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Long-term Observations of the Effects of Increasing Dry Pollution on the Myriapod Fauna of the Neiße Valley (East Germany)

by

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Abstract: The soil fauna, especially the Myriapoda, of a spruce forest and of a neighbouring deciduous wood was first investigated in 1960/61. At this time it was in a healthy state despite high ash deposition. After spruce destruction by increasing pollution, but without acidification, a second investigation was made in 1988/89. Most of the diplopod and chilopod populations had increased in density at this time. None of the reactions of the 32 species studied can be interpreted as directly influenced by the action of chemical pollutants from power stations.

1. Introduction:

Observations on the reaction of the soil fauna to pollution are usually made by comparing populations under more and less polluted conditions. This method, however, neglects the possibility that the specific properties of the sites may have a decisive influence on the results. In the Neiße valley south of Görlitz we took advantage of a rare opportunity for long-term observations with increasing pollution at the same site over a 28-year period.

2. Sites, and Ecosystem Reactions to Pollution:

In the Neiße valley between Ostritz and Hirschfelde (O-Germany, SE) we investigated the soil fauna of a natural *Arunco-Aceretum* (site L) and a spruce forest (site F) for the first time in 1960/61. The aim was to describe the fauna of this very characteristic valley, deeply incised in the foothills of the Isergebirge. Many plant, vertebrate and invertebrate species typical of the Sudeten and the Zittau sandstone mountains have settled here in demontane enclaves, where there is a more humid and summer-cool climate on the valley bottom.

The second aim was to find out if an ash horizon of up to 25 cm, caused since 1910 by the 4 km-distant "Hirschfelde" power station, influences the soil fauna. The results of the first investigation period show that there was an obviously characteristic species composition in spite of the enormous ash deposition (DUNGER 1972, ENGELMANN 1972, HIEBSCH 1972, TOBISCH & DUNGER 1973, VOGEL 1980). They show furthermore that wood growth was even improved by the flying carbon ash, which in combination with the emission of a calcite factory effects a kind of humus amelioration (DUNGER et al. 1972).

Later, technical changes in the Hirschfelde station and the opening of a second power station on Polish territory 5 km south-east caused destruction of spruce, increasing from 1965 and resulting in the complete devastation of the spruce forest (F) in about 1975. Throughout this period the development of the soil fauna was observed sporadically, but was consistently investigated during a second period 1988/89. At this time the *Arunco-Aceretum* (L) exhibited only slight signs of disturbance. The late spruce forest site F was overgrown by a very dense maple shrub. The old spruce litter raw humus had persisted in a reduced "subfossil" state, covered by a shallow but complete *mull humus* horizon with a small A horizon (possibly due to the continued ash emmission). The pH of the mineral top soil is 4.7, thus differing very little from the 1960 value. Base saturation (V = 22 %) and the Ca-content (8,2 mval 100^{-1} g soil) are also unchanged, and reach only half the values found for the deciduous tree site L. As

expected, the C/N relation in the F site topsoil is only slightly ameliorated from 22.0 (1960) to 19.8 (1989), but is much better in the L site (13,3). The chemical properties confirm that minimal survival conditions for Diplopoda and Isopoda are given.

Comparison of the results of the first (1960) and the second (1989) investigation period showed that the total biomass of earthworms had increased strongly at the devastated "spruce" site F (0.018 : 3.5 g m^{-2}), but had decreased slightly at the deciduous tree site L (18.4 : 14.3 g m^{-2}). Millipedes and woodlice, like the earthworms, had maintained an almost equal biomass at the L site, but had increased strongly at the former spruce site F. The increased biomass of macrohumiphages at the F site is probably the result of improved nutrition.

For the zoophagous macrofauna, prey supply is one of the limiting factors. Evaluations of the soil microarthropod population density showed a strong increase from about 60000 (1960) up to 150000 individuals m^{-2} at the F site (1989), oribatids invariably dominating. At the L site there was no important change: the density almost always approximated 100000 ind. · m^{-2}, with a dominance of oribatids in 1960, but of collembolans in 1989. Compared with the population density in 1960, the biomass of the zoophagous macrofauna showed a considerable increase in Staphylinidae and spiders at the F site, whereas the biomass of Carabidae and Chilopoda underwent no remarkable alteration. Nevertheless it can be assumed that different reactions occur at the species level.

3. Methods:

The above data provide no evidence of negative reactions of the soil fauna as a whole to the pollution or even to the destruction of the spruce forest. However, single species may have been influenced, which would be of interest from the point of view of bioindication. To investigate this question, it was necessary to obtain more information about single species than available from quantitative methods. Field sampling methods, hand sorting of soil cores (1,5 and 3,0 l) in the laboratory and slow extraction by moderate exsiccation yielded altogether only some hundred individuals of Myriapoda. Therefore we also used pitfall traps for at least one year in each investigation period in addition to occasional trappings for the rest of the time. The approximately 4000 specimens thus obtained constitute an adequately representative material for settling the question of a possible response at the species level.

4. Results:

4.1. Diplopoda:

We registered 15 species of millipedes as regular inhabitants of the Neiße valley. As shown in Fig. 1, population density increased from 1961 to 1989 at both the L and F sites. These trends were confirmed by pitfall trapping as well as by density estimations based on area-related samplings. The most important increase in the biomass of Diplopoda per square meter is recorded at the F site. The species responsible for this augmentation are *Julus scandinavius* LATZEL, 1884, *Mycogona germanicum* (VERHOEFF, 1892) and *Polydesmus complanatus* (L., 1761) at the F site, and particularly *Strongylosoma pallipes* (OLIVIER, 1792) at the L site.

Figure 2 shows the relative presence and dominance of Diplopoda species at the spruce forest (F) and deciduous forest (L) in 1961 and 1989. Most striking is the behaviour of *St. pallipes;* this species was entirely lacking at the F site, but highly dominant at the L site in 1989. This species is well known from the river valleys of the surroundings and is found in great numbers during spring when copulation and migration take place. Possibly the moisture preference of *St. pallipes* is responsible for the high trapping numbers during the unusually dry spring in 1989, the animals being attracted to the wet trapping funnels. In most cases the adults die after copulation. The juvenils, occurring from September onwards, do not migrate and were consequently not trapped in adequate numbers. In addition to this species, *P. complanatus, M. germanicum* and *J. scandinavicus* increased strongly in density from 1961 to 1989; only moderately *Ochogona caroli* (ROTHENBÜHLER, 1900), *Unciger foetidus* (C.L. KOCH, 1838) and *Polydesmus inconstans* LATZEL, 1884. Only *P. denticulatus* C.L. KOCH, 1847 showed a clear decrease in numbers. Other species were represented by only few specimens (*Megaphyllum projectum kochi* (VERHOEFF, 1907), *Mastigona bosniense* (VERHOEFF, 1897), *Craspedosoma rawlinsi* LEACH, 1815, *Glomeris hexasticha* BRANDT, 1833, *Melogona voigti* (VERHOEFF, 1899, *Proteroiulus fuscus* (AM STEIN, 1857) and *Polyzonium germanicum* BRANDT, 1831). With the exception of *J. scandinavius, P. inconstans* and *C. rawlinsi,* the inhabitants of the F site also increased in numbers. In the spruce forest, the total absence

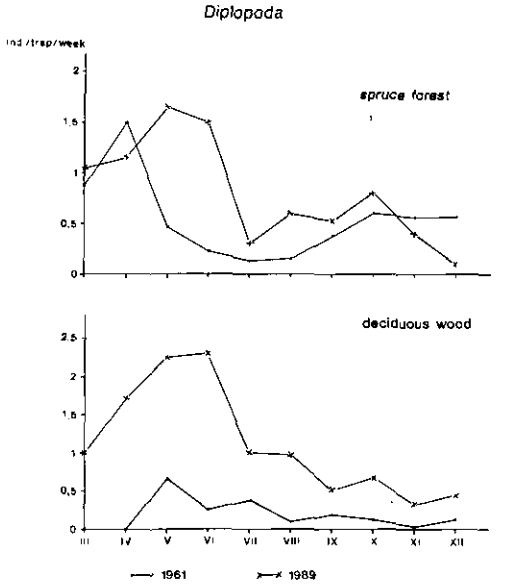

Fig. 1: Monthly averages of the activity density of Diplopoda at two sites of the Neiße valley south of Görlitz before (1961) and after (1989) heavy pollution.

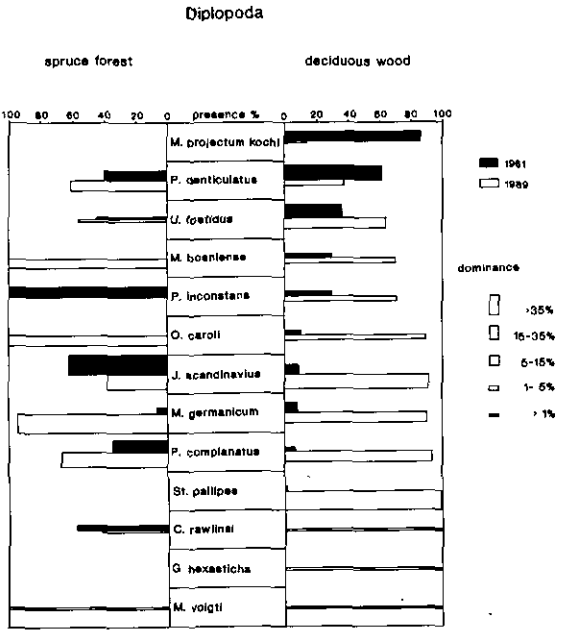

Fig. 2: Relative presence (horizontal length of columns) and dominance (thickness of columns) of diplopod species at the sites studied in 1961 and 1989. Figures are based on average activity densities.

of *St. pallipes* is most remarkable. It could be explained by the poor supply of nutrition (spruce needle litter) and by climatic factors: The intact spruce forest was more open, had more extreme temperatures and therefore was slightly drier than the deciduous wood. But these differences were probably not large since, for example, the dense appearance of the moss *Plagomnium affine* (1960) indicated a humid climate even in the intact spruce forest (MARSTALLER 1989). Furthermore, these slight differences were no longer evident in 1989.

As a result, the vitality of Diplopoda is proved to increase at both sites and shows no negative influence due to pollution. There is not a single species that could be used as an indicator for an injurious effect of the emissions.

4.2. Chilopoda:

Exactly the same result was produced by the study of Chilopoda species. The overall increase of activity is shown in Fig. 3, and is stronger at the L site. The area-related samples confirm this conclusion. The phenology of the centipedes is determined by the dominant *Lithobius mutabilis* L. KOCH, 1862. At the L site, all species show a more or less elevated activity density in 1989 as compared with 1961 (Fig. 4). At the F site, only *L. mutabilis, L. austriacus* VERHOEFF, 1937, *L. dentatus* C.L. KOCH, 1844 and *L.* cf. *lusitanus valesiacus* VERHOEFF, 1935 are present in higher densities following the spruce devastation and growth of deciduous shrub. A clear population decrease is shown by *L. forficatus* (L., 1758), *L. microps* MEINERT, 1868 and (with reduced absolute densities) *L. nodulipes* LATZEL, 1880 and *L. agilis* (C.L. KOCH, 1847). All these species prefer more open localities and therefore cannot be considered to be influenced by pollution effects.

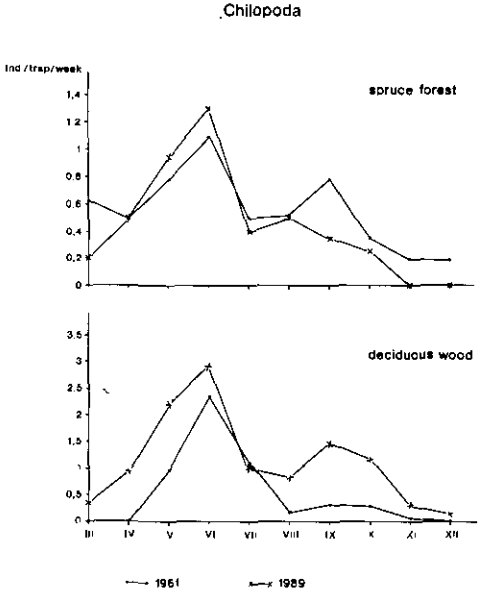

Fig. 3: Monthly averages of the activity density of Chilopoda at two sites of the Neiße valley south of Görlitz before (1961) and after (1989) heavy pollution.

The geophilids were not caught in sufficient numbers to permit a quantitative estimation of their behaviour. The results from trapping and soil-core sampling indicate no detrimental effects on these species (*Strigamia transsilvanica* (VERHOEFF, 1935), *St. acuminata* (LEACH, 1814),

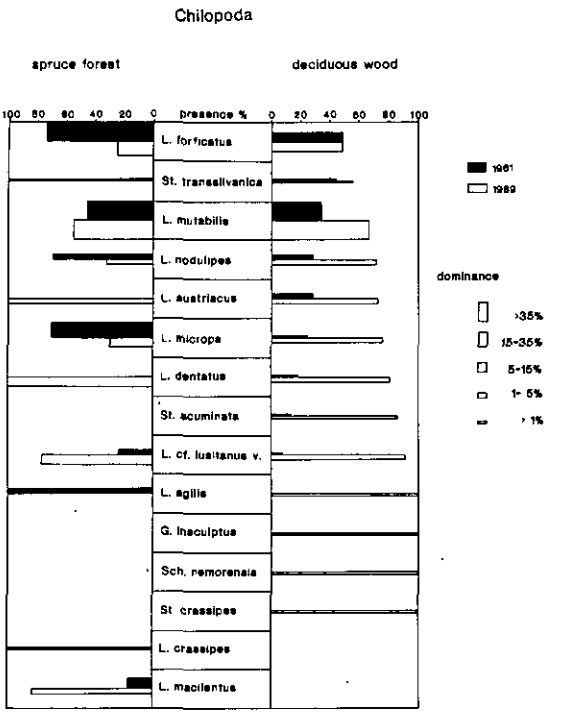

Fig. 4. Relative presence (horizontal length of columns) and dominance (thickness of columns) of chilopod species at the sites studied in 1961 and 1989. Figures are based on average activity densities.

St. crassipes (C.L. KOCH, 1835), *Schendyla nemorensis* (C.L. KOCH, 1837), *Geophilus insculptus* ATTEMS, 1895, *G. electricus* (L., 1758), *Necrophloeophagus longicornis* (LEACH, 1814)).

5. Discussion:

Investigations on the reactions of Myriapoda to emissions from a power station or a factory within a region near to the emittent and with dry deposition have been carried out very seldom at species level.

PETER (1984) found 7 species of Diplopoda and 8 species of Chilopoda in a grassland catena near Jena polluted by industrial emissions. Of these, the dominating millipede *Polydesmus inconstans* did not penetrate into the most polluted plots, whereas *Uncinger foetidus* seemed to be not affected. Similarly, the centipedes *Lithobius calcaratus* C.L. KOCH, 1844 and *L. muticus* C.L. KOCH, 1847 are restricted to the non devastated plots, whereas *Cryptops parisi* BROLEMANN, 1920, *L. melanops* NEWPORT, 1845, *L. crassipes* L. KOCH, 1862 and *L. forficatus* could be found even in the most severely damaged areas. In all cases, the factors determining distribution should be sought in the climate rather than in direct effects of polluting chemicals.

Better comparable with the findings from the Neiße valley are unpublished observations made in the course of studies on the pattern and phenology of Staphylinidae in polluted pine forests of the Dübener Heide (near Halle, O-Germany, STEINMETZGER & TIETZE 1980). The results seem to indicate a very similar situation to that found in the Neiße valley, but this needs to be confirmed by further studies.

It must be pointed out that all these observations were made at sites showing no acidification. Under these circumstances, our investigations as well as results available from the literature prove that there is no direct influence of chemical pollutants from power stations on any of the species studied.

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