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SHORT COMMUNICATION

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Long-lasting asynchronous emergence of loggerhead sea turtle *Caretta caretta* in one of the northernmost nests on the Adriatic coast

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The loggerhead sea turtle *Caretta caretta* (L., 1758) is an endangered species distributed throughout subtropical and temperate regions. Due to menaces affecting its conservation status in the Mediterranean basin (Wallace et al., 2010), several conservation and management programmes have been established to protect and monitor its nesting sites (Casale, 2015).

In 2023, there were known to be 26 loggerhead sea turtle nests along the western coast of the Adriatic Sea. Most of these occurred in the Puglia region, except for two, which were located in the province of Teramo in Abruzzo and in the province of Ravenna in Emilia Romagna. The last two cases represent two of the most northern successfully hatched nests along the eastern Italian coast, together with Pesaro, Marche in 2019 (Mancino et al., 2022) and Jesolo, Veneto in 2021, which to date is the northernmost location recorded (Sénégas et al., 2009) (Fig. 1). Here I describe observations on a nest at the beach of the Borsacchio Nature Reserve in Teramo (Fig. 1). This is not the first occasion in which a sea turtle nest has been reported in the Abruzzo region, but it is the first time it has been possible to protect the nest site, thanks to the commitment of local associations. The importance of this case is not only linked to its geographical position but to the dynamics regarding hatching, which, in addition to occurring at the original site, represents a record for the longest-lasting asynchronous emergence of hatchlings from the nest.

On the afternoon of 18 July 2023, recent traces of a sea turtle nest were found along the beach of the Borsacchio Nature Reserve (Roseto degli Abruzzi, TE) at a distance of approximately 24.5 m above the mean low-water mark. Once the presence of the nest was verified, the site was immediately secured by volunteers from the associations Centro Studi Cetacei and Guide della Riserva Borsacchio. To protect the nest, seven days before the emergence of the hatchlings, the volunteers installed a circular fence of 1 cm mesh plastic net around it (4.4 m diameter and height of 0.50 m). With the same type of net they created a 1 m wide corridor towards the sea, crossing the beach perpendicularly finishing a few metres from the sea. The net encircling the nest could be opened where it joined the corridor, to allow access to the sea at times when hatchlings were emerging but was otherwise closed. Later, a second circular fence was installed around the nest but with a greater diameter

Figure 1. The northern portion of the Adriatic Sea. Red dots correspond to the four most northern *Caretta caretta* nests recorded to date and successfully hatched.

(5.6 m) which allowed access to volunteers and experts but otherwise offered additional protection to the nest. The site was monitored 24 hours a day by volunteers and at night illuminated with low-impact red LED (RGB) lights with integral solar panels. The emergence of each turtle was monitored and assisted by volunteers from the associations, until they had entered several metres into the sea. Periodically, following the turtles' immersion, beach sections adjacent to the sea-entry corridor were checked in case the hatchlings had been dragged back onto the beach. Electronic probe thermometers (Arceli) were placed on the northern border of the net surrounding the nest with the probes penetrating the sand to a depth of 35 cm. An Aorlis electronic scale and a Zhjan digital calliper were used to collect morphometric data.

Figure 2. *Caretta caretta* hatchlings emerging from the nest site in the Borsacchio Nature Reserve in the province of Teramo, Abruzzo

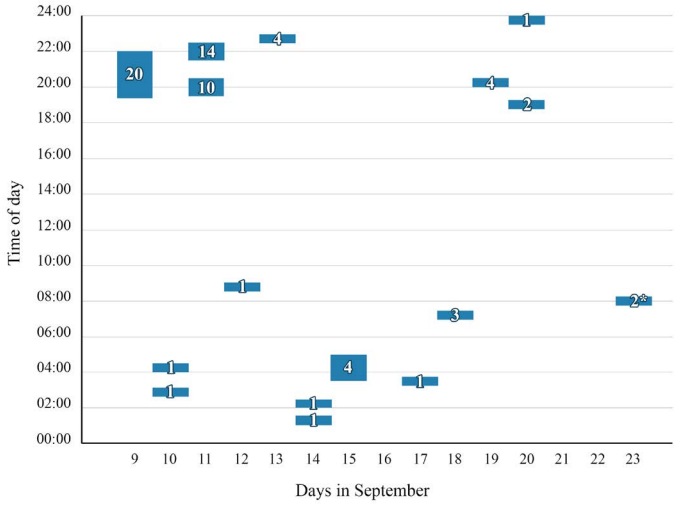

Figure 3. Date and time of day that hatchling *Caretta caretta* emerged from a nest in the Borsacchio Nature Reserve in the province of Teramo, Abruzzo. The bars represent time of hatchlings' activity (from emergence to immersion in the sea) and show the number of specimens. * Live specimens found during nest disinterring.

Since the nest was located within a nature reserve, it was free of bathing establishments in the nearby area, but was still frequented by residents and tourists. The area is almost completely natural, with the exception of a ruined building on the beach a few metres from the water, and a cycle path flanked by a railway parallel to the beach, located about 100–110 m from the sea. The beach consisted of fine white sand that was clean for about twenty metres from the sea. The closest sources of light pollution were located approximately 820 m north and 1,150 m south of the nest.

On the morning of 9 September, 53 days after the discovery of the nest, a depression formed in the centre of the nest at 07:30 h, which was a symptom of the imminent emergence of the hatchlings. The first specimens began to emerge twelve hours later, from 19:30 h to 22:00 h (Fig. 2), when 20 turtles found their way to the sea within two and a half hours. Two more specimens emerged during the night, before dawn. On the evening of 11 September, another 24 specimens emerged and headed towards the sea from 19:30 h to 22:14 h. In the following nine days, other specimens emerged individually or in small groups (max. 4) (Fig. 3).

The major activity of the hatchlings was observed from 18:45 h to 04:00 h, during twilight and night, while no activity was recorded from 09:00 h to 18:45 h (Fig. 3). The longest period of inactivity between emergences was 47 hours. Times from emergence to immersion in the sea (distance of about 24.5 m) varied from 20 to 45 minutes. The tracks left by the hatchlings on the sand provided evidence of the dispersal pattern within the delimited area circumscribing the nest. These were mainly orientated towards the south/south-east quadrant of the area. A few individuals 'inspected' the western portion of the fence, but none moved into the northern half, where the sand remained undisturbed.

On the morning of 23 September, 55 hours after the emergence of the last specimen, it was decided to disinter the nest due to an expected storm and the bad weather. In the egg chamber, which had a depth of 43 cm at the base, there were empty eggs shells, 12 infertile eggs, three dead hatchlings and two live hatchlings. Morphometric data of the last two specimens were taken before they were released. On average, they had a total length of 58 mm, carapace length of 40 mm, and weighed 15 g. The nest had contained a total of 84 eggs, from which a total of 70 hatchlings emerged, giving a hatch success rate of 86%. During the whole period of observation, the weather was almost continuously favourable. Strong winds never occurred and rain only fell on two occasions, both during the night. The temperature recorded by the electronic probes inserted into the subsoil showed no significant variations during the days when the nest was monitored, oscillating between 24.6 °C at night and a maximum of 25.7 °C during the day. The lowest temperature recorded was 24.2 °C during one of the two nights with rain.

Within the first three days of the emergence period two thirds of the hatchlings had left the nest, mostly in large groups, while the remaining third were distributed throughout the following days as single individuals or small groups consisting of a few individuals (Fig. 3). The incubation period of the eggs is not certain due to the wide spread of emergences from the nest but can at least be estimated roughly. It may be assumed that the nest was found on the morning after egg laying, we know that that the first hatchlings emerged 53 days later, that hatchlings are known to take from 2 to 7 days to reverse the folded posture assumed inside the egg, to absorb the yolk sac, and to dig themselves out of the nest (Godfrey & Mrosovsky, 1997; Miller et al., 2003). From this we can estimate that at least some of turtles hatched within about 46–51 days from egg laying. Most likely, the turtles did not all hatch at the same time, as 12 days elapsed between the first and last emergences from the nest, meaning that some of the hatchlings may have taken 14–19 days to emerge, while the last two specimens may have spent 17–22 days inside the egg chamber after hatching. As documented,

in some nests around the Mediterranean basin, within-nest temperature differences can generate variations in the hatchlings' emergence patterns (Adam et al., 2007; Glen et al., 2005; Field et al., 2021).

The emergence of the hatchlings from the nest occurred over a period of 12 days (approximately 292 hours between the first and the last emergence), with the addition of two live specimens recovered on the morning of the 15th day (approximately 324.5 hours from the first emergence). This case represents one of, if not the longest, asynchronous emergences reported in the literature (Hays et al., 1992; Houghton & Hays, 2001; Adam et al., 2007). Although extended asynchronous emergence might seem disadvantageous in terms of natural selection, minor emergence groups have higher chances of surviving aquatic predation, as the number of hatchlings entering the water is lower (Wyneken et al., 1998; Pilcher et al., 2000; Glen et al., 2005).

A subject for future research would be the dispersal pattern and orientation of the hatchlings following emergence in the localities where nests of this species rarely occur. Since the nest site was delimited by a fence, the hatchlings were directed into a corridor that crossed the beach perpendicular to the sea. However, immediately after emergence the hatchlings were free to orientate around the nest area and there was a tendency for them to attempt to disperse more towards the south rather than the east (in the direction of the water). This could be an effect of light pollution or other variables (Witherington & Bjorndal, 1991).

Human activity in coastal zones has a significant impact on the reproduction of sea turtles. This study highlights the importance of nature reserves together with the work of associations and volunteers in the delivery of effective ecosystem conservation.

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