Wild pig (*Sus scrofa* L.) occupancy patterns in the Brazilian Atlantic forest

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**Abstract:** Despite the great impacts of invasive wild pig (*Sus scrofa*) to natural ecosystems, habitat use by this species in the neotropics remains poorly studied. Here, we investigated the effects of local habitat and landscape covariates (vegetation types, running watercourses and roads) on occupancy patterns of wild pig in the Atlantic Forest of southern Brazil. We used single season occupancy modeling to estimate detection (p) and occupancy (ψ) probabilities, using 8-day camera-trap monitoring of 100 sampled sites. The cameras detected wild pig in 64 sites (naïve occupancy = 64%). The four best models explained 72.7% of the occupancy patterns, and the top model (with “water” variable) had a weight of 28.5%. Even though none of the tested variables had high explanatory power of wild pig occupancy, the water variable had a negative effect trend (β = -1.124; SE = 0.734), with 59% of occupancy when water was present and 82% when it was absent around the sampling sites. Vestiges of the presence of wild pig in different vegetation types revealed that they used plantations of *Pinus* sp., native forests, and corn and oat crops. The occupation pattern shows that wild pig are generalist at our study site at the Atlantic Forest being found everywhere, raising ecological and economic concerns about the high potential negative effects of its invasion.

**Keywords:** Occupancy modeling, feral pig, wild boar, landscape, Neotropics.

Padrões de ocupação do javali (*Sus scrofa* L.) na Mata Atlântica brasileira

**Resumo:** Apesar dos grandes impactos da invasão do javali (*Sus scrofa*) nos ecossistemas naturais, o uso de hábitats por esta espécie nos neotrópicos ainda permanece pouco estudado. Aqui, nós investigamos os efeitos do hábitat local e de covariáveis da paisagem (tipos de vegetação, cursos d’água e estradas) sobre os padrões de ocupação do javali na Mata Atlântica do sul do Brasil. Utilizamos a modelagem de ocupação de estação única para estimar as probabilidades de detecção (p) e de ocupação (ψ) dos jаяvalis, usando monitoramento de armadilha fotográfica por 8 dias em 100 locais. As câmeras detectaram jаяvalis em 64 locais (ocupação ingênua = 64%). Os quatro melhores modelos explicaram 72,7% dos padrões de ocupação, e o melhor modelo (com variável “água”) teve um peso de 28,5%. Embora nenhuma das variáveis testadas apresentaram alto poder explicativo na ocupação do javali, a variável água foi a que contribuiu com uma tendência de efeito negativo (β = -1,124; SE = 0,734), com 59% de ocupação quando a água estava presente e 82% quando estava ausente nos pontos de amostragem. Vestígios da presença de javali em diferentes tipos de vegetação revelaram que eles utilizaram plantações de *Pinus* sp., florestas nativas e culturas de milho e aveia. O padrão de ocupação mostra que o javali é extremamente generalista em nosso local de estudo na Mata Atlântica, sendo encontrado em todos os lugares, o que levanta preocupações ecológicas e econômicas sobre os potenciais efeitos negativos de sua invasão.

**Palavras-chave:** Modelagem de ocupação, porcos asselvajados, javali, paisagem, Neotrópicos.
**Introduction**

Non-native and invasive species are found in almost all ecosystems worldwide, a number that has increased markedly in the last two decades (Blackburn et al. 2011). These accidentally or intentionally introduced species are causing several damages to native species (Vitule et al. 2012), changes in community structure and in dynamics of natural ecosystems (Martin et al. 2009) and even reduction in biological diversity (Chapin III et al. 2000). Furthermore, anthropogenic disturbances of natural environments favor the success of invasive species (Gurevitch & Padilla 2004), and many changes promoted by invasive species are gradual and unnoticed (Simberloff et al. 2013).

Wild pig (*Sus scrofa* L.) are those pig invasive/non-native/introduced (Keiter et al. 2016, Melletti & Meijaard 2017), currently considered one of the 100 most invasive species of the world (Lowe et al. 2000, IUCN 2019). After humans, wild pig comprises the large-bodied size mammals with the broadest distribution in the world (Massaei & Genov 2004; Barrios-García & Ballari 2012). Since the wild pig had a wide native geographical distribution, it can be considered pre-adapted to a large array of environmental conditions (Baskin & Danell 2003).

Wild pig can move long distances in one single day in search for food (Leaper et al. 1999) and are able to cause major impacts on native plants and animals, on crop plantations and domestic animals, and on ecological processes (Oliver & Brisbin 1993; Hadjisterkotis 2004; Massaei & Genov 2004; Barrios-García & Ballari 2012; Myrphy et al. 2014). However, resource abundance and distribution can have strong impacts on population dynamics and survival rates of wild pig (Ostfeld & Keesing 2000). Wild pig population growth and abundance can be determined by presence or absence of food resources (Jedrzejewska et al. 1997; Honda 2009), landscape structure (Acevedo et al. 2006) and climatic factors (Honda 2009).

Models have been used recently to predict the distribution of wild pig and to understand their occupancy patterns in native and non-native areas (Bosch et al. 2012, Bosch et al. 2014, Acevedo et al. 2014, Gantchhoff & Belant 2015, McClure et al. 2015, Forsyth et al. 2016, Sales et al. 2017, Pittiglio et al. 2018). Such studies were based on models using camera traps and indirectly on signs and presence/absence data of wild pig associated with environmental (vegetation type and topography) and climatic variables, besides anthropogenic effects. These analyses revealed that areas occupied or with a potential to be occupied by wild pig are those where food and shelter are most abundant. Also, niche shifts in non-native areas might be explained mainly by the existence of unoccupied areas where the climate is similar to its native areas (Sales et al. 2017).

Native to Eurasia and north of Africa, the wild pig were introduced in South America at the beginning of the 20th century, invading Brazil by late 1980s from Uruguay into the southern part of the State of Rio Grande do Sul (Deberdt & Scherer 2007). In the wild, it interbred with the domestic pig (*Sus scrofa domesticus* Erxleben) resulting in fertile hybrids (Grossi et al. 2006), called “wild pig” (Keiter et al. 2016, Melletti & Meijaard 2017). Wild pig are one of the several invasive species present in the Brazilian Atlantic Forest (Deberdt & Scherer 2007, Hegel & Marini 2013, Pedrosa et al. 2015). These native forests offer resources such as water, food, and humid areas, and have nowadays low density of large predators, like jaguars or pumas (Machado et al. 2008), which have the potential to prey upon large ungulates (Hegel & Marini 2018). Wild pig impact on the Atlantic Forest is poorly known, but at a forest fragment in south Brazil, the impact on the native vegetation inside a reserve was evaluated and showed intense herbivory, rooting and soil overturning (Hegel & Marini 2013). Also worryingly, wild pig consumes and destroy the seeds and cones (Deberdt & Scherer 2007, Hegel & Marini 2013) of the critically endangered Parana Pine (*Araucaria angustifolia*) (Thomas 2013), which has already lost 97% of its geographical distribution (Gantzel 1982, Guerra et al. 2002). The increasing abundance and economic damage, such as partial loss of crop plantations, caused by wild pig in Brazil have promoted a series of laws by Brazilian governmental agencies allowing wild pig hunting (see IBAMA nº 03 of 31 January 2013, reissued in IBAMA nº 12 of 25 March 2019). However, there are no current estimates of wild pig densities and expansion rates at the Atlantic Forest. Finally, it is worthy to mention that the Atlantic Forest has lost approximately 90% of its original distribution (Ribeiro et al. 2009), is a world hotspot (Myers et al. 2010), and is still being deforested in the last decades (SOS Mata Atlântica 2014).

Thus, considering the potential threat of wild pig to native species and habitats, the high endangerment of the Atlantic Forest, and the scarcity of studies about the recent invasion of wild pig in the region, we tested the hypothesis that wild pig occupation patterns in the Atlantic Forest are related to vegetation types and landscape variables, resembling the patterns found in other native and non-native areas. To accomplish that, we estimated wild pig detection (*p*) and occupancy (*q*) probabilities in the Atlantic Forest. The findings provide unique information about how wild pig occupy an altered Atlantic Forest landscape, with potential applications to conservation and management plans.

**Material and Methods**

1. **Study site**

We conducted this study at the ‘Campos de Cima da Serra’ region, southern Brazil (28°13′54.2″ S and 51°10′14.9″ W), at the southern part of the Atlantic Forest. We studied a region up to 50 km centered at the reserve ‘Estação Ecológica de Aracuri-Esmeralda’ (EEAE, with 275 ha), municipality of Muitos Capões, Rio Grande do Sul (Figure 1, Supplementary Table S1). Today, the vegetation of the region is composed of patches of disturbed Mixed Ombrophilous Forest, a type of Atlantic forest of southern Brazil with *Araucaria angustifolia* as the most emblematic tree, in a matrix of native grasslands, wetlands, secondary vegetation, ‘vassorais’ (*Baccharis* dominated vegetation) and crop plantations (Brasil 2008). The study region is located around 700-950 m elevation with mean annual rainfall ranging from 1,700 to 2,200 mm well distributed along the year and mean annual temperature ranging from 14° and 16°C (Brasil 2008), with four well defined seasons.

2. **Sampling sites and variables**

We conducted a 10-day sampling design preliminary study at the end of July 2015, using one camera-trap in each of 16 sites. Then, we used this result to simulate in program MARK (White & Burnham 1999) the number of days and sampling units necessary to estimate our parameters of interest (i.e., occupancy (*q*) and detection (*p*) probabilities) during one single season. Based on the results of this simulation we designed our study to register wild pig with camera traps during 8 days at 100...
Figure 1. Wild pig (Sus scrofa) occupancy study region showing the sampling sites (red dots) in the Atlantic Forest, state of Rio Grande do Sul, southern Brazil.

At each site, the percentage of four vegetation types (native forests, native grasslands, wetlands, and crop plantations) was estimated around 500 m from the point that each camera was mounted using Google Earth images treated with ArcGIS (Esri 2011). Overall, the native forest was the most common vegetation type (56.5% of the area), followed by crop plantations (25.7%), native grasslands (9.9%), and wetlands (7.8%). To run the single-season occupancy modeling analysis, we used six variables: two landscape variables (distance from roads - categorical, up to 50 m and further than 50 m, and distance from running watercourses - categorical, up to 30 m and further than 30 m) and the four vegetation types, each one as a variable (native forests, native grasslands, wetlands, and crop plantations (encompassing oat, corn, soybean, wheat, apple and grape orchards). We excluded Pinus sp. plantations from the analyses since they represented only a very small portion (0.12%) of total vegetation.

3. Statistical analyses

We used a single-season occupancy modeling approach to estimate occupancy ($\psi$) and detection ($p$) probabilities of wild pig (Mackenzie et al. 2002). The assumptions of the method are that (1) within the sampling period the occupancy status of the species was closed (no colonization or extinction occur during the sampling) (Mackenzie et al. 2006); (2) the probability of detecting the species was independent among sampled sites; and (3) the species was not falsely detected. We considered occupancy as a measure of habitat use, because home ranges of wild pig may exceed the size of our sampling unit (0.7 – 6 km$^2$) (Baber & Coblentz 1986, Ilse & Hellgren 1995, Gabor et al. 1999). The assumption that sites are close to changes in occupancy during the sampling occasions may be relaxed if changes in the occupancy status of sites are random. In this case, occupancy should be interpreted as ‘use’ and movement throughout the sampled sites (Mackenzie et al. 2004; Mackenzie & Royle 2005). The detection probability incorporated to the models accounts for imperfect detection, reducing bias in parameters estimation (Mackenzie et al. 2006).
Our modeling process followed three steps in program MARK (White & Burnham 1999). First, we built a global additive model with occupancy varying by the presence of running watercourses (water), roads (road), amount of forest (forest), grassland (grass), wetlands (wetlands), and crop plantations (crops). In this global model, we maintained detection constant because the temporal version did not estimate all parameters, and because we did not have specific hypotheses on detection variation. Next, we built a set of 64 models with all possible combinations. This resulted in a balanced model set to estimate the importance (cumulative weights, hereafter \( w_i^+ \)) of each landscape variable, following the recommendation of Burnham & Anderson (2002). Finally, to have a reliable set of candidate models, we excluded from the analysis models with non-informative parameters, following Arnold (2010). Although vegetation variables appeared as non-informative parameters, we decided to maintain models with these variables based on our field observations and the importance of vegetation to the presence and distribution of wild pig. We conducted goodness-of-fit analysis with program PRESENCE (Hines 2006) to evaluate the global model fit and to estimate the variance inflation factor (c-hat), which we used to adjust the Akaike’s Information Criterion for small sample size (QAICc, see Mackenzie & Bailey 2004). We used QAICc to rank competing models and we considered models with QAICc values < 2 equally supported and used them to make inferences (Burnham & Anderson 2002). We considered the QAICc \( w_i \) (hereafter \( w_i \)) as the relative weight of support of each model and we model-averaged occupancy \( (\psi) \) across the final set of models (Burnham & Anderson 2002, Doherty et al. 2012). Finally, we did not use null \( p \)-values to clarify uncertainties in the modeling to avoid mixing the paradigms “hierarchical model selection” and “null hypothesis testing”, following Wasserstein et al. (2019).

**Results**

We recorded wild pig in 64 of the 100 sampled sites in the Atlantic Forest. We built all possible combinations of additive models, resulting in a set of 64 models (Supplementary Table S2). In these models, the variable “water” had the highest cumulative weight (\( w_{i}^{+} = 0.60 \)), followed by “crops” (\( w_{i}^{+} = 0.34 \)), “grass” (\( w_{i}^{+} = 0.31 \)), “forest” (\( w_{i}^{+} = 0.29 \)), “wetlands” (\( w_{i}^{+} = 0.27 \)), and “roads” (\( w_{i}^{+} = 0.25 \)). After excluding from the analysis models with non-informative parameters, only 11 models remained with the most important variables affecting detection and occupancy probabilities of wild pig. From these, the four top-ranked models accounted for 72.7% of the total model weight and QAICc < 2 (Table 1). We considered them to explain variation in occupancy probability of wild pig in the Atlantic Forest. The top model (\( w_{i} = 0.285 \)) had “water” as a covariate on occupancy, in the second model the occupancy was “constant” (\( w_{i} = 0.208 \)), and in the third and fourth models, the occupancy was explained by “crops” and “grass” (\( w_{i} = 0.123 \) and 0.111), respectively (Table 1).

No single variable highly explained wild pig occupancy in the Atlantic Forest (Tables 1 and 2). The two best models answered for 49.3% of the weight of all models (“water” – 28.5% and “constant” – 20.8%). However, the top model showed a slight tendency towards a negative effect of “water” (running watercourses), with a decrease of wild pig occupancy at sampling sites close to running watercourses (\( \beta = -1.12 \); \( SE = 0.58 \)). When the “water” variable was analyzed alone, the results indicated that in the presence of running watercourses the percentage of occupation by wild pig was lower (59%) than in the absence of running watercourses (82%). The second model, “constant”, reinforces the generalist habit of wild pig indicating a random pattern of occupation of the landscape. The next models with the variables “crops”, “grass”, “forest”, and “wetlands” had inconclusive tendencies with weak explanatory weights (between 7.2 and 12.3%) (Table 1) and confidence intervals of the \( \beta \) parameters overlapping zero (Table 2). Furthermore, “roads” did not contribute to explaining the occupation of wild pig (\( \beta < 0.001; SE = 0.51 \)). Wild pig were detected equally in areas with (\( N = 32 \)) and without (\( N = 32 \)) roads near the sampling sites with cameras.

**Discussion**

Our results showed uncertainties about the influencing variables of wild pig occupation on South Atlantic Forest, indicating a random pattern of occupation of the landscape that reinforces the generalist habit of the species (Mayer & Brisbin 2009; West et al. 2009). Nevertheless, we detected a slight tendency for a negative effect of running watercourses and wetlands on wild pig occupation. This is opposite to expected since McClure et al. (2015), in a macro-spatial study in the USA, found that both distance to water and landscape heterogeneity were important in their models, with localities far away from the water having lower occurrence of wild pig. This lower occupancy near running watercourses could represent a threat to young pig because of a higher danger of drowning when crossing deeper watercourses, because of hypothermia due to the low-fat content in the first months of live (Rossell et al. 2001). Also, wild pig tends to avoid areas near watercourses probably because of lower protection from predators (Kurz & Marchinton 1972; Massei et al. 1997), which can prey upon juveniles and piglets (Hegel & Marini 2018). However, wetlands are known to be used as a shelter, for breeding, feeding and mainly regulation of body temperature by mud baths (Mendina Filho et al. 2015), which can also help clean out ectoparasites (West et al. 2009). Other studies have shown that the only environmental condition that can effectively avoid the presence of wild pig in an area is the lack of superficial water (Mayer & Brisbin 2009; Beasley et al. 2014). Also, wild pig prefer to construct nests in areas with dense cover and water nearby (Fernández-Llario 2004). One explanation for this contradiction between our results and previous studies is probably related to the 45% above average rainfall at our study site in 2015 (INPE 2016), related to an “El Niño” effect in the southern Neotropical region. Thus, the excess of rain, and of humid areas, might have changed landscape use by wild pig during our sampling, allowing them to occur in areas independently of local water availability.

The single-season occupancy modeling analysis indicated that there is no specific preference for any vegetation type by wild pig. Thus, the occupation patterns of wild pig showed that it is a habitat-generalist at the Atlantic Forest, similar to other native and introduced regions of the world, being found at several vegetation types, such as native and planted forests, grasslands, humid areas, and plantations (Spitz 1986 apud Oliver & Leus 2008; Mayer et al. 2000; Wilson 2004). Accordingly, we also observed vestiges of wild pig in different vegetation types such as *Pinus* sp. plantations, and corn and oat crops. Similarly, in the USA, wild pig preferred *Pinus* sp. trees (Graves 1984), indicating that this species might be beneficial for wild pig at introduced localities. Wild
Wild pig occupancy in the Atlantic forest

Table 1. Single-season occupancy modeling: 11 models generated to explain detection and occupancy of wild pig in the south Atlantic Forest, were \( p = \) detection probability, and \( \psi = \) occupancy probability. The table presents the values of QAICc, \( \Delta \text{QAICc} \), AICc weights \((w_i)\) of each model and the number of parameters \((K)\).

| Model | QAICc  | \( \Delta \text{QAICc} \) | Weights \((w_i)\) | K |
|-------|--------|-----------------|-----------------|---|
| \( \psi(\text{water}) \ p(.) \) | 470.802 | 0 | 0.285 | 3 |
| \( \psi(.) \ p(.) \) | 471.431 | 0.629 | 0.208 | 2 |
| \( \psi(\text{crops}) \ p(.) \) | 472.486 | 1.684 | 0.123 | 3 |
| \( \psi(\text{grass}) \ p(.) \) | 472.683 | 1.880 | 0.111 | 3 |
| \( \psi(\text{forest}) \ p(.) \) | 473.055 | 2.252 | 0.092 | 3 |
| \( \psi(\text{wetlands}) \ p(.) \) | 473.205 | 2.403 | 0.085 | 3 |
| \( \psi(\text{road}) \ p(.) \) | 473.558 | 2.755 | 0.072 | 3 |
| \( \psi(\text{water + wetlands + grass + forest + crops}) \ p(.) \) | 477.495 | 6.692 | 0.010 | 7 |
| \( \psi(\text{wetlands + grass + forest + crops}) \ p(.) \) | 478.567 | 7.765 | 0.005 | 6 |
| Global \( \psi(\text{road + water + wetlands + grass + forest + crops}) \ p(.) \) | 479.844 | 9.041 | 0.003 | 8 |
| \( \psi(\text{road + wetlands + grass + forest + crops}) \ p(.) \) | 480.881 | 10.078 | 0.001 | 7 |

Table 2. Single-season occupancy modeling: seven first models with one variable to explain beta values each parameter, were \( \beta = \) value of the variable beta parameter, SE = standard error, CI = lower and upper limits of 95% Confidence Interval.

| Model | \( \beta \) | SE | CI  |
|-------|------------|----|-----|
| \( \psi(\text{water}) \ p(.) \) | -1.1219 | 0.5895 | -2.2773 | 0.0335 |
| \( \psi(\text{crops}) \ p(.) \) | -2.6349 | 2.1169 | -6.7840 | 1.5142 |
| \( \psi(\text{grass}) \ p(.) \) | 2.6147 | 2.3915 | -2.0727 | 7.3021 |
| \( \psi(\text{forest}) \ p(.) \) | 3.8145 | 4.8289 | -5.6482 | 13.2812 |
| \( \psi(\text{wetlands}) \ p(.) \) | -3.5177 | 4.6996 | -12.7290 | 5.6935 |
| \( \psi(\text{roads}) \ p(.) \) | 0.26 E-5 | 0.5166 | -1.0125 | 1.0125 |

Pig are attracted to areas with these trees, at least in part because of their behavior of rubbing their bodies against trees to remove parasites after mud baths (Campbell & Long 2009). The preference of wild pig for conifers might also be related to antimicrobial activity against bacteria and fungi, properties of the resin that helps heal wounds (Sipponen et al. 2012). A native conifer, the Parana pine \( \text{Araucaria angustifolia} \), which occurs at southern Atlantic forests, is also used by wild pig for rubbing (C. Hegel, pers. obs.), and as a food source (Deberdt & Scherer 2007, Hegel & Marini 2013). Wild pig presented a seasonal variation in occupation in coniferous forests of New Zealand, being present in more places in the summer than in the winter (Forsyth et al. 2016).

In turn, because of wild pig broad diet, food available in the forests is not expected to be a limiting factor (Ballari & Barrios-Garcia 2014). We observed vestiges of the presence of the wild pig especially in corn and oat plantations, but not in other cultures and plantations (soybean, wheat, and apple and grape orchards), though they were poorly sampled. Thus, proper year-round use of habitats is necessary to evaluate seasonal and spatial use of the landscape. Wild pig are known to consume large amounts of several crops (oat, corn, sugar cane, wheat, sorghum, barley, and oilseeds) as well as tree saplings in the USA (Mayer et al. 2000). In Spain, wild pig often occurred in large forest fragments surrounded by crops, and adjacent to other large forests close to mountains or riparian forests (Virgos 2002). Also, Caley (1993) found that wild pig consumes not only standing crops but also rooting crop residues after harvest, evidencing its food flexibility. Since wild pig have a generalist diet, the potential impact on specific crops should be evaluated throughout the year and at different stages of each crop.

Areas of grasslands also had no effect on the detection or occupancy of wild pig at our study site. Native grasslands at our study site might have been used, like roads, only for movement among adjacent vegetation types. However, wild pig caused vegetation disturbance in pastur lands and plantations adjacent to forests in southern England (Wilson 2004). Roads were used by wild pig to move among preferred habitats, such as humid areas and crops (Mayer & Brisbin 2009; Beasley et al. 2014). In Argentinian Patagonia, wild pig were present only in humid lands, and occupancy was lower closer to settlements but higher closer to roads (Gantchoff & Belant 2015).

Although our study has seasonal limitations of sampling and the possible influence of a climatic phenomenon that increases the precipitation in the south of Brazil, our results are similar to other regions either where wild pig are native or introduced. Here, wild pig showed an overall broad and unselective use of the landscape occupying most vegetation types, with a poor relationship with running water bodies and roads. The tendency of higher occupation of some vegetation types demonstrates only weak preferences, such as for forests, and some crops, such as corn and oat. This broad occupation pattern stresses the major potential of invasion of wild pig even at subtropical regions like the southern Atlantic Forest. The rich and highly fragmented and altered Atlantic Forest, a world hotspot, seems prone to be invaded by wild pig since wild pig can benefit from and occupy the current mosaic of vegetation types in the region. The fact that wild pig can cause economic and environmental impacts is worrisome, requiring urgent attention by governmental authorities to manage and control wild pig, especially in pine forests and other forest types in the Atlantic Forest domain,
before their populations increase even further. We also recommend the financial incentive to year-round studies of wild pig occupation patterns not only in the Atlantic Forest but also in other Brazilian environments and their transition areas.

Supplementary material

The following online material is available for this article:
Table S1 - Geographical coordinates and name of the localities of the 100 sampling sites.
Table S2 - Single-season occupancy modeling: 64 models generated to explain detection and occupancy of wild pig in the south Atlantic Forest.

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Author Contributions

Carla Grasiele Zanin Hegel - Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.
Luane Reis dos Santos - Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation; Contribution to manuscript preparation.
Mauro Pichorim - Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.
Miguel Ângelo Marini - Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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