Bird Study

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tbis20

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Published online: 15 Feb 2013.

To cite this article: Alexandre Roulin & Sylvain Dubey (2013): Amphibians in the diet of European Barn Owls, Bird Study, 60:2, 264–269

To link to this article: http://dx.doi.org/10.1080/00063657.2013.767307

Bird Study (2013) **60**, 264–269
http://dx.doi.org/10.1080/00063657.2013.767307

SHORT REPORT

Amphibians in the diet of European Barn Owls

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Capsule: We present a review of the propensity to eat amphibians in the Barn Owl *Tyto alba* in Europe. Based on the analysis of 596 published studies reporting 3.32 million prey items identified in pellets, 17 869 amphibians (0.54%) were found. An analysis of 9036 amphibians identified to the species level showed that Barn Owls avoid consuming toxic species, and they are able to capture tree frogs (Hylidae) only rarely. The true frogs (Ranidae) are by far the most frequently captured amphibians followed by spadefoot toads (Pelobatidae) and Parsley frogs (Pelodytidae).

The Barn owl (*Tyto alba*) is a generalist predator feeding mainly upon small mammals (Glutz von Blotzheim & Bauer 1994). In an attempt to understand the circumstances in which other groups of animals can be an important food source, we reviewed the abundant literature about the diet in European owls. In a previous article (Roulin & Dubey 2012), we showed that reptiles are rarely captured by these owls (0.08%), but can be a non-negligible food source in southern Europe and on islands (maximum percentage of reptiles is 17.4%: Orti & Gonzales 2001). We also found that Barn Owls never consume venomous snakes. Here, our aim is to determine whether amphibians are a non-negligible prey in some countries or some circumstances and whether Barn Owls avoid consuming poisonous amphibians.

As stated in a previous article (Roulin & Dubey 2012), our review of Barn Owl diet in Europe is based on an extensive collection of studies published in all of the international and local journals that we could find. Among the 596 studies considered in the present review, 248 (41.6%; Table 1) reported at least one amphibian prey item (Figure 1), which is much more than the percentage of studies reporting at least one reptile (11.8%). This larger percentage is probably explained by the fact that contrary to reptiles most amphibians are nocturnal and slow-moving and hence easy to capture. Furthermore, on rainy nights when owls find it more difficult to capture agile prey such as small mammals, they may specialize on amphibians that become abundant in the open landscape (pers. obs.).

Contrary to reptiles (that were mainly found in the diets of Barn Owls from southern Europe), the proportion of amphibians was not significantly associated with latitude (generalized linear model: $\chi^2_1 = 0.0002$, $P = 0.99$, after controlling for year: $\chi^2_1 = 92.65$, $P < 0.0001$). Note that the effect of year is due to a large proportion of amphibians consumed between 1940 and 1949 (out of 55 studies, 3 reported percentages of amphibians larger than 13% in the Barn Owl diet during this period) rather than any consistent change over time (Figure 2). Indeed, if we consider only those studies performed after 1949 there is no relationship between year and proportion of amphibians (Spearman's correlation: $r_s = -0.003$, $n = 478$, $P = 0.95$). Thus, declines in amphibian populations due to recent climate change, traffic mortality and habitat loss (Elzanowski et al. 2009, Curado et al. 2011) do not appear to have affected the Barn Owl's propensity to eat amphibians, which may not be surprising given that these owls capture amphibians relatively infrequently (Table 1, Figure 1).

Table 2 shows that the amphibian family that is most often consumed is the Ranidae or 'true frogs' ($n = 6669$ items; *Rana* spp. and *Pelophylax* spp.), with species of the genus *Rana* migrating in spring from forests to ponds to reproduce. Hence, large numbers of *Rana* spp. become available on rainy nights, probably explaining why Barn Owls can suddenly capture many of them. Interestingly, Barn Owls also consume an important number of *Pelophylax* spp., despite a lack of seasonal migration in these species that live strictly nearby

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Table 1. Proportion of the Barn Owl diet composed of amphibians in different European countries and islands. Number of amphibian species present in each country is based on the Amphibian Database (http://research.amnh.org/vz/herpetology/amphibia/) (http://www.reptile-database.org/; Frost 2011). The references used to compile these tables can be found as supplementary material on the article's web page at: http://dx.doi.org/10.1080/00063657.2013.767307.

	Number of amphibian species present in the country/island	Number of studies	Number of amphibians as prey	Number of prey identified	% of amphibians in the diet
Albania	18	1	0	68	0
Austria	19	8	35	11298	0.31
Balearic Islands	2	3	2	10425	0.02
Belgium	17	10	687	155883	0.44
Bosnia	6	1	0	1782	0
Bulgaria	22	5	51	41787	0.12
Corfu	7	1	100	3097	3.23
Corsica	7	3	417	11295	3.69
Cos	2	1	9	2277	0.4
Crete	3	2	0	1284	0
Croatia	15	3	2	8633	0.02
Czech Republic	20	22	0	103037	0
Denmark	14	1	297	36173	0.82
France	34	88	9530	680353	1.4
Germany	19	149	2438	662271	0.37
Greece	24	11	22	9583	0.23
Hungary	16	23	121	107697	0.11
Ireland	3	16	239	25481	0.94
Italy	37	62	73	96460	0.08
Luxemburg	15	6	74	9678	0.76
Malta	3	2	0	424	0
Netherlands	16	10	623	126070	0.49
Poland	17	15	781	112769	0.69
Portugal	21	8	17	20343	0.08
Romania	19	3	29	3283	0.88
Sardinia	9	5	0	2415	0
Serbia	8	2	0	8576	0
Sicily	6	2	8	997	0.8
Slovakia	17	8	16	23431	0.07
Slovenia	16	6	7	6179	0.11
Spain	33	43	1376	166017	0.83
Sweden	11	1	0	1661	0
Switzerland	17	16	414	291168	0.14
Tenerife	2	1	34	2058	1.65
UK	11	58	467	571552	0.08
Total		596	17869	3315505	0.54

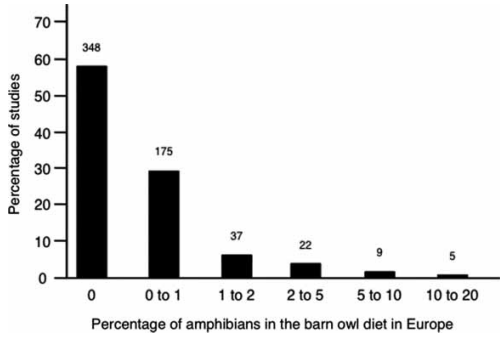

Figure 1. Frequency distribution of 596 studies reporting various percentages of amphibians in Barn Owl diet in Europe. Number above bars indicates the absolute number of studies.

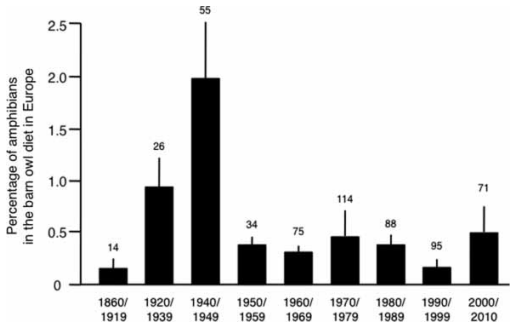

Figure 2. Mean (± se) percentage of amphibians in the Barn Owl diet in Europe between 1860 and 2010. Numbers above bars indicate the number of studies.

Table 2. Amphibians identified in Barn Owl pellets collected in different European countries and islands. Papers used to generate this table are reported in

	A	B	BU	Cor	Cos	Cr	F	G	Gr	H	Ib	Ir	It	L	N	P	Po	R	UK	S
Anura sp.	0	0	0	0	0	0	49	12	0	0	0	0	0	18	0	29	3	0	0	0
Bufonidae																				
Bufo bufo	0	0	0	22	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0
Bufo calamita	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Alytidae																				
Discoglossus galganoi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discoglossus jeannae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discoglossus pictus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylidae																				
Hyla arborea	0	0	0	78	2	0	15	0	3	0	0	0	0	2	0	0	0	1	0	0
Hyla meridionalis	0	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelobatidae																				
Pelobates cultripes	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0
Pelobates fuscus	0	0	0	0	0	2	1	173	0	25	0	0	0	1	1	595	0	12	0	4
Pelobates syriacus	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Pelobates sp.	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
Pelodytidae																				
Pelodytes sp.	0	0	0	0	0	0	301	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelodytes punctatus	0	0	0	0	0	0	168	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranidae																				
Pelophylax esculenta	2	0	0	0	0	0	524	120	0	0	0	0	1	0	0	0	0	0	0	0
Pelophylax perezi	0	0	0	0	0	0	47	0	0	0	1	0	0	0	0	0	5	0	0	0
Pelophylax ridibunda	0	0	27	0	0	0	0	1	0	0	0	0	9	0	0	0	0	0	0	0
Pelophylax lessonae	0	0	0	0	0	0	5	2	0	0	0	0	10	11	0	0	0	0	0	0
Pelophylax sp.	0	0	0	0	0	0	234	0	0	0	0	0	0	0	0	0	0	0	0	0
Rana dalmatina	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rana arvalis	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0	0
Rana dalmatina	0	0	0	0	0	0	59	0	0	0	0	0	1	88	0	0	0	0	0	0
Rana graeca	0	0	0	0	1	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
Rana temporaria	0	3	0	0	0	0	1556	192	0	0	0	78	0	457	0	4	0	0	25	0
Rana temporaria/agilis	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0
Rana sp.	3	0	0	0	0	0	2259	66	0	3	0	0	3	0	144	27	0	13	0	3
Salamandridae																				
Urodela	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Triturus marmoratus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total	6	3	51	100	3	2	5607	622	18	28	1	78	24	577	145	655	15	28	25	7

A: Austria; B: Belgium; BU: Bulgaria; Cor: Corfu; Cos: Cos; Cr: Croatia; F: France; G: Germany; Gr: Greece; H: Hungary; Ib: Ibiza; Ir: Ireland; It: Italy; L: Luxe
P: Poland; Po: Portugal; R: Romania; UK: UK; S: Slovenia; SP: Spain; SW: Switzerland; T: Tenerife.

water bodies. Hence, it suggests that these birds are able to exploit various amphibian ecological niches. The second most frequent group is the Pelobatidae or spadefoot toads (n = 1,041) with fossorial adults and aquatic tadpoles. The third most frequent group is the Pelodytidae or Parsley frogs (n = 544) that are closely related to spadefoot frogs and, like them, live in open areas and sandy soils. The arboreal life of Hylidae (tree frogs) probably explains why this group of amphibians is less often captured (n = 173).

Three other groups of amphibians are rarely consumed: Bufonidae (*n* = 44), Alytidae (*n* = 138) and Salamandridae (*n* = 3), all of which include toxic species. Indeed, the diets of owls apparently do not include a number of very toxic species even though at the European scale the sample size is large (*n* = 9036, Table 2). Some of the toxic species are relatively common (e.g. the European Fire-bellied Toad *Bombina bombina* and Yellow-bellied Toad *B. variegata*, Bombinatoridae), and species of the Green Toad complex *Pseudepidalea* (*Bufo*) *viridis*, Bufonidae; Obert & Schneider 1978, Balboni et al. 1992, Tashmukhamedov et al. 1994). In addition, in southeastern Europe, where *Pseudepidalea viridis* and *Pelobates syriacus* co-occur, only the latter non-toxic species (which is uncommon compared to *P. viridis*) is consumed (Miltschev & Georgiev 2009), reinforcing the hypothesis of toxic prey avoidance in Barn Owls. Another example is the absence of the Fire Salamander (*Salamandra salamandra*) that is large and easy to capture, but toxic (Mebs & Pogoda 2005). Because amphibians are not the primary source of food for the Barn Owl, it has apparently not evolved the ability to consume these toxic animals. In Australia some birds have learnt how to consume the non-toxic parts of extremely toxic invasive toads (such as the tongue; Beckmann et al. 2011). Toxic species are mostly consumed when the availability of alternative non-toxic prey is low, such as on islands (Corsica in this study). Such a switch has been documented in Australian bird species when the availability of non-toxic prey is low (Beckmann & Shine 2011). In addition, some of these animals are probably less likely to be captured because they live in water (e.g. newts and Bombinatoridae) or below stones and in holes (e.g. midwife toad; Alytidae; König et al. 2012) and so are relatively unavailable.

To conclude, amphibians are a more important food source than reptiles for Barn Owls in Europe. As for reptiles, our review emphasizes the fact that owls avoid consuming toxic prey. This challenges the idea that the Barn Owl is strictly opportunistic by taking its prey only proportionally to their availability. It would be interesting to review the literature at the worldwide scale to see whether owls in some regions do consume toxic amphibians. This may be the case on islands where the diversity of prey species is lower than on mainland.

ACKNOWLEDGEMENTS

We thank Patrick Bayle, Bernd von Bülow, Nathalie Indelicato and Vasileios Bontzorlos for sharing unpublished data, and Rick Shine and Boyan Milchev for useful comments. We are grateful to the Swiss Ornithological Institute for opening their library to us.

REFERENCES

Balboni, F., Bernabei, P.A., Barberio, C., Sanna, A., Rossi Ferrini, P. & Delfino, G. 1992. Cutaneous venom of *Bombina variegata pachypus* (Amphibia, *Anura*): effects on the growth of the human HL 60 cell line. *Cell Biol. Int. Rep.* **16:** 329–338.

Bauer, K. 1952. Eine interessante Beuteliste der Schleiereule (*Tyto alba* L.), Osterreichischer Lehrerverein für Naturkunde 1.

Bauer, K. 1956. Schleiereule (*Tyto alba* Scop.) als Fledermausjäger. *J. Ornithol.* **97:** 335–340.

Bauer, K. 1965. Die Beutetiere südburgenländischer Schleiereulen (*Tyto alba* Scop.). *Natur und Land* **5:** 112–113.

Becker, K. 1958. Die Populationsentwicklung vonn Feldmäusen (*Microtus arvalis*) im Spiegel der Nahrung von Schleiereulen (*Tyto alba*). *Zeitschr. F. Angew. Zoologie* **45:** 403–431.

Beckmann, C. & Shine, R. 2011. Toad's tongue for breakfast: exploitation of a novel prey type, the invasive cane toad, by scavenging raptors in tropical Australia. *Biol. Invasions* **13:** 1447–1455.

Beckmann, C., Crossland, M.R. & Shine, R. 2011. Responses of Australian wading birds to a novel toxic prey type, the invasive cane toad *Rhinella marina*. *Biol. Invasions* **13:** 2925–2934.

Bekasinski, R., Kasprzyk, K. & Ruprecht, A.L. 1996. Chronologiczna analiza pokarmu ptomykowki, *Tyto alba guttata* (C. L. BR.) z Rowniny Rychwalskiej (Wielkopolska). *Badania Fizjograficzne nad Polską Zachodnią Seria C, Zoologia* **43:** 47–54.

Bethge, E. & Hayo, L. 1979. Untersuchungen an einer Population der Schleiereule *Tyto alba* in einem ländlichen Bezirk des westlichen Saarlands. *Anz. Orn. Ges. Bayern* **18:** 161–170.

Böhr, H.J. 1962. Zur Kenntnis der Vogelwelt von Korfu. *Bonn. Zool. Beitr.* **13:** 50–114.

Bosé, M. & Guidali, F. 2001. Seasonal and geographic differences in the diet of the barn owl in an agro-ecosystem in northern Italy. *J. Raptor Res.* **35:** 240–246.

Bruijn, O. de 1979. Feeding ecology of the barn owl *Tyto alba* in the Netherlands. *Limosa* **52:** 91–154.

Brunet-Lecompte, P. & Delibes, M. 1984. Alimentacion de la lechuza comun *Tyto alba* en la cuenca del Duero, Espana. *Donana, Acta Vertebrata* **11:** 213–229.

Von Bülow, B. 1981. Sumpfspitzmaus in Gewöllen aus Bütow/Pommern, 1975. *Z. Säugetierkd.* **46:** 122–123.

Cabard, P. 1988. Contribution à la connaissance du régime alimentaire de la Chouette effraie (*Tyto alba*) en Touraine. *La Sterne* **1988:** 105–113.

Cabrera Ganan, F. & Buenestado Ganan, D. 1992. Alimentacion de la lechuza comun (l) en la comarca de los peroches (Cordoba). *Oxyura* **6:** 87–90.

Campos, F. 1978. Regimen alimenticio de *Tyto alba* en las provincias de Salamanca y Zamora. *Ardeola* **24:** 105–119.

Cooke, D., Nagle, A., Smiddy, P., Fairley, J. & Muircheartaighm, I. O. 1996. The diet of the barn owl *Tyto alba* in county Cork in relation to land use. *Biol. Environ.* **96:** 97–111.

Cortés, J.A. 1988. Sobre diferencias individuales en la alimentacion de *Tyto alba*. *Donana, Acta Vertebrata* **15:** 99–109.

Creutz, G. 1937. Das Vorkommen der Schleiereule (*Tyto alba guttata* Brehm) in der Umgebung von Pirna. *Mitt. Ver. Sächs. Ornithol.* **5:** 145–148.

Cruz, R. 2001. Estudo da ecologia alimentar da Coruja-das-torres (*Tyto alba* Scopoli, 1769) no Nordeste Algarvio e Sudeste Alentejano, University of Lisbon, Faculty of Sciences.

Cuisin, J. & Cuisin, M. 1979. Le régime alimentaire de la chouette effraye (*Tyto alba* (Scopoli)) dans le canton des Riceys (Aube) et ses environs immédiats. *L'Oiseau et R. F. O.* **49:** 81–89.

Curado, N., Hartel, T. & Arntzen, J.W. 2011. Amphibian pond loss as a function of landscape change – a case study over three decades in an agricultural area of northern France. *Biol. Conserv.* **144:** 1610–1618.

Dechambre, E. 1938. Notes sur les petits mammifères de Camargue. *Bull. Soc. Nat. Acl. France* **85:** 464–468.

Delmée, E. 1985. Régime alimentaire de la chouette effraie (*Tyto alba*) et évolution du statut des micromammifères d'un paysage agricole. *Aves* **22:** 169–174.

Ekiert, T. 2005. Sowa plomykowka *Tyto alba guttata* i badania nad nia w powiecie Ostrow Wielkopolski, http://www.pwg.otop.org.pl/tyto.php.

Elzanowski, A., Ciesiolkiewicz, J., Kaczor, M., Radwanska, J. & Urban, R. 2009. Amphibian road mortality in Europe: a meta-analysis with new data from Poland. *Eur. J. Wildl. Res.* **55:** 33–43.

Emma, F. & Endre, F.C. 2004. Seasonal changes in the diet of Barn Owl (*Tyto alba*). *Aquila* **111:** 81–87.

Festetics, A. 1959. Neuere Angaben zur Ernährung der Schleiereule. *Aquila* **66:** 41–51.

Frost, D.R. 2011. Amphibian Species of the World: An Online Reference. Version 5.5 (31 January 2011). American Museum of Natural History, New York, NY, USA.

Giban, J., Gatineau, M. & Guibert, R. 1948. Etude d'une famille d'Effraie (*Tyto alba* Scopoli) en Charente-Maritime. *Ann. Epiphyt.* **5:** 247–265.

Gigirey, A., Fernandez, M. & Garcia, J.L. 2004. Datos sobre la alimentacion de la lechuza comun (*Tyto alba*) en Santiago de Compostela (A Coruna). *Chioglossa* **2:** 27–31.

Gleinich, W. & Hummitzsch, P. 1977. Zum Brutvorkommen der Eulen im mittleren Oberelbe-Röder-Gebiet. *Faunist. Abh. Staatl. Mus. Tierkunde Dresden* **6:** 237–262.

Glutz von Blotzheim, U.N. & Bauer, K.M. 1994. *Handbuch der Vögel Mitteleuropas. Band 9 Columbiformes Piciformes*. Aula-Verlag, Wiesbaden.

Godin, J. 1975. Données sur le régime alimentaire de la Chouette effraie (*Tyto alba*) en Belgique et dans le nord de la France. *Aves* **12:** 105–126.

Glue, D. & Jordan, R. 1989. Early 20th century barn owl *Tyto alba* diet in Hampshire, Hampshire Bird Report 1988.

Goutner, V. & Alivizatos, H. 2003. Diet of the barn owl (*Tyto alba*) and little owl (*Athene noctua*) in wetlands of northeastern Greece. *Belg. J. Zool.* **133:** 15–22.

Greschik, E. 1912. Magen- und Gewölluntersuchungen unserer einhiemischen Raubvögel. *Aquila* **19:** 141–177.

Guérin, G. 1928. Régime et croissance de l'Effraye commune en Vendée, Thèse Faculté des Sciences de Poitiers.

Hädecke, K. 1973. Zur Ernährung einiger Eulenarten im Kreis Merseburg. *Apus* **3:** 32–34.

Haensel, J. & Walther, H.J. 1970/71. Vergleichende Betrachtungen über die Ernährung der Eulen des Harzes und des nördlichen Harzvorlandes mit Hinveisen zur Kleinsäugerfaunistik. *Naturk. JBer. Mus. Heineanum* **5:** 83–98.

Hayo, L. 1978. Beobachtungen und Erfahrungen über die Schleiereule. *DBV* **8:** 1–43.

Heim, R. 1958. Gewölle von Waldkäuzen (*Strix aluco*) aus dem Westerwald und von Schleiereulen (*Tyto alba*) aus Bonn. *Orn. Mitt.* **8:** 141–147.

Hernandez, A., Sanchez, A.J. & Alegre, J. 1987. Datos sobre el régimen del Mochuelo (*Athene noctua*) y la lechuza comun (*Tyto alba*) en habitats esteparios de la cuenca del Duero (Leon y zamora, Espana). *Actas I Congreso Internacional de Aves Esteparias, Leon 1987* 183–192.

Herrera, C.M. 1974. Regimen alimenticio de *Tyto alba* en Espana sudoccidental. *Ardeola* **19:** 359–396.

Hoekstra, B. 1961. Knoblauchkröte und Frösche als Nahrung von *Tyto alba*. *Limosa* **34:** 280–282.

Hoffmann, M. 1981. Beitrag zur Nahrung der Schleiereule (*Tyto alba*) im Untertaunus. *Zeitschrift für Vogelkunde und Naturschutz in Hessen – Vogel und Umwelt* **1:** 251–254.

Indelicato, N. 2003. Cartographie des micromammifères dans le Limousin (France) par valeurs d'un indice d'abondance, http://perso.wanadoo.fr/nathalie.indelicato/

Jentzsch, M. 2008. Gewöllanalyse aus dem Naturschutzgebiet Bucher Brack – Bölsdorfer Haken. *Nat.schutz Land Sachsen-Anhalt* **45:** 45–48.

von Knorre, D. 1973. Jagdgebiet und täglicher Nahrungsbedarf der Schleiereule (*Tyto alba* Scopoli). *Zool. Jb. Syst. Bd.* **100:** 301–320.

König, E., Zhou, M., Wang, L., Chen, T., Bininda-Emonds, O.R.P. & Shaw, C. 2012. Antimicrobial peptides and alytesin are co-secreted from the venom of the Midwife toad, *Alytes mauras* (Alytidae, Anura): implications for the evolution of frog skin defensive secretions. *Toxicon* **60:** 967–981.

Kulczycki, A. 1964. Study on the make up of the diet of owls from the Niski Beskid Mts. *Acta Zool. Cracov.* **9:** 529–559.

Lange, L. 2003. Rauchschwalben *Hirundo rustica* aus Gewöllen der Schleiereule *Tyto alba* in der Wilstermarsch (Schleswig-Holstein, Krs. Steinburg). *Vogelkdl. Ber. zw. Küste u. Binnenland* **2:** 144.

Langgemach, T. & Becker, J. 1997. Bruten der Schleiereule *Tyto alba* in Baumnistkästen bei Frankfurt (Oder) mit Angaben zu Baumbruten in anderen Gebieten Deutschland. *Vogelwelt* **118:** 307–314.

Lopez-Gordo, J.L., Lazaro, E. & Fernandez-Jorge, A. 1977. Comparacion de las dietas de *Strix aluco*, *Asio otus* y *Tyto alba* en un mismo biotopo de la provincia de Madrid. *Ardeola* **23:** 189–221.

Martin, A., Emmerson, K. & Ascanio, M. 1985. Regimen alimenticio de *Tyto alba* (Scopoli, 1769) en la Isla de Tenerife (Isla Canarias). *Ardeola* **32:** 9–15.

Mebs, D. & Pogoda, W. 2005. Variability of alkaloids in the skin secretion of the European fire salamander (*Salamandra salamadra terrestris*). *Toxicon* **45:** 603–606.

Mikuska, J. & Vukovic, S. 1980. Qualitative and quantitative analyse der Nahrung von Schleiereulen, *Tyto alba* Scop. 1769, in dem Gebiet Baranja mit Rückblück auf die Verbreitung von kleinen Säugetieren. *Larus* **31 32:** 269–288.

Mikuska, J., Pancic, S. & Pivar, G. 1986. The nutrition of the barn owl, *Tyto alba* Scop. 1769, of Eastern Slavonia with special respect to the distribution of small mammals. *Larus* **36 37:** 77–88.

Milchev, B., Boev, Z. & Kodjabashev, N. 2006. Breeding distribution and diet composition of the barn owl *Tyto alba* (Scopoli, 1769), (Aves: Strigiformes) in the North-Western Upper Thracian plain (Bulgaria). *Acta Zool. Bulg.* **58:** 83–92.

Miltschev, B., Boev, Z. & Georgiev, V. 2004. Die Nahrung der Schleiereule (*Tyto alba*) in Südost-Bulgarien. *Egretta* **47:** 66–77.

Miltschev, B. & Georgiev, V. 2009. Der Einfluss von Wühlmaus-Gradationen und Rodentiziden auf die Brutzeitliche Nahrungszusammensetzung der Schleiereule *Tyto alba* (Scopoli 1769) in Südost-Bulgarien. *Egretta* **50:** 82–87.

Montanari, P. 1995. Dieta di barbagianni, *Tyto alba*, e comparazione con allocco, *Strix aluco*, in un sito delle colline Piacentine. *Riv. Ital. Orn., Milano* **65:** 21–28.

Niethammer, J. 1989. Gewöllinhalte der Schleiereule (*Tyto alba*) von Kos und aus Südwestanatolien. *Bonn. Zool. Beitr.* **40:** 1–9.

O'Connell, P., Cogan, R. & Dunne, J. 2006. The diet of the Barn Owl *Tyto alba* at two sites in county Galway. *Irish Birds* **8:** 91–96.

Obert, H.J. & Schneider, H. 1978. Glands in the skin of the fire-bellied toad (*Bombina bombina* (L.); Discoglossidae, Anura): type, number and distribution under natural and experimental conditions. *Zeit. Mikrosk. Anat. Forsch.* **92:** 241–272.

Obuch, J. & Benda, P. 2009. Food of the Barn Owl (*Tyto alba*) in the Eastern Mediterranean. *Slovak. Rapt. J.* **3:** 41–50.

Orti, F.C. & Gonzales, A.G. 2001. Variación estacional de la dieta de una pareja de Lechuza Común *Tyto alba* en el Racó de l'Olla (Valencia). *Dugastella* **2:** 43–48.

Pailley, M. & Pailley, P. 2000. Le régime alimentaire de la Chouette effraie *Tyto a. alba* en Maine-et-Loire. *Crex* **5:** 41–53.

Petretti, F. 1977. Seasonal food habits of the barn owl (*Tyto alba*) in an area of central Italy. *Le Gerfaut* **67:** 225–233.

Plant, C.W. 1976. Some observations on the winter diet of the barn owl, (*Tyto alba*), on Skomer Island, Dyfed, Wales. *Nature in Wales* **15:** 54–59.

Pomares, A.L. 2002. Contribucion al conocimiento de la dieta de la lechuza comun (*Tyto alba*) en la provincia de Albacete. *Albacete* **6:** 177–217.

Pribbernow, M. 1996. Nahrungsökologische Untersuchungen an Schleiereulen (*Tyto alba*, Scopoli 1769) in der Uckermark, Humboldt-Universität zu Berlin, Diplomarbeit.

Rettig, K. 1962. Beutetiere aus Schleiereulenge Wöllen von Harkenbleck (Krs. Hannover). *Beitr. Nat.kd. Niedersachs.* **15:** 6–8.

Rigaux, P. & Riols, C. 2008. Régime alimentaire de l'Effraie des clochers (*Tyto alba*) à Courpière, Val de Dore (Puy-de-Dôme). *Le Grand Duc* **72:** 27–29.

Rodriguez, C. & Peris, S.J. 2007. Habitat associations of small mammals in farmed landscapes: implications for agri-environmental schemes. *Anim. Biol.* **57:** 301–314.

Roman Sancho, J., José Ibanez, F. & de Angulo, F. 1999/2001. Alimentacion invernal de la lechuza campestre (*Asio flammeus*) y de la lechuza comun (*Tyto alba*) en un area marismena de Donana. *Anuario Ornitologico Donana* **1:** 148–153.

Roque, I.M.F. 2003. Populacao de Coruja-das-torres *Tyto alba* (Scopoli 1769) no concelho de Coruche: abundancia e distribuicao, seleccao de habitat, biologia de reproducao, alimentacao e mortalidade, Relatorio nao publicato. Universidade de Evora, Evora. 90 pages.

Roulin, A. & Dubey, S. 2012. The occurrence of reptiles in Barn Owl diet in Europe. *Bird Study* **59:** 504–508.

Ruprecht, A.L. 1964. Analyse der Nahrungsbestandteile der Schleiereule *Tyto alba guttata* (C.L.BR.), vorkommend in Aleksandrow Kuj., Ciechocinek und Raciazek in den Jahren 1960–1961. *Zesz. Nauk. UMK, biol.* **7:** 45–66.

Ruprecht, A.L. 1979. Food of the Barn Owl, *Tyto alba guttata* (C.L.Br.) from Kujawy. *Acta Ornithol.* **16:** 493–511.

Sandor, D.A. 2009. The summer diet of barn owl (*Tyto alba*) (Aves: Strigiformes) in the southern part of Danube delta biosphere reserve. *Acta Zool. Bulg.* **61:** 87–92.

Sardin, J.-P. 1984. Contribution à l'étude du régime alimentaire de la chouette effraie. *Tyto alba,* en Charente Limousine. Pica **3:** 44–58.

Schnurre, O. 1973. Ernährungsbiologische Studien an Schleiereulen (*Tyto alba*) im Berliner Raum. *Milu, Leipzig* **4:** 476–484.

Schnurre, O. 1975. Ernährungsbiologische Studien an Schleiereule (*Tyto alba*) und Waldkauz (*Strix aluco*) im gleichen Lebensraum (Kloster Chorin Kr. Eberswalde). *Milu, Leipzig* **3:** 748–755.

Sommer, R., Zoller, H., Kock, D., Böhme, W. & Griesau, A. 2005. Feeding of the barn owl, *Tyto alba* with first record of the European free-tailed bat, *Tadarida teniotis* on the island of Ibiza (Spain, Balearics). **54:** 364–370.

Sommer, R., Niederle, M., Labes, R. & Zoller, H. 2009. Bat predation by the barn owl *Tyto alba* in a hibernation site of bats. *Folia Zool.* **58:** 98–103.

Steinfatt, O. 1940. Uber die Beute der Schleiereulen, *Tyto alba alba*, in Luxemburg und Frankreich. *Zeit. Säugetierkd.* **15:** 276–284.

Stöckel, G. 1978. Ein Nachweis des Springfrosches für den Bezirk Potsdam in Gewöllen der Schleiereule. *Falke* **25:** 174.

Stubbe, M. 1987. Gewöllanalysen zur Untersuchung der Ernährungsbiologie von Eulen. *Populationsökologie Greifvogel- u. Eulenarten* **1:** 429–451.

Tashmukhamedov, M.S., Mirzaakhmedov, Sh.Ya., Zakirova, O. K., Ibragimov, B.T., Kamaev, F.G., Umarkhadzhaev, A.S & Salikhov, Sh.I. 1994. Arenobufagin and gamabufagin and gamabufotalin from the venom of the central Asian toad *Bufo viridis*. *Chem. Nat. Comp.* **30:** 133–134.

Thiollay, J.M. 1968. Le régime alimentaire de nos rapaces: quelques analyses françaises. *Nos Oiseaux* **24:** 249–267.

Tomé, R. 1994. A coruja das torres (*Tyto alba* Scopoli, 1769) no estuario do tejo: fenologia, dinamica populacional, utilizacao do espaco e cologia trofica, Relatorio de Estagio da Licenciatura em Biologia Recursos Faunisticos e Ambiente, Faculdade de Ciencias de Lisboa.

Uttendörfer, O. 1952. Neue Ergebnisse über die Ernährung der Greifvögel und Eulen, Eugen Ulmer, Stuttgart/z.Z. Ludwigsburg, Verlag für Landwirtschaft, Gartenbau und Naturwissenschaften.

Vargas, J.M., Miguel, E. & Blasco, M. 1982. Estudio estacional camparativo del regimen alimentario de *Tyto alba* Scopoli en Fuentepiedra de Malaga y el Padul de Granada (Espana). *Misc. Zool.* **6:** 95–102.

Veiga, J.P. 1980. Alimentacion y relaciones troficas entre la lechuza comun (*Tyto alba*) y el buho chico (*Asio otus*) en la sierra de Guadarrama (Espana). *Ardeola* **25:** 113–142.

Walsh, P.M. 1984. Diet of Barn Owls at an urban Waterford roost. *Irish Birds* **2:** 437–444.

Wuntke, B. 2003. Zur Ernährung der Schleiereule *Tyto alba* im Gebiet des Altkreises Brandenburg-Land. Beitr. *Gefied. kd. Morphol. Vögel* **9:** 66–69.

Yalden, D.W. 1985. Dietary separation of Owls in the Peak District. *Bird Study* **32:** 122–131.

(MS received 9 November 2012; revised MS accepted 22 December 2012)