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Trachemys scripta (Slider Terrapin)

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History of Introduction, Distribution and Impact on Native Species

Trachemys scripta, the slider terrapin, has been traded worldwide since at least the 1950s, and quickly became a very popular pet because of its cheap price and the reasonably simple husbandry. Sliders are probably the most commonly traded reptile: more than 52 million individuals were exported from the US during the period 1989–1997 (Telecky, 2001). Although sliders are mostly traded as pets, in some areas they are also imported or farmed for human consumption, particularly in Asia (Scalera, 2007). Three subspecies of *T. scripta* are currently recognized (Bonin et al, 2006): *Trachemys scripta scripta* (Thunberg in Schoepff, 1792), *T. s. elegans* (Wied, 1838) and *T. s. troostii* (Holbrook, 1836) (Figure 28.1). *Trachemys scripta elegans* (the red-eared slider terrapin) was the most widely traded subspecies until 1997. The European Union interrupted the import of *T. s. elegans* in 1997 (Regulation 338/1997; Regulation 349/2003) due to the high risk of biological invasion. However, these regulations considered only the subspecies *T. s. elegans* and, as a consequence, the trade in the other two subspecies (*T. s. scripta*, *T. s. troostii* and hybrids among subspecies) sharply increased after the ban (Scalera, 2007). Young sliders are sold at a size of just a few centimetres, but can grow quickly. As owners are rarely prepared to maintain large adults for many years, they often release terrapins into natural or semi-natural wetlands (Teillac-Deschamps et al, 2009).

Distribution

Trachemys scripta is native to the eastern US and northeast Mexico, but has been introduced worldwide (Figure 28.2). Feral individuals have been reported in at least 73 countries or overseas territories (Table 28.1) (Lever, 2003; Pupins, 2007; Kraus, 2009; Pendlebury, 2009; Scalera, 2009; Kikillus et al, 2010).

Reproduction has not been recorded in all areas with feral individuals; feral adults can survive long periods in suboptimal areas, where the climate is not suitable for reproduction because of low temperature or limited precipitation (Bringsøe, 2001; Ficetola et al, 2009). Also, ascertaining the reproduction of freshwater terrapins in natural wetlands can be challenging because juveniles are more difficult to spot than adults, and because it is difficult to ascertain whether juveniles originated from local reproduction or from recent release. Reproduction of non-native populations has been recorded in Mediterranean areas of Europe, Germany, in Japan and southeast Asia, Australia, New Zealand, in the West Indies and in the introduced range in the US (Lever, 2003; Cadi et al, 2004; Ramsay et al, 2007; Ficetola et al, 2009; Kikillus et al, 2010).

Impact on native species

Trachemys scripta can have notable impacts on native reptiles, amphibians, fish and invertebrates. There have been extensive studies on the interaction between sliders and two European species of terrapins: the European pond turtle, *Emys orbicularis*, and the Spanish terrapin, *Mauremys leprosa*. Freshwater terrapins often

(a)

(b)

Source: (a) G. F. Ficetola; (b) D. Rödder

Figure 28.1 *Feral individuals of (a)* Trachemys scripta elegans; *(b)* T. s. scripta

Note: Several presence localities, both in the native and in the invasive range, are depicted in Figure 28.3.

Source: Lever (2003); Pupins (2007); Kraus (2009); Pendlebury (2009); Scalera (2009); Kikillus et al (2010)

Figure 28.2 *Native range of* Trachemys scripta *(black) and countries where feral slider terrapins have been recorded (grey)*

Table 28.1 *Countries or territories where feral sliders have been reported*

Region	Countries/territories
Europe	Andorra, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, UK, Greece, Hungary, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland
Africa	Egypt, Kenya, Namibia, Reunion (France), South Africa
Asia	Bahrain, Hong Kong, India, Indonesia, Israel, Japan, Malaysia, Saudi Arabia, Seychelles, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, Turkey, Viet Nam
Central and North America	Aruba (Kingdom of the Netherlands), Bahamas, Bermuda (UK), British Virgin Islands (UK), Canada, Cayman Islands (UK), Guadeloupe (France), Martinique (France), Mexico, Netherlands Antilles, Nicaragua, Panama, Trinidad and Tobago, US Virgin Islands, US outside the native range
South America	Brazil, Chile, Guyana, Paraguay, Suriname
Oceania	Australia, Commonwealth of the Northern Mariana Islands (US), French Polynesia, Federated States of Micronesia, Guam (US), New Zealand

compete for basking sites, since basking is vital in temperate regions for thermoregulation and to activate metabolism (Meek and Avery, 1988). As sliders are larger and more aggressive than other species of terrapins, they can outcompete them both in the native and in the invaded range (Lindeman, 1999; Cadi and Joly, 2003; Spinks et al, 2003; Macchi, 2008). Cady and Joly (2003, 2004) used experimental ponds to assess competition and behavioural interactions between sliders and the threatened European pond turtle. Both turtle species preferred the same sites for basking but, when sliders where present, the European pond turtle shifted to suboptimal basking sites. Subsequent experiments performed by Macchi et al confirmed that competition for basking sites, and aggressive interactions between sliders and the European pond turtle, can threaten this native species (Macchi, 2008; Macchi et al, 2008). Similarly, in presence of sliders, the Spanish terrapin reduces basking activity and avoids basking sites where sliders are present (Polo-Cavia et al, 2010b). Sliders also have behavioural and physiological advantages compared to the Spanish terrapin, such as a higher tolerance to human disturbance, and a body shape determining better thermoregulatory abilities (Polo-Cavia et al, 2008, 2009). The competition with sliders for basking sites and perhaps other resources (e.g. food, nesting sites) may also be a cause of the decline of other freshwater terrapins, such as the Western pond terrapin *Actinemys marmorata* in California (Spinks et al, 2003).

Interactions with native species can also occur during foraging. In European ponds, there is a wide overlap between the diet of sliders and the diet of native terrapins, suggesting that competition for food may occur (Pérez-Santigosa et al, 2011); competition with sliders can decrease foraging success and even increase mortality in European pond turtles (Cadi and Joly, 2004). Furthermore, tadpoles of several European amphibians can chemically detect the presence of native predatory terrapins and modify their behaviour to reduce predation risk, but they are unable to appropriately respond to the presence of sliders. Therefore, sliders might capture and consume tadpoles more easily than native terrapins, and thus have a competitive advantage during foraging (Polo-Cavia et al, 2010a). The release of sliders into natural ecosystems may also increases the risk of transmission of pathogens (such as nematodes and bacteria) to native terrapins (e.g. Spinks et al, 2003; Hidalgo-Vila et al, 2009).

The impact of sliders on other components of biota is less studied, but can be important. Sliders are omnivorous, and shift from a carnivorous to a more herbivorous diet during growth (Hart, 1983; Prévot-Julliard et al, 2007). Sliders can predate on crustaceans, aquatic insects, fish and amphibians, and their presence can therefore affect whole freshwater communities (Lever, 2003; Teillac-Deschamps and Prevot-Julliard, 2006; Prévot-Julliard et al, 2007; Pérez-Santigosa et al, 2011). For instance, tadpoles of some European species of anuran amphibians (*Pelophylax perezi*, *Pelobates cultripes* and *Hyla arborea*) reduce activity in presence of native predatory terrapins, but they do not show such antipredatory behaviour when alien terrapins (such as sliders) are present. The lack of antipredatory behaviour is probably caused by the absence of a shared evolutionary history between prey and the alien predator, and may expose native amphibians to a high predatory pressure (Polo-Cavia et al, 2010a). Additionally, adult sliders feed on wetland vegetation, and can heavily damage it, particularly if they are at high density, or in small wetlands (Ficetola, G. F., unpublished data).

Ecological Niche and Potential Distribution

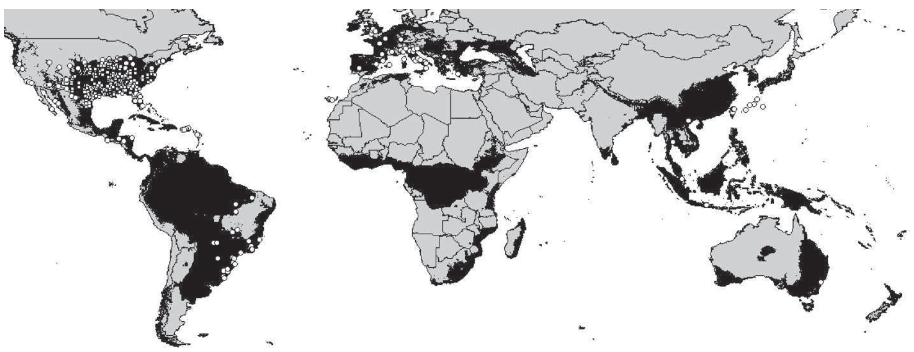
Successful establishment of alien invasive reptiles at a given site strongly depends on the availability of suitable habitats, therefore specific climate conditions can be a good predictor of invasion success (Bomford et al, 2010). As an aquatic species, the slider depends on continuous water availability throughout the year, whereby almost any kind of water body provides suitable habitats. Its breeding behaviour and digestive turnover rates are strongly temperature dependent, and the species does not feed at body temperatures lower than about 10°C (Parmenter, 1980). This makes the slider dependent on certain ambient temperature regimes to maintain a positive annual energetic balance.

Breeding is the most critical stage necessary for long term establishment of slider populations. In the native range, sliders usually lay eggs in subterranean nests from April to July (Gibbons et al, 1982; Aresco, 2004). Depending on incubation temperatures, time from egg deposition to hatching of the newborns ranges from 60–130 days, with lower incubation temperatures causing slower development. In Louisiana, eggs were reported to hatch in approximately 68–70 days (Dundee and Rossman, 1989). In areas with a high seasonality hatchlings may hibernate inside the nest. This may ultimately limit the slider's distribution in northern parts of its native range as hatchlings may die at temperatures below –0.6 to –4.0°C (Packard et al, 1997; Tucker and Packard, 1998). Furthermore, successful egg development depends on sufficient moisture (Tucker and Packard, 1998) and warmth during incubation, ca. 26.0–32.5 °C (Wibbels et al, 1991; Crews et al, 1994).

A further important requirement for long term persistence of the slider is a balanced sex ratio within populations. In slider embryos, as in most chelonians, sex determination is temperature dependent. During egg incubation, low temperature during a sensitive phase of approximately two weeks increases the number of males. By contrast, with warmer egg incubation temperatures, more females hatch (Wibbels et al, 1991; Crews et al, 1994; Ewert et al, 1994). Only within a transitional range between 28.3 and 30.6 °C are both sexes differentiated (Morosovsky and Pieau, 1991; Cadi et al, 2004). These requirements for successful clutch development and balanced sex ratio strongly influence the native range of the slider (Rödder et al, 2009a), and likely have a strong effect also on its establishment success in other areas.

Several authors have assessed the potential distribution of the slider at both the regional and global scale (Ficetola et al, 2009; Rödder et al, 2009a, 2009b; Kikillus et al, 2010). We herein provide results of a mechanistic species distribution model (Kearney and Porter, 2009) based on physiological thresholds of the species within its native range as described in Rödder et al (2009b). These include variables affecting both physiology and reproduction of sliders: the upper avoidance temperature of the species (ca. 37°C; Lamb et al, 1995) reflected by the maximum temperature of the warmest month; frost tolerance of neonates described by the minimum temperature of the coldest month (–12.6°C); annual mean temperature >8.3°C accounting for a positive energetic balance; annual precipitation >278mm, and precipitation of the driest quarter >22mm to account for water availability. Regions meeting these requirements comprise huge areas of North, Central and South America, Europe, West and Central Africa, the East African coast, eastern Asia, and eastern and western parts of Australia (Figure 28.3). In many of these areas the slider is actually distributed. We used the area under the curve (AUC) of the receiver operator characteristic plot (Manel et al, 2001) to assess the capability of this model to correctly identify areas where native and invasive populations of sliders are present. The model was tested using 375 native and 205 invasive records compiled through online databases (Global Biodiversity Information Facility, www.gbif.org; HerpNET, www.herpnet.org) and literature search (for a detailed list of sources see Rödder et al, 2009b). The discrimination performance of the resulting model was good in both the native (AUC = 0.85) and invasive range of the slider (AUC = 0.80).

The model presented in Figure 28.3 characterizes the requirements of the slider at the global scale. However, at a finer scale, suitable microhabitat features may become more important. Being a generalist, the species is able to occupy most wetlands. Nevertheless,



Note: Potential distribution of Trachemys scripta *is indicated by black areas. Native populations are indicated as small white dots, and invasive populations as large white dots.*

Source: Species records were compiled from online databases and a literature search (for details see Rödder et al, 2009b)

Figure 28.3 *Potential distribution of* Trachemys scripta *derived from physiological thresholds* the slider prefers water bodies with certain features: still to slow running waters, eutrophic, 1 to 2m deep, and with dense vegetation providing cover from predators and supporting high densities of aquatic invertebrates on which it feeds (Morreale and Gibbons, 1986). The presence of suitable basking sites can be a further important feature for this species. Nevertheless, basking sites are rarely a limiting factor, because when no aquatic basking sites are available, the slider may be able to bask along the shore or at the water surface. The slider is a generalist omnivore (see above), and this probably contributes to its widespread distribution (Morreale and Gibbons, 1986).

Management Efforts

Prevention is certainly the most effective approach to limit the introduction of sliders into natural and semi-natural environments. Therefore, initial efforts should include the ban of import/trade of individuals, but regulations must be carefully planned to make them effective. The European regulation on the import of sliders (see above) is a clear example of the complexity of this task (Scalera, 2007). Furthermore, it is still legal to keep sliders and distribute them across the European countries (Scalera, 2007), including captive breed juveniles hatched in the European Union. A more effective regulation should ban the trade of all slider subspecies, and of any other freshwater terrapin potentially capable of establishing naturalized populations. A first assessment of the probability of successful establishment may be performed through the use of bioclimatic models that evaluate suitability on the basis of climate similarity between the native range of the species and the areas where they are imported (see above) (Figure 28.3) (Jeschke and Strayer, 2008; Rödder et al, 2009b; Gallien et al, 2010; Kikillus et al, 2010).

Environmental education can also play an important role. Communication campaigns are essential to increase public awareness, and they should be a priority to avoid new introductions of terrapins by owners. Effective education campaigns should include communication targeted to explain the problems caused by introduced terrapins (e.g. exhibitions in public parks), but also more general information, encouraging people to change their perception toward nature and support biodiversity conservation. This can be achieved through enhanced outdoor activities and increasing personal contact with nature (Teillac-Deschamps et al, 2009).

Multiple techniques can be used to remove non-native sliders from wetlands. Traps are the most frequent approach to capture freshwater terrapins, including sliders, wherein basking traps and funnel hoop traps are the common techniques (Fowler and Avery, 1994; Savage, 2002). Basking traps (also called sink box traps) are floating boxes or barrels, with the rim just above the waterline. Terrapins crawl up onto the top of the box to bask in the sun and fall into the trap. The boxes can be made with hardware cloth with a mesh size of <2cm, allowing the capture of individuals of all sizes. The shape of the entrance must ensure that trapped individuals cannot climb the trap and escape.

Funnel hoop traps are barrel shaped traps that may be made by hardware cloth or cord/rope nets. They should have a funnel shaped entrance allowing terrapins to enter easily but that is reduced to a small slit entering the main trap space. The main section of the trap should be baited with meat, entrails or fish, wherein the bait should be suspended from the upper frame. The trap should be kept rigidly in place, and the upper part should be above the waterline to avoid the terrapins drowning. Traps of different sizes can be used to capture individuals of different body size (Fowler and Avery, 1994; Gianaroli et al, 2001; Savage, 2002; Gamble, 2006). Overall, basking traps seem to be a particularly effective approach. However, although both trapping techniques can be useful for adults, small juveniles are more difficult to spot and capture, particularly when using hoop traps (Gianaroli et al, 2001; Chen, 2006; Gamble, 2006). For this reason, it has been proposed that early removal of feral individuals, before they become naturalized and start to reproduce, would be desirable (Ficetola et al, 2009). Other approaches for the control of feral individuals include the use of nets, the complete draining of wetlands followed by removal of alien turtles, and the use of sniffer dogs to detect terrapins and their eggs, which can be removed after the identification of nesting areas (O'Keeffe, 2005; Scalera, 2009).

However, as individuals are still being released in natural and semi-natural wetlands, the capture of feral individuals is not sufficient to fully remove sliders, and can result only in short time effects. A combination of capture with environmental communication is probably the most effective approach to reduce the number of sliders present both in areas where they breed and in areas where reproduction is not successful (Teillac-Deschamps et al, 2009).

Controversies

Controversies on potential establishment/impact

Since the 1980s there have been remarkable controversies on the potential for establishment and impact of sliders in Europe. Despite the introduction of a very large number of individuals in multiple countries, some researchers suggested that the likelihood of slider establishment in the wild, and its potential impact on the native biota, would be limited. For instance, Bringsøe (2001) suggests that in northern Europe the climate is too cold, while in the Mediterranean region summers are too dry for successful egg development, and only small areas in southern Europe would have a suitable climate for this species. Similarly, field experiments performed in the 1990s suggested a limited reproductive capability and a very low survival of juveniles in the introduced range in central Italy (Luiselli et al, 1997). However, during the last decade the number of reproduction records in Mediterranean Europe has steadily increased (see data in Kikillus et al, 2010), indicating that sliders are establishing over larger areas. Projections of species distribution models onto future climate change scenarios suggest that the invasiveness of populations may increase in the near future (Ficetola et al, 2009; Kikillus et al, 2010).

Terrapin eradication and management: The social dimension does matter

When alien species are domesticated or used as ornamental animals, the decision to remove them may face the opposition of the public. Most people are familiar with slider terrapins, and their management should take into account social aspects. It has been suggested that the presence of alien terrapins in urban green spaces may be a reason for the general public to visit these areas. Once attracted to green spaces, people may encounter other aspects of nature, increase their receptivity toward environmental communication, and therefore become more willing to support biodiversity conservation (Teillac-Deschamps et al, 2009). This line of reasoning suggests focusing the management efforts (terrapin removal) on natural wetlands where sliders pose a serious threat to native biodiversity, while a complete removal might be not necessary in urban contexts (Teillac-Deschamps et al, 2009).

Controversies arise also after terrapins are captured. People and animal rights organizations may contest the killing of captured individuals, as has happened for other ornamental alien species (Bertolino and Genovesi, 2003). For this reason, in some European countries captured individuals are maintained in rescue centres. However, sliders are long lived animals. Maintaining thousands of terrapins for decades requires important resources and large dedicated areas. Hence, allocating resources for these animals can reduce the already limited funding available for biodiversity conservation. A possible solution to this issue is adding a charge to the price of sold terrapins. This money could be allocated for the management of issues caused by sliders, such as removing feral individuals and maintaining the captured ones, or for environmental education campaigns. Explaining the reasons for the increased price to the consumers may also increase their awareness of the issues that can be caused by invasive species, and perhaps discourage them from introducing terrapins in natural wetlands.

Acknowledgements

We thank N. Polo-Cavia for constructive comments. GFF was funded by a grant of the University of Milano-Bicocca on invasive species.

References

Aresco, M. J. (2004) ‘Reproductive ecology of *Pseudemys floridana* and *Trachemys scripta* (Testudines: Emydidae) in northwestern Flordia’, *Journal of Herpetology*, vol 38, pp249–256

Bertolino, S. and Genovesi, P. (2003) ‘Spread and attempted eradication of the grey squirrel (*Sciurus carolinensis*) in Italy, and consequences for the red squirrel (*Sciurus vulgaris*) in Europe’, *Biological Conservation*, vol 109, pp351–358

Bomford, N., Barry, S. C. and Lawrence, E. (2010) ‘Predicting establishment success for introduced freshwater fishes: A role for climate matching’, *Biological Invasions*, vol 12, pp2559–2571

Bonin, F., Devaux, B. and Dupré, A. (2006) *Toutes les tortues du monde*, Delachaux et Niestlé, Paris

Bringsøe, H. (2001) '*Trachemys scripta* (Schoepff, 1792) – Buchstaben-Schmuckschildkröte', in U. Fritz (ed) *Handbuch der Reptilien und Amphibien Europas. Schildkröten (Testudines)*, AULA, Wiebelsheim, pp525–583

Cadi, A. and Joly, P. (2003) 'Competition for basking places between the endangered European pond turtle (*Emys orbicularis galloitalica*) and the introduced red-eared slider (*Trachemys scripta elegans*)', *Canadian Journal of Zoology*, vol 81, pp1392–1398

Cadi, A. and Joly, P. (2004) 'Impact of the introduction of the read-eared slider (*Trachemys scripta elegans*) on survival rates of the European pond turtle (*Emys orbicularis*)', *Biodiversity and Conservation*, vol 13, pp1511–2518

Cadi, A., Delmas, V., Prévot-Julliard, A.-C., Joly, P. and Girondot, M. (2004) 'Successful reproduction of the introduced slider turtle (*Trachemys scripta elegans*) in the South of France', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol 14, pp237–246

Chen, T.-H. (2006) 'Distribution and status of the introduced red-eared slider (*Trachemys scripta elegans*) in Taiwan', in F. Koike, M. N. Clout, M. Kawamichi, M. De Poorter, and K. Iwatsuki (eds) *Assessment and Control of Biological Invasion Risks*, Shoukadoh Book Sellers and IUCN, Kyoto, Japan and Gland, Switzerland, pp187–195

Crews, D., Bergeron, J. M., Bull, J. J., Flores, D., Tousignant, A., Skipper, J. K. and Wibbels, T. (1994) 'Temperature-dependent sex determination in reptiles: Proximate mechanisms, ultimate outcomes, and practical applications', *Developmental Genetics*, vol 15, pp297–312

Dundee, H. A. and Rossman, D. A. (1989) *Amphibians and Reptiles of Louisiana*, State University Press, Baton Rouge

Ewert, M. A., Jackson, D. R. and Nelson, C. E. (1994) 'Patterns of temperature-dependent sex determination in turtles', *The Journal of Experimental Zoology*, vol 270, pp3–15

Ficetola, G. F., Thuiller, 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 Distributions*, vol 15, pp108–116

Fowler, J. F. and Avery, J. L. (1994) 'Turtles', in S. E. Hygnstrom and R. M. Timm (eds) *Prevention and Control of Wildlife Damage*, University of Nebraska, Lincoln, ppF27–F31

Gallien, L., Münkemüller, T., Albert, C., Boulangeat, I. and Thuiller, W. (2010) 'Predicting potential distributions of invasive species: Where to go from here?', *Diversity and Distributions*, vol 16, pp331–342

Gamble, T. (2006) 'The relative efficiency of basking and hoop traps for painted turtles (*Chrysemys picta*)', *Herpetological Review*, vol 37, pp308–312

Gianaroli, M., Lanzi, A. and Fontana, R. (2001) 'Utilizzo di trappole del tipo "bagno di sole artificiale" per la cattura di testuggini palustri', in Atti 3° Congresso nazionale SHI, Pianura, (Pavia, 2000), pp153–155

Gibbons, J. W., Greene, J. L. and Patterson, K. K. (1982) 'Variation in reproductive characteristics of aquatic turtles', *Copeia*, vol 1982, pp776–784

Hart, D. R. (1983) 'Dietary and habitat shitfts of red-eared turtles (*Pseudemys scripta*) in a southern Louisiana population', *Herpetologica*, vol 39, pp285–290

Hidalgo-Vila, J., Díaz-Paniagua, C., Ribas, A., Florencio, M., Pérez-Santigosa, N. and Casanova, J. C. (2009) 'Helminth communities of the exotic introduced turtle, *Trachemys scripta elegans* in Southwestern Spain: Transmission from native turtles', *Research in Veterinary Science*, vol 83, pp463–465

Jeschke, J. M. and Strayer, D. L. (2008) 'Usefulness of bioclimatic models for studying climate change and invasive species', *Annals of the New York Academy of Sciences*, vol 1134, pp1–24

Kearney, M. and Porter, W. (2009) 'Mechanistic niche modelling: Combining physiological and spatial data to predict species' ranges', *Ecology Letters*, vol 12, pp334–350

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*, vol 13(suppl. 1), pp5–15

Kraus, F. (2009) *Alien Reptiles and Amphibians: A Scientific Compendium and Analysis*, Springer, Dordrecht

Lamb, T., Bickham, J. W., Lyne, T. B. and Gibbons, J. W. (1995) 'The slider turtle as an environmental sentinel: Multiple tissue assays using flow cytometric analysis', *Ecotoxicology*, vol 4, pp5–13

Lever, C. (2003) *Naturalized Amphibians and Reptiles of the World*, Oxford University Press, New York

Lindeman, P. V. (1999) 'Aggressive interactions during basking among four species of Emydid turtles', *Journal of Herpetology*, vol 33, pp214–219

Luiselli, L., Capula, M., Capizzi, D., Filippi, E., Jesus, V. T. and Anibaldi, C. (1997) 'Problems for conservation of pond turtles (*Emys orbicularis*) in Central Italy: Is the introduced Red-Eared Turtle (*Trachemys scripta*) a serious threat?', *Chelonian Conservation and Biology*, vol 2, pp417–419

Macchi, S. (2008) 'Eco-ethological characterization of the alien slider Trachemys scripta and evaluation of the effects of its introduction on the conservation of Emys orbicularis', PhD Thesis, Insubria University, Varese, Italy

Macchi, S., Balzarini, L. L. M., Scali, S., Martinoli, A. and Tosi, G. (2008) 'Spatial competition for basking sites between the exotic slider *Trachemys scripta* and the European Pond Turtle *Emys orbicularis*', in C. Corti (ed) *Herpetologia Sardiniae*, Belvedere, Latina, pp338–340

Manel, S., Williams, H. C. and Ormerod, S. J. (2001) 'Evaluating presence–absence models in ecology: The need to account for prevalence', *Journal of Applied Ecology*, vol 38, pp291–931

Meek, R. and Avery, R. A. (1988) 'Thermoregulation in chelonians', *Herpetological Journal*, vol 1, pp253–259

Morosovsky, N. and Pieau, C. (1991) 'Transitional range of temperature, pivotal temperatures and thermosensitive stages for sex determination in reptiles', *Amphibia-Reptilia*, vol 12, pp169–179

Morreale, S. J. and Gibbons, J. W. (1986) *Habitat Suitability Index Models: Slider Turtle*, US Fish and Wildlife Service Biological Report 82, Washington DC

O'Keeffe, S. (2005) 'Investing in conjecture: Eradicating the read-eared slider in Queensland', in *Proceedings of the 13th Australasian Vertebrate Pest Conference*, The Museum of New Zealand (Te Papa), Wellington, New Zealand

Packard, G. C., Trucker, J. K., Nicholson, D. and Packard, M. J. (1997) 'Cold tolerance in hatchling slider turtles (*Trachemys scripta*)', *Copeia*, vol 1997, pp339–345

Parmenter, R. R. (1980) 'Effects of food availability and water temperature on the feeding ecology of pond sliders (*Chrysemys s. scripta*)', *Copeia*, vol 1980, pp503–514

Pendlebury, P. (2009) '*Trachemys scripta elegans*', in *IUCN/SSC Invasive Species Specialist Group, www.issg.org/database/species/ecology.asp?si=71&fr=1&sts=*

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,* vol 32, in press

Polo-Cavia, N., Lopez, P. and Martin, J. (2008) 'Interspecific differences in responses to predation risk may confer competitive advantages to invasive freshwater turtle species', *Ethology*, vol 114, pp115–123

Polo-Cavia, N., Lopez, P. and Martin, J. (2009) 'Interspecific differences in heat exchange rates may affect competition between introduced and native freshwater turtles', *Biological Invasions*, vol 11, pp1755–1765

Polo-Cavia, N., Gonzalo, A., Lopez, P. and Martin, J. (2010a) 'Predator recognition of native but not invasive turtle predators by naïve anuran tadpoles', *Animal Behaviour*, vol 80, pp461–466

Polo-Cavia, N., Lopez, P. and Martin, J. (2010b) 'Interspecific differences in heat exchange rates may affect competition between introduced and native freshwater turtles', *Biological Invasions*, vol 12, pp2141–2152

Prévot-Julliard, A. C., Gousset, E., Archinard, C., Cadi, A. and Girondot, M. (2007) 'Pets and invasion risks: Is the Slider turtle strictly carnivorous?', *Amphibia-Reptilia*, vol 28, pp139–143

Pupins, M. (2007) 'First report on recording of the invasive species *Trachemys scripta elegans*, a potential competitor of *Emys orbicularis* in Latvia', *Acta Universitatis Latviensis – Biology*, vol 723, pp37–46

Ramsay, N. F., Ng, P. K. A., O'Riordan, R. M. and Chou, L. M. (2007) 'The read-eared slider (*Trachemys scripta elegans*) in Asia: A review', in F. Gherardi (ed) *Biological Invaders in Inland Waters: Profiles, Distribution, and Threats*, Springer, Dordrecht, pp161–174

Rödder, D., Kwet, A. and Lötters, S. (2009a) 'Translating natural history into geographic space: A macroecological perspective on the North American Slider, *Trachemys scripta* (Reptilia, Cryptodira, Emydidae)', *Journal of Natural History*, vol 43, pp2525–2536

Rödder, D., Schmidtlein, S., Veith, M. and Lötters, S. (2009b) 'Alien invasive slider turtle in unpredicted habitat: A matter of niche shift or of predictors studied?', *PLoS ONE*, vol 4, ppe7843

Savage, J. M. (2002) *The Amphibians and Reptiles of Costa Rica*, University of Chicago Press, Chicago

Scalera, R. (2007) 'Virtues and shortcomings of EU legal provisions for managing NIS: *Rana catesbeiana* and *Trachemys scripta elegans* as case studies', in F. Gherardi (ed) *Biological Invaders in Inland Waters: Profiles, Distribution, and Threats*, Springer, Dordrecht, pp669–678

Scalera, R. (2009) '*Trachemys scripta* (Schoepff), common slider', in DAISIE (ed) *Handbook of Alien Species in Europe*, Springer, Dordrecht, p374

Spinks, P. Q., Pauly, G. B., Crayon, J. J. and Shaffer, H. B. (2003) 'Survival of the western pond turtle (*Emys marmorata*) in an urban California environment', *Biological Conservation*, vol 113, pp257–267

Teillac-Deschamps, P. and Prévot-Julliard, A. C. (2006) 'Impact of exotic slider turtles on freshwater communities: An experimental approach', in *First European Congress of Conservation Biology, Book of Abstracts*, Society for Conservation Biology, Heger, Hungary, pp162–163

Teillac-Deschamps, P., Lorrilliere, R., Servais, V., Delmas, V., Cadi, A. and Prévot-Julliard, A. C. (2009) 'Management strategies in urban green spaces: Models based on an introduced exotic pet turtle', *Biological Conservation*, vol 142, pp2258–2269

Telecky, T. M. (2001) 'US import and export of live turtles and tortoises', *Turtle and Tortoise Newsletter*, vol 4, pp8–13

Tucker, J. K. and Packard, G. C. (1998) 'Overwinter survival by hatchling sliders (*Trachemys scripta*) in West-Central Illinois', *Journal of Herpetology*, vol 32, pp431–434

Wibbels, T., Bull, J. J. and Crews, D. (1991) 'Chronology and morphology of temperature-dependent sex determination', *The Journal of Experimental Zoology*, vol 260, pp371–381