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## Home range and movement patterns of male dwarf caimans (*Paleosuchus palpebrosus* and *Paleosuchus trigonatus*) living in sympatry in Amazonian floodplain streams

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### ABSTRACT

Dwarf caimans (Alligatoridae: *Paleosuchus palpebrosus* and *Paleosuchus trigonatus*), are small crocodylians exhibiting cryptic behaviour and complex habitat use that occur throughout the Amazon region. Our goals were to evaluate individual home range, habitat occupancy and movement patterns where they occur in sympatry in relation to seasonal water-level variation. We tracked five *P. palpebrosus* and seven *P. trigonatus* using VHS radio transmitters along the shores of two streams directly influenced by the flooding pulse of the Purus River. *Paleosuchus palpebrosus* individuals moved greater distances on a daily basis and had larger home ranges than *P. trigonatus*, and the species had different responses to increases in water levels. *Paleosuchus palpebrosus* moved into flooded forests, as do their principle prey species. Conversely, larger *P. trigonatus* individuals usually remained near the main stream, and were relatively sedentary. Intraspecific home-range overlap was higher than interspecific overlap in both species. Thus, habitat occupancy patterns as a function of water-level variation might facilitate coexistence of the two species of dwarf caimans in the same location. This study shows that when living in sympatry under a seasonal flooding regime, *Paleosuchus* species show a degree of habitat partitioning evidenced by different daily movement rates, home-range sizes and home-range locations.

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seasonal flood regime;  
sympatry; telemetry

### Introduction

Ecological theory suggests that two species using the same limited resource in the same manner cannot coexist in the long term [1–3], and habitat is often considered an important factor limiting coexistence. Crocodylians have cryptic amphibious habits, remaining most of the time submerged or hidden in vegetation or burrows along the shoreline of water bodies [4,5]. Within the same general aquatic environments, different crocodylian species may occupy distinct microhabitats and this may facilitate their coexistence [6]. Four crocodylian species (Alligatoridae: *Melanosuchus niger*, *Caiman crocodilus*, *Paleosuchus palpebrosus* and *Paleosuchus trigonatus*) occur in sympatry in several locations in the Amazon basin [7–12]. Their coexistence has been suggested to be a result of food-resource partitioning [13–15], differences in feeding behaviours [16], nest-site choice [17,18] and different parental-care strategies [19]. General patterns of habitat use have been documented for some Amazonian caiman species, especially the more conspicuous *M. niger* and *C. crocodilus* [7,8,20] and to a lesser degree *Paleosuchus* species [21]. However, it is not well understood to what extent

Amazonian crocodylians living in syntopy partition the habitat they occupy, especially as a function of seasonal hydrological changes.

The two South American dwarf caiman species (*P. palpebrosus* and *P. trigonatus*) occur in syntopy along the shores of floodplain streams in the Amazon basin, whose extent and depth are largely controlled by the seasonal fluctuations of large-river water levels [22–24]. Water-level variation affects crocodylian population densities, behaviour and diet [5,11,25,26]. Floodplain streams are subjected to predictable and long-lasting floods [23,27]. This causes a considerable increase in the availability of aquatic environments within flooded forests during the high-water period. However, it is not known to what extent home range and movement patterns of Amazonian dwarf caimans may be affected by the flooding regime in these wetland systems.

By radio-tracking for over three years sympatric adult *P. palpebrosus* and *P. trigonatus* males in a floodplain-stream system of the Amazon basin, we evaluated how the seasonal hydrological regime influences habitat occupancy, movements, home-range size and individual location within the studied streams.

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## Materials and methods

### Study site

The study was carried out between 18 May 2014 and 18 July 2017 along the shores of two streams (Figure 1) located on the lower portion of the Purus River, both directly influenced by the flood pulse. We tracked five *P. palpebrosus* and seven *P. trigonatus* individuals using VHS radio transmitters. All tracked individuals were sub-adults or adults and no hatchlings were monitored in this study. The streams belong to two different flood-plain-stream watersheds with similar physical characteristics [24]. During the low-water season (normally between September and January) these are small flood-plain streams. However, during the high-water season (between April and July), the Purus River inundates the entire watershed and water level can rise over 10 m.

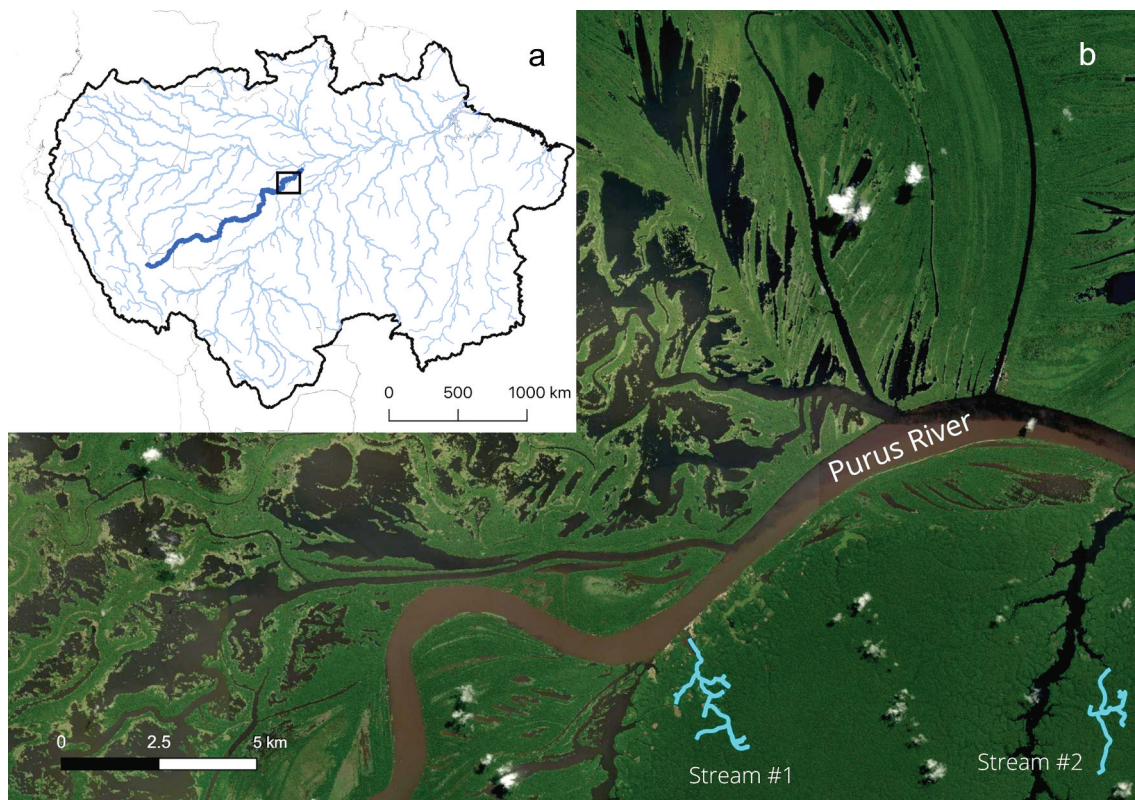
Caimans in this area are not hunted or otherwise persecuted by humans in either of the studied localities, although local residents commonly use both areas for subsistence fishing or family agriculture activities.

Variation in the water level of Purus River (in cm) was collected at a nearby scientific station of the Instituto Piagaçu, and was calibrated with the river levels reported by the Brazilian National Water Agency ([www.ana.com.br](http://www.ana.com.br)). The Purus River annual flood pulse is considered the most predictable of 90 rivers worldwide [27] and its mean annual amplitude

was 1002 cm during the past 20 years [24]. During the three-year study period, maximum river-level amplitude was 1357 cm.

### Telemetry

Tracked individuals were captured on different dates and always at night during the high-water season (Table 1) with locking cable snares on a restraining pole. The following morning at the nearby scientific station located <10 km from the study sites, we sexed, measured and weighed the caimans (snout-vent length [SVL] in cm, total length [TL] in cm and mass in kg), then attached to each caiman a VHF radio transmitter (Advanced Telemetry System®, Minnesota-US: Model A2930B, 65 g to 75 g weight) with frequency between 152 and 165 MHz and battery life of approximately 400 days. The transmitter was attached to the dorsal side of the tail between double scutes (Figure 2) just proximal to the first single scute [28] as described in Brien and Read [29]. We did not use anaesthesia because of possible long recovery times, prioritizing returning the animal to the capture site soon after procedure [30]. The maximum time between capture and release was 12 h, which occurred at the same point. All procedures described were carried out under authorizations emitted by the Brazilian Environmental Ministry (MMA license number



**Figure 1.** Study area showing (a) Amazon basin (black outline) and main-rivers network (light blue) and Purus river (dark blue); (b) Streams (S#1 and S#2; blue line) where caimans were monitored are affluents of the Purus River.



**Table 1.** Summary data for radio-tracked males *Paleosuchus trigonatus* (PT) and *Paleosuchus palpebrosus* (PP). Individual identification (id), species (sp), stream captured (str), snout-vent length in cm (svl), tracking start and end dates (date\_start; date\_end), total number of locations (total loc), locations with intervals less than 7 days (loc < 7 days), total cumulative distance moved in meters (cumul), mean daily movement in meters (avg mov\_day) and percentage of movements larger than 100 m per day (mov\_day > 100).

id	sp	str	svl	date_start	date_end	total loc	loc < 7 days	cumul	avg mov_day	mov_day > 100
GU	PP	1	72.3	21/05/14	04/05/15	81	67	14,526	65	20.1
GO	PP	1	97.4	27/07/14	19/06/17	69	52	20,315	87	30.7
NE	PP	1	81.1	19/02/15	29/01/16	63	57	18,136	113	40.4
SI	PP	1	85.6	20/04/16	27/07/16	13	10	3653	76	30
TO	PP	1	55.1	01/02/16	24/05/16	32	30	4387	47	10
BU	PT	2	89.0	22/07/16	28/08/17	41	19	8077	58	15.8
EL	PT	2	72.2	21/04/16	11/05/17	21	11	3362	34	0
EZ	PT	1	61.2	15/02/15	04/07/15	49	49	4442	38	12.2
ER	PT	1	50.3	18/04/16	25/01/17	48	40	4877	29	0
LU	PT	2	69.4	14/06/16	09/09/16	20	15	2334	32	0
MA	PT	1	74.5	16/02/15	19/02/16	42	35	6012	44	11.4
TA	PT	2	44.4	14/06/16	12/05/17	15	7	1103	17	0



**Figure 2.** VHF transmitters attached to an individual before its release.

53,343–3), and by the Committee for Animal Use Ethics (CEUA/INPA), registered with protocol n° 033/2017, SEI 01280.000772/2017-61.

The number of caimans tracked per week during the 155-week study, varied from two to nine individuals and monitoring was carried out between 07:00 and 17:30 during the day with few exceptions (<5%) when some locations were registered during night surveys in the same locations. Tracking was carried out from a small canoe at least twice a week during the high-water seasons. However, during low-water seasons, tracking frequency was reduced due to inaccessibility of sampling sites. For both species, more than 70% of total locations were monitored with a maximum of four-day intervals. However, in 13.5% of cases for *P. palpebrosus* and 15.3% for *P. trigonatus*, the interval between locations was longer than seven days. The latter locations were not considered for daily-movement analysis because the long interval could affect results [25].

Once an individual was located, we recorded its GPS position using a Garmin 78S GPS receiver, always with at least five meters accuracy. In each location, we

gathered information on stream depth and width, and caiman distance to the land-water interface. We then calculated the distance of each location to the larger-stream main channel using satellite images.

### Data analysis

Caiman movements were considered as the distance moved per day [31] and estimated as daily movements (mov/day = distance between consecutives locations/number of days). We also estimated cumulative distance as equivalent to the sum of distances between all locations (Table 1). In order to estimate location of all caimans within their respective home range, we considered the most downstream position (MDP) of every tracked individual as a reference point.

With sufficient locations (>35), the area traversed by an individual can be described as a probability function [32] and we estimated utilization distributions considered as individual home ranges [33] using fixed-kernel densities (KDE). Using the bandwidth estimator with least square cross-validation (h-lscv) resulted in highly patchy areas [26], so we used only the reference bandwidth (h-ref = 114 m) to estimate home-range sizes. The choice of bandwidth is critical to estimate the positions of outer contours of utilization distributions [29,34,35]. We considered 95% contours to be total home ranges for individual caimans and 50% contour areas to be core-use areas as commonly used with telemetry studies [36–38].

The Minimum Convex Polygon (MCP) has been frequently used with crocodylians [25,30,39,40], but it has many limitations and several publications have concluded that this method might overestimate the area that animals normally use because it can be strongly influenced by outliers [41,42]. Nevertheless, it permits evaluation of home range with less locations per animal and is simpler to estimate [43], so for comparisons between seasons (high- and low-water) we considered MCP polygons only with points corresponding to each

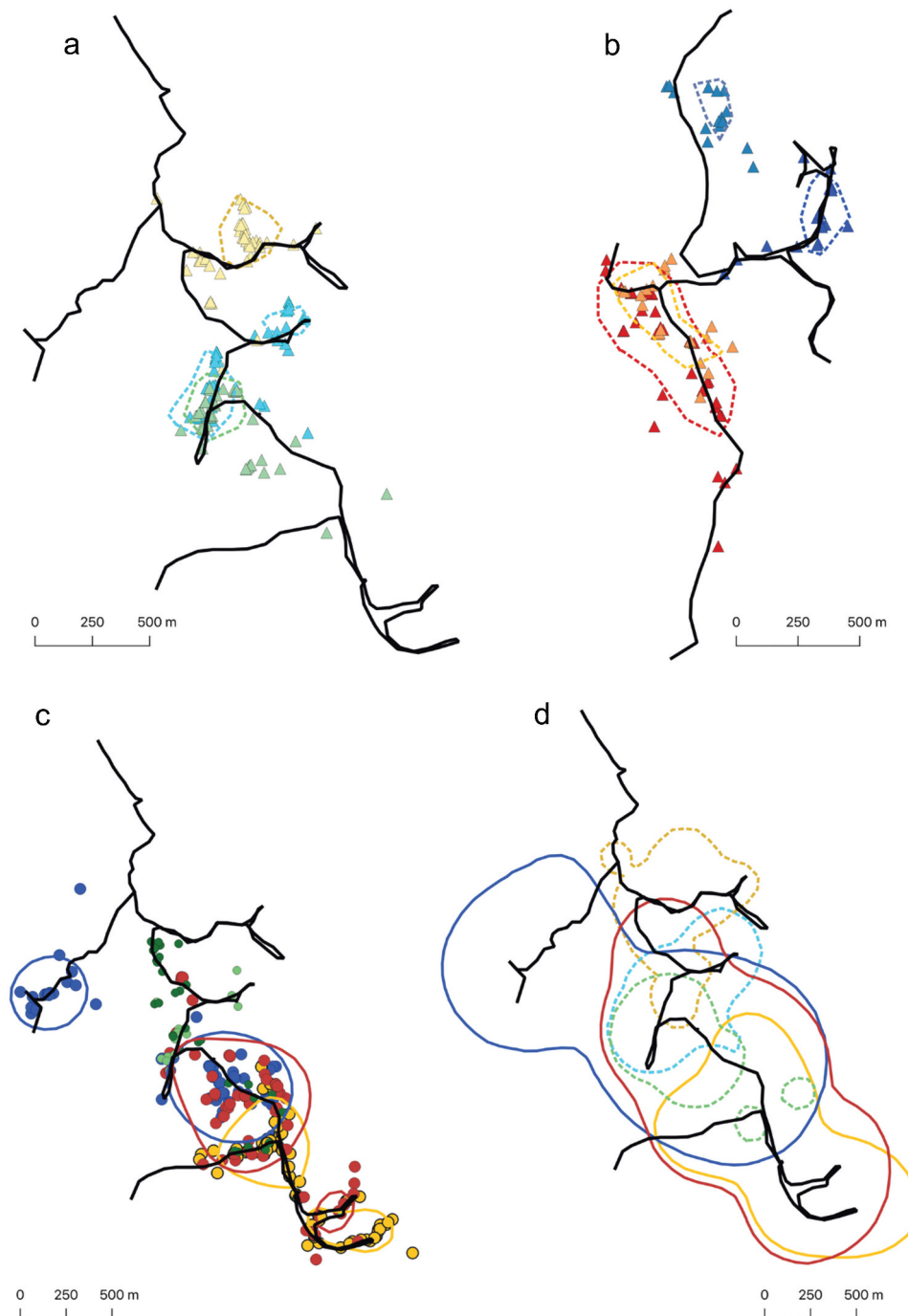
season as the area used by individuals. These results must be interpreted cautiously as home range size did not stabilize due to the low number of fixes for some individuals, especially for seasonal estimation, and this increases uncertainty [29].

Distance between locations, area calculation and other GIS analyses were undertaken using the QGIS 3.4 Madeira package [44]. We used the R 3.6 [45] *adehabitatHR* package [46] to estimate home-range sizes (hectares – ha) and the *nlme* package [47] for maximum-likelihood linear mixed models described

in results (LME). Independent-sample t-tests were used to compare species home-range sizes and individual movement rates. Figures were produced using the *ggplot2* package also in R software [48].

## Results

We installed VHF radio-transmitters on three male *P. trigonatus* individuals in stream #1 (–61.8041 W; –4.3020 S at the mouth, Figure 3a) and four males in stream #2 (–61.7111 W; –4.3044 S, Figure 3b).



**Figure 3.** Locations of three male *Paleosuchus trigonatus* in Stream #1 (a), four males in Stream #2 (b) and five male *Paleosuchus palpebrosus* in Stream #1 (c); dotted lines represent core areas of each individual. Total home range overlap (d) for three males of *P. trigonatus* (dotted lines) and three males of *P. palpebrosus* (unbroken lines) estimated in Stream #1. Each colour represents an individual.

Transmitters were also installed on five male *P. palpebrosus* only in stream #1 (Figure 3c). Snout-vent length of *P. palpebrosus* varied from 55.1 to 97.4 cm (mean 78.3 cm  $\pm$  16) and 80% of individuals were considered adults [49]. For *P. trigonatus* individuals, SVL varied from 44.4 to 89.0 cm (mean 65.8 cm  $\pm$  15). We assumed that 57% of individuals were adults [supposing a minimum reproductive body size of SVL > 65 cm for males; [50]. More detailed information about tracked caimans is summarized in Table 1. Mean SVL did not differ statistically between species (t-test,  $p = 0.207$ ), indicating that our study focused on similar size distributions for both species.

### Dwarf caiman movements

Daily movements of tracked caimans varied considerably among individuals during the monitoring period, from no movement (<1% of observations) to over 200 m in a single day (4% of locations). Mean daily movements differed between species (t-test,  $p = 0.015$ ); *P. palpebrosus* were more active (mean = 78 m/day  $\pm$  25) than *P. trigonatus* (mean = 36 m/day  $\pm$  13). All five *P. palpebrosus* males showed daily movements over

**Table 2.** Linear mixed-effect model (mov\_day ~ water level:sp + size:sp ~ 1|id) showing the influence of main-river water level (WL) and body size on *Paleosuchus palpebrosus* (pp) and *Paleosuchus trigonatus* (pt) daily movements. The id term was a random effect, the rest were fixed.

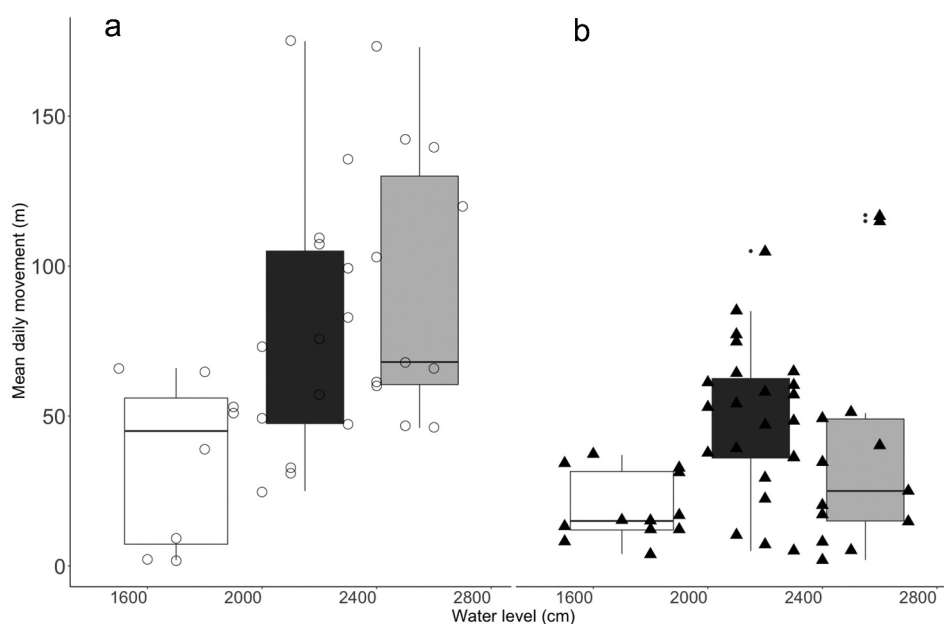
	coeff	t-value	p-value
WL:pp	0.052	3.339	0.000
WL:pt	0.026	1.843	0.066
Size:pp	0.638	1.641	0.135
Size:pt	1.043	2.687	0.025

100 m/day (Table 1), which represented 26% of their moves. Four *P. trigonatus* were never recorded moving 100 m/day and the other three males moved that distance only in 13% of cases.

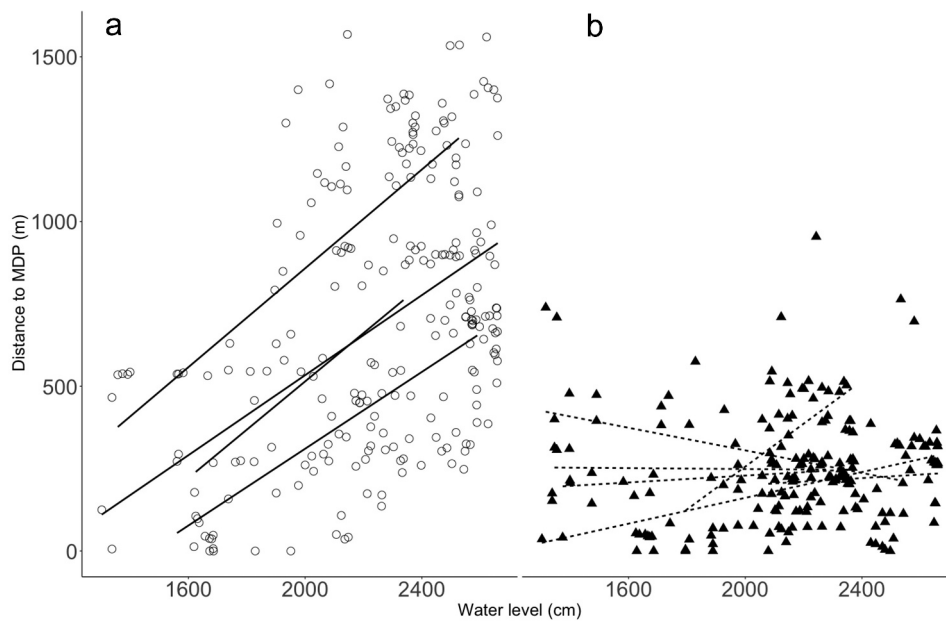
Results (Table 2) of a linear mixed-effect (LME) regression model (daily movement ~ water level:species + body size:species, random|id) provided strong evidence that water level influenced movements of *P. palpebrosus* ( $p < 0.001$ ), but the evidence was weaker for *P. trigonatus* ( $p = 0.066$ ). Individual body size affected movements of *P. trigonatus* ( $p = 0.025$ ) but had no detectable effect on *P. palpebrosus* ( $p = 0.135$ ). Water level influenced mean distance moved daily by both species, principally after the dry season (Figure 4) when water level was rising.

### Home-range locations

The position of individuals within the stream drainage varied as a function of the main-river water level and the depth of the stream, which varied from zero to 8.6 m (mean = 3.7 m  $\pm$  2.2) at caiman locations. The mean distance that individuals moved away from their respective most downstream position (MDP) differed between species (t-test;  $p < 0.001$ ; mean 700 m in *P. palpebrosus* and 249 m in *P. trigonatus*). A LME regression model (distance to MDP ~ water level:species + size:species, random|id) indicated a positive effect of water level on the distance that individuals moved from their MDP in *P. palpebrosus* ( $p < 0.001$ ), but the evidence was weaker for *P. trigonatus* ( $p = 0.066$ ). Body size significantly affected distance to MDP in *P. trigonatus* ( $p = 0.034$ ), but not for *P. palpebrosus* individuals ( $p = 0.877$ ). Nevertheless,



**Figure 4.** Variation in daily mean movement of (a) *Paleosuchus palpebrosus* (circles) and (b) *Paleosuchus trigonatus* (triangle) as a function of main-river water level during three periods: low water (white), transition (black) and high water (dark grey). Each point represents an individual location.



**Figure 5.** Effect of main-river water level on the distance to most downstream position (MDP – m) of A) *Paleosuchus palpebrosus* (circles) and B) *Paleosuchus trigonatus* (triangles). Lines represent linear-regression models for each male *P. palpebrosus* (black lines) or *P. trigonatus* (dotted lines).

individual *P. trigonatus* responded idiosyncratically to water level rise, some moving upstream, and others returning to MDP (Figure 5).

Stream depth was positively related to the Purus River water level (Pearson  $r = 0.71$ ) and all tracked caimans remained close to the principal stream channel with permanent water during the four months of the low-water season. Individual *P. palpebrosus* were encountered 35% of the time in the stream channel and moved on land at distances up to 32 m from the water. In contrast, *P. trigonatus* were encountered in 70% of the cases in the stream channel, and no individual moved farther than 5.5 m from main channel.

During the high-water-level season, all individuals moved farther away from the main channel into the flooded forest and there was some evidence of a difference between species (t-test;  $p = 0.065$ ). Individual *P. palpebrosus* were located 70% of the time at more than 10 m away from the stream and some moved longer distances away from the middle of the main channel (maximum = 245 m, mean = 31 m). In contrast, 43% of locations of *P. trigonatus* were less than 10 m from the main channel (maximum = 226 m mean = 25 m).

A LME regression model (distance to stream channel ~ depth + species + size + size\*sp, random|id) indicated that the distance a caiman moved away from the main channel was affected only by stream depth ( $p < 0.001$ ) but not by the species ( $p = 0.341$ ) or individual body size ( $p = 0.410$ ). The model also indicated that there was no interaction between size and species ( $p = 0.289$ ). A simple linear regression model (Figure 6a) was consistent with the conclusion that body size did not influence

the distance *P. palpebrosus* moved from the main channel ( $p = 0.255$ ,  $r^2 = 0.19$ ), but indicated that larger *P. trigonatus* moved away from the main channel less than smaller caimans (distance to stream channel ~ size;  $p = 0.043$ ,  $r^2 = 0.60$ ), so the lack of significance of the overall model should be interpreted cautiously.

### Home-range areas

All 12 males (seven *P. trigonatus* and five *P. palpebrosus*) had their total MCP estimated. However, data from two individuals (one of each species) were eliminated because of insufficient locations to estimate MCP during both low- and high-water seasons, respectively (Table 3). Total home range of *P. trigonatus* varied from 5.0 to 30.1 ha (mean = 17.8 ha  $\pm$  9.0) and home range of *P. palpebrosus* varied from 35.0 to 88.6 ha (mean = 60.7 ha  $\pm$  21.9).

Only seven individuals (three *P. palpebrosus* and four *P. trigonatus*) had the minimum number of locations needed to estimate both the entire and the core home-range areas using the kernel-density estimator (Table 3). Kernel home ranges were greater than those estimated with MCP for both species. For *P. palpebrosus* individuals, it varied from 104.1 to 198.3 ha (mean = 161.4 ha  $\pm$  50.3), and core areas varied between 26.1 and 45.3 ha (Figure 3c). *P. trigonatus* entire home ranges were generally smaller (t-test,  $p = 0.055$ ), varying from 42.1 to 86.2 ha (mean = 56.2 ha  $\pm$  20.2), and core areas varied from 6.5 to 20.7 ha (Figures 3a and 3b). All adult *P. palpebrosus* showed two distinct core areas, with centroids that were always more than



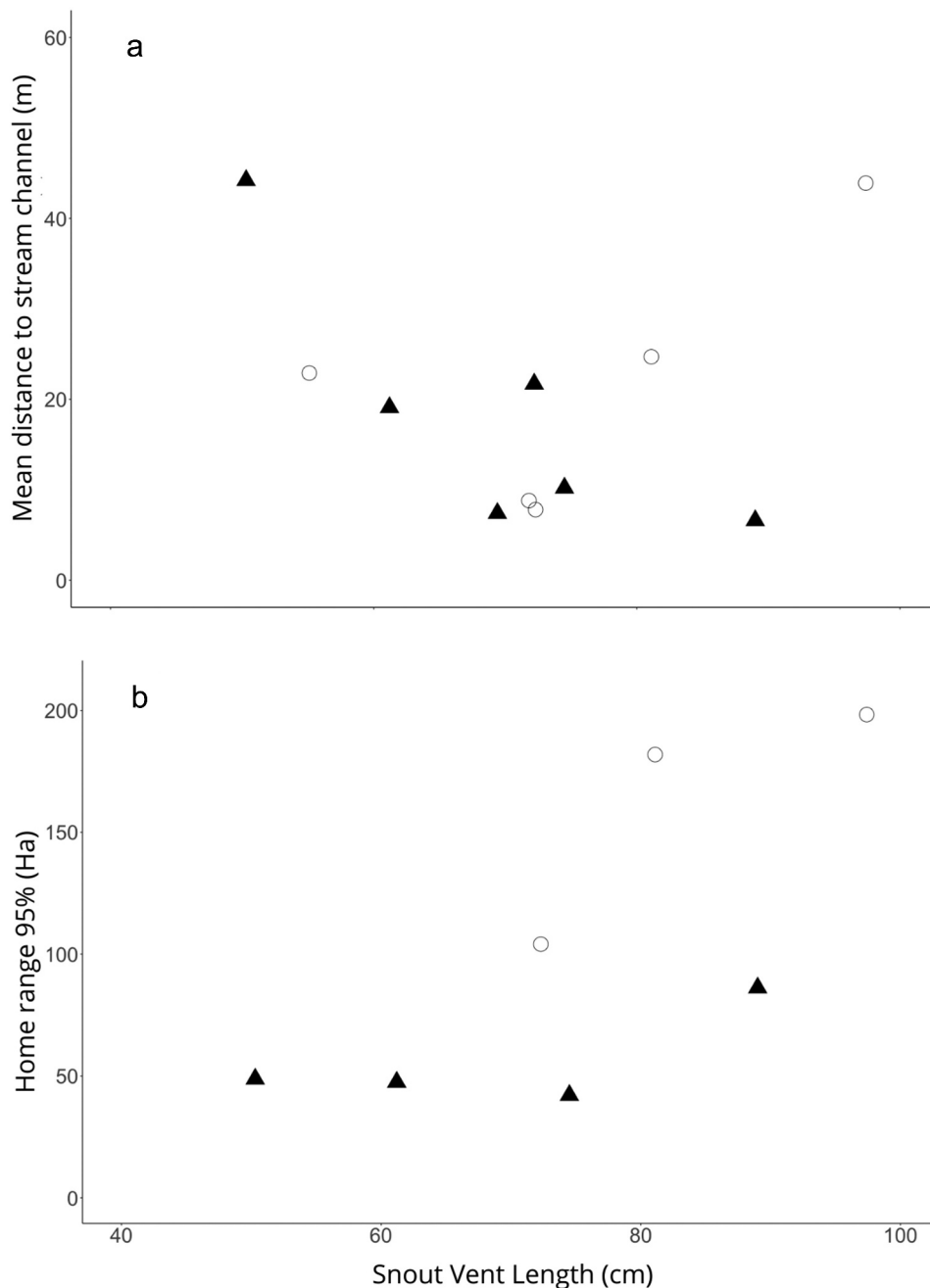
650 m from each other. In contrast, only one *P. trigonatus* showed two core areas; all other individuals had only one core area.

Considering all tracked individuals, a multiple linear regression model (home range ~ body size + species;  $p = 0.018$ ,  $R^2 = 0.80$ ,  $df = 4$ ) indicated that the size of the entire home range was influenced by the species ( $p = 0.033$ ) but not by their body size ( $p = 0.139$ ). This was consistent with simple linear regressions that did not detect effects of male size on home-range size for either *P. palpebrosus* ( $p = 0.338$ ) or *P. trigonatus* ( $p = 0.283$ ;

Figure 6b). Similarly, there was no detectable effect of individual size on core-area size for *P. palpebrosus* or *P. trigonatus* ( $p = 0.466$  and  $p = 0.257$ , respectively).

### Home-range overlap

We analysed the data for the six males tracked in the same stream (three for each species) to quantify their inter- and intra-specific overlap in home ranges estimated with the kernel estimator (Figure 3d). Home ranges of most tracked individuals overlapped, except



**Figure 6.** Relationship between snout-vent length (cm) and (a) mean distance (m) individuals moved away from the main stream channel and (b) entire home-range size (ha) estimated using Kernel Density Estimates for *Paleosuchus palpebrosus* (circles) and *Paleosuchus trigonatus* (triangles). Each point represents an individual.

**Table 3.** Estimated home-range size in hectares for seven male (id) *Paleosuchus trigonatus* (sp-PT) and five male *Paleosuchus palpebrosus* (sp-PP). href95 = Kernel density estimator with 95% probability corresponding to entire area of use, href50 = Kernel density estimator with 50% probability and corresponding to core area, mcp100 = Minimum convex polygon with 100% of points registered, mcp\_high = Minimum convex polygon with 100% of points registered in the high-water season, mcp\_low = Minimum convex polygon with 100% of points registered in the low-water season. Individuals without estimated area did not have sufficient locations for that estimator.

id	sp	href95	href50	mcp100	mcp_high	mcp_low
BU	PT	86.2	20.7	23.4	17.9	13.6
EL	PT	-	-	11.3	6.6	7.1
EZ	PT	47.5	10.8	20.3	10.3	5.3
ER	PT	48.8	7.0	30.1	4.1	20.9
LU	PT	-	-	10.6	4.4	4.7
MA	PT	42.1	6.5	24.2	18.2	6.1
TA	PT	-	-	5.0	-	-
GU	PP	104.1	26.1	52.6	38.7	18.1
GO	PP	198.3	44.5	88.6	42.5	84.8
NE	PP	181.9	45.3	77.8	59.8	31.5
SI	PP	-	-	49.4	-	-
TO	PP	-	-	35.0	7.3	28.9

**Table 4.** Mean percentage (minimum and maximum) area overlap for three male *Paleosuchus palpebrosus* and three male *Paleosuchus trigonatus* co-existing in stream #1. over\_same: mean percentage overlap over entire home range (95) and core area (50) of individuals of the same species; over\_diff: mean percentage overlap over entire home range (95) and core area (50) for individuals of the other species.

	<i>P. palpebrosus</i>	<i>P. trigonatus</i>
over_same 95	55.3 (38.3 – 73.6)	32.2 (21.2–42.9)
over_diff 95	52.4 (12.1–77.1)	13.2 (5.80–19.4)
over_same 50	41.4 (21.7–60.7)	22.3 (0.00–40.5)
over_diff 50	13.3 (0.00–21.0)	2.6 (0.00–4.70)

for the smallest *P. trigonatus* (SVL = 50.3 cm) and the smallest *P. palpebrosus* (SVL = 72.3 cm). Those individuals did not overlap their home ranges because they used different portions of the stream. Overlap of home ranges for *P. palpebrosus* individuals was similar intra- (mean = 55%) and inter-specifically (mean = 52%). In contrast, the intraspecific overlap of entire home ranges in *P. trigonatus* was lower (mean = 32%) than that of *P. palpebrosus* (Table 4). This was more evident at the interspecific level, where the overlap was always less than 20% (mean = 13%). The extent of intraspecific-overlap areas within core areas of *P. palpebrosus* was double (41%) that of *P. trigonatus* (22%). Furthermore, the mean probability (0.62) of a *P. palpebrosus* individual overlapping the area of a *P. trigonatus* individual was almost twice that of the probability of a *P. trigonatus* (0.33) overlapping a *P. palpebrosus* area.

## Discussion

Little is known on the spatial ecology *Paleosuchus trigonatus* and *Paleosuchus palpebrosus*, two of the most cryptic and understudied vertebrate predators

in the Amazon basin, and there is no published information on home-range size and habitat occupancy in areas under the influence of seasonal floods.

Overall, our results show that *P. palpebrosus* individuals move greater distances on a daily basis and have larger home ranges than *P. trigonatus*. Additionally, both species show distinct behaviors when water level rises. Thus, presumably habitat occupancy patterns as a function of water-level variation facilitates coexistence of the two species of dwarf caimans.

Phylogenetically closely related species with similar morphological characteristics, such as dwarf caimans [51], could be highly competitive due to niche conservatism [52]. However, we might expect syntopic species to exhibit differences in resource use that would reduce competition. Many sympatric crocodylian species show different snout shapes [8,53,54], as observed in *Paleosuchus* species [55]. These morphological differences usually evolved with divergences in diet and feeding behavior [56]. Differences in resources consumed or the way that these are obtained reduce interspecific competition [57], as observed in sympatric neotropical tree boas exhibiting food-resource partitioning [58].

Such differences could also be related to spatial segregation facilitated by morphological differences and habitat occupancy, a common pattern in small stream fish [59], which compose an important part of the diet of some caiman [13]. In the case of *Paleosuchus* species, additional to divergences in dependence on terrestrial or aquatic prey previously found in the same region [15], the differences in habitat occupancy found in this study could be a factor that further facilitates their coexistence. When water levels rise, all *P. palpebrosus* moved principally upstream toward new aquatic environments formed in flooded forests. This behavior is similar to that of their main prey, as most fish species of floodplain areas occupy flooded forests when water levels rise [60] to take advantage of the temporally abundant resources. In contrast, *P. trigonatus* individuals, who are less dependent on aquatic prey [13,15], behaved differently as a function of water-level variation. Their movements seem more complex and less predictable, as some individuals moved upstream, and others moved downstream, as has been observed in the Madeira River [37] and French Guiana [21].

Throughout the Amazon basin, animal species living in floodplains near major rivers are subjected to seasonal floods and droughts, and thus they must be ecologically adapted to radical changes in these habitats [24]. The main effects of water level on the ecology of Amazonian crocodylians are related to habitat utilization [8,20], changes in population density [11], availability of nesting sites [18], or variation in diet throughout the year [14]. Our results indicate that movements and spatial position within home ranges

of *Paleosuchus* species are also influenced by seasonal water-level variation, as reported for other caiman species in a different environment [25].

During the low-water season, home-range area and daily movements of both species decrease. During the low-water season, both species show average home ranges about half the size of the total area occupied. This has been observed in other crocodylian species [29,30]. Some individuals were occasionally found on land during the low-water season. Larger *P. trigonatus* individuals usually remained near the main stream channel and were relatively sedentary as reported in previous studies [21,50]. This is in line with findings from small non-flooded forest streams, where hatchlings disperse over large distances, but adults do not, usually remaining in burrows or retreats near the stream bank [50]. This behavior has also been reported in *P. palpebrosus* [61] and the African dwarf crocodile (*Osteolaemus tetraspis*) [62] and may explain why transmitter signals were weak and occasionally some individuals were often not located.

Intraspecific home-range overlap was higher than interspecific overlap in both dwarf caiman species indicating a major interaction with individuals of their own species. Home-range overlap by *P. trigonatus* conspecifics was lower than the overlap observed in one non-seasonally flooded forest stream [21] and similar to that found in a previous study [50], both suggesting that males are territorial.

In our study area, *P. palpebrosus* showed higher mobility and the median home-range size was twice that of *P. trigonatus*. In the floodplains of the mid-reaches of the Madeira River, the median home-range size for *P. palpebrosus* was only 25% greater than that of *P. trigonatus* [37]. However, water-level variation in our study site was 6.5 m greater than that in the Madeira River site and the greater flooding intensity in our study area might reduce available areas for *P. trigonatus*, whose home-range size was half that reported for the Madeira River site [37].

Both species of *Paleosuchus* are relatively small [13,49], they can occur in the same locality [12,37,63,64] and sometimes use the same type of habitat, such as steep banks [20] or small streams with low temperatures [65,66]. However, this study shows that even when living in sympatry under a seasonal flooding regime, the two *Paleosuchus* species show a degree of habitat segregation based on different daily movement rates, distinct home-range sizes and home-range centroids. Habitat use by these two cryptic species in the study area is complex and further studies in more localities, including hatchlings, juveniles and adult females, should be undertaken to fully understand the processes that lead to their coexistence.

## Geo-location information

The study was carried out along the shores of two streams (Figure 1; stream #1: -61.8041 W; -4.3020 S at the mouth, and stream #2: -61.7111 W; -4.3044 S), directly influenced by the flood pulse of the lower Purus River (Brazil), a major affluent of the Amazon River.

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## Authors contributions

BM: study design, fieldwork, data analysis and writing. WEM: study design, data analysis and writing. RCV: writing. FV: fieldwork, data analysis and writing.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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