

**Preferences for different substrates in *Phalangium opilio* (Opiliones: Phalangiidae) in natural environment**

Preference navadnega matije, *Phalangium opilio* (Opiliones: Phalangiidae) do različnih substratov v naravnem okolju

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**Abstract.** *Phalangium opilio* is the most widespread and one of the most common harvestman species in anthropogenic environments. A preliminary field experiment was carried out in Slovenia testing its preferences for different substrates. A two metres high rectangular tower with walls constituted of vertical bands of concrete, twice fired tile, wood and styrofoam was placed in a meadow. The wood proved to be the most suitable substrate, providing the most stable temperatures and moisture levels in comparison with the other experimental materials. In anthropogenic environment, various available substrates in microhabitats of *Ph. opilio* considerably contribute to a fine regulation of searching relatively thermally and moist-stable resting sites.

**Key words:** harvestman, arachnids, Arachnida, Slovenia, substrate preference, synanthropy

**Izvleček.** *Phalangium opilio* je v svetu najbolj razširjena in najbolj običajna vrsta suhih južin v antropogenem okolju. Avtorji so preliminarno preizkušali preference vrste do različnih podlag v antropogenem okolju. Na travniku so postavili 2 m visok pravokoten preizkuševalni stolp iz stranic, sestojčih iz navpičnih pasov betona, dvakrat žgane opeke, lesa in stiropora. Les se je izkazal za najugodnejši substrat, ki zagotavlja najbolj stabilno temperaturo in vlago v primerjavi z ostalimi preskusnimi materiali. V antropogenem okolju omogočajo podlage iz različnih materialov izbor toplotno in vlažnostno najugodnejših mest za mirovanje.

**Ključne besede:** pajkovci, preferenca do substrata, sinanthropija, Slovenija, suhe južine

## Introduction

*Phalangium opilio* Linnaeus, 1758 is the most widespread opilionid species in the World, living in Europe, North and Central Asia and Asia Minor; it was also introduced from Europe to North America, North Africa and New Zealand (Martens 1978, Edgar 1980, Blick & Komposch 2004). It inhabits open habitats, as meadows

and mires/bogs, open/lightful forests, and various types of anthropogenic habitats, as gardens, agroecosystems, forest edges, hedgerows, lawns, quarries, and in urban centres green habitats, walls and bridges made of various materials (Todd 1949, Edgar & Yuan 1965, 1968, Clingenpeel & Edgar 1966, Martens 1978, Edgar 1980, Komposch 1993, Newton & Yeargan 2002, Novak & al. 2002, Hillyard 2005). It has been often discussed

as a synanthropic harvestman (Edgar & Yuan 1965, 1968, Martens 1978, Kuschka 1991, Komposch 1993, Thaler & Knoflach 1995, Klimeš 1997, Novak & al. 2002, Komposch & Gruber 2004, Merfield & al. 2004, Allard & Yeargan 2005, Willemart & al. 2006). In fact, the species belongs to the so called »Kulturfolger« sensu Povolný (1963) – meaning an organism occurring in cultivated landscapes (»following« such habitats) for ecological reasons, like coprophagous arthropods which are common in cattle herds and sheep flocks. In open sites with tall objects, *Ph. opilio* also climbs such objects. During bad weather it takes shelter in grass and the understory, as well as in anthropogenic habitats also beside different commercial, especially building materials.

In Central Europe, *Ph. opilio* matures steno-chronously once a year in late summer and early autumn (Kaestner 1926, Ruffer 1966, Martens 1978), while there are more generations in North America (Edgar & Yuan 1968). The eggs and juveniles develop most rapidly at temperatures between 20–30°C, whereas their embryonic development is completely retarded at temperatures below about 10°C (Juberthie 1964, Ruffer 1966, Bachmann & Schäfer 1983). *Ph. opilio* is predominantly nocturnal, executing ca. 90% of its activity between 6 p.m. and 6 a.m. (Edgar & Yuan 1965, 1968). In natural habitats it is exposed to sun and wind, thus hardy in tolerance of desiccation and adapted to relatively high illumination levels (Edgar & Yuan 1968, Edgar 1980, Clingenpeel & Edgar 1966). In urban areas in Slovenia, petrophily has been found to be predominant in synanthropic harvestmen, including *Ph. opilio* (Novak & al. 2002).

Experimentally gathered data about the thermo- and hygro-preference of *Ph. opilio* in the USA (Edgar & Yuan 1965, 1968, Clingenpeel & Edgar 1966) differ a lot from the field data recorded in the UK (Todd 1949). In Europe, these preferences have not been studied experimentally. Since the 1990s, the traditional areas for behavioural study have largely been abandoned, but many long-standing challenges remain (Owens 2006). The scope of this study was preliminary testing preferences of *Ph. opilio* for different substrates, and to find reasons for unequal affinities for different commercial, especially building substrates in human settlements. We also tried to contribute to an

ecophysiological explanation for why *Ph. opilio* is a common species in human habitats.

## Material and Methods

*Phalangium opilio* specimens: 37 ♂, 31 ♀ and three subadults used in the experiment were collected in Žavcarjev vrh in north-eastern Slovenia (46°36' N, 15°32' E, alt. 800 m). The experiment was arranged in a plane meadow near Slovenske Konjice in north-eastern Slovenia (46°21' N, 15°27' E, alt. 360 m) and carried out from August 10<sup>th</sup> till September 18<sup>th</sup> 2005 when it was ended entirely because of cold, rainy weather.

In order to test preferences for different substrates, a square experimental tower was constructed with walls measuring 44 x 200 cm (Fig. 1). Each wall consisted of vertical belts – 1 cm thick and 11 cm wide – of the following four experimental surfaces, affixed to a wooden plate. Their thermal conductivity coefficient,  $\lambda$ , in W/mK, according to Engineering Toolbox (2006), is in parentheses: concrete (1.16), twice fired tile (1.05), pinewood (0.14) and styrofoam (0.04). The concrete and the wood were porous, while the tile, and the styrofoam due to its waterproof surface nonporous materials. These materials served as the arbitrary resting substrates for the specimens. The top of the tower was covered with a translucent plastic plate extending 10 cm over the edges, to avoid concealment of individuals inside. A 50 cm high plastic fence was erected 1 m from the tower to prevent escapes, and to provide a grassy habitat for hiding and hunting. Twice a week, meadow insects were caught and released inside the fence to provide the prey species availability by chance and choice. The experimental individuals were placed into the arena 10 days before starting the experiment to acclimate. The records were kept exclusively in nice days, and at least two days after a rainfall.

The measurements started at 1:00 p.m. to guarantee data from the hottest period of the day when *Ph. opilio* does not move (Edgar 1980). At the resting site of each specimen on the tower, the compass direction of the chosen wall, the height, the selected substrate, the air temperature (T) and the relative humidity (RH) 1 cm from the specimen's body, using a handheld aspiration psychrometer (Ahorn FN 864, Germany), were



Fig. 1: The experimental tower in a provisory site (the experimental meadow in behind).

recorded. The only records kept were of those specimens with the whole body and more than half of the legs positioned on a selected substrate. It was hypothesized, that during hot days 1) hotter the day, higher the settled site on the tower, and 2) stony surfaces (concrete, tile) are preferable to *Ph. opilio*.

For statistical purposes one way ANOVA was used in testing the differences between substrate in means for height, T and RH of the resting specimens. For testing differences in preferences, the Chi-square test was used. To provide the F test for RH, the data were *arcsin*-transformed. SPSS 12.01 for Windows was used in the procedures.

## Results

During the experiment, the weather was good with two rainy intervals – each in a few days in duration. The number of specimens settled on

the tower decreased logarithmically from on the first to the 37<sup>th</sup> experimental day (Fig. 2). Cumulatively, 90 measurements were provided, thus some records referred to the same specimens. During the time of the experiment, the subadults moulted. In their resting sites, there were no statistical differences between sexes and between adults and subadults in height, temperature (T) and relative humidity (RH) (One way ANOVA,  $P > 0.05$ ); therefore the data for further statistical analyses were pooled. Individuals usually terminated their activity period by performing an exploratory movement for a few seconds within a radius of 10 to 25 cm before settling. On rainy days, they took shelter in the grass.

Near the surface of the experimental substrates, concrete was found to provide the least thermal stability (CV=18.4 %), and styrofoam the least humidity stability (CV=18.7 %), while wood was generally the most stable material with respect to both measurements (Table 1).

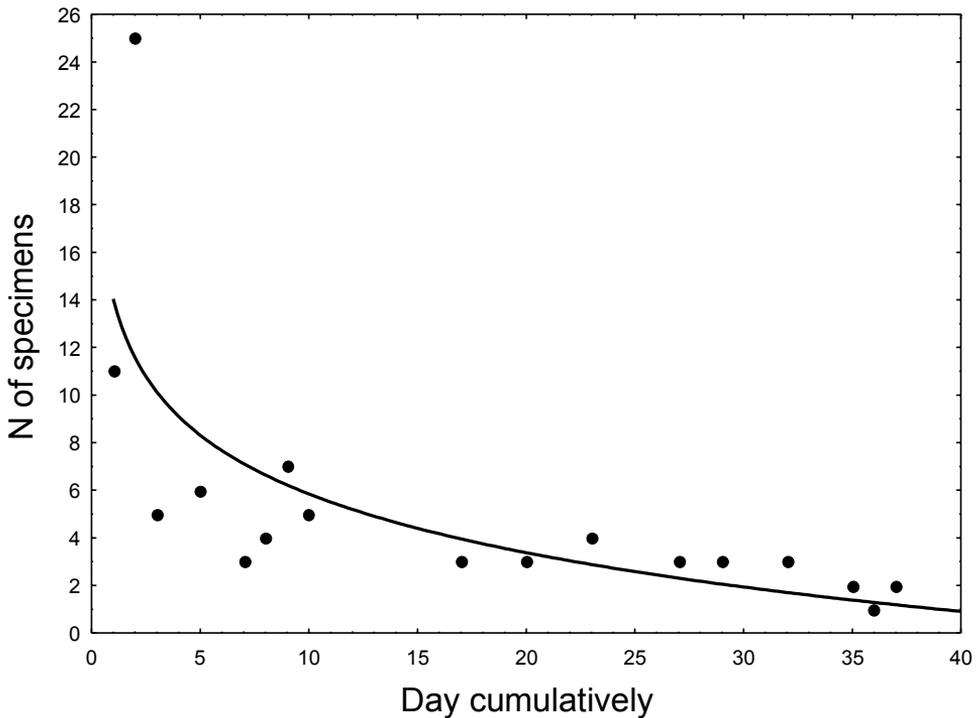


Fig. 2: Individual records of *Phalangium opilio* on the experimental tower diminished logarithmically during the experiment.

During their daytime rest, the specimens positioned themselves irregularly according to substrates (Table 1). The concrete, tile and styrofoam were comparable, while the wood was significantly more frequently occupied. Most specimens placed themselves on the wood, while the tile was the least preferred substrate ( $\chi^2 = 11.96$ ,  $df = 3$ ,  $p = 0.008$ ).

The specimens spread over the whole range of the tower's height, in the range of mean heights between 43 and 160 cm, both extremes on the tile. Regardless of the compass direction, the T means for different substrates were between 20.9 and 24.9°C, both extremes on the concrete, and the RH mean between 58.1 and 79.0%, both on the styrofoam.

T and RH were in a moderate negative correlation with each other ( $r = -0.73$ ,  $P < 0.001$ ). On the one hand, the concrete, tile and styrofoam, which differ in their thermal conductivity

29-times (Engineering Toolbox 2006) were comparably frequently settled, while wood and styrofoam, on the other hand, which differ only 3.5-times, were not.

## Discussion

Although harvestmen behave quite similarly in the laboratory as in natural habitats (Edgar & Yuan 1968), various unnatural circumstances in the laboratory, such as inappropriate experimental containers, light conditions, food etc., can influence the experimental results. In experiments with predators, the use of factitious prey can hardly be avoided, which cannot be favourable to the experimental specimens (Merfield & al., 2004). On the other hand, in nature, a range of instabilities often renders the interpretation of results difficult. The experimental tower in the meadow enabled

Table 1: Mean, standard deviation, minimum, maximum and coefficient of variation, CV, of the height, temperature, T, and relative air humidity, RH, at the sites of *Phalangium opilio* with respect to the substrates.

Substrate	N	Height (cm)	T (°C)	RH (%)
		Mean ± SD Min – Max CV (%)		
Concrete	17	55.0 ± 49.6 10 – 200 90.2	21.5 ± 4.0 16.1 – 27.1 18.4	73.6 ± 12.9 54.1 – 91.2 17.5
Tile	15	80.8 ± 60.8 10 – 200 56.5	23.0 ± 4.0 15.5 – 28.4 17.2	65.4 ± 10.4 47.4 – 88.1 16.0
Wood	36	80.8 ± 63.0 2 – 195 77.9	22.6 ± 3.2 15.7 – 29.1 14.3	66.2 ± 10.4 50.9 – 86.1 15.6
Styrofoam	22	81.9 ± 62.3 5 – 200 76.5	21.8 ± 3.1 13.9 – 26.8 14.1	67.0 ± 12.5 53.1 – 98.3 18.7

accurate measurements and optimally reflected responses of *Ph. opilio* within mixed artificial-natural habitats in the temperate zone.

In comparison with the T of 15.5°C found to be the thermopreference in field populations in Great Britain (Todd, 1949), and 27.6°C in an experimental one in the USA (Edgar, 1980), the mean preferred T of 17.8–23.2°C in our experimental population indicates that the preferences depend on thermal acclimatization in concrete habitats. In hot days, in *Ph. opilio*, adapted to habitats that are well sun-radiated (Edgar, 1980), the substrate selection among others helps in maintaining their thermal stability at relatively high levels in avoiding of hyperthermy at the same time.

The micrometeorological conditions for different substrates were strongly influenced by their properties. The existence of comparably frequently settled substrates that differ greatly in their thermal conductivity, on the one hand, together with unequally settled substrates that differ less, on the other hand, indicates that the thermal conductivity of a substrate does not by itself have an impact on the substrate selection. The concrete was thermally the least stable substrate because of its porosity, and different intensities of evaporation and desiccation during the day. The properties of tile were comparable. In spite of its low thermal conductivity, and although kept moist in the laboratory (Klee &

Butcher 1968, Edgar 1980), in the field styrofoam displayed low moisture capacity. The preference for wood in *Ph. opilio* can be understood by its thermal stability as the consequence of its low thermal conductivity and the steady moderate release of moisture, both providing comparatively the most stable microclimate at a site. This is in agreement with the statements of Kuschka (1991), that *Ph. opilio* is a thermophilous and moderately hygrophilous species.

The persistence of *Ph. opilio* in the human settlements is the consequence of a combination of facts. In this opportunistic feeder (Martens 1978, Morse 2001), its thermophily and hardiness against desiccation and drought (Edgar & Yuan 1968, Edgar 1980) assure relatively fast metabolism and development. Individual selection of various substrates proved to be one of the T and RH regulation mechanisms, while the selection of compass direction, the height of climbing tall objects, as well as a cryptic behaviour during unpleasant weather should be tested with this respect in avoiding auto-replicates as further means of assuring relatively fine regulation of the optimal metabolism and development. In anthropogenic environment, various substrates available in microhabitats of *Ph. opilio* considerably contribute to a fine regulation of searching relatively thermally and moist-stable resting sites.

## Conclusions

In conclusion,

- among commercial, especially building substrates, a wood is the preferable substrate to *Ph. opilio*,
- the apparent preference for concrete substrate in human settlements is the consequence of an irregular distribution of different substrates within the settlements.

## Povzetek

*Phalangium opilio* je najbolj razširjena vrsta suhih južin in obenem najbolj običajna v antropogenem okolju. Pogosto jo obravnavajo kot sinantropno vrsto v širšem smislu. Preliminarno smo ugotavljali preference vrste do različnih podlag, na katerih osebkii mirujejo v antropogenem okolju, ker takšni poskusi niso bili opravljeni. Stranice 2 m visokega preizkuševalnega stolpa so bile iz navpičnih pasov betona, dvakrat žgane opeke (klinkerja), smrekovega lesa in stiropora.

Stolp je bil ograjen z 0,5 m visoko plastično ograjo, da poskusne živali niso ušle. Meritve temperature in vlage smo opravili tik ob osebkiih po njihovi umiritvi od 13<sup>h</sup> naprej, ko je bila temperatura najvišja. Les se je med preskusnimi materiali izkazal za preferenčen substrat, ker zagotavlja najbolj stabilno temperaturo in vlago. Poleg ostalih dejavnikov, kot so stran neba, višina namestitve nad tlemi in drugi, omogočajo različni materiali v antropogenem okolju osebkii izbor toplotno in vlažnostno najugodnejše podlage za mirovanje.

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