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SHORT NOTE

Natal dens of invasive raccoons (*Procyon lotor*) in the wetlands of the Warta Mouth National Park (western Poland)

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Abstract. Fourteen raccoon (*Procyon lotor*) natal dens were discovered through direct searches during research in the Warta Mouth National Park in 2025 and 2026. Twelve were in tree cavities, and only two were in an artificial wooden box. Cavities varied in structure, from enclosed hollows to open-topped hollow stumps. Natal dens were usually located in the largest trees in the vicinity. All were live trees, with an average circumference at breast height of 414 ± 243 cm. Litter hollows were found at an average height of 320 ± 212 cm. Litter sizes ranged from three to six cubs, with a mean of 4.19 ± 1.05. These results, which show higher litter sizes than in other studies within the introduced range, may indicate higher female productivity where access to a diverse food base is available in this productive wetland. Listening for the sounds of cubs has proven to be an effective method for detecting litters in tree cavities. Collected data can be used for more effective and ethical management; removing cubs from dens allows the simultaneous removal of several individuals and prevents the cubs from slowly starving if only the female is euthanised.

Key words: invasive alien species, litter size, reproductive biology, tree cavities

Introduction

Raccoons *(Procyon lotor)* were brought from North America and introduced to Europe in the 20th century (Müller-Using 1959, Chesnokov 1989). In Poland, the species' population has grown rapidly over the past few decades. Although already recorded throughout the country, the raccoon remains most abundant in western Poland (Gabryś et al. 2014, Panek & Kolasiński 2025). The raccoon has been listed as an invasive alien species of European Union concern since 2016. Its management in Poland is regulated under the Act of 11 August 2021 on Alien Species (Journal of Laws 2021, item 1718).

Despite its long-standing presence in Europe, knowledge of key aspects of its biology on the continent remains limited. Population biology has been investigated in detail only in forest and urban environments in Germany (e.g. Lutz 1996, Hohmann 2000) and in wetlands in western Poland (Bartoszewicz et al. 2008). To date, the only study of the species' reproductive biology in Europe has been conducted in Germany (Michler 2018). In the Czech Republic, the first documented case of raccoon infanticide was reported (Brynychová et al. 2026). In other European countries, there is currently no data on raccoon natal dens or details about the mating season.

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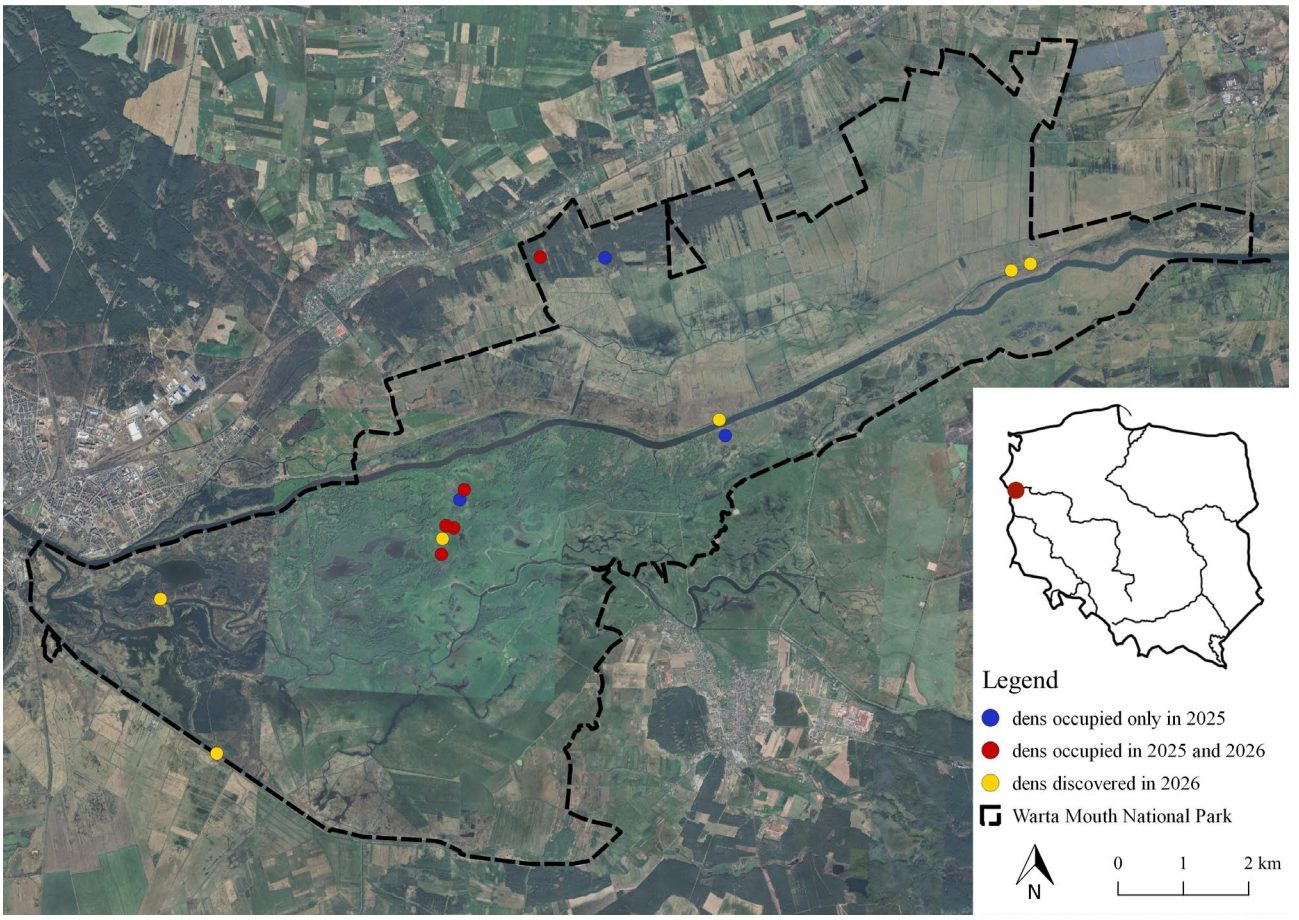

Fig. 1. Locations of raccoon natal dens discovered in Warta Mouth National Park (western Poland) in 2025 and 2026.

In the native range, raccoons often select tree cavities as natal dens (Endres & Smith 1993), and a lack of suitable cavities can constrain and shape local population dynamics (Beasley & Rhodes 2012). Compared with other cavity-dwelling species, raccoons require robust cavities because of their large body size. This often means that suitable cavity trees for raccoons are large (mean diameter at breast height 63.7 cm; Robb et al. 1996). In the native range, average litter size ranges from 2.0 to 4.8 (e.g. Ritke 1990, Beasley & Rhodes 2012).

The purpose of this study is to present data on raccoon natal dens (type, dimensions, habitat type) and aspects of their reproductive biology in an invasive range, specifically the open floodplain of western Poland (Warta Mouth National Park – WMNP). This is an area where the species' expansion in Poland began over 20 years ago. Based on hunting statistics, raccoon density in this region (Lubuskie province) is likely among the highest in Poland (Panek & Kolasiński 2025). As various countries continue to develop strategies to manage raccoon populations, data on preferred breeding sites across habitats and on reproductive biology are essential to support effective, evidence-based management of this increasingly widespread invasive species.

Study area

The study was conducted in the WMNP, western Poland (52°34', 14°43') (Fig. 1). The area is protected under the Ramsar Convention and the Natura 2000 network (PLC080001) and covers about 80 km^2 of the lower River Warta valley near its mouth to the River Odra. The lower River Warta valley is surrounded by dikes, creating an artificial reservoir that acts as a catchment for floodwater. The floodplains of the River Warta can cover about half of the area. South of the River Warta, there is a mosaic of marshy meadows and pastures for cattle and horses, old river beds, irrigation channels, and extensive willow thickets (*Salix* spp.). Willows constitute approximately 82% of the wooded vegetation (859.5 ha), followed by black alder (18% – 188.6 ha), whereas other tree species occur only marginally (Warta Mouth National Park 2021). Among the old trees, there are also many elms *(Ulmus laevis).* North of the Warta, meadows and pastures devoid of trees predominate. There is only a small alder *(Alnus glutinosa)* forest, covering about 80 ha.

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Table 1. Characteristics of 14 raccoon natal dens in Warta Mouth National Park (western Poland) in 2025 and 2026. CBH – circumference at breast height (130 cm); ND – no data (measurements not possible due to lack of direct access to the tree hollow); * – trees with nestboxes excluded.

ID number	Year of occupancy	Tree species	CBH (cm)	Entrance height (cm)	Depth (cm)	Entrance dimensions (cm)	Entrance shape	Den lining	Distance to the nearest birth site (m)	No. of cubs
1	2025, 2026	*Salix* sp.	227	152	128	15 × 20	open from the top	wood mulch	234	6 (2025) 4 (2026)
2	2025, 2026	wooden nestbox on *Salix* sp.	117	278	15	ø 14	circular	none	124	5 (2025) 4 (2026)
3	2025, 2026	*Salix* sp.	169	334	47	8 × 12 × 12	triangular	wood mulch	124	5 (2025) 6 (2026)
4	2025	*Salix* sp.	402	550	15	15 × 15	open from the top	ND	167	min. 3
5	2025, 2026	*Salix* sp.	173	250	75	ø 12	circular	wood mulch	167	4 (2025) 4 (2026)
6	2025	*Salix* sp.	650	600	5	11 × 44	oval	wood mulch	-	5
7	2025, 2026	*Alnus glutinosa*	156	253	113	13 × 26	oval	wood mulch	997	min. 5 (2025) ND (2026)
8	2025	*Salix* sp.	291	860	ND	ND	oval	ND	997	min. 3
9	2026	*Salix* sp.	558	122	100	17 × 18 × 19	triangular	wood mulch	207	3
10	2026	wooden nestbox on *Salix* sp.	140	250	37	ø 12	circular	hay	-	4
11	2026	*Salix* sp.	720	217	15	12 × 47	oval	wood mulch	-	ND
12	2026	*Salix* sp.	865	75	0	12 × 26	oval	wood mulch	310	3
13	2026	*Salix* sp.	522	293	65	17 × 23	oval	wood mulch	310	ND
14	2026	*Salix* sp.	240	240	75	24 × 30	oval	wood mulch	-	min. 3
		Median	347*	252	47					4.00
Summary		Mean	414*	320	53					4.19
		SD	243*	212	43					1.05

The area is important for birds: during the moulting season, up to 25,000 ducks congregate here, and during migration, over 250,000 birds rest and feed in WMNP (Warta Mouth National Park 2025). The reservoir is also a wintering site for several tens of thousands of birds. Due to large and sudden fluctuations in water level, artificial nesting structures (wooden duck boxes) have been installed in this area for many years.

Material and Methods

This study was based on direct field observations of raccoon natal dens, which began in mid-March 2025. All natal dens located in 2025 were checked for raccoon presence in April and May 2026. To locate them, potential breeding areas in optimal habitats (patches of habitat with hollow-bearing trees) were examined. Tree hollows with a diameter of at least 12 cm were inspected in trees with a circumference that would allow an adult raccoon to fit inside. A total of 81 tree hollows were inspected within WMNP. In addition, duck nestboxes were controlled (2025: n = 12, 2026: n = 60). If raccoon hair was found at the edges of a tree hollow or nestbox but the animal's presence was not detected, the hollow was re-examined within a few days. For deep (> 40 cm), high, or otherwise difficult-to-access hollows, an endoscopic camera on a 5-m cable was used to determine the presence of raccoons in the tree hollow. In all locations, listening tests were conducted to detect cubs through their vocalisations, as vocal exchanges between a mother and her cubs are complex and intensive. This approach was particularly useful when visual inspection of the tree hollow was difficult, e.g. in very deep or high-lying tree hollows, or when the female concealed the offspring by covering the bottom of the hollow.

Once an occupied tree hollow (or wooden box) was found, its coordinates were determined using a Global Positioning System (GPS) device and recorded along with the date the litter was discovered. The following measurements of the occupied natal dens were taken: tree species, circumference at breast height (130 cm), entrance height, entrance dimensions, depth, and type of den lining. In the first season (2025), motion-activated camera traps (Wilsus Tradenda 4G Wireless) were attached to trees 5-10 m from the tree hollow to record the female's entries and exits. Camera traps were positioned, whenever possible, to include the entrance to the tree hollow in the frame. For high-lying hollows, the base of the tree containing the hollow was recorded instead. The cameras were set to record 30-second videos with no interval between motion-triggered events and were checked every three days. In 2026, camera traps (Browning Spec Ops Elite HP5) were deployed in late May next to three natal dens that were still occupied at the time, and they monitored the litters until the young left the dens.

The distance to the nearest natal den within the same suitable habitat patch was measured. The suitable habitat patch is defined here as a single patch of flooded woodland containing trees of a size suitable for raccoons (see above), not separated by an environmental barrier, e.g. a large river. Litter size was determined, when possible, by direct counting of cubs in the hollow and/or by recording the number of offspring leaving the natal den in the video recordings from camera traps. In cases of uncertainty, if the number of observed cubs was believed to represent a whole litter, the minimum number of offspring was recorded. Based on the camera trap recordings, the date and time of each departure from the tree hollow were determined, as well as the duration of the process of leaving the den.

Results

In total, 14 raccoon natal dens were found (Fig. 1) – 12 within tree structures and two in artificial wooden nestboxes designated for ducks, hung on willow trees (Table 1). Eleven dens were situated in willows, and one in a black alder. All den trees, except one, were living and thick (circumference at breast height 156-865 cm, median 347 cm). Entrance dimensions and shapes varied among dens, and entrances were located 75-860 cm (median 252 cm) above the ground. Cavities varied in structure, from enclosed hollows within main trunks to open-topped hollow stumps and wooden boxes. The den lining in tree hollows consisted of wood mulch. One nestbox was partially filled with hay placed there by people during installation, while no padding was found in the second nestbox. Most natal dens were located in floodplains, where the distance to the nearest water body changed throughout the nursing season, ranging from several to several hundred metres. Natal dens were located in trees distinguished by their thickness or height, in open areas – surrounded by meadows, pastures, and willow thickets. The distance to the nearest natal den in the same suitable habitat patch varied from 124 to 997 m (Table 1), indicating a high density of breeding females in some areas.

Litter sizes ranged from three to six cubs (Table 1). In three cases, dead cubs were found in the natal den or its vicinity: one at the beginning of the breeding

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season and two just before the estimated date of den abandonment. In two cases, three dead cubs were found, but it is uncertain whether these constituted entire litters. In one case, there were four cubs. The minimum average litter size was 4.19 ± 1.05 (n = 16). Departure from the dens occurred during the day, starting between 9:55 and 13:15 and lasting up to 1.5 h. Five of the natal dens discovered in 2025 were also occupied during the 2026 breeding season (Fig. 1).

Discussion

The raccoon is a relatively hefty mammal species and therefore requires large holes in appropriately sized trees (Robb et al. 1996). Mature, large-diameter trees (mainly willows) are abundant in the WMNP. Therefore, the availability of potential breeding sites in this area is very high. The results presented on average tree-cavity height and circumference at breast height align well with those from Germany (Michler 2018), where the averages of these dimensions were 626 ± 442 cm and 301 ± 109 cm, respectively. The difference in average tree-cavity height is expected in this case and results from the specificity of the tree species in which raccoons bred in both studies. Michler (2018) documented 70% of natal dens in beech (*Fagus sylvatica*). Beech and willow differ markedly in their growth form and wood structure. While beech trees attain substantial height before reaching large diameters, willows can attain relatively large trunk diameters at comparatively low heights. This may explain why suitable breeding cavities were located closer to the ground in this study.

Two of the discovered litters were found in wooden nestboxes designated for ducks. These structures have been installed in the WMNP for almost 50 years. So far, only two have been identified as natal dens for raccoons, but raccoons are regularly observed using the boxes as daytime resting sites. This use of nestboxes highlights the risk of predation on cavity-nesting birds. Raccoons are known to be important predators of cavity-nesting ducks (Robb & Bookhout 1995, Yetter et al. 1999), and the use of nestboxes by breeding females may further increase this risk. Bartoszewicz & Zalewski (2003) demonstrated that boxes hung in the WMNP can prove to be a trap for birds in the presence of mammals that can climb efficiently. The presence of raccoons in the boxes also means that placing nestboxes increases the availability of breeding sites for raccoons, while at the same time competing for nesting places with cavity-nesting birds, such as some species of ducks and owls (Robb & Bookhout 1995, Kobayashi et al. 2014).

The minimum average litter size of raccoons in WMNP was 4.19. This result falls within the range reported by studies from the native distribution, which is 2.0-4.8 (e.g. Ritke 1990, Beasley & Rhodes 2012). However, it differs slightly from that reported in Germany (3.14; Michler 2018). These differences may reflect the food base available in the WMNP area. Wetlands can provide raccoons with a wide variety of food, allowing them to maintain a nutrient-rich diet. Raccoons in these areas make extensive use of wetland-related resources – rodents, birds, and molluscs, as well as fish, insects, and plant food (Bartoszewicz et al. 2008, Baranowska et al. 2026). This may translate into greater female productivity and/or increased pup survival. However, confirming this hypothesis requires longer, more detailed observation across a wider range of areas.

Three cases of dead young raccoons were found in or under the natal dens. One occurred at the beginning of the breeding season – three cubs were less than a week old. They appeared to have fallen from a tree hole. However, visual inspection indicated that the natal den was relatively deep, making spontaneous falls unlikely, as cubs at this stage are relatively inactive. Furthermore, camera-trap monitoring revealed that the site was visited by more than one adult raccoon. This suggests that infanticide may have occurred. This behaviour, in which the male kills the female's offspring, enabling him to impregnate her again, is sometimes observed in raccoons and was recently documented for the first time in Europe by Brynychová et al. (2026). The second litter, three cubs found dead under a tree, died around May 30th, 2025. The young were already highly mobile and should have left the natal den soon. However, the shelter was very shallow (about 15 cm), and the young were seen several times during site inspections climbing at its edge. Based on this, it can be concluded that the young likely fell out of the tree hole. A third litter was found dead inside the natal den, which in this case was a nestbox. On May 26th, 2026, the nestbox was visited to determine the litter size, and the cubs found inside were in an advanced state of decomposition. A dead adult raccoon was also discovered approximately 100 m from the box. It can therefore be assumed that the adult raccoon was the mother of the young in the box, and that they starved to death following her demise. However, the animal's state of decomposition made it impossible to determine its sex.

During this study, it was observed that listening by an observer is the most effective method for detecting raccoon litters, especially in relatively

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low-lying tree hollows. Raccoon cubs often vocalise in a distinctive manner from the first days of life, becoming increasingly loud over time. Furthermore, this method does not require specialised equipment such as thermal imaging cameras or endoscopes. Although entrance dimensions varied among dens, they provide a useful indication of the minimum cavity size (at least approximately 12 × 12 cm), facilitating the identification of potential natal dens during field surveys. We also discovered that the same natal dens are readily occupied in subsequent breeding seasons. The knowledge gained during this study on preferred raccoon breeding sites and detection methods may have practical applications for population management of this species. According to Polish law (the Act of 11 August 2021 on Alien Species, Journal of Laws 2021, item 1718), anyone who detects the presence of invasive alien species in the environment is required to report this to the relevant local authorities. Management measures should then be taken. Permitted methods of eliminating animal species classified as IAS in Poland include, among others, capture by hand or using tools (in particular scoops, live traps), destruction of developmental forms, shooting with firearms, and keeping captured animals in isolated facilities such as animal sanctuaries. Raccoons are subject to year-round population control, including the breeding season. Removal of young from tree hollows may constitute both an effective and ethically justified management approach. Young individuals removed from dens may be placed in a sanctuary or euthanised, thereby avoiding prolonged suffering that could occur if the female is eliminated and the offspring are left to starve. Moreover, it allows for the simultaneous elimination of several individuals before they begin feeding independently and exerting negative impacts on the environment. Culling should be carried out using methods approved for this species in the manual on humane management of invasive vertebrates (Smith et al. 2022). However, due to legal restrictions associated with the species' status as IAS of European Union concern, certain research methods are not permitted in Poland. In particular, telemetry studies are not allowed, as they would require capturing individuals and releasing them back into the environment. Therefore, it is not possible to track marked females with transmitters or locate natal dens, as was done in Germany (Michler 2018). Despite these limitations, the results presented demonstrate that, at a local scale (e.g. in protected areas with dedicated field personnel), it remains feasible to locate natal dens and to undertake measures aimed at limiting both the population size and the spread of the species.

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Author Contributions

W. Baranowska and M. Bartoszewicz designed the study, collected and analysed the data. Both authors read, edited and approved the final version of the manuscript. W. Baranowska coordinated the study.

Data Availability Statement

Data supporting this study's findings are available at the Research Data Repository of the University of Warsaw: https://doi.org/10.58132/VYE8CT.

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ChatGPT was used to improve the manuscript's clarity and readability. All AI-generated suggestions were critically reviewed, verified, and edited. The authors retain full responsibility for the final content of the manuscript.

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