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Habitat heterogeneity and behavior of the Sanderling (*Calidris alba*) in an urban neotropical coastal wetland

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Abstract. Sanderling *Calidris alba* is a migratory coastal bird species whose populations are affected by climatic and anthropogenic issues. Additionally, its behavioral patterns depend on habitat heterogeneity. The aim of this study was to evaluate the variation in the frequency and duration of *C. alba* behavior in relation to habitat heterogeneity in a Peruvian coastal wetland. Based on behaviors recorded in a previous study of *C. alba* during August and September 2019 at low, mid, and high tide periods in three habitats of the Coastal Wetland Poza La Arenilla (HCPA) (La Punta, Callao, Peru), differences and diversity in the frequencies and durations of such behaviors between habitats were assessed according to tide condition using the Kruskal-Wallis test, Bray-Curtis similarity index, and the number equivalent of behaviors (^{1}D) based on the Shannon-Wiener entropy index. Additionally, a Spearman correlation analysis between the duration and frequency of behaviors for each habitat according to tide condition was conducted. General differences in behaviors (frequency and duration) between habitats were evident based on tide condition, although there was a high similarity of behaviors between areas particularly when mid and high tide levels were present. The greatest diversity of behaviors, both in frequency and duration, was observed generally during mid-tide conditions in rocky habitats. In most cases, there was a high correlation between the frequency and duration of behaviors for habitats according to tide condition. It is concluded that mid-tide conditions are associated with greater availability of soft substrates, favoring a wide variety of behaviors for *C. alba*, including behaviors related to foraging and locomotion.

Keywords: Bird behavior patterns, Coastal wetlands, Migratory birds, Food availability regarding tidal level, spatial distribution

Introduction

The Sanderling (*Calidris alba*) is a boreal migratory bird species that prefers habitats in the surf zone and near the breakwater line (Cotillo et al. 2018; Mazzochi et al. 2022). *Calidris alba* is a small shorebird (between 19 and 21 cm in length) belonging to the Scolopacidae family, characterized by abundant and seasonally fluctuating populations (Scherer and Petry 2012; Podestá and Barona 2021), and facing issues related to population decline, habitat loss, and pressures due to sea-level rise as a consequence of climate change (Payne 2010; Galbraith et al. 2014).

The behavior of shorebirds like *C. alba* can be directly influenced by tidal cycles, food availability, and access to prey, resulting in local movements to access suitable roosting areas during high tide and feeding sites during low and mid-tide periods (Martínez-Curci and Petracci 2016; Quiñonez and Hernandez 2017; Houpt et al. 2020), where they can find a wide variety of marine invertebrates crucial for their diet (Ferrari et al. 2012, Tallei et al. 2021). Additionally, birds may exhibit different behaviors based on habitat (Myers et al. 1985; Londe et al. 2021).

Podestá *et al.* (2022) successfully characterized the behavior of *C. alba* in the Poza La Arenilla wetland (HCPA), La Punta, Callao, Peru, in great detail. Currently, HCPA is home to 98 bird species and is among the three most significant wetlands in Callao (the other two being the Ventanilla Wetlands Conservation Area and the "El Mirador" Lagoon in Ventanilla). One of its standout features of HCPA is its proximity to the urban environment, separated by a promenade for tourism and birdwatching (Podestá et al. 2021; Podestá and Barona, 2021). It also serves as a mandatory stopover point for migratory birds during their annual migration, with the presence of the species *C. alba*, a sandpiper from the Scolopacidae family, being particularly notable during the spring months (Podestá et al. 2017; García-Olaechea et al. 2018).

A question that can be posed regarding the behavior of *C. alba* in HCPA is whether it changes simultaneously with the tide flow and differ depending on the type of micro-scale spatial habitat. Therefore, this study presents the results of observations of *C. alba* behavior in two types of habitats and tides during the months of August and September 2019.

Materials and methods

Study Area.

The Coastal Wetland "Poza La Arenilla" (HCPA) is located in the district of La Punta, Callao, on the coastal strip between 10°04'00"S and 10°04'30"S latitude, and 78°10'30"W longitude. This wetland was formed as a result of the construction of two rocky barriers between 1965 and 1967 to protect the southern zone of the La Punta district from abnormal sea surges (Troll 2000). Additionally, due to the strong abnormal sea surges, a 50-meter wide inlet that connected these rocky barriers was filled, forming the Isla de Guilligan (DHM 1987) and enclosing this area with calm and semi-stagnant waters, which is nowadays known as the Coastal Wetland "Poza de la Arenilla" (HCPA). This wetland is also characterized by its proximity to the urban area, which has a tourist circuit that attracts visitors, including university and school students, as well as birdwatchers (Podestá and Barona 2021; Troll 2000). This study takes into account the zoning of the wetland based on the use of the area by birds, as proposed by Cotillo *et al.* (2018).

HCPA has eleven zones or habitats (Figure 1). Three zones or habitats were assessed for the current study: Cobbles from Boulder Zone (BZ), Sand Shore 1 (SS1), and Sand Shore 2 (SS2). These three areas are the primary zones used by *C. alba* for activities such as feeding and resting within the wetland. BZ has been described as an area with relatively shallow waters (Cotillo et al. 2018). Initially, SS1 and SS2 differ in that the former receives water flows from the West inlet, while the latter borders the Water Mirror 2 (W2), which is a lentic water body receiving water from the East inlet and is the longest of the water bodies. Additionally, it is characterized by a lower water flow compared to the Water Mirror 1 (W1), which is much closer to its respective inlet (Cotillo et al. 2018).

Recording of Behaviors.

The behaviors used for analysis were those documented by Podestá *et al.* (2022) (Annex 1), who developed an ethogram for the species *C. alba* through sampling conducted during the period when this species arrives at the wetland as part of its migratory cycle. This evaluation covered 12 days in the months of August and September 2019, with a total of 670 effective minutes of observation (40,200 seconds) and the recording of 58 different behaviors belonging to eight behavior categories (Podestá et al. 2022) (Annex 1).

The sampling was conducted during periods of low, mid, and high tide. Observation was carried out by tracking a focal individual, regardless of gender and without considering age. The focal sampling technique was employed, which involves recording the occurrence (frequency) and duration of behaviors of a randomly selected single individual from a group of organisms (Suen and Ary 2014). However, when the observed individual interrupted its behavior, another individual from the population was immediately observed within the time frame specified by the observer, without interrupting the sampling.

The recording of the activity of each focal subject was supported by 10-minute videos, which were later analyzed for better identification of bird behaviors. Additionally, the observation time for each focal subject was 10 minutes.

Statistical Analysis.

Since the data did not meet the necessary assumptions for parametric tests, the non-parametric Kruskal-Wallis test was applied to verify statistically significant overall differences in behaviors both among the three evaluated zones (habitats) and among tides. Subsequently, the following secondary analyses were conducted: 1) a similarity analysis for both the frequency and duration of behaviors between zones and tides using the Bray-Curtis similarity index, which is useful for assessing quantitative data (Birkl et al. 2018), 2) the calculation of the equivalent number of behaviors (frequency and duration) (^{1}D) based on the Shannon-Wiener entropy index (Ligon et al. 2018) to determine which of the three habitats exhibited greater diversity of behaviors in terms of their frequency and duration, and 3) a Spearman correlation analysis between the duration and frequency of behaviors for each habitat based on tide conditions.

Results

The non-parametric Kruskal-Wallis test indicated that there were overall differences in the frequency (p-value=9.7×10^{-23}) and duration (p-value=4×10^{-22}) of behaviors between habitats based on tides. The similarity analysis conducted using the Bray-Curtis index revealed the existence of clusters with similarity greater than 50% for both similarity of behavior frequency (Figure 2A) and behavior duration (Figure 2B). In the first case, three paired comparisons showed similarities greater than 50% (SS1-mid versus SS2-high: 80%; BZ-mid versus SS1-mid: 54%; BZ-mid versus SS2-high: 52%), i.e. habitats based on tide condition with more than half of shared behaviors (Figure 3A). In the second case, three paired comparisons also showed similarities greater than 50% (SS1-mid versus SS2-high: 68%; SS2-mid versus SS2-high: 52%; SS1-mid versus SS2-mid: 48%) (Figure 3B).

Regarding the diversity analysis, the equivalent number of behaviors based on the Shannon entropy index revealed that, concerning the frequency of behaviors, the highest equivalent number was for the BZ habitat at mid-tide (^1D=26.8), while the lowest value was obtained by SS2 at mid-tide (^1D=7). Concerning the duration of behaviors, the highest equivalent number was for the BZ habitat at mid-tide (^1D=25.3), and the lowest value was for BZ at low tide (^1D=3.9) (Table 1). Additionally, Figures 4 and 5 display the frequency and duration of the main behaviors and behavior categories in each habitat according to each tide condition.

Table 1. Behaviors in each habitat according to each type of tide. Habitats BZ at high tide, SS1 at high tide, and SS2 at low tide have been omitted since no behavior was recorded in these habitats under these tidal conditions.

	BZ-Low	BZ-Mid	SS1-Low	SS1-Mid	SS2-Mid	SS2-High
Behavior (number)	16	58	28	24	10	21
Behavior category (number)	4	8	7	6	5	7
Frequency (Number of occurrences)	57	1033	152	508	51	661
Duration (seconds)	2400	22496	3000	6304	2400	3600
^1D (Behavior frequency)	9.4	26.8	21.5	7.1	7	7.5
^1D (Behavior duration)	3.9	25.3	17	9.6	4.6	7

Most frequent behavior (Number of occurrences)	R (19)	R (168)	Pe (17) Ru (17)	Pe (160)	Ru (14)	Pe (172)
Highest duration behavior (seconds)	R (1062)	RBBW (4499)	LRF (636)	W (1189)	Ru (1093)	W (1131)

In most cases, a high correlation was observed between the frequency and duration of behaviors for habitats according to tidal condition ($\rho > 0.82$; p-value < 0.05), with the only exception being habitat SS2 under mid tidal condition ($\rho = 0.36$; p-value = 0.3).

Discussion

No behaviors were recorded for habitat BZ during high tide. Podestá *et al*. (2017) attribute the absence of shorebirds (such as *C. alba*) during the summer season in several key areas of HCPA to the occurrence of anthropogenic activities. Additionally, high tide levels contribute to several species having difficulties in finding specific areas to use as roosting sites (resting areas for birds) (Senner and Howe 1984; Becerra and Ferrari 2012; Giner and Perez-Emán 2015; Senner et al. 2017), which is relevant information since the "Resting" behavior is one of the main behaviors exhibited by *C. alba* in the HCPA.

Shores are areas with soft substrates, and it is precisely in these areas where the highest activity of the species *C. alba* was observed, especially during foraging. Yates *et al.* (1993) and Scheiffarth *et al*. (1996) attribute this behavior to the greater accessibility and availability of prey in the wet substrate, making it easier for these birds to penetrate. Regarding the population dynamics of invertebrates, which constitute the diet of *C. alba*, Cañete *et al*. (2010) mention that it is influenced by the following factors: larval stages, food availability, substrate characteristics, natural disturbances, and human presence. However, similar to habitat BZ, no behaviors were recorded in SS1 during high tide. Hernández *et al.* (2012) and Houpt *et al.* (2020) relate the movement of shorebirds to the accessibility of prey during cyclical tide periods, with the birds moving short distances to other areas with similar characteristics that provide their basic needs (foraging). This could also be due to the preferred depth for each species, which limits their presence to certain specific habitats (Vargas-Fonseca 2014).

No behaviors were observed during low tide in habitat SS2. This area is used by species from the pelecaniform and suliform orders, which rest here during the day during low tide periods. Some species of gulls also join them. This leads to a decrease in the available space for various activities of *C. alba* (such as foraging), as these birds are displaced due to the pressure from other species occupying the habitat under these conditions. Levey (1988) and Daniel *et al.* (2019) consider that ecological interactions, such as inter and intraspecific competition, determine the dispersal of birds among different wetlands. This is important for planning conservation actions in different areas, taking into account the movement of *C. alba*, as well as its presence and absence in specific locations, particularly because various ecological-evolutionary processes are related to the development of behaviors linked to interspecific interactions (Lawrence et al. 2012).

On the other hand, greater similarity was found when considering both the frequencies and duration of behaviors between SS1 at mid-tide and SS2 at high tide (Figures 2 and 3). This could be related to the location of these two areas within the HCPA, which are connected to spaces where the water flow constantly varies with the tide movements; for instance, water mirror 1 adjacent to SS1 and water mirror 2 to SS2. This would allow *C. alba* to engage in nearly the same activities in both places. The similarity in behaviors between SS1 at mid-tide and BZ at mid-tide, as well as between BZ at mid-tide and SS2 at high tide, may be due to their proximity, as BZ and SS1 are adjacent habitats affected by tides coming from the West inlet, while BZ and SS2 are also relatively close to each other (Figures 2 and 3).

The greatest diversity in both the frequency and duration of behaviors for habitat BZ was observed at mid-tide. For SS1, this greater diversity occurred at low tide, and for SS2 it was at high tide (Table 1). According to previous studies, the sandpiper *C. alba* is present in HCPA for most of the time in the mid-littoral zone, near the breakwater adjacent to BZ. This area is more frequently used by this species, as well as areas near the shore (Podestá et al. 2017; Cotillo et al. 2018). However, a certain diversity of behaviors associated with the shores during both low and high tide has also been recorded. This is related to the species' preference for locations with continuous tidal movement, due to the presence of muddy and sandy-mud areas where it can easily find food (Mazzochi et al. 2022; Podestá et al. 2022).

Regarding the BZ habitat, the categories of resting, locomotion, and grooming are the most frequent, although the locomotion category has the longest duration, covering more than 65% of the total time (Figures 4 and 5). Behaviors included in the foraging category, on the other hand, were only observed during mid-tide, which can be explained by the greater availability of food. This is because both low and high tide, with their rocky nature and water levels, do not favor food availability (Cotillo et al. 2018). Carmona (2003) pointed out that physical factors, such as substrate moisture and texture, directly influence prey acquisition due to tidal inundation in two ways: 1) easier substrate penetration and 2) increased invertebrate activity, making them more susceptible to capture by predators, especially shorebirds. These prey items may be more available during periods of low and mid-tide when the substrate texture is wet and soft, benefiting various shorebirds, especially *C. alba*, which is one of the smallest and has a short beak, requiring a soft substrate for penetration.

Furthermore, Ramli and Norazlimi (2016) observed differences in shorebird behavior in relation to tidal cycles, as they influence population abundance and behavior (greater abundance and more foraging during low tide periods). Similarly, Manrique and

Williams (2005) observed differences in relation to prolonged diving behavior of birds and tides (more diving activity during low tide and less surface resting time during high tide). It is also important to note that high and low tide cycles are extreme points, resulting in prolonged periods of mid-tide, precisely when most activities carried out by *C. alba* are favored.

In SS1 and SS2, the most frequent behaviors were those classified under the categories of foraging and locomotion, although during low tide in SS1, foraging decreases in frequency, and behaviors related to the grooming category occur more frequently. The high duration of the behavior 'long range flight' (LRF) in SS1 during low tide is also significant, despite the low frequency of this behavior (number of occurrences) in that habitat under such tidal conditions. This is consistent with the study by Burger *et al.* (2018), which showed that the local abundance of *C. alba* tends to decrease during low tide hours, so the increase in LFR is probably due to individuals searching and moving to other habitats with better conditions for resting or feeding. Bird *et al.* (2019) reported that as the tide drops, invertebrates accustomed to intertidal zones that inhabit muddy or sandy substrates are exposed to drastic temperature changes, moving to greater depths of the substrate, thus compensating for these changes to avoid desiccation. These behavioral adaptations may be reflected in the results of the present study, which identified a lower frequency and duration of behaviors belonging to the foraging category by *C. alba* in SS1 during low tide .

The duration and frequency of behaviors are highly correlated, and therefore, evaluating either of them for *C. alba* provides very similar information about the behavior pattern for the studied species. However, the low association observed between the duration and frequency of behaviors for habitat SS2 in mid-tide conditions occurs because the duration of very infrequent behaviors like 'rest with beak between wings' and LRF, with only a single occurrence, were up to seven times longer than other more frequent behaviors, such as 'pecking', for that habitat and tidal condition. This could be due to the fact that habitat SS2 is one of the most diverse habitats in HCPA in terms of sandpipers (Cotillo et al. 2018), and thus, greater competition for space may influence the higher occurrence and longer duration of non-feeding-related behaviors.

Conclusion

C. alba prefers areas with soft and moist substrate, where there is little competition for space with larger species, and where food is more readily available. These features mainly occur during mid-tide, when there is greater diversity of behaviors and higher frequency/duration of behaviors related to foraging and locomotion.

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Figure Legends

Figure 1. Habitats of the Coastal Wetland "Poza La Arenilla." Modified from Cotillo *et al*. (2018).

Figure 2. Cluster plot based on Bray-Curtis similarity. A. Frequency of similarity of behavior. B. Duration of similarity of behavior.

Figure 3. Map depicting the three combinations (habitat and tide) with the highest Bray Curtis similarity in terms of behavior frequency (A) and duration (B). Modified from Cotillo *et al*. (2018).

Figure 4. Primary behaviors recorded in each habitat under different tide conditions. The top five behaviors by frequency (black bars) and duration (gray bars) are displayed (out of 58 recorded behaviors), while the remaining behaviors are grouped under the category "other". Behavior nomenclature is provided in Annex 1 (Podestá et al. 2022).

Figure 5. Categories of behaviors recorded in each habitat under different tide conditions. A. Frequency of behavior categories. B. Duration of behavior categories.

Annex Legends

Annex 1. Behaviors of Calidris alba evaluated in the present study. From Podestá et al. (2022).

ANNEX 1.

Behaviors of *Calidris alba* evaluated in the present study. From Podestá *et al.* (2022).

Nº	**Behavior category**	**Description**	**Code**	**Time (s)**
Resting				
1	Rest	Resting mode in which the bird is standing on both legs.	R	5394
2	Rest with beak between wings	Behavior in which the bird is standing on both legs while the beak is hidden in the back between both wings.	RBBW	6031
3	Rest on one leg	The bird stands on one leg.	R1L	1131
4	Rest on one leg while beak lays between wings	The bird stands on one leg while the beak is hidden in the back between both wings.	R1LBBW	1932
5	Rest on substrate	Behavior in which the bird stays on substrate.	RS	285
6	Rest on substrate while beak lays between wings	Resting mode in which the bird keeps the beak hidden in the back between both wings, while stands on substrate.	RSBBW	210
Foraging				

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Nº	Behavior category	Description	Code	Time (s)
7	Food search	The bird performs a slight body inclination in search for food during foraging.	FS	391
8	Pecking	Foraging activity in which the bird introduces part of its beak into the substrate surface in a gentle and continuous way.	Pe	2957
9	Probing	Foraging activity in which the bird introduces its beak fully into the surface for a short or long time.	Pr	902
Flight				
10	Short range flight	The bird flies short distances during a short time within the inner boundaries of the evaluated zone.	SRF	410
11	Long range flight	The bird flies for a long time beyond the boundaries of the evaluated zone, returning or not to the evaluated zone.	LRF	2211
12	Landing	The bird finishes its flight activity and approaches the ground for landing.	L	183

Nº	Behavior category	Description	Code	Time (s)
Locomotion				
13	Walking	The bird walks slowly within or beyond the evaluated zone.	W	3763
14	Running	The bird moves quickly, within or beyond the evaluated zone.	Ru	5381
15	Jump on two legs	The bird jumps on two legs. This display can include horizontal or vertical movement while jumping.	Ju	44
16	Jump on one leg	The bird jumps on one leg. This display can include horizontal or vertical movement while jumping.	Ju1L	266
17	Jump on two legs and flap the wings	The bird jumps and flap its wings simultaneously.	JuFW	601
18	Jump on one leg and flap the wings	The bird jumps on one leg and flap its wings simultaneously.	Ju1LFW	40
19	Walking in circles	The bird does a short walk following a circular path.	WaC	35

№	Behavior category	Description	Code	Time (s)
20	Wing display	The bird leans its body forward and its wings are displayed upwards, with both legs stretched.	WiD	405
Grooming				
21	Grooming left wing with beak	Includes grooming in different spots of the left wing using the beak.	GBLW	559
22	Grooming right wing with beak	Includes grooming in different spots of the right wing using the beak.	GBRW	481
23	Grooming left wing with beak while standing on one leg	Includes grooming in different spots of the left wing using the beak while standing on one leg.	GBLW1L	11
24	Grooming right wing with beak while standing on one leg	Includes grooming in different spots of the right wing using the beak while standing on one leg.	GBRW1L	36
25	Stretches right wing and right leg	The bird slightly leans its body forward and stretches the right wing completely and lifts the right leg horizontally.	SRWL	9

Nº	Behavior category	Description	Code	Time (s)
26	Stretches left wing and left leg	The bird slightly leans its body forward and stretches the left wing completely and lifts the left leg horizontally.	SLWL	28
27	Shakes head	The bird strongly shakes its head.	ShH	101
28	Shakes entire body	The bird strongly shakes its body.	ShEB	377
29	Shakes rear body	The bird strongly shakes and raises its tail steadily during a short amount of time.	ShRB	71
30	Shakes wings	The bird strongly shakes its wings.	ShW	356
31	Wing flapping	The bird rapidly moves its wings while standing in the same ground spot.	WF	185
32	Grooming chest with beak	The bird is standing on two legs and leans its head towards its chest for grooming.	GBCh	1017
33	Grooming chest with beak while standing on one leg	The bird is standing on one leg and leans its head towards its chest for grooming.	GBCh1L	21
34	Grooming neck with beak	The bird is standing on	GBNe	115

Nº	Behavior category	Description	Code	Time (s)
		two legs and leans its head towards its neck for grooming.		
35	Grooming neck with beak while standing on one leg	The bird is standing on one leg and leans its head towards its neck for grooming.	GBNe1L	58
36	Grooming between wings with beak	The bird tilts its head towards its back, between wings, for grooming.	GBBW	653
37	Grooming between wings with beak while standing on one leg	The bird tilts its head toward its back, between wings, for grooming, while standing on one leg.	GBBW1L	6
38	Grooming tail with beak	The bird tilts its head toward its tail, for grooming the rear-end feathers.	GBTa	348
39	Head fractioning/rubbing on back	The bird rubs its head on its back, using a lateral movement.	HFB	39
40	Head fractioning/rubbing on chest	The bird rubs its head on its chest, using a lateral movement.	HFC	3
41	Scratch the head with left leg	The bird uses its left leg to scratch or arrange its head feathers.	SHLL	240

Nº	Behavior category	Description	Code	Time (s)
42	Scratch the neck with left leg	The bird uses its left leg to scratch or arrange its neck feathers, between the chest and head.	SNLL	107
43	Scratch the head with right leg	The bird uses its right leg to scratch or arrange its head feathers.	SHRL	136
44	Scratch the beak with left leg	The bird scratches its beak with its left leg.	SBLL	13
45	Beak cleaning on left wing	The bird rubs its beak on its left wing, using a lateral movement.	BCLW	30
46	Beak cleaning on right wing	The bird rubs its beak on its right wing, using a lateral movement.	BCRW	17
47	Beak cleaning with stretched left wing	The bird rubs its beak on its stretched left wing, using a lateral movement.	BCSLW	6
48	Beak cleaning on the back	The bird rubs its beak on its back, using a lateral movement.	BCB	30
49	Beak cleaning on the chest	The bird rubs its beak on its chest, using a lateral movement.	BCC	256
Bath				

Nº	Behavior category	Description	Code	Time (s)
50	Head bath	The bird puts its head in the water during a certain amount of time.	HB	946
51	Complete body bath	The bird puts its head and body in the water during a certain amount of time.	CBB	462
52	Shake body in water	The bird strongly shakes its entire body in the water.	SBW	125
53	Shake tail in water	The bird strongly shakes its rear body (tail) and raises it steadily during a short amount of time.	STW	43
54	Lateral bath (left)	The bird tilts its body to the left and towards the water.	LBL	131
55	Lateral bath (right)	The bird tilts its body to the right and towards the water.	LBR	57
Vigilance				
56	Guard	The bird has its neck directed upwards while watching its surroundings.	G	491

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№	Behavior category	Description	Code	Time (s)
57	Guard standing on one leg	The bird stands on one leg and has its neck directed upwards while watching its surroundings.	G1L	1
Social agonistic				
58	Aggression between two birds	The bird fights another bird.	A	63

77°9'40"W
77°9'30"W
N
Pacific Ocean
Bolognesi Ave.
Grau Ave.
East inlet
12°4'10"S
12°4'20"S
12°4'30"S
Legend chart
S: Sand
C: Channel
BZ: Boulder zone
W1: Water mirror 1
W2: Water mirror 2
WC: Wall/Channel
S: Shore
SS1: Sand shore 1
SS2: Sand shore 2
R1: Rocky area 1
R2: Rocky área 2
Pacific Ocean
West inlet
0
75
150
300
m

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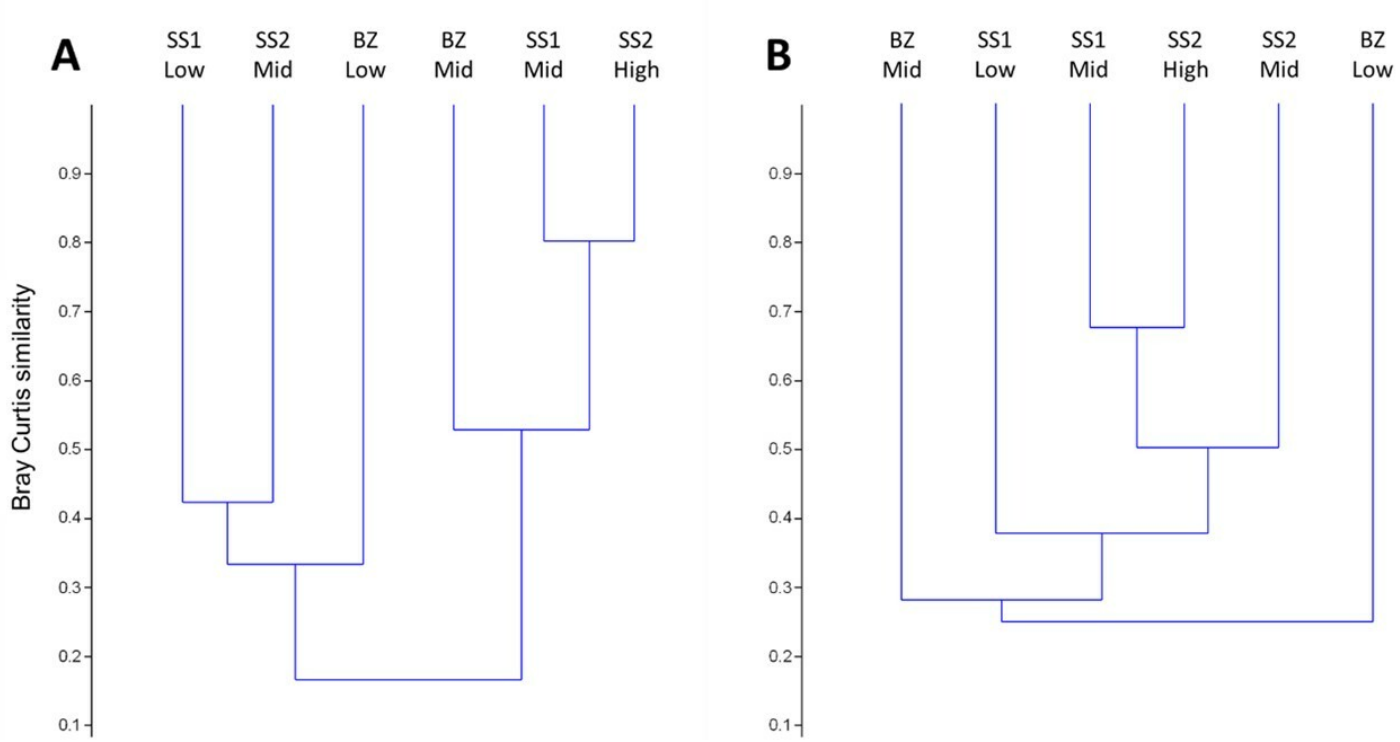

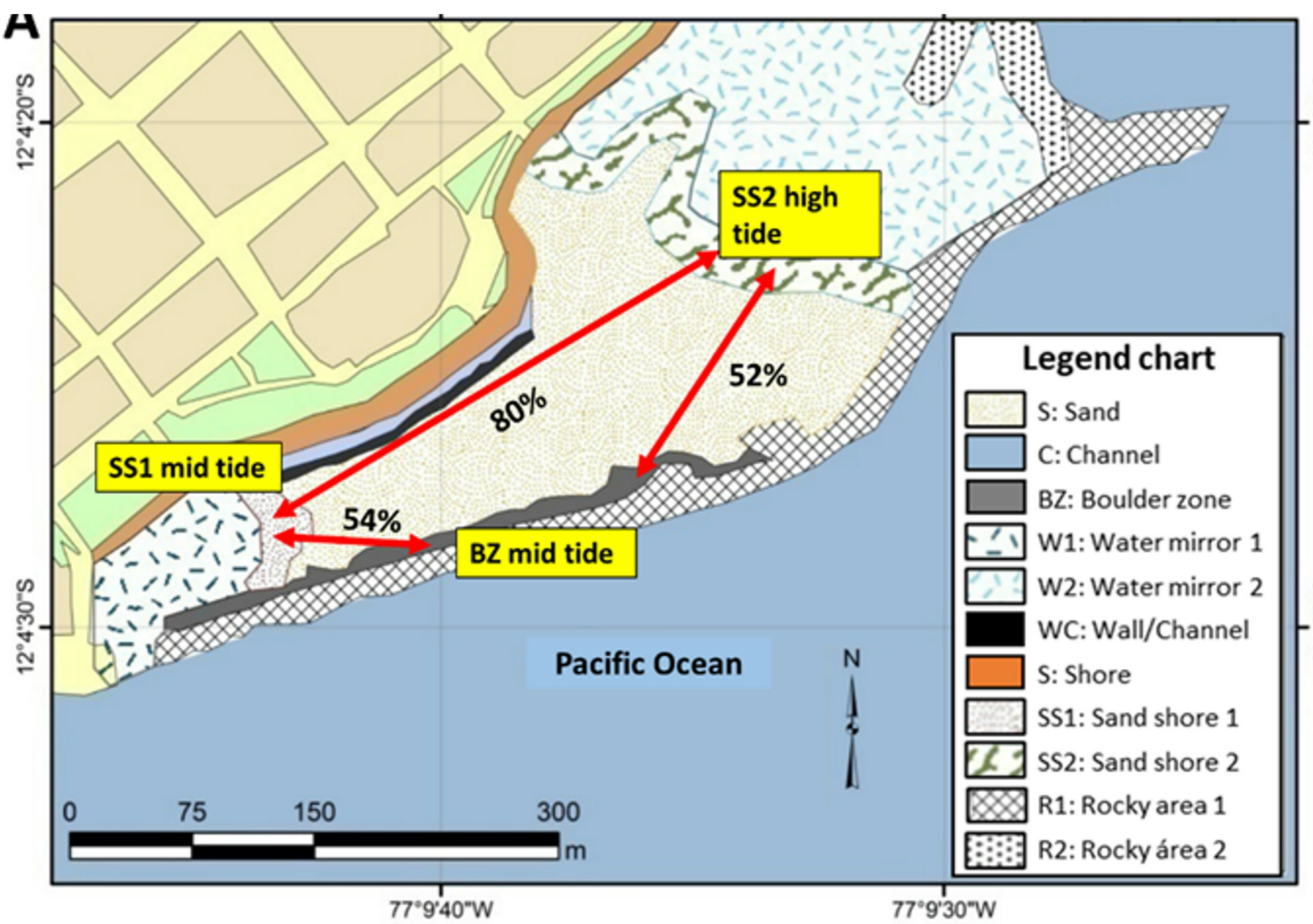
A
12°4'20"S
12°4'30"S
SS2 high tide
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52%
SS1 mid tide
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BZ mid tide
Pacific Ocean
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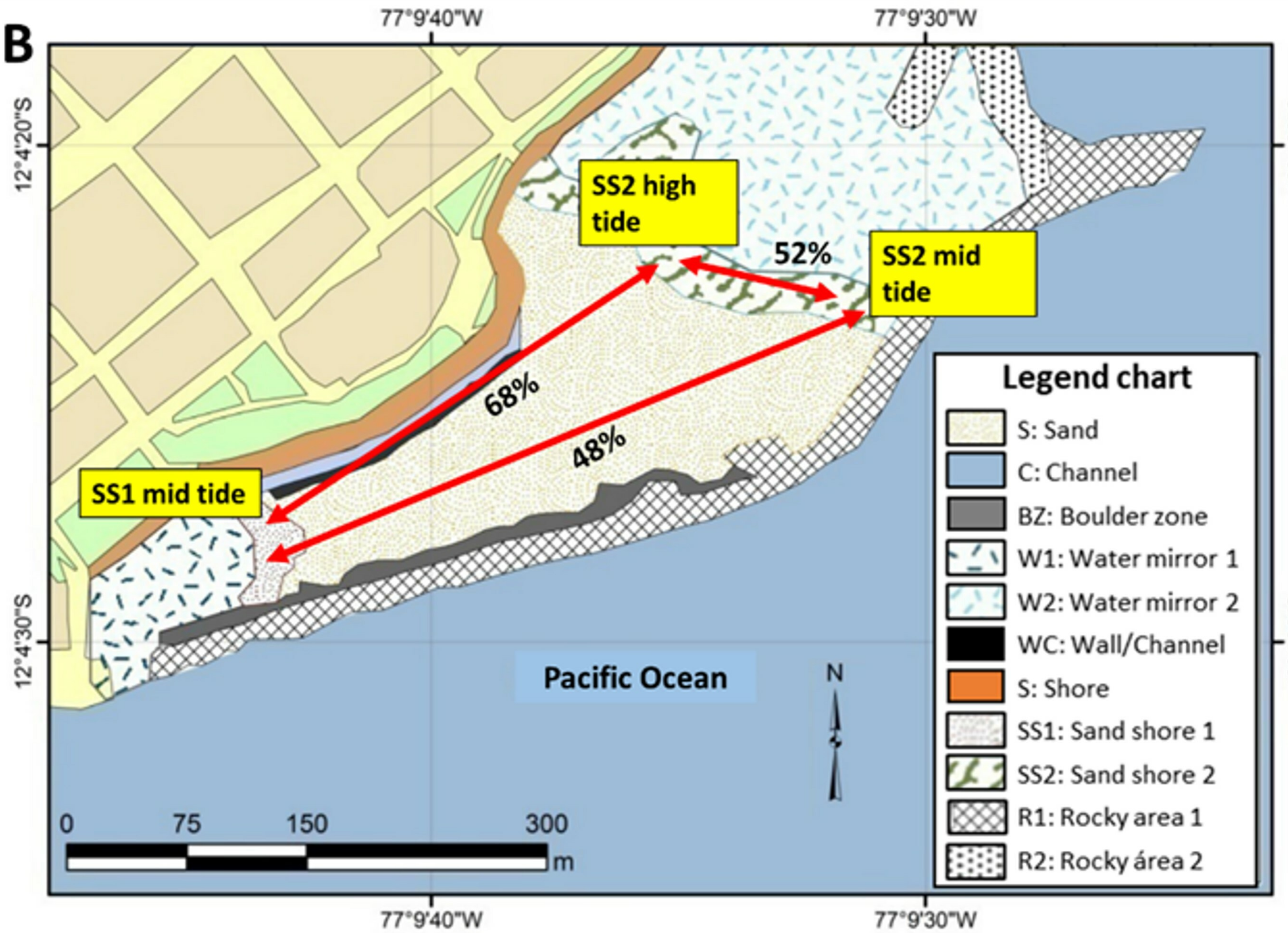
300
m
77°9'40"W
77°9'30"W
Legend chart
S: Sand
C: Channel
BZ: Boulder zone
W1: Water mirror 1
W2: Water mirror 2
WC: Wall/Channel
S: Shore
SS1: Sand shore 1
SS2: Sand shore 2
R1: Rocky area 1
R2: Rocky área 2


B
77°9'40"W
77°9'30"W
12°4'20"S
12°4'30"S
SS2 high tide
52%
SS2 mid tide
68%
48%
SS1 mid tide
Pacific Ocean
N
0
75
150
300
m
Legend chart
S: Sand
C: Channel
BZ: Boulder zone
W1: Water mirror 1
W2: Water mirror 2
WC: Wall/Channel
S: Shore
SS1: Sand shore 1
SS2: Sand shore 2
R1: Rocky area 1
R2: Rocky área 2

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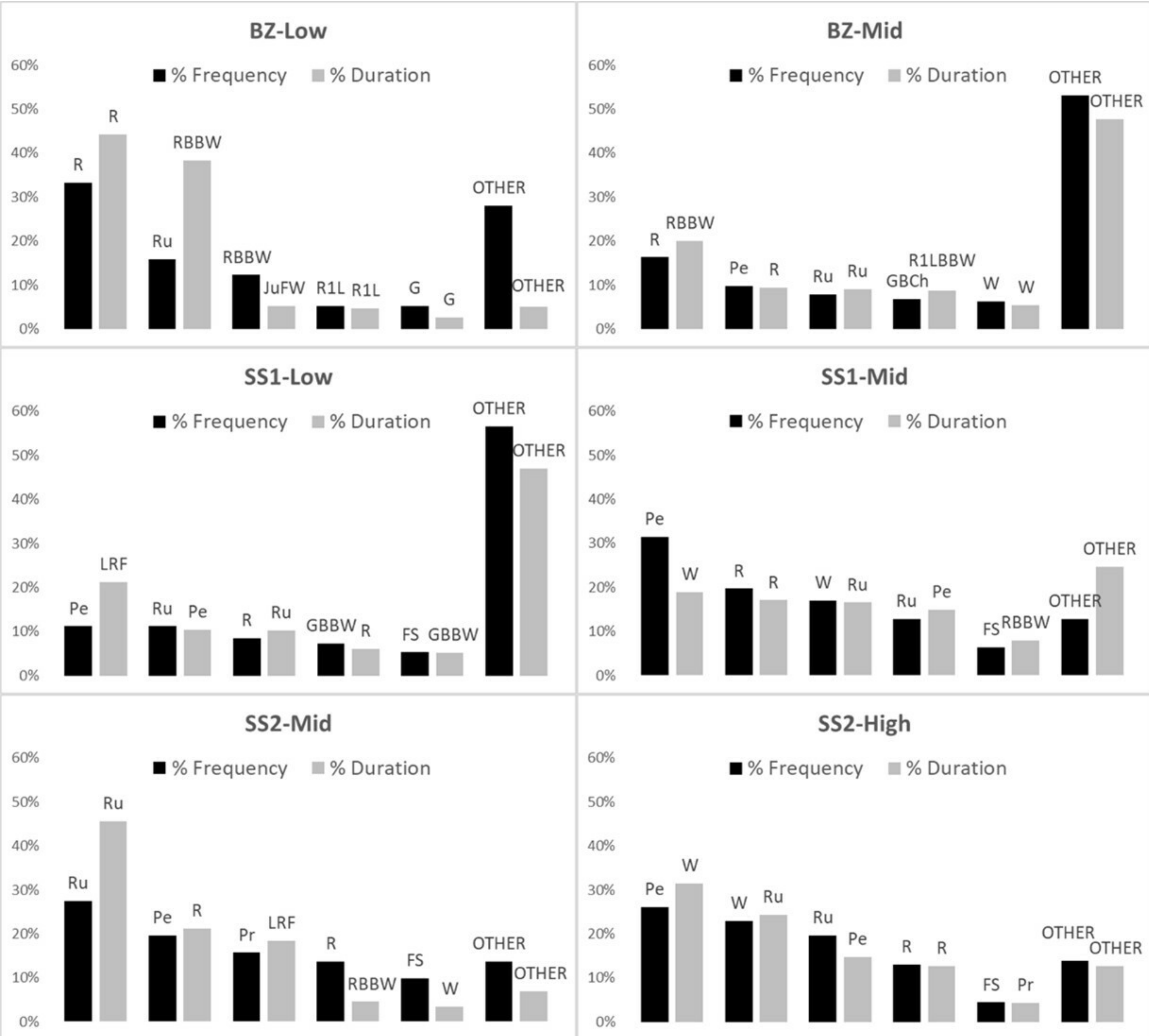

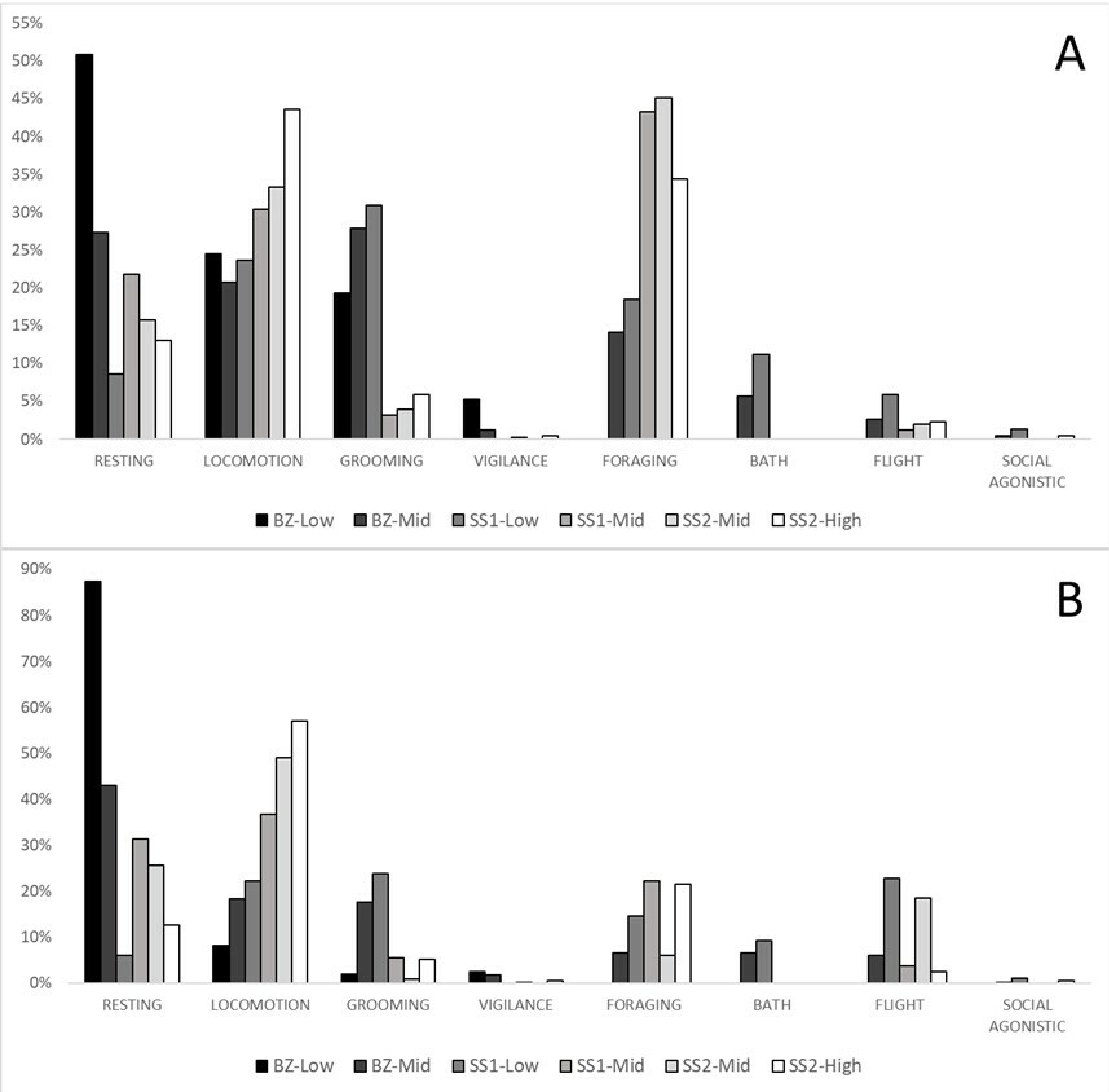
A
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RESTING
LOCOMOTION
GROOMING
VIGILANCE
FORAGING
BATH
FLIGHT
SOCIAL AGONISTIC
BZ-Low
BZ-Mid
SS1-Low
SS1-Mid
SS2-Mid
SS2-High
B
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70%
60%
50%
40%
30%
20%
10%
0%
RESTING
LOCOMOTION
GROOMING
VIGILANCE
FORAGING
BATH
FLIGHT
SOCIAL AGONISTIC
BZ-Low
BZ-Mid
SS1-Low
SS1-Mid
SS2-Mid
SS2-High