Abstract.- A camera trap inventory of terrestrial vertebrates was carried out in the Atlantic Forest of Paraguay around the small rural community of Isla Alta in the Department of Paraguarí. One Reconxy HC600 camera trap was used over the course of 398 camera trap nights in 12 different sites around the periphery of Isla Alta. The area surveyed covers roughly 500 ha within an 8,600 ha forest fragment connected with Ybycuí National Park (YPN). A total of 22 wild vertebrate species were identified: one reptile, nine birds, and twelve mammals. Noteworthy species registered were margay (Leopardus wiedii), greater naked-tailed armadillo (Cabassous tatouay), and Azara’s agouti (Dasyprocta azarae). These three species have not been recorded from YNP and are of potential concern for conservation. However, the absence of certain large mammals from the forest surrounding Isla Alta which are registered within YNP may indicate impact from local hunting pressure occurring outside of the park.

Key Words: forest fragmentation, hunting pressure, Leopardus wiedii, Cabassous tatouay, Dasyprocta azarae.

The Atlantic Forest is one of the most diverse and also threatened ecosystems in the world, ranking as one of the five most vulnerable biodiversity “hot spots” (Myers et al., 2000). It extends westward from the Atlantic coast, and southward from the equator in Brazil to temperate latitudes in Paraguay and Argentina. The long north to south extension results in a heterogeneous ecosystem complex, comprised of 15 ecoregions (Fundación Vida Silvestre Argentina and WWF, 2017). Its largest ecoregion, the Upper Paraná Atlantic Forest (UPAF), is found around the tri-national border region of Brazil, Argentina, and Paraguay. The UPAF climate is subtropical with an average annual temperature of 16-22°C and 1,000-2,200 mm of rainfall per year mostly in the austral summer (Di Bitetti et al., 2003).

The UPAF has lost 92% of its original forest cover, mostly to agricultural land conversion (Fundación Vida Silvestre Argentina and WWF, 2017). The remaining 8% of the UPAF cover...
is severely fragmented, with almost half of the total remaining area comprised of fragments of <100 km² (Di Bitetti et al., 2003). This has significantly impacted habitat and reduced biodiversity within much of the UPAF ecosystem. Fragmentation in the Atlantic Forest leads to a disproportionate decrease in mammalian biomass (Chiarello, 2000), and diminished local biodiversity, particularly in bird assemblages (Ribon et al., 2003; Turner, 1996).

In addition to providing inadequate habitat for many species, fragmentation exposes the UPAF to greater risk of edge effect impacts, which can include tree mortality, changes in forest structure, and increased accessibility to humans and invasive species (Harper et al., 2005).

Given the extensive habitat loss in the UPAF, it is important to evaluate which species can adapt to various degrees of degradation and pressure. To date, little species inventory work to date has been done in the UPAF of Paraguay outside of a few protected national parks (Lowen et al., 1996; Brooks et al., 1993; Fragano et al., 2003). The study presented here provides species inventory data on forest fragments within an agricultural matrix, which is the type of landscape now most common throughout the Paraguayan UPAF.

METHODS

Study Area

Ybycuí National Park, located in the department of Paraguarí and managed by the Secretariat of the Environment (SEAM), is a small remnant of the UPAF in Paraguay. This park consists of 5,124 ha under strict national protection (FCA-UNA, 2015).

A meandering and mostly continuous forest corridor not part of YNP, extends northeast from the park (Fig. 1). This 8,600 ha corridor, roughly 15km long and 1-3km wide, is part of a patchwork agricultural matrix of mostly small-scale, family-level agriculture. National regulations require the preservation of forests on steep slopes to prevent erosion. Because much of this forest corridor is situated on steep terrain (up to 20% grade), this regulation, along with

Figure 1. Fragment area. Yellow diamond indicates the location of Isla Alta. Red square indicates the approximate boundaries of the Ybycuí National Park (YNP). Map data: Google, Landsat/Copernicus.

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some voluntary conservation of private forested properties, may explain why much of this forest corridor has been preserved.

The community of Isla Alta, within the municipality of Ybycuí, is situated at the northern terminus of this forest corridor. Isla Alta has a population of around 200 individuals, the majority of which engage in small-scale agriculture. Many families also voluntarily preserve about 1-20 ha of native forest along with their land under agricultural production.

The natural vegetation of the study area is typical of the transition zone between UPAF and the humid Chaco ecosystem to the west. The study area is defined as isolated UPAF (Di Bitetti et al., 2003; FCA-UNA, 2015). The UPAF in this area is a dense, semideciduous, subtropical forest intermixed with patches of natural grassland. Vines, bromeliads, and bamboos are common understory features in this area. Small streams are common in the forests around Isla Alta.

Most of the private forested properties around Isla Alta are used to range a small amount of cattle throughout the year. Many residents also selectively harvest native trees for lumber, firewood, or charcoal production according to personal or financial need. Frequent hunting/trapping occurs around Isla Alta, primarily of nine-banded armadillo (Dasypus novemcinctus), Azara’s agouti (Dasyproctus azarae), coati (Nasua nasua), and rusty-margined guan (Penelope superciliaris).

Based on interviews with the property owners of the camera trap site locations, hunters enter each forested property an average of eight times a month (range: 3-28). The hunters often enter the property without the expressed permission and usually against the wishes of the property owners. Hunters tend to prefer the use of traps over rifles and tend to hunt more in the summer (Oct-Feb). Puma (Puma concolor), and mesopredators such as foxes (Cerdocyon thous) and tegu (Salvator merianae) which are perceived to be a threat to domestic poultry, are also sometimes killed by the general public if detected.

**Data collection.**

One HC600 Reconxy camera trap (Reconyx Inc. Holmen, W1) was used from December 2014 to October 2016 to gather a total of 2,687 photos of animals from the forest surrounding Isla Alta. Twelve camera trap site locations were established opportunistically as appropriate locations were discovered (Fig. 2). No formal spatial analysis of Isla Alta was made before the study, and locations were not chosen to specifically monitor any species, habitat, or ecological process. The primary intention of using the camera trap was to promote environmental awareness amongst local community members. However, camera trapping has been shown to be an effective method for registering biodiversity in tropical ecosystems (Sollmann et al., 2013; Tobler et al., 2008; O’Connell et al., 2011; Srbek-Araujo et al., 2005). Locations, trails, and properties were selected as appropriate to capture the most comprehensive record of animal diversity possible.

All camera trap sites were under complete forest cover and set to monitor a cattle, wildlife, or human trail on the private property of a community member of Isla Alta. Camera trap sites were set around the periphery of Isla Alta on average 320m (range: 65-992m) from the nearest residence, and on average 124m (range: 26-360m) from the nearest forest edge (Fig. 2). Maximum distance between sites was 2,500 m. Distances were estimated using Google Earth.

The average duration of camera trap activity for the sites was 33 camera trap nights (range: 7-80 nights). The camera trap was used continuously throughout the study. Because only one camera trap was available, sites were never monitored simultaneously. The camera trap was set at 50-150cm height on the most suitable available tree for monitoring the target trail. Vegetation was cleared when necessary to provide a full view of the trail being monitored.
RESULTS

22 species of wild vertebrates were identified in this study (Table 1). Three domesticated species and humans were also occasionally detected. The number of distinct capture events of each species were recorded. A capture event indicates when an individual animal passed in front of the camera, and the number of capture events does not necessarily indicate the number of photos obtained of that species (i.e. one individual animal while passing the camera one time may have paused in front of the camera for several minutes triggering the camera trap to take several photos). A gap of 15 minutes between photos of the same species was used as the standard for an independent capture event. If multiple individuals of the same species appear together in a photo each individual was counted as a capture event (i.e. a flock of three guans appearing together counts for three capture events). The number of difference sites around Isla Alta in which a species was registered in was also recorded.

DISCUSSION AND CONCLUSION

It is probable that the 12 species of mammals registered in this study represent the majority of medium-large (>1kg) terrestrial mammal species present in the study area as newly encountered mammal species tapered off substantially over the course of the study (Figure 3). A few bird and reptile species were also registered incidentally throughout this study. The fact that this study only set the camera to monitor clearly established trails could bias the study to favor species that readily use trails. However, camera traps have shown a clear tendency to register more medium-large mammals on trails than off of them, even for rarely registered species (Reilly, 2015; Kolowski et al., 2017).

Of the species registered around Isla Alta, the margay, greater naked-tailed armadillo, and Azara’s agouti are of particular interest due to their conservation status. Margays (L. wiedii) are classified as Near Threatened by the IUCN and with a decreasing population are likely to
classify as Vulnerable in the near future. This feline species is highly arboreal and likely to suffer further from a continued loss of forest cover (Bou, 2012; Henriquez et al., 2002). Greater naked-tailed armadillos (C. tatouay), although not threatened, are generally difficult to register due to their highly fossorial habits (Smith, 2008). Azara’s agoutis (D. azarae) are classified as Data Deficient by the IUCN. These important seed dispersers of Atlantic forest trees are listed as potentially Vulnerable in Argentina but appear to retain a population around Isla Alta and have been recorded throughout the UPAF of Paraguay (Brooks et al., 1993). None of these three species of interest have been recorded in YNP (FCA-UNA, 2015). However, it is likely that they are in fact present within the park. Their absence from park records might be explained by the fact that no species inventory has been carried out in the park using a camera trap, or at least to date have not been published.

The other species around Isla Alta detected in this study are classified as Least Concern by the IUCN and are generally considered common in other Paraguayan and Brazilian Atlantic Forest fragments, including YNP (FCA-UNA,

Table 1. Species capture events within Isla Alta.

<table>
<thead>
<tr>
<th>species name</th>
<th>common name (English)</th>
<th>total encounters</th>
<th>number of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvator merianae</td>
<td>black and white tegu</td>
<td>21</td>
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<tr>
<td>Penelope superciliaris</td>
<td>rusty-margined guan</td>
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<td>7</td>
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<td>Nyctidromus albicollis</td>
<td>pauraque</td>
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<td>Crypturellus tataupa</td>
<td>tataupa tinamou</td>
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<tr>
<td>Leptotila verreauxi</td>
<td>white-tipped dove</td>
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</tr>
<tr>
<td>Turdus rufiventris</td>
<td>rufous-bellied thrush</td>
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<td>2</td>
</tr>
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<td>Turdus amaurochalinus</td>
<td>creamy-bellied thrush</td>
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<td>pale-breasted thrush</td>
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<td>Arremon flavirostris</td>
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<td>Zonotrichia capensis</td>
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<td>1</td>
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<td>Galictis cuja</td>
<td>lesser grison</td>
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<td>1</td>
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<td>Nasua nasua</td>
<td>coati</td>
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<td>Cercocyon thous</td>
<td>crab-eating fox</td>
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<td>margay</td>
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<td>Brazilian cottontail</td>
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<td>Dasyprocta azarae</td>
<td>Azara's agouti</td>
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<tr>
<td>Cuniculus paca</td>
<td>spotted paca</td>
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</table>
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2015; Brooks et al., 1993; Albuquerque et al., 2013; Rocha et al., 2015; Machado et al., 2016; Hannibal, 2014).

However, no large terrestrial mammals normally common in the UPAF such as brocket deer (Mazama spp.), puma, collared peccary (Pecary tajacu), and tapir (Tapirus terrestris) were recorded in this study. Moreover, residents of Isla Alta anecdotally support these camera trap findings, reporting that roughly two decades ago brocket deer, collared peccary, and puma were regularly encountered in the area, and are now absent. Brocket deer and collared peccary are known to currently persist in YNP (FCA-UNA, 2015), a nearby connected and nearly identical forest habitat.

Other Atlantic Forest fragments in Paraguay have shown a conspicuous decrease of mammalian diversity in areas experiencing unregulated hunting pressure (Brooks et al., 1993; Paviolo et al., 2009), and Brazilian Atlantic Forest fragments have shown a 37% decrease in bird and mammalian abundance due to heavy hunting pressure, particularly affecting brocket deer and nine-banded armadillo (Cullen et al., 2000). Consequently, local hunting pressure may be responsible for a substantial reduction, if not the elimination, of these large mammals within the study area around Isla Alta, and may continue to threaten certain species.

This study in Isla Alta and others in the Atlantic Forest show that medium to small-sized forest fragments can still provide habitat for a variety of mammals (Turner, 1996), including some of concern for conservation. These remaining fragments may also serve as valuable starting points for habitat restoration efforts to reconstruct connectivity between larger fragments of the UPAF (Di Bitetti et al., 2003). However, efforts to work with communities to manage local hunting practices around Isla Alta and similar regions may be an important step towards allowing these small fragments to serve as viable habitat for a number of species.

The absence of certain large mammals around Isla Alta demonstrates the vital importance of protected areas as reserves for species susceptible to over hunting.

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Figure 3. Accumulation curve for medium to large sized mammal species detected throughout the study.
ACKNOWLEDGEMENTS

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LITERATURE


