Predation of newts (Salamandridae, Pleurodelinae) by Eurasian otters *Lutra lutra* (Linnaeus)

GARETH S. PARRY[1,2], NATHALIE YONOW[2] & DAN FORMAN[2*]

[1]Gloucestershire Wildlife Trust, The Conservation Centre, Robinswood Hill Country Park, Reservoir Road, Gloucester, GL4 6SX, UK
[2]Swansea Ecology Research Team, Department of Biosciences, College of Science, Swansea University, Swansea, SA2 8PP, UK
*Corresponding author email: d.w.forman@swansea.ac.uk

ABSTRACT - The remains of newts (Pleurodelinae) were recorded in Eurasian otter (*Lutra lutra*) spraints collected from two river systems on the Gower peninsula, Wales, U.K., between 2005 and 2007. Spraints were collected during detailed field surveys undertaken every two weeks as part of a two-year otter study. Palmate newt remains, mainly vertebrae and maxillae, were identified in 9.27% (43/464) of the spraints analysed by comparison with a reference collection of bones. This study demonstrates for the first time the extent to which otters may consume newts in the UK. Newt remains were recorded in spraints collected during all but two months (February and March) with the largest proportion of occurrences falling between April and July. Conservative estimates of the number of individuals consumed ranged between one and 31 newts per spraint. Newts represent a profitable prey for otters and, as with other amphibians, may represent a seasonally important dietary component with the newts becoming particularly vulnerable during reproductive accumulations. Sporadic but occasionally intense predation of newts by otters may affect both the breeding success and the dynamics of local newt populations. The presence of otters should be taken into consideration when planning conservation and translocation programs for newts. A photographic guide and morphological descriptions of amphibian remains is provided to aid future identification of amphibians in the diets of mammalian predators.

INTRODUCTION

Research into the predation of amphibians has predominantly focused on the impact of alien species of fish, amphibian, and crayfish (Kats et al. 2003); however, amphibians are also predated by a number of mammalian carnivores (Sidorovich & Pikulik 1997, McDonald 2002, Azevedo et al. 2006). The significance this holds for the dynamics and life history strategies of mammal and amphibian populations is poorly understood, representing a gap in our knowledge of the role of amphibians in trophic web dynamics. Investigating predation of amphibians by mammalian carnivores is limited by the difficulty in identifying amphibian remains to family or species level through faecal hard part analysis, which is the most frequently used dietary analysis technique.

Although the Eurasian otter (*Lutra lutra*) - hereafter referred to as the otter - is primarily piscivorous, this species actively exploits non-fish prey, particularly (and unsurprisingly) those species associated with aquatic environments (Carss 1995). As with many terrestrial mammalian carnivores, otter dietary studies usually rely upon the identification of prey remains in faeces or stomachs (Parry, 2010). Amphibian remains are frequently recorded in otter diet (e.g. Weber 1990, Brezeziński et al. 1993, Parry et al. 2011) and in some localities they form an important component of otter diet, particularly during late winter when the availability of fish prey is reduced (Carss 1995) or during spring when anurans aggregate in high densities to spawn (Clavero et al. 2005).

Unlike fish prey, which is usually assigned to family, genus, or even species level, amphibian remains are rarely described in detail. Predation of newts has been recorded in the American river otter *Lontra canadensis* (Toweill 1974), but confirmed predation of newts has only been recorded in a handful of published otter dietary studies (Britton et al. 2006, Pedroso and Santos-Reis 2006, Parry et al. 2011). Furthermore, to our knowledge, newt predation has not been recorded in published dietary studies of other mustelid species that can forage in freshwater environments, such as polecat (*Mustela putorius*), European mink (*M. lutreola*), and American mink (*Neovison vison*).

The scarcity of reports of newts in mustelid diet, in particular that of the otter, seems unusual considering that they occupy sympatric or parapatric habitat to anurans, which frequently occur in mustelid diet (Lode 1997, Sidorovich et al. 2007, Parry 2010). As with many amphibian species, newts aggregate for breeding (Hedlund and Robertson 1989), although these are less dense and subject to greater temporal variation than frogs and toads (Díaz-Paniagua 1992). Despite this, newts are a potential prey resource for mustelids such as the otter and that their availability will increase during the breeding season.

The infrequency of records of newt predation in the literature may be due to difficulties in identifying amphibian prey remains to family and genus level. Only two European studies have recorded the low occurrence of newts forming part of the amphibian diet of the Eurasian otter (Polednik et al. 2007, Cogalniceanu et al. 2010). In this study we report

the occurrence of palmate newts in otter diet on the Gower Peninsula, Wales, United Kingdom, a landscape that contains common frog *Rana temporaria*, common toad *Bufo bufo*, palmate newt *Lissotriton helveticus*, smooth or common newt *Lissotriton vulgaris*, and great crested newt *Triturus cristatus* (Russell, 2002). We also provide a photographic guide and morphological descriptions to aid future identification of amphibians in diets of mammalian predators.

METHODOLOGY

Dietary analysis
Otter spraints were collected at fortnightly intervals between December 2005 and January 2007 under licence (Countryside Council for Wales licence number OTH: SA: 178:2007) from rocks, trees, and boulders in the riparian corridors of the River Clyne (51°35'57"N, 3°59'48"W) and Burry Pill (51°37'21"N, 4°14'31"W) as part of a long-term study of otters on the Gower Peninsula in South Wales. Spraints were stored at -17°C until dietary analysis was undertaken. Individual spraints were soaked for 24 hours in a saturated solution of biological detergent before being rinsed through a 0.5mm sieve and left to air dry. Hard remains were identified using keys (Conroy et al. 2005) and a reference collection of vertebrae collected by the authors including samples from common toad, common frog, palmate newt, smooth or common newt, great crested newt, and slow worm (*Anguis fragilis*). Diet was described as Relative Frequency of Occurrence (RFO %)

The minimum number of individual newts was determined by counting maxillae using the assumption that two maxillae in one spraint sample represented a minimum of one newt. This is a conservative approach as the occurrence of two maxillae in one spraint could reflect the consumption of one or two newts.

Production of images
The images were produced using two programs: CombineZP (www.hadleyweb.pwp.blueyonder.co.uk/CZP/Installation.htm) and Image Composite Editor or ICE (www.research.microsoft.com/en-us/um/redmond/groups/ivm/ICE/).All photographs were taken with a webcam fitted with an adaptor slotting into the microscope (Wild M3Z) eyepiece.

RESULTS

Occurrence of newts in spraints
Vertebrae and maxillae of the palmate newt *L. helveticus* were recorded in 16.90% (36/213) of spraints collected from the River Clyne and 1.23% (11/898) of spraints collected from the Burry Pill (Fig. 1). There was a large difference in the occurrence of palmate newt remains recovered from spraints between the two riparian corridors of the permanent and ephemeral ponds of the rivers, with the vast majority being recorded from the river Clyne. Newt remains were recorded throughout the year with clear peaks in April and June in the river Clyne. The median number of maxillae recovered in spraints containing newts was one. By pairing maxillae, and after accounting for single occurrences in spraints collected on the same day, it was ascertained that a minimum of 95 individual

newts had been consumed by otters between December 2005 and April 2007. The maximum number of maxillae recorded from a single spraint was 62, representing a minimum of 31 individual newts. The majority of occurrences were between March and July, with 32 occurrences representing a minimum of 82 individual newts recorded in spraints during this period (Table 1). In spraints collected between August and November eleven occurrences were recorded, representing a minimum of eight individual newts. Palmate newt remains in four spraints representing a minimum of five individuals were recorded between December and Feb over the period 2005-2007.

Month	Burry Pill			River Clyne		
	FO %	RFO %	N spraints	FO %	RFO %	N spraints
January	2.53	2.90	79	3.20	0.00	23
February	0.00	0.00	122	0.00	0.00	12
March	0.00	0.00	111	0.00	7.89	22
April	0.00	0.00	200	0.00	28.33	52
May	0.00	0.00	51	0.00	2.94	10
June	0.00	0.00	47	0.00	8.33	20
July	2.88	1.72	104	2.77	3.03	10
August	6.06	1.19	33	18.36	0.00	8
September	0.00	0.00	41	0.00	17.14	29
October	3.13	1.81	32	9.78	0.00	7
November	3.57	1.69	56	6.38	0.00	3
December	4.55	2.70	22	20.68	2.77	17

Table 1. Frequency (FO) and relative frequency (RFO) percentages of occurrence of palmate newts in otter spraints fortnightly over a two-year period 2005 - 2007.
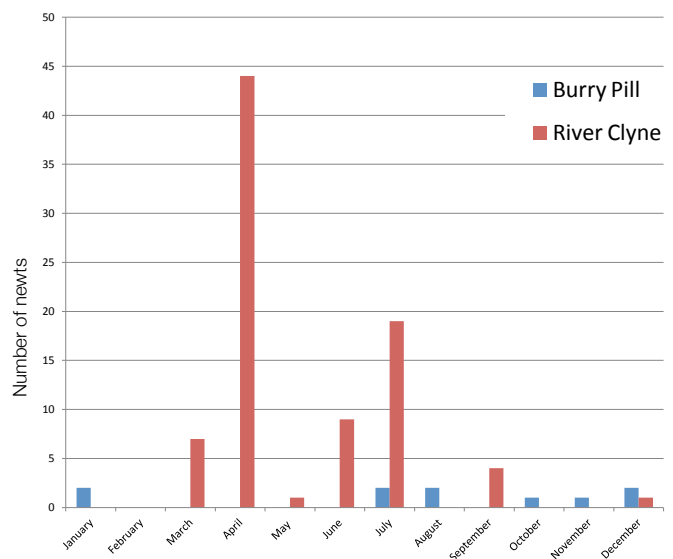

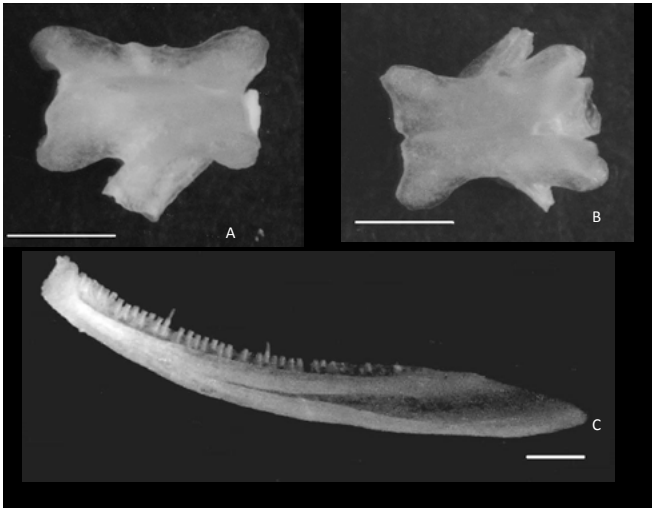**Figure 1**. The minimum number of newts predated per month in each of the two river systems sampled.

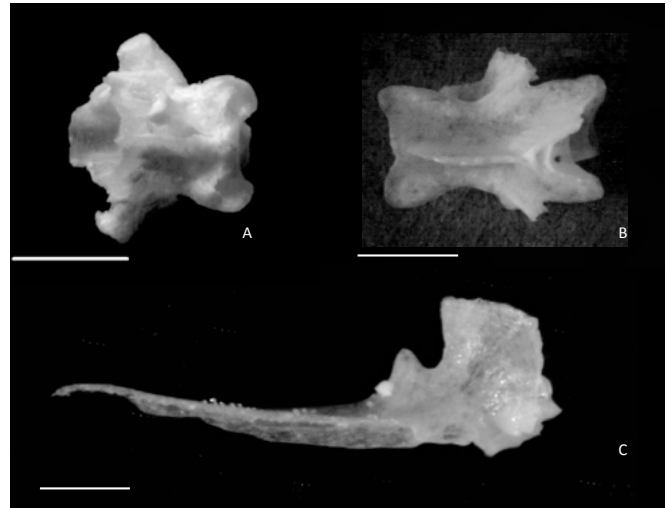**Figure 2** Palmate newt *L. helveticus* - scale bars 1 mm.

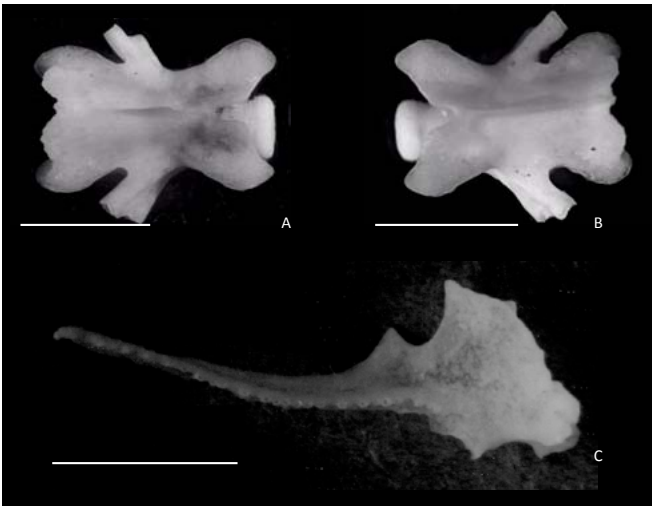**Figure 3** Smooth or common newt *L. vulgaris* - scale bars 2 mm.

Figure 4 Great crested newt *T. cristatus* - scale bars 2 mm.

Figure 5 Frog *R. temporaria* - scale bars 2 mm.

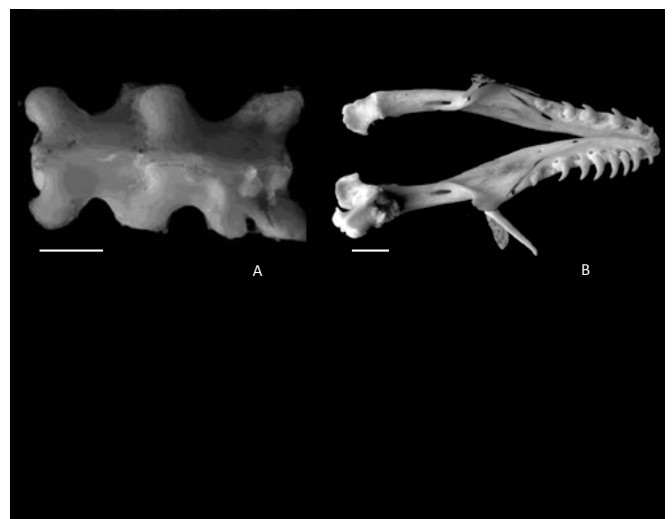

Figure 6 Toad *B. bufo* - scale bars 2 mm.

Figure 7 Slow worm *Anguis fragilis* - scale bars 2 mm.

Figures 2 - 7. Amphibian and reptilian remains used for identification in spraints. A and B mid-trunk vertebrae, C maxilla except Fig. 6 B maxilla.

Identifying newt remains

Newt vertebrae (Figs. 2a, b – 4a, b) are easily distinguishable from anuran vertebra (Figs. 5a, b and 6a, b) but resemble those of the slow worm (Fig. 7a). The ventral surfaces of newt vertebrae have distinct transverse processes, which form between two and four tubes, often associated with the transverse foramen. In contrast, slow worm vertebrae have short transverse processes. The centrum of a newt vertebra is convex both anteriorly and posteriorly, i.e. is amphicoelous. Newt maxillae (Figs. 2c – 4c) are very different from anuran maxillae (Figs. 5c and 6c), which are also very different from each other; the slow worm maxilla (Fig. 7b) clearly differs from all of these.

DISCUSSION

It is clear that otters have the ability to actively exploit non-fish prey, particularly those associated with wetland areas (Kruuk 2006). Otters are explorative foragers turning over rocks and entering aquatic vegetation to flush out prey (Kruuk 2006), so newts are likely to be encountered during normal foraging patterns. In the UK, adult newts reach 9 - 15 cm (Chinery 1995), bringing them into the typical prey size range for otters (Kruuk and Moorhouse 1990). Additionally, newts are likely to be relatively easy to catch compared with many fish species, therefore representing an efficient energy gain for relatively little cost. This leads to the question why newt remains have not been recorded more frequently in otter spraints, particularly when other amphibian species, notably the anurans, are recorded relatively frequently (Weber 1990, Clavero et al. 2005). It was suggested by Chanin (1985) that either newts are not being predated or that they are being missed through standard spraint analysis. The evidence presented here shows definitively that newts are actively predated by otters, which suggests that where newts are consumed, they are being overlooked, possibly due to the lack of identification aids.

The greatest number newts inferred in the spraints was detected between March and July which, based on observations made at breeding sites on Gower (Russell 2002), appears to coincide with spawning accumulations, although it is acknowledged that there can be some variation in the timing of newt breeding depending upon environmental conditions (Díaz-Paniagua 1992). The data presented in this paper confirm previous observations that spawning amphibians are extremely vulnerable to mammalian predation (Clavero et al. 2005). Otter predation on newts was reduced during winter months when torpid newts would have been in terrestrial and fresh water refuges that would limit access by otters. Nevertheless over-wintering amphibians at low population densities still appear to be vulnerable to occasional otter predation, and suggests that otters are more adept at foraging in the varied terrestrial environments associated with aquatic systems than has been previously thought. The marked difference in newt predation between the two river systems is likely due to idiosyncratic differences in lotic habitats adjacent to the main river channels, with River Clyne being associated with a larger number of ponds than the Burry Pill.

The lack of newt records in previous studies investigating

otter diet could be in part due to newts being generally less available to otters than other amphibians groups. Breeding newts are more discrete than the highly vocal anuran species, which should reduce their vulnerability to predation. When foraging on land, otters rely primarily on olfaction and audition to locate their prey (Chanin 1985, Dunstone and Gorman 1998), so the lack of vocalisation in newts may provide a degree of protection. However, tactile and visual cues are the primary senses used by otters foraging in water, a medium where audition and olfaction are of limited use (Chanin 1985, Dunstone and Gorman 1998). In particular, otters utilise their highly sensitive vibrissae to detect underwater prey movement (Dunstone 1998, Lanszki et al. 2006), undertaking explorative foraging in submerged and emergent vegetation (Kruuk 2006). Consequentially, newts in breeding ponds are likely to be as vulnerable to predation as other amphibians. All newt species exhibit aquatic lekking (Malmgren and Thollesson 1999) and males undertake courtship displays involving considerable amounts of movement, flashes of colour, and the production of tail vibrations (Halliday 1975, Beebee 1980). Such behaviours will make them very conspicuous to a foraging otter. Moreover, otters are able to learn foraging techniques maternally (Watt 1993), so it is not unfeasible that the location of a seasonally rich amphibian patch could be passed down the matriline.

Although there is some difference in body lengths between newt species (Harrison et al. 1984, Malmgren and Thollesson 1999), this can be subject to geographical variation (Harrison et al. 1984, Arntzen and Wallis 1999). Additionally newts show tail regeneration (Harrison et al. 1984) and there is a degree of overlap in total body length between species due to sexual dimorphism (Harrison et al. 1984, Malmgren and Thollesson 1999). Fundamentally, it is not possible to estimate body length based on vertebrae remains in spraints as it cannot be assumed that all vertebrae from an individual newt are recovered. Neither is it possible to determine accurately the number of newts predated from vertebrae only. Studies carried out on newts have identified few differences in head morphology between sex and between species (Malmgren and Thollesson 1999); thus, it is unlikely that maxillae alone can be used for species identification. In newts, body size and age are not strongly correlated (Halliday and Verrell 1988) so estimations of age cannot be obtained from hard remains in spraints (Steward 1969, Hagstrom 1977). Otters are likely to select for the largest individuals as they will be the most conspicuous, representing the best predation profit, and a large body size is associated with reduced swimming and running speed in newts (Gvozdik and Van Damme 2006).

The effect of otter predation on newt population dynamics may currently be underestimated. Newt populations undergo considerable long-term fluctuations, and intensive predation can be a causative factor in long-term population declines (Beebee and Griffiths 2005). Although newts were a relatively infrequent food item, spraints collected during one fortnightly survey in April 2006 contained a minimum of 44 individuals, demonstrating that otters can locally consume newts in surprisingly large numbers. It is unknown if this had a significant impact on the newt population as no previous

data for abundance within the study area was available. Otters also predate species such as invasive crayfish, which not only consume adult newts but also the larval stages and eggs (Alford and Richards 1999) and this otter feeding behaviour could provide some benefit to newt populations. Localised predation by otters and other mammals, which forage in habitats associated with aquatic systems, such as mink (*Mustela vison*) and polecat (*Mustela putorius*), may influence the demographic and breeding success of newt populations (Dunstone 1993, Lode 1997). Worldwide amphibian populations are under threat with up to one third of all species undergoing severe declines (Wake 1991, Stuart et al. 2004); however, otter populations in the UK are recovering their former range (Mason and Macdonald 2003, Jones and Jones 2004) and this may impact on recovering amphibian populations. Increased predation pressure on newt spawning aggregations could be highly detrimental to local newt populations.

Non-fish prey is frequently a seasonally important component of otter diet, particularly when fish are less available (Carss 1995, Jurajda et al. 1996), so the continued decline of amphibian populations is also a concern for otter conservation as there are no obvious groups to substitute for the decline in amphibian prey. How otters will respond to the reduced availability of amphibians remains to be seen. It is likely that they will switch to alternative prey, particularly those which are abundant at times of year when amphibians traditionally form an important dietary component. There may be an increase in the consumption of semi-terrestrial and terrestrial prey groups leading to the possibility of increased intra-guild competition within the Mustelidae. Low prey diversity has also been linked to increased predation on commercial fish stocks (Jacobsen 2005) and a reduction in the availability of non-fish prey, such as amphibians, may be accompanied with increased raiding of commercial fishponds that remain well stocked at times of the year when wild fish are less available.

ACKNOWLEDGEMENTS

REFERENCES

Alford, R.A. & Richards, S.J. (1999). Global amphibian declines: A problem in applied ecology. *Annual Review of Ecology and Systematics* 30: 133 – 165.

Arntzen, J.W. & Wallis, G.P. (1999). Geographic variation and taxonomy of crested newts (*Triturus cristatus* superspecies): morphological and mitochondrial DNA data. *Contributions to Zoology* 68: 181 - 203.

Azevedo, F. C. C., Lester, V., Gorsuch, W., Lariviere, S., Wirsing, A. J., & Murray, D. L. (2006). Dietary breadth and overlap among five sympatric prairie carnivores. *Journal of Zoology* 269: 127 - 135.

Beebee, T.J.C. (1980). Belly colour and foot webbing in newts of the genus *Triturus*. *Journal of Herpetology* 6: 59 - 61.

Beebee, T.J.C. & Griffiths, R.A. (2005). The amphibian decline crisis: A watershed for conservation biology. *Biological Conservation* 125: 271 - 285.

Brezeziński, M., Jedrezejwski, W. & Jedrezejwsk, B. (1993). Diet of otters (*Lutra lutra*) inhabiting small rivers in the Bialowieza National Park, eastern Poland. *Journal of Zoology, London* 230: 495 - 501.

Britton, J.R., Pegg, J., Shepherd, J.S. & Toms, S. (2006). Revealing the prey items of the otter *Lutra lutra* in South West England using stomach contents analysis. *Folia Zoologica* 55: 167 – 174.

Carss, D.N. (1995). Foraging behaviour and feeding ecology of the Otter (*Lutra lutra*): a selective review. *Hystrix Italian Journal of Mammalogy* 7: 179 – 194.

Chanin, P. (1985). *The Natural History of Otters*. Croom Helm, Kent, U.K., pp 179.

Chinery, M. (1995). *Wildlife of Britain and Europe*. London, UK: Larousse. 142 pp.

Clavero, M., Prenda, J. & Delibes, M. (2005). Amphibian and reptile consumption by otters (*Lutra lutra*) in a coastal area in southern Iberian Peninsula. *Herpetological Journal* 15: 125 - 131.

Cogalniceanu, D., Márquez, R. & Beltrán, J.F. (2010) Impact of otter (*Lutra lutra*) predation on amphibians in temporary ponds in Southern Spain. *Acta Herpetologica* 5: 217 - 222.

Conroy, J.W.H., Watt, J., Webb, J.B. & Jones, A. (2005). *A Guide to the Identification of Prey Remains in Otter Spraint*. 3rd Edition. London, UK: The Mammal Society. 48 pp.

Dunstone, N. (1993). *The Mink*. London, UK: T. & A. D. Poyser Ltd. 232 pp.

Dunstone, N. & Gorman, M. (1998). *Behaviour and Ecology of Riparian Mammals*. Cambridge, UK: Cambridge University Press (Symposia of the Zoological Society of London). 404 pp (hbk).

Díaz-Paniagua, C. (1992). Variability in timing of larval season in an amphibian community in SW Spain. *Ecography* 15: 267 - 272.

Gvozdik, L. & Van Damme, R. (2006) *Triturus* newts defy the running-swimming dilemma. *Evolution* 60: 2110 – 2121.

Hagstrom, T. (1977). Growth studies and ageing methods for adult *Triturus vulgaris L.* and *Triturus cristatus* Laurenti (Urodela, Salamandridae). *Zoologica Scripta* 6: 61 - 68.

Halliday, T.R. (1975). On the biological significance of certain morphological characteristics in males of the smooth newt *Triturus vulgaris* and of the Palmate newt *Triturus helveticus*. *Journal of the Linnean Society* 56: 291 – 300.

Halliday, T.R. & Verrell, P.A. (1988). Body size and age in amphibians and reptiles. *Journal of Herpetology* 22: 253 – 265.

Harrison, J.D., Gittins, S.P. & Slater, F.M. (1984). Morphometric observations of smooth and palmate newts in mid-Wales. *British Journal of Herpetology* 6: 410 - 413.

Hedlund, L., & Robertson, J. G. (1989). Lekking behaviour in crested newts, *Triturus cristatus*. *Ethology* 80: 111 - 119.

Jacobsen, L. (2005). Otter (*Lutra lutra*) predation on stocked brown trout (*Salmo trutta*) in two Danish lowland rivers. *Ecology of Freshwater Fish* 12: 59 - 68.

Jones, T. & Jones, D. (2004). *Otter Survey of Wales 2002*. Bristol, UK: Environment Agency. 58 pp.

Jurajda, P., Prasek, V. & Roche, K. (1996) The autumnal diet of otter (*Lutra lutra*) inhabiting four streams in the Czech Republic. *Folia Zoologica* 45: 9 - 16.

Kats, L.B. & Ferrer, R.P. (2003) Alien predators and amphibian declines: review of two decades of science and the transition to conservation. *Diversity and distributions* 9: 99 – 110. DOI: 10.1046/j.1472-4642.2003.00013.x

Kruuk, H. & Moorhouse, A. (1990). Seasonal and spatial differences in food selection by otters (*Lutra lutra*) in Shetland (Scotland, UK). *Journal of Zoology, London* 221: 621 – 638.

Kruuk, H. (2006) *Otters: Ecology, Behaviour and Conservation*. Oxford, UK: Oxford University Press. 280 pp.

Lanszki J., Molnár M. & Molnár, T. (2006). Factors affecting the predation of otter (*Lutra lutra*) on European pond turtle (*Emys orbicularis*). *Journal of Zoology London* 270: 219 – 226.

Lode, T. (1997). Trophic status and feeding habits of the European Polecat *Mustela putorius L.* 1758. *Mammal Review* 4: 177 – 184.

Malmgren, J.C. & Thollesson, M. (1999). Sexual size and shape dimorphism in two species of newts *Triturus cristatus* and *T. vulgaris* (Caudata: Salamandridae). *Journal of Zoology; London* 249: 127 - 136.

Mason, C.F. & Macdonald, S.M. (2003). Growth in otter (*Lutra lutra*) populations in the UK as shown by long-term monitoring. *AMBIO: A Journal of the Human Environment* 33: 148 - 152.

McDonald, R. A. (2002). Resource partitioning among British and Irish Mustelids. *Journal of Animal Ecology* 71: 185 - 200.

Pedroso, N.M. & Santos-Reis, M. (2006). Summer diet of Eurasian otters in large dams of south Portugal. *Hystrix Italian Journal of Mammalogy* 17: 117 - 128.

Parry, G.S. (2010). Analyses of the Eurasian otter (*Lutra lutra L.*) in South Wales: diet, distribution and an assessment of techniques. PhD thesis, Swansea University, pp 152 – 178.

Parry, G.S., Burton, S., Cox, B., Forman, D. W., (2011). Diet of coastal foraging Eurasian otters (*Lutra lutra L.*) in Pembrokeshire south-west Wales. *European Journal of Wildlife Research* 57: 485 - 494.

Poledník L., Poledníková K., Kranz A. a Toman A. (2007) Variability in the diet of Eurasian otter (*Lutra lutra L.*) on Fishponds in the Czech-Moravian Highlands. *Lynx (Prague)* 38: 31 – 46.

Russell, L. (2002). A survey of Great Crested Newt (*Triturus cristatus*) and Palmate Newt *(T. helveticus)* populations at Pilton, Gower, South Wales and an evaluation of their habitat. MSc Thesis, Swansea University.

Sidorovich, V. E., & Pikulik, M. M. (1997). Toads Bufo spp. in the diets of Mustelid predators in Belarus. *Acta Theriologica* 42: 105 - 108.

Sidorovich, V., Kruuk, H., Macdonald, D. W., & Moran, T. (2007). Diets of semi-aquatic carnivores in northern Belarus, with implications for population changes. *Behaviour and ecology of riparian mammals* 71: 177.

Steward, J.W. (1969). *The Tailed Amphibians of Europe*. Newton Abbot: David and Charles. 180 pp.

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fischman, D.L. Waller, R.W. (2004). Status and trends of amphibian declines and extinctions worldwide. *Science* 306: 1783 – 1786. DOI: 10.1126/science.1103538

Toweill, D.E. (1974). Winter Food Habits of River Otters in Western Oregon. *Journal of Wildlife Management* 38: 107 - 111.

Wake, D.B. (1991) Declining amphibian populations. *Science* 253: 860.

Watt, J. (1993) Ontogeny of hunting behaviour of otters (*Lutra lutra L.*) in a marine environment. *Symposium of the Zoological Society of London* 65: 87 – 104.

Weber, J.M. (1990). Seasonal exploitation of amphibians by otters (*Lutra lutra*) in north-east Scotland. *Journal of Zoology, London* 220: 641 – 651.