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First Record of Introduced Eastern Mediterranean Tortoises, *Testudo hermanni boettgeri*, in Southern France

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Hermann's tortoise (*Testudo hermanni*), from Mediterranean Europe, has a highly fragmented distribution in the western part of its range, in France, Spain, and Italy (Cheylan, 1981). Two subspecies are recognized and can be identified by external features (e.g., comparison of interpectoral and interfemoral seam lengths, or plastral coloration [Bour, 1986]). The western subspecies (*T. h. hermanni*) is considered "nearly threatened" (IUCN, 1996) and conservation programs have been initiated in various parts of its range (Ballasina, 1995; Cheylan, 1995; Massana, 1995; Stubbs, 1995), but only a few demographic studies (Stubbs and Swingland, 1985; Stubbs et al., 1991; Guyot, 1997a) and management recommendations (Guyot and Clobert, 1997) are available.

Genetic data are not yet available to differentiate between the two recognized subspecies, *T. h. hermanni* and *T. h. boettgeri*, and morphology and coloration may in fact be more sensitive criteria for subspecies characterization than either mitochondrial or nuclear DNA sequencing, at least within the current limitations of the technology. For example, the two giant tortoise forms on southern Isabela in the Galapagos Islands, *Geochelone nigra vicina* and *G. n. guntheri*, are visually easily distinguishable as adults although this has not been demonstrated by genetic evaluation using either technique (Louis, 1997; Powell and Caccone, 1999).

In the case of *T. hermanni*, the natural ranges of the two subspecies are allopatric, and the two are easily distinguished, even under field conditions, by criteria described by Bour (1986) and Guyot and Devaux (1997). The latter authors cited data that demonstrated the essential homogeneity of the Spanish and French mainland populations, and some evidence that the insular (Corsican) population was so variable as to have possibly been derived from multiple human introductions from different sources (R. Bour, *pers. comm.* to Guyot and Devaux). Workers with field experience in southeastern France who have seen numerous *T. h. hermanni* in the wild and numerous *T. h. boettgeri* in the pet trade quickly develop an ability to differentiate essentially 100% of individuals even without taking confirmatory measurements. *Testudo h. hermanni* is easily identified, apart from its generally smaller adult size, by the following criteria:

a) Color. The background coloration of live individuals is orange-yellow, whereas *T. h. boettgeri* is greenish-yellow.

b) Form and intensity of the plastral figure. This is intensely black and forms two thick, longitudinal bands, sometimes posteriorly connected, in *T. h. hermanni*, whereas in *T. h. boettgeri*, the plastral figure, although very variable, is reduced to a series of gray-black blotches, much reduced in both intensity and extent from the condition in *T. h. hermanni*.

c) A difference especially evident in adult males is the posterior broadening and shortening of the carapace and plastron in *T. h. boettgeri*. This has the effect of reducing the interfemoral seam to a length less than that of the interpectoral seam (IP/IF ratio averages 1.65 in Spanish samples, 1.58 in France, 0.75 for Greece). For our field identifications in France, we recorded which of these seams was the longer, but did not take actual measurements because the latter were frequently rendered ambiguous by the corresponding seams between sequential scutes meeting the midline at slightly different points.

Methods. — We searched for tortoises at Les Mayons, southern France, a site to which tortoises had previously been relocated. The study site was approximately 35–40 ha in area. Surveys occupied several days per month between May and October 1995, and population estimates were made by the capture-recapture method. Animals captured were individually marked by filing notches in the marginal scutes (method of Stubbs et al., 1984), measured, and sexed when possible. Locations were plotted to within 10 m. We estimated the age of young animals by counting annual growth annuli on the dorsal scutes. Adults were classified into three categories when the number of growth annuli was unclear (Castanet, 1994). The categories were based upon the degree of wear of growth annuli (see Guyot, 1997a, for details).

Results and Discussion. — Thirty-five tortoises were captured and identified as native *T. h. hermanni* (relatively high IF/IP seam ratio, yellow-orange tint and continuous streaks of intense black pigmentation on the plastron). But 7 other animals (Table 1) had different IF/IP ratio (all had IF ≤ IP), less intense and interrupted black pigmentation on the plastron, and pale yellow overall tint. They were referable to the eastern subspecies, *T. h. boettgeri*, or possibly intergrades between the two subspecies. They included an old female and 6 young tortoises (age 4–7 years). The female had a relatively very deep carapace, although one apparent *T. h. hermanni* in our series had about the same proportions, and carapace height was greater than in 377 females recorded at another shrubland site at la Pardiguière, France (Guyot, 1997a).

The presence of an adult female and immatures of various ages of *T. h. boettgeri* suggests introduction and establishment of this non-native subspecies in the area. The presence of the female and immatures not far from a vineyard

Table 1. Characteristics of *T. h. boettgeri* recorded. Sex: female (F) or indeterminate (I), SCL: straight carapace length, Age: growth rings totally worn (old) or number of growth annuli present, Ventral scutes: comparison of interpectoral (p) an interfemoral (f) seams. SCL, width, and height in mm, weight in g.

Indiv.	Sex	Date of Capture	Ventral scutes	SCL	Weight	Width	Height	Age
400	F	16 Jun 95	p>f	188	1300	134	89	old
400	F	5 Jul 95	p>f					
615	F	7 Aug 95	p>f	103	250	81	53	6
532	I	8 Jun 95	p>f	115	360	92	58	7
534	I	8 Jun 95	p>f	95	200	74	48	4
700	I	21 Sep 95	p>f	71	100	64	39	4
701	I	21 Sep 95	p>f	68	80	60	37	5
702	I	21 Sep 95	p>f	86	170	70	47	4

where good nesting places were available suggest that reproduction of *T. h. boettgeri* might have occurred (Fig. 1). The real population size could not be estimated because of low recapture data and ambiguity as to whether intergrades were present. But as our search effort was low and capture rates of immatures may have been as low as values obtained in another shrubland site for *T. h. hermanni* (< 10% to 60%; Guyot, 1997a), we may have missed many tortoises.

The origin of the parental stock is unknown. These tortoises could not be derived from experimental reintroductions that had occurred nearby in 1995 (native immatures) and in 1991 (native adults) because all these tortoises were individually and permanently marked. They could either be the results of escapes from the first breeding colony of SOPTOM located nearby 10 years earlier (before relocating to Gonfaron), or from deliberate releases by pet owners or breeders. Genetic pollution of some Italian populations of Hermann's tortoises has been recorded, and traced to an introduction of *T. h. boettgeri* in Italy (Frisenda and Ballasina, 1990) but no such observations have been documented in France.

Deliberate eradication of the introduced *T. h. boettgeri* and the apparent intergrades seems the best solution to protect the genetic integrity of French *T. h. hermanni*. But such an operation might not be practical because no genetic tags are available to discriminate native animals from intergrades. Furthermore, the unknown number of animals released, the parameters of their dispersal, the dates of release, the numbers of offspring produced, and the low capture rates might all lead to an underestimation of the real population size and the area concerned. It could induce a false sense of security after a short eradication campaign. Long-term monitoring and genetic analyses should be undertaken first.

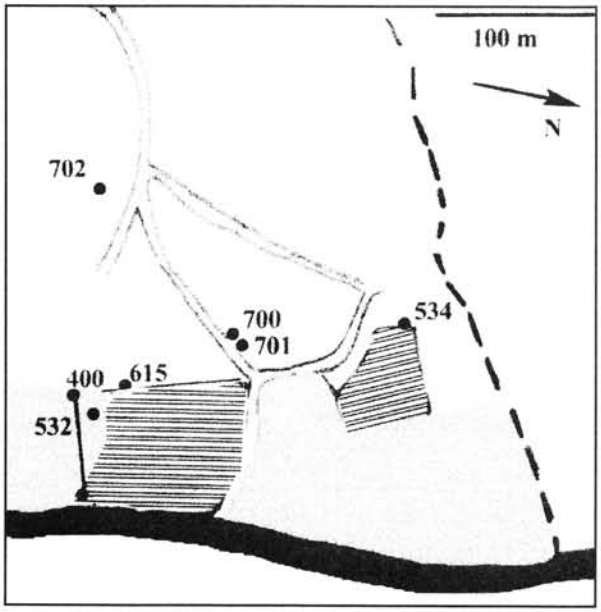

Figure 1. Locations of individual *T. h. boettgeri*. Shaded areas = abandoned cultivation; striped areas = vineyards.

In recent years, a number of hobbyists and reptile breeders in France have cross-bred the two subspecies of *T. hermanni,* producing viable intergrade specimens. The tortoise conservation center SOPTOM, in Gonfaron, constructed several enclosures to receive unwanted or displaced captive-produced intergrade specimens in 1997 (Guyot, 1997b), although definitive plans for these tortoises have still not been drawn up.

It is indeed difficult to devise a regional or nationwide plan for the appropriate disposal of tortoises that are genetically (or in the other ways) unsuitable for release into the wild. Certainly, genetic contamination of wild populations should not be made more acute by the continuing release of such animals, and it is important to initiate public education campaigns to discourage such actions. Release of long-term captive females even of pure *T. h. hermanni* is also unwise, not only because of the possibility of introducing disease organisms such as has occurred with both *Gopherus agassizii* and *G. polyphemus* in North America (Jacobson, 1993), but also because they may have mated with male *T. h. boettgeri* in captivity, which may result in the production of genetically mixed offspring for several or even many years after such contact (Saint-Girons, 1975; Fox, 1977). Nevertheless, few facilities today will accept donations of genetically mixed tortoises, and it is unfortunate that there are few easy solutions to offer to owners of such tortoises who wish to dispose of them.

Remaining possible strategies for dealing with tortoises found in the wild whose phenotypes and genotypes are clearly inappropriate for the area include "no action," euthanasia, release in areas that have had tortoises extirpated, and taking them into captivity for the remainder of their lives, presumably with successful reproduction not allowed to occur.

The "no action" alternative will only have a successful outcome in southern France if it can be assumed that native *T. h. hermanni* in western Europe is better adapted to the local environment than *T. h. boettgeri*, and that it would ultimately prevail in the face of protracted competition. However, *T. h. boettgeri* is a larger form than *T. h. hermanni*, with a potentially higher annual reproductive output, and this might easily override any subtle "better adaptation" of *T. h. hermanni* in its own terrain. Thus, although "no action" does essentially reflect national legislation in France, where it is illegal to capture a wild tortoise without having a permit, it would be appropriate to seek a system whereby competent individuals finding such animals could be included within existing research permits and allowed to capture them.

Euthanasia may be biologically justified, but it is unlikely to find many supporters. Both the general public and those studying tortoises professionally generally have a sympathetic regard for "their" animals, and would probably only endorse euthanasia in the case of tortoises that were terminally ill and suffering.

Release of intergrade tortoises in areas from which tortoises have been extirpated for a long time is a tempting solution, but in the real world there may be few opportunities for such an approach. Whatever factors extirpated tortoises in the first place would have to be corrected before new ones could be released, and this approach, at best, is likely to work only in a small number of tightly controlled, experimental situations. It is not a general solution.

Thus, in the absence of acceptable alternatives, it may be necessary to establish a system parallel to that utilized for *Gopherus agassizii* in California, where live animals that are displaced, unwanted, found wandering in urban areas, or otherwise come into the hands of the wildlife authorities are "adopted out" (Anonymous, 1994). They are not made available to the general public, but "adoption" is restricted to licenced and committed private individuals, who agree to follow appropriate rules that include a prohibition on buying, selling, or releasing the tortoises, and who understand that a tortoise, if adequately cared for, may well outlive its owner.

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