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ARTICLE

Population estimate of *Mergus octosetaceus* in the Jalapão region, Tocantins, Brazil

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ABSTRACT: The Brazilian Merganser is a threatened species and classified as Critically Endangered. Its world population is estimated to be fewer than 250 individuals surviving in the wild. Currently, the species is known from disjunct populations distributed in the states of Minas Gerais, Goiás, and Tocantins (in the Jalapão region). For this study, the stretches of the Preto, Novo, Soninho, and Sono Rivers were surveyed by airboat to better estimate the species distribution in the region. Brazilian Mergansers were found only on the Novo River along a stretch upstream from *Da Velha* waterfall. Four pairs and a few other adult individuals were identified there. A 50 km stretch of the Novo River was selected for monthly censuses (n = 13) from August 2009 to October 2010 to estimate the relative abundance and population size of the Brazilian Merganser. The Abundance Kilometric Index was 0.125 individuals/km. The Novo River, from *Da Velha* waterfall until near its headwaters, is 145 km long and our survey estimated a population of 13.7 individuals. Changes caused by uncontrolled tourist activities on the Novo River, such as rafting during the species' breeding season, riparian forest deforestation, and proposed hydropower projects, can negatively impact this small Brazilian Merganser population putting it in great risk of local extinction.

KEY-WORDS: Brazilian Merganser, censuses, river width, Novo River, relative abundance.

INTRODUCTION

The Brazilian Merganser (*Mergus octosetaceus* Vieillot, 1817) is a globally and locally endangered species (MMA 2014, IUCN 2015). It is one of the most threatened waterfowl species of the Neotropical region (Bartmann 1988, Collar *et al.* 1992), with probably less than 250 individuals surviving in the wild (Birdlife 2015). Monogamous and sedentary, it feeds on small fish (Characidae), which are captured during fast dives (Silveira & Bartmann 2001). Its nests are made in tree or rock cavities (Bruno *et al.* 2010, Barbosa *et al.* 2011) right beside water bodies (Lamas & Santos 2004), and its breeding season usually ranges from June to September. It inhabits only shallow, clear water rivers or small streams, with stretches of rapids, and bordered by riparian vegetation. Due to its low population densities and high sensitivity to environmental disturbance, the species is most threatened by the loss of suitable habitat and/or reduction of water quality, complicating the species' conservational status.

Historically, this species occurred in Paraguay, Argentina and Brazil, but is presently only found in the latter country. In Paraguay, the species occurred at the headwaters of the Paraná river basin, where it is currently considered to be extinct in the wild. In Argentina, the species occurred within the Paraná river basin in Misiones, but the last sightings there and within that country as a whole were made in 2002 (Giraudo & Povedano 2003). In Brazil, the species exists as disjunct small populations, occurring in tributaries of the upper São Francisco River, in the state of Minas Gerais (Silveira 1998, Silveira & Bartmann 2001, Lamas & Santos 2004) and right bank tributaries of the Tocantins River Basin, in the states of Goiás and Tocantins (Braz *et al.* 2003, Bianchi *et al.* 2005, Barbosa & Almeida 2010, Barbosa *et al.* 2011). The first records of the species at Jalapão State Park (*Parque Estadual do Jalapão*), eastern Tocantins, were made as recently as 2002 along the Novo River (Braz *et al.* 2003), a tributary of the Sono River basin, at the border of the Jalapão State Park (Figure 1), where it was subsequently recorded (Pacheco & Olmos 2010). Between 2007 and

2010 the species was studied along the Novo River by first author (Barbosa & Almeida 2010, Barbosa *et al.* 2011). Considering the critical status of the Brazilian Merganser and the little knowledge about it at the Jalapão region, we have studied its occurrence and distribution on the main suitable rivers present in the region, estimating population sizes and evaluating the local availability of the species' habitat requirements.

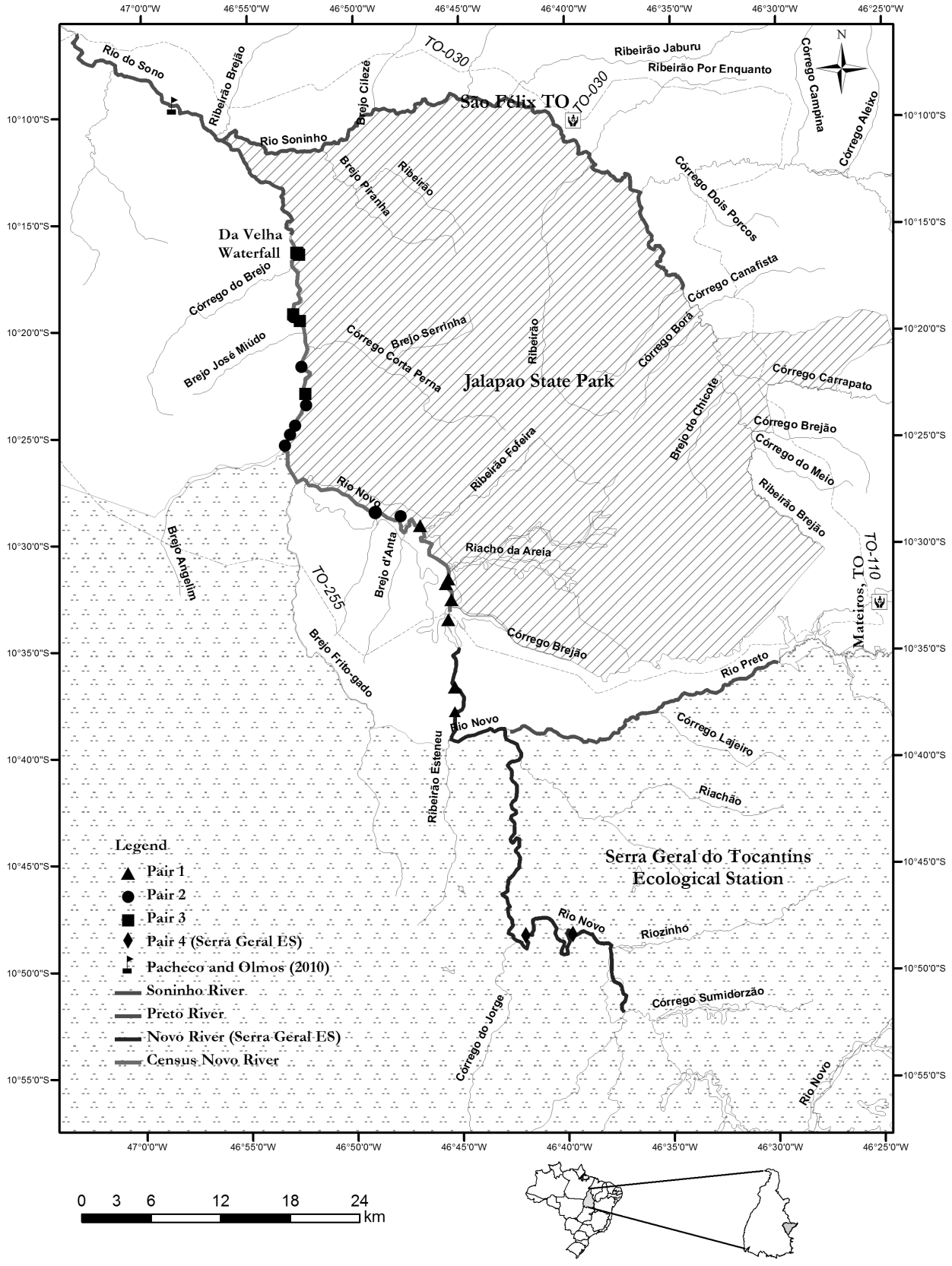

FIGURE 1. Map of the study area showing the distribution of four pairs of the Brazilian Merganser *Mergus octosetaceus* identified along the Novo River during this study as well as a pair on the Sono River (Pacheco & Olmos, 2010). The stretches of rivers surveyed are highlighted in black and grey.

METHODS

Study area

The study was conducted at the Jalapão State Park, located in the eastern portion of the State of Tocantins (10°30'34.87''S; 46°34'36.40''W). The region where the Jalapão State Park was created represents one of the best preserved areas of *Cerrado* in Brazil and it is formed by the different protected areas that together constitute a total area of roughly two million hectares. The largest protected areas are Jalapão State Park (158.885 ha), Serra Geral do Tocantins Ecological Station (645.378 ha), and Nascentes do Parnaíba National Park (645.378 ha).

The climate in the region has two markedly distinct seasons, with a rainy season extending from October to April and a dry season from May to September. The vegetation is *Cerrado* with prevalence of grasslands, which grow on poor (oligotrophic) and sandy soils. The region is characterized also by the presence of plateaus that can reach 800 m, where the headwaters of many watercourses that flow to the Tocantins river basin are located (Von Behr 2004).

Local range

We conducted searches for this species along the Novo, Preto, Soninho and Sono Rivers (this latter river named after the confluence of Novo and Soninho Rivers) by boat. The stretches of Novo and Soninho rivers were surveyed during two days whereas the Preto and Sono along a single day only. These rivers were selected because they present potential habitat conditions for the Brazilian Merganser such as clear water, rapids, and well-preserved vegetation along their banks. The choice of river sections sampled was made based on: 1) previous visits to the study area; 2) previously known observation localities for the species (Braz *et al.* 2003, Barbosa & Almeida 2010, Pacheco & Olmos 2010); and 3) satellite images.

The following stretches were surveyed: 24 km (representing 35% of the total river length) along the Preto River (n = 1), with a starting point at the municipality of Mateiros (10°34'33.96''S; 46°28'21.06''W), in September 2009; 69 km (76%) along the Soninho River (n = 1), with the starting point at the *Chácara da Gildete* (10°20'24.47''S; 46°32'53.02''W), in October 2010; 20 km (9%) along the Sono River (n = 1), with the starting point at the confluence with the Novo River (10°10'58.98''S; 46°56'21.04''W), in October 2010, which included a previously known locality for the species (Pacheco & Olmos 2010); and a total of 130 km (85%) along the Novo River (Ecological Station [n = 2]; *Da Velha* downstream [n = 1]; *Da Velha* upstream [censuses stretches [n = 13]), with the starting point located 25 km downriver from its headwaters (10°51'57.22''S; 46°37'24.75''W) and extending toward its confluence with the Sono River. The different distances surveyed were determined by habitat suitability along each river as well as access and navigability issues.

Characterization of the rivers

In order to characterize each section of the surveyed rivers, we measured variables of the environment and structural differences each 1.5-2.0 km along the Novo (28 points in 50 km), Preto (12 points in 24 km) and Soninho/Sono Rivers (14 points in 27 km). Geographic coordinates and elevation were taken using a Garmin Map60CSx GPS, this being the second measure used to verify the declivity (relative drop in elevation) for each stretch of the rivers sampled. Variables such as vegetation type and clarity of the water, were used to further characterize each river section. We photographed river banks and satellite images were used to aid vegetation analyses at each sampling point. Vegetation types were characterized on both banks according to the classification of Coutinho (1978), i.e., *campo limpo* (open fields), *campo úmido* (wetland), *campo Cerrado* (cerrado field), *cerrado sensu stricto*, *mata ciliar* (riparian forest), and *cerradão* (woods). The clearness of the water was classified in three categories, according to the capacity for clear vision of the river bottom, and ranging from low visibility (dark water) to moderate visibility and high visibility (extremely clear water).

To test how the structural differences on the landscape may affect the presence of the species, we generated probabilistic models based on the presence/absence of the species at the survey points in relation to the following variables: river width, type of flow and flow level. The width of the river was measured through analyses of high-resolution satellite images. Type of flow was classified as "remanso" (slowly-flowing water) or "corredeira" (rapids), and the level of flow was obtained by eye according to the intensity and declivity of each rapid, being attributed the following levels: 1 – low; 2 – moderate; and 3 – high.

Populational data

To estimate the relative abundance of the Brazilian Merganser along the Novo River, we selected a section with nearly 50 km, located between the bridge on the TO-255 road (10°33'02.43''S; 46°45'34.73''W) and *Da Velha* waterfall (10°16'17.29''S; 46°52'44.51''W), where the species had already been documented (Braz *et al.* 2003, Barbosa & Almeida 2010). Monthly censuses (n = 13) were conducted between August 2009 and October 2010 by boat in a controlled speed between 4 and 7 km/h, during five to eight hours per day. Each census started around 08:00 h and lasted for two days.

The identification and classification of the individuals (number of individuals, sex, pairs, groups, and pairs with

young) were made from direct sightings using binoculars (Nikon 8 x 42). Each point was georeferenced using Garmin Map60CSx GPS. The difference in elevation on each 5 km at the Novo River was measured in order to verify a possible correlation between the presence of the species and the river gradient of descent. The exact point of each individual/group recorded on the river was taken right after the sighting and they were counted only when parallel to the boat to avoid errors.

In order to determine the proportion of each river section (50 km) that was effectively occupied by the species and to obtain an accurate estimate of the number of individuals that occupy the Novo River, we estimated the Proportion of Occupied Area (Ψ). We selected 28 equidistant points (every 1.5–2 km), defined as surveying sites (the same points used to obtain the variables through the section at the Novo River); therefore, we obtained the records of presence (1) and absence (0) of the species at each of the surveying sites during the censuses. The observation of any individual located 750 m up or down river from each survey site was interpreted as presence at that particular site.

Statistical analyses

In order to identify possible differences in the mean width of the sampled rivers, we conducted a Kruskal-Wallis, non-parametric test. The differences between types of flow were evaluated using CHI-Square Test (χ^2). The correlation between Brazilian Merganser presence and altitude every 5 km along the sampled rivers was obtained by the Pearson Linear Correlation Test, performed using BioEstat 4.0. The significance of each test was $\alpha = 0.05$ (Zar 1999).

Relative abundance of Brazilian Mergansers along the Novo River was estimated using the Kilometrical Abundance Index (KAI) (Telleria 1986), which consists of determining the number of individuals detected per kilometer of survey; here we considered only adult individuals detected on the census section (50 km). That index was estimated for each census period in order to verify possible seasonal variations.

The proportion of the 50-km area that was occupied by the species was obtained using PRESENCE 3.0 (Hines 2006). That algorithm estimates the proportion of area occupied or the probability of a given site being occupied, through comparing the number of sites where the species was recorded in relation to the total number of surveyed sites (MacKenzie *et al.* 2002). The models generated by the software were ranked according to the Akaike's Information Criterion (AIC: Akaike 1974). We used the single-season analysis and the model pre-defined by the software, which considers the proportion of occupied area (Ψ) and a detection probability (P) constant.

In order to verify which landscape features are related to the presence of the species (e.g. river width, type of flow and flow level), we created seven probabilistic models (Table 1) through a simple regression (with one of the variables), including a null model, and using the statistical package *R* 2.13.2, we made simple and multiple regressions. The models were calculated using the AIC, adjusted to small samples (Burnham & Anderson 1998). This method is useful for comparing similar models with different complexity levels; AIC is an index that rank models according to their probability of being selected given the proposed variables, i.e., the smaller the value, the more likely the model to explain the observed data.

TABLE 1. Models of occurrence of the Brazilian Merganser *Mergus octosetaceus* along rivers of the Jalapão region, TO run by software *R*. R Development Core Team. 2012.

Models	Variables	AICc	R^2	Δi AIC	AICw	Evidence weight
Model 0	No variables	73.423	0	4.709	0.041	10.534
Model 1	River width	68.714	0.094	0	0.441	1
Model 2	Flow type (rapids)	75.045	0.005	6.33	0.018	23.695
Model 3	Flow level	74.948	0.006	6.233	0.019	22.578
Model 4	River width + Flow type	70.186	0.101	1.471	0.211	2.087
Model 5	River width + Flow level	70.582	0.096	1.867	0.173	2.544
Model 6	Flow type + Flow level	76.941	0.006	8.226	0.007	61.151
Model 7	River width + Flow type + Flow level	71.983	0.104	3.268	0.086	5.126

AICc; value related to the correction for small samples; ΔiAIC (delta) refers to the relative difference of a model to the lowest AIC value, being more representative those values lower than 2.; AICw (evidence weight) is the chance of a model being selected, varying between 0 and 1, on which the highest values represent a higher chance of the model best respond to the species' presence.

RESULTS

Regional distribution

Brazilian mergansers were recorded only in the Novo River at the section located above the *Da Velha* waterfall; no records were obtained along the Preto, Soninho and Sono rivers. During a total sampling effort of 132 hours and 130 km along the Novo River, 125 contacts with Brazilian mergansers were obtained along a 115 km stretch between *Da Velha* waterfall and inside the Serra Geral do Tocantins Ecological Station (Figure 1).

Rivers characterization

The river sections surveyed presented similar features, and in general showed well preserved marginal vegetation with predominance of *Cerrado sensu stricto*, *Campo* and *Mata Ciliar*, and good water quality; however, the river sections are structurally distinct. The Soninho River is relatively narrow, with a total width varying between 26 and 105 m, with a mean of 46.9 m (SD = 22.3 m); that river flows through a steep gradient along its length, with a predominance of rapids (85.7%, $\chi^2 = 7.14$, df = 1, P = 0.007) over smoothly-flowing waters. The flow of rapids was predominately low (66.7%) to moderate (25%), with a low visibility of the river bottom due to the presence of humus related compounds that confer a dark color to the water.

The Preto River was the narrowest one sampled, with a width varying from 10 to 37 m (mean = 14.4 m, SD = 7.73 m). It is a fast river, with 66.7% of the surveyed points composed of rapids, mainly at its central portion, with rapids proportionately distributed with the calmer water sections ($\chi^2 = 1.33$, df = 1, P = 0.24 rather than P = 0.05 or ns). In general, the rapids were moderate (62.5%) to low (37.5%). This river presents a moderate visibility of the bottom, due to the dark color of the water mainly near its confluence with the Novo River.

The Novo River was the widest one sampled, with the width varying between 36 and 170 m (mean = 87.2 m, SD = 32.5 m). The presence of rapids is relatively equal to the presence of smooth current water (46.4% versus 53.6%, respectively), with long sections of each type and no significant difference at the proportions of each type ($\chi^2 = 0.14$, df = 1, P = 0.70 rather than P = 0.05 or ns). That river presents a sandy bottom and very clear water, which confers a high visibility to the river, and sandy banks formed mainly during the rainy season from the sand carried by the smaller tributaries whose headwaters are located in regions dominated by sandstone.

Factors related to the species occurrence

The model that best explained the species occurrence according to the landscape features was model #1, which is represented by the variable river bank/river width (Table 1). However, models #4 and #5, representing variables river width plus type of flow and river width plus level of flow, respectively, presented delta AIC values lower than two. In fact, the width significantly varied among rivers (H = 35.36, P < 0.0001), the Novo River being the widest (mean width = 87.2 m) and the Preto River the narrower (mean width = 14.4 m); moreover, the target species was detected primarily at wider sections of the sampled rivers, where the width varied between 50 and 100 m (Figure 2).

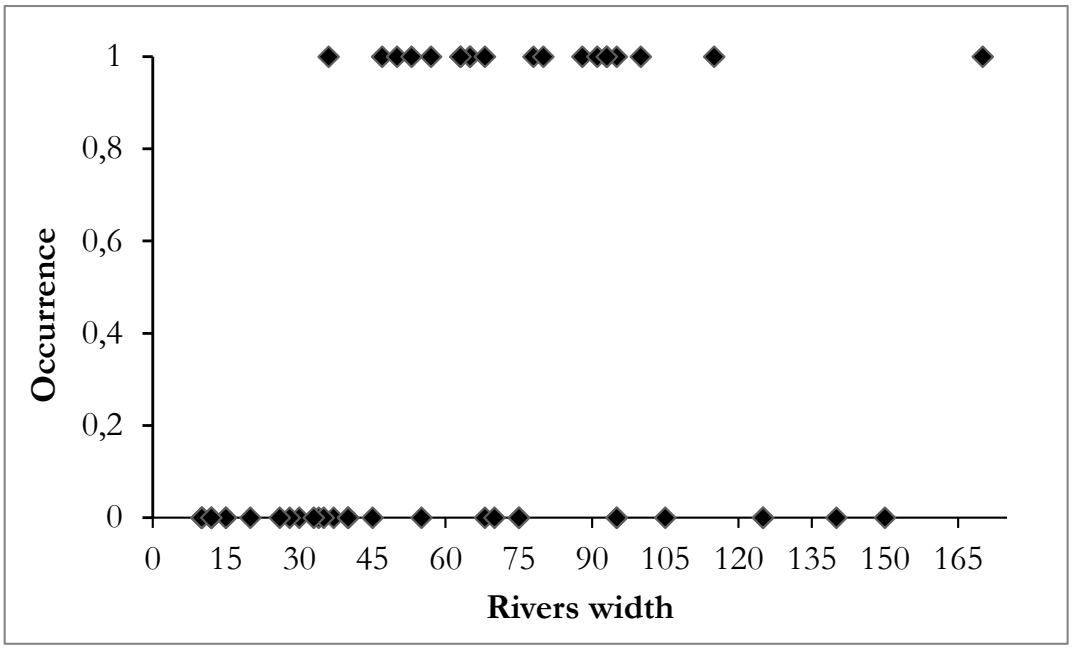

FIGURE 2. Occurrence of the Brazilian Merganser *Mergus octosetaceus* at sampling points along the Novo, Soninho and Preto Rivers, relative to the width of rivers in the Jalapão region, TO. Present = 1 and Absence = 0.

The Brazilian Merganser was recorded only on the Novo River, with most of the contacts (87.3%) made within the lotic section, an area of highest gradient descent and with presence of rapids (Figures. 3A and B). At that section, there is a positive correlation (P = 0.0077) between the number of contacts and the difference of river gradient calculated at each five kilometers (Figure 4). Even though there was no significant correlation found, in general the species was more frequently recorded in river sections with presence of rapids (χ^2 = 2.18, df = 1, P = 0.13 rather than P = 0.05 or ns) than in calm waters, and with a predominance observed within low intensity rapids. The contacts obtained in rapids level 1 (70.59%) were significantly more frequent (χ^2 = 24.06, df = 1, P < 0.0001) than those obtained in remaining levels. The results agree with the other two selected models (#4 and #5), which associate the variable "river width" with type and level of flow (Table 1).

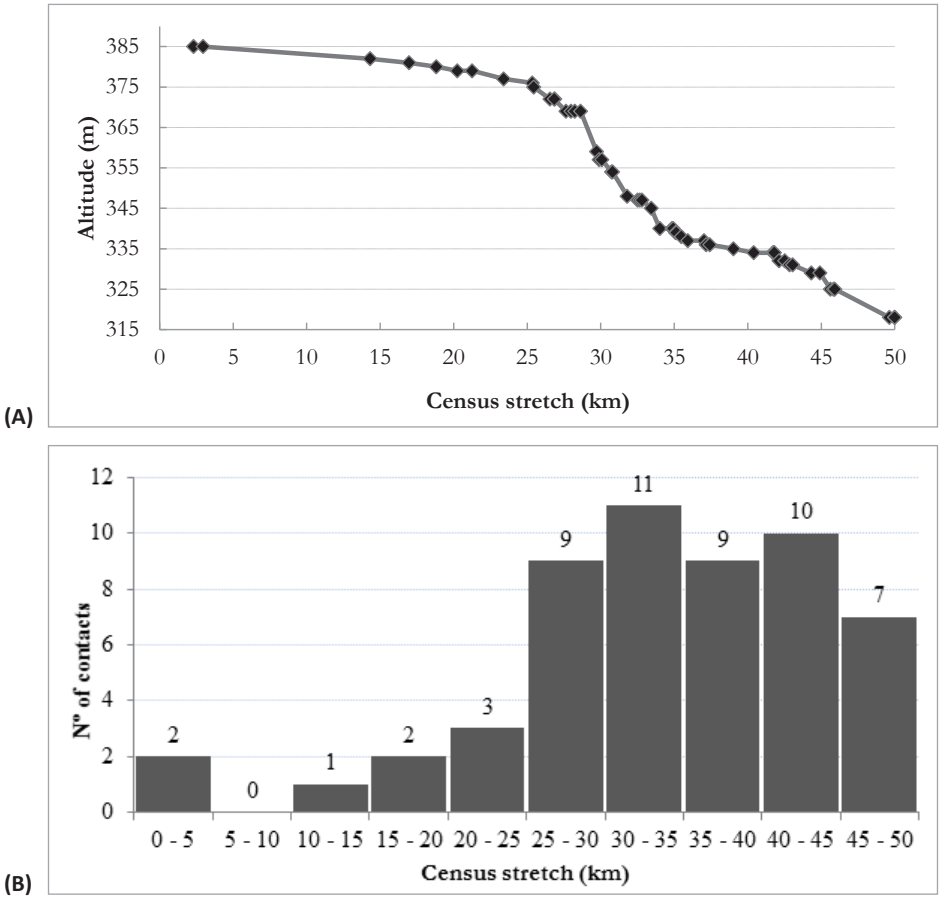

FIGURE 3. (A) Altimetry of contact points with the Brazilian Merganser *Mergus octosetaceus* along a stretch of Novo River (50 km), Jalapão, TO. (B) Frequency of contacts with the Brazilian Merganser *Mergus octosetaceus* at intervals of 5 km along a stretch of Novo River (50 km), Jalapão, TO.

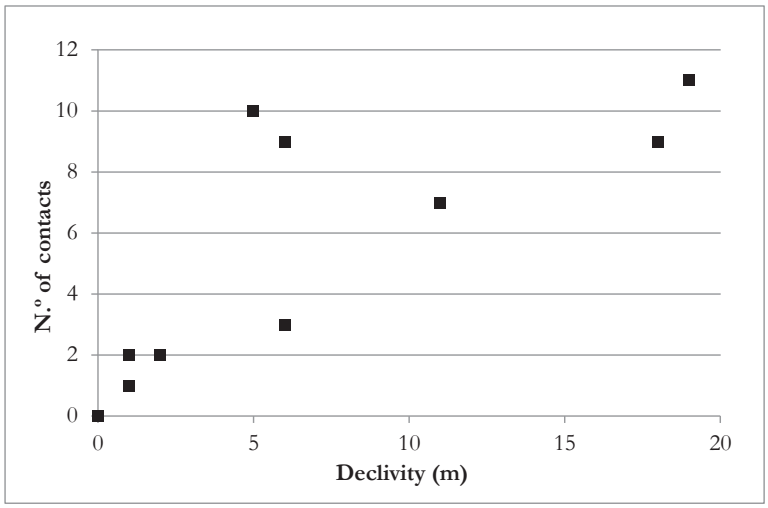

FIGURE 4. Correlation between the number of contacts with the Brazilian Merganser *Mergus octosetaceus* and declivity difference calculated at every 5 km of surveyed stretch of the Novo River (50 km), Jalapão, TO (Pearson r = 0.7876, P = 0.0077).

Populational data

Relative abundance of the Brazilian Merganser along the Novo River was 0.125 individuals/km. Based on that value, we estimate a total of 6.23 individuals for the 50 km section of the Novo River selected for the censuses. Considering the length of 145 km between *Da Velha* waterfall and *Riacho Verde* (near its headwaters) – the only section where the species were confirmed – we estimate a population of 18 adult individuals inhabiting the Novo river, which has a total length of roughly 160 km (Table 2).

Estimation of Occupied Area Proportion of the Novo River was Ψ = 0.7563, i.e., 75.6% of the surveyed section was occupied (Table3). Based on these data and considering that the estimate for the 145-km section with the species occurrence is equivalent to that obtained at the sections where the censuses were made, we estimate a population of 13.7 individuals for the Novo River. Subsequent surveys conducted in September and October 2009 and July and August 2010 in a 115-km section of the Novo River (including the sections of census and at the Serra Geral do Tocantins Ecological Station), the observed population size is similar to the estimated, with 12 individuals recorded in 2009 and 14 in 2010.

Species' distribution at the Novo River

Brazilian Mergansers were present in all censuses at the Novo River, and a total of four distinct pairs were identified, with three of them (Pairs 1, 2 and 3) being previously recorded (Barbosa & Almeida 2010). A total of 14 ducklings were recorded for those three pairs (see Barbosa & Almeida 2010 for 2007–2009 data). However, it was observed that there appeared to be a reduction of the survival of the ducklings of pairs 2 and 3, which occupy an area in which local people use to practice rafting (Table 4). The fourth pair was recorded at Serra Geral do Tocantins Ecological Station (Pair 4, Figure 1). During the survey throughout the Novo River, located inside the Serra Geral do Tocantins Ecological Station, during the reproductive seasons of 2009 and 2010, no ducklings were recorded accompanying that pair. The characteristics used to define a pair were the presence of a close relationship between individuals and the presence of a worn nuchal crest on the female, regarded as evidence of recent mating. Single individuals and/or groups of up to three individuals presenting adult plumage were observed on the Novo River as well, sometimes occupying the same river section as the pairs.

TABLE 2. Relative abundance and population estimates of the Brazilian Merganser, *Mergus octosetaceus*, along the Novo River, Jalapão, TO.

Census	N.° of adults observed per census	KAI (50 km)	PopEst (145 km)	PopEst*Ψ
Aug 2009	7	0,14	20,3	15,4
Aug 2009	9	0,18	26,1	19,8
Sep 2009	4	0,08	11,6	8,8
Nov 2009	7	0,14	20,3	15,4
Dec 2009	4	0,08	11,6	8,8
Feb 2010	9	0,18	26,1	19,8
Mar 2010	5	0,1	14,5	11
Apr 2010	5	0,1	14,5	11
May 2010	8	0,16	23,2	17,6
Jun 2010	7	0,14	20,3	15,4
Jul 2010	5	0,1	14,5	11
Sep 2010	6	0,12	17,4	13,2
Oct 2010	5	0,1	14,5	11
Mean (±SE)	**6,23** (±0,48)	**0,125** (±0,01)	**18,07** (±1,40)	**13,7** (±1,06)

(KAI) Kilometric Abundance Index for the census stretch - 50 km; (PopEst) Populacional Estimate for a stretch of 145 km; (Ψ) Proportion of Area Occupied (PAO) obtained at the census stretch (Ψ = 0,7593).

TABLE 3. Modeling of the proportion of area occupied by the Brazilian Merganser *Mergus octosetaceus* on a stretch (50 km) of the Novo River, Jalapão, TO, obtained with the software PRESENCE.

Model	AIC	AIC wgt	*P* (± SE)	Ψ (± SE)	Ψ Observed
Constant *P*	300,97	1.0	0.1954 (0.0266)	0.7593 (0.0931)	0.7142

AIC - Akaike's Information Criterion; AIC wgt – model weight; *P* - probability of detection; Ψ – Proportion of area occupied (Ψ Observed, i.e, ration between the total sampled sites by the number of sites with presence of species).

TABLE 4. Number of ducklings recorded of three pairs of the Brazilian Merganser *Mergus octosetaceus* on a stretch of Novo River during 2009 and 2010.

Year	Pairs	N.º of ducklings	Date	Locality/stretch	Coordinates (Datum WGS 84)	Details/observation
2009	Pair 1	?	?	Pair not detected on the stretch. It was occupying the stretch of river (APA Jalapão) upstream of bridge over TO-255 road, out of the census stretch.		
	Pair 2	1 *	02 August 2009 20 August 2009	Novo River, 3 km downstream of Corta Perna stream (700 m away from Pair 3).	10°19'S, 46°52'W 10°21'S, 46°52'W	(*) Pair observed on September 23 without ducklings.
	Pair 3	2 *	02 August 2009 20 August 2009 23 August 2009	Novo River, 2.3 km downstream of Corta Perna stream.	10°19'S, 46°52'W 10°19'S, 46°52'W 10°16'S, 46°52'W	(*) On November 25, the pair was observed without ducklings.
2010	Pair 1	5	12 August 2010	Novo River/APA Jalapão, upstream of Korubo camping.	10°36'S, 46°45'W	Pair observed during survey into the Serra Geral do TO (SGTES).
	Pair 2	6 *	27 July 2010 16 September 2010 15 October 2010	Novo River, 3 km downstream of Praia dos Crentes.	10°28'S, 46°47'W 10°24'S, 46°52'W 10°24'S, 46°53'W	Ducklings with about a week of age; (*) On 16 September 2010 the pair was found with 5 ducklings (with about two months of age) and on 15 October 2010 4 ducklings already capable of flight were observed.
	Pair 3	x	28 July 2010 16 September 2010 15 October 2010	Novo River, stretch near the nest.	10°19'S, 46°52'W 10°19'S, 46°52'W 10°18'S, 46°52'W	Nest found on 10 June 2010 with a female inside it. Probable nest desertion due to the presence of the boat.

(*) Observed decrease in the number of surviving ducklings during subsequent surveys.

DISCUSSION

The Jalapão region includes an important portion of the water courses that converge within the Sono river basin, which flows into the Tocantins River. Considering the exceptional features of the streams in this region, the low density of human population (Mamede *et al.* 2002) and the vast portion of protected, well preserved riparian areas, we expected that the region could shelter a larger population of Brazilian Merganser than what we found, as observed at Serra da Canastra, in the State of Minas Gerais, where approximately 80 individuals are known to occur (Lamas 2006). Most of the water courses in the Jalapão region represent small to narrow streams, forming the typical *veredas* and with marginal vegetation and low water volume, thus not providing the most favorable conditions for the species occurrence. Therefore, we believed the larger streams would represent areas of greater potential occurrence of the species in the study site. However, we observed this greater presence only on the Novo River.

The Novo River presents some distinctive features that distinguish it from the others surveyed (Preto, Soninho and Sono), especially concerning its width. It is considerably wider than the others, which we believe is an important condition for the presence of the Brazilian Merganser in the Jalapão region. Nevertheless, in other sites where the species is known to occur (e.g. Serra da Canastra and Chapada dos Veadeiros) it reportedly occurs in narrower streams than the Novo River. It is important to highlight that the river width itself is not an essential feature for the presence of the species throughout its range. In general, records were obtained in portions of the River Novo that varied between 50 and 100 m in width (Figure 2), an interval distinct from the mean width of Preto and Soninho Rivers. Wider sections allow birds to have a wide visual field, which would facilitate protection from natural predators and of humans disturbance (humans are commonly present at Novo River, mostly due to the practice of rafting and of camping in river banks).

Clearness of the water is also an important factor that distinguishes the Novo River from the others present at the region. The low depth and presence of sand and sandstone sediment favor seeing and capturing prey by the mergansers, which could also be a important factor for presence of the species along this river. The Novo River differs from the other rivers in the region also in the higher percentage of rapids along its course, due to having more sections with higher gradient descent. Due to the fact that the lotic parts of the river correspond to the sites where the species was detected, it is important to highlight that the presence of rapids itself is not an essential feature for the presence of the species, as all the other rivers surveyed presented rapids on their courses as well. However, when variables such as type of flow, flow level and river width are associated (models #4 and #5), it becomes evident that the merganser selects a set of landscape features as their habitat.

A few studies highlight that the Brazilian Merganser occurs exclusively on upland rivers, inhabiting the upper portions of rivers where the presence of large, aquatic predators (*ictiofauna*) would be a limiting factor (Partridge 1956, Willis & Oniki 2003). On the upper Novo River, the *Da Velha* waterfall works as a natural barrier to large predatory fishes, preventing the occurrence of species such as Jaú (*Zungaro zungaro*) and Caranha (*Pyaractus brachipomus*), among others that occur at Soninho, Sono and the lower portions of the Novo River. Thus, the absence of those predators along Novo River, upstream from *Da Velha* waterfall, may play some role in the observed presence of the species on that portion of the river.

Pacheco & Olmos (2010) mention the presence of a pair of Brazilian Merganser on a sandy bank at the Sono River, roughly 5 km downstream from the confluence of Novo and Soninho Rivers. The pair was spotted during a flyby, as part of a rapid ecological assessment of the region. In the present study, we surveyed 69 km along the Soninho River and 20 km along the Sono River, including the spot where Pacheco & Olmos (2010) obtained the aforementioned record, but without observing any Brazilian Merganser there. Considering that the species was detected in all censuses along the Novo River, and that it has been reported along the Sono River as well, we expected that the species would be recorded there too.

Beginning in 2011, new fruitless searches were made along the Soninho River (Valtécio Carvalho *pers. comm.*). Moreover, during a study for the implementation of a hydroelectric plant at Perdida River, an important tributary of the Sono River, intensive searches for the species were also unsuccessful. Although our sampling effort has been small (n=1), these data and information seem to indicate the absence of the species at Sono and Soninho Rivers is real and may mean they are extinct there at present.

Conservation at the Jalapão region

Among the main factors that can potentially threaten the local population of the Brazilian Merganser at Jalapão region are the establishment of hydroelectric plants and the practice of rafting. The modification of the flow is considered the most serious and permanent threat to the ecological sustainability of rivers and their banks (Sparks 1995, Lundqvist 1998, Ward *et al.* 1999). The impoundment of a river represents the interruption of an open-end transport system to a closed and

accumulation system (Junk & Mello 1990). According to Bunn & Arthington (2002), the modification of the water flow changes the habitat and influences the species' distribution and abundance, as well as the diversity and composition of the aquatic communities. Regarding the rivers in the Jalapão region, changes in water flow by impoundment caused by future hydroelectric ventures planned for the Novo and Sono rivers, similar to eight plants constructed on the Palmeiras River (at the outskirts of Serra Geral do Tocantins Ecological Station) and two under construction on the Perdida River (tributary of the Sono River), could affect and threaten the survival of the already small population of Brazilian Mergansers that inhabits the region.

An important threat to the species' survival within the Novo River is the practice of rafting by tourists where the species was previously known to reproduce (Barbosa & Almeida 2010, Barbosa *et al.* 2011). The peak of that sporting activity coincides with the species' reproductive season and the disturbance caused by such activity may affect the species' reproductive dynamics and interfere with mating, nest construction, incubation, and duckling survival. We have witnessed that during approach by boats, ducklings disperse and are temporarily abandoned by the parents. In some cases the disturbance keeps the ducklings away from the parents for a prolonged time, with the risk of getting lost and/or being more exposed to predation. We also noticed an extensive degree of movements along the river of adults and ducklings following disturbance by rafting that may contribute to a lower efficiency of ducklings' foraging and lower reproductive success and recruitment.

The fact that the Brazilian Merganser presently occurs only on the Novo River upstream from *Da Velha* waterfall in the Jalapão region, reinforces the importance of that river section for the survival of the species at its northernmost range limit. Concerning the pairs we recorded, only one can be considered to be protected, since it occurred inside the Serra Geral do Tocantins Ecological Station. The other three pairs inhabit stretches at Área de Proteção Ambiental do Jalapão (reserve of sustainable use), or at the borders of Jalapão State Park, which are not entirely protected. For the effective protection of such pairs it seems important to enlarge the area of the Jalapão State Park, or create new protected areas that encompass the left bank of the Novo River, as suggested by Barbosa and Almeida (2010). It is also important that an effective control of the practice of rafting is established to avoid high disturbance especially during the reproductive season, and that education initiatives focused on informing tourists and local communities about the importance of conservation of the Brazilian Merganser in the Jalapão region be put in place.

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