Rapid ecological assessment of mammals from a locality of middle basin at Palmar River, Zulia state, Venezuela

Belkis A. Rivas
Instituto Nacional de Salud Agrícola Integral-INSAL, Ministerio de Agricultura y Tierra, Pueblo Llanco, CP 5125, Mérida, Venezuela; and Fundación La Salle de Ciencias Naturales, Museo de Historia Natural La Salle, Apartado Postal 1930, Caracas 10101 A, Venezuela.belkisarivas@gmail.com

Arnaldo Ferrer
Fundación para el Desarrollo de las Ciencias Físicas, Matemáticas y Naturales, FUDECI. Palacio de las Academias, Edif. anexo, piso 2, Av. Universidad de Bolsa a San Francisco, CP 185, and Fundación La Salle de Ciencias Naturales, Museo de Historia Natural La Salle, Apartado Postal 1930. Caracas, Venezuela.

Olga L. Herrera-Trujillo
Pontificia Universidade Católica do Rio Grande do Sul (PUCRS), Laboratório de Biologia Genômica e Molecular, Av. Ipiranga 6681, Porto Alegre, RS 90619-900, Brazil; Fundación para el Desarrollo de las Ciencias Físicas, Matemáticas y Naturales, FUDECI. Palacio de las Academias, Edif. anexo, piso 2, Av. Universidad de Bolsa a San Francisco, CP 185; Fundación La Salle de Ciencias Naturales, Museo de Historia Natural La Salle, Apartado Postal 1930. Caracas, Venezuela.

David A. Prieto-Torres
Eje BioCiencias; Centro de Modelado Científico de la Universidad del Zulia (CMC-LUZ), and Museo de Biología de La Universidad del Zulia (MBLUZ). Facultad Experimental de Ciencias, CP 4004. Maracaibo, Venezuela.

Abstract. Here we present the results from a rapid ecological assessment of mammals within Campo Boscán, located in the middle basin of the Palmar River in Zulia state, Venezuela. Records for species inventories were obtained from mist-nets and traps surveys and direct observation across three-vegetation types; we also include data from surveys to local communities. We identified 47 mammal species representing 24 families and nine orders, including the first record of the Hairy Big-eared Bat (Micronycteris hirsuta) for the Maracaibo Lake Depression region. Orders Chiroptera, Rodentia and Carnivora represented the most diverse and abundant taxa. Insectivores and carnivores were the most diverse trophic groups. Approximately 13% of the species are included within some threat category. Our results can be used for developing future monitoring programs in order to increase the knowledge on terrestrial vertebrates and biodiversity in general within the region.

Key words: Ecology, species richness, mammals, Maracaibo Lake Depression, Zulia state.

Introduction

The first step for studying biodiversity is the assessment of species richness and its space and time dimensions given that this information represents the most important knowledge resource for developing systematic conservation planning; including its management and monitoring (Sánchez et al. 2004, Martins et al. 2016). In this sense, information regarding presence/absence, abundance and diversity of species, especially mammals, has been fundamental for further understanding other important ecological parameters such as population dynamics, communities structure and ecological processes (e.g., dispersion, pollination), as well as to identify and assess biodiversity loss (Voss & Emmons 1996, Wright et al. 2000, Prieto-Torres et al. 2011, Martins et al. 2016).

In Venezuela, knowledge about the taxonomy and biogeography of mammals has considerably increased recently, including a complete and updated list (Linares 1998, Sánchez & Lew 2012). According to a recent update on mammals of the world from Wilson and Reeder (2005) the total number of mammal species reported for Venezuela is 391; this includes 14 orders, 47 families and 184 genera (Sánchez & Lew 2012, Quiroga-Carmona & Woodman 2015). However, despite these contributions, diverse studies have shown that species diversity values are evidently an underestimation (e.g., Ceballos et al. 2002, Sánchez and Lew 2012), suggesting the existence of significant knowledge gaps and absence of studies in numerous regions and habitats, especially in the northwest region of the country (e.g., Prieto-Torres et al. 2011, 2015a, b).

In this sense, the Maracaibo Lake Depression (MLD; Figure 1) is located in the Zulia state (northwest Venezuelan) and is considered a unique and important bioregion in the country, due to its climatic, geologic and ecological (including species diversity) characteristics (e.g., PDVSA 1993, MARN 2000, Rivas 2006, Rodriguez et al. 2010, Prieto-Torres et al. 2011). The most up-to-date information about this region indicated an approximate of 160 mammal species (representing 35 families and 11 orders), which represent ~83 and ~41% of all mammal species reported for Zulia state and Venezuela, respectively (Rivas 2006, Prieto-Torres et al. 2015b). Despite this bioregion offers great potential from a taxonomic perspective it has received
relatively little attention from ecologists and conservationists, as compared with Venezuelan Andes, the Central Coast Cordillera and the Guyana regions (e.g., Soriano et al. 1999, Machado & Soriano 2007, Lasso et al. 2009, Garcia et al. 2015, 2016). Furthermore, it is important to highlight that MLD has been affected, in the last 70 years, by agricultural and oil-extraction activities, which has resulted in rapid modification and fragmentation of ecosystems (Duarte 1991, Romero & Monasterios 1996, Colonello & Lasso-Alcala 2011). Based on this accelerated environmental deterioration (i.e., habitat loss), it is urgent to reliably assess the magnitude of these problems in local scales. This information will allow to design alternative measures for conservation, protection and adequate management of the natural areas within the region (e.g., Lasso et al. 2009, Rossi et al. 2016).

Here we present the results from the first rapid ecological assessment (REA; Lasso et al. 2009) of mammals from Campo Boscán, located in the middle Basin of the Palmar River on MLD. Our specific goals are: a) to provide a mammal species list for the study area, and b) to provide a brief characterization of the mammal species reported in terms of trophic level, distribution and conservation categories ñ both national and international. Additionally, we discuss about the importance of these results to increase the current knowledge of MLD's biodiversity and set the basis for future monitoring programs in the region.

Materials and methods

Study area. Campo Boscán is located southwest of Maracaibo city, in the middle basin of the Palmar River (Figure 1); which is part of the natural region known as Altiplanicie de Maracaibo (with a slope lower than 2%) inside of the MLD province. Soils are relatively recent, or incipient, due the dry and semiarid climate of the area, and its surface corresponds mainly to sediments originating from Sierra de Perijá (COPLANARH 1975). The annual precipitation patterns are seasonal, with maximum rainfall peaks in October and May, while the average annual temperature is 27.7°C with a mean of 76% of relative humidity (SVMC 2008). Four vegetation types are present (Fernández et al. 2007, Rodríguez et al. 2010, Colonello et al. 2014): (a) the lowland dry forests, which represent the dominant vegetation before deforestation; (b) the riparian evergreen forests, located with lowest density in the floodplain of the Palmar River; (c) the intervened scrubs (with 2 to 6 m in height), which are located in non-flooded and abandoned pastures of highlands in the northeast sectors of Campo Boscán; and (d) the flooded and non-flooded grasslands (not included in our study) that correspond to artificial environments delimited by ridges and introduced pastures.

Data collection. In order to obtain a preliminary diversity estimation of mammals within the area, we performed a rapid ecological assessment (from 20 to 30 November 2004, with 8 days duration). Sampling methods included traps and mist-nets, as well as records obtained from direct observations and surveys to local communities. Collecting procedures were authorized by the Venezuelan Ministry of Environment under a scientific collection license and followed the ethical guidelines for animal research established by Latin American Mammalogy Network (RELAM, in Spanish).

First, for capturing small and medium non-volant mammals, we implemented three lineal transects (two in the lowland dry forests and one in the grassland/scrubs; Figure 1), where three types of catch traps (i.e., Tomahawk, Sherman and Victor [i.e., blow]) were placed properly baited (Tirira 1998, Prieto-Torres et al. 2011). Each transect had 36 Tomahawks, 36 Sherman and 36 blows traps, 10-15 m apart, alternately arranged. The traps were baited with a mixture made of peanut butter, sardines, and cornmeal (Tirira 1998, Rossi et al. 2016). These were checked daily in the morning, and all captured individuals were collected. For this method, the sampling effort was of 342 to 537 trap-nights in the lowland dry forests and the grassland/scrubs, respectively. Complementarily, a total of 11 mist nets (of 912 m in length) were used in order to capture bat species; these were placed only in the lowland dry forests and the riparian evergreen forests (Figure 1) with a sampling effort of 64 hours/mist nest. Third, medium- and large-sized species having diurnal and/or nocturnal activity were inventoried from censuses carried out at a constant speed (i.e., ~1.5 km/h) along the transects at each sampling site. For each record, the following data was registered: species observed, number of individuals within the group (in the case of social species), detection method (visual or auditory), place and time of observation. In addition, occasional observations and indirect evidence (footprints, scats, nests, and carcasses) were also considered (e.g., Tirira 1998, Prieto-Torres et al. 2011, Rossi et al. 2016). Further, interviews with local people were conducted based on illustrations found in Linares (1998).

Each collected specimen was either prepared as skin, skull, and skeleton or fixed in 10% formalin and later preserved in 70% alcohol. These specimens were deposited in the mammal collection of the Museo de Historia Natural La Salle (MHNLS), Caracas, Venezuela (Table 1). All specimens were identified according to Sánchez and Lew (2012), which represent the most updated list of mammals for Venezuela since Wilson and Reeder (2005). This last update incorporates new species’
descriptions (e.g., Sánchez-H et al. 2005), new records of species for the country, as well as the recent reviews of species and description of new genera (e.g., Emmons 2005, Larsen et al. 2007, Quiroga-Carmona & Woodman 2015).

Data analyses. We estimated species rarefaction curves for species collected by both methods together (i.e., traps and mist nests). To test sampling sufficiency during the study, we estimated the species richness using the first order Jackknife and its respective confidence intervals, using program EstimateS 9.1.0 (Colwell 2013), considering as sampling unit each collecting day. These curves represent the cumulative number of species against the increase of collecting effort, obtained after 50 randomizations. The Jackniffe was used because it is easy to interpret, as it expresses the total estimated species richness through a relatively simple function of the number of rare species (Heltshe & Forrester 1983).

In order to briefly characterize the mammal species, we provided information about the distribution, trophic levels and conservation categories for each species. First, all species were categorized based on their national distributional range (see Linares 1998) in: a) Widely Distributed (WD; those that occupy large and continuous extensions in the country); b) Broad Distributed (BD; those that occupy large but discontinuous extensions); c) Broad-Restricted (BR; those species that despite occupy large areas are restricted to a particular habitat or ecosystem); and d) Restricted (R; those distributed throughout two or three continuous bioregions). Then, we calculated the percentage of species corresponding to each trophic level (e.g., omnivore, frugivorous, granivorous, others). Finally, we indicated the conservation status to species at national (Rodríguez et al. 2015) and International levels (IUCN 2015), as well as indicate those species included in the Appendixes of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES 2011).
Results
Species richness. For this study, we recorded 47 species belonging to nine orders and 24 families (Table 1). From these species, 32 were recorded during field work (28 collected and 4 observed), while 15 corresponded to species referred by local people. The greatest richness was observed for the Chiroptera order with 20 species (42.55%), followed by Rodentia and Carnivora with nine (19.14%) and eight species (17.02%), respectively. However, the rarefaction curves (Figure 2) showed that the survey did not reach the asymptote, which indicates that more species are expected in the sampling site. The first order Jackknife estimator of species richness predicted a richness of 59.95 species, which was beyond the 95% confidence intervals of the observed cumulative curve (Figure 2).

Distribution, trophic levels and conservation categories. The Table 1 and Figure 3 shows a brief characterization based on distribution, trophic levels and conservation categories for the mammal community reported in Campo Boscán. Of all species recorded, 42 (89.4%) occupy a broad geographic distribution (WD = 18; BD = 14; and BR = 10), and five (10.6%) were described with restricted distribution (Table 1). We observed that 59% (n = 28) of reported species correspond ecologically to riparian evergreen forests (with 20 species reported only in this vegetation), while 43% (n = 20) correspond to the lowland dry forests (with 13 exclusive species) and 17% (n = 8) to grassland (5 exclusive species). Furthermore, based on the trophic levels found, insectivorous species were the most dominant (41.9 %), followed by groups of carnivorous (n = 6; 14 %), omnivores (n = 5; 11.6 %), frugivorous (n = 4; 9.3 %) and granivorous (n = 4; 9.3 %).

Finally, according to the national and international conservation status of species, three species (i.e., Leopardus tigrinus, Lontra longicaudis, and Tapirus terrestris) are considered Endangered. From these, the species L. tigrinus, L. pardalis and L. longicaudis are include in the Appendix I of CITES, while T. terrestris, Puma concolor, and Bradypus variegatus are considered within the Appendix II. In addition, the Official Gazette of Venezuela Republic (1996) considers three of these species (L. pardalis, L. tigrinus, and L. longicaudis) as Under Special Protection. The remaining species (~87 %) do not have direct or indirect pressures of importance that promote their inclusion within some threat category.
### Table 1. Composition of mammal species recorded at Campo Boscán in the middle Basin at Palmar River, Zulia State, Venezuela. The records were divided in Co= collected, Obs= observed, and Ref= Referenced by local people. We reported vegetation type (LDF: Lowland Dry Forest, REF: Riparian Evergreen Forest and G/S: Grassland/Scrubs), distribution (WD=Widely Distributed, BD= Broad Distributed, BR= Broad Deposited in species name correspond to specimens deposited in the Museo de Historia Natural La Salle (MHNLS; see Species List in results). Numbers in species name correspond to specimens deposited in the Museo de Historia Natural La Salle (MHNLS; see Species List in results).

| Taxa                                      | Evidence | LDF | REF | GDs | Distribution Range | Trophic level | IUCN Ref. List | National category |
|-------------------------------------------|----------|-----|-----|-----|--------------------|---------------|----------------|------------------|
| **DIDELPHIMORPHA**                        |          |     |     |     |                    |               |                |                  |
| Didelphis marsupialis Linnaeus, 1758       | Co, Obs  | WD  | Omn | LC  | LC                 |               |                |                  |
| Marmosa robinsoni Bangs, 1898              | Co       | x   |     |     | Ins-Frug           | LC            |                |                  |
| Marmosa murina (Linnaeus, 1758)           | Co       | x   |     |     | Ins-Frug           | LC            |                |                  |
| **RODENTIA**                              |          |     |     |     |                    |               |                |                  |
| Hydrochoerus isthmius Goldman, 1912        | Ref      |     |     |     |                    |               |                |                  |
| Calomys hummelinki (Husson, 1960)          | Co       | x   |     |     | BD                 | Omn           | LC             | LC               |
| Oecomys bicolor (Tomes, 1806)              | Obs      | x   |     |     | WD                 | Gran-Frug     | LC             | LC               |
| Sigmodon alstoni (Thomas, 1881)            | Co       | x   |     |     | BR                 | Herb          | LC             | LC               |
| Zygodontomys brevicauda (Allen & Chapman, 1893) | Co      | x   |     |     | WD                 | Herb          | LC             | LC               |
| Conuscus pacus (Linnaeus, 1766)            | Ref      |     |     |     |                    |               |                |                  |
| Coendou prehensilis (Linnaeus, 1758)       | Ref      |     |     |     |                    |               |                |                  |
| Prochoeres canicollis (Allen, 1890)        | Co       |     |     |     |                    |               |                |                  |
| Notiosurus granatensis Humboldt, 1811      | Ref      |     |     |     | WD                 | Omn           | LC             | LC               |
| **LAGOMORPHA**                            |          |     |     |     |                    |               |                |                  |
| Sylvilagus floridanus (Allen, 1890)        | Co, Obs  |     |     |     | WD                 | Foli          | LC             | LC               |
| **CARNIVORA**                             |          |     |     |     |                    |               |                |                  |
| Ursus cinereorargenteeus (Schreber, 1775)  | Ref      |     |     |     |                    |               |                |                  |
| Leopardus pardalis (Linnaeus, 1758)        | Obs      | x   |     |     | WD                 | Carn           | LC             | Vu/USP           |
| Leopardus tigrinus (Schreber, 1775)        | Ref      |     |     |     | WD                 | Carn           | Vu             | Vu/USP           |
| Puma concolor (Linnaeus, 1771)             | Ref      |     |     |     | WD                 | Carn           | LC             | LC               |
| Puma yagouaroundi (E. Geoffroy Saint-Hilaire, 1803) | Ref |     |     |     | WD                 | Carn           | LC             | LC               |
| Conopuma canescens (Geoffroy, 1789)        | Ref      |     |     |     |                    |               |                |                  |
| Lontra longicaudis (Allen, 1890)           | Co, Obs  |     |     |     |                    |               |                |                  |
| Procyon cancrivorus (Cuier, 1798)          | Ref      |     |     |     |                    |               |                |                  |
| Cebus albifrons (Humboldt, 1812)           | Obs      | x   |     |     | BD                 | Ins-Frug      | LC             | LC               |
| **CHIROPTERA**                            |          |     |     |     |                    |               |                |                  |
| Nycticeius dobsoni natio (Wied-Neuwied, 1820) | Co      |     |     |     |                    |               |                |                  |
| Saccopteryx bilineata (Temminck, 1838)     | Co       |     |     |     |                    |               |                |                  |
| Noctilio albiventris Desmarest, 1818       | Co       | x   |     |     | BR                 | Ins-Pisc       | LC             | LC               |
| Lonchionycteris aurita (Tomes, 1863)       | Co       | x   |     |     | BR                 | Ins           | LC             | LC               |
| Micropteropus hirsuta (Peters, 1869)       | Co       | x   |     |     | BR                 | Ins-Frug      | LC             | LC               |
| Micropteropus megalotis (Gray, 1869)       | Co       | x   |     |     | WD                 | Ins-Frug      | LC             | LC               |
| Saccopteryx microt (Wright, 1899)          | Co       |     |     |     |                    |               |                |                  |
| Micropteropus minutus (Gervais, 1850)      | Co       |     |     |     |                    |               |                |                  |
| Micropteropus schmidtorum Sanborn, 1935    | Co       |     |     |     |                    |               |                |                  |
| Gardneria crenulatum (Geoffroy Saint Hilaire, 1810) | Co |     |     |     | WD                 | Carn-Ins      | LC             | LC               |
| **PRIMATES**                              |          |     |     |     |                    |               |                |                  |
| Alouatta seniculus (Linnaeus, 1766)        | Obs      |     |     |     |                    |               |                |                  |
| Cebus albifrons (Humboldt, 1812)           | Obs      |     |     |     |                    |               |                |                  |
| **PERISSODACTYLA**                        |          |     |     |     |                    |               |                |                  |
| Bradypus variagatus Schinz, 1825           | Ref      |     |     |     |                    |               |                |                  |
| Tapirus terrestris (Linnaeus, 1758)        | Ref      |     |     |     |                    |               |                |                  |
Figure 3. Representative mammal species inventoried in sampling sites at Campo Boscán, middle basin of the Palmar River in Zulia state, Venezuela. Letters correspond to: Marmosa robinsoni (a); Proechimys canicollis (b); Procyon cancrivorus (c); Alouatta seniculus (d); Marmosa murina (e); Lonchorhina aurita (f); Mimon crenulatum (g); Lophostoma silvicolum (h); Rhynchonycteris naso (i); Desmodus rotundus (j); Micronycteris schmidtorum (k); Micronycteris hirsuta (l). Photos of Oscar Lasso and Arnaldo Ferrer.
Discussion

For MLD’s mammals, studies on inventories, population dynamics and community structure are practically non-existent in the middle basin at Palmar River. In this context, the present study contributes to increase the current knowledge of biodiversity and threatened species in region. Mammals families and species reported in Campo Boscán represent 52.2 % and 12.7 % of the total reported for Venezuela, respectively (Sánchez & Lew 2012); as well as the 63.2 % and 33.6 %, respectively, for the Zulia state (Rivas 2006, Prieto-Torres et al. 2015b). Despite that these results can be described as satisfactory, it is important to note that only approximately ~78 % (considering the 15 species reported by local people) of richness predicted by the Jackknife richness estimator were recorded. This last fact was due to the short sample period (a characteristic of REDAs studies; Lasso et al. 2009), the climatic conditions that produced floods in the riparian evergreen forests (producing a lower sampling effort during the study), and capturing methods used (e.g., Voss et al. 2001, Martins et al. 2016). Unlike other vertebrates that can be effectively poisoned, captured and/or hunted, most of mammals can only be inventoried by trapping, which could require in most cases long-term efforts to obtain a complete data (e.g., Voss et al. 2001, Prieto-Torres et al. 2011, García et al. 2015, 2016, Martins et al. 2016). This is the case of some forest canopy species (e.g., arboreal marsupials and rodents), which require of other additional techniques such as acoustic methods and camera traps (Ochoa et al. 2005, García et al. 2015, 2016, Martins et al. 2016); here not used due the logistical difficulties and resource unavailability.

All species documented have been previously reported for other areas in the Zulia state (e.g., Osgood 1910, 1912, Méndez-A 1953, Pirlot1963, Handley 1976, Duarte 1991, MARN-PROFAUNA 1991, 1997, Viloria & Calchi 1993, Sánchez et al. 1999, Rivas 2006, Prieto-Torres et al. 2011). However, the Hairy Big-eared Bat specimen (Micronycteris hirsuta) herein reported, represents the first record of the species for MLD region (Prieto-Torres et al. 2015a). This species had only been reported for the state in Sierra de Perijá, on elevations up to 1,000 m. only (Prieto-Torres et al. 2015b). Consequently, it is expected that the recorded 47 species are not the only representatives within this locality. In fact, survey’s effort was carried out in the length of 10 days, less than in other surveys (e.g., Prieto-Torres et al. 2011, Martins et al. 2016); therefore, it is expected that by increasing the sampling effort throughout the four vegetation types, new species should be reported for the area (see Figure 2).

Despite the differences on sampling efforts for all vegetation types, the percentage of species reported associated with the riparian evergreen (n = 20; 42 %) and lowland dry (n = 13; 28 %) forests could be explained, on one hand, by the bats sampling (see below; Table 1) during the study. However, alternatively, results can be explained by the greater spatial heterogeneity of riparian habitats, which provide greater diversity of refuges and food (e.g., Machado et al. 2016). It is also possible to infer that the species richness observed in Campo Boscán is considerably high due the overlap of different environments (i.e., ecotones) in this region; this is evidenced by the presence of four species (Sylvilagus floridanus, Calomys hummelincki, Sigmodon alstoni, and Urocyon cinereoargenteus) defined as characteristic elements of dry forests and savannas. This mixed composition increases the biological importance of region (e.g., Costa et al. 2000, Joshi 2016, Machado et al. 2016), which emphasizes the need for its conservation in order to preserve the biodiversity of these fragments.

Most species of mammals in our study have wide distributions along Venezuela and some medium-size and large species were strongly associated with diverse ecotones mainly dependent on water body for example L. longicaudis, Procyon cancrivorus, and Hydrochaeris isthmus. Felid species (Carnivora), such as Puma concolor and P. yagouaroundi, are mainly associated with riparian evergreen forest areas, but can expand their home range given their ability to occupy open areas with intervened covers such as pastures and crops (MARN-PROFAUNA 1997, Prieto-Torres et al. 2011, Machado et al. 2016). Furthermore, despite Primates are among the most endangered groups, it is important to note that there is few information on the ecology and conservation status of species such as Alouatta seniculus and Cebus albifrons in MLD’s areas (Portillo & Velásquez 2006). These species have broad phenotypic flexibility and occur in small forest fragments, which demonstrates a high capacity to adapt to environmental changes (Boubli et al. 2008, de la Torre et al. 2015). Therefore, although these species usually inhabit larger areas, its presence in areas outside close Protected Areas (i.e., Sierra Perijá and Juan Manuel National Parks) could be important for its preservation (Portillo & Velásquez 2006).

Bat species composition and richness varied along sampling sites at Campo Boscán (Table 1). The high abundance of most common species such as Noctilio albiventris, Desmodus rotundus and Glossophaga longirostris could indicate the availability of resources for generalists such as roost sites and food sources (e.g., livestock for D. rotundus and artificial lakes stocked with fish for N. albiventris). This last idea is supported by the presence of varied species of insectivores, frugivores, nectarivores, hematophages, and piscivores (Novaes & Nobre 2009, Shapiro & Bordignon 2014). In addition, the presence of individuals from the subfamily Phyllostominae which are considered bio-indicators (Fenton et al.1992) could indicate a fair ecosystem health, despite the level of perturbation observed, given that bats provide valuable ecosystem services such as...
insect populations’ control (including agricultural pests), seed dispersal, and plant pollination (e.g., Kelm et al. 2008, Kunz et al. 2011, Shapiro & Bordignon 2014). However, further sampling is necessary at this site to assess the role of these species in the secondary succession and the regeneration of degraded forests in the area (Kelm et al. 2008, Kunz et al. 2011). Further, based on the high relative frequency observed for the common vampire bat (D. rotundus), a transmitter of bovine rabies (Baer 1982; Greenhall et al. 1983), future studies should be implemented regarding sanitary control to avoid economic loss.

In terms of conservation, unfortunately there is no other information about the extant wildlife found in the area; however, it is evident the negative effects of habitat loss and hunting over local wildlife populations. Forests have been reduced considerably, only leaving isolated relicts in almost the entire area (Duarte 1991, Romero & Monasterios 1996, Rodríguez et al. 2010, Colonello & Lasso-Alcalá 2011). Many mammal species are dependent on native vegetation cover, thus, fragmented and reduced habitats I such as Campo Boscá’i can lose the original mammal community if species are not able to find the resources for long-term survival (Chiarello 1999, 2000, Machado et al. 2016). This is probably the case for species such as T. terrestris I considered locally extinct (IUCN 2015, Rodríguez et al. 2015) and the Brown Spider Monkey (Atelidae hibrydus), a common species in other MLD’s localities (Portillo & Velásquez 2006), which was not observed or referenced during the study, as well as neither the armadillo (Cabassous centralis), deer (Mazama amaricana, M. bricenii, and Odocoileus cariaticus) and peccaries (Pecari tajacu and Tayassu pecari) species I all species reported as heavily hunted in the region (e.g., Prieto-Torres et al. 2011). In this sense, the information obtained suggests the need for implementation of improved conservation strategies focusing on the importance of minimizing impacts in the area.

Definitely, a single-species approach to conservation, management, and monitoring is insufficient to combat the threat to the overall biological diversity of an area (Joshi 2016). Thus, rapid ecological assessment and multi-species-based monitoring approaches are believed to be more reliable, timely, and informative in describing and measuring changes in populations, communities and biological diversity in general (Joshi 2016, Martins et al. 2016). In this sense, our results provide a valuable database in order to recognize and promote this area as an important wildlife resource; which currently have been affected by important problems related to the loss, fragmentation and degradation of habitats (Romero & Monasterios 1996, Rodríguez et al. 2008, Colonello & Lasso-Alcalá 2011, Colonello et al. 2014). This information can be used for the development of monitoring and conservation programs, promoting the recovery, reforestation and connectivity of forest patches I important for endangered species with large home-range such as L. pardalis, L. tigrinus and L. longicaudis. Additional studies on the abundance/distribution and status of wildlife species, also involving local communities and all stakeholders, from MLD is of supreme importance for securing long-term persistence of mammalian fauna in the area.

Acknowledgements

We would like to acknowledge the contributions of the Fundación La Salle de Ciencias Naturales, which provided financial and logistical support. Monica Chocrom by the assistance in fieldworks. Oscar Lasso and Giuseppe Colonnello kindly provided the photos of the specimens and sampling sites. Cristina Vallejo kindly reviewed the translation.

References

BAER, G. M. 1982. Historia natural de la raba. México, Ed. La Prensa Médica Mexicana.

BOUBLI, J. P., et al. 2008. Alouatta seniculus. The IUCN Red List of Threatened Species 2008: e.T40642A10347360. Available in: http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T40642A10347360.en. Downloaded on 16 December 2016.

CEBALLOS, G., et al. 2002. Mammíferos de Venezuela. Pp. 567-582 in Diversidad y conservación de los mamíferos del Neotrópico (Ceballos G & Simonetti JA eds.). Comisión Nacional para el Conocimiento y Uso de la Biodiversidad - CONABIO y la Universidad Nacional Autónoma de México. Ciudad de México, México.

CHARELLO, A. G. 1999. Effects of fragmentation of the Atlantic forest on mammal communities in south-east Brazil. Biological Conservation 89:71-82.

CHARELLO, A. G. 2000. Density and population size of mammals in remnants of Brazilian Atlantic Forest. Conservation Biology 14:1649-67.

CITES. 2011. Convention on International trade in endangered species of wild fauna and flora. Available in: http://www.cites.org/eng/app/appendices.shtml.

COLONNELLO, G. & O. LASSO-ALCALÁ. 2011. Diagnóstico ambiental de la Cuenca del Lago de Maracaibo, Venezuela. Pp. X-Z in Informe para gestores y encargados de tomar decisiones (Voipedo AV, et al. eds.), RED CYTED 411RT0430. Buenos Aires, Argentina.

COLONNELLO, G., et al. 2014. Cambios en la composición de plantas asociadas a humedales como consecuencia de la intervención humana en el litoral lago Maracaibo, Venezuela. Revista de la Facultad de Agronomía 73:19-34.

COSTA, E. P., et al. 2000. Biogeography of South American forest mammals: endemism and diversity in the Atlantic Forest. Biotropica 32:872-881.

DE LA TORRE, S., et al. 2015. Cebus albifrons. The IUCN Red List of Threatened Species 2015:e.T39951A81236767. Available in: http://dx.doi.org/10.2305/IUCN.UK.2015.RLTS.T39951A81236767.en. Downloaded on 16 December 2016.

DUARTE, M. 1991. Contribución al conocimiento de la fauna de mamíferos del Estado Zulia (Thesis dissertation). Zulia state, Venezuela: Universidad del Zulia. 126 pp.

EMMONS, L. H. 2005. A revision of the genera of arboreal Echimyidae (Rodentia: Echimyidae, Echimyinae), with descriptions of two new genera. Pp. 247-309 in Mammalian diversification from chromosones to phylogeny (A Celebration of the Career of James L. Patton) (Lacey EA & Myers P eds.). USA: University of California Publications. Zoology, Vol. 133.

FENTON, M. B., et al. 1992. Phyllostomidae bats (Chiroptera: Phyllostomidae) as indicators of habitat disruption in the Neotropics. Biotropica 24:440-446.

FERNÁNDEZ, A., et al. 2007. Inventario de la diversidad florística de un sector del curso medio del río Palmar, estado Zulí. Revista de la Facultad de Agronomía (LUZ) 24: 415-421.

GARCÍA, F. J., et al. 2016. Mamíferos de la Sierra de Aroa, estado Yaracuy, Venezuela: Listado taxonómico y la importancia de su conservación. Memoria de la Fundación La Salle de Ciencias Naturales 73:13-34.
Phylum Chordata
Class Mammalia
Order Didelphimorphia

**Phylopotes cuniculus**
Linnaeus, 1758

**Description:** Recognizable chiefly by small size (averaging only larger than seals). Distribution non-Amazonian. Head and body length moderate to large, usually < 250 mm. Dorsal color grayish; pelage very soft, aristiform spines narrow with long whipp-like tip; tail with very narrow scale annuli. Roof: short and broad; postorbital process of zygoma well-developed; upper and lower molars always with two folds.

**Order Lagomorpha**
**Brandt, 1855**

**Family Leporidae**
Fischer, 1817

**Sylvilagus floridanus**
(Allen, 1890) Ú. Güerev (1964); Chapman et al. (1980); Hall (1981)

**Material examined:** MHNLS M–11953 (Figure 3b)

**Description:** Distribution non-Amazonian. Head and body length moderate to large, usually < 250 mm. Dorsal color grayish; pelage very soft, aristiform spines narrow with long whip-like tip; tail with very narrow scale annuli. Roof: short and broad; postorbital process of zygoma well-developed; upper and lower molars always with two folds.

**Order Carnivora**

**Leopardus pardalis**
Linnaeus, 1758

**Description:** It is the second largest cat (8 kg). It has two thin black stripes around the eyes.

**Order Caniformia**

**Canis lupus**
Linnaeus, 1758

**Description:** It resembles a large dog and is found in a variety of habitats across the world.

Appendix 1. Taxonomic comments and most relevant characters used to identify the specimens reported in this study. All specimens collected were deposited at the Museo de Historia Natural La Salle (MHNLS).
Description: It has a small size with shape of a domestic cat. Its color is yellow to yellow-brown on the back and sides, white on the belly and chest, accompanied by black stripes and black rosettes. These rosettes consist on the back of a dark yellow ring surrounded by a black ring, while the ventral rosettes are simple and black. It has eyes border and muzzle of white color. Its tail represents the 50% of body length. The legs and hands are short and digitigrade. Cranial box is slightly convex and narrow, flat front area.

Puma concolor (Linnaeus, 1771) [Carriès (1883); Pocock (1917); Weigel (1961); Hemmer (1978); Kratochvil (1982); Murray & Gardner (1997)]

Description: It has a uniform dorsal pelage, with colorations ranging from light brown to dark brown, while ventral pelage is fur cream color. It has white color under the nose and throat, black on the side and upper side of the muzzle and at the posterior base of the ears. The tail is large and cylindrical, with a dark brown or black tip and approximately 30% of the total length of the animal. The skull is rounded and short.

Puma yagouaroundi (E. Geoffroy Saint-Hilaire, 1803) [Lacépède (1809); Desmarest (1816); Weigel (1961); Hemmer (1978); Kratochvil (1982); Culver et al. (2000)]

Description: It has short, dense and rigid pelage. Its body has homogenous coloration, which may be brown, grayish brown, reddish brown, yellow or black. Its tail length is greater than 60% of body length. The legs and hands are short and digitigrade. It has narrow skull and short facial area (about 20% of skull length). They have a differentiated and deep pit between the internal back and the anterior part of the interfrontal sagittal sutures.

Family Mephitidae Bonaparte, 1845

Conopatus semistriatus (Boddart, 1784) [Cabrera (1957)]

Description: They have long body with short legs, with dark brown to black color. Their pelage is dense and rough. Their feet and hands have long, strong and black claws. They have a white band from the head to the shoulders, and two parallel bands on the lower back, separated by a black band. The tail is usually erect, short (about half head-to-body length), spongy, and wholly white with black base. Their head is conical, long and bare muzzle. Their short, black ears with white hairs at base.

Family Mustelidae Fischer, 1817

Lontra longicaudis (Olfers, 1818) [Pohle (1920); Cabrera (1957); Harris (1968); Van Zyll de Jong (1972); Hall (1981); Larivière (1999)]

Description: Its pelage is dense and lustrous brown. Dorsal pelage is darker than the muzzle, upper lip, mandible and belly. Its ears are short and rounded. Its tail reaches approximately 70% of the body length, is wide, cylindrical and gradually decreases in thickness towards the tip. Its feet have well-developed inter-digital membranes.

Family Procyonidae Gray, 1825

Procyon cancrivorus (Cuvier, 1798) [Cabrera (1957)]

Material examined: MHNLs M-11994 (Figure 3f)

Description: It has medium size with height about 23 cm. Dorsal pelage short and thick and brown to gray; short and thick pelage on the neck. Its face has a white line along midline (may be faint in some individuals); no vertical groove between the eyes and muzzle. They have stubby noses. They have a long prehensile tail > 50 cm, which is covered with fur except for the last third of the underside I allowing it to grab branches. They are bearded and with a very prominent throat. The jawbone is large, covered with fur except for the last third of the underside I. They have long, prehensile and very hairy claws.

Order Primates Linnaeus, 1758

Family Atelidae Gray, 1825

Aotus vociferans (Humboldt, 1812) [Hernández-Camacho & Cooper (1976)]

Material examined: Figure 3d

Description: The color is a deep reddish-brown. Their faces are surrounded by fur and they have stubby noses. They have a long prehensile tail > 50 cm, which is covered with fur except for the last third of the underside allowing it to grab branches. They are bearded and with a very prominent throat. The jawbone is large, especially the body of the mandible. The position of the foramen magnum is very posterior to make way for the expanded jaw and enlarged hystoid bone.

Family Cebidae Bonaparte, 1831

Cebus albifrons (Humboldt, 1812) [Hernández-Camacho & Cooper (1976)]

Material examined: Figure 3f

Description: This primate is a medium-sized monkey with a light brown back and a creamy white underside. Its pelage is moderately large and loose. Head light brown to dark with a medial black narrow line, and white cheeks. Tail is long, prehensile and very hairy.
Phyllostomus discolor Wagner, 1843
Material examined: MHNLS M-11981
Description: Length of calcar shorter than length of hind foot; length of ear (from notch) less than 25 mm; sagittal crest absent or weakly developed; first upper and lower incisors broad (wider than high).

Lophostoma silvicolum (Döderle, 1836) ñ Davis & Carter (1978); Medellín & Anta (1989); Wilson & Reeder (2005)
Material examined: MHNLS M-11920 ñ 11926, MHNLS M-11952 (Figure 3h)
Description: May or may not have white postauricular patches; ventral pelage pale, often strongly frosted white; anterior surface of second upper premolar overfaded by first upper premolar; population in western Ecuador has conspicuous white postauricular patches and a whitish venter.

Trachops cirrhosus (Spix, 1823) ñ Cramer et al. (2001)
Material examined: MHNLS M-11983
Description: They are medium-sized (forearm 58–65 mm, greatest length of skull 27–31 mm). They have presence of papilla-like protuberances on the chin and lips and by the finely serrated margins of the noseleaf. The tail extends to the middle of the intermaxillary membrane and the calcar is about the same length as the foot. Their dental formula is 2/2, 1/1, 2/3, 3/3 × 2 = 34.

Glossophaga longirostris Miller, 1898 ñ Koopman (1958); Jones & Carter (1976); Webster & Handley (1986); Handley & Webster (1987); Webster et al. (1998); Soriano et al. (2000); Timm & Genoways (2003)
Material examined: MHNLS M-11943 ñ 11945; MHNLS M-11954; MHNLS M-11958 ñ 11959
Description: Lower incisors not crowded. Rostrum approximately equal to braincase in length; lower incisors well developed, usually spaced evenly, and not separated medially by a conspicuous gap.

Artibeus planirostris Spix, 1823 ñ Sanchez & Lew (2012)
Material examined: MHNLS M-11979
Description: Interfermolar membrane practically naked, and not fringed medially; horsehoe of noseleaf with lower rim and usually free from upper lip; wing tips pale; maxillary toothrows convergent anteriorly; lateral margins of rostrum convergent posteriorly; Facial stripes present but weakly defined. Fur shorter, gray to gray brown; tubercles on lower lip larger, always more than 4 on each side of chin. Forearm more than 61 mm; length of skull more than 29.5 mm; breadth across upper molars more than 14 mm.

Stenurus lilium (Geoffroy St. Hilaire, 1810) ñ Jones & Phillips (1976); Genoways (1998); Timm & Genoways (2003)
Material examined: MHNLS M-11982
Description: Forearm 45.5 mm or less; greatest length of skull 20.0 ñ 24.5 mm; tips of inner upper incisors narrow, often pointed; zygomatic breadth less than 14 mm. Maxillary ramus of zygomatic arch noticeably bowed outward; zygomatic arches not converging anteriorly; maxillary toothrows arched outward (not parallel)

Desmodus rotundas (E. Geoffroy, 1810) ñ Greenhall et al. (1983)
Material examined: MHNLS M-11912; MHNLS M-11935 ñ 11940 (Figure 3i)
Description: Thumb greatly elongated, longer than hind foot, and with two basal pads. Uropatagium sparsely haired. Wing membranes normally lack white markings. Coronoid process is anterior to ventral bend in ramus. Inner lower incisors bilobate; one upper molar on each side.

Diphylla ecaudata Spix, 1823 ñ Greenhall et al. (1994)
Description: Thumb shorter than 13 mm and lacking a basal pad. Uropatagium well furred; coronoid process posterior to ventral bend in ramus; lower incisors broad with no central gap between them; two upper incisors and two lower molars on each side.

Family Molossidae Gervais, 1856
Molossus molossus (Pallas, 1766) ñ Cabrera (1958); Hall & Kelson (1959); Husson (1962); Varona (1974); Genoways et al. (1981); Dolan (1989); Simmons & Voss (1998); Timm & Genoways (2003)
Material examined: MHNLS M-11894; MHNLS M-11895; MHNLS M-11956 ñ 11957
Description: Forearm 35 ñ 40 mm; and condylobasal length less than 16 mm.

Family Vespertilionidae Gray, 1821
Myotis nigriceps (Schinz, 1821) ñ Bogan (1978); Corbet & Hill (1980); López-González et al. (2001)
Material examined: MHNLS M-11896
Description: No fringe on uropatagium; little or no frostig on dorsal hairs. Angle of slope of frontal variables; size moderate to small; forearm usually less than 40 mm; greatest length of skull usually less than 14.5 mm. Fur rarely longer than 4 mm; fur weakly to moderately bicolor, often blackish.

Order Pilosa Flower, 1883
Family Bradypodidae Gray, 1821
Bradyus variegatus Schinz, 1825
Description: No mane present; facial hair shorter, contrasting in color with dorsal body hair. Pelage with blotches of pale color on dorsal dorsum. Males have a speculum (mid-dorsal) of short hair containing a black median stripe border by yellow - or orange-stained hair). Throat and sides of face brown. Prominent dark brown forehead and suborbital stripe outline paler color of eye patch on face. Skull larger and mandibular spout shorter.

Family Myrmecophagidae Gray, 1825
Tamandua mexicana (Saussure, 1860)
Description: Fourth digit on manus conspicuous. Rostrum 50 % or less than condyloasal length of skull. Size intermediate, total length of adults less than 1.3 m; tail nearly naked along distal three-quarters of its length. Four pairs of orbital foramina (foramen rotundum and orbital fissure separate); posterior border of infraorbital foramen symmetrical and crescent shaped; body with black vest contrasting with pale background.

Order Cingulata Illiger, 1811
Family Dasyopidae Gray, 1821
Dasypus novemcinctus Linnaeus 1758 ñ McBee & Baker (1982)
Description: Relatively rigid carpace with eight movable bands; margins of scutes of movable bands overlapped by triangular scales; rosettes of rounded scutes on scapular and pelvic shields; foreclaws moderate in size; tail long, over 55% of head-and-body length, and with slender tip; rostrum long, 55% or more of condyloasal length; condyloid process much shorter than coronoid process. No enlarged scutes on knee. Carpace with only inconspicuous, sparse hair. Length of head and body more than 360 mm.

Order Perissodactyla Owen, 1848
Family Tapiridae Burnet, 1830
Tapirus terrestris (Linnaeus 1758) ñ Herskovitz (1954); Cabrera (1961); Padilla & Dowler (1994)
Description: It is dark brown, pale in the face, and has a low, erect crest running from the crown down the back of the neck. The round, dark ears have distinctive white edges. Newborn tapirs have a dark brown coat, with small white spots and stripes along the body. The South American tapir can attain a body length of 1.8 to 2.5 m with a 5 to 10 cm short stubby tail and an average weight around 225 kg.