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IMPLICATIONS OF HABITAT SELECTION BY JAGUARS FOR CONSERVATION ACTIONS IN THE PANTANAL WETLANDS

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Abstract: Understanding the use of habitats by jaguars (*Panthera onca*) is fundamental to comprehend the ecological role of the species in the environments in which they occur. In Brazil, the Amazon and Pantanal biomes are considered fundamental for the conservation of the species. The Pantanal wetlands are in the centre of South America and the jaguar occupies about 47% of the territory. Poaching and habitat loss are the main threats to the population in this region. The highest densities of *P. onca* are found mainly in the north-central regions of Pantanal, where is situated the Taiamã Ecological Station (TES), a small federal protected area. The present study aims to elucidate fine-scale jaguar habitat selection in the TES region and check for seasonal differences. Through GPS collar information obtained from 11 animals, an analysis with the integrated step selection function (iSSF) was performed to investigate jaguar habitat selection. Our analysis indicated that these felines often use forested areas close to rivers, in contrast to open areas and away from watercourses. During the wet season, these cats tended to use forested areas more often than in the dry season. These data are important to support actions for the conservation of jaguars in the studied region.

Keywords: GPS collar, iSSF, *Panthera onca*, Taiamã Ecological Station.

INTRODUCTION

Animals select habitats that maximise fitness by optimising access to food, mates, and other resources (Klaassen & Broekhuis 2018). It is commonly assumed that species occupy habitats that most suit their dietary and reproductive needs if the benefits received outweigh the risks from competitors or other predators (Manly *et al.* 2002). In addition to prey abundance, the physical characteristics of the habitat, such as the presence or absence of water, and the landscape context, which can be understood as the variation of selection of a cover depending on the local background, are also important covariates of habitat selection (McGarigal *et al.* 2016). In this sense, obtaining these correlations can bring important information about the ecology of animals, their distributions, and population dynamics. Habitat selection studies can also provide information on environmental characteristics necessary for animals to

consistently assist in the development of wildlife management and conservation (Calenge 2007, Froehly *et al.* 2020, Wang 2021). The improvement of predictive habitat models has greatly increased our ability to identify the actual and potential occurrence of species to enhance biodiversity conservation planning (Peterson & Dunham 2003). These models can make predictions that can be used to assess the impact of change on land use, detect important areas for reintroduction or conservation, and identify potential conflicts with human activities (Kramer-Schadt *et al.* 2005, 2011, Johnson *et al.* 2006, Rio-Maior *et al.* 2019).

Studies on habitat selection by jaguars (*Panthera onca*, Linnaeus 1785) have been carried out by several researchers (Conde *et al.* 2010, Cullen *et al.* 2013, de la Torre *et al.* 2017, Morato *et al.* 2018a, Kanda *et al.* 2019, de Azevedo *et al.* 2021). The main findings are the importance of water bodies and forested areas for the species, the tendency to return to the home-range centre, and the selection differences between the sexes, among other characteristics. This type of information is very important for the implementation of conservation efforts, such as the National Action Plan for the Conservation of Big Cats in Brazil (ICMBio 2018).

In Brazil, the Amazon and the Pantanal are considered important jaguar refuges (Sanderson *et al.* 2002). The Pantanal wetlands (150,355 km²) are located in the upper Paraguay River basin, in the centre of South America, covering neighbouring areas in Brazil, Bolivia and Paraguay, with roughly 80% of this area on the Brazilian side. In this biome, the jaguar occupies about 47% of the territory, with an effective population size smaller than 1,000 individuals (Morato *et al.* 2013). The highest densities of *P. onca* are found mainly in the north-central regions of Pantanal (Alvarenga *et al.* 2021), and these regions are considered extremely important for the long-term conservation of this large cat (Quigley & Crawshaw 1992, Tortato *et al.* 2021). Retaliatory killing and poaching, as well as the loss of habitat associated with agricultural expansion are the main threats to the population in this region (Morato *et al.* 2013, Süssekind 2019). However, there are also examples of the use of the jaguar in ecological tourism with excellent returns for local populations as well as for jaguar conservation (Tortato & Izzo 2017). Therefore, the present study aims to: (1) elucidate fine-scale jaguar habitat selection in the Taiamã Ecological Station (TES) region and (2) determine if there is a seasonal difference in habitat selection.

MATERIAL AND METHODS

Study Site

The TES is an island delimited by the Paraguay river and its branch (locally named as Bracinho river) in the northern Pantanal, Cáceres municipality, Mato Grosso state of Brazil, comprising an area of 115.55 km² (Figure 1). The Pantanal is one of the largest freshwater wetlands in the world (Harris *et al.* 2005, Junk & Cunha 2005, Tomas *et al.* 2019), harbouring a great diversity of aquatic environments influenced by the flooding pulse (Calheiros & Oliveira 2010). This protected area is mainly composed of floodplains, and its interior contains a great variety of aquatic environments, such as permanent, temporary lagoons, meander lagoons, and 'corixos' (natural connections between rivers and lagoons that have great importance to water bodies in the Pantanal). The TES has the highest jaguar population density estimate to date (12.4 jaguars/100 km²) (Eriksson *et al.* 2022) and was declared a Ramsar site in 2018 (Brasil 2021).

The TES is inserted in a region that plays important roles in the flood control and sediment depositional processes of the north Pantanal. This region is characterised by the overflow of waters of the Paraguay river, and it is flooded during most of the year (Assine & Silva 2009).

Near the TES, an environmental regulation (Resolution 02/2018 of the State Fisheries Council of the State of Mato Grosso, Brazil) delimits an area where fishing is prohibited to protect the fish fauna present in this region. To the north and adjacent to the TES, there is a private reserve, Reserva Particular do Patrimônio Natural Jubran, with an area of 355.31 km². To the southeast of TES it is located the Sararé Island, which belongs to the Brazilian state and is part of the proposal to create a federally protected area (Tortato 2018).

Habitats

To characterize the types of macrohabitats found in the TES and surroundings areas, the Maximum Likelihood methodology was used in the

Quantum GIS software with the help of the Semi-Automatic Classification – SCP plugin, which is based on spectral information from pixel-by-pixel classification. The search for homogeneous/equal regions in a Landsat-8 satellite image dated 02/07/2017 was carried out in a supervised manner through the determination of regions of interest for each macrohabitat. To assess the types of these macrohabitats, a Phantom 4 Pro drone was used to capture images of the vegetation. All coordinates and images collected were authorised under license from the Chico Mendes Institute for Biodiversity Conservation- ICMBio (SISBIO number 66671-1).

Band accuracy was performed in the SCP plugin to determine the quality of the classification, which was based on the Kappa's index (IK) (Landis & Koch 1977), in which values less than < 0.00 are classified as Poor, from 0.00–0.20 Slight, 0.21–0.40 Fair, 0.41–0.60 Moderate, 0.61–0.80 Substantial and 0.81–1.00 Almost Perfect.

Description of macrohabitats

Field: these are wetlands covered with grasses, herbs, and shrubs, with a very variable floristic composition during the annual cycle, and depending on the duration of the dry period, shrubs and some trees may grow. The fields remain completely flooded in the wet season (in the study area) and are the most extensive physiognomy of the Pantanal. It is also significant at the TES (72% of the area) (ICMBio 2017, Frota *et al.* 2020).

Polyspecific Forest (PEF)*:* this macrohabitat is located mainly on the banks of rivers and is formed by shrubs and pioneer forests along the river (8% of the TES area) (Frota *et al.* 2020).

Monospecific Abobreiro's Forest (Abobral) (MAF): this is the local name used when the dominant pioneer formation is composed of individuals of the species *Erythrina fusca* Lour (Fabaceae) (16% of the TES area) (Frota *et al.* 2020).

These two types of macrohabitats above are classified as Seasonal Semideciduous Alluvial Forest (IBGE 2012).

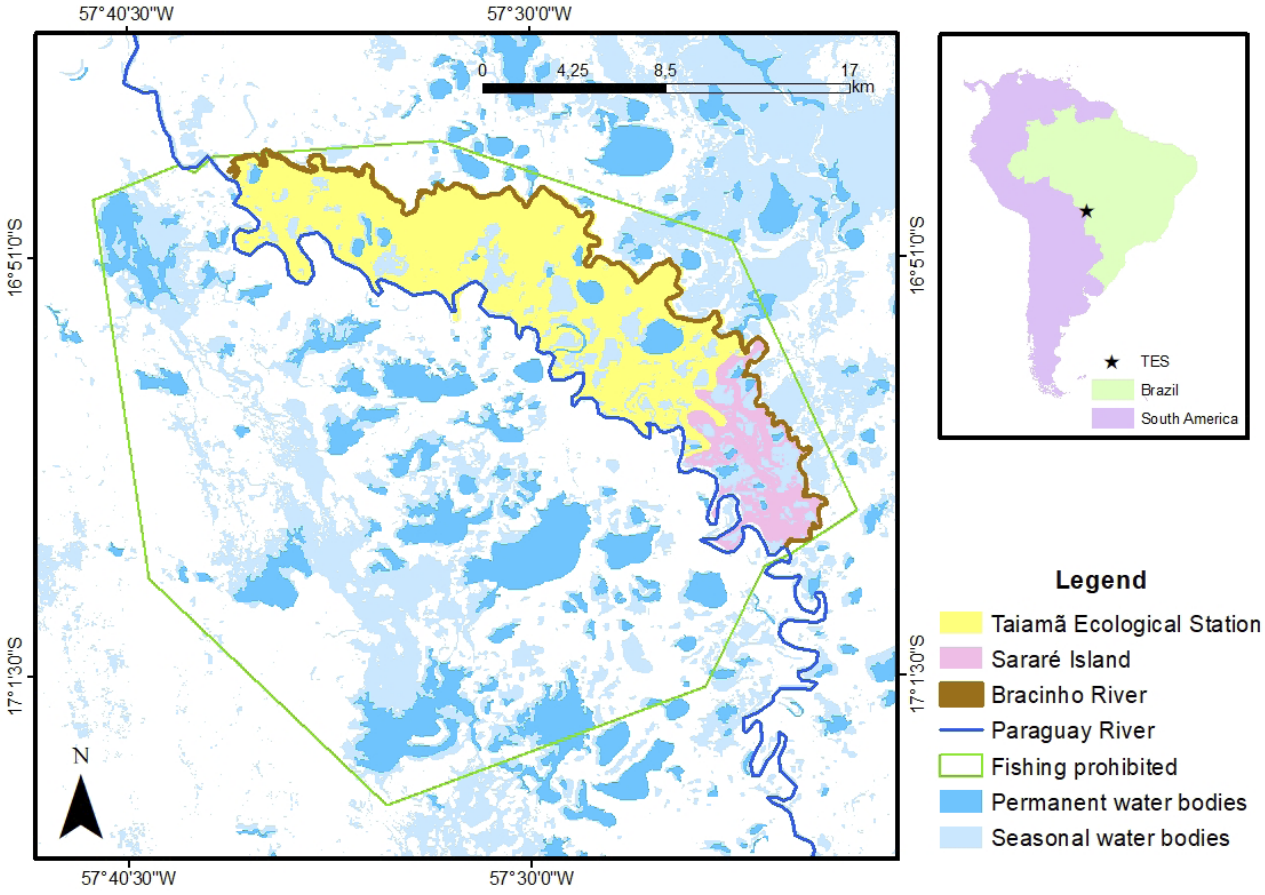

Figure 1. Region of the Taiamã Ecological Station (TES), delimited by the Paraguai River and one of its branches; note that the region is an area with many water bodies.

Lakes: popularly known as bays, lakes have different shapes and sizes ranging from tens to hundreds of meters (4% of the TES area) (Frota *et al*. 2020).

River: the river channel, as a macrohabitat, is represented by the channels of the Paraguay river, which delimit the TES.

The two types of forests presented above were separated in this analysis because they occupy different proportions of the TES area (PEF with 8% and MAF with 16%) (Frota *et al*. 2020), and the *E. fusca* forests have a very irregular soil due to aerial roots. In addition, MAF can colonise areas that are seasonally flooded longer than PEF (Martins *et al*. 2020; Olivo-Neto *et al*. 2020).

Data collection

Eleven jaguars (six males and five females) were monitored using GPS collars at the TES between October 2013 and April 2016 under license from ICMBio (SISBIO number 308963). All data used to develop this study are available to the scientific community (Morato *et al*. 2018b). The animals were captured according to the foot snare method (de Araujo *et al*. 2021), immobilised with a combination of tiletamine and zolazepam (Zoletil 100®, Virbac SA, Carros-Cedex, France), and fitted with GPS-satellite collars (Lotek-Iridium). These collars were programmed to obtain locations every hour. The drop-off system was programmed for 400 days, and when triggered, the transmitter collar automatically loosened from the animal. The collars were programmed to send data to the Iridium satellite system every 24 hours.

Statistical analysis

We applied an integrated step selection function (iSSF) (Avgar *et al*. 2016) using the amtGUI (Buchmüller *et al*. 2018), a graphical interface to the package *amt* for R (Signer *et al*. 2019) to investigate jaguar habitat selection. Locations were treated as linear steps between two consecutive relocations (Fortin *et al*. 2005, Thurfjell *et al*. 2014). Step selection functions test for habitat selection by conducting a conditional logistic regression comparing available to used habitat, while iSSFs allow to include movement parameters into habitat selection analysis (Avgar *et al*. 2016), which reduces inferential bias (Forester *et al*. 2009). Step lengths (m) were assumed to follow a gamma distribution. Jaguar locations were resampled to an interval of 1 h ± 10 min to achieve a regular time interval and a set of random steps (n = 10) created for each true step.

Habitat covariates extracted at step end were simplified in four categorical variables to macrohabitats ('PEF', 'MAF', 'RIVER' and 'LAKE') and in 10 classes of "distance from the river" (0–100 m buffer from the river, 100–200 m, up to 900–1000 m). We chose to use open land (field) as the intercept in the testing habitat selection and the first buffer (0–100 m from the river) as the reference for the tests. The field was chosen as the intercept because it is one of the most abundant macrohabitats in the study area (71% of the TES) (Frota *et al*. 2020), to avoid errors when making the comparisons, and we knew in advance that there were selection differences between fields and the analysed forests.

For non-seasonal analyses of selection strength (*versus* distance from river and macrohabitats), the means of individual results were used. Due to the difficulty of obtaining statistically significant data for the different animals in short periods (seasonal analyses), the records of the animals' movements were grouped by period (drought and flood). Then the selection of habitats was carried out for "distance from the river" and macrohabitats.

To make comparisons between different seasonal periods, the months of February, March, and April were considered for the period of maximum flooding (wet season) and August, September, and October for the lowest level of the river in the TES region (dry season) (station ruler - data from November 2018 to present). It was not possible to seasonally compare the selection strength for LAKE and RIVER, as the results contained many non-significant values. The same occurred in the seasonal analyses with the classes of "distance from the river", and it was only possible to perform the analyses for 100–200 m, 200–300 m, and 300–400 m. Only results that were statistically significant ($p < 0.05$) were considered for the various analyses performed in the study.

RESULTS

During the four years of radio collar/GPS monitoring of jaguars, it was possible to

obtain 42,741 location points. Variations in the monitoring period were observed, among which are M5 and M4, the animals with more and fewer days monitored, with 10.990 and 572 coordinate points, respectively (Table 1).

The Kappa index of the macrohabitat areas classified by the Maximum Likelihood methodology in the Quantum GIS software was 0.8396, characterising it as an almost perfect classification of characteristics. Among the macrohabitats obtained, jaguars preferred the PEF (β = 1.1306 ± 0.11, SE) and MAF (β= 0.7558 ± 0.10, SE) (Figures 2 and 4). For the LAKES (β=-0.1415.1306 ± 0.17, SE) and RIVERS (β=-0.4380 ± 0.14, SE) categories, negative selection results were obtained. Importantly, the results obtained for all animals (11) were statistically significant for the macrohabitat PEF, followed by MAF with ten individuals, LAKE with five, and RIVER with six animals.

Table 1. Monitoring period of 11 jaguars at the Taiamã Ecological Station and surroundings from 2013 to 2016.

ID	Sampling period (months)
M1	10/2013 to 05/2015 (20)
M2	09/2014 to 05/2015 (09)
M3	11/2014 to 04/2015 (06)
M4	09/2014 (01)
M5	12/2014 to 08/2015 (09)
M6	10/2015 to 04/2016 (07)
F1	10/2013 to 04/2014 (07)
F2	10/2014 to 12/2015 (15)
F3	12/2014 to 04/2015 (05)
F4	10/2015 to 02/2016 (04)

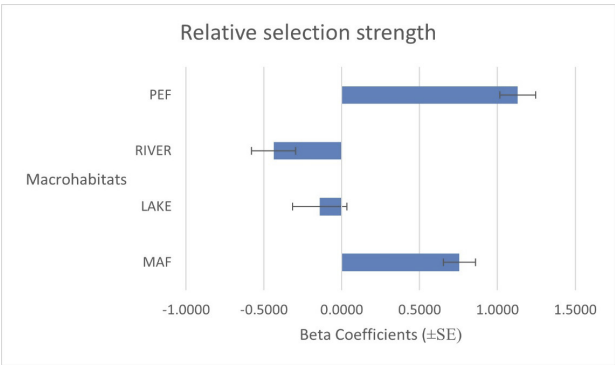

Figure 2. Relative strength of macrohabitat selection by jaguars at the Taiamã Ecological Station, Mato Grosso, Brazil; the blue bars represent the selection coefficients (±SE).

In the analysis related to the different uses for the classes "distance from the river", it is possible to observe that the further away from the river, the lower the probability of use of the areas by the jaguars (Figure 3 and 4). In eight individuals, all values obtained for all distance classes were significant. All data from one of the animals (F3) were excluded from the analysis because they were not significant. In two individuals, the results of five classes were also removed, as they were not significant.

When comparing the different levels of relative selection strength of macrohabitats in different periods of the year (dry and wet), in 2014 and 2015, animals increased the use of forested areas during the flooding season. (Figure 5). When comparing the relative selection levels relative to the "distance from the river" classes in 2015, the selection levels for the 100–200 m, 200–300 m, and 300–400 m categories were always more negative for the wet seasons. In 2014, the same phenomenon was observed, but there is almost no seasonal difference in selection for the 100-200 m class (Figures 6 and 7).

DISCUSSION

Habitat selection is a hierarchical process by which a species makes decisions that occurs on four spatial scale or orders: 1st order = selection of the physical or geographical range of a species; 2nd order = selection of a home range of an individual or social group; 3rd order = selection

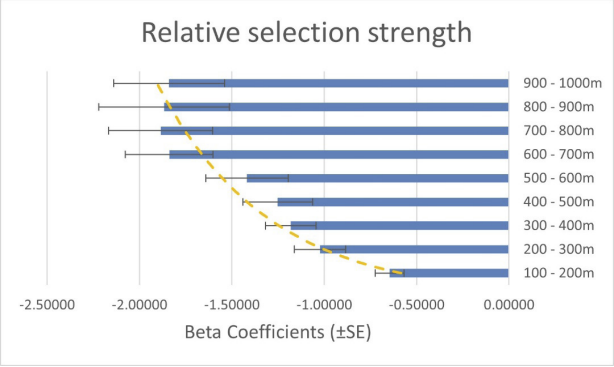

Figure 3. Relative selection force of "distance from the river" classes by jaguars (n=11) at the Taiamã Ecological Station, Mato Grosso, Brazil; the blue bars represent the selection coefficients (±SE) and the yellow dashed line represents logarithmic trend line (R2 = 0.9328).

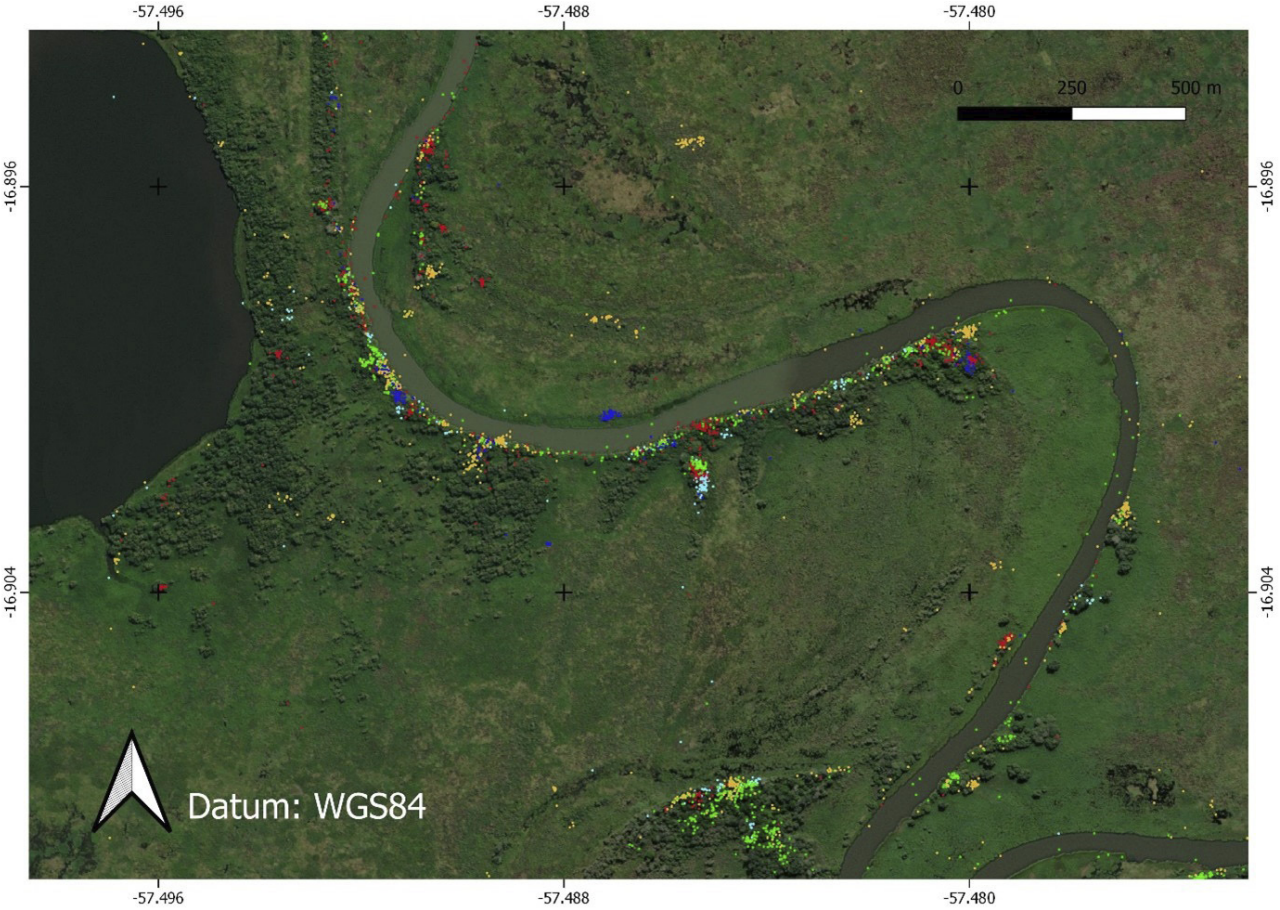

Figure 4. Satellite image of the Paraguay River, border of the TES. The dots represent the locations of the jaguars, with one color for each individual, where it is possible to see that the most used areas are those closest to the rivers and more forested; satellite image: ESRI Satellite (ArcGIS/World_Imagery).

of various habitat patches within the home range; and 4th order = selection of specific resources within a habitat patch (Johnson 1980). In order to identify the main habitats used by the TES jaguars, a habitat selection analysis was carried out, which corresponds to Johnson's third order, since it allows the identification of fine-scale movement within home range.

Understanding how large carnivores select habitats in a mosaic of human-altered and naturally occurring land cover is critical to the appropriate allocation of resources for the conservation and management of such populations. Furthermore, such information may be useful for identifying areas with high potential for species persistence (Dellinger *et al.* 2013). In this way, the data generated in this study can be used to support actions for the conservation of jaguars in the studied region.

The study region is flat and is characterised by the overflow of waters in the Paraguay river, and it is flooded during most of the year (Assine & Silva 2009, Lo *et al.* 2019). During the wet season, only some portions of the soil are higher, locally known as "cordilheiras", which take longer to flood or do not even get flooded, depending on the annual variations of water flow in the hydrographic basin. The origin of the "cordilheiras" is associated with the old and recent marginal dikes of the rivers, which are covered by vegetation and serve as places of refuge for wild animals during the flood season (Souza & Souza 2010) and, in the case of TES they are the areas most used by jaguars.

The data obtained for habitat selection and selection of "distance from rivers" classes clearly indicate that the jaguars very often use forested areas (mainly PEF) close to rivers, in contrast to open areas and away from rivers (Figure 4). The preference for forest habitats and water appears to be common for this species in Brazil (Astete *et al.* 2007, Morato *et al.* 2018a, Kanda *et al.* 2019). Their selection may be related to a preference for

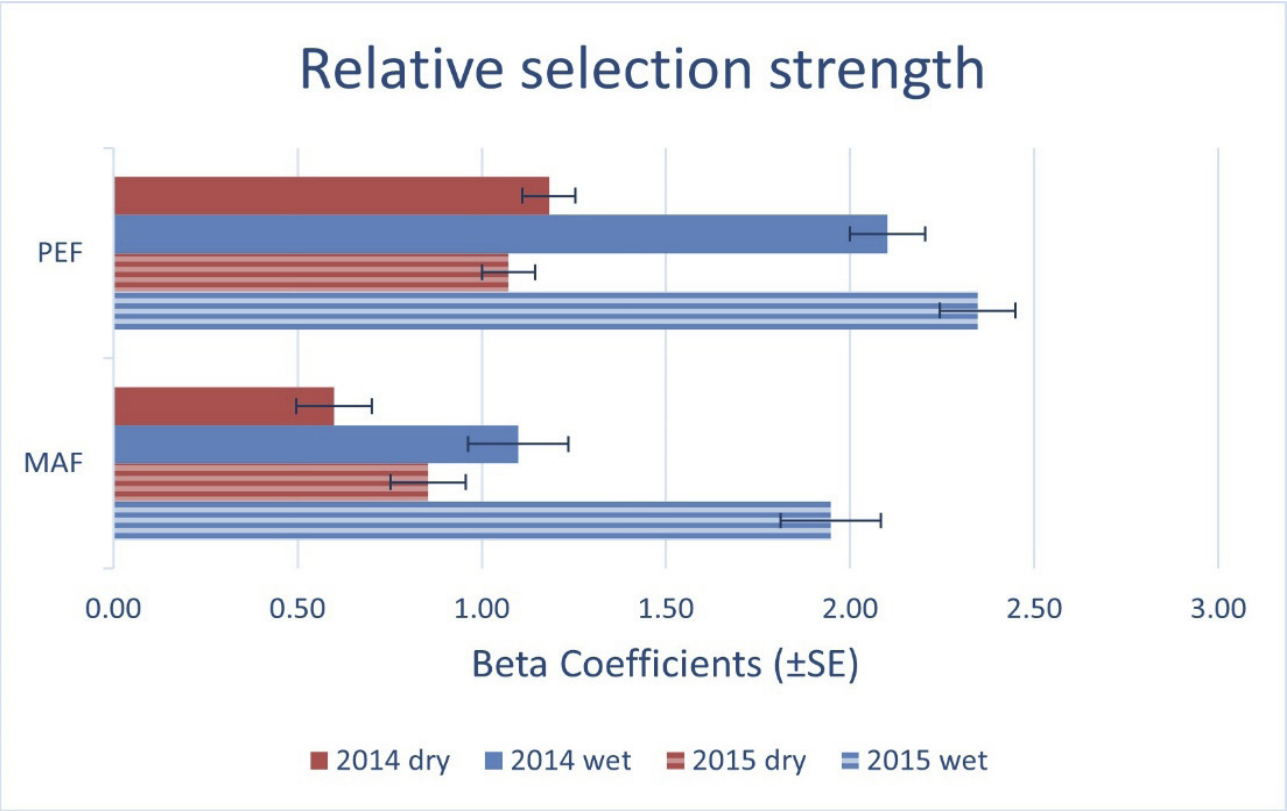

Figure 5. Seasonal differences in relative macrohabitat selection strength by jaguars at the Taiamã Ecological Station, Mato Grosso, Brazil; PEF= Polyspecific Forest; MAF = Monospecific Abobreiro's Forest; the bars represent the selection coefficients (±SE).

consuming prey associated with these habitats (Astete *et al.* 2007, de Azevedo & Murray 2007, Cavalcanti & Gese 2010). This association seems to be directly related to the diet of jaguars from TES since the main items in their diet are caiman and fish (Eriksson *et al.* 2022). The annual variation of the water level of the Paraguay river in the TES is approximately 1.50 m, which is the smallest amplitude recorded for the entire Paraguay river (Oliveira *et al.* 2013). Due to the flat feature of the region (ICMBio 2017), the water level above approximately 1 m during the peak of the annual flood makes it possible for jaguars to move within the flooded area also enabling the capture of aquatic prey. In addition, the region of the study area is a place with high temperatures, so the use of forested areas is a way to avoid the incidence of sunlight.

The difference between the coefficients of the two types of forested areas (PEF and MAF) is probably due to the characteristics of these two macrohabitats: (1) Areas with monodominant forest are susceptible to a longer period of flooding than the polyspecific forest areas and (2) the aerial roots of *E. fusca* make the MAF terrain very uneven compared to the PEF (Olivo-Neto *et al.* 2020). Thus, it is possible to assume that jaguars prefer less flooded forests with less uneven terrain. Even with approximately twice the area of occurrence of the MAF relative to the PEF in the TES (Frota *et al.* 2020), the jaguars more strongly selected the polyspecific forest. It is important to state that the methodology used in this study to identify habitat selection uses only real and random steps to estimate the coefficients, so that the differences between the proportions of macrohabitats in the home ranges do not directly interfere with the calculations performed.

Solitarily living species that have few social interactions except during mating and do not show cooperative behaviours (Sandell 1989) form the majority (80–95%) of carnivore species (Gittleman 1986). If a limiting resource is predictable in space and time and restricted to a constrained area, this leads to territorial defence (Hixon 1980), while unpredictability or variation leads to overlapping ranges or roaming tactics (Erlinge & Sandell 1986, Sandell 1989). In this way,

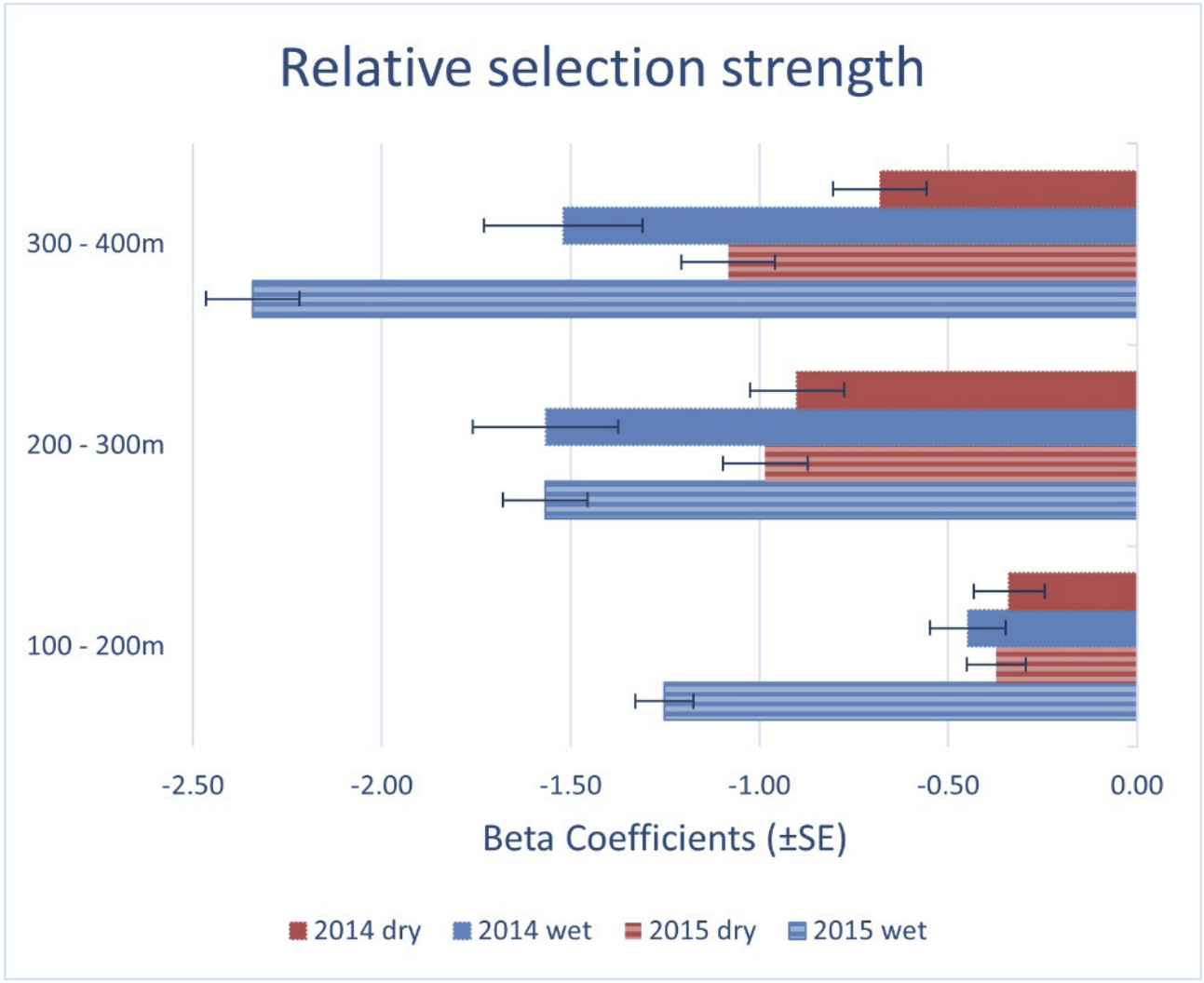

Figure 6. Seasonal differences in relative selection strength between "distance from the river" classes by jaguars from the Taiamã Ecological Station, Mato Grosso, Brazil; the bars represent the selection coefficients (±SE).

solitary carnivores are expected to form spatial groups when the heterogeneity of resources is high and competition among residents for those resources is low (Macdonald 1983, Carr & Macdonald 1986, Gehrt & Fritzell 1998). Evidence of high social tolerance of jaguars at TES includes highly overlapping home ranges, substantial time spent co-traveling, and social interactions directly observed by video monitoring, and the main cause of this behaviour, considered unusual for the species, is the abundance of aquatic prey (Eriksson *et al.* 2022). The preferential use of narrow strips near the rivers, as observed in this study, should lead to many encounters between individuals, so this information complements the aforementioned scenario. In addition, many social interactions observed by video (Eriksson *et al.* 2022) were obtained by equipment installed in areas very close to the rivers.

Landscape attributes and prey abundance appear to be the factors that regulate resource selection in carnivores (Stephens & Krebs 2019). The choice of feeding habitat by predators can be governed by the location of abundant prey or where capture is easiest (Hopcraft *et al.* 2005). In the case of Serengeti lions (*Panthera leo* - Felidae, Carnivora), the animals preferentially hunt in areas with short grass rather than high prey densities to improve hunting success (Hopcraft *et al.* 2005). In contrast, other studies (Litvaitis *et al.* 1986, Murray *et al.* 1994, Palomares *et al.* 2001, Spong 2002, Santos *et al.* 2019) have shown that they selected their habitats according to the sites of greatest abundance of prey. Both hypotheses use

Figure 7. Seasonal differences scheme in relative selection strength between "distance from the river" classes by jaguars from the Taiamã Ecological Station, Mato Grosso, Brazil; the shades of green represent the use of the classes; the darker green the more used the class by the jaguars; blue represents the river.

the same theoretical framework: predators select hunting habitats where they can obtain food with the least amount of energy (Hayward & Kerley 2005). In the case of jaguars from TES, the second hypothesis seems to occur, since jaguars use the territories close to rivers more frequently, which is the place where their prey (fish and caiman) are more abundant.

Data related to seasonal variation in the use of forested areas and distance from the river indicate that the annual variation of flooding and drought in the study area imposes changes in the distribution of resources for jaguars. During periods when the water level is higher, jaguars use the "cordilheiras" more frequently, since these areas are above the water, or submerged for a short time. The open areas (in this study indicated as macrohabitat "Field") and away from the rivers have lower altitudes than "cordilheiras" and are flooded when the river level is high, and so during the dry season, these cats tend to use these open places more often than during the wet season. However, even in the dry season, the areas closest to the rivers are still the most used.

In a habitat selection study with jaguars carried out in the southern Pantanal (de Azevedo *et al.* 2021), the animals responded to local increases in water levels within their home ranges by selecting forested areas more strongly, like jaguars from TES. Accordingly, the same pattern was observed in these two studies, which is the most intense use during the flood of forest areas that remain submerged for little or no time.

Conservation implications

The target population of this study has the highest density of individuals ever recorded and has a unique characteristic for the species (Eriksson *et al.* 2022) so, with a deeper knowledge of the characteristics of this population, it will be possible to carry out conservation actions more efficiently. In this way, it is necessary to guarantee the maintenance of the jaguars' preferred habitats, such as the Polyspecific Forest and the areas close to the rivers so that the way of life of this population is not altered. The preservation of forest remnants on the banks of the river as permanent preservation areas (Brazilian Federal Law nº 12651/12) of rural properties that are close to the river channel must also be considered for ecological corridors from the TES to the Pantanal Matogrossense National Park (Silveira *et al.* 2014). The gene flow between the jaguar populations in these two conservation units has already been identified (Kantek *et al.* 2021).

One of the actions that can cause severe impacts on the riverbanks in the study region is the large-scale navigation coming from port units planned to be implemented upstream of the TES (Tortato *et al.* 2022). In previous experiences of navigation of this type, however on a much smaller scale than current intentions, the riverbanks were seriously impacted by the navigation of barges (WWF 2001). This happens because the rivers that surround the TES have a width much smaller than the average of the Paraguai river, both above and below the Station, and in some stretches, the width of the Bracinho river is approximately 55 meters. In addition, in this region, the river is also much more sinuous, with sharp curves (Figure 1). To cross these winding regions, convoys of barges used the concave banks as an auxiliary element for manoeuvres, having to make consecutive

movements backwards after collisions with the riverbank to be able to move.

As a result of the seasonal nature of dry and flood periods in the Pantanal, the planned vessels will be more used when the water level in the rivers is high since there will be less difficulty in navigation and because the flood season coincides with the seasonal period of soy exportation. In this way, if we consider that floods are the most intense periods of riverbank use by the studied jaguars, it is possible that the seasonal nature of the use of these large vessels even further affects the behaviour of these felines.

Our study provides the type of data that could be used to improve management decisions to minimise the loss of preferred habitats for jaguars in the TES region and thus may help improve human-predator conflicts. The Pantanal is rich in wildlife diversity, yet more than 95% of its area is privately owned, with livestock being the main economic activity (Quigley & Crawshaw 1992, Soisalo & Cavalcanti 2006). Illegal jaguar control in response to livestock depredation is a significant source of jaguar mortality (Schaller & Crawshaw 1980). However, jaguars from the TES do not eat cattle (Eriksson *et al.* 2022) and have few traces of cattle-related diseases (Onuma *et al.* 2014, 2015) and thus, the maintenance of these characteristics depends on the absence of cattle in the riverbanks of the farms that border the Station. In Brazil, the presence of cattle in areas close to rivers is prohibited by law (Brazilian Federal Law n°12.651/2012), but not always respected (Paula De Oliveira *et al.* 2009, Chaves *et al.* 2020), so compliance with the legislation in the study area would be good for the analysed feline population.

The fact that protected areas often fail to provide adequate area to support viable populations of large carnivores is not a new finding and has been documented extensively in the scientific literature (Newmark 1985, Simonetti & Mella 1997, Chape & Mulongoy 2004, Johnson *et al.* 2006, Baeza & Estades 2010). However, small protected areas for large carnivore conservation can be enhanced by improving the quality of the surrounding landscape (Baeza & Estades 2010, Cardoso *et al.* 2020). The environments most preferred by jaguars near TES are crucial for these animals to disperse, hunt wild prey and take care of their cubs without being disturbed, and thus, management efforts should focus on protecting these environments, through conservation projects or the creation of protected areas, whether public or private.

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