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The Occurrence and Frequency of Scars in Centipedes

by

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Abstract: Centipedes collected in the field quite often exhibit cicatriced lesions. An overview is given on the frequency of the different kinds of scars in Lithobiidae. Samples of populations of some species from various locations are compared as to the proportion of scarred individuals. In some cases statistically significant differences can be found. Their informational value for understanding the life of centipedes is discussed.

1. Introduction:

In order to investigate the life of unobservable species, such as centipedes in the soil and litter strata, indirect evidence must be used to obtain insight into some details of their behaviour or life cycle. The present paper discusses the possibility of taking the frequency of scars in centipedes as an indicator for predation intensity or general ecological stress. Beak-mark frequency in butterflies (SHAPIRO 1974) and the frequency of tail-autotomy in salamanders (SHAFFER 1978) have been used as indicators for seasonal or regional variation in predation intensity.

2. Material Examined:

The frequency of scars was recorded in nearly 6000 centipedes collected from various locations and at different times between 1976 and 1989. Data about the collections are given in Table 1.

The site of collections A and D is described by BECK (1978) and BECK & MITTMANN (1982), that of collection G by SCHMIDT (1985). Site description and additional information on the chilopod communities for collection B can be found in FRÜND (1983, 1987), for collection E in SCHULTE et al. (1990). The centipedes of collection F are from pitfall-traps installed in the south-facing ecotone of a Buglossoido-Quercetum from its fringe up to 20 m inside the wood (leg. Leipold). For collection H the traps were situated in a number of forest-isolates (sized from < 1 ha to several ha) from the forest-fringe up to 50 m inside the wood (leg. Balkenhol).

3. Results:

3.1. Types of Scars in Centipedes:

About every fourth to more than every second centipede collected in the field has one or several scars (cf. Table 1). These cicatriced lesions may be missing legs, missing antennal articles or scars at the trunk of the body. In contrast to fresh wounds, caused during collection of the animals, the scars considered here are darkly scabbed, or the coxae of missing legs are characteristically shaped with an unusual setation. It takes more than five days for a dark scab to develop on the fresh wounds of animals kept in captivity. Therefore if the centipedes are conserved soon after catching, wounds incurred during the process can easily be distinguished from scars previously acquired during the normal course of their life. The frequency of the different kinds of scars in a sample of Lithobiidae collected in the Steigerwald (B in Table 1) is given in Table 2.

Table 1: Origin, sample size, dominant species and overall frequency of scarred individuals for the Chilopoda collections studied.

	Locality	Habitat	Sampling time	Total catch	Dominant species	With scars ¹⁾
Chilopoda from hand-collecting						
A	Black Forest (Karlsruhe)	beech-forest humus: moder	1976 - 86	1677	py, ma, Sa	26 %
B	Steigerwald (Steigerwald)	beech-forest humus: moder	1979 - 81	2560	mb, cu	32 %
C	Osnabrück (surroundings)	deciduous forests	1981 - 89 sporadic	173	cr (de, mb)	33 %
Chilopoda from pitfall - trapping:						
D	Black Forest (Karlsruhe)	same as A	1976 - 84	458	ma, Sa	50 %
E	city of Bonn	streetside green	1987 4-7, 9-11	356	mi, fo	31 %
F	Steigerwald (Würzburg)	oak-forest-ecotone	1979 - 80	204	mb, cr, ca	45 %
G	Main-valley (Würzburg)	old fallow vineyards	1982 4-10	45	ca, mi	56 %
H	Steinfurt (Westphalia)	oak/beech forest patches	1989 8-11	263	de, mu, fo	34 %
X	Lingen (Lower Saxony)	pine-wood	1989 8-11	100	fo, cr	32 %

1) Only *Lithobius* spp. considered.

Explanation of species codes: ca *Lithobius calcaratus* C.L. KOCH, cr *L. crassipes* L. KOCH, cu *L. curtipes* C.L. KOCH, de *L. denatus* C.L. KOCH, fo *L. forficatus* (L.), ma *L. macilentus* L. KOCH, mb *L. mutabilis* L. KOCH, mi *L. microps* MEINERT, mu *L. muticus* C.L. KOCH, py *L. pygmaeus* LATZEL, Sa *Strigamia acuminata* LEACH.

It can be seen that damage to or loss of body appendages accounts for the great majority (about 95 %) of the scars encountered in Lithobiidae. Most frequently the point of damage lies at the anterior or posterior end of the body. Collectors know that the last legs of Lithobiidae are easily broken off, sometimes giving the impression of autotomy. Apart from this, the antennal lesions, the scars on the body trunk and on the forceps, and partially missing legs are evidence of direct damage to the animals.

In a sample of 493 Geophilomorpha (mainly *Strigamia acuminata* (LEACH) and *Geophilus insculptus* ATTEMS) collected by Professor L. Beck and his coworkers (site A in Table 1) scars on the body trunk were recorded 26 times (41 % of total sum of scars), missing or injured legs 21 times (33 %), damaged antennae or last legs occurred 7 times (10 %), and one animal had a damaged forceps. The differences between Geophilomorpha and Lithobiomorpha correspond well with the specific behaviour of geophilomorph centipedes when disturbed. They curl up with their ventral defence pores on the outside.

3.2. Variation of Scar Frequency between Age Classes:

It was invariably found that more adult lithobiomorph centipedes have scars than their anamorphic and early epimorphic developmental stages. In the Steigerwald collection B (cf. Table 1) for example, 49 % of adult individuals vs. 28 % of juvenile individuals showed scars. The higher

Table 2: Frequency of typical lesions in relation to the total sum of cicatrized wounds in 2560 Lithobiidae collected 1979 - 81 in a beech-forest in the Steigerwald near Würzburg, Germany.

Cicatrized Lesion	Frequency
Leg 14 or 15 missing or injured	33 %
Antenna or tip of antenna missing	26 %
Other leg (1-13) missing or injured	25 %
Leg present only as regenerating bud	8 %
Scar at the body trunk	5 %
Forceps missing or injured	2 %
Missing leg with unusual shape and setation of coxa (no dark scab)	2 %

percentage of scarred animals in the catches from pitfall-traps compared to those from hand-collecting, as shown in Table 1, is partly attributable to the greater proportion of anamorphic and early epimorphic developmental stadia in hand-collected samples.

3.3. Variation of Scar Frequency between Species:

Figure 1 shows the proportion of scarred individuals for the more common species in the material examined. The boxes contain the letter of the collection according to Table 1 together with the sample size on which the percentage value of scarred individuals is based. For Chilopoda sampled by hand-collecting (rounded boxes with open circles) the values are based on adult individuals (\geq PL 5) only.

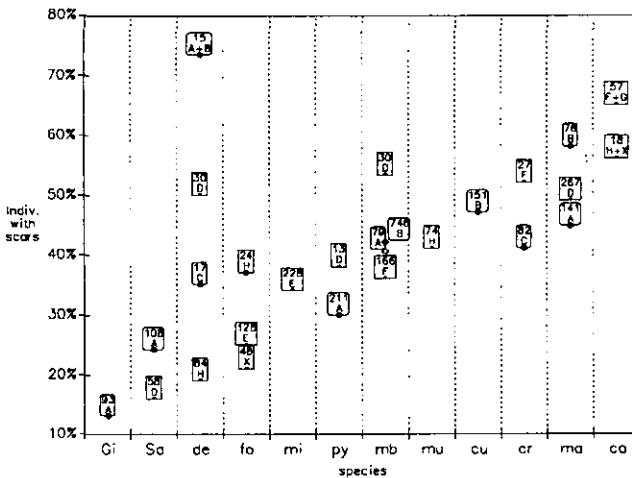


Fig. 1: Proportion of scarred individuals in 10 *Lithobius*-species and 2 species of Geophilomorpha from various locations in West-Germany. Letters in the boxes refer to the collections listed in Table 1. Numbers indicate the sample sizes. Calculations for hand-collected samples (rounded boxes and open-circle marks) are based on adults (\geq PL 5) only. The sample of *Lithobius dentatus* for (A + B) contains stage PL 4. Species codes: ca *Lithobius calcaratus* C.L. KOCH, cr *L. crassipes* L. KOCH, cu *L. curtipes* C.L. KOCH, de *L. dentatus* C.L. KOCH, fo *L. forficatus* (L.), ma *L. macilentus* L. KOCH, mb *L. mutabilis* L. KOCH, mi *L. microps* MEINERT, mu *L. muticus* C.L. KOCH, py *L. pygmaeus* LATZEL, Gi *Geophilus insculptus* ATTEMS, Sa *Strigamia acuminata* LEACH.

The differences in scar frequencies shown in Fig. 1 were tested for statistical significance. χ^2 was only calculated if either collection (data source) or species were identical. Results with $p < 7\%$ are given in Table 3.

Table 3: χ^2 -values and probabilities for comparisons of scar frequency between species and sites (cf. Fig. 1).

Pair compared	χ^2	$p \leq$
Sa (A) - Gi (A)	4,07	0,041 *
Sa (A) - mb (A)	5,76	0,016 *
Sa (A) - ma (A)	11,31	0,001 **
py (A) - ma (A)	8,08	0,005 **
mb (B) - ma (B)	7,13	0,008 **
ma (A) - ma (B)	3,45	0,060
fo (E) - mi (E)	3,26	0,067
de (H) - mu (H)	8,81	0,003 **
de (H) - de (D)	10,70	0,002 **

Sites: cf. Table 1. Species: **de** *Lithobius dentatus* C.L. KOCH, **fo** *L. forficatus* (L.), **ma** *L. macilentus* L. KOCH, **mb** *L. mutabilis* L. KOCH, **mi** *L. microps* MEINERT, **mu** *L. muticus* C.L. KOCH, **py** *L. pygmaeus* LATZEL, **Gi** *Geophilus insculptus* ATTEMS, **Sa** *Strigamia acuminata* LEACH.

There is considerable variation of scar frequency between the different species. It seems that some species like *Lithobius calcaratus* or *L. macilentus* are characterized by relatively high scar frequencies while others like *Geophilus insculptus*, *Strigamia acuminata* or *Lithobius forficatus* generally have populations with a lower proportion of scarred individuals. In a pitfall-trapped sample of *Lithobius microps* in public lawns and flower-beds in Berlin (W) (March - May 1990; FRÜND & GRAEFE unpubl.) 31 % of 39 animals caught had scars. This is in good correspondence with the value shown in Fig. 1 for this species in urban habitats of Bonn. A very high intraspecific variation of scar frequency was observed for the different samples of *Lithobius dentatus*. In the small forest-patches in North-West Germany, where *L. dentatus* is a common and dominant centipede in pitfall-traps together with *L. muticus*, the former species has an exceptionally low frequency of scarred individuals. In the beech-woods of Steigerwald and Black Forest in Southern Germany *L. dentatus* was represented in hand-collected samples as a sporadic species with only very few individuals, all being adult or subadult (\geq PL 4; 6 in collection A, 9 in collection B). A high proportion of these individuals bears scars, and multiple scars are also frequent.

3.4. Temporal Variation of Scar Frequency:

Figure 2 shows the variation of scar frequency in the more numerous *Lithobius* spp. of a moder-humus beech forest near Karlsruhe (Collection A, Table 1). The changes in scar frequency over the years run largely parallel in the 3 samples. Especially the decrease of abundances in 1983 goes together with a clear rise of scar frequency in all 3 *Lithobius* species.

3.5. Seasonal Variation of Scar Frequency:

As can be seen from Fig. 3, Lithobiomorpha show the highest proportion of scarred individuals during the springtime. This could be observed in the Steigerwald (collection B) and in the long-term data from the Black Forest (collection A). Statistical significance, however, is reached only for the Lithobiomorpha of collection A ($\chi^2 = 9.2$; $p = 0.027$ *). Geophilomorpha show a different pattern again.

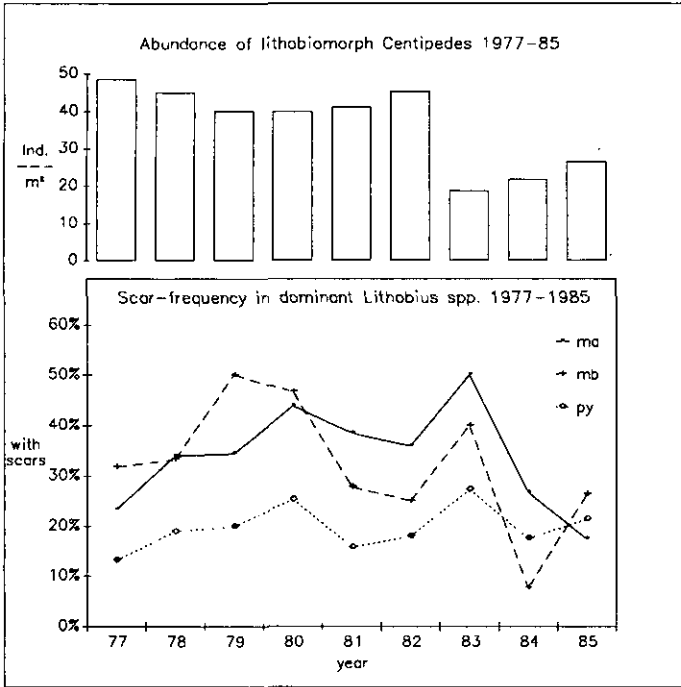


Fig. 2: Scar-frequency in 3 dominant *Lithobius*-species (*L. macilentus*, *L. mutabilis*, *L. pygmaeus*) and total abundance of lithobiomorph centipedes from 1977 to 1985. Monthly quadrat samples (3 x 0.11 m²), collection A of Table 1.

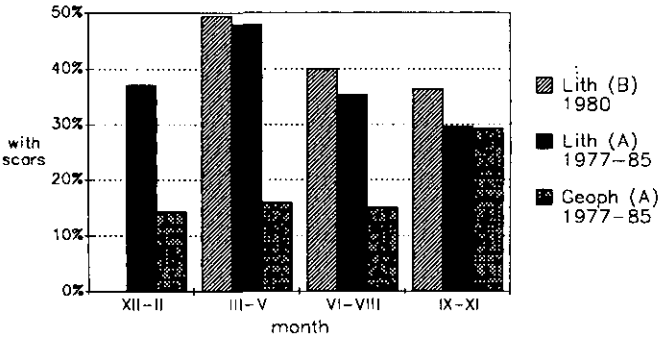


Fig. 3: Seasonal variation of scar frequency in adult Lithobiomorpha (A 1977 - 85, B 1980) and Geophilomorpha (A 1977 - 85). Hand-collected quadrat-samples from beech forests in the Steigerwald (B) and in the Black Forest near Karlsruhe (A).

3.6. Scar Frequency in Different Litter Horizons:

The scar frequency of Lithobiomorpha and Geophilomorpha in the L-, F-, and H-layer of the Black Forest beech-wood (collection A) is shown in Fig. 4. There is a significant decrease of scar frequency in Lithobiomorpha between the F- and the H-horizon ($\chi^2 = 9.37$; $p = 0.009 \star\star$). In

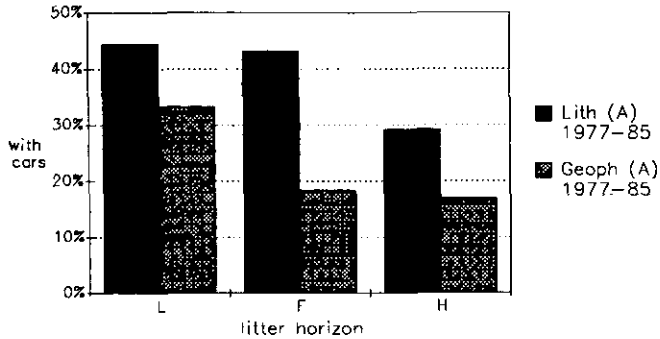


Fig. 4: Scar frequency of adult Lithobiomorpha and Geophilomorpha in the litter-horizons of a moder-humus beech-forest near Karlsruhe (collection A, 1977 - 85).

Geophilomorpha there is no difference between F- and H-layer, but of the 12 animals collected from the uppermost L-horizon (less than 6 % of sample total) the proportion of scarred individuals is higher than from deeper litter-layers.

No significant difference was found between scar frequencies in Lithobiomorpha from the upper and the lower litter strata of the Steigerwald beech-forest (collection B), where only two litter strata were distinguished. The upper layer included the L- and upper F-horizon, the lower one the remaining F- and the upper H-horizon (FRÜND 1987). For the year 1980 the percentage of scarred adults in the upper layer was 41 % and 49 % in the lower stratum.

4. Discussion:

There is apparently almost no data concerning scar frequencies in other Arthropoda. The frequency of beak-marks in butterflies (2 - 17 %), reported by SHAPIRO (1974) from the Sacramento Valley, California, lies somewhat below the scar frequencies in Chilopoda, but a beak-mark is only one type of damage, and other scars must surely also occur in butterflies. SHAFFER (1978) reports 2 - 30 % of neotropical salamanders with tail loss. The results show that Chilopoda, especially Lithobiomorpha, are at a rather high risk of being damaged. The scars in centipedes may be the result of

- damage because of habitat disturbance (trampling, digging, scraping by man, small mammals, birds) or
- damage resulting from unsuccessful predator-attacks (e.g. spiders, Staphylinidae, shrews, birds).

The soil and litter in the forests studied was not visibly influenced by trampling. Soil perturbation by birds and small mammals definitely played a much more important role. For example, HALLE (1989) estimated the total length of mouse-tunnels in forest-plantations on recultivated soils to be about 2300 m per ha. There were numerous traces of burrowing by small mammals in the Steigerwald and Black Forest beech-woods. Predatory shrews (*Sorex* spp.) were regularly caught in pitfall-traps, but BRAUN & KISCHNIK (1987) consider that the polyphagous bank vole (*Clethrionomys glareolus*) is the main burrowing species in the beech-forest near Karlsruhe.

Probably the most important predators of lithobiomorph centipedes are spiders (FRÜND 1983). In beech-forests these are mainly *Coelotes*-spp. and *Amaurobius fenestralis* (STRÖM), but smaller spiders like *Macrargus rufus* (WIDER) also readily accept Chilopoda as prey (BUCHE 1966). Staphylinidae (*Quedius* sp.) may also feed on Chilopoda (FRÜND 1983). The view of predation-pressure being an important factor in the formation of scars in centipedes is supported by

the seasonally coincident maxima of predator activity (DUMPERT & PLATEN 1985) and Lithobiomorpha scar frequency. It is also interesting, that the centipedes collected from urban habitats, where larger predators are rare, show a relatively low proportion of scarred individuals.

Broadly speaking, scar frequency can be taken as an indicator for the "interactive stress", faced by a population of Chilopoda. This term includes predation, side effects of burrowing, and aggressive encounters between Lithobiomorpha, which must also be taken into account.

It seems as if the risk of damage is connected with the animal's movement. Taking the coefficient between the numbers caught by pitfall traps and those caught by quadrat sampling as an index of mobility, it can be found that *L. macilentus*, the most mobile species in the Black Forest beechwood, has the highest frequency of scarred individuals while it is lowest in the less mobile *L. pygmaeus*. Higher mobility of adult and subadult developmental stages of centipedes may also partly explain why they exhibit a higher scar frequency than the younger stages. The biological interpretation of this phenomenon is that moving around implies that the centipedes leave their usual shelter in the soil and are at a higher risk of encountering an ambush predator. In this interpretation the rare and highly scarred individuals of *Lithobius dentatus* in the Steigerwald and Black Forest samples can be seen as invaders, unsuccessful in their search for suitable resting places.

The interpretations given here are highly speculative. They have to be validated by additional experimental and synecological data. But they may suffice to illustrate the informational value of the documentation of scar frequency, which is an easily recognisable character of hand-collected and pitfall-trapped centipedes.

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