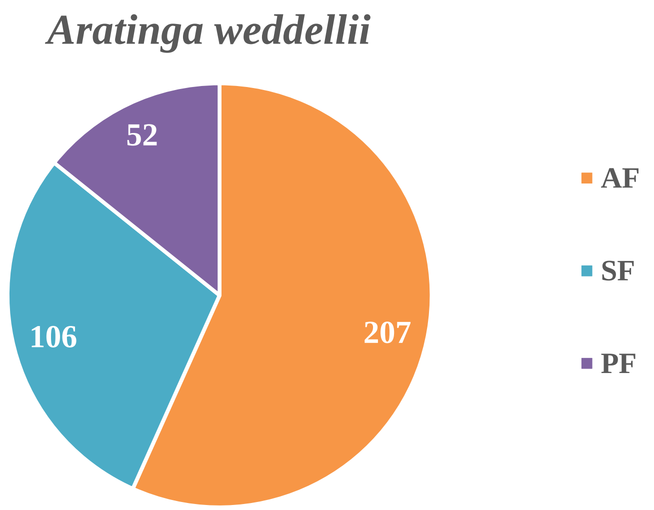


Figure 23 Abundance of *Aratinga weddelli* within certain habitats (AF- agroforests, SF- secondary forests, primary forests

Table 7 Results of nested ANOVA for *Aratinga weddellii* shows the significant differences in case of habitat types ($p<0.05$)

	Effect F/R	Sum of square	Mean square	F	p
Locality (1-36)	Random	235.43	7.13	0.87	0.672898
Habitat type (AF, SF, PF)	Fixed	265.05	132.52	18.57	0.000004
Error		888.47	8.227		

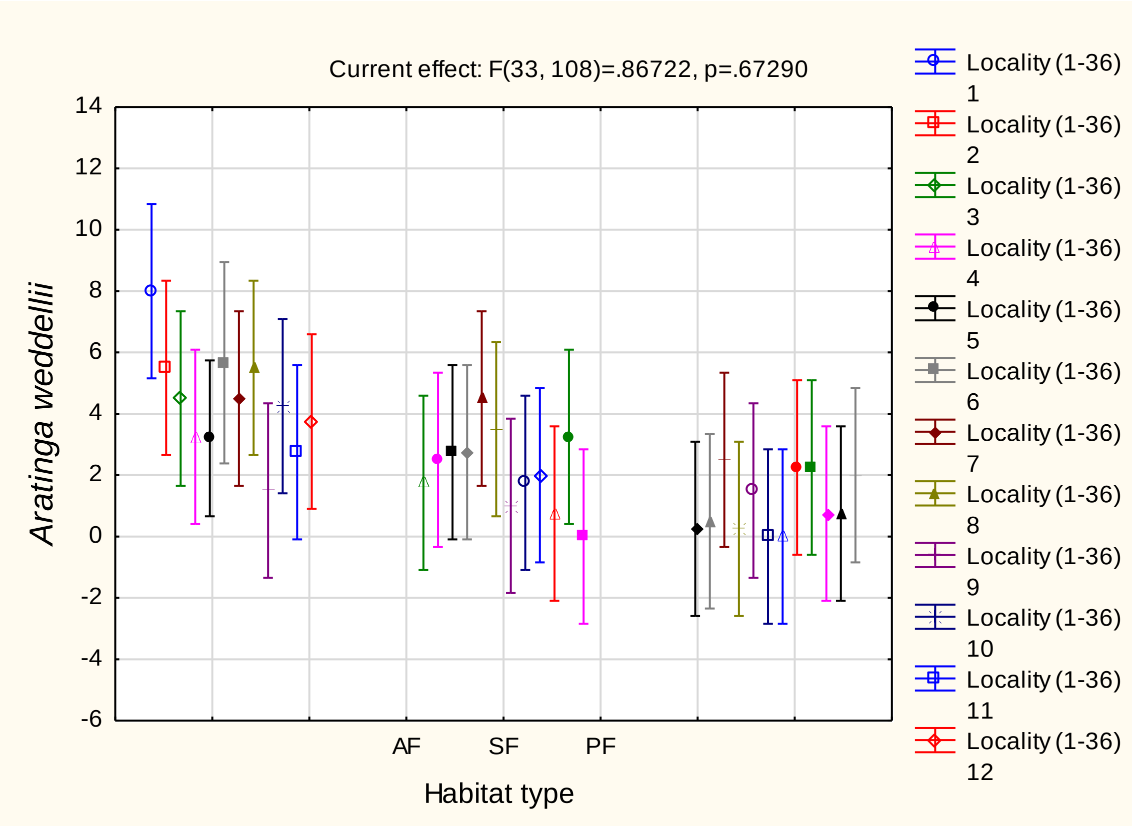


Figure 20 Graphic illustration of an average values of all recorded individuals of *Aratinga weddellii* in each locality within all surveyed habitats (1-agroforestry, 2-secondary forest, 3- primary forest)

5.3.5. Abundance of *Ortalis guttata*

In total I have counted 158 individuals within all surveyed habitats. *Ortalis guttata* is only species, which has the highest occurrence in secondary forest with 81 individuals. We found significant differences between habitats (Table 8). Agroforestry system hosted 49 individuals and only 28 individuals were found in primary forest. The most individuals were most commonly present on locality number 18 (the same as were the most average occurrence of *C. violaceus* present) with an average presence of 4.25 individuals (Figure 21).

The habitats has an effect on presence of *O. guttata*, however localities does not show any statistical significant influence (Figure 22; table8). Analysis shown that secondary forest has the highest effect on species distribution, than primary forest and agroforests. Difference between primary forest and agroforest is not statistically significant.

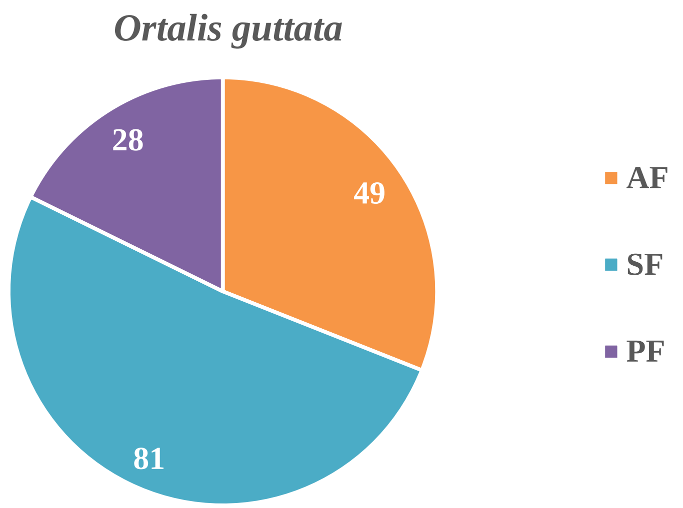


Figure 24 Abundance of *Ortalis guttata* within certain habitats (AF- agroforests, SF-secondary forests, primary forests

Table 8 Results of nested ANOVA for *Ortalis guttata* shows the significant differences in case of habitat types ($p<0.05$)

Ortalis guttata	Effect F/R	Sum of square	Mean square	F	p
Locality (1-36)	Random	106.99	3.24	1.347	0.128946
Habitat type (AF, SF, PF)	Fixed	29.7	14.85	4.584	0.01747
Error		259.97	2.41		

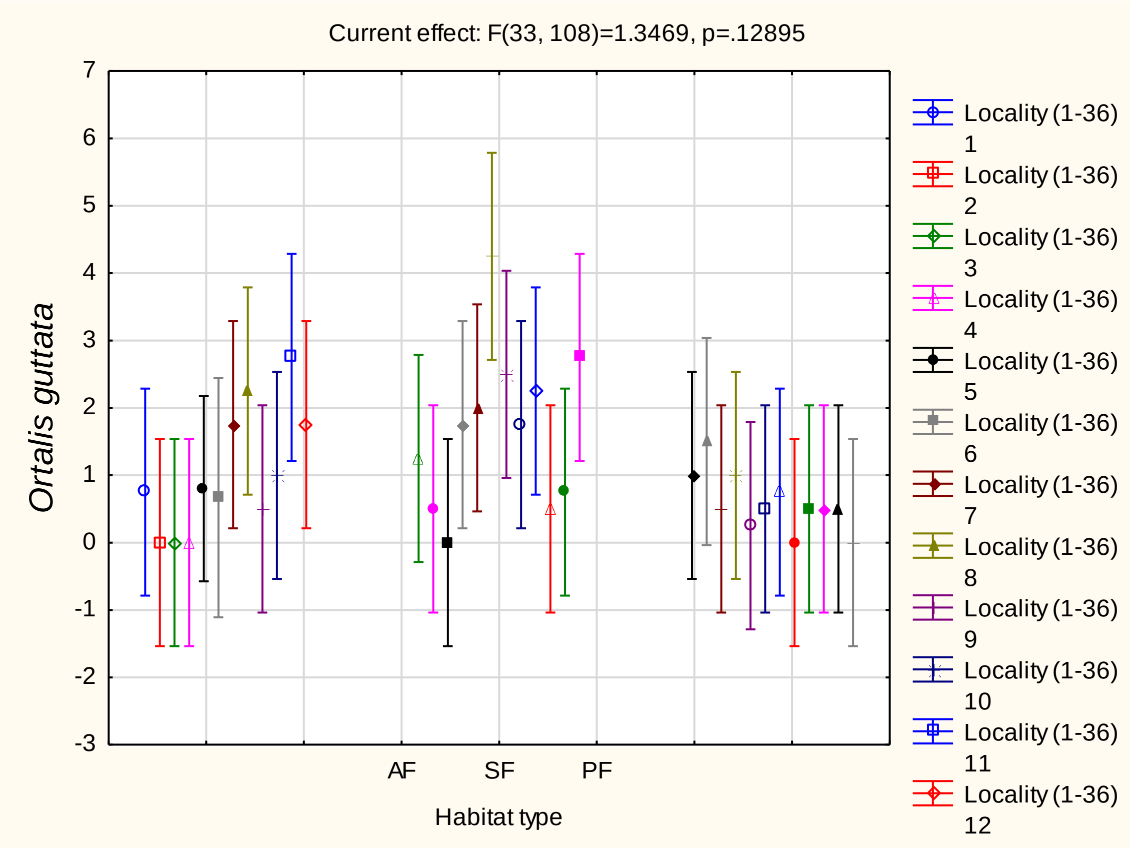


Figure 25 Graphic illustration of an average values of all recorded individuals of *Ortalis guttata* in each locality within all surveyed habitats (1-agroforestry, 2- secondary forest, 3- primary forest)

5.4. Effect of habitat on common occurrence/non-occurrence of selected species

The resulted ordination diagram of detrended correspondence analysis (DCA) is assessment of common occurrence/ non-occurrence of selected bird species. The aim of this analysis was an identification of two main gradients (biotic/abiotic factors influencing presence of species). Diagram shown separation of presence *A. weddellii* from *O. guttata* along the major axis. Species *C. cela* and *P. angustifrons* were separated along the second axis (Figure 23). However, the main importance has the separation along the first axis, because all other axes are perpendicular to the first one. The resulted ordination diagram, shows that habitat type has an influence on common presence, distribution and abundance of selected species. The gradient length is 3.5, what is the reason for using DCA a not PCA (length of gradient result in arch effect, so the linear respond cannot be used).

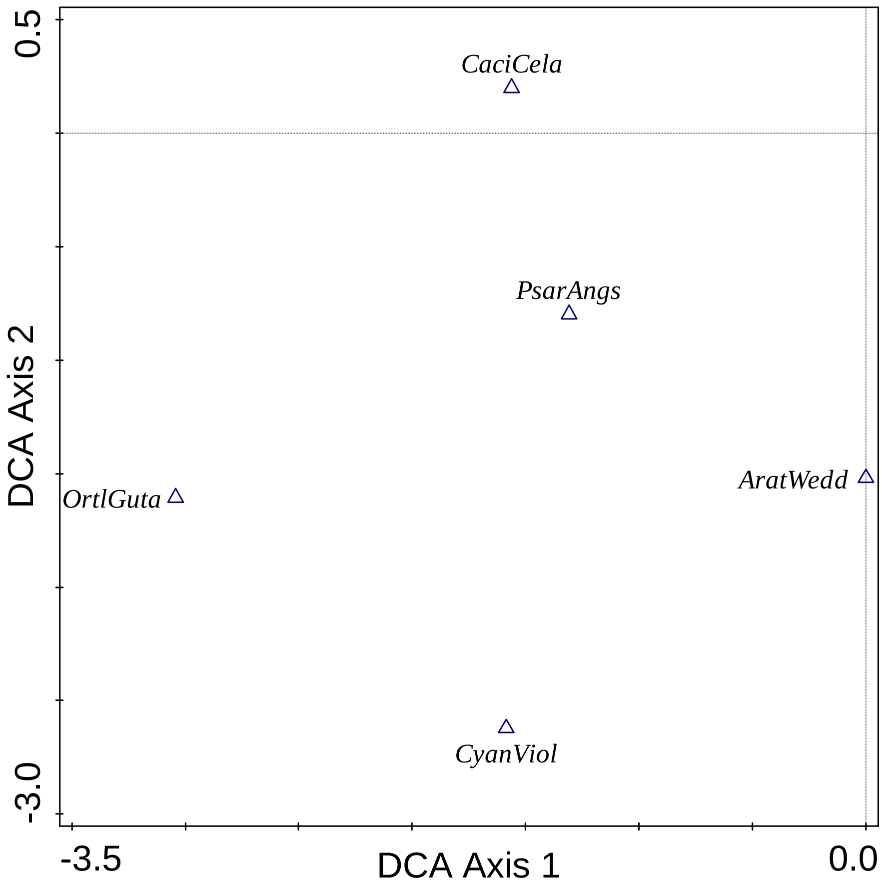


Figure 26 Resulted ordination diagram of DCA, based on common presence and non-presence of species

Canonical Correspondence Analysis (CCA) was used for test of forest type influence on common occurrence/ non-occurrence of five selected bird species. Furthermore, other factors as temperature, daytime, weather type and altitude were deducted from the data, which means, that I have tested "pure" effect of forest on common occurrence/ non-occurrence of species. Species distribution in the ordination space of CCA with used environmental covariates is similar to the results of DCA, which particularly applies to the first axis. Test of both canonical axis is statistically significant. Therefore it can be said that truly exist relation between recorded species composition and habitat type (pseudo-f = 2.9, p = 0.005).

Along the first axis the analysis separate *Aratinga weddellii* and *Ortalis gutata* with regard to the separation of agroforestry systems from the primary and secondary forest.

The position of species in the ordination diagram along the second axis is different from results of DCA (Figure 24). From this fact we can consider that the second DCA does not have the direct link on forest type. If we assess just position of certain species in ordination space (without the link on position of other species) then we can considered that *O. guttata* is the species mainly of the secondary forest *A. weddelli* is mainly linked with agroforestry and the most related species with primary forest is *Psarocolius angistifrons*. Separation along axes in ordination diagram is not enormously significant. However, I did not focused on how significant is an effect, but if the effect exist. Therefore the tested hypotheses that habitat type has an effect on common occurrence/ non-occurrence of selected species is statistically confirmed.

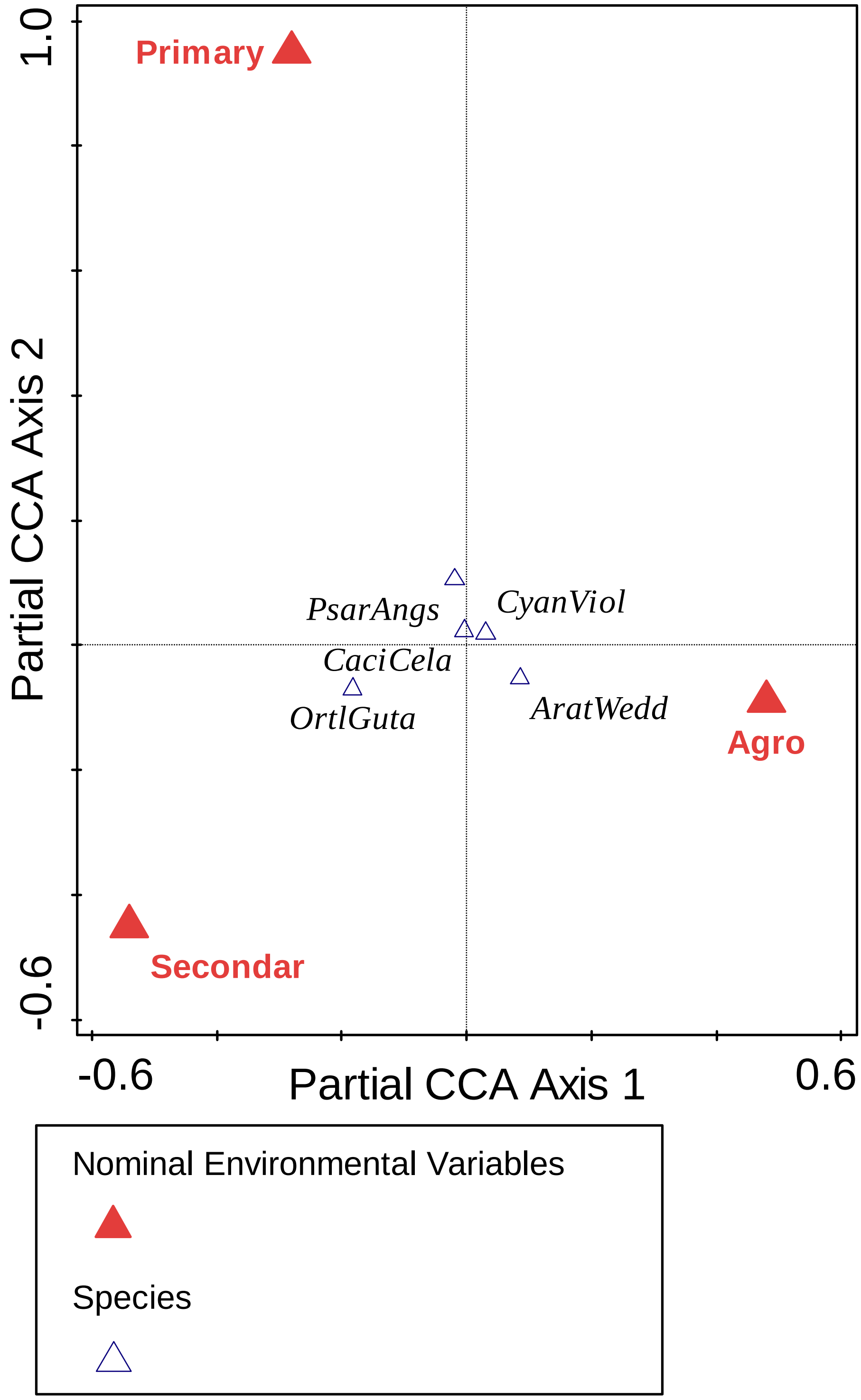


Figure 27 Resulted ordination diagram of partial DCA, based on common presence and non-presence of species in relation with forest type

6. Discussion

This research is part of long-term ongoing project which addresses influence of the cocoa based agroforest on some biodiversity model groups. However, short-term character of this study does not allowed addressing many ecological questions. The research had been realized within the period from the beginning of October until beginning of December. The aim of this study was to find out, if habitat types as agroforestry system, secondary forest and primary forest have influence on presence of selected species. Regarding to ecology of bird species and simplicity of their identification, we have selected five species, which were surveyed: russet-backed oropendola *(Psarocolius angistifrons)*, violaceous jay *(Cyanocorax violaceus)*, yellow-rumped cacique (*Cacicus cela)*, dusky-headed parakeet (*Aratinga weddellii)* and speckled chachalaca (*Ortalis guttata*).

Point counting method was chosen regarding to ecology of selected species. However, Srinivas and Koh (2016) recommend for bird diversity assessment mist-netting method and they have considered point-counting as less suitable method. They have done similar research in the same area (forests close to Pucallpa (primary and secondary forest) and oil-palm plantation in Campo-verde) within the dry period in 2010, however the 64 captured species did not include even one species I have surveyed. It can be caused by the fact, that mist netting is method suitable mainly for understory species, while selected bird species are mainly found in midstory and upper canopy. In the fact I would agree with Pagen et al. (2002) that combination of both methods, thus multiple surveys, would give the great overview of bird abundance and species abundance.

The overview of all species shown, that the most abundant species with 365 individuals is *A. weddellii*. More than half of them were found in agroforestry systems, however the great abundance (106 ind.) was found even in the secondary forest. The second most abundant species is *C. cela*, with 145 individuals recorded in agroforestry systems and much less (85) in secondary forest. Except *O. guttata*, which was the most abundant in the secondary forest, all selected species were recorded mainly in the agroforestry systems.

Statistical analyses proofed, that forest habitat has an influence on presence of species. The relation between bird abundances and forest habitats over localities were significant for *A. weddellii* and agroforestry system, *O. guttata* and secondary forest and had borderline significance for *P. angustifrons* and primary forest. Robiller (1990) stated that *A. weddellii* use hollows in the standing dead trees/log for nest establishment. In selected localities of AF there were many standing dead trees, probably due to the technique of AF establishment (cut trees, burnt of remaining trees). It can be one of the reasons for high occurrence of *A. weddellii* in AF. Furthermore, the cacao based AF provide various fruit and seeds, which are the main diet of this species. *O. guttata* was only species which were significantly more frequent in secondary forest. The secondary forest was closer to the river and its canopy was denser. This is the largest species from selected bird species and AF does not provide close canopy as shelter, such as secondary forest. According to Barrio (2011) cracids are hunted by local people as food resource. The lower presence of this species, belonging into cracids, in agroforestry systems can be caused by local farmers´ hunting pressure.

The overall presence of bird species is significantly higher in the agroforestry systems, than in primary and secondary forest. However, there is necessary to take into account the fact, which was suggested by Van Bael et al. (2008), that agroforestry system is source of food and not all recorded species necessarily use it as a nesting habitat. On the other hand some species had undoubtedly visible nest in the upper canopy (*C. cela and P. angustifrons*). Some of the localities served as habitat for significantly higher abundance of some species. From the graphs is visible that locality number 11 (Figure 9) host repeatedly high number of individuals. The structure of this AF system was different, than the others. It was only AF locality with great abundance of palms, which according to Schulenberg et al. (2010) serves as home tree for Icteridae (oropendolas, caciques, etc.) in general. This locality was flat, despite the others- the others were oriented in the slope. Also it was the locality, which was close to San Alejandro River. All these factors probably influenced the presence and abundance of species. On the locality number 18 was the highest bird abundances in the frame of secondary forest. Even the greatest abundances of *O. guttata* were recorded right there. Greeny and Gelis (2007) stated, that this species commonly occur in riparian forest close to the rivers. This locality was located close to the river, which is in my opinion reason for high abundance of *O. guttata* on this locality. Differences in bird abundances among primary system were not significant.

The results show, that the lowest abundance of selected species were found in the primary forest. However, the most mammals and other bird species were detected mainly in primary forest, even in the greatest abundances. This leads into question, if the low presence of selected bird species in the primary forest could be negatively influenced by other species. The size of selected species is relatively small in comparison with some other species recorded in primary forest, as harpy eagle, red howler, sloth, etc. Furthermore, as Aguiar-Silva et al. (2013) stated, Harpy eagle predates on smaller bird species and according to Schulenberg et al. (2010), the main diet of toucans consist of eggs of smaller birds. The greatest abundances of these other species were recorded right in the primary forest. It means that the presence of these predators decrease abundance of selected bird species- directly by consumption of individuals, or their eggs, or indirectly by startling of target species, by presence of predators (decrease of vocalization, escape).

Agroforestry systems and secondary forests near San Alejandro count just dozens hectares and they are more as single "islands", than continuous forest units. It means that there are spread couple of hectars of forests and between them are agriculture fields and small communities. I agree with Canadell et al. (2007) that AF could serve the function as corridors, which usually host higher abundance of species and individuals, because they easily cannot spread on the wider area. Therefore, CICFOR Macuya is a large continuous primary forest (cca 2,470 ha), which has a bigger capacity and species can be easily spread. Due to this fact could be occurrence of species caused also by landscape fragmentation as mentioned by McNeely (2004). I have to agree with Gustafsson and Hansson that agroforestry systems would be great solution for connectivity in landscape between forests and agricultural land. It would create an eco-corridor and thus serve function as biodiversity conservation tool. Furthermore, thus the agroforestry would create the border of forest, the inside forest could be more protected from the deforestation.

7. Conclusion

We found the highest abundance of selected species in agroforestry systems. Conversely the lowest abundance of selected species was recorded in primary forests. From the results is obvious, that habitat type has an influence on abundance of selected species. Well managed agroforestry system is able to provide easily assessable food source and the occurrence of predators is relatively low, which serve protection to selected species. Furthermore, patchy structure of agroforests provides refuge for species in fast urbanizing surroundings. Agroforestry systems in surrounding of San Alejandro town can be deemed a great habitat for most of selected bird species especially for *Aratinga weddelli* and for *Cacicus cela*, which were recorded in great abundances. I have realized, that secondary forest has an influence on abundance of species *O. guttata*, which is the largest bird of selected species. Its abundances were the highest in secondary forests, probably due to denser canopy and presence of San Alejandro River. However, in primary forest were recorded even other species as Harpy eagle, Hoacins, sloths and red-howler, which would hardly inhabit surveyed agroforestry systems. Thus the need for continuous research in field of bird´s, mammal´s and reptile´s diversity is crucial. Despite this, I would recommend establishment of agroforestry systems around forest borders to connect forests and agriculture landscape and thus landscape connectivity with several benefits ensure. As this study shows, agroforestry can serve as biodiversity conservation.

In my opinion, well managed agroforestry has a potential to conserve biodiversity, due to great provision of different food resources and different niches for variety of native species of fauna and flora.

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