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# Seasonal habitat preference by the flagship species *Testudo hermanni*: Implications for the conservation of coastal dunes



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## ABSTRACT

In this study, we explored if, how, and when the European Union habitats (EU *sensu* Habitats Directive 92/43/CEE) are used by the flagship species *Testudo hermanni* in a well-preserved coastal dune system of the Italian peninsula. Radio telemetry data and fine-scale vegetation habitat mapping were used to address the following questions: (a) is each EU habitat used differentially by Hermann's tortoises? (b) is there any seasonal variation in this utilization pattern? (c) how does each habitat contribute to the ecological requirements of the tortoises? Nine tortoises were fitted with transmitters and monitored for the entire season of activity. The eight EU habitats present in the study area were surveyed and mapped using GIS. The seasonal preferential use or avoidance of each habitat was tested by comparing, through bootstrap tests, the proportion of habitat occupied ( $p_iTh$ ) with the proportion of available habitat in the entire landscape ( $p_iL$ ). The analysis of 340 spatial locations showed a marked preference for the *Cisto-Lavanduleitalia* dune sclerophyllous scrubs (EU code 2260) and a seasonal selection of *Juniperus macrocarpa* bushes (EU code 2250), wooded dunes with *Pinus* (EU code 2270) and mosaic of dune grasslands and sclerophyllous scrubs (EU codes 2230, 2240, 2260). Seasonal variation of habitat preference was interpreted in light of the different feeding, thermoregulation and reproductive needs of the tortoises. Our results stress the ecological value of EU coastal dune habitats and suggest prioritization of conservation efforts in these ecosystems.

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## 1. Introduction

Coastal dunes represent extremely interesting environments both from an ecological and a landscape perspective [1], but at the same time, they are among the most fragile and threatened ecosystems worldwide [2]. Coastal ecosystems are particularly vulnerable to climate variability and to coastal erosion, and in recent years, they have undergone consistent transformations due to urban expansion, agricultural and afforestation spread, and industrial and harbour development [3]. The degradation and loss of the littoral landscape has

concerned all coastal countries of the European Union and is particularly striking in the Mediterranean [4]. For this reason, sandy coastal vegetation types are of most concern among EU directive habitats [5], and most of the sand dune coastal fauna is included as threatened or endangered in the IUCN Red List [6]. Some of these endangered species could act as flagship species, driving public awareness on conservation issues of the coastal dunes. Among these, the tortoises (family *Testudinidae*) are the best candidates for coastal dune conservation, as they are charismatic and appealing to the target audience (e.g., EU Life Projects), are often endemic [7], and symbolize the uniqueness of the coastal dunes to foster a sense of local pride [8].

Specifically, we focused on the Hermann's tortoise *T. hermanni* (Gmelin 1789), endemic to the northern

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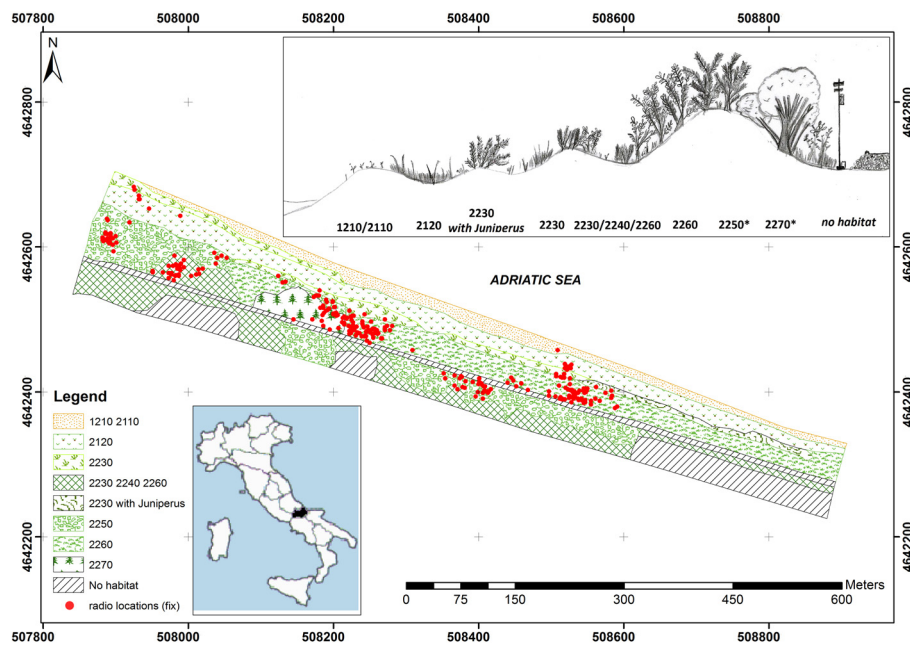


Fig. 1. (Color online.) Detailed vegetation map of the study area and radiolocations. The profile diagram indicates the sequence along the sea inland gradient of the mapped EU habitats. For codes, see Table 1.

coastal Mediterranean region, and the only indigenous species of Testudinidae found in Italy. The subspecies *T. hermanni hermanni* is listed as endangered in the IUCN Red Data Book [6] and is threatened by the degradation and destruction of its habitat, especially in coastal areas [7,9]. This species is strictly protected by the Bern Convention and the European Habitat Directive (92/43 EEC, Annex II, IV), while the international trade of the species is regulated by the Washington Convention (CITES, App. II, C1). It is common in coastal areas of western central Italy; it is less common in the eastern coast and hilly landscapes [7].

The Hermann's tortoise occurs in Italy with two subspecies: *T. h. boettgeri*, mostly found along the northern Adriatic coast, and *T. h. hermanni*, prevailing along the Tyrrhenian coast. Hermann's tortoises are located in the xeric areas of the Mediterranean region, characterized by thermo- and meso-Mediterranean climate [9], mainly in the littoral pinewoods, coastal dunes, Mediterranean scrub, and garrigues [10–13]. Most studies regarding the eco-ethology of *T. hermanni* have been conducted in Spain, southern France [14,15], Greece [16,17], and Italy [18,19].

The habitat preferences of this species have been investigated in a variety of habitats, from coastal dunes [8,20,21] to rural landscapes [22], while habitat preference studies taking into account the seasonal utilization of the different vegetation types are still necessary [23].

In this study, we explored if, how, and when the EU coastal dune habitats (*sensu* Habitats Directive 92/43/CEE) are used by Hermann's tortoises in a well-preserved coastal dune system of the Italian peninsula. Radio telemetry data and fine-scale vegetation habitat mapping were used to address the following questions:

- is each EU habitat used differentially by Hermann's tortoises?
- is there any seasonal variation in this utilization pattern?
- how does each habitat contribute to the ecological requirements of the tortoises?

We assumed that the utilization by tortoises of the EU habitat dune mosaic is not homogeneous, but varies through space and time. By linking the EU coastal habitats to the survival of the flagship Hermann's tortoise, we contribute to the prioritization of the conservation in this fragile and highly vulnerable ecosystem.

## 2. Method

### 2.1. Study area

The study area is part of the eastern coast of southern Italy (Molise region, Fig. 1). The Molise coast stretches for 30 km along the Adriatic Sea and is mainly composed of sandy beaches. Recent dunes (Holocene) occupy a narrow strip along the seashore. They are not very high (less than 10 m high) and are relatively simple in structure (usually only one dune ridge) [24]. In the dune profile, abiotic conditions vary greatly, moving along the sea inland gradient. Under natural conditions, the vegetation zonation follows this ecological gradient, ranging from pioneer annual communities on the beach to Mediterranean macchia on the landward fixed dunes [24–26]. The Mediterranean macchia can be considered the most mature vegetation type on fixed dunes. The climate of the area is typically Mediterranean, with dry summers, mild and rainy winters, and frequent precipitation

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