MIGUEL ÂNGELO PARDAL
JOÃO CARLOS MARQUES
MANUEL AUGUSTO GRAÇA
Scientific Editors

Aquatic Ecology of the Mondego River Basin
Global Importance of Local Experience

Coimbra • Imprensa da Universidade

MIGUEL ÂNGELO PARDAL
JOÃO CARLOS MARQUES
MANUEL AUGUSTO GRAÇA
Scientific Editors

Aquatic Ecology of the Mondego River Basin
Global Importance of Local Experience

Coimbra • Imprensa da Universidade

COORDENAÇÃO EDITORIAL
Imprensa da Universidade de Coimbra

CONCEPÇÃO GRÁFICA
António Barros

INFOGRAFIA
António Resende
Estímulus [design] • Coimbra

EXECUÇÃO GRÁFICA
GRAFIASA

ILUSTRAÇÃO DA CAPA
P. P. Cunha e J. Dinis

ISBN
972-8704-04-6

DEPÓSITO LEGAL
175038/02

OBRA PUBLICADA COM O PATROCÍNIO DE:
IMAR – INSTITUTO DO MAR
IPIMAR – INSTITUTO DE INVESTIGAÇÃO DAS PESCAS E DO MAR

José Miguel Oliveira [1,2]
Tiago Múrias [1]
Mário Reis [2]

AMPHIBIAN POPULATIONS IN THE LOWER MONDEGO RIVER VALLEY: SPECIES OCCURRENCE AND DISTRIBUTION PATTERNS

Abstract

The lower Mondego River valley encompasses ca. 15,000 ha of fertile lowlands in central Portugal. Land-use is mostly agricultural. Projected infra-structural works aim to modify over 80% of the surface, including terrestrial and aquatic habitats, and may affect the occurrence and distribution of the local wildlife. We mapped the occurrence and distribution of amphibians in 1999. The following nine species were found: *Salamandra salamandra, Pleurodeles waltl, Triturus marmoratus, Discoglossus galganoi, Pelodytes ibericus, Bufo bufo, Hyla arborea, Hyla meridionalis* and *Rana perezi*. The highest species richness was found in the southern hills, adjacent to the valley. The core of the valley showed low amphibian diversity with only *Rana perezi* and *Hyla arborea* present.

Introduction

The lower Mondego River valley is located in the central part of Portugal. The valley is roughly east-west orientated and 40 km long (from the city of Coimbra to the estuary near Figueira da Foz, Fig. 1) and bordered by gently sloping hills. The floodplains cover ca. 15,000 ha of fertile land and have traditionally been used for agriculture. Currently, the main crops are rice and corn. Production is intensive. In consequence of the agricultural land-use, the floodplains form a monotonous landscape, with low habitat diversity. The most important places in terms of biodiversity are the numerous drainage ditches with, in some places, important settings of marginal and occasionally submerged aquatic vegetation. Many of these ditches are connected into a network, that, for some species, may function as corridors for dispersal (Andresen and Bóia 1999). The network is at places connected to the Mondego river with locally flourishing floral and faunal communities, underlining its importance (Andresen and Bóia 1999). The local nature reserves form part of the network also. The landscape of hills bordering the valley is structurally more complex, less intensively cultivated, with fair amounts of semi-natural

(1) IMAR – Instituto do Mar, Centro Interdisciplinar de Coimbra a/c Departamento de Zoologia, Universidade de Coimbra, 3004-517 Coimbra Portugal

(2) ICN – Instituto da Conservação da Natureza

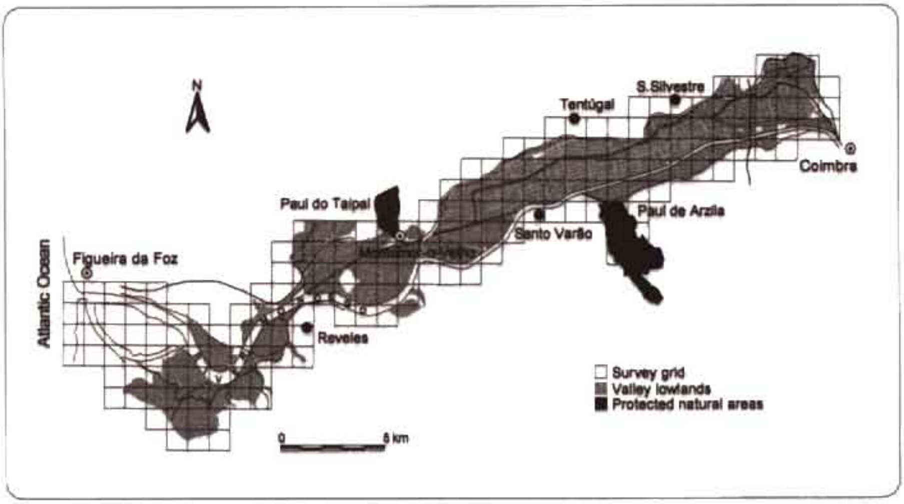

Fig. 1. Representation of the study area and survey grid used (1 km UTM squares).

vegetation and potentially presenting a mosaic of habitats suitable for amphibians. Altitude varies and with that, habitat types, including small forests, small agricultural parcels and a relatively high number of small water bodies with a more varied aquatic vegetation.

The near future will see the implementation of a re-allotment program in which the small agricultural parcels of the floodplains will be fused to form larger ones. The purpose of the project is to further increase the efficiency of production. The program will cover 67% of the surface and over 90% of the ditches (Andresen and Bóia 1999). These drainages, currently the main potential breeding sites for amphibians in the area, will either be transformed or disappear completely. Obviously, environmental changes of this magnitude will affect existing amphibian populations. Unfortunately, data on the distribution of amphibians in the lower Mondego River valley, such as in the national atlases (Crespo and Oliveira 1989, Malkmus 1995, Godinho et al. 1999) are limited – numerically, and also in terms of resolution. Detailed data are available for two of the protected areas of the valley only, namely Paul de Arzila and Paul do Taipal (Anastácio and Amaro 1989a, 1989b, Ferrand de Almeida et al. 1983, 1984, Ferrand de Almeida 1986, 1991, Ferreira et al. 1993). In order to be able to assess the response of amphibians to the imminent habitat change, it is important to now gather basic information on their distribution.

Materials and Methods

The study area was defined as the lowlands of the lower Mondego River valley, up to and including the slopes of surrounding hills and excluding the subsidiary rivers' basins. Surveys were made on the basis of the 1x1 km UTM grid system, marked on

1:25,000 military maps (Instituto Geográfico do Exército). The study area encompassed 192 grid cells. Each square was visited once over the period March – December 1999. The different surveyed areas of the valley were randomly visited during the study period. Every site of interest was searched. Special attention was given, during the breeding season from March to July, to the relatively few water bodies suitable for amphibian reproduction.

Water bodies were searched with the help of a dip net with a 4-mm mesh size, which allows detection of all stages of newts, frogs and toads (Griffiths and Raper 1994). Additionally, we searched for eggs that can be identified to the species, such as those of *Triturus marmoratus*, *T. boscai* and *Bufo bufo*. Larvae were identified following the tables in Arnold and Burton (1978) and Barbadillo (1987). Potential terrestrial habitats were searched, including the leaves and branches of small bushes, that may be used by *Hyla arborea* and *H. meridionalis* (Barbadillo 1987, Crespo and Oliveira 1989). Night searches (n=7) distributed across the valley were carried out during warm and humid nights and following rain, aiming for *Bufo bufo* and *B. calamita* in particular (Denton and Beebee 1992). Call recordings were also used as a survey tool, in particular for *Hyla arborea* and *Rana perezi* (Márquez and Matheu 1998).

Preliminary data vouch for *P. clarkii* (Girard 1852), an allochtonous crustacean, as an important predator on some amphibian species (J. W. Arntzen, pers. comm.). Its presence was surveyed from live individuals and, indirectly, from legs, carapaces and burrows.

Environmental data recorded included geographic location, weather conditions and a brief site description and its surroundings (e.g. nature of the habitat such as pond, lake, river, ditch or otherwise, vegetation, distance from water etc.). All biological material handled during the survey was released following identification. In face of the difficulty to obtain accurate population density estimates (Griffiths and Raper 1994) analyses were restricted to presence-absence data. Selected information is included in a Geographic Information System database of the Mondego valley, under the responsibility of I. C. N.

Results

Survey

The following nine species of amphibians were found: *Pleurodeles waltl*, *Salamandra salamandra* and *Triturus marmoratus* (order Urodela); *Discoglossus galganoi*, *Pelodytes ibericus*, *Bufo bufo*, *Hyla arborea*, *Hyla meridionalis*, and *Rana perezi* (order Anura). For further nomenclature see Table 1. All observations are in Figs 2 – 10, arranged according to UTM grid cells. *Rana perezi* and *Hyla arborea* were found across the valley, thus showing a more or less even distribution. The other seven species were found in the southern rim of the valley only. These differing distribution patterns are illustrated in Fig. 11. Fig. 12 shows amphibian species richness of the Mondego valley. Finally, the distribution of *P. clarkii* is shown in Fig. 13.

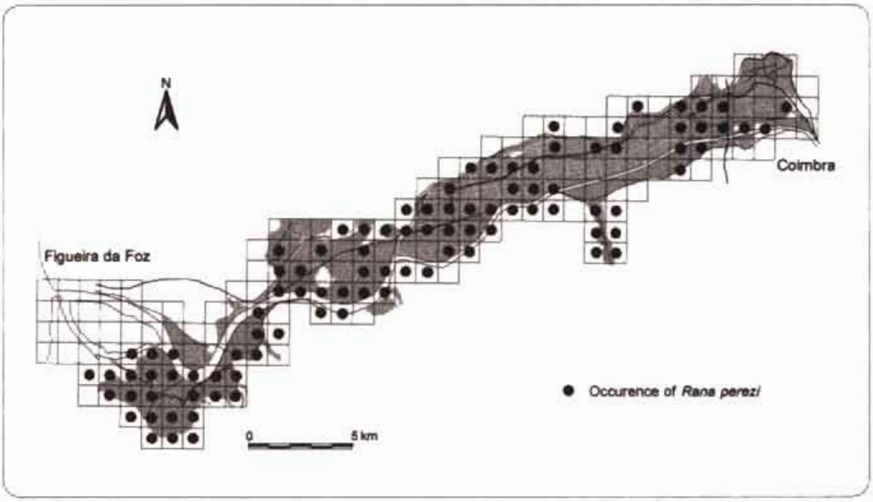

Fig. 2. Distribution of *Rana perezi* in the lower Mondego River valley.

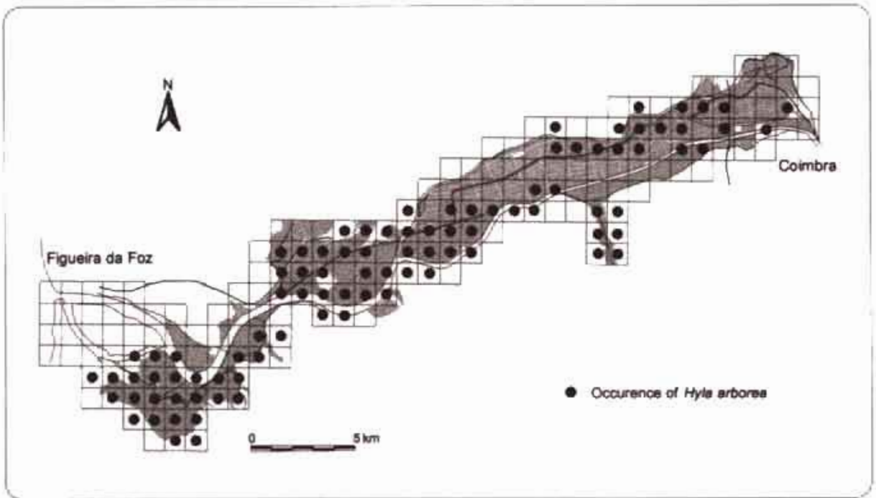

Fig. 3. Distribution of *Hyla arborea* in the lower Mondego River valley.

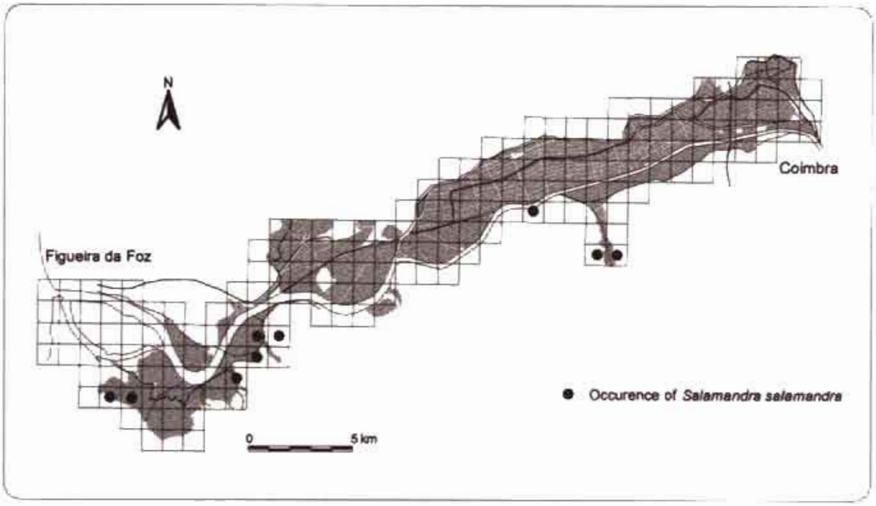

Fig. 4. Distribution of *Salamandra salamandra* in the lower Mondego River valley.

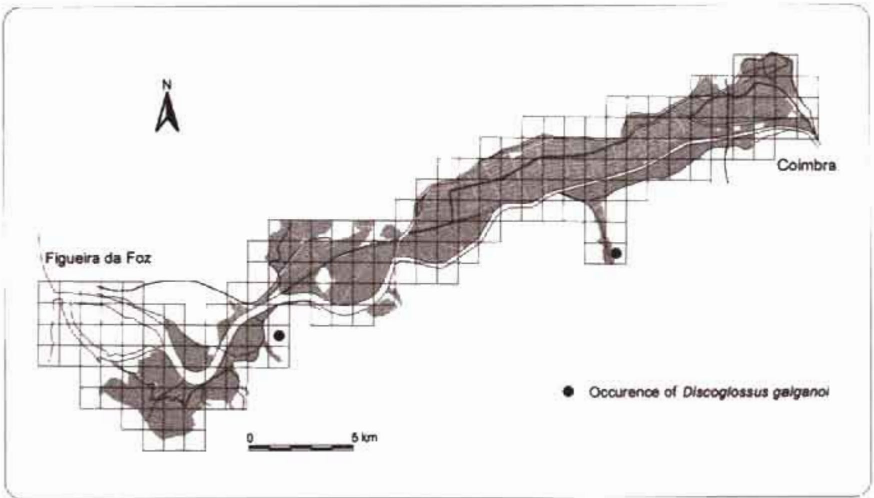

Fig. 5. Distribution of *Discoglossus galganoi* in the lower Mondego River valley.

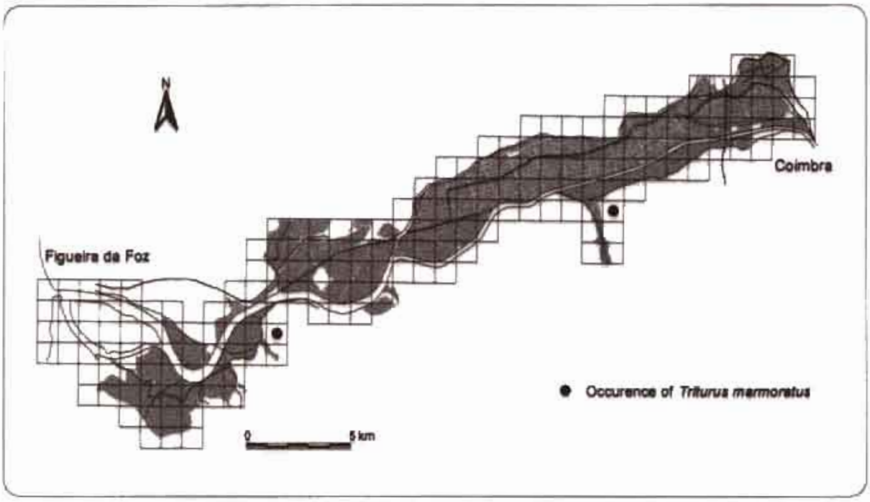

Fig. 6. Distribution of *Triturus marmoratus* in the lower Mondego River valley.

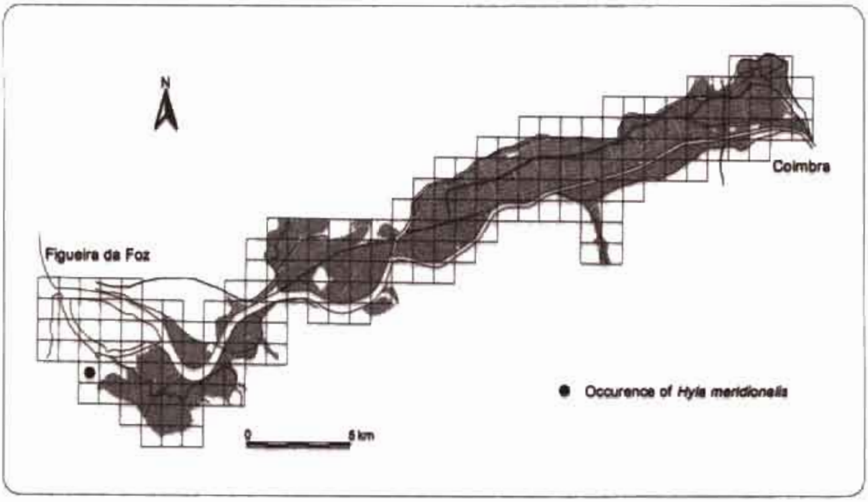

Fig. 7. Distribution of *Hyla meridionalis* in the lower Mondego River valley.

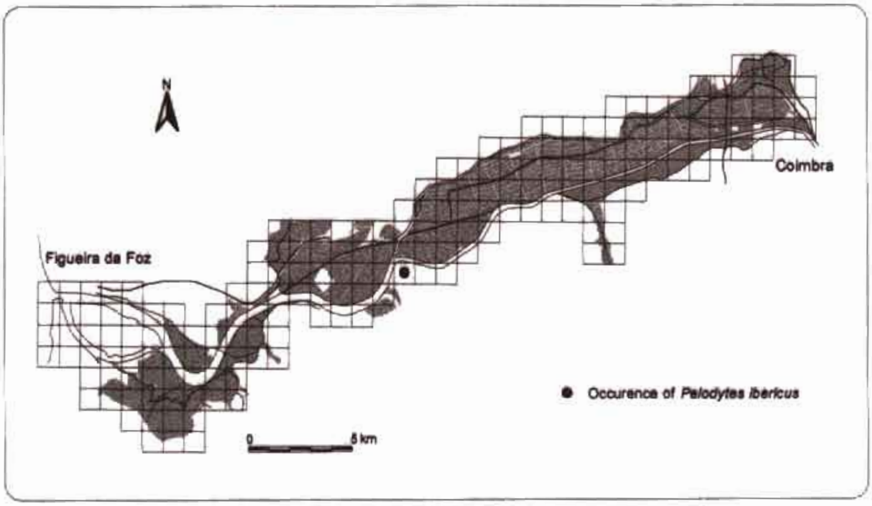

Fig. 8. Distribution of *Pelodytes ibericus* in the lower Mondego River valley.

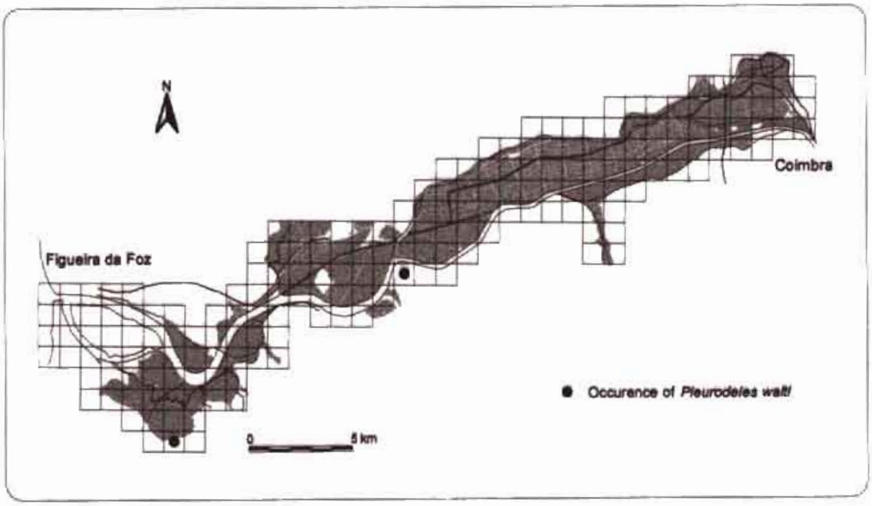

Fig. 9. Distribution of *Pleurodeles waltl* in the lower Mondego River valley.

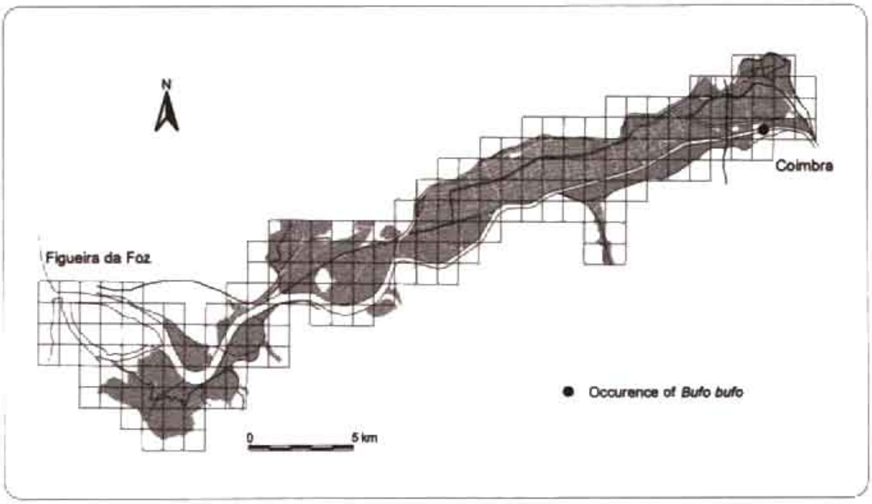

Fig. 10. Distribution of *Bufo bufo* in the lower Mondego River valley.

Table 1. Amphibian species found in the lower Mondego river valley in 1999, with their Portuguese and English vernacular names.

Species	English name	Portuguese name
Pleurodeles waltl Michahelles, 1830	Ribbed newt	Salamandra-de-costelas-salientes
Salamandra salamandra (Linnaeus, 1758)	Fire salamander	Salamandra-de-pintas-amarelas
Triturus marmoratus (Latreille, 1800)	Marbled newt	Tritão-marmorado
Discoglossus galganoi Capula, Nascetti, Lanza, Bullini and Crespo, 1985	Iberian Painted frog	Sapo-de-focinho-ponteagudo
Pelodytes ibericus Sánchez-Herráiz, Barbadillo, Machordom, Sanchiz, 2000*	Iberian Parsley frog	Sapinho-de-verrugas-verdes
Bufo bufo (Linnaeus, 1758)	Common toad	Sapo
Hyla arborea (Linnaeus, 1758)	European tree frog	Rela
Hyla meridionalis Boettger, 1874	Mediterranean tree frog	Rela-meridional
Rana perezi Seoane, 1885	Iberian waterfrog	Rã-verde

* *Pelodytes* from southern Spain and Portugal are no longer classified as *Pelodytes punctatus*, but, following the study on external morphology and allozymes by Sánchez-Herráiz et al. (2000), considered to belong to the newly recognised *P. ibericus*.

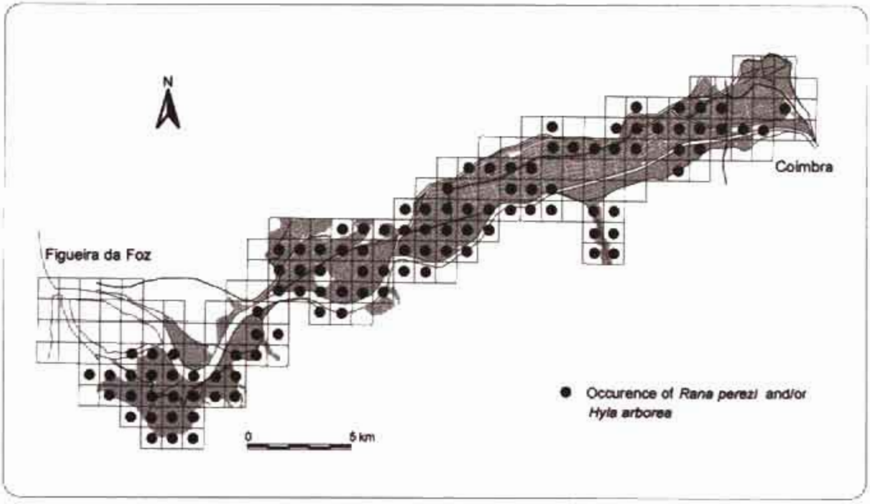

Fig. 11a. Distribution of *Rana perezi* and *Hyla arborea* in the lower Mondego River valley.

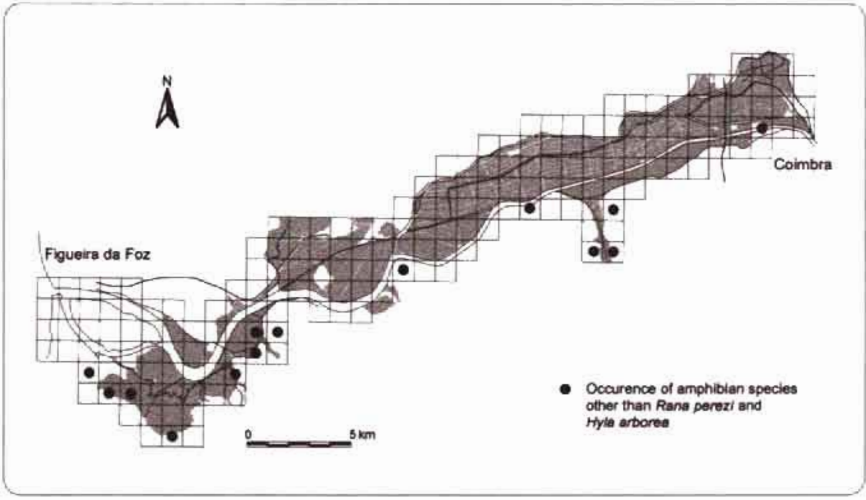

Fig. 11b. Distribution of amphibian species other than *Rana perezi* and *Hyla arborea*.

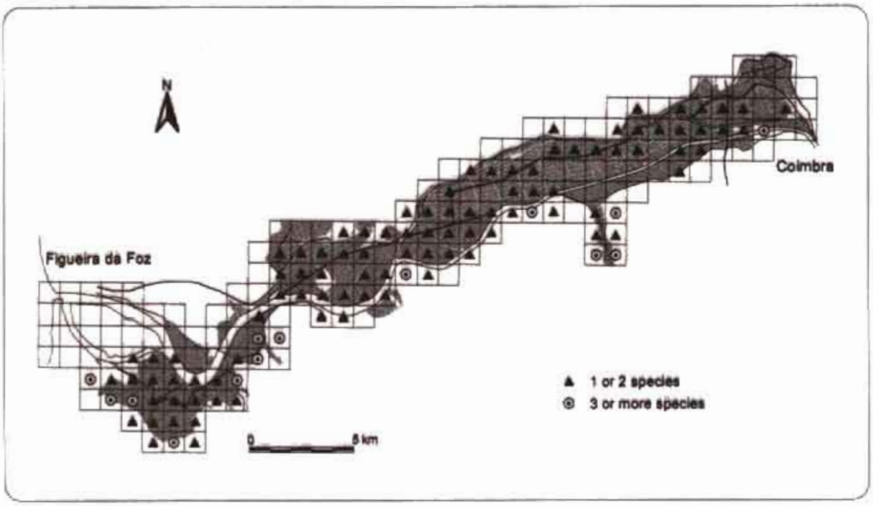

Fig. 12. Species Richness in the lower Mondego River valley.

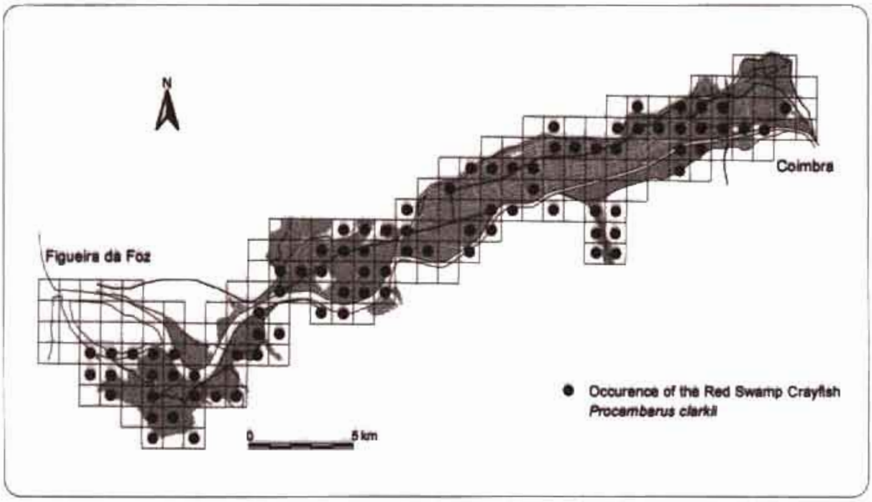

Fig. 13. Distribution of the Red Swamp Crayfish *Procambarus clarkii* in the lower Mondego River valley.

Discussion

Species accounts

The following accounts are arranged in decreasing order of observed species abundance.

Rana perezi was observed in all types of water bodies, including ditches, wells, ponds, rivers, quarries and channels, as well as on land, mostly in short vegetation near the water. With an observed presence in 96 of the 192 (50 %) grid cells *R. perezi* appears to be the most widespread amphibian of the lower Mondego with a wide ecological amplitude. It is probably the most widespread and abundant amphibian of Portugal (Godinho et al. 1999), and it is reported to tolerate strong pollution (Barbadillo 1987). Where crayfish density was high in shallow water, tadpoles frequently had damaged or cut tails, suggestive of crayfish attacks. However, direct predations of crayfish on the frogs were not observed.

Hyla arborea was observed in 92 out of 192 grid cells (48 %). From late spring onwards the species was easily detected by day, on the leaves and branches of small shrubs. In the Reveles village surroundings densities were estimated as up to six freshly metamorphosed froglets per m^2. While the species is in decline at the European scale (Stumpel 1997), it is as yet common and widespread in the Mondego valley. A close association was observed between *H. arborea* and the invasive umbelliferid *Eryngium pandanifolium* Cham. and Schlect. of South African origin. *Hyla arborea* was observed to often hide in between its spiky leafs, particularly so by daytime and in winter. This behaviour is similar to other tropical hylid frogs which rest in bromeliads and leave only the head exposed, potentially reducing evapotranspiration (Siebert et al. 1974, in Duellman and Trueb 1986). In Portugal *E. pandanifolium* is currently only known for the Mondego valley (Andresen and Bóia 1999), providing opportunities for a comparative study on the local adaptive behaviour shown by *H. arborea*.

All seven species with non-widespread distributions were limited to the southern rim of the valley. Adults and/or larvae of *Salamandra salamandra* were detected in nine grid cells (5 %). *Pleurodeles waltl*, *Triturus marmoratus* and *Discoglossus galganoi* were observed in two grid cells each (1 %). Observations on *P. waltl* concerned larvae. *T. marmoratus* were adults and eggs. No reproduction was observed for *D. galganoi*, for which species only adults were found. The remaining three species, *Bufo bufo*, *Hyla meridionalis* and *Pelodytes ibericus*, were observed in one grid cell each.

Bufo bufo was observed in the Mata Nacional do Choupal area as adults. The wide Eurasian range would suggest a wide ecological amplitude for this species and one might expect it to be widespread at a local scale also (Crespo and Oliveira 1989, Malkmus 1995, Borkin and Veith 1997). Perhaps we missed some occurrences due to inappropriate methodology. The survey method was carried mostly at daytime, while *Bufo*-adults are easier to detect at night (Denton and Beebee 1992). Also we may have missed the short period of breeding in early spring (Arntzen 1999). However, the night searches for other species were successful, and no *Bufo bufo* tadpoles were ever detected and we conclude that the species is genuinely rare locally. Honegger (1981) reported a decline of *Bufo bufo* on cultivated lowlands. In the absence of historical data we cannot establish the conservation status of the species in the lower Mondego valley.

Hyla meridionalis was detected in the southwestern part of the valley, which record constitutes one of the northernmost localities for this species in the western half of the country (cf. Godinho et al. 1999). Its close proximity to sites with *H. arborea* suggests their possible co-occurrence, which would provide the opportunity to study ecological and genetic species interactions, including hybridization (Oliveira et al. 1991).

Pelodytes ibericus is known to be difficult to observe, due to its weak voice, enigmatic ecological preferences and secretive behaviour. The recent recognition of this endemic taxon at the species level highlights our lack of basic knowledge on the species' natural history. The sister species *P. punctatus* was considered to be among the least known species of the Palaearctic herpetofauna (Toxopeus et al. 1993, Guyétant et al. 1999). The locality in the Mondego valley is a reproduction site, as evidenced by our observations on pairs in amplexus and tadpoles. Unfortunately, the locality may be under threat from future building activities. This is a serious concern, given the rarity of the species within its small, south-western Iberian range.

Amphibian landscape ecology

Two geographical patterns were observed for amphibian species in the lower Mondego valley. The first pattern arises from the distribution of *Rana perezi* and *Hyla arborea* that show a regular distribution across the valley (Fig. 11a). The coastal areas are not included, possibly due to a high level of salinity of the still waters. *Rana perezi* has a high reproductive capacity an account of an early sexual maturity, high female fecundity and the tolerance of tadpoles to conditions of poor water quality. The species thrives over a wide spectrum of environmental conditions and is tolerant to certain kinds of pollution (Barbadillo 1987, Nöllert and Nöllert 1995). The preponderance of *Hyla arborea* in the lower Mondego river valley suggests that good habitat conditions are available for this species also. Many of the ditches and some rice fields contained tadpoles of *Rana perezi* and *Hyla arborea*, whereas no other species were found.

The second distribution pattern arises from the shared distribution data on the other species, showing a distribution along the southern rim of the valley (Fig. 11b). Conversely, the northern margins of the valley do not seem to present similar species richness. A possible reason is that the area is more disturbed than at the south. It is also less accessible, which may have resulted in a survey bias.

Considering the known distribution and ecology of the 17 amphibian species of continental Portugal (Crespo and Oliveira 1989, Malkmus 1995, Gasc et al. 1997, Godinho et al. 1999), four more species could have occurred in the study area but were not detected. This involves Bosca's newt, *Triturus boscai* (Lataste 1879), the common midwife toad, *Alytes obstetricans* (Laurenti 1768), the Iberian spadefoot, *Pelobates cultripes* (Cuvier 1829) and the natterjack, *Bufo calamita* Laurenti 1768. Their apparent absence may be linked to a variety of factors, the most important ones probably are the scarcity of suitable breeding ponds and particular soil characteristics. Proper ponds are scarce in the valley. In large areas the drainage ditches are the only places available for breeding, but to several species these do not offer the right conditions. Similarly, soil characteristics are generally unsuitable for species with a fossorial mode of life. These species prefer sandy soils while most of the valley is dominated by acidic argillaceous substrates, often disturbed by agricultural machinery and periodic floods.

Conservation status and threats

The main potential factors influencing the local distribution of amphibians and their threats we assess as i) habitat availability and habitat change, ii) pollution and biocides, and iii) allochtonous species.

Habitat availability and change – The lower Mondego valley has been used for agricultural purposes for centuries. In former times, however, the land use was diverse, patchy and not intensive (Andresen and Bóia 1999), whereas at present agriculture is intensive, with a few main crops, and with little or no land remaining unoccupied. This suggests that the complexity of the ecosystem has been higher, potentially favouring species numbers and coexistence, in contrast with the present day situation of open, almost laser-leveled fields, with shelter of any sort, important to many species, and adequate breeding structures nearly absent. Only *Rana perezi* and *Hyla arborea* appear capable to use the ditches and temporary inundated rice fields for breeding. The almost absence of other types of standing water is the most likely single factor that prevents other species, now restricted to the margins, to occupy the core of the valley.

Pollution and biocides – Data on the effects of pollution on amphibians are scarce. Some evidence suggests that fungicides, herbicides and insecticides hinder reproduction and development (Blaustein and Wake 1995). Fourty-one different biocides were used in the Lower Mondego valley in 1998, for just corn and rice (Andresen and Bóia 1999). Soil disinfection is considered indispensable and common practice. In spite of legislation, insecticides based on organophosphates are still in use, alongside with pyrethroids and carbamates. Their application in April and May coincides with the breeding season of most amphibians. The use of liquid herbicides in rice cultivation extends in to July. Spread compounds such as chlorpyriphos are highly toxic. Moreover, the long half-life time of other used substances such as dimethoate may have serious environmental effects as to jeopardise human health (Andresen and Bóia 1999). In view of the intensive farming in the valley, the perceived need to increase production and known practices, the contamination of surface waters in the valley is more than likely and a certain impact on amphibians plausible.

Allochtonous species – Introduced species are increasingly recognised as serious threats to amphibian (Blaustein and Wake 1995), including known predators such as some decapod crustaceans (Axelsson et al. 1997). The red swamp crayfish, *Procambarus clarkii* is known to inhabit the Mondego valley since 1987. The density of this allochtonous crustacean rapidly increased and already by 1990 it was considered an agricultural pest (Marques et al. 1992), causing serious damage to the drainage systems through its borrowing activities (Anastácio and Marques 1995). The capacity of *P. clarkii* to settle in new habitats, its tolerance to a wide range of environmental conditions (Hobbs et al. 1989 in Anastácio and Marques 1995) and multiple recruitment periods in Portugal (Anastácio and Marques 1995) may have contributed to the success of the species in the Mondego valley.

The effects of this crustacean on the amphibian fauna might be either direct through e.g. predation on eggs and larval stages, or indirect, through alterations to the habitat. Axelsson et al. (1997) demonstrated with laboratory experiments the predatory activity of this group of crustaceans on amphibian eggs and larvae, including *Hyla arborea* and *Bufo bufo* (despite tadpoles of the latter species being unpalatable to many predator species, Duellman and Truebb 1986, Denton and Beebee 1991, Banks et al. 1993). Indirect effects include a decrease in the habitat complexity through a reduction in aquatic vegetation from crayfish grazing and burrowing, therewith reducing space available for shelter and for egg deposition. Indeed, Axelsson et al. (1997) showed that a reduced habitat complexity increased crayfish predation on *Hyla arborea* tadpoles. In 1990, massive amounts of xenobiotics (including dimethoate, endosulfan and parathion) were used in an attempt to eradicate the crayfish (Marques et al. 1992). The measures had no marked effect, and in 1991 the number of crayfish populations had further increased. Instead, the high doses that were applied caused serious risk to public health (Marques et al. 1992). The effects on the amphibian populations of the Lower Mondego valley remained unstudied.

Recommendations for future work

We assessed amphibian species presence and distribution across the lower Mondego river valley. The work constitutes a first and preliminary contribution to our knowledge of the local amphibian fauna. The Lower Mondego river valley shows an interesting diversity of amphibian species, which is surprising given the intensive human pressure in the area. However, future work is mandatory. Several species were only detected in one or two localities. Further surveying and the monitoring of populations is in order. In addition to mapping, it would be of importance for future reference to estimate the size of one or more populations for each of the species. Future surveying should include the secondary river basins. Several localities that harbour locally rare species deserve special attention in agricultural engineering and landscape planning. Habitat creation and restoration would be particularly beneficial for species that are locally abundant but rare and endangered elsewhere, such as *Hyla arborea*. Implementation of a program for pond creation could be an efficient and relatively inexpensive way of counteracting the negative impact of anthropogenic interventions on the amphibian populations of the valley. The potential effects of each of the threatening factors on the viability of amphibian populations in the valley require also careful assessment. For instance, the effects of the widely distributed *P. clarkii* on the amphibian populations of the valley remains unclear. In view of the potential regulatory role in amphibian ecosystems, a deeper look into crayfish - amphibian interactions seems warranted. Indeed, experimental confirmation and quantification of the effects of the mentioned factors on the regulation of the amphibian populations would be a first step towards the conservation of this group of vertebrates in the Lower Mondego river valley.

Acknowledgements

We thank Dr. J. W. Arntzen for encouragement and for critical comments on an earlier version of the manuscript and Manuel da Luz for assistance with the production

of the figures. J.M.O. was supported by I.C.N. through a grant conceded by the "Programa Nacional de Estágios em Áreas Protegidas".

References

Anastácio, P.M. and Amaro, P.N. 1989a. Levantamento ornitológico da Quinta do Taipal. FCTUC-UC e Serviço Nacional de Parques, Reservas e Conservação da Natureza.

Anastácio, P.M. and Amaro, P.N. 1989b. Breves notas sobre os estudos faunísticos na Quinta do taipal. Actas do II Congresso das Áreas Protegidas: 259-267.

Anastácio, P.M. and Marques, J.C. 1995. Population biology and production of the red swamp crayfish *Procambarus clarkii* (Girard) in the lower Mondego River valley, Portugal. J. Crust. Biol. 15: 156-168.

Andresen, T. and Bóia, C. (Coord.) 1999. Estudo de impacte ambiental do perímetro de emparcelamento de Alfarelos no Baixo Mondego. Departamento de Ambiente e Ordenamento, Universidade de Aveiro, Aveiro.

Arnold, E.N. and Burton, J.A. 1978. Guia de campo de los reptiles y anfibios de España y de Europa. Ed. Omega, Barcelona.

Arntzen, J.W. 1999. Sexual selection and male mate choice in the common toad, *Bufo bufo*. Ethology, Ecology and Evolution 11: 407-414.

Axelsson, E., Nyström, P., Sidenmark, J., Brönmark, C. 1997. Crayfish predation on amphibian eggs and larvae. Amphibia-Reptilia 18: 217-228.

Banks, B., Beebee, T.J.C., Denton, J.S. 1993. Long term management of a natterjack toad *(Bufo calamita)* population in southern Britain. Amphibia-Reptilia 14: 155-168.

Barbadillo, L.J. 1987. La guía INCAFO de los anfibios y reptiles de la Península Ibérica, Islas Baleares y Canarias. Ed. INCAFO, Madrid.

Blaustein, A.R. and Wake, D.B. 1995. The puzzle of declining amphibian populations. Scientific American 272: 56-61.

Borkin, L.J. and Veith, M. 1997. *Bufo bufo* (Linnaeus, 1758). *In* Atlas of Amphibians and Reptiles in Europe. Edited by J.P. Gasc, A. Cabela, J. Crnobrnja-Isailovic, D. Dolmen, K. Grossenbacher, P. Haffner, J. Lescure, H. Martens, J.P. Martinez Rica, H. Maurin, M.E. Oliveira, T.S. Sofianidou, M. Veith and A. Zuiderwijk. Societas Europaea Herpetologica and Muséum National d'Histoire Naturelle (IEGB/SPN), Paris. pp. 118-119.

Crespo, E.G. and Oliveira, M.E. 1989. Atlas da distribuição dos anfíbios e répteis de Portugal continental. Serviço Nacional de Parques, Reservas e Conservação da Natureza. Lisboa.

Denton, J.S. and Beebee, T.J.C. 1991. Palatibility of anuran eggs and embryos. Amphibia-Reptilia 12: 111-114.

Denton, J.S. and Beebee, T.J.C. 1992. An evaluation of methods for studying natterjack toads *(Bufo calamita)* outside the breeding season. Amphibia-Reptilia 13: 365-374.

Duellman, W.E., Trueb, L. 1986. Biology of Amphibians. McGraw-Hill Book Comp., New York, St. Louis, San Francisco.

Ferrand de Almeida, F.X., Ferrand de Almeida, P., Ferrand de Almeida, N.M., Moura, A.R., Silva, M.G., Paiva, J.A.R., Nogueira, I.M., Soares, A.F., Reis, R.P.B.P., Godinho, M.M., Oliveira, J.M.P. 1983. Aspectos faunísticos, florísticos, geológicos e geográficos do Paúl de Arzila. Ciênc. Biol. Ecol. Syst. 5: 43-76.

Ferrand de Almeida, F., Ferrand de Almeida, P., Ferrand de Almeida, N. 1984. Nova contribuição para o conhecimento da fauna do Paúl de Arzila. Ciênc. Biol. Ecol. Syst. 5: 191-194.

Ferrand de Almeida, F. 1986. Paúl de Arzila: futura reserva da biosfera. Cyanopica 4: 495-516.

Ferrand de Almeida, F. 1991. A criação da "reserva Natural do Paúl de Arzila" e nova contribuição para o conhecimento da sua fauna. Ciênc. Biol. Ecol. Syst 11: 47-58.

Ferreira, M.J., Antunes, P.M., Pereira, R.M. 1993. Distribuição dos anfíbios na Reserva Natural do Paúl de Arzila. Relatório de Estágio, FCTUC/UC.

Gasc, J.-P., Cabela, A., Crnobrnja-Isailovic, J., Dolmen, D., Grossenbacher, K., Haffner, P., Lescure, J., Martens, H., Martinez Rica, J.P., Maurin, H., Oliveira, M.E., Sofianidou, T.S., Veith, M. and Zuiderwijk, A. (Eds.) 1997. Atlas of Amphibians and Reptiles in Europe. Societas Europaea Herpetologica and Muséum National d'Histoire Naturelle (IEGB/SPN), Paris.

Godinho, M.R., Teixeira, J., Rebelo, R., Segurado, P., Loureiro, A., Alvares, Z.F., Gomes, N., Cardoso, P., Camilo-Alves, C., Brito, J.C. 1999 Atlas of the continental Portuguese herpetofauna: an assemblage of published and new data. Revista Española de Herpetologia 13: 61-82.

Griffiths, R.A. and Raper, S.J. 1994. A review of current techniques for sampling amphibian communities. JNCC Report No. 210. Joint Nature Conservation Committee, Peterborough.

Guyétant, R., Temmermans, W., Avrillier, J. N. 1999. Phénologie de la reproduction chez *Pelodytes punctatus* Daudin, 1802 (Amphibia, Anura). Amphibia-Reptilia 20: 149-160.

Honegger, R. E. 1981. Threatened amphibians and reptiles in Europe. Ed. by the European Comittee for the Conservation of Nature and Natural Resources - Council of Europe. Akademische Verlagsgesellschaft, Wiesbaden.

Malkmus, R. 1995. Die Amphibien und Reptilien Portugals, Madeira und der Azoren. Westarp Wissenschaften, Magdeburg.

Marques, J. C., Adão, H., Anastácio, P. 1992. Lagostim vermelho da Louisiana, *Procambarus clarkii* (Girard), espécie exótica em Portugal: bioecologia, impacto e controlo. 3ª Conferência Nacional sobre a Qualidade do Ambiente. Universidade de Aveiro. Aveiro. pp 303-312.

Márquez, R. and Matheu, E. (Eds.) 1998. Guia Sonora de las Ranas y Sapos de España e Portugal. Ed. Alosa, Barcelona.

Nöllert, A. and Nöllert, C. 1995. Los anfibios de Europa. Identificación, amenazas, protección. Ediciones Omega, S.A. Barcelona.

Oliveira, M. E., Paillette, M., Rosa, H. D., Crespo, E. G. 1991. A natural hybrid between *Hyla arborea* and *Hyla meridionalis* detected by mating calls. Amphibia-Reptilia 12: 15-20.

Sánchez-Herráiz, M.J., Barbadillo, L.J., Machordom, A., and Sanchiz, B. 2000. A new species of Pelodytid frog from the Iberian Peninsula. Herpetologica 56: 105-118.

Stumpel, A. 1997. *Hyla arborea* (Linnaeus, 1758). *In* Atlas of Amphibians and Reptiles in Europe. Edited by J.P. Gasc, A. Cabela, J. Crnobrnja-Isailovic, D. Dolmen, K. Grossenbacher, P. Haffner, J. Lescure, H. Martens, J.P. Martinez Rica, H. Maurin, M.E. Oliveira, T.S. Sofianidou, M. Veith and A. Zuiderwijk. Societas Europaea Herpetologica and Muséum National d'Histoire Naturelle (IEGB/SPN), Paris. pp. 124-125.

Toxopeus, A.G., Ohm, M., Arntzen, J.W. 1993. Reproductive biology of the parsley frog, *Pelodytes punctatus*, at the northernmost part of its range. Amphibia-Reptilia 14: 131-147.

Série

Investigação

•

Coimbra
Imprensa da Universidade

2002