ESTABLISHMENT OF A MEDITERRANEAN ISOPOD (*CHAETOPHILOSCIA SICULA* VERHOEFF, 1908) IN A NORTH AMERICAN TEMPERATE FOREST

BY

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ABSTRACT

Chaetophiloscia sicula (Oniscidea, Philosciidae) was collected in an urban forest patch in Baltimore, Maryland. The species is indigenous to the northern Mediterranean from Greece to Spain. This is the first record of the genus and species in North America. Other oniscideans from the same forest patch are *Hyloniscus riparius*, *Trichoniscus pusillus*, *Haplophthalmus danicus*, *Philoscia muscorum*, *Porcellio scaber*, and *Cylisticus convexus*. All are introduced species having been brought to the region most probably during early European settlement. *Chaetophiloscia sicula* is the third most abundant species in the habitat with a density of 22 ind/m^2. Females outnumbered males at a 1 : 5 ratio, and they are significantly larger than males. Gravid females were found during June and July with 7-18 offspring per brood pouch. The known distribution and population characteristics of *C. sicula* indicate that it was recently introduced and it has a restricted but established population in the Baltimore area.

RÉSUMÉ

Chaetophiloscia sicula (Oniscidea, Philosciidae) a été récoltée dans une parcelle de forêt urbaine à Baltimore, Maryland. L'espèce est indigène du nord de la Méditerranée, de la Grèce à l'Espagne. C'est le premier signalement du genre et de l'espèce en Amérique du Nord. D'autres oniscidés de la même parcelle de forêt ont été identifiés: *Hyloniscus riparius*, *Trichoniscus pusillus*, *Haplophthalmus danicus*, *Philoscia muscorum*, *Porcellio scaber* et *Cylisticus convexus.* Toutes sont des espèces introduites ayant été appontes dans la région le plus probablement au cours des premiers établissements d'européens. *Chaetophiloscia sicula* est la troisième espèce la plus abondante dans l'habitat avec une densité de 22 ind/m^2. Les femelles sont plus nombreuses que les mâles avec un rapport de 1 : 5, et elles sont significativement plus grandes que les mâles. Les femelles gravides ont été trouvées en juin et juillet avec 7-18 individus par poche incubatrice. La répartition et les caractéristiques des populations de *C. sicula* indiquent qu'elle a été récemment introduite et que cette espèce a une population réduite mais bien établie dans la région de Baltimore.

INTRODUCTION

Species introduction is a central issue in current studies of ecology and conservation biology. Introduced species can out-compete native species, alter ecosystem structure and function, and cause considerable economic loss (Elton, 1958; Mooney & Drake, 1986; Pimentel et al., 2000). Urban areas are often hotspots of species introduction (McDonnell & Pickett, 1990; Sukopp, 1990). Exotic species can easily colonize the heavily disturbed urban habitats. Having established they can grow in number and begin to expand their range.

One of the central questions of the Baltimore Ecosystem Study, a recently established Long Term Ecological Research (LTER) site in the United States, is the significance of non-native species in urban habitats. As part of this project, we have been surveying the soil fauna in urban and rural habitats in the Greater Baltimore Metropolitan Area, in Maryland. In our study an oniscidean species of a genus new to the site and to the United States was recorded: *Chaetophiloscia sicula* Verhoeff, 1908 (see Vandel, 1962: 496).

The terrestrial isopod fauna of the northeastern United States is dominated by introduced species (Van Name, 1936, 1940, 1942; Vandel, 1949; Jass & Klausmeier, 1990, 2000; Schultz, 1963). Native terrestrial isopods are few and they are recorded from caves and specialized habitats (see Hatchett, 1947; Schultz, 1970, 1975, 1977). Most of the non-indigenous species are of European origin with well-established populations. Lindroth (1957) discussed 22 species of oniscideans recorded in North America, which also are common in Europe. Knowledge of the biology and range of each species was further enhanced by Van Name (1936, 1940, 1942). Jass & Klausmeier (2000) summarized the present knowledge of endemic and introduced isopod species including a list by province of Canada and by state of the United States, north of Mexico. Other local studies on the distribution and establishment of oniscideans in North America include Hatch (1947) and Schultz (1961). Even though introduction of soil invertebrates is likely to continue, e.g., via ornamental plants, no recent surveys have been made on the terrestrial isopod fauna of North America. In this paper, we discuss the establishment of *Chaetophiloscia sicula* from the Mediterranean region at an urban site in Maryland, U.S.A.

MATERIALS AND METHODS

The site is an urban forest nearby an apartment complex, named Cross Keys, in Baltimore City, Maryland (fig. 1). The most common trees are *Liriodendron tulipifera* L., *Quercus nigra* L., *Q. rubra* L., *Fagus grandifolia* Ehrh., *Acer ru-*

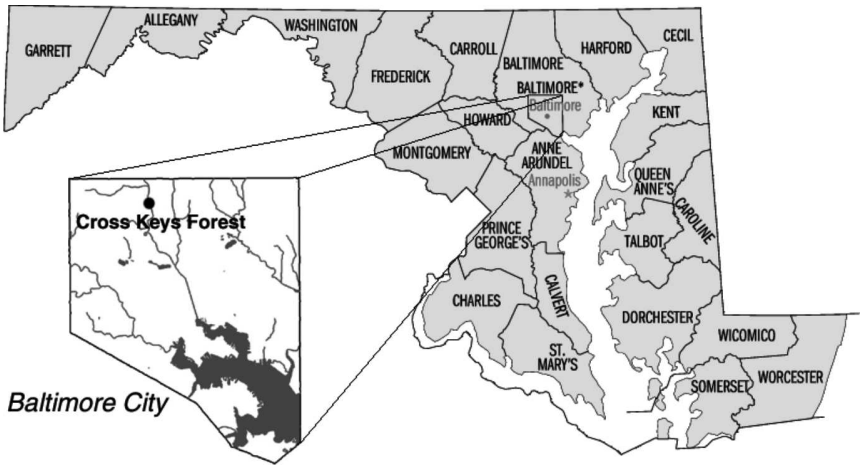

Fig. 1. Map of Maryland counties and Baltimore. Cross Keys is in the Jones Falls Watershed.

brum L., *Cornus florida* L., and *Prunus serotina* Ehrh. The herbaceous layer is dominated by ground ivy (*Hedera helix* L.), poison ivy (*Rhus radicans* L.), may-apple (*Podophyllum peltatum* L.), and *Aster* spp. A thin layer of leaf litter covers the forest floor. The silt-loam soil consists of 44% sand, 40% silt, and 16% clay with a pH value of 4.7.

Collecting methods

Sampling took place between June 2000 and August 2001. We collected the isopods both by hand and by dry funnel extraction. To estimate absolute densities, 25 × 25 cm quadrats were placed randomly on the forest floor in ten replicates. Leaf litter and upper 5 cm of soil were separately extracted in modified Tullgren funnels. Departure from random spatial distribution was tested by calculating the Index of Dispersion (Southwood, 1991):

$$I_D = \frac{s^2(n-1)}{\bar{x}}$$

where n = the number of samples, $\bar{x}$ = estimated mean density, and s^2 = estimated variance.

RESULTS

Species composition and abundance of isopod assemblage

Up to the present we have recorded a total of eleven terrestrial isopod species from the Greater Baltimore Metropolitan Area, out of which seven were also found in the Cross Keys forest (table I). All species are introduced, and all but *Chaetophiloscia sicula* are known from many sites in the northeastern United States.

In Cross Keys we collected a total of 705 specimens. *Hyloniscus riparius* (C.L. Koch, 1838) was the most abundant, whereas *Porcellio scaber* Latreille, 1804 and *Cylisticus convexus* (De Geer, 1778) were only occasionally found (less than 10 individuals collected). The latter two species as well as *Trichoniscus pusillus* Brandt, 1833 were found only in the qualitative samples; therefore, we do not present abundance data for them.

These values correspond to 555.2 ind/m^2, 91.2 ind/m^2, 22.4 ind/m^2, and 3.2 ind/m^2 mean densities for *H. riparius*, *Haplophthalmus danicus* Budde-Lund, 1880, *C. sicula*, and *Philoscia muscorum* Scopoli, 1763, respectively. The high variances along with high values of the dispersion index suggest a strong spatial aggregation (χ^2 test, $p < 0.01$), especially for *H. riparius* and *H. danicus* (table II).

Population and reproductive characteristics of *Chaetophiloscia sicula*

We measured and sexed 81 individuals. Reproductive stage of the females was determined, and, when possible, the number of eggs or larvae counted.

Male to female ratio was 1 : 5. Females are significantly larger than males both in body length ($\chi^2 = 48.4$, $p < 0.01$), and in head width ($\chi^2 = 18.7$, $p < 0.01$) as shown in table III and fig. 2A-B.

TABLE I

List of Oniscidea in the Greater Baltimore Metropolitan area with species present (P) or absent (A) in the Cross Keys forest

Family	Species	Cross Keys
Trichoniscidae	*Hyloniscus riparius* (C.L. Koch, 1838)	P
	Trichoniscus pusillus Brandt, 1833	P
	Haplophthalmus danicus Budde-Lund, 1880	P
Philosciidae	*Philoscia muscorum* Scopoli, 1763	P
	Chaetophiloscia sicula Verhoeff, 1908	P
Oniscidae	*Oniscus asellus* L., 1758	A
Cylisticidae	*Cylisticus convexus* (De Geer, 1778)	P
Porcellionidae	*Porcellio scaber* Latreille, 1804	P
Trachelipidae	*Trachelipus rathkei* (Brandt, 1833)	A
Armadillidiidae	*Armadillidium vulgare* (Latreille, 1804)	A
	Armadillidium nasatum Budde-Lund, 1885	A

TABLE II

Mean density (per 25 × 25 cm quadrat), Index of Dispersion (I_D), and relative frequency of the four most abundant species in the Cross Keys forest

	Density	Index of Dispersion (I_D)	Relative frequency (% of total)
Hyloniscus riparius	34.7 ± 65.1	122.34	82.6
Haplophthalmus danicus	5.7 ± 16.7	48.62	13.6
Chaetophiloscia sicula	1.7 ± 1.9	2.73	3.3
Philoscia muscorum	0.2 ± 0.42	0.89	0.5

TABLE III

Size differences between males and females of *Chaetophiloscia sicula* Verhoeff

	Females	Males
N	67	14
Body length: Range (mm)	4.3–7.1	3.3–5.2
Median (mm)	5.9	4.3
Head width: Range (mm)	0.8–1.3	0.8–1.1
Median (mm)	1.0	0.9

The majority of females in June and July were gravid (91% and 82% of all females, respectively). Only non-gravid females were collected in April, August, and September. Gravid females carried mainly eggs in June and larvae in July. Brood size ranged between 7 and 18 for eggs and was 5-8 for larvae. The smallest gravid females were 4.7 mm long. Individuals with both eggs and larvae (35%) or an empty marsupium (65% out of the total gravid females) were present at the end of June 2001. In the temperate region the average duration of the gravid period is about one month (Paris & Pitelka, 1962; Sunderland et al., 1976). Assuming this duration for *C. sicula*, the high ratio of females with empty marsupium at the end of June indicates that the first gravid *C. sicula* females had to appear by the end of May. However, further field studies have to verify this speculation. In mid-July females carried mostly larvae or their marsupium was empty. Since we did not find gravid females in later months, we conclude that reproduction occurs from late spring to mid-summer.

DISCUSSION

Chaetophiloscia sicula is known from the Mediterranean region, from Spain to Greece (Schmalfuss, 1990). It is often found together with *C. elongata* (Dollfus, 1884), but the distribution of *C. sicula* is more restricted to the northern

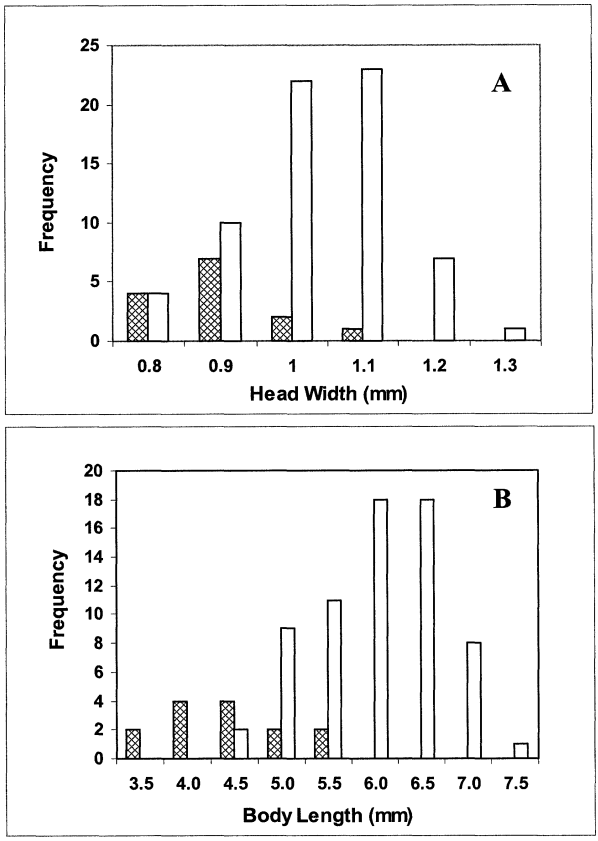

Fig. 2. Size distribution of *Chaetophiloscia sicula* Verhoeff, 1908. Males, hatched bars; females, open bars; A, body length; B, head width.

Mediterranean. The typical vegetation *C. elongata* and *C. sicula* are associated with is Mediterranean grassland, and transitional habitat at the sclerophyll forest ("macchia") edge (Vandel, 1962; Schmalfuss 1991; Taiti, pers. comm.). In contrast, *C. sicula* lives in a mature temperate deciduous forest in Baltimore.

Vandel (1962) noted that the northern limit of *C. elongata*'s distribution in France corresponds with the 5°C January isotherm in its native Mediterranean habitat. The distribution of *C. sicula* is even more restricted in France (Vandel, 1962). Although Baltimore is at about the same latitude as Sicily, its winter is colder. January mean temperature is 0.9°C, taking the average of the last ten years (Keefer, 2001). *Chaetophiloscia sicula* was collected in two consecutive years, indicating that they can survive the winter in the Baltimore region.

The oniscidean fauna of the northeastern part of North America was introduced mainly from Western Europe. Although these species originate from different zoogeographical regions, today they all are widely distributed in Europe. *Chaetophiloscia*, on the other hand, has a truly Mediterranean distribution. There they range from the Macaronesian Islands to Western Asia (Schmalfuss, 1986, 1991). *Chaetophiloscia elongata aharoni* Verhoeff, 1923, *C. lagoi* Arcangeli, 1934, and *C. warburgi* Schmalfuss, 1991 are the members of the second most abundant species group in northern Israel (Warburg, 1993; Warburg & Hornung, 1999). To our knowledge, *C. sicula* is the only introduced oniscidean in North America that is restricted to one, well-defined biogeographical region in its native continent.

The size range data of the Baltimore *C. sicula* population (table III) show that the individuals are longer than reported in the literature. Schmölzer (1965) gives a 4.5-5.5 mm range for the species, but he does not distinguish between males and females. Males are 4-5 mm long according to Vandel (1962), and maximally 4 mm long in Schmalfuss (1990), as opposed to 3.3-5.2 mm in our study. Schmalfuss (1990) gives the maximum length of females as 6.5 mm. Pregnant females are 7-8 mm in Vandel (1962), whereas we have found breeding females as short as 4.7 mm. Although body length data should be treated with caution, these differences may reflect true inter-population variation. More data have to be collected to resolve this problem.

Another interesting feature of the North American *C. sicula* population is its activity period and the timing of reproduction. Apart from a few notes by Vandel (1962) nothing is known on the breeding biology of this species in its native Mediterranean habitat. He found the largest number of gravid females in May. However, Lymberakis et al. (2003) reported that in Greece *Chaetophiloscia cellaria* (Dollfus, 1884) has two activity peaks, one in spring and another in autumn, which correspond to the wet seasons in the region. They found gravid females between March and May. In contrast, *C. sicula* in the Baltimore region is active from spring to autumn with a reproductive peak in June and July, perhaps because there is no marked wet season in the region. Our brood size data (7-18 eggs per marsupium) for *C. sicula* are similar to the range (5-20) given by Vandel (1962).

Chaetophiloscia is a new genus to the North American terrestrial isopod fauna. Although we surveyed several urban and rural forests in the region, so far we had found *C. sicula* only at the Cross Keys site. The other oniscidean species are more widely distributed. We speculate that *C. sicula* was recently introduced and locally it has reached a considerable density.

Terrestrial isopods are not the only soil invertebrate group in North America with many introduced species. Out of the five earthworm species found in the

Cross Keys forest, two came from Europe, one from Asia. The introduced : native ratio is even higher in the region (Csuzdi, unpubl. data). Diplopoda generally have less introduced species, but the dominant ones are non-natives (Korsós, unpubl. data).

Species invasions consist of introduction and subsequent establishment of a non-native species. Worldwide traveling and trade resulted in the disappearance of natural geographical barriers of dispersal. Other elements of global change, such as major habitat alteration, changing of disturbance regimes, and climate change, can enhance chances of a species for successful colonization. Warmer climatic temperature increases winter survival, decreases generation time, and can shift ranges of distribution northward (Cannon, 1998; Dukes & Mooney, 1999). *Chaetophiloscia sicula* survives and reproduces in an environment that is very different from its native one. Long term monitoring will reveal how stable the population is, and if it spreads further.

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