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Testudo hermanni hermanni in the Albera Mountains, Catalonia, northern Iberian Peninsula

The critical situation facing many species of tortoises worldwide has made the intervention of man essential to halt their decline and prevent extinction. The case of Hermann's Tortoise, specifically the western subspecies *Testudo hermanni hermanni*, is a good example. Its range has declined alarmingly in the last century due to human activity, and now we have only the remnants of a former population once continuously distributed along the north-western shores of the Mediterranean Sea.

The catastrophic population decline suffered by the species and the threat of local extinction has required the creation of several conservation centres within their dwindling range, where projects have been initiated to restore populations now extinct in adjacent areas. These include the *Village des Tortues SOPTOM*, in Provence (France), the *CARAPAX Centre* (currently inactive; effective December 2012) in Tuscany (Italy), *CRARC* in Catalonia (focusing on two reintroduced populations), and the *Albera Tortoise Breeding Centre* (*C.R.T.*), also in Catalonia.

In the case of the *C.R.T. Albera*, its basic function is the captive breeding of this species, in order to reinforce to the population in the Albera Mountains (eastern Pyrenees), the only site in the Iberian Peninsula where the species has survived naturally to this day. Other objectives are to provide environmental education, and the restoration of populations of the European Pond Turtle *Emys orbicularis* and the Mediterranean Pond Turtle *Mauremys leprosa*; studying the ecology and biology of these species can influence measures to better conserve their habitats. *C.R.T. Albera* works in close collaboration with the regional government of Catalonia.

Fig. 1. *Testudo h. hermanni* in the Albera. Photo: X. Capalleras

Fig. 2. Zone of transition between shrubbery with cork oaks and sunny, stony clearing. Photo: X. Capalleras

Ecology and Biology

In north-eastern Catalonia, specifically in the Albera range, the last natural population of Hermann's Tortoise *Testudo h. hermanni* of the entire Iberian Peninsula occupies an area close to the 20,000 ha. Because of the critical situation most of the range occupied by this population enjoys protection as a *Natural Site of National Interest* (1986) and *Natura 2000 Network* (2006).

However, this retreat has suffered a major decline, which suggests that conservation measures are inadequate, requiring a greater involvement by government and local groups.

The Hermann's Tortoise in the Albera (Fig. 1) occupies a precise niche involving several important elements such as topography, the availability of sun-exposed areas and those appropriate for hibernation and egg-laying; vegetation as food and shelter; and presence and prevalence of predatory carnivores. All of these form a complex that has been evolving over time (Figs. 2-6).

Predators and competitors have undergone significant changes, as large wild herbivores have given way to domestic cattle, and whereas large carnivores and predators have disappeared, increasing numbers of equally predatory species such as the fox, beech marten and wild boar continue to impact the tortoise population negatively. Man is the main catalyst deciding the future of the species, through his transformation of the landscape for grazing, agriculture, and due to forest fires.

At present the estimated maximum densities in certain sectors amount to 2.5 individuals per hectare, while in the whole territory occupied by the species in the Albera, the average density would be less than 0.5 individuals/ha (Budó *et al*. 2002, Bertolero 2010, Bertolero *et al*. 2011). The current low population density indicates near extinction according to experts (Cheylan 2001, Budó *et al*. 2004). This is an aging population nearly without recruitment, and unfortunately fragmented by various anthropogenic actions in recent decades, some of them promoted by the same authorities who have pledged to protect the species.

The life cycle of the tortoise can be divided into five phases (Cheylan 1981) closely linked to environmental condi-

tions: the awakening from hibernation (March/April), spring (May/June), summer (July/August), autumn (September and October) and hibernation (November to February). The climate in the Albera during March and April is changeable and is not conducive to continuous surface activity. Thermoregulation occupies much of the tortoises' earliest weeks out of hibernation. In the second half of March, 60-75% of the tortoises may be observed during the warmest hours of the day. In April, when the temperatures reach 18 °C, all tortoises have emerged from hibernation, and mating begins. The males spend more time actively searching for or pursuing females, and most mating behaviour occurs during this month (Soler Massana & Martínez Silvestre 2005). However, periods of bad weather, including frosts, are still common into April, although day length and the average number of sunlit hours increase gradually. It is not surprising that tortoises ignore food during the first eight or ten days following hibernation. Only after this period, and when their metabolism is stimulated by solar heat, do they become more active and search for food.

In the spring, tortoise's activity is more regular due to more stable weather. During this time there is an abundance of food, which is why most specimens spend much of the day feeding or searching for food. They also may wander in search of a mate but are always obliged to thermoregulate carefully during all daylight hours (Cheylan 1981). The longest periods of activity take place during the month of May, during which nesting may also begin

Fig. 3. Slope with cork oak, shrubs and herbs. Photo: X. Capalleras

Fig. 4. Overview of a favorable biotope for *Testudo h. hermanni* in the Albera. Photo: X. Capalleras

Fig. 5. Meadow with food plants. Photo: X. CAPALLERAS

although some females are not ready to nest until June.

In summer, the increase in temperature at the end of the nesting period causes a marked decrease in activity. We can identify two peaks of daily activity: first, between 7:00 and 10:00 am (when temperatures begin to reach 20-25 °C) and the other between 15:00 and 17:00 hours. However, some animals are active until 20:00 (personal observation; HAILEY *et al*., 1984). After the end of June no more than a quarter of the tortoises remain active more or less daily. The high summer temperatures enable the tortoises to thermoregulate within their shelters – often in the shade of plants, preferably in dense brush, most of the time. Towards the end of August begins a new period of mating, usually quite intense.

In September, the first autumn rains cause a fall in temperature and tortoises respond by gradually reducing their activity. However courtship continues into the first weeks of autumn. At first they feed less, and eventually stop feeding

Fig. 6. Bushes for hiding. Photo: X. CAPALLERAS

altogether. Tortoises are active only during the hottest hours of the day, the first hours of activity being devoted to thermoregulation. In October the tortoises spend most of the time basking in the sun, and despite warm periods, their activity levels drop drastically.

With the arrival of cold, tortoises seek secure shelter where they remain dormant during the unfavourable weather from November to mid-March. Most specimens bury themselves either in the soil or under leaves, which act as insulation and will maintain a constant temperature (Huot-Daubremont *et al*. 1996).

Herman's tortoise is primarily herbivorous, consuming leaves, flowers and fruits of different species (composites, grass, legumes). They may occasionally eat carrion, and various invertebrates (annelids, arthropods, gastropods).

The study of the diet of the Western Hermann's Tortoise (*Testudo h. hermanni*), has been carried out in semi-captive conditions in France (Cheylan 1981, Guyot & Lescure 1994, Longepierre & Grenot 1999), and under natural conditions in Italy (Calzolai & Chelazzi 1991).

In Catalonia, the first work on the Hermann's Tortoise feeding under natural conditions was conducted in the *Albera Natural Area* (Budó *et al*. 2001). From 1984 to the present, the authors have been studying different aspects of the biology and ecology of this species in the Albera range, and whenever a tortoise was surprised while eating, a sample of the food item is taken for subsequent identification. To date, a total of 46 plant species belonging to 23 families have been identified, and it is noted whether the tortoise ate the leaves, flowers or fruit. The consumption of two species of mushrooms, as well as snails, dried cow dung and carrion were also documented (Budó & Mascort 2001, Budó *et al.* 2009). Among the reintroduced population of tortoises in the *Montsant Natural Park* (Tarragona, Catalonia), 47 plant species have been identified as food items (Soler *et al*. 2007, Munoz *et al*. 2009).

Threats to the survival of the wild population, regression factors

This species has a very particular demographic strategy characterized by low fertility, significant juvenile mortality, and extreme longevity (Cheylan 1981). Such demographics, not widespread in nature, correspond to Model "K" (MacArthur & Wilson 1967) in which the species compensates with significant longevity for a lengthy but low fertility and prolonged immaturity. From an adaptive point of view, this type of demographic strategy favours the species living in stable ecosystems, but is faced with disadvantaged colonizing ability. This makes it a sensitive species when obliged to adapt to any alteration or modification of habitat, resulting in the loss of living space and fragmentation of populations. Only with strict conservation measures we can continue to enjoy this singular species in the future. Here are the major threats to the tortoises' continued survival:

Changing landscape

During the seventeenth and eighteenth centuries the cultivation of the vine and the olive spread through all the valleys and slopes of the mountains, avoiding only the highest or most shady areas. This distribution coincides fully with the habitat of the tortoises. While this caused a great impact on the population, the subsequent massive abandonment of fields and pastures in less productive areas (on steep slopes and unproductive land) gave them another chance. The progressive rural depopulation over the centuries has allowed a partial recovery approaching the original distribution.

Fig. 7. Former tortoise biotope, cleared by heavy machinery for fire prevention. Here the tortoise population has been severely reduced. Photo X. Capalleras

Today human activity is the leading cause of negative impacts on the species. The opening of new forest roads and the paving of some of the existing ones allow human access to previously remote or closed areas, and increase the number of visitors. Touristic promotion of such places, with the opening of restaurants, picnic areas, etc. in sensitive areas for the Hermann's Tortoise leads to an increase in mortality from crushing on motor roads, and especially to the removal of specimens to be kept as pets.

The alteration of habitat caused by the clearing of undergrowth, to prevent forest fires, carried out with heavy machinery and without prior environmental impact evaluation (Fig. 7) terminates the lives of thousands of tortoises and leaves the habitat in unsuitable conditions for the species for several years. Similarly the patchwork creation of forest plantations, besides damaging the existing population, impedes the establishment of new ones (Cheylan 1984, Fèlix 1985, Llorente *et al.* 1995, Bertolero & Marín 2002, Budo & Capalleras 2006). Legal or illegal construction of vacation homes, domestic or feral dogs, and the indiscriminate use of agricultural pesticides and herbicides, pose other serious threats to the species (Willemsen & Hailey 2001). In short we can declare that increased human activity in tortoise habitat inexorably leads to a decline in the number of tortoises.

Trade

Since the 1960s and '70s, the commercial trade in tortoises as pets has posed a serious threat to their survival. Thousands of specimens were collected for the market until the Animal Protection Act, adopted by the Government of Catalonia in 1988, put an end to this situation. Being declared a protected species, gradually the awareness of the dramatic decrease of their populations has risen, and their capture has diminished. The impact of this trade was the trigger for all subsequent declines, leaving the population too weakened to overcome other serious assaults. Even today, some tortoises chanced upon by visitors to the core area still inhabited by them are taken as pets.

Forest fires

Large, sometimes serial forest fires in the Albera Mountains during the '70s and

'80s represented a serious setback for the species, whose loss of population density was very pronounced. Hermann's Tortoise, like other animals with little ability to move quickly, are among the species most affected in the event of a fire, unless the fire occurs at night or during aestivation periods when they are below the surface, when most are likely to survive. In general, however, the mortality from major fires in the Sierra was very high.

Data from three fires in these mountains:

- The fire of July 1986, the greatest one so far, hit the heartland of the Hermann's Tortoise range, burning some 15,000 hectares and causing a serious loss of the population. In one valley surveyed, with a former density of 10.95 specimens per hectare, 30.4% of the population was killed (Fèlix *et al.* 1990), even though the fire occurred at night. The mortality was particularly high among juveniles and adult females, because most males were inactive at that time. Such a reduction in those classes has further aggravated the challenges facing this population.

- In 2000, after a fire affecting a thousand hectares of a peripheral area of the population, 96 individuals (30 living and 66 dead) were found, interpreted as a mortality rate of 68.75% among a population density of only 0.096 individuals/ha (Franch *et al.* 2002a).

- After a small fire during August 2011 which burned 83 hectares, a total of 6 living and 53 deceased individuals were located (an estimated mortality of 89.83%). All surviving specimens were found in the burrows of badgers, foxes or rabbits. The ratio was 1:2.09 young: adults, and the sexual ratio 1 ♂ : 2.46 ♀. After the fire, the population density was determined to be somewhere between 0.60 - 0.71 individuals/ha (Vilardell-Bartino *et al.* 2011).

To prevent forest fires, the understory of the woodland has to be cleared from too much scrub and deadwood. In tortoise habitats, this should be done manually (Fig. 8), and in cooperation with the herpetologists and ornithologists.

Predation

In the Albera Mountains, tortoises naturally suffer heavy predation, especially to nests and upon juveniles. A large increase in predators in recent decades, coinciding

Fig. 8. Manual clearing of shrubs between the cork oaks. This creates favourable habitats for tortoises! Photo: X. Capalleras

with the declining tortoise population, has magnified the problem, making it one of the biggest obstacles to recovery, effectively cancelling recruitment (Vilardell *et al*. 2012).

In a study in the Sierra de Albera, the incidence of predation of tortoise nests was estimated at 53.7% (Budó *et al.* 2003). In 2005 a trial was conducted to evaluate the potential rate of predation on nests within the protected area. We distributed a total of 72 artificial nests (with quail eggs), of which 71 were found to be depredated (potential rate of predation 98.6%; Vilardell *et al*. 2008).

In recent years several studies have been performed in order to identify the true predators of tortoises and their clutches. Using photo traps we evaluated the effectiveness of chemical repellents to control nest predation and have tested the results of creating new nesting areas as an indirect method of curbing predation. After studying photographs, it was determined that the main predator of tortoises and nests were the beech marten (*Martes foina*), the badger (*Meles meles*), the wild boar (*Sus scrofa*), and foxes (*Vulpes vulpes*) (Vilardell *et al*. 2009). In 2006 a project was undertaken to evaluate the efficacy of two commercial chemical repellents, the goal being the reduction of nest predation (Vilardell *et al*. 2008). Of these products, one was proven to be effective against specific mustelids and the second for the wild boar. The effectiveness of these applications was tested by distributing 200 artificial nests in 8 plots occupying a surface of 625m^2, in an area of high nest concentration (Vilardell *et al*. 2008). Repellent products were applied to four of the eight plots, the others representing controls. In both cases the rate of predation was close to 100% in just four days; such a level of predation was alarming, showing a very low effectiveness of repellent products.

The creation of new nesting areas could be a strategy to reduce predation because it increases the dispersion of the egg clutches (Fig. 9). In early June 2009 a study funded by the AGAUR (ACOM 2009) was undertaken, in which we tested the hypothesis that if we increase the dispersion of nests, we will be able to reduce current levels of predation. The study was conducted in 3 areas within the Albera protected area, characterized by a high concentration of nests. The series of tests conducted are intended to evaluate the effectiveness of controlling predation by creating 27 new nesting plots of 4.25 and 100 m^2. In an initial test, 486 artificial nests were set in 36 plots (9 of which were controls). The predation was very high at first, so we decided to reduce the number of artificial nests per plot intending to reduce sources of scent. Despite this change, further predation did not differ significantly from previous tests. Predatory species observed were the beech marten (*Martes foina*), wild boar (*Sus scrofa*) and foxes (*Vulpes vulpes*). This study showed the ability of predators to memorize nest locations, a very important factor to consider in designing any strategy to control predation of Hermann's Tortoise nests (Vilardell *et al*. 2012).

In light of this research, Madec (1996) offered a cluster of proposals to significantly reduce nest predation, but although it was possible to alter the current pattern of nest concentration in selected areas, predator density and pressure are so great in the Albera that the rate of predation remains high.

Non-native species

The presence of exotic and potentially invasive vertebrate fauna is a growing problem in Spain (Orueta 2007). In the

Fig. 9.
Newly created possible egg-laying site for the tortoises. Photo: X. Capalleras

case of reptiles, the literature focuses mainly on the freshwater terrapins from North America, of the families Emydidae and Chelydridae (Pleguezuelos 2002, Martínez-Silvestre *et al*. 2001, 2003, Arribas 2008), probably due to the enormous commercial pressure to which they have been subjected in the past 30 years. Consequently, species of these families are the major ones released into our natural ecosystems. Copious data on the reproduction of these allochthonous species exist (Martinez-Silvestre *et al*. 1997, De Roa & Roig 1998, Capalleras & Carretero 2000), and on their colonization of Spanish aquatic ecosystems (Martínez Silvestre *et al*. 2003, 2006, Perez-Santigosa *et al*. 2008; Figs. 10, 11). Consequently, the scientific community has recognized invasive chelonians to be the American freshwater turtles of the genus *Trachemys*, and possibly of other genera. Besides often being superior competitors of the native turtles (Polo-Cavia *et al*. 2012, Cadi & Joly 2004) these invasive turtles may harbour diseases which they transmit to the indigenous fauna (see for example Verneau *et al.* 2011). In 2011 the government adopted the *Spanish Royal Decree 1628/2011* of 14 November which regulates the Spanish catalogue and list of invasive alien species, prohibiting the possession, transport and trade of the main species of the genus *Trachemys*, among others. However, with regard to terrestrial chelonians, no such analysis or legal action has been carried out, probably because these species are less conspicuous and are difficult to locate in habitats where introduced and occurring in low density (Mateo *et al.* 2011).

The study by Soler *et al.* (2010) shows the expansion of exotic terrestrial chelonian species into north-eastern Iberia (Fig.12) , which are well adapted to the Mediterranean climate, being able to hibernate and reproduce under these conditions (Martinez-Silvestre *et al*. 2001). These released tortoise pets may be introducing potentially disastrous diseases into the native tortoise populations (Martel *et al*. 2009), an additional problem to that of the ongoing spread of exotic species.

Conservation

Law 3/1988 of March 4, animal protection, approved by the *Government of*

Fig. 10. *Trachemys scripta elegans* in the nature reserve *Aiguamolls de l'Empordà* . Photo: C. Pfau

Catalonia, includes Hermann's Tortoise in Appendix 2, declaring it to be a protected species in Catalonia. This statute prohibits the capture, possession, trafficking, trade, sale, importation, exportation, and public display of both the adults and eggs of protected species and their young, and of all subspecies and lower taxa, regardless of their origin.

Royal Decree 1997/1995 of 7 December promotes measures to ensure biodiversity by conserving natural wildlife habitats, and *Royal Decree 1193/1998* of 12 June, which modifies the above, includes Hermann's Tortoise in Annex II as a species of community interest whose conservation requires the designation of *Special Areas of Conservation*. The species is also included in Annex IV as a species of community interest requiring strict protection.

In 2011, the Spanish government granted the Albera population of Hermann's Tortoise the status of nationally endangered species.

Fig. 11. Abandoned *Trachemys scripta elegans* in the *Remolar* reserve of the Delta de Llobregat. Photo: B. Pfau

The *C.R.T.*

The *Albera Tortoise Breeding Centre* (*C.R.T. Albera*), functioning since 1994, includes facilities for the captive breeding of Hermann's Tortoise whose population distribution on the Iberian mainland is restricted to the Albera Mountains. The *C.R.T.* is located on the grounds of the Sanctuary del Camp (Fig. 13) in Garriguella, Alt Empordà. These lands were granted by the Bishop of Girona to the *Association of Friends of the Albera Tortoises* (*ATA*), which manages the Centre as part of the Hermann's Tortoise Recovery Program in Catalonia, as designed by the Ministry of Environment of the Catalan Government, in collaboration with the *Albera Natural Park of National Interest*.

A classroom-museum and information centre (with explanatory graphics on the origin, evolution, problems, biology and conservation of the Hermann's Tortoise in this region) provide educational functions, attracting school groups as well as individual visitors.

Currently the centre has about 140 adult breeding Hermann's Tortoises, all of them originally from the surrounding Albera range, so as to maintain this ecotype (Fig.14). Its natural habitat is duplicated insofar as is possible to include vegetation and land features close to those in the wild.

Fig. 12. Very large *Testudo graeca ibera* which had been found within a biotope of *Testudo h. hermanni* in the Albera. Photo: B. Pfau

In addition, the centre also has a breeding area for the European Pond Turtle (*Emys orbicularis*; Fig. 15), a species widely distributed in Europe, western Asia, and North Africa, but currently facing range-wide population decline.

Finally, there is room for holding tortoises and turtles obtained by donation or from confiscation (Figs. 16, 17), and for the exhibition of exotic species (Figs. 18, 19) , mainly from elsewhere in the Mediterranean basin. If the animals are in good condition and the possibility of repatriation is solid, these chelonians are sent back to their places of origin. Otherwise they remain at the centre for educational purposes.

Fig. 13.
View of the *Santuari del Camp*, where the *C.R.T.* is located. Photo: X. Capalleras

Reproduction and reintroduction of Hermann's Tortoise

The *C.R.T. Albera* facility has established an intensive breeding program (Capalleras *et al*. 2010; Figs. 20, 21) to ensure the survival of most specimens hatched, resulting in an accelerated increase of the total population so as to reinforce the remaining, dwindling natural population. About 350 tortoises each year are hatched at *C.R.T. Albera* (484 young in 2011; Figs. 22, 23). Captive-bred juveniles are released in selected areas to support the existing population. The selection criteria for the areas of release are: (1) suitable habitat, (2) low tortoise density, (3) difficult access and low human frequency, and (4) inclusion within the *Natura 2000* net.

Until two years ago, specimens born at the centre were released during the second year, coinciding with the awakening from hibernation in spring (Franch *et al.* 2002b; Fig. 24). However, high losses among the released juveniles have been noted

Fig. 14. *Testudo h. hermanni*, showing the typical black markings of the Albera ecotype. Photo: X. Capalleras

Fig. 15. *Emys orbicularis* in the breeding enclosure in the *C.R.T.* Photo: J. Wiechert

Fig. 16. *Trachemys scripta scripta* basking atop of *Pseudemys concinna concinna* in the exotic turtle pond of the *C.R.T.* Photo: C. Pfau

Fig. 17. *Mauremys sinensis* in the *C.R.T.* Photo: B. Pfau

Fig. 18. *Centrochelys sulcata* in the *C.R.T.* Photo: C. Pfau

Fig. 19. North-African *Testudo graeca* in the *C.R.T.* Photo: C. Pfau

in recent years due to predation by foxes (*Vulpes vulpes*), beech marten (*Martes foina*), genet (*Genetta genetta*), wild boar (*Sus scrofa*), badger (*Meles meles*), feral dogs (*Canis lupus familiaris*), and even wood mice (*Apodemus sylvaticus*) (Vilardell *et al.* 2009). While the goal remains to boost the currently low density of tortoises in the Albera, improvements are essential so as to boost the survival of the released juveniles (Bertolero *et al*. 2007).

In 2008 a pilot project was started, consisting of 30 young kept in conditions of continuous growth in indoor terraria, without a period of winter dormancy, were compared with another 30 kept under natural conditions (including hibernation). Individual growth was checked periodically, revealing that individuals maintained under conditions of continuous growth attained significantly larger sizes than those which hibernated. Living under conditions of continuous growth led to having yearlings which had attained the dimensions of 4 year-old tortoises raised under natural conditions (Stubbs & Swingland 1985, Capalleras

et al. 2010). These larger tortoises should be protected by their size against the attacks of many predators (García *et al*. 2003).

To test whether these head-started juveniles are in fact better protected against predation, we selected 30 animals from this group: These were at least 2 years old, had carapace lengths of 8-10 cm, weights of ca. 100 g and a well calcified carapace. For the test they were equipped with radio transmitters and released (Fig. 25). The results of this experiment will show whether head-starting is an efficient measure to avoid too heavy predation in the released tortoises.

Since the breeding facilities in the *C.R.T.* are limited and preclude rising a large number of Herman's tortoises for many years, the tortoises have to be raised more quickly than with natural growth rates (see also Lapid *et al*. 2004), in order to be released with a sufficient size that most of them could survive predator attacks. We know that this may take effect on their health status (Ritz

Fig. 20. Nesting site for Hermann's Tortoise in the *C.R.T.*: Protection against nest predators, especially magpies. Photo: X. Capalleras

Fig. 21. Hermann's Tortoise nesting in the *C.R.T.* Photo: X. Capalleras

Fig. 22. Incubator for tortoise eggs. Photo: X. CAPALLERAS

Research Projects on tortoises

Currently the *C.R.T.* has launched several projects, one being the management of a Hermann's Tortoise population affected by a newly constructed railway line. After completion of the actual infrastructure and careful environmental restoration, we began reintroducing young tortoises to restore the former population. Some of these animals are followed by radio tracking.

In 2011 we launched a project funded by the Biodiversity Foundation to prepare a manual of advised practices on behalf of the habitat of the Hermann's Tortoise, intended especially for private landowners located within the Albera distribution of the Hermann's Tortoise.

At the same time, a census employing specially trained dogs (see also CABLK & HEATON 2006) will be carried out on the tortoise population of a particular valley, in which a population

2012), so we are working on optimizing the raising conditions to minimize that adverse effect (Fig. 26).

Fig. 23. Terraria for temporary housing of the young tortoises. Photo: X. CAPALLERAS

Fig. 24. JOAN BUDÒ in an outdoor raising and acclimatisation enclosure for Hermann's Tortoises before release. Photo: X. CAPALLERAS

survey had been carried out previously, between 1997 and 2002 (MASCORT 1998a, BUDÓ *et al.* 2004). With this project we will try to optimize population survey methods for the Albera tortoises (STUBBS *et al*. 1984).

Environmental Education

The *C.R.T.* carries out educational functions in reference to:

- All formally enrolled students of primary, secondary, and vocational school, and at the university level (Fig. 27).
- Groups and associations seeking our services, guidance, or promotion.
- Other private entities or non-profit groups requesting participation in and collaboration with organizations like ours.

Activities carried out include:

- Guided tours of the installations of the *Albera Tortoise Breeding Centre*;
- Tours to various parts of the *Albera Nature Park* (Figs. 29, 30);

Fig. 26. XAVIER CAPALLERAS feeding juvenile tortoises in the *C.R.T.* educational area. Photo: B. PFAU

25: *Testudo h. hermanni* juveniles fitted with radio transmitters. Photo: X. Capalleras

- Workshops, lectures, conferences and audiovisual presentations;
- Publication of educational material (videos, DVDs, books, press releases, posters);
- Formal agreements with universities for the training of students.

Breeding and reintroduction of the European Pond Turtle and the Mediterranean Pond Turtle

Two species of aquatic turtles inhabit some of the rivers, streams and wetlands of Catalonia. The more abundant one, nonetheless quite rare, is the Mediterranean Pond Turtle *Mauremys leprosa* (Fig. 31). The second species, the European Pond Turtle, *Emys orbicularis*, is even less widespread nowadays. Both species may attain a total carapace length of 20 centimetres, and both are dependent on unpolluted aquatic habitats, where they feed mainly on fish, amphibians, insects and vegetation.

The Mediterranean Pond Turtle *Mauremys leprosa* occurs in North Africa and the Iberian Peninsula, and finds its northernmost limit of distribution in the Albera range, at the border to France (Fraysse 2002). In Catalonia it is present in some streams of the Empordà and La Selva, in parts of central Catalonia, and in lagoons and canals of the Ebro Delta as well as in some of its upstream tributaries. Smaller populations of the European Pond Turtle are found in the districts of Alt Empordà, Baix Empordà, La Selva, Tarragonés, and at the Ebro Delta.

Mauremys leprosa tolerates brackish water or mildly polluted water bodies, and is adapted to the flood-drought cycle of Mediterranean rivers, including seasonal inactivity due to low winter temperatures, and because of low water or even absolute desiccation. The Mediterranean Pond Turtle still has some good densities in the Empordà, but elsewhere in Catalonia has been adversely affected by habitat destruction and the channelling of riverbeds (Bertolero & Oro 2009).

The situation of the few remaining European Pond Turtle populations in Catalonia is alarming (Mascort 1998b). Only isolated specimens or very small groups remain. In the last fifty years, the pollution of inland waters, coastal development, the establishment of exotic

Fig. 27. School children observing the tortoises in the *C.R.T.* Photo: X. Capalleras

Fig. 28. Overview of a tortoise biotope in the Albera. Photo: X. CAPALLERAS

Fig. 29. Garrigue in bloom. Photo: X. CAPALLERAS

aquatic turtle species, and even traditional hook-and-line recreational fishing have brought this species to the brink of extinction, both in Catalonia and in many other parts of Europe.

The *C.R.T. Albera* participated in the *LIFE* project 2005-2008: "Recovery of the habitat of *Emys orbicularis* and amphibians in the wetlands of the Lower Ter" (www.lifeemyster.com; Fig. 32). Another project, started in 2010 with a duration of 4 years, is the participation in the project "Improvement of habitats and species of the Natura 2000 network in Banyoles" (*LIFE NAT/E/000078*) for the recovery of the European Pond Turtle (*Emys orbicularis*). In this project, the *C.R.T.* is responsible for breeding, reintroducing and monitoring the European Pond Turtle population at the Banyoles lake (www.consorcidelestany.org; Figs. 33-35). Certainly it is not enough to release turtles in a seemingly appropriate habitat as in the ponds besides the Banyoles lake. Especially freshwater biotopes in areas which are accessible to visitors must be monitored continuously for released pet turtles, which might carry diseases or compete for resources with

Fig. 30. *Mauremys leprosa*. Photo: X. Capalleras

the reintroduced turtles, or which, even worse, could be of the same species but of a non-native genotype, and thus corrupt the genetic integrity of the reintroduced population. Therefore it is necessary to set up traps during the whole summer season, and to control them at regular intervals. At the Banyoles lake basking traps are used and several exotic turtles have been caught there, mainly *Trachemys* spp. and *Pseudemys* spp., but also an *Emys orbicularis* of the "polish" genotype had been found and removed.

Visiting the *C.R.T.* and the Albera range

Visitors are welcome in the centre during the opening hours which can be checked on the internet page www.tortugues.cat. On hot summer days it is advisable to come early in the day or after the hours of maximum heat, when the tortoises are active. The centre is signposted in the village which you will leave to the north on a very small road. The parking lots are near the street and you will have to walk about five minutes

Fig. 31. *Emys orbicularis* ready for reintroduction at the Banyoles lake. Photo: B. Pfau

Fig. 32.
Emys orbicularis with transmitters. Photo: X. CAPALLERAS

from there to the entrance of the monastery and the centre.

After registration the visitors usually go directly out on the boardwalk to see the animals. For obvious reasons is not allowed to take large bags with you when visiting the enclosures, the luggage can be left at the counter. Most of the walk is constructed as a boardwalk (Fig. 36) so that the tortoises can pass underneath, and the visitors will not be able to touch the animals.

The promenade starts at the large enclosure for the breeding group of the Albera form of *Testudo h. hermanni*. Sometimes you will have to watch for a while to see the tortoises (Fig. 37), since the site is well planted to give a good impression of the habitat. The most important plants are labelled and there are information panels with explanations in Catalan, French and English (Fig. 38). In the lower part of the site there are the enclosures for the other turtles and tortoises. These enclosures are not as spacious (Fig. 39), because the animals are kept for educational purposes and they should not be able to hide from view. Nevertheless turtle and tortoise keepers can get quite some hints for their private enclosures when looking at the installations (Fig. 40).

You will always find a competent discussion partner in the *C.R.T.*, but since there are often groups or school classes visiting the centre it is advisable to call or mail well in advance to make a date for talking (Fig. 41).

If you want to see truly "wild" freshwater turtles, you can visit the nature reserve *Aiguamolls de l'Empordà* which you can reach by a car drive of about half an hour from Garriguella. This park is famous for bird watching, but you can also be lucky and see *Emys orbicularis* and *Mauremys leprosa* there (Fig. 42). There are also some creeks and rivers near the centre where you can watch *Mauremys leprosa* and, of course, *Trachemys scripta elegans*.

It is not easy to find truly "wild" *Testudo h. hermanni*, and the people in the region know that their indigenous tortoises are a treasure and that they have to safeguard them. To avoid misunderstandings it is best not to go out to search for them.

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Fig. 34.
Emys orbicularis reintroduction at the Banyoles lake. Photo: X. CAPALLERAS

Fig. 35.
Turtle trap at the Banyoles lake. Photo: B. PFAU

help with the Text for the English edition of the RADIATA.

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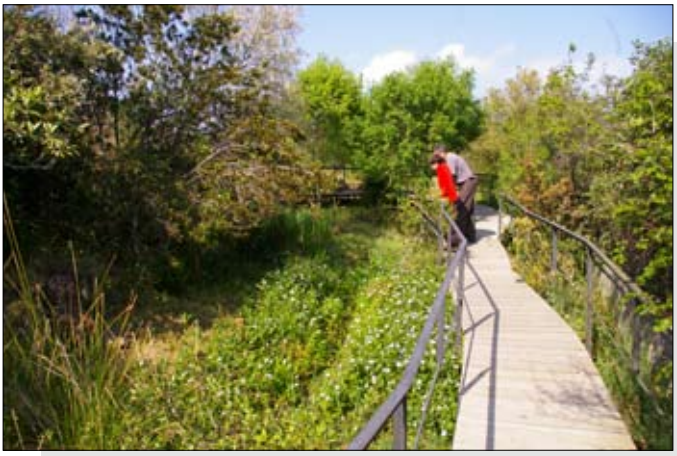

Fig. 36.
The boardwalk over the *Testudo h. hermanni* enclosure at the *C.R.T.* Photo: X. Capalleras

Fig. 37.
Hermann's Tortoise female with fire scars, hiding between the plants of the enclosure.
Photo: C. Pfau

Fig. 38. Information panel in the *C.R.T.* Photo: B. PFAU

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Fig. 39. Pond for North American turtles at the *C.R.T.* Photo: X. CAPALLERAS

Fig. 40.
Planted barrel filter at the *C.R.T.* pond.
Photo: B. Pfau

Fig. 41.
Discussion with the *C.R.T.* team.
Photo: J. Wiechert

Fig. 42.
Emys orbicularis and *Mauremys leprosa* basking on the same log in the *Aiguamolls de l'Empordà* nature reserve.
Photo. C. Pfau

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