SOCIETÀ TOSCANA DI SCIENZE NATURALI
RESIDENTE IN PISA

ATTI
DELLA
SOCIETÀ TOSCANA
DI
SCIENZE NATURALI

MEMORIE • SERIE B • VOLUME CXXXI • ANNO 2024

Edizioni ETS

ATTI DELLA SOCIETÀ TOSCANA DI SCIENZE NATURALI
MEMORIE
Via Santa Maria, 53 - 56126 Pisa

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Atti are published yearly in two Issues (Serie A - Abiological, ISSN 0365-7655; Serie B - Biological, ISSN 0365-7450) in December. Some monographic volumes may be published as Supplementi.

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SOCIETÀ TOSCANA DI SCIENZE NATURALI
Fondata nel (*founded in*) 1874
Via Santa Maria, 53 - 56126 Pisa

Autorizzazione n. 17/56 del 26 luglio 1956, Trib. di Pisa
Direttore responsabile (Editor in Chief): Paolo Roberto Federici

Atti Soc. Tosc. Sci. Nat., Mem., Serie B, 131 (2024)
pagg. 57-62; figg. 2; *doi: 10.2424/ASTSN.M.B.2024.05*

Pietro Giovacchini [(1)], Luca Passalacqua [(2)], Roberto Sacchi [(3)], Marco A.L. Zuffi [(4)]

GECKOES AND THE CITY. HOW URBAN SCENARIOS OF SOUTHERN TUSCANY, CENTRAL ITALY, CAN AFFECT DETECTABILITY AND DENSITY ESTIMATION OF *TARENTOLA MAURITANICA*

Abstract - P. Giovacchini, L. Passalacqua, R. Sacchi, M.A.L. Zuffi, *Geckoes and the city. How urban scenarios of Southern Tuscany, Central Italy, can affect detectability and density estimation of* Tarentola mauritanica.

Anthropogenic impacts in urban areas can induce favourable effects on herpetofauna. For example, the artificial nocturnal light determines an increase in the availability of prey and a greater level of occupation of the potential breeding sites close to the foraging areas. Research on Italian urban reptiles are very few when relate strictly to the urban settlement. We have been therefore aimed at determining relative abundance of the Common wall gecko *Tarentola mauritanica* as a function of environmental factor variability. In twelve urban centres of the province of Grosseto (Tuscany, central Italy) we selected 13 transects of 500 m, one for each city and two for Grosseto, with surveys between 8:00 pm and 11:00 pm from April to July 2017 and from April to October 2018. Each transect, through observations performed with binoculars and with a head torch, concerned dry walls and building walls, and was repeated over the two years for three replicas per locality. During the 39 repeated surveys, we obtained 307 detections of *T. mauritanica* with a minimum of one and a maximum of 79 for single survey. Population size was estimated by using Poisson N-mixture models for closed population on the data set collected through each repeated transect. The Bayes estimates indicated population size between three and 80 individuals/transect. It was possible to detect an important relation with the hour and, to a lesser extent, with the transect date for *T. mauritanica*.

Key words - geckoes, urban settlements, Tuscany, Italy, density

Riassunto - P. Giovacchini, L. Passalacqua, R. Sacchi, M.A.L. Zuffi, *I gechi e la città. Come gli scenari urbani della Toscana meridionale possono influenzare la rilevabilità e la stima di densità di* Tarentola mauritanica.

Gli impatti antropogenici nelle aree urbane possono indurre effetti favorevoli all'erpetofauna. Ad esempio, la luce notturna artificiale determina l'aumento della disponibilità di prede e un maggior livello di occupazione dei potenziali siti riproduttivi prossimi alle aree di foraggiamento. Le ricerche sui rettili urbani italiani sono molto poche per lo meno per quanto riguardano strettamente gli insediamenti urbani. Ci siamo quindi posti l'obiettivo di determinare l'abbondanza relativa del geco comune, *Tarentola mauritanica*, in funzione della variabilità dei fattori ambientali. In dodici centri urbani della provincia di Grosseto (Toscana, Italia centrale) abbiamo selezionato 13 transetti di 500 m, uno per ogni città e due per Grosseto, con rilevamenti tra le 20:00 e le 23:00 da aprile a luglio 2017 e da aprile a ottobre 2018. Ciascun transetto, attraverso osservazioni effettuate con binocolo e con lampada frontale, ha riguardato muri a secco e murature di edifici, ed è stato ripetuto nell'arco dei due anni per tre repliche per località. Nel corso delle 39 indagini ripetute abbiamo ottenuto 307 rilevamenti di *T. mauritanica* con un minimo di uno e un massimo di 79 individui per singola indagine. La dimensione della popolazione è stata stimata utilizzando modelli N-mixture per popolazione chiusa sul set di dati raccolti attraverso ciascun transetto ripetuto. Le stime ottenute hanno indicato una dimensione della popolazione compresa tra tre e 80 individui/transetto. È stato possibile rilevare un'importante relazione delle stime di abbondanza con l'ora e, in misura minore, con la data del transetto.

Parole chiave - gechi, insediamenti urbani, Toscana, densità

Introduction

Numerous anthropogenic impacts in urban areas have been slightly investigated from a biological perspective. These impacts can often lead to favourable effects on herpetofauna (Powell & Henderson, 2008; Stabler *et al.*, 2011). Among others, light pollution has been shown to have severe ecological implications on species distribution and abundance in urban areas (Rich & Longcore, 2006). The artificial nocturnal light determines an increase in the availability of preys and a greater level of occupation of the potential breeding sites close to the foraging areas (Luiselli & Capizzi, 1999; Perry *et al.*, 2008). On the other hand, using the same microhabitats for some species detectable in syntopy, in the absence of divergent ecological niches, can affect more often and negatively, for example, the health of populations (Dangremond *et al.*, 2010). Urban environments may lead also to different degrees of contamination, due to multiple factors (e.g.: pesticides, pharmaceuticals, heavy metals, and acidity) as pointed out by Croteau *et al.* (2008), despite these aspects are not always present in all human settlements. Moreo-

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ver, long time series provided evidence that the number of species may decrease significantly, as a result of the urbanization of urban green areas (De Souza *et al.*, 2023). However, urban ecosystems show an extreme variability of the sites available to reptiles (Powell & Henderson, 2008). Specifically, De Souza *et al.* (2023) state that "ecological attributes of taxa of urban areas include species that use terrestrial substrates and feed on prey commonly found in urban environments". Other studies underline how urbanization has additional effects on some behavioural traits (e.g.: decreasing of escape performance, reproduction) and many species disappear also due to locally adapted predators (as domenstic cats), while others adapt perfectly to urban scenarios (French *et al.*, 2018).

Despite research on Italian urban reptiles are quite common (Capula & Luiselli, 1994; Luiselli & Capizzi, 1999; Rugiero, 2004; Rugiero & Luiselli, 2006; Simbula *et al.*, 2019), very few relate strictly to the urban settlement (Luiselli & Capizzi, 1999). Actually, no one has still considered distribution, density nor abundance of gekkonid species in urban frameworks. The presence of gekkonid lizards in towns and small cities, especially along or close to Mediterranean coasts, in Italy and in other Mediterranean countries is a matter of fact (Ibrahim, 2004; Luiselli & Capizzi 1999; Martín *et al.*, 2018; Simbula *et al.*, 2019). Geckoes find suitable alternative rocky habitats to those found in natural environments and likely benefit of predator scarcity and high prey availability. Therefore, information on reptile abundance is a crucial information in order to understand how species are responding and eventually adapting to the novel, albeit artificial, environments (Aprea *et al.*, 2010; Atzori *et al.*, 2007; Gasc *et al.*, 2004; Lo Cascio & Corti, 2008). It is evident a general scarcity of information on the ecology of these species (Gomez-Zlatar *et al.*, 2006; Perry *et al.*, 2008) and especially on those present in Italy (Luiselli & Capizzi, 1999; Simbula *et al.*, 2019). Despite these data, artificial habitat usage by wild gekkonid populations remains unresolved, in the light of adaptation of these species to not natural environments. We were specifically interested in assessing the consistency of gecko's populations in some urban areas of Tuscany (Central Italy), as a potential proxy of habitat suitability for this group of reptiles. Therefore, we aimed at determining the relative abundance of the Common wall gecko (*Tarentola mauritanica*) as a function of environmental (anthropogenic) factor variability.

Materials and methods

We considered twelve urban centres of the province of Grosseto (Fig. 1), in mainland Tuscany, 11 out of 12 in the inner part of the region, and one close to the coast. Cities are from 15 to 810 m asl, and ranged from 255 to 81275 people. Within each city, we selected only historic neighbourhoods, where old buildings are supposed to offer multiple refuges, more than in the outskirts. Therefore, we selected 13 transects of 500 m each, one for each city and two for Grosseto and we surveyed three times between 8:00 pm and 11:00 pm (solar time), from April to July 2017 and from April to October 2018. The selected period is typical of gecko's activity (Aprea *et al.*, 2010; Di Francesco & Di Tizio, 2013; Vanni & Nistri, 2006). The adopted methodology largely follows monitoring rules applied to the Kotschy gecko (*Mediodactylus kotschyi*) (Liuzzi & Mastropasqua, 2016). Observations and counts were carried out on sight with adequate optics (Swarovski 7×42) and, where necessary, with a head torch. These observations and counts focused exclusively on dry walls and walls of buildings, trying to provide a suitable estimate of any meaningful trend. Each transect was repeated over the two years for a total of n = 3 surveys per locality and it was divided into five segments of 100 m length, noting in a special form the data collected and referring to each of them (species/number individual/age). To assess age classes, discriminating between juveniles and adults, we considered size ≤ 5.5 cm (Atzori *et al.*, 2007; Lisičić *et al.*, 2012; Martin *et al.*, 2018). Population size was estimated by using Poisson N-mixture models for closed populations (Ficetola *et al.*, 2018) on the data set collected through each repeated transect. To help stabilizing the numerical optimization algorithm, we standardized all the covariates. In a first full model, detection was modelled in function of Julian date (referred to 1st April) and hour. Models were fit in a Bayesian analytical framework available through the R v. 4.1.2 (R-Core Team, 2021) using the package R2jags (Su & Yajima, 2015), which bases on the samplers implemented in JAGS 4.3.0. Since geckos were detected in almost all surveys, we did not include into the model a layer of hierarchy accounting for zero-inflation. By contrast, to account for over-dispersion we included a random survey effect in the observation model. Uninformative normal priors ($\mu = 0$ and $\sigma = 0.0001$) were used for model's coefficients, and uniform prior ($a = 0$ and $b = 3$ corresponding to $\mu = 1$ and $\sigma = 1{,}000$) was used for the random survey effect (σ). Three independent chains were ran, with 340,000 iterations each. The first 4000 values were discarded, and thinning was set to 5 in order to break within-chain autocorrelation. Convergence was checked via visual inspection of results, and violations of one or more model assumptions were analysed through a goodness-of-fit test aimed at assessing if simulated data differ from the real data in some systematic way (Conn *et al.*, 2018). Results from the posterior distribution are reported as the half sample mode (HSM, Bickel & Frühwirth, 2006) with 95% and 50% highest density intervals, HDI95 (Meredith & Kruschke, 2018).

Figure 1. Distribution of the twelve urban centres of the province of Grosseto, in mainland Tuscany.

RESULTS

During the 39 repeated surveys, we observed 307 *T. mauritanica*, with a minimum of one and a maximum of 79 records for single survey. On average, we observed 15.05 *Tarentola* individuals/man-hour of survey. The Poisson full model with over-dispersion had goodness-of-fit test $P_{simulated>fitted} = 0.517$. This did not occurr for the full model without over-dispersion ($P_{simulated>fitted} < 0.001$). Both hour and date had some effect on the detectability of *T. mauritanica*, although the effect of the latter was rather less evident (Tab. 1). In synthesis, the detection probability increased with Julian date and with hour. The Bayes estimates indicated population size between three and 80 individuals/transect (Tab. 2). The highest number of *Tarentola mauritanica* was obtained in the cities closest to the coast and at the lowest altitudes (i.e. Tirli and Grosseto; average 15 m). Intermediate numbers were estimated in the central northwestern part of the province at intermediate altitudes (i.e., Monterotondo Marittimo, Sticciano, Batignano, Cinigiano; average 314 m) and in southern coast, at the lowest altitude (i.e., Porto Ercole). The lower (or even null: Castell'Azzara; 810 m) values occurred in the cities located more internally within the province at an average medium altitude (i.e., Castel del Piano, Santa Fiora, Roccalbegna, Semproniano; average 607 m) (Fig. 2).

Table 1. Bayesian estimates for the beta coefficients used for modelling the detectability of *T. mauritanica*. HSM = half sample mode, HDI_{95} = 95% credible interval.

Variable	HSM, (HDI_{95})	$P_{\beta>0}$
Date	0.558, (-0.484-1.628)	0.853
Hour	0.864, (-0.225-1.959)	0.944

Table 2: Bayesian estimates of the abundance of *T. mauritanica* in 12 cities of the province of Grosseto. HDI_{95} = 95% credible interval.

City	N (HDI_{95})	Range observed
Batignano	14 (14-20)	0-14
Castel del Piano	3 (3-5)	1-3
Castell'Azzara	0 (0-0)	0
Cinigiano	23 (22-29)	6-22
Grosseto 1	24 (23-29)	1-23
Grosseto 2	23 (22-29)	2-22
Monterotondo M.mo	25 (24-31)	0-24
Porto Ercole	12 (12-14)	10-12
Roccalbegna	3 (3-5)	2-3
Santa Fiora	7 (7-11)	1-7
Semproniano	2 (2-4)	1-2
Sticciano	8 (8-12)	0-8
Tirli	80 (79-88)	11-79

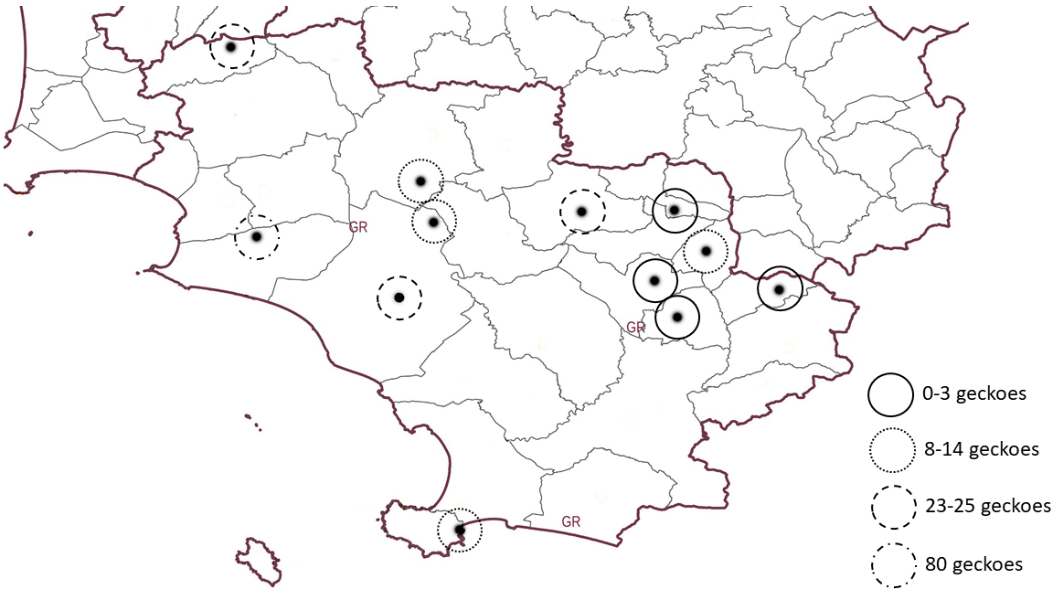

Figure 2. Distribution of monitored geckoes and their density estimation in considered urban centres.

Discussion

The common gecko occurred in all the cities we surveyed in the province of Grosseto, in southern Tuscany, confirming, on average, previous distributional data, even though those data referred to a much wider scale distribution pattern (Vanni & Nistri, 2006). Our research also confirmed species presence after more than 15 years since the last report (Vanni & Nistri, 2006). Our model found important relation with the hour and, to a lesser extent, the transect date for *T. mauritanica*, not to the. transect position (i.e.: they have no statistical effect). However, due to the absence of data on abundance or density in this species in urban areas (but see Zug, 1991), comparisons are not possible yet. *Tarentola mauritanica* is undoubtedly a common species, appearing to be more abundant in those cities closest to the coast (i.e. Tirli and Grosseto). Intermediate estimates relate to the central and northwestern portions of the province and in southern coast, whereas the lower values occurred in the cities located more internally and at the highest altitudes within the province (i.e., Castel del Piano, Santa Fiora, Roccalbegna, Semproniano). Density and population regulation have been recorded for the leaf-toed gecko, *Euleptes europaea*, on an isolated historical building far from the town of Genua, in northern Italy (Salvidio & Oneto, 2008), thus not strictly comparable to our study sites. Furthermore, a recent research on three syntopic species, on a coastal natural area of Tuscany reported relative abundance for three species, where *Tarentola* resulted much less represented than the dominant one, *Hemidactylus turcicus* (Radi & Zuffi, 2022). During evening and night, Moorish gecko is usually much active in the open and, in urban contexts, is easily detectable in close proximity to light sources (Perry *et al.*, 2008). Furthermore, it is usually common in the considered transects and cities, where preys are more abundant (Hódar *et al.*, 2006; Perry *et al.*, 2008) and visible, and where they can find additional basking sites (Werner, 1990). Thus, urban habitats provide suitable ecological conditions in which geckoes had more chances to find higher prey availability (Hódar *et al.*, 2006) and reduce or minimize the risk of predation. Similarly, urban habitats show higher densities of geckoes than natural habitats (Selcer, 1986; Zug, 1991). Our data showed that, at least in this part of the region and -likely- in other part of our country, *H. turcicus* is systematically less abundant than *T. mauritanica* (personal observations; data non provided), with only few exceptions (Radi & Zuffi, 2022). Possible reason for this difference could be a different adaptation to urban environments, despite both species widely overlap in diet composition (Capula & Luiselli, 1994), or to predation, as recently demonstrated by Giacobbe *et al.* (2010), suggesting a possible competitive exclusion. Further studies are strongly needed to enhance our knowledge of density and regulation of geckoes in urban habitats (Luiselli & Capizzi, 1999; Simbula *et al.*, 2019), especially considering prey availability and light pollution.

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(ms. pres. 27 marzo 2024; ult. bozze 15 dicembre 2024)