

- VOGT, R.C. 2008. Amazon Turtles. Lima, Peru: Wust Editions, Grafica Biblos, 104 pp.
- WYLIE, L. 2010. Frontier fictions: the place of Amazonia in Cesar Uribe Piedrahita's Toá. Bulletin of Spanish Studies: Hispanic Studies and Researches on Spain, Portugal and Latin America 87:959–974.
- ZOLEZZI, E.R. 2003. Las clasificaciones Ashaninka de la fauna del Piedemonte Central: un caso de diferente niveles de aproximación. Boletín del Instituto Francés de Estudios Andinos 32:185–212.

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Comparing Activity Patterns and Aquatic Home Range Areas Among Exotic and Native Turtles in Southern Spain

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ABSTRACT. – We radiotracked individuals of the exotic aquatic turtle *Trachemys scripta elegans* and 2 coexisting species of native turtles (*Mauremys leprosa* and *Emys orbicularis*) in southern Spain. Aquatic home range areas differed among species only in winter, when *T. s. elegans* moved in larger areas and showed shorter inactivity periods than the native turtles. Differences in these activity patterns may provide an advantage for individuals of the exotic species, which were already moving widely when native turtles started their posthibernation activity and would have been expected to be recolonizing their home ranges in depleted physical condition.

The introduction of invasive species and their impact on co-occurring native species is one of the most important causes of biodiversity loss in natural ecosystems (Walker and Steffen 1997; Simberloff 2001; Strayer et al. 2006; Strayer 2010). Among reptiles, *Trachemys scripta elegans* is the most widespread aquatic invader globally (Lowe et al. 2004; Kraus 2009). These turtles have been introduced from their native range in the southeastern United States to numerous countries through the pet trade (e.g., Ramsay et al. 2007), although the confirmation of establishment of reproducing populations has not been so widely reported (Chen and Lue 1998;

Pérez-Santigosa et al. 2006; Perry et al. 2007; Ficetola et al. 2009; Kikillus et al. 2010).

Control of *T. scripta* requires efficient methods for population removal as well as knowledge of the factors influencing their successful establishment in nonnative areas. It is also important to detect the effect of these exotic turtles on the native community, especially on closely related species with which they may compete for resources. In Spain, exotic turtles may coexist in aquatic habitats and potentially compete with 2 native species, *Emys orbicularis* and *Mauremys leprosa*, both presently considered to be vulnerable species in Spain, with competition with exotic turtles being included among their main threats (Pleguezuelos 2002).

The ecology of *T. scripta* has been studied intensively in their native range (e.g., Gibbons et al. 1990). These turtles are diurnal and may remain in aquatic habitats in all seasons, even for hibernation (Gibbons et al. 1990). They are active mainly from early spring to late autumn, reducing their movements during the colder winter months (Spotila et al. 1990). Their home range areas have been considered among the largest reported for freshwater turtles and are larger for males than for females (Schubauer et al. 1990). However, there is little information regarding their populations established in invaded areas, although competition with native species has received special attention. From experimental studies, it was concluded that exotic *T. s. elegans* compete with *E. orbicularis* for basking sites, forcing native turtles to use suboptimal basking resources and causing an increase in their mortality rate (Cadi and Joly 2003, 2004). Their presence also affects basking behavior in *M. leprosa*, which reduced their basking activity when they were in coexistence with exotic turtles under experimental conditions (Polo-Cavia et al. 2010). None of these effects have been confirmed in wild populations.

Trachemys scripta elegans is widely distributed in Spain, where reproducing populations have been reported for different localities, especially in eastern and southern areas (Martínez-Silvestre et al. 2011). The characteristics of established populations, reproductive ecology, and diet in southern Spain have been described in detail (Pérez-Santigosa et al. 2006, 2008, 2011).

In order to contribute to the knowledge of the ecology and behavior of *T. s. elegans* in their introduced habitats and their interactions with native aquatic turtles, we aimed to describe its aquatic home range areas and activity periods. This information was compared with similar data obtained for the 2 co-occurring native turtle species, *M. leprosa* and *E. orbicularis*.

Methods

We monitored exotic and native turtles using radio-transmitters in El Portil Pond (lat 37°14'N, long 7°2'W) from May 2003 to June 2004. This is a freshwater pond close to the Atlantic coast in which a reproducing population of *T. s. elegans* was established before 1996. This pond has an area of 18 ha and a maximum depth of

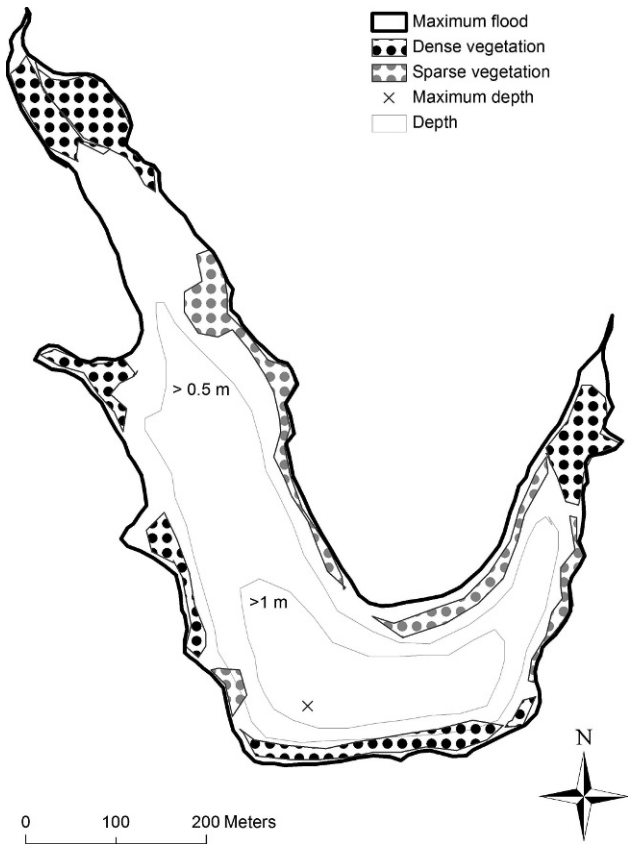


Figure 1. Schematic description of El Portil Pond.

approximately 200 cm and experiences wide fluctuations in depth seasonally (Fig. 1). A detailed description of the study area and composition of established populations of exotic turtles in this pond was given in Pérez-Santigosa et al. (2006).

We radiotracked 5 *T. s. elegans*, 6 *M. leprosa*, and 3 *E. orbicularis*, all of which were captured in the same pond (details on biometry and sex of radiotracked individuals are given in Table 1). We used baited fyke nets for trapping native turtles, but this method was not efficient for *T. scripta*. Thus, for this species we could monitor only females, 2 of which were captured on land returning to the pond after nesting and 3 that were captured by diving in the pond. The uniform growth of shell plates and large size of the monitored individuals of *T. s. elegans* indicated that these turtles had been born in the wild and were not released pets.

We attached Biotrack 10 TW-3 single-celled tag radiotransmitters on carapaces of *M. leprosa* and *E. orbicularis* and Biotrack 5 TW-3 twin celled tag on carapaces of *T. s. elegans*. Signal reception was recorded through a Yaesu FT-290R II handheld receiver and a Lintec flexible 3-element Yagi antenna. Transmitters were glued with epoxy on the costal scutes of the posterior carapace. The sites of capture and release of each monitored turtle are indicated in Figs. 2–4.

From May to October 2003 we located turtles monthly over a 3-d period. We received the radio signal 1–6 times/day, although we finally considered only 1

Table 1. Body mass, straight-line carapace length (SCL), and sex of monitored individuals of *Trachemys scripta elegans*, *Mauremys leprosa*, and *Emys orbicularis* in El Portil Pond. The aquatic home range and hibernation areas, the length of the hibernation period, dates of the start and end of monitoring periods, and the number of locations used for these estimates are also shown for each individual.

| Species | No. | Sex | Mass (g) | SCL (mm) | Monitoring period | Locations (n) | Hibernation period | Home range (ha) | Hibernation area (ha) |
|-----------------------|------------------|--------|----------|----------|-------------------------|---------------|-------------------------|-----------------|-----------------------|
| <i>T. s. elegans</i> | 210 ^a | Female | 1974.0 | 233.7 | 22 May 2003/18 May 2004 | 13 | — | 7.56 | — |
| <i>T. s. elegans</i> | 211 | Female | 1187.0 | 184.5 | 16 May 2003/28 Apr 2004 | 62 | 29 Dec 2003/22 Mar 2004 | 2.84 | 0.15 |
| <i>T. s. elegans</i> | 214 | Female | 801.0 | 171.0 | 1 Jul 2003/22 May 2004 | 77 | 23 Jan 2004/11 Mar 2004 | 3.90 | 0.10 |
| <i>T. s. elegans</i> | 216 | Female | 1512.0 | 219.0 | 11 Aug 2003/18 May 2004 | 32 | 29 Dec 2003/31 Jan 2004 | 7.23 | 0.10 |
| <i>T. s. elegans</i> | 223 | Female | 1075.0 | 194.4 | 16 Sep 2003/9 Jun 2004 | 36 | Active in winter | 5.78 | 1.07 |
| <i>E. orbicularis</i> | 2003 | Male | 502.0 | 146.8 | 22 May 2003/18 May 2004 | 85 | 17 Dec 2003/2 Mar 2004 | 3.24 | 0.08 |
| <i>E. orbicularis</i> | 2012 | Male | 451.0 | 142.3 | 16 May 2003/13 Apr 2004 | 82 | 14 Nov 2003/9 Apr 2004 | 3.24 | 0.26 |
| <i>E. orbicularis</i> | 2013 | Female | 433.0 | 129.7 | 1 Jul 2003/9 Jun 2004 | 67 | 14 Nov 2003/9 Apr 2004 | 4.07 | 0.08 |
| <i>M. leprosa</i> | 5511 | Male | 533.0 | 168.6 | 30 Jun 2003/22 May 2004 | 38 | 7 Jan 2004/11 Mar 2004 | 2.21 | 0.03 |
| <i>M. leprosa</i> | 5517 | Male | 470.0 | 151.3 | 14 Oct 2003/22 May 2004 | 26 | 17 Dec 2003/22 Mar 2004 | 4.15 | 0.32 |
| <i>M. leprosa</i> | 5521 | Male | 778.0 | 178.5 | 14 Oct 2003/22 May 2004 | 28 | 28 Nov 2003/2 Mar 2004 | 3.51 | 0.02 |
| <i>M. leprosa</i> | 5563 | Female | 1048.0 | 191.3 | 16 May 2003/30 Jun 2004 | 94 | 17 Dec 2003/23 Jan 2004 | 3.32 | 0.21 |
| <i>M. leprosa</i> | 5591 | Female | 774.0 | 179.3 | 16 May 2003/28 Apr 2004 | 83 | 17 Dec 2003/9 Apr 2004 | 3.90 | 0.26 |
| <i>M. leprosa</i> | 5602 | Male | 528.0 | 163.0 | 24 May 2003/22 May 2004 | 55 | 17 Dec 2003/11 Mar 2004 | 2.54 | 0.26 |

^a This individual was not found from 2 Jul 2003 to 15 Oct 2003 and from 14 Nov 2003 to 9 Apr 2004.

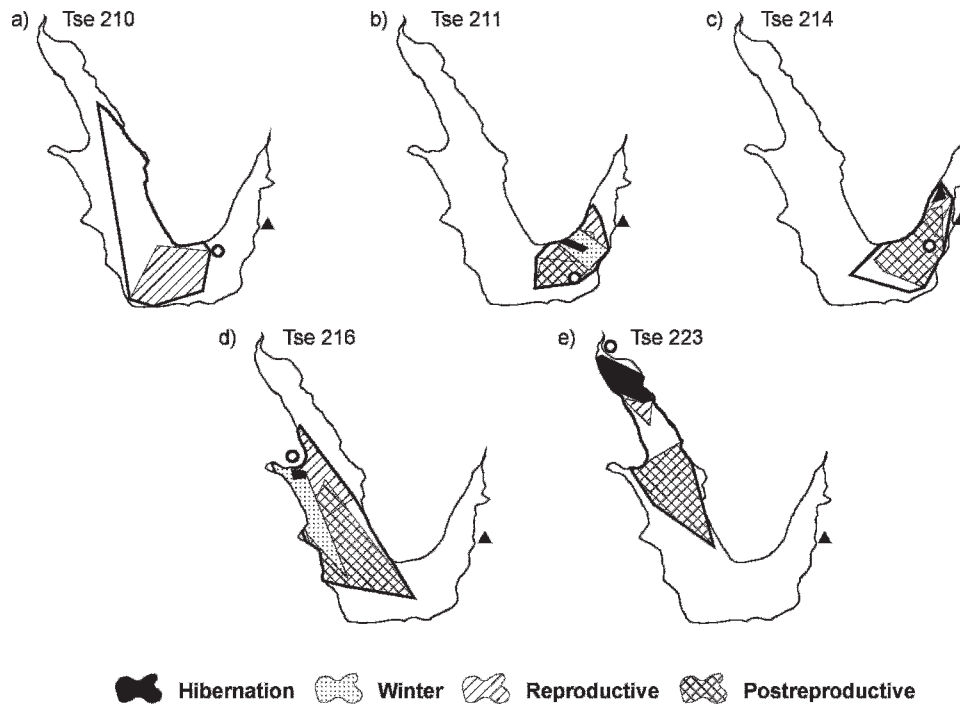


Figure 2. Minimum convex polygons estimates of home ranges of monitored *Trachemys scripta elegans* for the winter, hibernation (inactivity period in winter), and reproductive and postreproductive periods. Capture sites are indicated with circles, release sites with triangles.

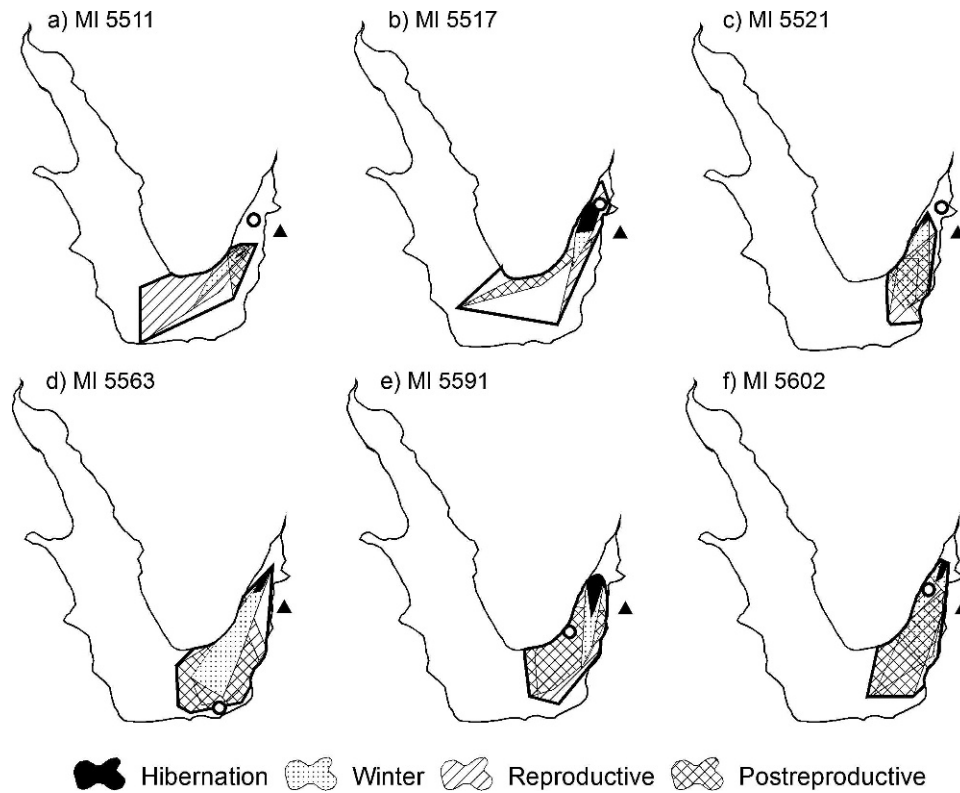


Figure 3. Minimum convex polygons estimates of home ranges areas of monitored *Mauremys leprosa* for the winter, hibernation, and reproductive and postreproductive periods. Capture sites are indicated with circles, release sites with triangles.

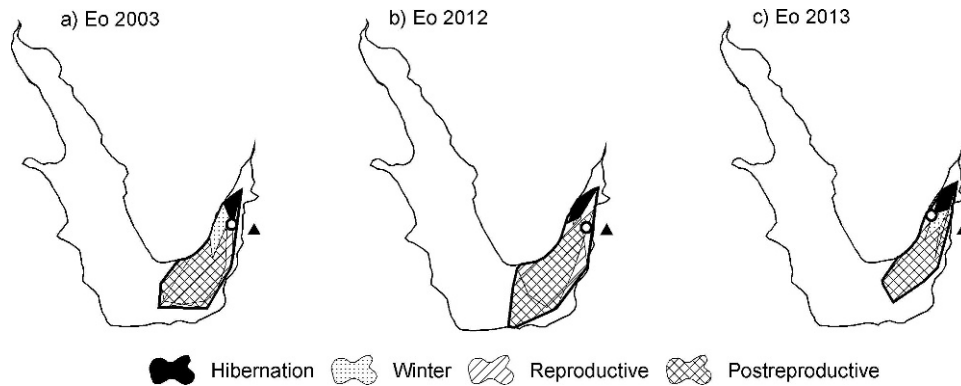


Figure 4. Minimum convex polygons estimates of home range areas of monitored *Emys orbicularis* for the winter, hibernation, and reproductive and postreproductive periods. Capture sites are indicated with circles, release sites with triangles.

location/day (recorded about midday). From November 2003 to February 2004, we located turtles in a 1-d period, recording 1–3 locations/month. We lost the signal of some transmitters in March and April 2004; the remaining active transmitters were then recorded within 3–10-d intervals until June (Table 1).

Turtle locations were obtained by triangulation from 3 different reference sites at the shores of the pond. The resulting turtle positions were uploaded into Arc View 3.2 (Environmental Systems Research Institute, Inc., Redlands, CA, USA) and projected onto a digital orthophoto of the area (Junta de Andalucía 2003).

To estimate home range areas, we calculated minimum convex polygons (MCP; White and Garrot 1990) using the Home Range extension of ArcView 3.2 (Rodgers and Carr 1998). These estimated areas were then corrected by subtracting the terrestrial portions of the area to calculate the aquatic home range areas. We estimated lineal distances between locations in consecutive months. Hibernation period was considered as the period when turtles considerably reduced their movements in winter, which we designated as the time when intramonth locations were within 50 m of one another. The MCP estimated in this period was then termed the hibernation area. We also calculated the aquatic home range areas for each turtle in 3 different periods: winter (November–February) and reproductive (March–June) and postreproductive (July–October) periods.

We used Pearson correlation to assess the relationships between carapace length of the turtles and their total aquatic home range. We compared aquatic home range and hibernation areas among species and periods as well as the length of hibernation periods using analysis of variance. We transformed (logarithmic or square-root transformation) the variables when it was necessary to fit normality and heteroscedasticity assumptions of residuals.

Results

Home Range. — The periods during which each turtle was monitored and their individual aquatic home

range areas are shown in Table 1. In general, considering individuals of the 3 species together, aquatic home range areas were significantly correlated with the carapace length of the individuals ($r = 0.787$; $p = 0.001$; $n = 14$). The largest home ranges detected (> 7 ha) were for 2 individuals of *T. s. elegans*, although there was much variation within and among species.

All turtles moved in areas around their sites of capture, even those that had been released on the side of the pond opposite their capture sites. Except for 3 *T. s. elegans* individuals that moved mainly among palustrine vegetation of the shorelines, all other turtles moved both in deep and shallow areas (over the entire depth range) of the pond (Figs. 2–4).

We did not find significant differences in aquatic home range areas among turtle species ($F_{2,34} = 0.82$; $p = 0.449$). However, home range areas differed among periods ($F_{2,34} = 6.09$; $p = 0.0007$), and post hoc comparisons revealed that they were significantly lower during the winter period (winter vs. reproductive, $p = 0.004$; winter vs. postreproductive, $p = 0.0002$), but there was no difference between the reproductive and postreproductive periods ($p = 0.198$). In winter, the aquatic home range areas were marginally different among species ($F_{2,9} = 3.21$; $p = 0.089$), with those of *T. s. elegans* being larger than those of the other species (post hoc Tukey HSD comparisons: *T. s. elegans* vs. *M. leprosa*, $p = 0.835$; *T. s. elegans* vs. *E. orbicularis*, $p = 0.010$; *M. leprosa* vs. *E. orbicularis*, $p = 0.138$). However, hibernation areas did not differ among species ($F_{2,10} = 1.50$; $p = 0.27$).

The aquatic home range area of *M. leprosa* did not differ among activity periods ($F_{2,15} = 2.36$; $p = 0.13$). However, for *T. s. elegans* the aquatic home range areas were significantly different among periods ($F_{2,9} = 4.36$; $p = 0.048$), with larger areas during the postreproductive period than in the other periods (postreproductive vs. reproductive, $p = 0.041$; postreproductive vs. winter, $p = 0.023$) and the smallest areas during winter (reproductive vs. winter, $p = 0.041$). For *E. orbicularis*, we detected a notable reduction of the aquatic home range

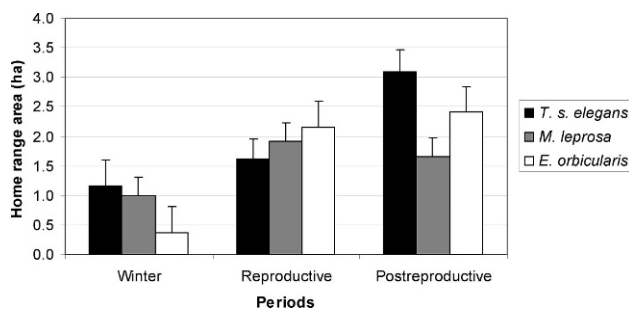


Figure 5. Mean (\pm SE) home range sizes of monitored individuals of the 3 species of aquatic turtles (*Trachemys scripta elegans*, *Mauremys leprosa*, and *Emys orbicularis*) in winter and reproductive and postreproductive periods.

area in winter, significantly smaller than their range areas in the other 2 periods ($F_{2,6} = 35.36$; $p = 0.0004$; winter vs. other periods, $p < 0.005$; Fig. 5).

Hibernation Period. — Length of the hibernation period differed significantly among species ($F_{2,10} = 5.42$; $p = 0.025$). Individuals of *T. s. elegans* had shorter hibernation periods than the other species. The first turtles that reduced their activity were 2 individuals of *E. orbicularis*, about mid-November, whereas the third turtle that we monitored of this species became inactive by mid-December. Individuals of *M. leprosa* were inactive from late November to early January. For *T. s. elegans*, 1 turtle was active during the whole winter period, whereas the remaining 3 turtles reduced their activity by late December. All monitored *T. s. elegans* turtles were active by March. Two *E. orbicularis* and 1 *M. leprosa* delayed the start of activity until April (Table 1).

Discussion

In general, large-bodied species move longer distances than smaller species (Morreale et al. 1983; Gibbons et al. 1990). Among our 3 studied species, *T. s. elegans* reaches the largest body size, as described in detail by Pérez-Santigosa et al. (2006), and probably uses wider areas than native species. In this study, the largest individuals of *T. s. elegans* had the largest aquatic home range areas, although we found no differences in home range size among species. The lack of significance among species is probably due to the wide variation in size among the individuals monitored as well as their low number that included only females in the case of *T. s. elegans*.

The largest home range detected in this study was 7.6 ha, notably smaller than the home ranges reported for *T. s. elegans* in localities in its native range (39.8 ± 6.1 ha for males and 15.0 ± 3.5 ha for females; Schubauer et al. 1990). No turtle ranged through the entire pond, but they moved across half or two-thirds of its total area, indicating that pond size in this locality did not constrain turtle movements.

The 2 native turtle species showed similar aquatic home range areas. Home ranges reported for different turtles of Testudinoidea from North and Central America show wide variation, ranging between 0.076 ha for *Glyptemys muhlenbergii* (Pittman and Dorcas 2009) and 103.5 ha for *T. scripta* in South Carolina (Schubauer et al. 1990). Compared with these reported home ranges, our native species (*M. leprosa* and *E. orbicularis*) showed a large home range area (approximately 2–3 ha).

Turtle movements differed seasonally in the 3 studied species. *Trachemys scripta elegans* experienced a gradual increase in their movements, showing the largest home range in summer, during the postreproductive period. This differed from the movement pattern described in their native range in the United States, where they moved within larger home range areas in spring compared with summer (Gibbons et al. 1990). The increase in their movements in the invaded area of southern Spain may be due to the availability of spatial resources they have found in the large and permanent waters of El Portil Pond.

In contrast, the 2 native turtle species moved in similarly wide areas in both the reproductive and postreproductive periods. Home ranges have been reported for *E. orbicularis* in France (Cadi and Joly 2004), Italy (Lebboroni and Chelazzi 2000), and Lithuania (Meeske and Mühlenberg 2004), where they gradually increased the home ranges during their activity period; home ranges became wider in June, July, and August in France and Lithuania, whereas they decreased their movements in spring. In our study area, the lack of seasonal differences could not be related to spatial constraints but may be influenced by co-occurrence with *T. s. elegans*. Because exotic turtles start their annual activity period earlier than native turtles, they also have earlier access to the available feeding or basking areas, which are colonized when native turtles are still inactive or just starting their activity period.

In this study, one of the main differences among exotic and native turtles was the length of the hibernation period and the extent of their wintering areas. Native turtles had long hibernation periods, as reported for *E. orbicularis* in other localities in Europe (Dall'Antonia et al. 2001; Cadi and Joly 2004). In contrast, the individuals of *T. s. elegans* monitored in winter did not experience a true inactivity period. Similar patterns have been described for *T. scripta* in the United States, where turtles remain active during rainy winters (Gibbons et al. 1990).

Although it is not known whether maintenance of winter activity causes energetic costs detrimental to *T. s. elegans*, a consequence is that they increase their postwinter activity earlier than native turtles. Therefore, most of them were already moving widely when native turtles were starting their posthibernation activity. During hibernation, turtle physical condition is depleted and must be restored at the beginning of the activity period (Lawrence 1987). Thus, during the first days after hibernation, turtles are still weak and are probably not able to perform normal movements. At this time, they

also have to recolonize their foraging and basking areas that are already occupied by the exotic species. Thus, alien turtles have distinct advantages over the native turtles in establishing feeding and basking areas because of their shorter winter inactivity period and their larger body size.

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LITERATURE CITED

- CADI, A. AND JOLY, P. 2003. Competition for basking places between the endangered European pond turtle (*Emys orbicularis galloitalica*) and the introduced slider turtle (*Trachemys scripta elegans*). *Canadian Journal of Zoology* 81:1392–1398.
- CADI, A. AND JOLY, P. 2004. Impact of the introduction of the slider turtle (*Trachemys scripta elegans*) on survival rates of European pond turtle (*Emys orbicularis*). *Biodiversity and Conservation* 13:2511–2518.
- CHEN, T.-H. AND LUE, K.-Y. 1998. Ecological notes on feral populations of *Trachemys scripta elegans* in northern Taiwan. *Chelonian Conservation and Biology* 3:87–90.
- DALL'ANTONIA, L., LEBBORONI, M., BENVENUTI, S., AND CHELAZZI, G. 2001. Data loggers to monitor activity in wild freshwater turtles. *Ethology, Ecology & Evolution* 13:81–88.
- FICETOLA, G.F., THULLER, W., AND PADOA-SCHIOPPA, E. 2009. From introduction to the establishment of alien species: bioclimatic differences between presence and reproduction localities in the slider turtle. *Diversity and Distribution* 15: 108–116.
- GIBBONS, J.W., GREENE, J.L., AND CONGDON, J.D. 1990. Temporal and spatial movement patterns of sliders and other turtles. In: Gibbons, J.W. (Ed.). *Life History and Ecology of the Slider Turtle*. Washington, DC: Smithsonian Institution Press, pp. 201–215.
- JUNTA DE ANDALUCÍA. 2003. Ortofotografía Digital de Andalucía. Sevilla: Consejería de Obras Públicas y Transportes, Instituto de Cartografía de Andalucía, Junta de Andalucía (Spain). DVD.
- KIKILLUS, K.H., HARE, K.H., AND HARTLEY, S. 2010. Minimizing false-negatives when predicting the potential distribution of an invasive species: a bioclimatic envelope for the red-eared slider at global and regional scales. *Animal Conservation* 13(Suppl 1):1–11.
- KRAUS, F. 2009. *Alien Reptiles and Amphibians: A Scientific Compendium and Analysis*. New York: Springer, 563 pp.
- LAWRENCE, K. 1987. Seasonal variations in blood biochemistry of long term captive Mediterranean tortoises (*Testudo graeca* and *T. hermanni*). *Research in Veterinary Science* 43:379–383.
- LEBBORONI, M. AND CHELAZZI, G. 2000. Waterward orientation and homing after experimental displacement in the European pond turtle, *Emys orbicularis*. *Ethology Ecology & Evolution* 12:83–88.
- LOWE, S., BROWNE, M., BOUDJELAS, S., AND DE POORTER, M. 2004. 100 of the World's Worst Invasive Alien Species. A Selection from the Global Invasive Species Database. Updated and reprinted version. Auckland: IUCN/SSC Invasive Species Specialist Group, 12 pp.
- MARTÍNEZ-SILVESTRE, A., HIDALGO-VILA, J., PÉREZ-SANTIGOSA, N., AND DÍAZ-PANIAGUA, C. 2011. Galápagos de Florida—*Trachemys scripta*. In: Salvador, A. and Marco, A. (Eds.). *Enciclopedia Virtual de los Vertebrados Españoles*. Madrid: Museo Nacional de Ciencias Naturales. www.vertebradosibericos.org.
- MEESKE, A.C.M. AND MÜHLENBERG, M. 2004. Space use strategies by northern population of the European pond turtle, *Emys orbicularis*. *Biologica* 59(Suppl 14):95–101.
- MORREALE, S.J., GIBBONS, J.W., AND CONGDON, J.D. 1983. Significance of activity and movement in the yellow-bellied slider turtle (*Pseudemys scripta*). *Canadian Journal of Zoology* 62:1038–1042.
- PÉREZ-SANTIGOSA, N., DÍAZ-PANIAGUA, C., AND HIDALGO-VILA, J. 2008. The reproductive ecology of exotic *Trachemys scripta elegans* in an invaded area of southern Europe. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18:1302–1310.
- PÉREZ-SANTIGOSA, N., DÍAZ-PANIAGUA, C., HIDALGO-VILA, J., MARCO, A., ANDREU, A.C., AND PORTHEAULT, A. 2006. Características de dos poblaciones reproductoras del galápagos de Florida, *Trachemys scripta elegans*, en el suroeste de España. *Revista Española de Herpetología* 20:5–16.
- PÉREZ-SANTIGOSA, N., FLORENCIO, M., HIDALGO-VILA, J., AND DÍAZ-PANIAGUA, C. 2011. Does the exotic invader turtle, *Trachemys scripta elegans*, compete for food with coexisting native turtles *Amphibia-Reptilia* 32:167–175.
- PERRY, G., OWEN, J.L., PETROVIC, C., LAZELL, J., AND EGELHOFF, J. 2007. The red-eared slider, *T. s. elegans*, in the British Virgin Islands. *Applied Herpetology* 4:88–89.
- PITTMAN, S.E. AND DORCAS, M. 2009. Movements, habitat use, and thermal ecology of an isolated population of bog turtles (*Glyptemys muhlenbergii*). *Copeia* 2009:781–790.
- PLEGUEZUELOS, J.M. 2002. Las especies introducidas de anfibios y reptiles. In: Pleguezuelos, J.M., Márquez, R., and Lizana, M. (Eds.). *Atlas y Libro Rojo de los Anfibios y Reptiles de España*. Madrid: Dirección General de la Conservación de la Naturaleza-Asociación Herpetológica Española, pp. 501–532.
- POLO-CAVIA, N., LÓPEZ, P., AND MARTÍN, J. 2010. Competitive interactions during basking between native and invasive freshwater turtle species. *Biological Invasions* 12:2141–2152.
- RAMSAY, N.F., ABIGAYLE, P.K., O'RIDAN, R.M., AND CHOU, L.M. 2007. The red-eared slider (*Trachemys scripta elegans*) in Asia: a review. In: Gherardi, F. (Ed.). *Biological Invaders in Inland Waters: Profiles, Distribution, and Threats*. Dordrecht: Springer, pp. 161–174.
- RODGERS, A.R. AND CARR, A.P. 1998. HRE: the Home Range Extension for ArcView. Thunder Bay: Ontario Ministry of Natural Resources, Centre for Northern Ecosystem Research, 27 pp.
- SCHUBAUER, J.P., GIBBONS, J.W., AND SPOTILA, J.R. 1990. Home range and movement patterns of slider turtles inhabiting Par Pond. In: Gibbons, J.W. (Ed.). *Life History and Ecology of the Slider Turtle*. Washington, DC: Smithsonian Institution Press, pp. 223–232.
- SIMBERLOFF, D. 2001. Biological invasions—how are they affecting us, and what can we do about them? *Western North American Naturalist* 61:308–315.

- SPOTILA, J.R., FOLEY, R.E., AND STANDORA, E.A. 1990. Thermoregulation and climate space of the slider turtle. In: Gibbons, J.W. (Ed.). *Life History and Ecology of the Slider Turtle*. Washington, DC: Smithsonian Institution Press, pp. 288–298.
- STRAYER, D.L. 2010. Alien species in fresh waters: ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology* 55(Suppl 1):152–174.
- STRAYER, D.L., EVINER, V.T., JESCHKE, J.M., AND PACE, M.L. 2006. Understanding the long-term effects of species invasions. *Trends in Ecology and Evolution* 21:11.
- WALKER, B. AND STEFFEN, W. 1997. An overview of the implications of global change for natural and managed terrestrial ecosystems. *Conservation Ecology* 1(2):2. www.consecol.org/vol1/iss2/art2.
- WHITE, G. AND GARROT, R. 1990. *Analysis of Wildlife Radio-Tracking Data*. New York: Academic Press, 383 pp.

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Notes on a Nest and Emergence of Hatchlings of the Euphrates Softshell Turtle (*Rafetus euphraticus*) at the Dez River, Iran

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ABSTRACT. – We report on a Euphrates softshell turtle (*Rafetus euphraticus*) nest and hatchlings that emerged from the nest that was constructed in a sand patch of the Dez River in southwestern Iran and discovered on 8 July 2012. Information on nest location and structure and hatchling morphology is presented.

Freshwater turtles are long-lived animals characterized by low mortality in adults but often high mortality in

embryonic and hatchling stages (Cagle 1950; Gibbons 1968; Moll and Legler 1971; Wilbur 1975). An important source of mortality for hatchlings is emergence and dispersal from the nest, which often entails high risk because of the increased exposure to predators, temperature extremes, and desiccation while the hatchlings find their way to water (Plummer 2007). Most of our knowledge regarding emergence of hatchling turtles comes from the many studies on sea turtles (e.g., Dial 1987; Witherington et al. 1990; Hays et al. 1992; Gyuris 1993; Godfrey and Mrosovsky 1997), while emergence behavior of freshwater turtle hatchlings is less well known (Doody 1995; Kuchling 1999; Doody et al. 2001; Butler et al. 2004; Plummer 2007).

The Euphrates softshell turtle (*Rafetus euphraticus* Daudin 1802) is a medium-sized trionychid turtle with a geographic range confined to the Euphrates and Tigris basins of Turkey, Syria, Iraq, and Iran (Taşkavak and Atatür 1995, 1998; Ghaffari et al. 2008; Biricik and Turğa 2011). The range of *R. euphraticus* in Iran is limited to Khuzestan Province. It is one of the biologically least known trionychid species and is probably the most threatened freshwater turtle in Iran (Ghaffari et al. 2008).

The reproductive biology of the Euphrates softshell turtle is poorly known (Biricik and Turğa 2011), and there is no information on the species concerning hatchling morphology or emergence from natural nests in Iran. This article provides data on the characteristics of a Euphrates softshell turtle nest, hatchling emergence, and hatchling morphology from the Dez River in Khuzestan Province, Iran.

Study Area. — The Dez River flows southward from the mountain regions north of the cities of Dezful and Andimeshk onto the Khuzestan plain. The river has alluvial soil and sandy banks that provide suitable nesting habitat for *R. euphraticus* (Ghaffari et al. 2008). The vegetation along the banks and sandbars of the Dez River consists of *Tamarix* sp., *Populus euphratica*, *Lycium shawii*, *Vitex pseudonegundo*, *Salix* sp., *Capparis spinosa*, *Prosopis stephaniana*, and *Calotropis procera*. The climate of Khuzestan is generally hot and humid (Ghaffari et al. 2008). From 2005 to 2010, the mean ambient temperature at the Dezful station was 34°C in June and 36°C in July (Anonymous 2012).

Methods. — During the *R. euphraticus* breeding season in June and July, we conducted field surveys for possible nests on sandbars in the counties of Dezful and Andimeshk, Khuzestan Province. After the single nest described in this article was found, we centered a 4-m² plot on the nesting site. Within this area, we counted and measured the number of tree stems per square meter, the number of tree species, the number of shrub species, tree height, and distance to nearest tree within the plot. Tree and shrub height were ranked into 4 categories (< 0.5 m, 0.5–2 m, 2–5 m, and > 5 m). The distance between the river and the nest and nest dimensions were measured