

Distribution of domestic Psocoptera in Madrid apartments

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Abstract. Domestic Psocoptera were sampled in Madrid throughout a complete year (1991–92) by means of sticky traps in bathrooms, kitchens and inside windows. A total of 409 individuals comprising ten species of psocids was caught from 4056 traps inspected fortnightly. The predominant species were *Liposcelis decolor*, *Li. brunnea*, *Psyllipsocus ramburi*, *Li. bostrychophila*, *Li. pearmani*, *Dorypteryx domestica* and *Lachesilla pedicularia*, in descending order of abundance. Apartments were classified according to eight quantitative variables: age and area of building, level of apartment (i.e. storey), numbers of windows, inhabitants, their pets (birds and mammals), ornamental plants indoors; and two qualitative factors: floor material and presence or absence of trees adjacent to the house. Psocid communities in human habitations were assessed by the island biogeography theory: diversity increased with apartment size and the number of species decreased with building date. Psocid populations were most abundant in bathrooms, which presumably act as sources for dispersal to other parts of the premises. No other significant correlations were found with the other housing factors investigated. Whereas psocids were active indoors during all months of the year, the peak prevalence was in summer, July and August, one or two months ahead of the local seasonal pattern for non-domestic psocids. Although psocids are usually not seriously unhygienic, causing only minor problems of contamination and allergies, this information should help towards their environmental control.

Key words. Psocoptera, domestic psocids, humidity, island biogeography, seasonality, sticky traps, Madrid, Spain.

Introduction

Among the Psocoptera (booklice etc.) a considerable number of species occur typically in houses and other buildings feeding mainly on fungal hyphae and spores of moulds. In most cases, psocids are associated with products in food stores, granaries, warehouses, railway boxcars and ships' holds (Broadhead, 1954; Tada, 1956; Badonnel, 1974; Turner, 1987; Sinha, 1988). Psocids are common inhabitants of domestic environments such as humid rooms, basements, damp walls and room partitions where they find suitable conditions for development (Schneider, 1977; Lienhard, 1982; Kort, 1990).

Few effects on human health, building materials or furnishings are caused by Psocoptera, although certain species damage books, and infestations of foodstuffs are unhygienic. On rare occasions, psocid numbers attain pest proportions in

households (Sinha, 1988), and occasionally they may cause human health problems such as skin diseases or scalp infestations (Conci & Franceschi, 1953; Agostini *et al.*, 1982; Burgess *et al.*, 1991), allergies from house dust (Spieksma & Smits, 1975), and certain psocids serve as intermediate hosts of some cestodes (Svazhian, 1963; Kuznetsov, 1966).

In houses, psocids cause less tangible effects. As New (1987) pointed out, their main 'damage' to buildings is their effect on property values: law-suits resulting from the presence of psocids often prove costly. In some places, psocids have become considerable pests of recently built houses, living on the moulds that grow as the buildings dry out. Relationships between psocids and fungi on room partitions in the Netherlands were studied by Kort (1990). In a Spanish coastal town, three species of psocid (*Dorypteryx domestica*, *Liposcelis bostrychophilus* and *Psocatropos microps*) were clearly involved in spreading infestation of the alga *Pleurococcus* on recently constructed buildings (A. Baz, unpublished data).

Knowledge of the occurrence and distribution of psocids in domestic environments is therefore of interest for both

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Table 1. Summary values of environmental variables observed for 52 apartments in Madrid.

Factor	Mean $\pm$ SD	Minimum	Maximum	Categories	<i>n</i>
<i>Quantitative</i>					
Date of building	1964 $\pm$ 20	1895	1990	< 1980	41
				$\geq$ 1980	11
Area of house (m ²)	97 $\pm$ 41	18	200	< 100	31
				$\geq$ 100	21
Storey*	3.1 $\pm$ 2.6	0	10	$\leq$ 3	34
				> 3	18
External windows	4.5 $\pm$ 2.8	0	15	< 5	29
				$\geq$ 5	23
No. inhabitants	3.2 $\pm$ 1.3	0	5	$\leq$ 3	28
				> 3	24
No. pets					
Mammals	0.4 $\pm$ 0.6	0	2	0	36
				> 0	16
Birds	0.5 $\pm$ 1.7	0	12	0	40
				> 0	12
No. plants indoors	8.9 $\pm$ 8.9	0	45	$\leq$ 10	34
				> 10	18
<i>Qualitative</i>					
Floor material	—	—	—	wooden	36
				tile	16
Setting	—	—	—	with trees	21
				without trees	31

*storey = level of apartment, i.e. 0 = ground floor, 1 = first floor, 2 = second floor, etc.

diagnostic and preventive purposes. During our extensive studies on the entomofauna of human habitations in the city of Madrid, the Psocoptera were found to be one of the predominant insect Orders in the domestic environment (Monserrat & Gamarra, 1995).

Materials and Methods

Representative apartments in the city of Madrid were selected for sampling Psocoptera. These apartments were chosen to include wide ranges of age, size and socioeconomic conditions. Madrid has an equable climate with mean monthly temperatures ranging from 9°C in December–January to >30°C in July–August and annual mean relative humidity of 65%. Originally sixty-five apartments were selected, with occupants willing to collaborate in trapping; they also agreed not to use insecticides indoors during the study period. When deficiencies occurred with sampling in some apartments, those were excluded from the analysis of data. Therefore, results from only fifty-two apartments have been used in this study.

Psocids were collected with two types of adhesive traps (Johnson & Son, Madrid): two Mr StickyTM traps (each with upper horizontal adhesive surface area 140 cm²) were placed on the floor in each apartment, one in the bathroom the other in the kitchen, to collect walking psocid nymphs and wingless adults,

e.g. *Liposcelis* spp. Also one Fly Terminal RaidTM (adhesive surface area 54 cm²) was fixed to a window glass in the lounge area for sampling small flying insects. Traps were replaced every 14 days for a complete year (October 1991 to October 1992), giving a total of 4056 samples (3 traps $\times$ 26 samples $\times$ 52 houses). Psocoptera were identified to species by means of the keys of Badonnel (1943) and Lienhard (1990).

Each house was assessed for ten variable factors listed in Table 1, scored for data analysis. Relationships among environmental variables, the numbers of psocid species and individuals [normalized by log₁₀ (*x* + 1) transformation] were subjected to Analysis of Variance (ANOVA). Differences observed among psocid numbers and distributions inside houses of each category were tested for significance by χ^2 analysis.

Results

Species recorded

Psocoptera were obtained in 47 of 52 apartments sampled (90.4%), totalling 409 individuals of ten species (Table 2). Of these, only *Lachesilla pedicularia* and *La. bernardi* are winged, the other eight species being wingless or micropters, with the exception of *Psyllipsocus ramburi* which has an alate form; only six individuals of this form were found among 45

Table 2. Psocoptera collected from 52 apartments in Madrid: 26 fortnightly sets of three samples (total 4056 traps), Oct 91-Oct 92.

Species	No. (%) apartments positive	No. psocids collected	Mean no. psocids/ apartment
<i>Dorypteryx domestica</i> (Smithers 1958)	8 (15%)	58	7.3
<i>Dorypteryx pallida</i> Aaron 1884	1 (2%)	4	4.0
<i>Lachesilla bernardi</i> Badonnel 1938	1 (2%)	1	1.0
<i>Lachesilla pedicularia</i> Linnaeus 1758	8 (16%)	12	1.5
<i>Liposcelis bostrychophila</i> Badonnel 1931	11 (21%)	27	2.5
<i>Liposcelis brunnea</i> Motschulsky 1852	26 (50%)	117	4.5
<i>Liposcelis decolor</i> Pearman 1925	29 (56%)	121	4.2
<i>Liposcelis entomophila</i> (Enderlein 1907)	2 (4%)	3	1.5
<i>Liposcelis pearmani</i> Lienhard, 1990	10 (19%)	21	2.1
<i>Psyllipsocus ramburi</i> Selys-Longchamps 1872	19 (37%)	45	2.4

Table 3. Factorial analysis of variance for number of species.

*denotes significant trend.

Source of variation	Sum of squares	d.f.	Mean square	F-ratio	P
<i>Main effects</i>					
Date of building	6.089	1	6.089	3.85	0.05*
Surface (m ²)	8.091	1	8.091	5.12	0.02*
Ground material	0.013	1	0.013	0.009	0.92
<i>Residual</i>	75.815	48	1.579		
<i>Total (corrected)</i>	92.673	51			

individuals caught. *Liposcelis brunnea* and *Li. decolor* were the predominant species found, with apartment infestation prevalences of 50% and 56%, respectively.

Correlation with environmental variables

Significant relationships of psocid species number or abundance were found for only two of the ten variable factors investigated for 52 apartments (Table 1).

The species number was correlated with both the age of the apartment and its area (Table 3); newer and larger houses contained significantly more psocid species. Similar relationships were found when the numbers of psocid individuals were considered, although these trends were not significant (Table 4).

Distribution inside houses

Psocoptera were found on 272 out of 4056 sticky traps installed. Locations and numbers of traps on which each species was taken are listed in Table 5, showing that most (54%) were trapped in bathrooms ($\chi^2=67.25$; $P<0.001$). Disregarding the window sticky trap data, which is deficient

for wingless forms, psocids were significantly more frequent in bathrooms than in kitchens ($\chi^2=13.89$; $P<0.001$).

Considering individual species, *Dorypteryx domestica*, *P. ramburi* and *Li. pearmani* were found more frequently in bathrooms ($\chi^2=7.06$, $P<0.001$; $\chi^2=4.66$, $P=0.03$ and $\chi^2=4.16$, $P=0.04$, respectively), but other species showed no clear associations with sampling sites, viz. *Li. bostrychophila*, $\chi^2=0.5$, $P=0.47$; *Li. brunnea*, $\chi^2=2.88$, $P=0.09$; *Li. decolor*, $\chi^2=1.92$, $P=0.16$; except that the winged species *La. pedicularia* was caught more frequently on windows ($\chi^2=8.25$, $P=0.01$).

Seasonality

Populations of Psocoptera were active in human habitations throughout the year. However, a strong seasonal pattern was detected (Fig. 1) with a peak during midsummer months, July and August. This pattern was the same for all three biotopes sampled: kitchens ($\chi^2=58.33$, d.f.=25, $P<0.001$), bathrooms ($\chi^2=102.83$, d.f.=25, $P<0.001$) and windows ($\chi^2=57$, d.f.=25, $P<0.001$) with psocid catches significantly greater in summer than during winter months.

Table 4. Factorial analysis of variance for number of individuals.

Source of variation	Sum of squares	d.f.	Mean square	F-ratio	P
<i>Main effects</i>					
Date of building	2.830	1	2.830	3.42	0.07
Surface (m ²)	2.849	1	2.849	3.44	0.06
Ground material	1.160	1	1.160	1.40	0.24
Residual	39.664	48	0.826		
Total (corrected)	47.179	51			

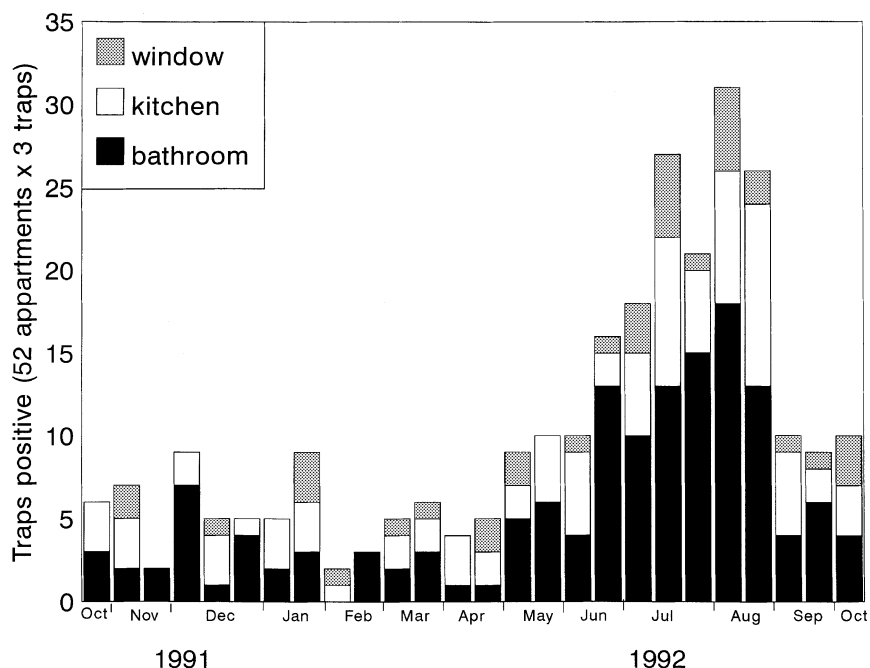
Table 5. Sticky trap positivity rates for ten species of Psocoptera in three domestic types of trapping sites in Madrid: 26 fortnightly collections (October 1991–92) in 52 apartments.

No. of traps:	Bathroom 1352	Kitchen 1352	Window 1352	Total 4056
<i>D. domestica</i>	24	9	0	33
<i>D. pallida</i>	1	0	0	1
<i>La. bernardi</i>	0	0	1	1
<i>La. pedicularia</i>	0	3	8	11
<i>Li. bostrychophila</i>	11	8	1	20
<i>Li. brunnea</i>	31	19	12	62
<i>Li. decolor</i>	41	31	6	78
<i>Li. entomophila</i>	0	3	0	3
<i>Li. pearmani</i>	10	3	4	17
<i>P. ramburi</i>	28	14	4	46
Total	146	90	36	272

Discussion

In Madrid, Psocoptera occur in at least 90% of apartments, along with Coleoptera, Diptera and other ubiquitous Orders of insects (Monserrat & Gamarra, 1995). The number of domestic psocid species obtained in Madrid (10 spp.) was less than reported from other countries, i.e. 13 spp. in Yugoslavia (Kalinovic, 1979, 1981), 15 spp. in Queensland (Champ & Smithers, 1965), 22 spp. in Luxembourg (Schneider, 1977) and 50 spp. mentioned by Mockford (1991) from stored products in houses of the U.S.A.

The majority of species infesting Madrid houses have almost global distributions, like other domestic arthropods such as certain species of silver fish (Thysanura: Lepismatidae), cockroaches (Dictyoptera) and house dust mites (Acari: Pyroglyphidae). Through their habits, Psocoptera have undoubtedly been transported by humans, via the holds of ships,

**Fig. 1.** Fortnightly samples (1991–92) of domestic psocids collected from sticky traps in three sampling sites (bathroom floor; kitchen floor; inside window) in 52 apartments in Madrid.

in packing materials and trade goods (New, 1987). For this reason, the geographical origin of many domestic psocids is unknown. The cosmopolitan presence of domestic psocids allows extrapolation of our results to other cities around the world, where houses may be inhabited by similar subsets of psocid species.

Psocids are often associated with recently constructed houses, in which walls and room partitions retain a high degree of humidity (Lienhard, 1982; Schneider, 1984; Burgess *et al.*, 1991). These favourable conditions allow psocids to become readily established in new houses. Most psocid species are wingless and consequently their own powers of dispersal are very limited. Presumably psocids usually reach houses primarily via infested materials brought by human activity. As newly built houses dry out structurally, the conditions favouring psocid colonization are reduced; consequently local extinctions of some species take place (Hubbell & Wright, 1983). With the ageing of houses therefore the number of psocid species tends to decrease because the range of suitable biotopes becomes restricted.

The diversity and abundance of domestic psocid species in Madrid were found to be correlated with only two of ten variable factors investigated (Table 1): the surface area of a house and its date of construction. This conforms with the suggestion that psocids usually invade houses randomly (Turner & Maude-Roxby, 1987). The dynamics of colonization and settlement of psocids in human habitations thus resembles the theory of island biogeography (MacArthur & Wilson, 1963, 1967).

Overall, Psocoptera were found to be significantly more prevalent in bathrooms than kitchens in Madrid apartments. Bathroom psocid populations can serve as sources of individuals invading other rooms (Pulliam, 1988). Populations of all life stages of Psocoptera occurred in Madrid apartments throughout the entire year, with the seasonal peak in July–August being equivalent for bathrooms, kitchens and windows. This seasonal rise of psocid population density indoors precedes that observed outdoors, where peak densities of non-domestic psocids occur during autumn in September and October (Baz, 1989). In central Spain, where the summer is hot and dry, some species of non-domestic psocid diapause or migrate to more humid habitats, e.g. from trees to leaf-litter (Baz, 1991). Inside houses, particularly in bathrooms, moisture levels remain high during the dry summer. High temperature and humidity accelerate psocid growth (Rees & Walker, 1990) facilitating peak population density during summer.

The need for moisture appears to be an important limiting factor in psocid biology: many studies have correlated relative humidity with psocid growth, survival and fecundity (Knulle & Spadafora, 1969; Fahy, 1971; Rudolph, 1982a,b; Turner & Maude-Roxby, 1988; Rees & Walker, 1990; Mills *et al.*, 1992). Hence, the degree of moisture in walls seems to be a major factor favouring the initial colonization of houses by psocids. Since their dependence on humidity determines the spatial distribution of psocids inside houses, maintaining low humidity has been suggested as an efficient measure for the control of psocid pests (Brown, 1942). This knowledge of

community dynamics, spatial distribution and seasonal patterns of domestic psocids should be useful for the control of these unhygienic and potentially allergenic pests of food and other materials.

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