

## Nocturnal activity in a Serbian population of *Podarcis muralis* (LAURENTI, 1768)

Lizards exhibit a wide variety of activity patterns resulting from the interaction between their internal rhythms and the cyclic processes in the environment (UNDERWOOD 1992). Regarding diel activity, even if some taxa (i.e. Gekkota) switched to a crepuscular life, most species are day active (UNDERWOOD 1992). Such diurnal patterns, nevertheless, may be altered either by unusually warm temperatures or by the presence of night light of anthropogenic origin, known as light pollution. Under these conditions, some diurnal species were reported to extend their activity into the night when located close to artificial lights (PERRY & FISHER 2006; PERRY et al. 2008).

Lacertids are among the strictly diurnal lizards, using heliothermia as the main thermoregulatory strategy (AVERY 1982). Certainly, their activity patterns may change depending on external factors such as environmental temperatures and photoperiod, and internal factors such as the particular species involved, its reproductive state and developmental stage (FOÀ et al. 1992, 1994). However, lizards' circadian cycles persist even when the animals are exposed to artificial light conditions in the laboratory, revealing endogenous rhythms (MARX & KAYSER 1949; CONSTANTINOU & CLOUDSLEY-THOMSON 1985; MOLINA-BORJA et al. 1986; BERTOLUCCI et al. 1999). Nevertheless, isolated but repeated instances of crepuscular and nocturnal activity were observed in *Timon lepidus* (DAUDIN, 1802) (VALVERDE 1967; FRANCO et al. 1980; HÓDAR et al. 1996) and *Gallotia* sp. (BÖHME et al. 1985; MOLINA-BORJA pers. comm.). Here, we report another apparent exception to the rule of strict diurnal activity in lacertids.

During herpetological field studies in Serbia, nocturnal observations were conducted at Kalemegdan Castle, located within the city of Belgrade (44.822110 N, 20.448127 E; altitude 97 m a.s.l.) on 3 September 2011. The night was extremely warm for the date (26°C air temperature recorded *in situ* by a street thermometer,

located 400 m NW of the study site and accessed under <http://weatherspark.com/>) with no wind. Similar conditions prevailed several days before and after this day (24-26°C in the period 22:00-00:00 h, local time; <http://weatherspark.com/>). Temperatures could not be recorded *ad hoc* due to the lack of proper equipment during the observations. Given these favorable ambient conditions, a searching transect of approximately 500 m was set along the eastern walls of the castle. The walls, built on large calcareous blocks covered by scarce herbaceous vegetation, were illuminated by powerful light reflectors of approximately 2 kW each. This transect was monitored by four observers for encounters of lizards between 22:00 and 22:30 (local time) in a north-south direction, and between 23:00 and 00:00 in the opposite way, when no other light than that from the reflectors was available. No further transects were inspected in the subsequent nights.

Although the initial targets of the studies were geckos, eventually introduced to Belgrade, unexpectedly, all resulting observations corresponded to the lacertid *Podarcis muralis* (LAURENTI, 1768). A total of 25 lizards were seen in the first transect pass and 11 in the second. Both adult (14 males and 13 females) and immature (9) individuals were involved in behaviors reaching from basking posture in front of a reflector to active foraging (images available from the authors) and escaping into crevices or up to the non-illuminated wall top. Several individuals were observed at a close mutual distance, and, at least one, an adult male, was observed capturing and eating a crane fly (Diptera: Tipulidae) attracted by a reflector.

*Podarcis* wall lizards, and *P. muralis* in particular, are well known to occupy urban habitats (CAPULA et al. 1993; GHERGHEL et al. 2009), including those in Serbia (LAZIĆ et al., submitted). Moreover, active *P. muralis* are frequently present at suboptimal thermal conditions (RUGIERO 1995). In fact, the environmental temperatures during the observations did not greatly differ from daytime temperatures under which this species is active in fall (GRBAC & BAUWENS 2001). Although body temperatures were not recorded, they should have been higher

in the vicinity of the reflectors and, hence, may have been sufficient for foraging (AVERY 1978). On the other hand, the abundant insects attracted by lights constitute an additional food resource in a dry period and may compensate for the disadvantages of increasing predatory risk and decreasing foraging success due to darkness (PERRY & FISHER 2006; PERRY et al. 2008). The alternative explanation of lighting disturbance of lizards inside their nocturnal refuges due to the reflectors can be discarded since stone walls had multiple deep crevices (>1 m) remaining in complete darkness. Nevertheless, it is remarkable that only one more similar case has been mentioned (HENLE 1980, for coastal Croatia), whereas none of the authors of this note had similar observations after years of research with *Podarcis* sp. in warm, urban areas. It is also noteworthy that the nocturnal activity was displayed by a substantial part of the population and not limited to isolated individuals. Further research should be addressed to systematically monitor the activity of *Podarcis* populations under natural and artificial light and temperature regimes in the wild in order to provide evidence on the eventual synergic effects of global climate change and additionally, light pollution. Furthermore, manipulative experiments (INNOCENTI et al. 1994; MINUTINI et al. 1995; PASQUALETTI et al. 2003) should be conducted to determine whether adaptive phenomena are taking place (ANGILLETTA 2009; ANGILLETTA et al. 2009).

**ACKNOWLEDGEMENTS:** The research was funded by the Ministry of Education and Science of the Republic of Serbia, Grant Nr 173025 and by an Integrated Action between Serbia and Portugal. The work of MAC was supported by the project PTDC/BIA-BEC/101256/2008 funded by Fundação para a Ciência e a Tecnologia (FCT, Portugal). NS is supported by a post-doctoral position (SFRH/BPD/26666/2006) also from FCT.

**REFERENCES:** ANGILLETTA, M. J. Jr. (2009): Thermal adaptation; Oxford University Press, Oxford, pp. 289. ANGILLETTA, M. J. Jr. & WILSON, A. S. & NIEHAUS, M. W. & SEARS, M. W. & NAVAS, C. A. & RIBEIRO, P. L. (2007): Urban physiology: city ants possess high heat tolerance.- PLoS One (electronic resource), Lawrence; 2: E258. AVERY, R. A. (1978): Activity patterns, thermoregulation and food consumption in two sympatric lizard species (*Podarcis muralis* and *Podarcis sicula*) from Central Italy.- Journal of Animal Ecology, Oxford etc.; 47: 143-158. AVERY, R. A. (1982): Field studies of body temperatures and thermoregulation; pp. 93-166. In: GANS, C. & POUGH, F. H.

(Eds.): Biology of the Reptilia. Vol. 12. Physiology C. London etc. (Academic Press). BERTOLUCCI, C. & LEORATI, M. & INNOCENTI, A. & FOÀ, A. (1999): Circannual variations of lizard circadian activity rhythms in constant darkness.- Behavioral Ecology and Sociobiology, Berlin etc.; 46: 200-209. BÖHME, W. & HUTTERER, R. & BINGS, W. (1985): Die Stimme der Lacertidae, speziell der Kanareneidechsen (Reptilia: Sauria).- Bonner zoologische Beiträge, Bonn; 36: 337-354. CAPULA, M. & LUISELLI, L. & RUGIERO, L. (1993): Comparative ecology in sympatric *Podarcis muralis* and *P. sicula* (Reptilia: Lacertidae) from the historical centre of Rome: What about competition and niche segregation in an urban habitat? - Bollettino di Zoologia, Torino etc.; 60: 287-291. CONSTANTINOU, C. & CLOUDSLEY-THOMSON, J. L. (1985): The circadian rhythm of locomotory activity in the desert lizard *Acanthodactylus schmidti*.- Journal of Interdisciplinary Cycle Research, Amsterdam etc.; 16 (2): 107-111. FOÀ, A. & TOSINI, G. & AVERY, R. A. (1992): Seasonal and diel cycles of activity in the ruin lizard *Podarcis sicula*.- Herpetological Journal, London; 2: 86-89. FOÀ, A. & MONTEFORTI, G. & MINUTINI, L. & INNOCENTI, A. & QUAGLIERI, C. & FLAMINI, M. (1994): Seasonal changes of locomotor activity patterns in ruin lizards *Podarcis sicula*.- Behavioral Ecology and Sociobiology, Berlin etc.; 34: 267-274. FRANCO A. & MELLADO, J. & AMORES, F. (1980): Observaciones sobre la actividad nocturna de reptiles en la España Mediterránea Occidental.- Doñana, Acta Vertebrata, Sevilla; 7: 261-262. GHERGHEL, I. & STRUGARIU, A. & SAHLEAN, T. C. & ZAMFIRESCU, O. (2009): Anthropogenic impact or anthropogenic accommodation? Distribution range expansion of the common wall lizard (*Podarcis muralis*) by means of artificial habitats in the north-eastern limits of its distribution range.- Acta Herpetologica, Firenze; 4: 183-189. GRBAC, I. & BAUWENS, D. (2001): Constraints on temperature regulations in two sympatric *Podarcis* lizards during autumn.- Copeia, Washington; 2001: 178-186. HENLE, K. (1980): Herpetologische Beobachtungen in der Umgebung Rovinjs (Jugoslawien).- Herpetofauna, Ludwigsburg; 2 (6): 6-10. HODAR, J. A. & CAMPOS, F. & ROSALES, B. A. (1996): Trophic ecology of the Ocellated Lizard *Lacerta lepida* in an arid zone of southern Spain: relationships with availability and daily activity of prey.- Journal of Arid Environments, Kidlington; 33: 95-107. INNOCENTI, A. & MINUTINI, L. & FOÀ, A. (1994): Seasonal changes of locomotor activity patterns in ruin lizards *Podarcis sicula*. II. Involvement of the pineal.- Behavioral Ecology and Sociobiology, Berlin etc.; 35: 27-32. MARX, C. & KAYSER, C. (1949): Le rythme nyctéméral de l'activité chez le lézard (*Lacerta agilis*, *Lacerta muralis*).- Comptes rendus de la Société de Biologie, Paris; 143: 1375-1377. MINUTINI, L. & INNOCENTI, A. & BERTOLUCCI, C. & FOÀ, A. (1995): Circadian organization in the ruin lizard *Podarcis sicula*: the role of the suprachiasmatic nuclei of the hypothalamus.- Journal of Comparative Physiology, Berlin etc.; (A) 176: 281-288. MOLINA-BORJA, M. & GONZALEZ-GONZALEZ, J. & GOMEZ-SOUTULLO, T. & GARCIA-DIAZ, C. (1986): 24 h entrainment and ultradian fluctuations in the activity of the lizard *Gallotia galloti* (Sauria - Lacertidae).- Journal of Interdisciplinary Cycle Research, Amsterdam etc.; 17(4): 295-305. PASQUALETTI, M. & BERTOLUCCI, C. & ORI, M. & INNOCENTI, A. & MAGNONE, M. C. & DE GRIP, W. J. & NARDI, I. & FOÀ, A. (2003): Identification of circadian brain photoreceptors mediating photic

entrainment of behavioural rhythms in lizards.- European Journal of Neuroscience. Oxford; 18: 364-372. PERRY, G. & BUCHANAN, B. W. & FISHER, R. N. & SALMON, M. & WISE, S. E. (2008): Effects of artificial night lighting on amphibians and reptiles in urban environments. pp. 239-256. In: MITCHELL, J. C. & JUNG-BROWN, R. E. & BARTHOLOMEW, B. (Eds.): Herpetological Conservation vol. 3. Salt Lake City (Society for the Study of Amphibians and Reptiles). PERRY, G. & FISHER, R. N. (2006): Night lights and reptiles: observed and potential effects. pp. 169-191. In: RICH, C. & LANGCORE, T. (Eds.): Ecological consequences of artificial night lighting. Washington, D.C (Island Press). RUGIERO, L. (1995): Winter activity of a common wall lizard (*Podarcis muralis*) population in central Italy.- Russian Journal of Herpetology, Moskva; 2: 148-152. UNDERWOOD, H. (1992): Endogenous rhythms. pp. 229-297. In: GANS, C. & CREWS, D. (Eds.): Hormones, brain, and behavior. Physiology E. Biology of the Reptilia Vol. 18, Chicago (University of Chicago Press). VALVERDE, J. A. (1967): Estructura de una comunidad de vertebrados terrestres.- Monografías de la Estación Biológica de Doñana (in Monografías de Ciencia Moderna). Madrid (Consejo Superior de Investigaciones Científicas - C.S.I.C.), pp. 218.

KEY WORDS: Reptilia: Squamata: Sauria: Lacertidae: *Podarcis muralis*, activity, behavior, light pollution, global warming, Serbia.

SUBMITTED: 7 February, 2012

AUTHORS: Miguel A. CARRETERO (corresponding author < carretero@mail.icav.up.pt >), CIBIO (Centro de Investigação em Biodiversidade e Recursos Genéticos) da Universidade do Porto, Campus Agrário de Vairão, 4485-661 Vairão, Portugal; Nefitalí SILLERO, CICGE (Centro de Investigação em Ciências Geo-Espaciais), Universidade do Porto, Faculdade de Ciências, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal; Marko M. LAZIĆ, Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš, Višegradska 33, 18000 Niš, Serbia; Jelka CRNOBRNJA-ISAILOVIĆ, Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš, Višegradska 33, 18000 Niš, Serbia / Institute for Biological Research “Siniša Stanković”, University of Belgrade, Despota Stefana 142, 11000 Belgrade, Serbia