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HABITAT USE OF URBAN NESTING YELLOW-LEGGED GULLS IN CROATIA DURING THE BREEDING SEASON

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Because of increasing urbanization, some opportunistic birds such as gulls, started to exploit various artificial marine and terrestrial food sources. To better understand urban gull ecology and habitat use, a study was done on a yellow-legged gull (*Larus michahellis*) during the breeding season in Zadar, a coastal city on the Adriatic Sea. Ten adult breeding yellow-legged gulls (five females and five males) were caught on building rooftops during the late incubation period and were fitted with GPS-GSM solar power transmitters. In total, 2377 trip segments (no. GPS points = 19906) were analyzed, with most of them being classified as nest attendance (56.32 %) and foraging movements (37.10 %). Tracking data showed that the gulls mostly use marine and urban areas, agricultural lands, a dump site, and grasslands. Females were more active while foraging, with a longer duration and trip segment length, travelling further away from the breeding colony, while males tended to rest more than females. Both males and females exploit various habitats for foraging and resting, however females used agricultural lands significantly more than males. Even though gulls are generalists, some individuals showed a preference for certain habitats. After calculating the proportional similarity index, individuals showed high specialization for a certain habitat.

Key words: gulls, Laridae, GPS-GSM tracking, coastal Croatia, sex related difference, generalist, proportional similarity index

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Zbog sve veće urbanizacije, neke vrste ptica poput galebova počele su koristiti razne antropogene morske i kopnene izvore hrane. Kako bismo bolje razumjeli ekologiju urbanih galebova i korištenje staništa, provedeno je istraživanje galeba klaukavca (*Larus michahellis*) tijekom sezone gniježđenja u Zadru. Deset odraslih gnijezdećih galebova klaukavaca (pet ženki i pet mužjaka) uhvaćeno je tijekom kasnog razdoblja inkubacije na krovovima zgrada te su opremljeni GPS-GSM solarnim odašiljačima. Ukupno je analizirano 2377 segmenata kretanja galebova (19906 GPS točaka) od kojih je većina klasificirana kao prisutnost na koloniji (56.32 %) i hranjenje (37.10 %). Podaci praćenja pokazali su da se galebovi uglavnom koriste morem, urbanim područjima, poljoprivrednim zemljištima, odlagalištima otpada te travnjacima. Ženke su bile aktivnije dok su tragale za hranom s većim trajanjem i dužinom segmenata te su letjele dalje od kolonije, dok su se mužjaci više odmarali. I mužjaci i ženke iskorištavali su različita staništa za traženje hrane i odmor, no ženke su znatno više od mužjaka koristile poljoprivredno zemljište. Iako su galebovi generalisti, nakon izračuna indeksa sličnosti proporcija (engl. proportional similarity index) pojedine ptice pokazale su preferenciju za određena staništa.

Ključne riječi: galebovi, Laridae, GPS-GSM praćenje, primorska Hrvatska, razlike kod spolova, generalist, indeks sličnosti proporcija

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INTRODUCTION

The increasing movement of people to urban areas and urbanization are having negative effects on the environment and a decrease in natural habitats, resulting in a loss of biodiversity. Around 21 % of the total number of breeding bird species in Europe coexist with people in urban areas because they can adapt to the urban environment and exploit anthropogenic sources of food (Jokimäki *et al.*, 2016). Usually, omnivorous and seed-eating birds adapt better to urban environments. Not only do they feed on human refuse, but people also deliberately feed them, especially in harsh winter conditions, which helps them survive and additionally attracts more birds into the cities (Kark *et al.*, 2007; Pais De Faria *et al.*, 2021a). Hole-nesters and cliff-nesting species benefit from nesting on buildings (Kark *et al.*, 2007; Jokimäki *et al.*, 2016), while ground-nesting birds find very few suitable breeding places because the scarce vegetation cover in urban habitats provides little protection.

Despite the benefits that some bird species get from breeding in urban areas, this habitat is generally not ideal for wildlife. Birds are exposed to various threats like collisions with buildings, death by traffic, pet predation, light pollution, high level of noise, pollutants and human pathogens (Fuirst *et al.*, 2018). Also, in some cases, mammalian and avian predator species can be more abundant in cities than in natural areas (Sorace, 2002; Jokimaki & Huhta, 2000). Quite often, some species of birds are persecuted by people due to the noise and excrement they make, which frequently results in nesting failure.

Although ground nesting birds often cannot find suitable habitat in urban ecosystems, several gull species (Laridae) use rooftops as a nesting site that offers them protection from ground mammalian predators. They have natural habitats, inaccessible islands and islets, by high buildings with flat rooftops that are not disturbed by people (Soldatini *et al.*, 2008; Pfeiffer *et al.*, 2023). Because of their opportunistic nature, gulls are known to forage in various man-made sites like fishing ports, dump sites, and city parks (Belant *et al.*, 1998; Duhem *et al.*, 2003; Kubetzki & Garthe, 2003; Kubetzki & Garthe, 2007; Camphuysen *et al.*, 2010; Washburn *et al.*, 2013; Huig *el al.*, 2016; Shaffer *et al.*, 2017; Fuirst *et al.*, 2018; Méndez *et al.*, 2020; Spelt *et al.*, 2020, Frixione *et al.*, 2023). Urban areas usually provide year-round accessible food sources, so it is not surprising that the number of urban gull colonies is increasing. Additionally, ambient temperature is warmer in cities, enabling gulls to breed earlier, while street light allows them to feed at night (Rock, 2005; Pais De Faria *et al.*, 2021a).

Unfortunately, gull presence in cities is not always welcome. There are increased conflicts with people since gulls can cause building damage, nuisances and aggressive behavior during the breeding season or while stealing food from people, and foraging in trash containers (Méndez *et al.*, 2020; Pais De Faria *et al.*, 2021a). Gulls can also cause a potential risk of spreading pathogens by defecation because they normally carry many types of bacteria as part of their normal microbiota (Fuirst *et al.*, 2018).

The yellow-legged gull (*Larus michahellis*) is mostly distributed along the coast of the Mediterranean and the Black Sea, but also along the Atlantic coast of Spain, Portugal and France (Olsen & Larsson, 2004). It is a species that successfully breeds in the urban areas of several European countries (Soldatini *et al.*, 2008; Lopes *et al.*, 2020; Méndez *et al.*, 2020; Pais De Faria *et al.*, 2021a). The way they use habitats has been studied mainly on individuals breeding in natural habitats, examining stomach contents and analyzing them with stable isotopes or using pellets, while only a few studies were done using telemetry in urban areas (Duhem *et al.*, 2003; Ceia *et al.*, 2014; Mendes *et al*. 2018; Méndez *et al.*, 2020; Reusch et al. 2020; Lopes *et al*. 2021; Pais De Faria *et al.*, 2021a). Until recently, yellow-legged gulls were breeding in Croatia only on natural habitats like uninhabited islands and islets in the Adriatic Sea. Urban breeding has been known since 2004 when the first breeding activity was recorded in Opatija (Juričić, pers. comm.).

This is the first research done on yellow-legged gulls breeding in urban areas of Croatia. We aim to analyze the movement and habitat use of urban nesting yellow-legged gulls during the late incubation and the chick-rearing period, and investigate differences between sexes. Coastal urban places provide various feeding opportunities in both marine and terrestrial habitats, and we want to assess any possible preference for certain habitats. There are few studies on the yellow-legged gull's urban ecology, so we aim to improve our understanding of their spatial dynamics, particularly in the most demanding time period of their life cycle, i.e. the breeding season.

MATERIALS AND METHODS

Study site and data collection

The study was done in Zadar city on the Adriatic coast of Croatia (44°06′56.4″N 15°14′29.5″E) (Fig. 1 A). Yellow-legged gulls were studied while breeding on two rooftops of residential buildings and on a hospital with an estimated 30 and six breeding pairs, respectively. The residential buildings are located next to each other, while the hospital is 1.2 km away. The city is surrounded by sea, agricultural lands, meadows, forests, and scrub. There is also a county dump site located 5 km away (Fig. 1 B).

Ten breeding adults were caught during the late incubation period (five on 30th April 2021 and five on 4th May 2022) using walk-in traps on the nest. Each bird was measured and ringed with a stainless steel and with a plastic color ring. GPS-GSM solar-powered devices, type Ornitella, were fitted on each individual using a Teflon chest harnesses. The devices were set up to record one GPS point every five minutes. Data were retrieved from the online Ornitella OrniTrack Control Panel. The total mass of the tag device was 19.70 g, representing 1.74-2.42 % of the gulls' body mass (814-1127 g), which is below the suggested threshold of 3 % for seabirds (Phillips *et al*., 2020) but not less than the 1 % limit proposed by BODEY *et al.* (2018), below which the negative effect on bird survival and reproductive success is at its minimum. Nevertheless, this type of tag and the weight does not seem to have deleterious effects on the behavior of gulls of similar sizes (Thaxter *et al*., 2016). Five males and females were tracked, and sex determination was done by analyzing blood samples using molecular methods (Fridolfsson & Ellegren, 1999).

Movement and habitat analysis

For the analysis of movement metrics and habitat use, we used the time period from late incubation until chick fledging. The fledging period was estimated by field observations. The analysis started with the second day of tracking because of the possibility that birds were not behaving normally immediately after the manipulation. In total, 62 and 57 days of tracking data were analyzed for gulls caught in 2021 and 2022, respectively.

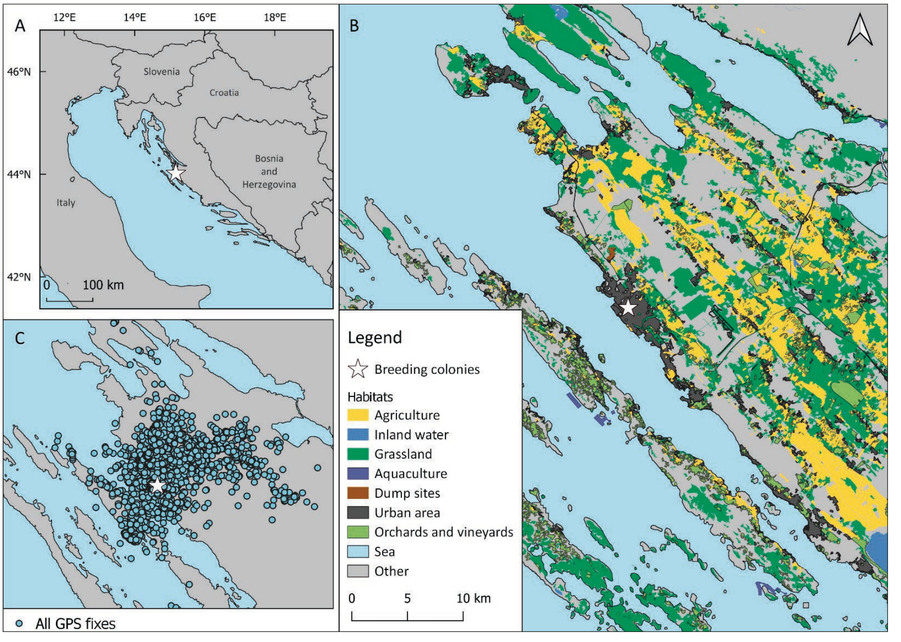

Fig. 1. A) Location of the breeding urban colonies of the yellow-legged gull in Zadar, Croatia marked with a white star. B) Map showing the National Habitat Classification of Croatia, grouped into nine simplified habitats. C) GPS positions of ten tagged individuals, tracked during late incubation and rearing period from end of April until middle of June. Five birds were tracked in 2021 and five in 2022 year.

For each GPS point, speed, duration and distance from the breeding colony were calculated. GPS points with unrealistic speeds were deleted using a speed threshold of 70 km/h as the maximum speed gulls could accomplish (Shaffer *et al.*, 2017). Even though the GPS transmitters were adjusted to record GPS points every five minutes, data explorations revealed many missing data. To standardize the time interval between GPS points, data were filtered to 30 minutes (n = 36770) and the movement metrics were recalculated.

To analyze bird movements, a classification of points was made. First, for each individual, GPS points within a radius of 150 meters of two central points, one representing two buildings (rooftop colonies) next to each other and one more distant rooftop, were classified as "in the colony". Then, all points were classified according to their speed as "stationary" (< 1 m/s), "flight" (> 5 m/s) and the rest as "foraging" (Isaksson *et al.*, 2015). Points classified as "in the colony" with a speed of less than one m/s were classified as "nest attendance", while the rest were not analyzed. The stationary movement represented the lowest gull activity outside the colony with travel speeds less than one m/s, which is considered as resting. Trips were divided into segments with a minimum of two consecutive GPS points of the same class. The number of trip segments, duration and length, and the maximal distance from the colony were calculated for each bird.

The National Habitat Classification of Croatia was used to analyze habitat use (Bardi *et al.*, 2016). Since the classification consists of many habitat types, similar habitats were merged for easier manipulation. In total, GPS points were annotated with nine different habitat types: urban (buildings, city parks, seaport, and industrial area), dump site, agricultural land, inland water (channel, rivers, and swamps), grassland, aquaculture (fish and shellfish sea farms), orchards and vineyards (fruit orchards, olive groves and vineyards), sea, and other (scrub and forest) (Fig 1 B). Habitat use was analyzed by the number of annotated GPS points and the calculated duration of consecutive points for each habitat.

A linear model was performed to analyze if there is any significant difference in habitat use between males and females, with habitats as dependent variables and sex as an independent variable. The data were log transformed to have a normal distribution. To analyze if there is any significant difference between males and females movement metrics, Welch's t-test was used. To investigate the individual specialization, the proportional similarity index (PSi) was performed, which measures the mean pairwise overlap between each individual and the population (Bolnick *et al.*, 2002). PSi values have a range from 0, indicating an absolute specialist in habitat use, meaning there is no inter-population overlap, and 1 which means that individuals use the full range of habitat used by the population, indicating an absolute generalist (Bolnick *et al.*, 2002). The mean of all PSi values represents an individual specialization index (IS) of the population. The statistical significance of the observed IS values was assessed by comparing the observed values against a null model, obtained by 999 Monte Carlo resampling of the original data set (Bolnick *et al*. 2002).

All analyses and graphical representations were done in R software, version 4.2.1 (R Core Team, 2022), using statistical packages: lubridate v. 1.8.0 (Grolemund & Wickham, 2011), tidyverse v. 1.3.2 (Wickham *et al*., 2019), fossil v. 0.4.0 (Vavrek, 2011), sp v. 1.4.6 (Pebesma & Bivand, 2005), ggplot2 v. 3.4.0 (Wickham, 2016), rgdal v. 1.5.-28 (Bivand *et al*., 2022), rstatix v. 0.7.1 (Kassambara, 2022) and RInSp v. 1.2.5 (Zaccarelli *et. al*., 2013).

RESULTS

In total, 2377 trip segments (no. GPS points = 19906, Fig. 1, C) were analyzed, with most of them being classified as nest attendance (56.32 %) and foraging movements (37.10 %) (Tab. 1). On the individual level, some birds spent very little time (less than 10 %) foraging and resting (stationary) (Fig. 2). During nest attendance both males and females spent a similar amount of time in the colony while incubating and guarding chicks with no significant difference found in duration $t(1298.63) = -0.07$, $p = 0.94$ and segment length $t(1312.97) = 1.29$, $p = 0.19$ (Tab 1). However, there was a significant difference between the duration $t(841.55) = 4.59$, $p = < 0.001$, the segment length of foraging, $t(845.71) = 8.53$, $p = < 0.001$ and the duration of stationery movements, $t(89.04) = -2.02$, $p = 0.046$. Females seemed to be more active while foraging with longer duration and segment length, while males tended to rest more than females. Also, there was a significant difference in travel distance from the colony for foraging $t(519.80) = 7.96$, $p = < 0.001$ and stationery movement $t(38.22) = 4.02$, $p = < 0.001$, where females, on average, travelled greater distances than males (Tab 1).

Birds were spending most of the time foraging, according to the GPS points at sea (21.11 %), in the urban area (20.51 %), agricultural lands (17.59 %), other habitats (14.59 %), grasslands (9.75 %) and the dump site (9.64 %). At the same time, during resting,

Tab. 1. Daily movement metric of trip segments for breeding females (n = 5) and males (n = 5) yellow-legged gulls. Each trip was classified according to flight speed as "stationary" (< 1 m/s), "flight" (> 5 m/s), "foraging" (flight speed between 1 m/s and 5 m/s) and nest attendance (movement inside the breeding colony with speed < 1 m/s). Trips with a minimum of two consecutive GPS points were analyzed.

	NEST ATTENDANCE		FORAGING		STATIONARY		FLIGHT	
	Female	Male	Female	Male	Female	Male	Female	Male
No. trip segments	665	650	481	401	39	129	8	4
Mean duration (h)	6.32	6.35	1.19	0.94	0.94	1.24	0.53	0.54
SD duration (h)	7.06	7.67	0.96	0.64	0.74	1.05	0.03	0.04
Min duration (h)	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.50
Max duration (h)	102.59	99.17	7.51	4.91	3.82	5.49	0.58	0.58
Mean trip segment length (km)	–	–	12.97	9.00	0.18	0.17	22.37	23.18
SD trip segment length (km)	–	–	8.20	5.55	0.10	0.24	2.62	2.09
Min trip segment length (km)	–	–	0.40	0.46	0.01	0.01	19.51	20.13
Max trip segment length (km)	–	–	71.55	33.73	0.42	2.51	27.55	24.85
Mean distance from colony	–	–	9.45	6.46	7.58	3.48	14.66	19.02
SD distance from colony	–	–	4.80	3.82	5.48	3.17	3.99	6.45
Min distance from colony	–	–	0.47	0.42	0.18	0.16	10.49	14.65
Max distance from colony	–	–	25.89	28.51	20.94	15.83	21.95	28.49

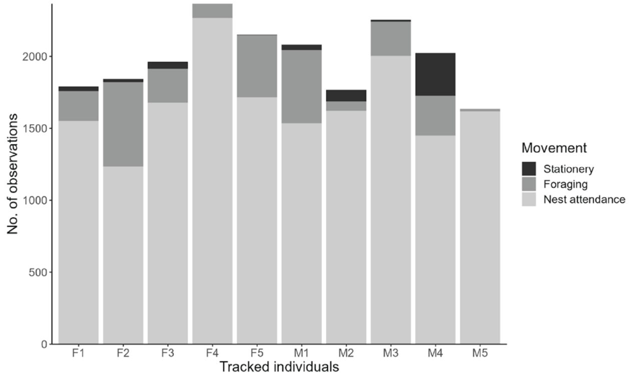

Fig. 2. Number of GPS points per individual according to movement classification: nest attendance (n = 16677), foraging (n = 2667) and stationary (n = 536). Flight movement is not shown due to a small number of observations (n = 24).

they mostly stayed in the urban area (41.23 %) and the dump site (33.02 %) (Fig. 3). Both males and females exploited various habitats for foraging and resting (Fig. 4). Females spent significantly more time than males foraging and resting on agricultural lands (Tab. 2).

Most individuals used similar habitats for foraging and stationary movements. Still, there were some individual preferences for certain habitats (Fig. 5). The PSi for foraging segments varied among individuals from 0.26 and 0.89 (Tab. 3, n = 10) with the mean value of the specialization index (IS) significantly different from the null model (IS = 0.71, permutation P = 0.001), showing more specialist habitat use while foraging. Regarding stationary movement, PSi values of individuals had a range from 0.03 to 0.88 (Tab. 3, n = 8, one male and one female were not analyzed due to the nonexistence of stationary movement outside the breeding colony) with IS being significantly different from the null model (IS = 0.52, permutation P = 0.001), showing even higher spe-

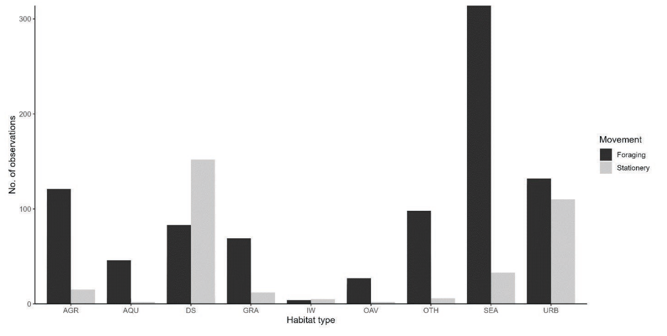

Fig. 3. The number of GPS points (n=3203) for foraging and stationary movement annotated to ten habitat types (AGR = agricultural land, AQU = aquaculture, DS = dump site, GRA = grassland, OAV = orchard and vineyard, OTH = other, SEA = sea, IW = inland water, URB = urban are) during the breeding period.

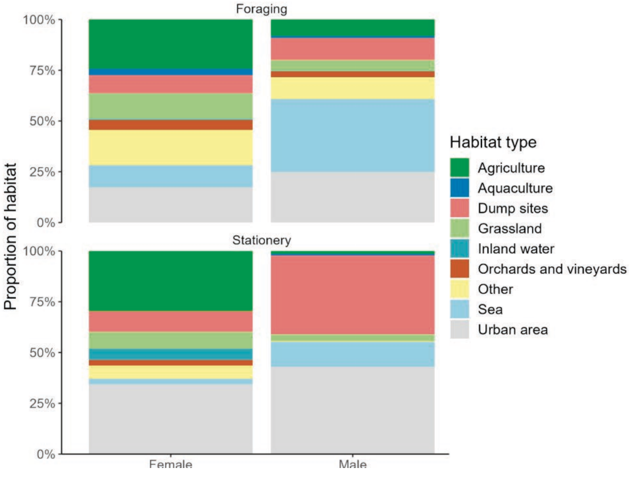

Fig. 4. The proportion of used habitat type by males (n = 5) and females (n = 5) according to the foraging (no. GPS points = 2667) and stationary movement (no. GPS points = 536) during the breeding period.

cialization. Comparing habitat preference between gender, males showed higher specialization than females for both foraging (IS =0.61, permutation P = 0.001, n = 5) and stationary movement (IS = 0.56, permutation P = 0.01, n = 4) while females were more generalist during foraging (IS = 0.84, permutation P = 0.001, n = 5), but specialist for stationary movement (IS = 0.64, permutation P = 0.001).

Male M5 was foraging mostly in the urban area (n = 16, 0.98 %, PSi = 0.26), however generally, this bird stayed most of the time in the colony (n = 1618, 98.60 %). The same goes for female F4 that rested only at the colony (n = 2268, 95.74 %). Male M1 preferred the sea for both foraging (n = 313, 62.48 %, PSi = 0.51) and stationary (n = 33, 89.18 %, PSi = 0.16) movement. More individuals seemed to have a preference for some habitat while resting, like female F5 using only agricultural lands, but this observation is based only on 4 GPS points (0.9 %, PSi = 0.04). Male M2 preferred to rest in the urban area (n = 70, 87.50 %, PSi = 0.57). From all individuals, the male M4 had more than half of the GPS points (55.41 %) classified as stationary movement, and most are annotated to the dump site (n = 152, 51.12 %) and the urban area (n = 110, 37.03 %, PSi = 0.89).

Tab. 2. Linear models for differences in number of GPS points between sexes (males compared to females) annotated to nine different habitats, showing habitat preferences of urban breeding yellow-legged gulls.

Habitat	Movement	Multiple R2	Coefficient estimates ± SD	Probability
Agriculture	Foraging	0.40	-2.15 ± 0.93	<0.05
Agriculture	Stationery	0.56	-1.79 ± 0.40	<0.05

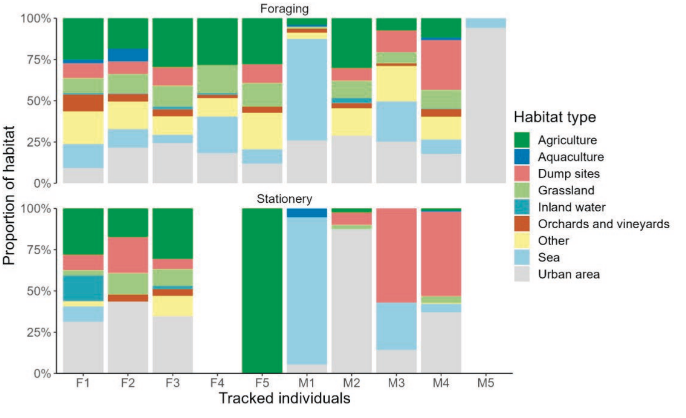

Fig. 5. The individual proportion of habitat use during foraging (no. GPS points = 2667) and **stationery** movement (no. GPS points = 536) during the breeding period. F1-F5 represents five tracked females, and M1-M5 five males. No GPS points were classified as stationary movement for individual F4 and M5.

Tab. 3. Values of proportional similarity index (PSi) which measures the mean pairwise overlap between each individual (five females, F1-F5, and five males, M1-M2) and the population according to the number of GPS points annotated to nine different habitats. Values closer to 0 indicate specialist while values closer to 1 generalist behavior in habitat use. No GPS points were classified as stationary movement for individual F4 and M5.

Individuals	Foraging	Stationary
F1	0.8118	0.7190
F2	0.8948	0.7203
F3	0.7597	0.5752
F4	0.7925	-
F5	0.7566	0.0353
M1	0.5096	0.1575
M2	0.7068	0.5733
M3	0.8246	0.5123
M4	0.7759	0.8887
M5	0.2555	-

DISCUSSION

As expected, yellow-legged gulls used both the sea and terrestrial habitats for foraging and resting during the breeding period. Gulls did not move far away from the colony, with a maximum travel distance of approximately 28 km, which is similar to or even lower than in other gull studies (Thaxter *et al.*, 2012; Juvaste *et al.*, 2017; Shaffer *et al.*, 2017; Mendes *et al*. 2018; Spelt *et al*., 2019; Reusch *et al*. 2020). Shorter foraging trips from the breeding colony are more beneficial because they minimize energy costs, and parents can provide better protection for their chicks, especially when they are still very young (Shaffer *et al*., 2017). Results also show that birds spend most of the time at the colony, attending the nest, with some individuals staying for a couple of days without leaving the area around the colony. Similar behavior was observed in other gull species like the great black-backed gull (*Larus marinus*), the lesser black-backed gull (*Larus fuscus*), Audouin's gull (*Larus audouinii*) and the kelp gull (*Larus dominicanus*), which spend approximately half of their daily activity, or even longer, at the colony (Bécares *et al*., 2015; Juvaste *et al*., 2017; Maynard & Ronconi, 2018; Reusch *et al*., 2020).

When not attending the nest, birds still spent most of the time in urban areas, while foraging and resting, similar to yellow-legged gulls breeding in Barcelona (52 % of GPS points annotated to urban habitat) (Méndez *et al*., 2020). The urban habitat offers a predictable and large amount of food. Also, some individuals spent most of the time at the colony, which suggests they can find food sources in the close vicinity of the colony, for example, feeding in trash containers (Bjelić, pers. obs.) Gulls can adapt to urban life by adjusting their foraging behavior to human time schedules, by making use of different anthropogenic resources depending on the timing of their availability (Spelt *et al*., 2020). Some gulls even specialized for preying on common city species like feral pigeons (*Columbia livia*), monk parakeets (*Myiopsitta monachus*) and even swifts (*Apus* sp.) (Méndez *et al*., 2020; Tomik, 2022). Considering that the dump site is located only 5 km from the urban colonies in this study, the results showed it is one of the most often used habitats for foraging and stationary movement. This is not uncommon because other gull species exploit dump sites as well (Duhem *et al*., 2003). However, it is questionable if they obtain sufficiently good quality food from foraging in dump sites, especially for chicks. Annett & Pierotti (1999) pointed out lower long-term breeding success in gulls feeding on human refuse, while Soldatini *et al.* (2008) showed there is no difference in breeding success between urban and natural colonies. Unfortunately, monitoring of breeding success was not done as part of this research. Considering that the sea was the most commonly used habitat by gulls, we expect this habitat should provide a higher quality food intake (Pais De Faria *et al*., 2021b). A significant issue is that feeding with anthropogenic food also provides a risk of ingesting non-food items like plastic that can cause injuries and even death to the bird (Lopes *et at.* 2021).

Apart from foraging in urban areas and the dump site, yellow-legged gulls spent a large proportion of time in another human-made habitat, i.e. agricultural land. It is known that gulls scavenge on carcasses and actively prey on different animals like invertebrates and mammals on agricultural fields, especially if they have access to open and tilled soils and regularly mowed pastures (Coulson & Coulson, 2008; Schwemmer *et al*., 2008; Camphuysen *et al*., 2010; Garthe *et al*., 2016; Rock *et al*., 2016; Spelt *et al*., 2019; Méndez *et al*., 2020). Our results also show that gulls forage in fruit orchards and vineyards, and even olive groves which was confirmed in the field by finding hundreds of olive seeds on islands without any olive trees or no vegetation at all. Also, gulls were seen actively eating olives from the ground and on top of the olive trees (Budinski pers. obs.). Gulls consuming olive seeds were described by other researchers as well (Calvino-Cancela 2011; Martín-Vélez *et al.* 2022). It will be interesting to see in the future if gulls will use terrestrial habitats more often than the sea due to the change in the fishing stocks (Camphuysen *et al*., 2010; Mendes *et al*. 2018).

Quite a few GPS points, in total 12.51 %, were annotated to a habitat classified as "other", mostly classified as forest and scrub. Of those, 15.84 % were located at less than 2 km distance from a dump site and 5.0 % from a fish farm. We assume they are connected with regular gull feeding at those places and resting afterward. 4.7 % are located just outside the city on a small olive grove patch not classified as an orchard, so we assume gulls are feeding there. For other points, 11.14 % are located on small natural patches inside urban areas, while 6.9 % are located in a predominantly pine forest (*Pinus* spp.) which is a popular recreational place for people. The rest of the points, 43.56 % are scattered over a natural area that mostly looks like scrub. It is possible that gulls are using areas that became more open after forest fires or that the classification of some areas is not up to date, for example, some abandoned fields can be classified as scrub. There is also a certain error in GPS positioning by a GPS-GSM tracking device that could misplace GPS points to a habitat that the bird did not actually use.

The proportion of habitats used by gulls differed among individuals, with some birds showing fidelity to a particular habitat type. These birds seem to be more specialized, which is not an unusual behavior for gulls (Camphuysen *et al.*, 2010; Camphuysen *et al.*, 2015; Juvaste *et al.*, 2017, Langley *et al.*, 2023). If they constantly find food in one habitat type, they will continue to exploit it (Ceia *et al.*, 2014; Carmona *et al.*, 2021). This is especially important during the breeding season because they reduce the energy costs of actively searching for food in different habitats, decreasing their travel time and distance from the colony (Lato *et al.*, 2021). Results show that few individuals rested in their foraging habitat. The most unusual bird was male M4 that foraged and rested in the dump site and urban area. Spelt *et al.* (2019) suggested that stationary movements on foraging grounds could indicate a "sit-and-wait" foraging method, e.g. gulls wait until the food appears instead of actively searching for it, like waiting for waste to be unloaded on dump sites before foraging on it. This "sit-and-wait" behavior of yellow-legged gulls was also observed in the field, on the dump site during this study. Even though individual variation does exist, because of the small sample size, it is not possible to calculate any correlation between individuals and habitat use, thus more research is necessary to understand these differences.

Our data showed that females spent more time and flew greater distances while foraging than males, similar to those in the study of Kasinsky *et al*. (2021). Several reasons could explain this behavioral difference between parents. Males are usually defending and guarding chicks and the nesting site from other gulls, so they tend to stay at the colony or near it (Dulude *et al*., 1987; Rock, 2005). Closer feeding sites or sites with more concentrated and predictable food, have a higher competition among individuals, so females could be pushed out from closer feeding sites (Patrick & Weimerskirch, 2014).

Regarding habitat use, females spend most of the time foraging on agricultural lands, the sea and urban areas, while males preferred to forage at sea. Similar behavior was noticed by Camphuysen *et al.* (2015) on the lesser black-backed gull with the proposed explanation that males are usually bigger birds and can handle more demanding flights and competition with other gulls over sea than females. Feeding on agricultural lands needs a different strategy. Prey is caught with less stress because gulls usually walk or run to snatch the prey (Camphuysen *et al.*, 2015).

The difference between sex and individuals recorded during this study should be taken with caution due to a small sample size and our analysis being based on 30 min GPS intervals, which are not the most accurate. Differences in habitat use can also result from variations in weather conditions and even tag deployment, as suggested by Langley *et al*. (2023). To get a better insight into the movement and habitat use of urban gulls, more data throughout longer periods, on a bigger number of studied birds is needed.

CONCLUSION

During the breeding period, urban yellow-legged gulls used mostly the sea but also man-made habitats, like urban areas, agricultural lands and the dump site. Birds did not travel far away from the colony, implying they could find enough food in the close vicinity of the breeding site. Urbanization is an important factor to explain the increase in the yellow-legged gull population size, as gulls find a safe place to breed in the cities and can use different food sources. Also, it will be interesting to see how the population structure will be affected because young gulls, and gulls with physical anomalies have a higher chance of surviving in urban areas (Carmona *et al*., 2021). This study confirms the opportunistic behavior of yellow-legged gulls and the use of different habitats for foraging and stationery movement, like the sea, urban areas, agricultural lands, grasslands and dump sites. Still, some individuals also show fidelity to certain habitat types. This behavior can be more efficient for saving energy and providing enough food for chicks. More research is needed to better understand the movement behavior of the parents and to explore how beneficial urban habitats are to gulls in comparison to natural colonies, because urban gulls are more exposed to human refuse and can intake items containing components that will affect their health.

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