The role of vegetation in microhabitat selection of syntopic lizards, *Phrynocephalus persicus*, *Eremias pleskei*, and *Eremias strauchi* from Armenia

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Abstract. Composition and density of vegetation are important habitat quality indicators for reptiles. The goal of this note was to determine dominant plant species, optimal size and density in habitats of syntopic lizards in the Goravan Sands Sanctuary. The role of vegetation variables was considered in relation to differences in thermoregulation of syntopic *Phrynocephalus persicus*, *Eremias pleskei*, and *Eremias strauchi*. Microhabitats of *P. persicus* differed from that of *E. pleskei* and of *E. strauchi* by a relatively frequent encounter of the plant *Achillea tenuifolia*, which is considered as potential habitat quality indicator. *Phrynocephalus persicus* generally used microhabitats with sparser vegetation. It is supposed that the excessive growth of shading vegetation can have a more negative impact on *P. persicus* than on *E. pleskei*.

Generally, reptiles use available habitat features in a non-random way in order to meet their own physiological, locomotor, behavioural, and ecological needs (Pianka, 1973; Toft, 1985; Huey, 1991; Smith and Ballinger, 2001). Alteration or loss of key habitat features may lead to population decline and even local extinction of reptile populations (Jaggi and Baur, 1999; Smith and Ballinger, 2001; Howes and Lougheed, 2004). Therefore, studies of habitat requirements are increasingly used as tools for a better scientifically oriented conservation of vulnerable animals, including lizards (e.g., McIntyre, 2003; Howes and Lougheed, 2004; Nemes et al., 2006).

Generally, loss of peripheral populations may diminish future evolutionary potential of a species (Lesica and Allendorf, 1995; Jaggi and Baur, 1999; Channel, 2004). The Asian desert lizards *Phrynocephalus persicus*, *Eremias strauchi*, and *Eremias pleskei* are found in peripheral north-western populations in the Ararat Valley (Armenia) (Ananjeva et al., 2004). *Phrynocephalus persicus* is acknowledged as an endangered species in the South Caucasus (Darevsky and Orlov, 1988; Ananjeva et al., 2004). Population decrease of *P. persicus* is generally connected with man-induced transformation of semi-desert habitats (Agasyan, 1985; Tadevosyan, 2006 a,b).

Being ectotherms, lizards first choose habitats and microhabitats that facilitate thermoregulation (Huey, 1991; Smith and Ballinger, 2001). However, foraging strategy, food, locomotor performance, predator avoidance and competition also might lead to different habitat requirements (Toft, 1985; Smith and Ballinger, 2001). Floristic composition and density of vegetation are also generally considered as important habitat factors and habitat quality indicators for reptiles (e.g., Pianka, 1973; Moulton and Corbett, 1997; Jaggi and Baur, 1999; Smith and Ballinger, 2001; Kingsbury and Gibson, 2002; Offer et al., 2003; Nemes et al., 2006). However, the existing data on the vegetation of habitats of *P. persicus*, *E. strauchi and E. pleskei* are limited to several generalized species lists (Chernov, 1939; Darevsky, 1957; Tadevosyan, 2002), and the role of vegetation in microhabitat selection by these lizards has not been explored yet. The goal of the present study was to determine vegetation-related microhabitat requirements of syntopic *P. persicus*, *E. strauchi*, and *E. pleskei* in the Goravan Sands Sanctuary (Ararat region, Armenia), with conservation considerations.

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Previous literature suggests that *E. pleskei* is more thermophilic than the two other species, and therefore it is active in hotter weather (Darevsky, 1957; Aslanyan, 2004). In addition, these species are reported to show some differences in habitat characteristics. For instance, in the vicinities of the Goravan Sands, *P. persicus* prefers sandy habitats, while *E. pleskei* and especially *E. strauchi* choose not only sands, but also habitats with more firm and stony soils (Darevsky, 1957). Preliminary observations also indicate additional interspecific differences: unlike *P. persicus* and *E. strauchi*, *E. pleskei* forages on shrubs and is an eater of several plant species (Chernov, 1939; Darevsky, 1957; Tadevosyan, 2001; Aslanyan, 2004). Moreover, large specimens of *E. strauchi* feed upon relatively larger prey (including young *P. persicus*, see Aslanyan, 2004), and *Phrynocephalus* uses visual orientation when foraging, in contrast to *Eremias* that uses olfaction (Rogovin et al., 2000). Probably, each of the above noted ecological peculiarities can potentially influence habitat selection (Rogovin et al., 2000; Smith and Ballinger, 2001), but this is still unknown.

In this paper, I specifically test the following key questions: (i) are there interspecific microhabitat differences (in terms of density, floristic composition, and size of shading plants) among *P. persicus*, *E. strauchi*, and *E. pleskei*? (ii) if microhabitat differences between species can be noted, are these differences linked to species-specific ecological differences? (iii) What are the conservation implications of the observed patterns?

The survey was performed in 10 plots of sandy habitats of the Goravan Sands with the total area of 175 hectares (894-1060 m a.s.l., E44°43′; N39°53′; Ararat region, Armenia) (Tadevosyan, 2006a). A visual encounter survey was used to register lizards in 35 random sampling quadrates (Crump and Scott, 1994; Jaeger and Inger, 1994; Tadevosyan, 2006b). Due to the fact that *P. persicus* were relatively rare, I recorded microhabitat data for this species also outside the sampling quadrates (Tadevosyan, 2006a). Vegetation variables were measured using in part the same methodology as in Jaggi and Baur (1999). On each point where a lizard was found, the graduated compass was put down to clearly identify directions. The four nearest semi shrubs, shrubs or other shading plants were selected for each of the four direction classes (*S1* (0-90° from N), *S2* (270-0°), *N1* (90-180°), *N2* (180-270°)) from this registration point.

The distance from the lizard registration point to each of the selected plants was measured and recorded. The length (X), width (Y) and height (Z) of each plant were also measured to calculate plant size (XYZ). A 30 m tape measure was used for all measurements.

The scientific names of the selected plants were recorded. Encounter frequencies for each plant species were classified into the following 5 categories: $0 =$ plants absent in all 4 directions, $0.25 =$ species registered only in 1 direction, $0.5 =$ species registered in 2 directions, $0.75 =$ species registered in 3 directions, and $1 =$ species registered in 4 directions.

Nomenclature follows Ananjeva et al. (2004 – reptiles) and Takhtajian and Fedorov (1972 – plants).

Due to the fact that encounter frequency of plant species, as well as distance from the lizards to the nearest plants, and plant size were not always normally distributed, non-parametric tests were used in this study.

To determine if the lizards' microhabitats differ according to plant encounter frequency, plant size, and distance between the lizards and the plants, the listed variables were compared using single factor Kruskal-Wallis test. Mann-Whitney U test was performed for paired comparisons of the lizard species. For these procedures the lizard species were used as grouping variables, whereas plant size, each plant species encounter frequency, as well as distances between the lizards and the plants were used as dependent variables. To ensure that there is no correlation between plant species, plant size, and distance between the lizards and the plants, the Spearman rank correlation test was used. All tests were automatically performed in one-tailed mode. The significance level ($P \leqslant 0.05$) was used for all tests. Two-sided exact P was used to assess significance of Mann-Whitney U test. Statistical treatment was performed with Statistica 6.0. software (StatSoft, Inc. Tulsa, OK, USA).

Differences among encounter frequency of 18 plant species in the lizards' microhabitats are summarized in table 1. *Achillea tenuifolia* was a dominant plant in microhabitats of *P. persicus*, in contrast to *Kochia prostrata* which was dominant in microhabitats of *E. pleskei* and *E. strauchi*.

The mean size (XYZ) of plants (±SD) for *P. persicus* was 0.42 ± 0.68 m^3 ($n = 356$; range $=$ 0.0004 to 5.17 m^3) and higher (Kruskal-Wallis: $H_{\text{df}} = 17.18_2$; $P < 0.001$; Mann-Whitney: $P < 0.0001$) than for *E. pleskei* (0.2 ± 0.31 m^3; $n = 220$; range $=$ 0.0009 to 1.91 m^3). However, there was not a significant difference (Mann-Whitney: $P = 0.07$) between plant sizes in microhabitats of *P. persicus* and *E. strauchi*

Table 1. Comparison of occurrence frequency of 18 plant species in basking microhabitats of the three lizard species studied in this paper. Full names of plant species: *Noaea mucronata*, *Kochia prostrata*, *Salsola glauca*, *Salsola iberica*, *Salsola cana*, *Salsola macera* (*Chenopodiaceae*); *Achillea tenuifolia*, *Artemisia fragrans*, *Chondrilla juncea*, *Helichrysum undulatum* (*Asteraceae*); *Calligonum polygonoides*, *Atraphaxis spinosa* (*Polygonaceae*); *Salvia dracocephaloides*, *Thymus kotschyanus* (*Lamiaceae*); *Acantholimon karelinii* (*Plumbaginaceae*); *Euphorbia marschalliana* (*Euphorbiaceae*); *Alhagi pseudalhagi* (*Fabaceae*); *Verbascum suworowianum* (*Scrophulariaceae*). M ± QR = Median ± quartile range, R = range; n = sample size. Significantly different encounter frequencies of plants ($P \leqslant 0.05$, according to the Kruskal-Wallis test) are in bold.

Plant species	Encounter frequency of plants in microhabitats of lizards:						*P*
	P. persicus ($n = 102$)		*E. pleskei* ($n = 78$)		*E. strauchi* ($n = 54$)		
	M ± QR	R	M ± QR	R	M ± QR	R	
N. mucronata	0.25 ± 0.5	0-1	0.25 ± 0.5	0-1	0.25 ± 0.75	0-1	0.97
K. prostrata	**0 ± 0.25**	**0-1**	**0.25 ± 0.75**	**0-1**	**0.25 ± 0.5**	**0-1**	**<0.01**
A. tenuifolia	**0.25 ± 0.5**	**0-1**	**0 ± 0.25**	**0-1**	**0 ± 0.25**	**0-0.75**	**<0.01**
C. polygonoides	0 ± 0	0-1	0 ± 0	0-0.25	0 ± 0	0-0.75	0.17
A. karelinii	**0 ± 0**	**0-0.5**	**0 ± 0**	**0-0**	**0 ± 0**	**0-1**	**<0.01**
E. marschalliana	0 ± 0	0-0.75	0 ± 0	0-0.25	0 ± 0	0-0	0.08
S. iberica	0 ± 0	0-0.75	0 ± 0	0-0	0 ± 0	0-0	0.07
H. undulatum	0 ± 0	0-0.25	0 ± 0	0-0	0 ± 0	0-0.5	0.51
A. pseudalhagi	**0 ± 0**	**0-0.5**	**0 ± 0**	**0-0**	**0 ± 0**	**0-0.75**	**<0.05**
A. fragrans	0 ± 0	0-0.5	0 ± 0	0-1	0 ± 0	0-1	0.09
Ch. juncea	**0 ± 0**	**0-0.5**	**0 ± 0**	**0-0.5**	**0 ± 0**	**0-0**	**<0.05**
A. spinosa	0 ± 0	0-0.25	0 ± 0	0-0.25	0 ± 0	0-0.5	0.42
S. dracocephaloides	**0 ± 0**	**0-0**	**0 ± 0**	**0-0**	**0 ± 0**	**0-1**	**<0.05**
S. cana	**0 ± 0**	**0-0**	**0 ± 0**	**0-0**	**0 ± 0**	**0-0.25**	**<0.01**
S. macera	**0 ± 0**	**0-0**	**0 ± 0**	**0-0.5**	**0 ± 0**	**0-0**	**<0.05**
V. suworowianum	0 ± 0	0-0.25	0 ± 0	0-0	0 ± 0	0-0	0.52
S. glauca	0 ± 0	0-0.25	0 ± 0	0-0.25	0 ± 0	0-0	0.72
T. kotschyanus	0 ± 0	0-0.25	0 ± 0	0-0	0 ± 0	0-0	0.52

(0.33 ± 0.2 m^3; $n = 64$; range = 0.017 to 3.02 m^3). There were also no significant differences between plant sizes in microhabitats of *E. pleskei* and *E. strauchi* (Mann-Whitney: $P = 0.48$).

The mean distance (±SD) from the lizard locations to the nearest plants for *P. persicus* (1.7 ± 0.8 m; $n = 101$; range = 0.25 to 4.13 m) was significantly higher (Kruskal-Wallis: $H_{\mathrm{df}} = 50.97_2$; $P < 0.0001$) than for *E. pleskei* (0.93 ± 0.45 m; $n = 78$; range = 0.11 to 2.44 ; Mann-Whitney: $P < 0.000001$) and for *E. strauchi* (1.22 ± 1.2 m; $n = 48$; range = 0.38 to 7.99 m; Mann-Whitney: $P < 0.00001$). There were no significant differences between *E. pleskei* and *E. strauchi* for this variable (Mann-Whitney: $P = 0.22$).

There was no correlation ($n = 624$; $r_S = 0.05$; $P = 0.2$) between floristic composition of lizard microhabitats and distances from the location of the sighting. On the other hand, plant sizes (XYZ) were slightly correlated with both plant species ($n = 624$; $r_S = -0.269$; $P < 0.0001$), and with the mean distance between plants and lizards ($n = 623$; $r_S = 0.297$; $P < 0.0001$).

Semidesert formations with achillea (*Achillea tenuifolia*), some saltworts (*Salsola* ssp.), and artemisia (*Artemisia fragrans*) were earlier noted as the most characteristic habitats of *P. persicus* in Armenia (Chernov, 1939; Darevsky, 1957; Takhtajian and Fedorov, 1972; Tadevosyan, 2002). According to this survey, even a slight prevalence of *A. tenuifolia* over two other dominant semi-shrubs (*K. prostrata* and *N. mucronata*) can serve as an indicator of microhabitat quality for *P. persicus*. This might be linked to some local differences in soil quality (Takhtajian and Fedorov, 1972; Tadevosyan, 2001, 2002), an aspect that nonetheless still needs additional research.

Overshading by vegetation can limit basking opportunities of ectotherms (Moulton and Corbett, 1997; Jaggi and Baur, 1999; Kingsbury and Gibson, 2002; Offer et al., 2003; Nemes et al., 2006). As determined during this survey, *P. persicus* generally uses microhabitats with sparser vegetation, and is apparently less thermophilous and active in cooler hours of the day than *E. pleskei* (Darevsky, 1957; Aslanyan, 2004). Thus, sparse vegetation probably increases basking opportunities for *P. persicus*. On the other hand, dense vegetation does not limit basking opportunities for *E. pleskei* during midday heat. Other ecological peculiarities of *P. persicus*, *E. strauchi*, and *E. pleskei*, as summarized in the Introduction, may lead to described differences in requirements for vegetation density. More research is needed to exclude all alternative hypotheses. Anyway, increased growth of shading vegetation can exert a more negative impact on *P. persicus* than on *E. pleskei*. Hence, dynamics of vegetation density should also be regularly monitored to prevent degradation of habitats of *P. persicus*.

Independence of vegetation density from floristic composition allowed us to conclude that each of these variables may be used, if separately accounted for, as an indicator of habitat quality. Until the causes of correlation between plant size and plant species, as well as between plant size and distances from the lizard capture point to the nearest plants are clarified, or other additional hypotheses tested, plant size cannot be considered as an indicator of habitat quality.

With regard to the study species, I suggest using the above mentioned values of the density, encounter frequency, and sizes of shading plants when (i) selecting optimal sites for translocations, (ii) recovering habitat, and (iii) developing an artificial habitat to *ex situ* conservation purposes (Tadevosyan, 2001). I also suggest using within-quartile range values as an optimal measure for relative encounter frequency of plants and for plant sizes. However, to determine optimal vegetation density, within-quartile range values of the distance from the lizard to nearest plants should be doubled.

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