Impact of pollution by nickel leaching rest on Carabidae, Silphidae and Staphylinidae in the surroundings of the nickel smelting plant at Sereď (Slovakia)

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The impact of pollution by nickel leaching rest was studied along an 8.5 km long transection in the arable land around an extensive dump of nickel leaching rest. The fall of nickel leaching rest had no influence on the cumulative abundance and biomass of the taxocoenoses of the three families. It caused, however, a visible decline in species number and strong structural changes in the taxocoenoses in the area of the fall intensity exceeding 800 t $km^{-2}year^{-1}$ and provoked striking changes in sex ratio of individual carabid species already in the area of fall intensity exceeding 300 t $km^{-2}year^{-1}$.

Key words: pollution, nickel leaching rest, nickel smelting plant, Carabidae, Silphidae, Staphylinidae, Sereď, Slovakia.

Introduction

The impact of industrial pollution and wastes on wildlife provokes a wide range of problems. Many papers exist dealing with the effect of various industrial imissions on carabid communities. E. g. Freitag and Hastings (1973), Freitag (1979), Hastings and Freitag (1972), Hastings et al. (1972) studied impact of imissions of Na_2SO_4 from kraft mills; Przybylski (1974, 1979), Dunger (1972), Tobisch and Dunger (1973) studied effect of flowing imissions containing calcium; Puszkar (1979a-f), Stubbe and Tietze (1980, 1982), Steinmetzger and Tietze (1980) studied impact of imissions of SO_2. Carabid communities in different crops in arable land in industrial regions were investigated by Kabacyk-Wasylik (1980) and Croy (1987). Dabrowska-Prot (1982) generally characterized some structural changes in animal communities in industrial regions in Poland while Khot'ko et al. (1982) dealt with them in Belorussia.

However, the impact of pollution by nickel leaching rest emitted primarily from the nickel smelting plant and, secondarily, blown away by wind in large amounts from an extensive dump situated in vicinity of the nickel smelting plant near Sereď in South Slovakia on wildlife in the dump surroundings represents an unique problem studied so far only by a few authors (Paulech (ed.), 1983; Darolová et al., 1989; Reichertová et al., 1989). Šustek et al. (1987) presented a brief synthesis of (sometimes misinterpreted) observations on the influence of the fall on nickel leaching rest on taxocoenoses of several invertebrate groups. The aim of the present paper is to give a more detailed description of the changes observed in the taxocenoses of Carabidae, Silphidae and Staphylinidae in the polluted area.

Table 1. Chemical composition of the nickel leaching rest in % (after REICHERTOVÁ et al., 1989).

Fe_2O_3	64.40	Al_2O_3	3.66
FeO	13.26	MgO	1.67
NiO	0.36	P_2O_5	0.10
Cr_2O_3	3.68	V_2O_5	0.02
CaO	3.35	TiO	0.12
SiO_2	7.10	S	0.08
CoO	0.06	Cu and Pb	$\leq$0.07

Material and methods

An 8.5 km long line of pitfall traps crossed the area of the fall gradient ranging from 250 to 800 t km^{-2}year^{-1} (Tab. 1) in the direction of the prevailing northwestern winds (Fig. 1). The length and direction of the traps line was determined in a way which made it possible to they allow to separate the proper impact of the fall of nickel leaching rest from the differences in the taxocoenoses structure reflecting their natural mosaic pattern, the influence of field crops, species competition and other anthropogenic factors potentially influencing these taxocoenoses in the studied area.

Altogether 32 formalin-filled pitfall traps (9.5 cm in diameter) were placed equidistantly 250 m from each other in the main line. Besides this, 11 traps were placed directly on the dump and in its immediate vicinity (Fig. 2). These traps were located to they allow us to discover the mode of colonisation of the dump by the representatives of all three families. The traps were exposed from early April to late November 1982 and controlled approximately once a month.

The obtained material consists of 66,441 individuals of carabids (88 species), staphylinids (84 species) and silphids (2 species).

Alpha-diversity was expressed by Shannon-Wiener's index and in the extremely small samples also by Brillouin's index. Beta diversity was evaluated according to WHITTEKER (1981). Body size structure (because of lack of space presented only in four selected samples) and changes of sex ratio were evaluated by the methods proposed by ŠUSTEK (1984a,b, 1986).

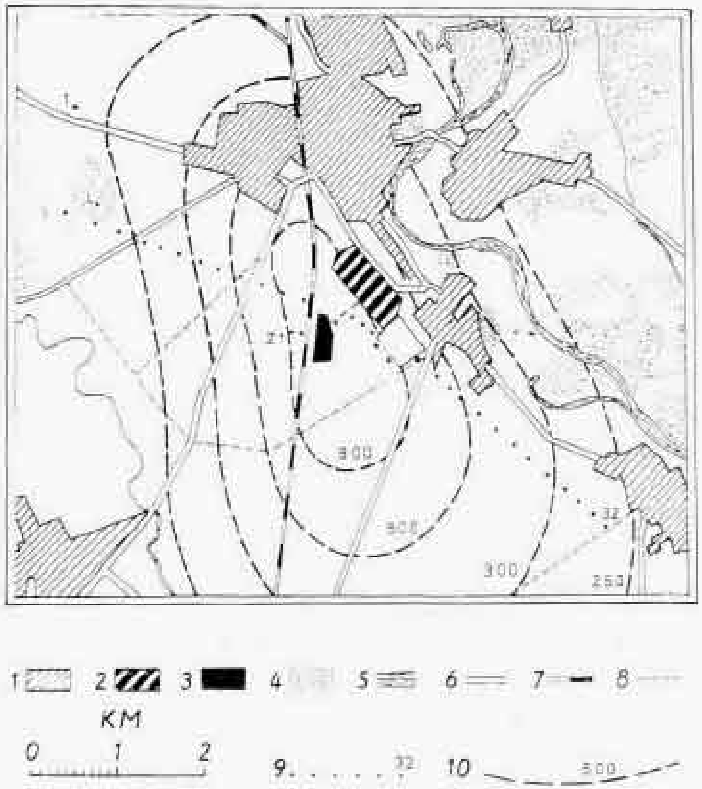


Fig. 1. Location of the traps in surroundings of the dump of nickel leaching rest near Sereď. (1 – built up areas, 2 – nickel smelting plant, 3 – dump of nickel leaching rest, 4 – forests, 5 – water flow, 6 – roads, 7 – railways, 8 – field roads, 9 – location and numbering of traps, 10 – isolines of the fall intensity in t km^{-2}year^{-1}).

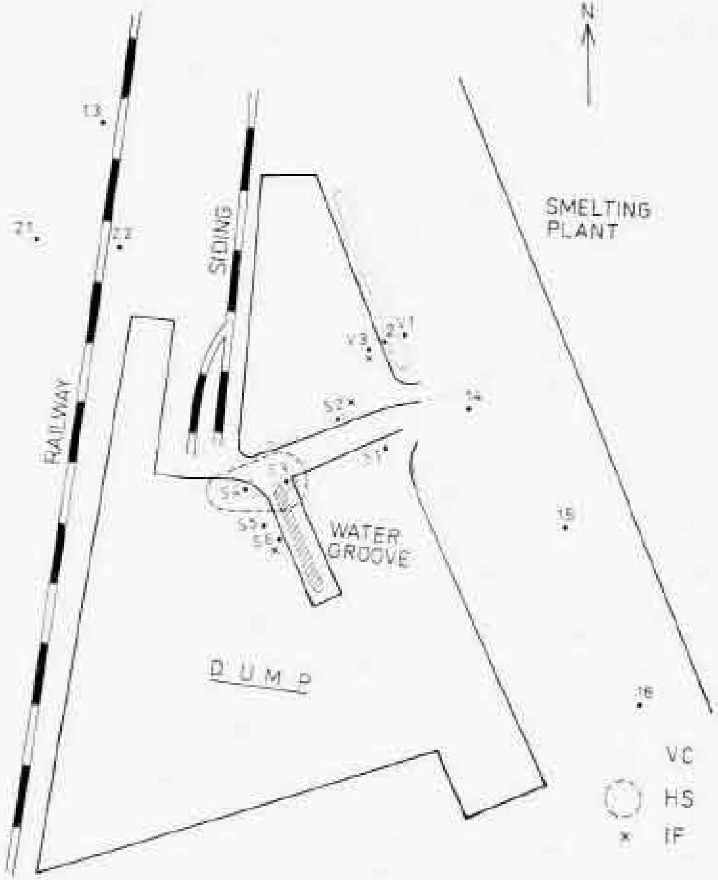


Fig. 2. Location of the traps in the close vicinity of the dump and in its interior (Z1 and Z2 – traps on the western slope of the dump, V1–V3 – traps on the eastern slope of the dump, S1–S6 traps in the dump interior, 13–16 trap in the main line of the transect, PC – plant cover, HS – area of occurrence of hygrophilous carabids in vicinity of water groove, IF – individual findings of water or ripicolous insects on the dump).

Specification of individual sampling sites

The sampling sites were situated in a typical intensively used homogeneous agricultural lowland landscape in the surroundings of the town of Sereď in South Slovakia. This territory is characterized by the average temperature of 20 °C in July and −2 °C in January and with the average annual precipitation amounting 550 mm. The soils were represented by chernitzas to chernozems on waterlogged loess.

A – traps in free landscape (Fig. 1 and 8)

1–3: homogeneous wheat field, trap 3 situated ca. 30 m from a small locust-tree copice; R: locust-tree copice with Sambucus nigra and Ligustrum vulgare in shrub stratum and dense growth of *Galium* sp. in spring, in summer dry, soil surface covered by a thick stratum of dry leaves; 4: a grassy strip ca. 5 m wide between a maize field and field road, individual shrubs and trees in vicinity; 5–6: sugar beet culture, the trap 5 destroyed, the material not evaluated; 7–8: mixture of oat and lucerne; 9–10: homogeneous culture of wheat; 11–12: grain maize field, the trap 12 destroyed, material not evaluated, 13: margin of grain maize field, at a dense group of *Syringa vulgaris*; Z1: grain maize field, ca. 100 m from dump margin; Z2: slopes of railway embankment; 14: grassy strip on margin of very weedy maize field, ca. 25 m from the dump, a strong cover of nickel leaching rest on the soil surface; 15–17: weedy maize field, 18–19 maize field, 20: private garden with fruit trees, vine and free-range poultry; 21–22: barley field, a private garden close to the trap 21, and a large dung-hill close to the trap 22; 23–26: homogeneous 2 m high

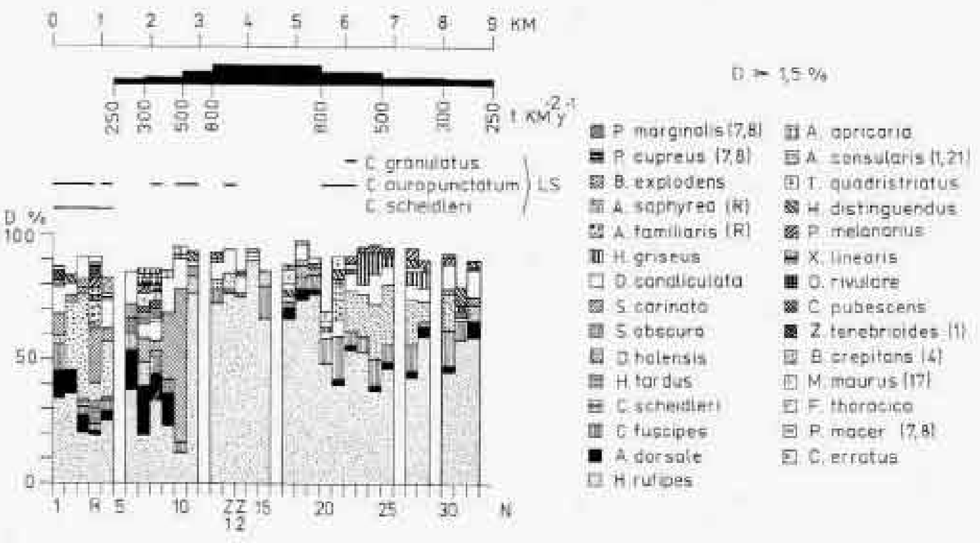


Fig. 3. Representation of the dominant and subdominant species in individual traps (T) along the pollution gradient (LS – large sized species – *Carabus granulatus*, *Calosoma auropunctatum*, *Carabus scheidleri*, full names of other species – *Poecilus marginalis*, *Poecilus cupreus*, *Brachynus explodens*, *Amara saphyrea*, *Amara familiaris*, *Harpalus griseus*, *Drusila canaliculata*, *Silpha carinata*, *Silpha obscura*, *Dolichus halensis*, *Harpalus tardus*, *Carabus scheidleri*, *Calathus fuscipes*, *Agonum dorsale*, *Harpalus rufipes*, *Amara apricaria*, *Amara consularis*, *Trechus quadristriatus*, *Harpalus distinguendus*, *Pterostichus vulgaris* (= *melanarius*), *Xantholinus linearis*, *Omalium rivulare*, *Conosoma pubescens*, *Zabrus tenebrioides*, *Brachynus crepitans*, *Microlestes maurus*, *Falagria thoracica*, *Pterostichus macer*, *Carathus erratus*, numbers and letters in parantheses after some species name indicates the traps of occurrence of less frequent species).

culture of grain maize, trap 26 destroyed, not evaluated; 27: wheat field neighbouring one with grain maize; 28–31: homogeneous grain maize field, the trap destroyed, not evaluated; 32: grassy strip between grain maize field and field road.

B – traps on the dump (Fig. 2)

V1: a grassy strip under pipes distributing nickel leaching rest, V2: a poor vegetation patches on a surface covered by a 20–30 cm thick stratum of nickel leaching rest; V3: eastern slope of the dump, ca. 20 m above the surrounding terrain, without any vegetation; S1: terrace in the dump interior, 15 m above the terrain, sparse cover of *Salsola cali*; S2: a grassy tongue at the dump foot, nickel leaching rest strongly mixed with loam; S3: small terrace at the dump foot, 1 m above the terrain, cover of *Salsola cali* and *Carex sp.*, in the distance of ca. 6 m a water groove; S4: little terrace of nickel leaching rest with admixed loam, densely covered with grass and sparse dewberry shrubs; S5: top plateau of the dump, in spring with sparse germinating plants, in summer without vegetation; S6: easterly oriented slope above a water groove, 20 m above terrain, without vegetation.

Structure of taxocoenoses of Carabidae, Silphidae and Staphylinidae along the transsection

89 species of Carabidae, two species of Silphidae and 87 species of Staphylinidae occurred in the studied area. On average 47 species were found in each trap along the whole trap line. The samples from the locust-tree copice and from its vicinity and from the gardens at the west margin of Sereď were the richest in species, whereas the samples from the closest vicinity of the dump, in the zone of the fall intensity exceeding 800 t $km^2 year^{-1}$ were a little poorer than those from the wider surrounding (Fig. 4).

The relative abundance of individual species represented by more than 1.5% of individuals in a sample is given in Fig. 3 (the limit of 1.5% was established arbitrarily according to the possibilities of graphical representation). The species spectrum as such changed along the transsection

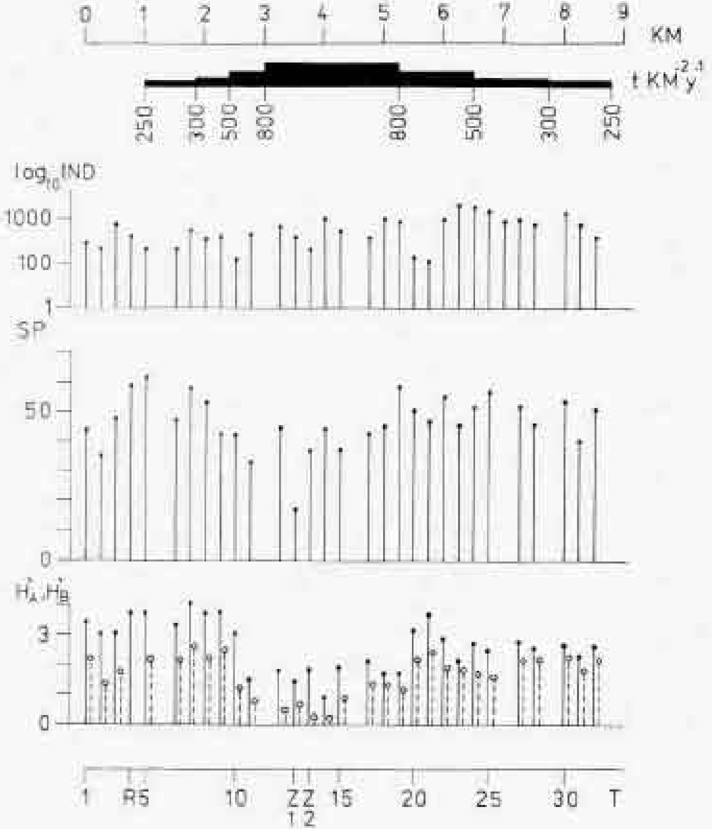


Fig. 4. Cumulative abundance of Carabidae, Silphidae and Staphylinidae ($\log_{10}$IND), species number (SP) and diversity based of abundance (H'_A, – solid columns) and biomass (H'_B – dashed columns) in individual traps (T) along the pollution gradient.

negligibly, as expressed by the low value of beta-diversity of 0.0049. There were however striking differences in the quantitative representation of the dominant species.

The samples from the traps 1–5 were characterized by a high relative abundance of *Harpalus rufipes* (ca. 30%), *Brachynus explodens* (20–30%), *Agonum dorsale* (ca. 5%) and *Drusila canaliculata* (10%). The phytophagous species *Zabrus tenebrionides* reached a higher relative abundance in this part of the transsection in the wheat field. In the vicinity of the locust-tree copice, the field community was enriched by *Carabus scheidleri*, *Calosoma auropunctata* and by the carrion beetle *Silpha carinata*.

In the next part of the trap line (traps 6–10), the community was simpler. *Brachynus explodens* was replaced nearly completely by the similarly sized species *Agonum dorsale*. A great part of the ecological niche was occupied by the carrion beetle *Silpha carinata*, especially in the trap 10. *Drusila canaliculata* maintained the same level of dominance as in the traps 1–5.

In the central part of the traps line (traps 11–18), in the zone of the fall intensity exceeding 800 t $km^{-2} year^{-1}$, the relative abundance of *Harpalus rufipes* regularly exceeded 70% and, in the closest vicinity of the dump (trap 14), it even reached 90%. At the same time, its biomass here amounted to 97% of the whole catch. Representation of other species decreased there suddenly, except for the staphylinid *Drusila canaliculata* (Fig. 3). The species *Harpalus rufipes* and *Drusila canaliculata* also exhibit an extremely high tolerance to industrial imissions and other anthropogenic factors in many other cases (STEINMETZGER, TIETZE, 1980; HÅGVAR, 1980; KABACYK-WASYLIK, 1980; ŠUSTEK 1984).

In the southern part of the trap line (traps 21–32), the community was more uniform than in the northern part. It consisted mostly of *Harpalus rufipes* reaching the relative abundance

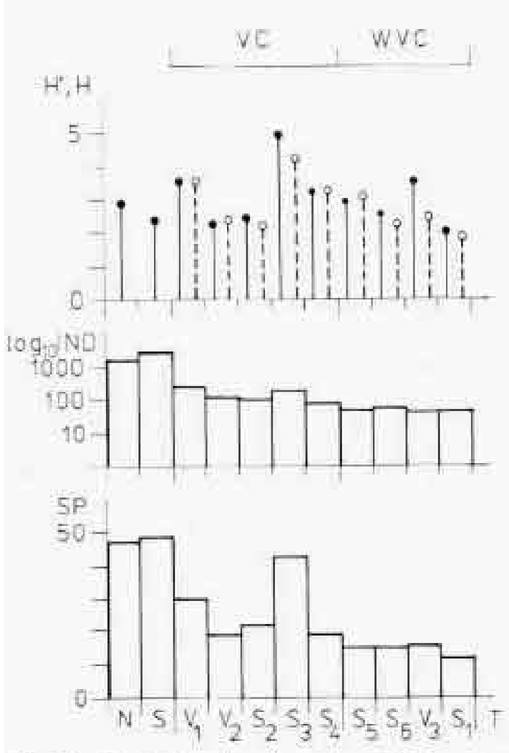


Fig. 5. Cumulative abundance ($\log_{10}$IND), species number (SP) and diversity according to Shannon-Wiener (H') and Brillouin (H) of Carabidae, Silphidae and Staphylinidae in individual traps (T) on the dump in places with vegetation cover (VC) and without vegetation cover (WVC) and comparison of their values with the average values from the northern (N) and southern (S) part of the main trap line (for the traps position see Fig. 2).

of 50 to 60% and of less abundant species *Calathus fuscipes*, *Dolichus halensis*, *Harpalus griseus* and *Drusila canaliculata* and locally also of *Pterostichus melanarius*. The community structure was very similar to the communities in maize fields in other places in South Slovakia (ŠTEPANOVIČOVÁ, BELÁKOVÁ, 1960; BELÁKOVÁ, 1960; ŠUSTEK, unpublished). The autumn breeding species predominated there. The large species *Carabus scheidleri* and *Calosoma auropunctatum*, occurring sporadically in the northern part of the trap line, were absent here because of lack of suitable refugia in the extensive monotone fields around this part of the traps line.

The traps 20 and 21 placed in private gardens on the margin of the village Dolná Streda represented a specific part of the trap line. In contrast to other parts, the species *Amara consularis*, *A. apricaria*, *Calathus erratus* and *Falagria thoracica* reached there a distinctly higher relative abundance and the mutual proportion of all species was more equal, whereas the cumulative abundance of representatives of all three families was distinctly lower than in other parts of the trap line. The ecotonal character of communities resulted from sparse cover of fruit trees.

Except for a slight decrease of the species number and the enormously high relative abundance of *Harpalus rufipes* in the central part of the trap line, in the close vicinity of the dump, the above differences in community composition reflected the individual species' response to the different microclimatic conditions in various field crops, the coincidence of the reproduction cycle with the presence of a crop on field and the mutual competitive relationships of individual species and the spatial diversity of vegetation structure.

Structure of the studied taxocoenoses on the dump

The species spectra on the dump were in general poorer but rather similar to those in its close vicinity. The carabid *Harpalus rufipes* occurred there regularly and, in the places covered with sparse vegetation, even reached the relative abundance of 40–60%. In addition a relatively wide scale of species penetrated here from the close vicinity. However they occurred here only individually and irregularly.

A specific ecological group of species was represented by the hygrophilous carabids *Bembidion velox*, *B. articulatum* and *B. biguttatum* found in the traps on the dump's surface and the species *Carabus granulatus* and *Oodes helopioides* occurring in the grassy patches at the water ditch margin. These species were also accompanied by some Dytiscidae, Haliplidae and ripicolous Heteroptera.

Changes of cumulative abundance and biomass of studied taxocoenoses along the transsection

On average 1,534 individuals of all three families were caught per one trap in the northern part of the trap line with the predominant cereal fields (traps 1–10). The number of individuals found in the wheat culture was less than this value, while the catches from the border of the oat and lucerne fields were richer (Fig. 4). In the central and southern part, passing mostly through maize fields (traps 11–32), the catches' size in individual traps was higher even in the traps situated in the immediate vicinity of the dump (traps 14 and 15). In the southern part, in very high maize stands (ca. 2 m), the catch size reached even 2,791 individuals.

Very large differences were found in the dry weight of the whole catch from individual traps. In the wheat culture the average weight amounted 30 g pre trap and year, in the central part of transsection 78 g per trap and year, and 135 g in the traps put in the high maize growth.

The described trends in cumulative abundance and biomass were caused mostly by the microclimate in individual crops and by coincidence of the crop's presence in a field with the reproductive cycle of individual species. The cultures of winter wheat favoured the spring breading, mostly small sized species like *Poecilus cupreus*, *Agonum dorsale* and *Brachynus explodens*, while the cultures of maize or sugar beet favoured the autumn breeding species, especially the medium sized *Harpalus rufipes*.

The results indicate that the influence of the fall of nickel leaching rest had no influence on the catch size in terms of cumulative abundance or biomass of the studied taxocoenoses in the surrounding fields even in the immediate vicinity of the dump and that the observed differences were of a different nature.

In contrast to this, immediately at the border of the dump the cumulative abundance and biomass sank rather suddenly. Only 100–200 individuals (Fig. 6) were found in the places with sparse vegetation at the foot of the dump. That is 10–20 times less than in the dump surroundings. Only 50 individuals were found in the places without vegetation, that is 20–40 times less than in surroundings (Fig. 5). These values seem to be independent of the traps position on the dump (Fig. 2 and 5). This is, however, caused by a small surface of the dump in relation to the dispersal power of the field Carabids or Staphylinids. The described changes are much more visible if expressed in terms of biomass. In the center of the dump the cumulative biomass of the catches in each traps sinks to 1/30 when compared with the wheat field and even to 1/100 when compared with the maize fields in the southern part of the trap line.

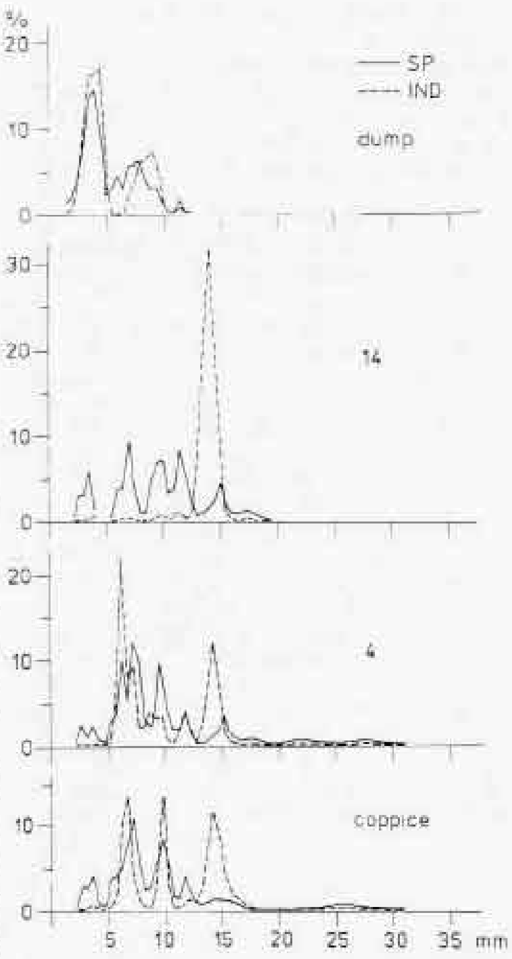


Fig. 6. Body size structure of Carabidae in four typical parts of pollution gradient (coppice, traps number 4, 14 and dump surface).

Changes of alpha-diversity of the studied taxocoenoses along the fall gradient.

The differences in vegetation structure in the dump surroundings and the fall intensity of the nickel leaching rest were reflected in the alpha diversity (Fig. 4) of the studied taxocoenoses as follows. In the northern part of the trap line, the alpha diversity reached the values of 3–4 bits (traps 1–10), while in the southern part it fluctuated between 2 and 3 bits (traps 23–32). In the traps 20 and 21 installed in private gardens, the alpha diversity was markedly higher than in the adjacent traps. The alpha diversity in the central part of the trap line, in the zone of fall intensity exceeding 800 t km^{-2}year^{-1}, sank to 1.5–1.8 bits (traps 11–19) and in the immediate vicinity of the dump even to 1.0 bit (trap 14, Fig. 4).

In individual traps on the dump the alpha-diversity (H and H', Fig. 5) was, except for one case, higher than the average alpha diversity in the southern or northern part of the trap line. The relatively high values of diversity on the dump were caused by a high number of species penetrating there in a small number of individuals from the surroundings.

Body size structure of Carabid taxocoenoses in the typical parts of the transsection.

The body size structure reflects different states of a community rather sensitively (Šustek, 1983, 1987, 1992). In regard to the large number of sampling points, only four typical cases of carabid communities were chosen, viz. those from the locust-tree copice and from the trap 4 in the more natural northern part of the transsection and from the trap 14 laying at a distance of 20 m from the dump and S3 from the dump interior.

The body size distribution of carabids in the locust-tree copice was polymodal, richly structurized and took the whole potential extent. The peaks of quantitative distribution corresponded with the peaks of the qualitative distribution. In the northern part of the trap line, in the wheat culture, the coincidence of peaks of the qualitative and quantitative distribution decreased significantly and the majority of individuals concentrated in two length octaves. In the close vicinity of the dump, the qualitative distribution of Carabids took only the range of 3–19 mm and the coincidence of peaks of the qualitative and quantitative distribution is very low because almost all individuals belong to *Harpalus rufipes* (12–16 mm). On the dump, the body size distribution was limited to the range of 2–12 mm. The coincidence of the qualitative and quantitative distribution is very high. It is due to the fact that majority of species was represented by only one individual.

Changes of sex ratio of Carabidae along the fall gradient

Šustek (1984) found that the populations of the more abundant species in the intermediately disturbed carabid communities tend to be female dominated, whilst in the strongly disturbed communities they tend to be male dominated. A similar effect was also observed by Müller (1970) at the margins of various ecological gradients.

In the dump surroundings the populations of *Harpalus rufipes* were female dominated in the marginal parts of the trap lines affected by

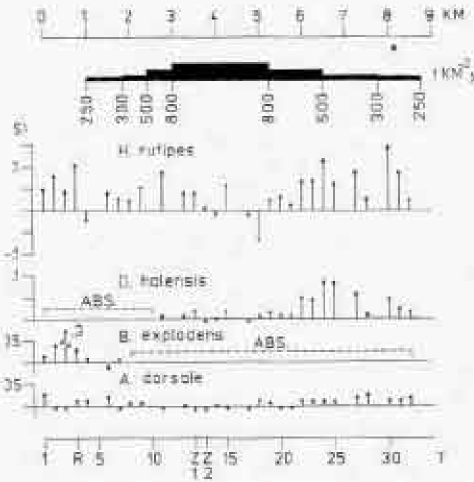
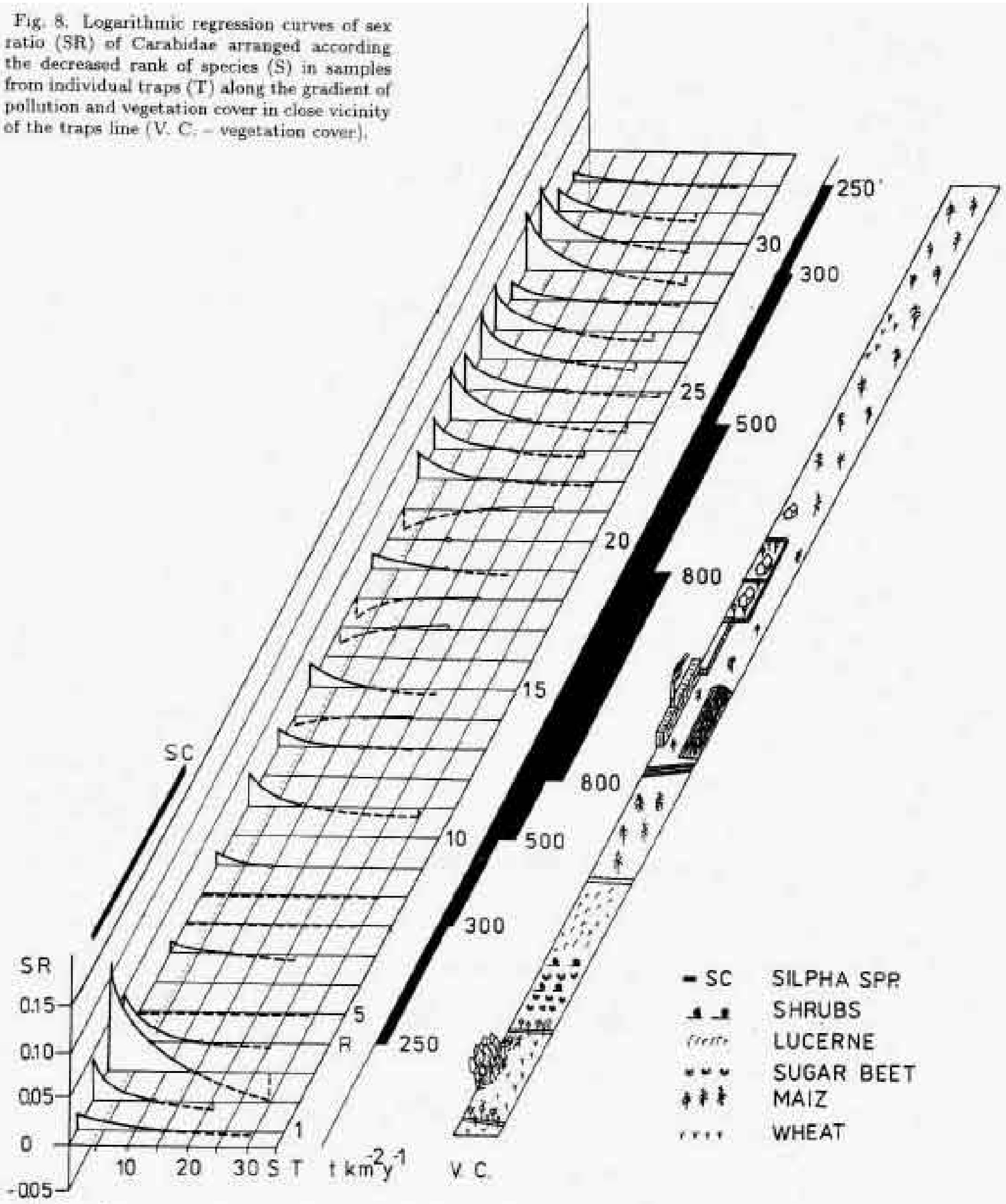


Fig. 7. Sex ratio (SI) in four carabid species (*Harpalus rufipes*, *Dolichus halensis*, *Brachynus explodens* and *Agonum dorsale*) in individual traps (T) along the pollution gradient (ABS – species absent in indicated area).

lower fall intensity (Fig. 7). The predominance of females sank obviously in the zone of the fall intensity exceeding 500 t km^{-2}year^{-1} and the males dominated in the zone exceeding 800 t km^{-2}year^{-1}. A similar trend was also visible in *Dolichus halensis*. In *Agonum dorsale*, however, the predominance of females declined as early as in the zone of the fall intensity exceeding 300 t km^{-2}year^{-1} (Fig. 7). In this case, however, the tendency to predominance of males may coincide with the lower representation of this species.

The changes of sex ratio shown in four selected dominant species can also be observed in the whole taxocoenosis (Fig. 8). The logarithmic regression curves calculated separately for each sampling point show that in the area of lower fall intensity the females predominated mostly in the populations of more abundant species, similarly as in many other intermediately disturbed communities. In the area of the traps 5–9 the regression curves indicate a tendency to balanced sex ratio in individual species. On the one hand it coincides with higher diversity of the vegetation cover diminishing effect of anthropic pressure and with the presence of large sized species indicating a more natural state of the carabid communities in that part of thetraps line. On other hand, a high number of the predaceous carrion beetles *S. carinata* and *S. obscura* ousts the carabids from their ecological niche of small soil surface predators. This

Fig. 8. Logarithmic regression curves of sex ratio (SR) of Carabidae arranged according the decreased rank of species (S) in samples from individual traps (T) along the gradient of pollution and vegetation cover in close vicinity of the traps line (V. C. – vegetation cover).



results in a lower population density of individual carabid species and more intensive immigration in which the more mobile males are more successful, as in the case of the gradients margins described by Müller (1970). In the zone of the highest intensity of nickel leaching fall the tendency to the predominance of males in the abundant species is obvious.

The described changes of sex ratio of Carabids can be interpreted as an effect of the fall of

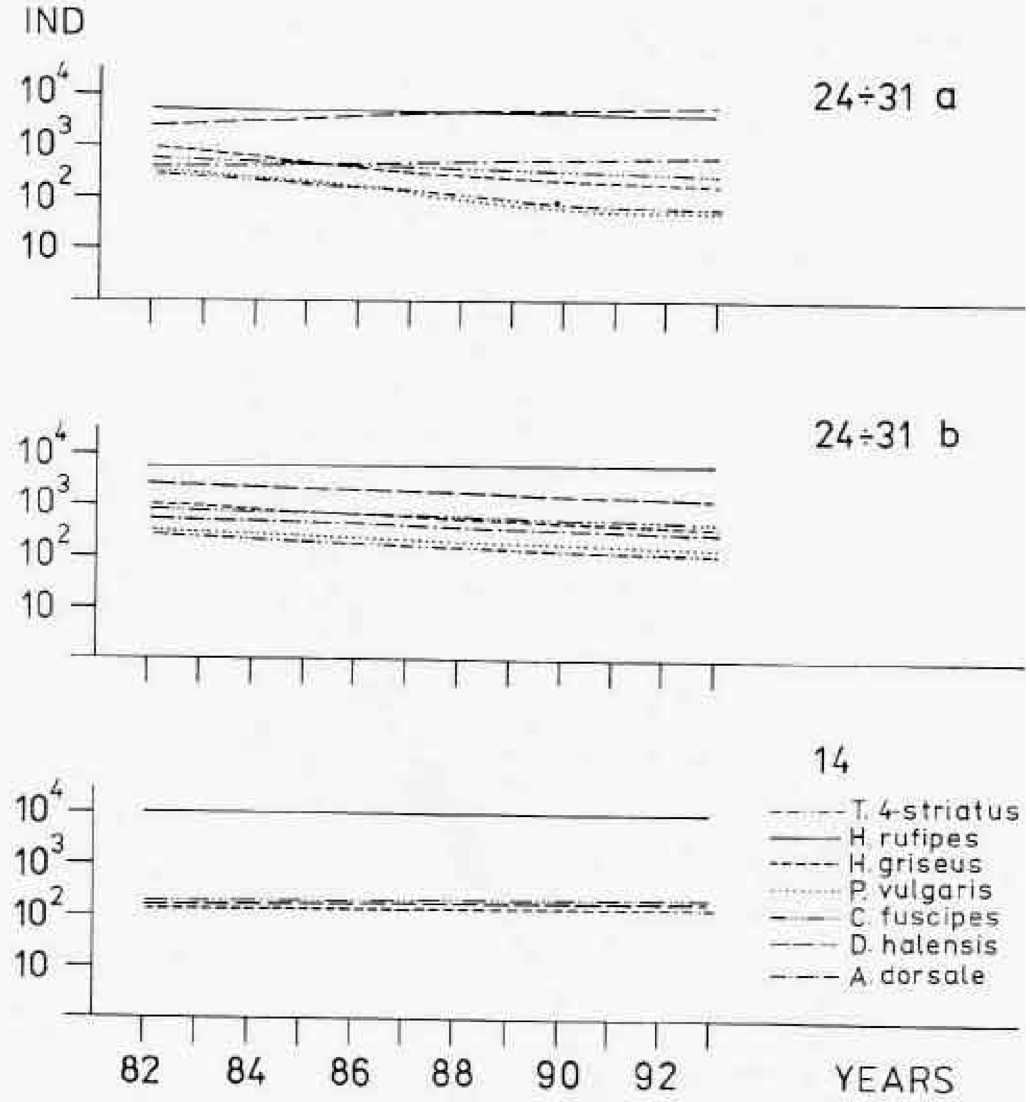


Fig. 9. Tentative estimate of development of populations of seven dominant carabid species based on their sex ratio found in 1982 in the southern part of transection (traps 24–31) and in close vicinity of the dump (trap 14).(a – model considering only different sex ratio, b – model considering dominance of biomas of each species).

nickel leaching rest reducing the size of local population and its intrinsic growth rate. The predominance of males in the zone of the highest intensity of the pollution indicates that the populations started to die out there, but that the decline in the number of individuals was compensated by immigration from the less polluted surroundings. So the negative effect of the fall of nickel leaching rest was not reflected in the cumulative abundance and/or biomass or in the abundance of the most tolerant and expansive species *H. rufipes*.

An attempt at estimation of the development of carabid communities in the polluted area during one decade after investigation

The sex ratio is one of the important factors responsible for population growth. Therefore, under certain simplifications, the sex ratio can be used for an approximate estimate of further development of each population or the whole community (Šustek, 1984a). The striking predominance of females in a limited number of dominant species in the less polluted parts of the studied area indicates that the communities in those area tend to oligospecificity or even to monospecifity, while the predominance of males in the majority of species in the strongly polluted parts of the studied area indicates a tendency to extinction of such populations.

The samples from the southern part of the trap line (traps 24–31) were taken as an example of the communities from the less polluted zone and the sample from the trap 14 as an example of the community from the most polluted zone.

Two different models of development of populations of seven dominant species have been used (Šustek, 1984a). The first model is based on sex ratio calculated as difference of females and males number divided by the total number of individuals of each species. In this model the number of individuals of the species with a predominance of females would increase and without respect on their original position they would become dominant. The second model uses the sex ratio weighted by the importance of each species in the community (relative biomass). In these models the gradual extinction of the male dominated species would be much slower. Abundance of the eudominant species *Harpalus rufipes* increases moderately whereas the abundance of other species decreases slowly. Under the simplified conditions of omitting other factors managing the population growth in individual populations and under presumption of stability of the sex ratio in each species, the carabid community in the wider surroundings of the dump (traps 24–31) would reach the state observed in the immediate vicinity of the dump (trap 14) approximately within 30–60 years. The existence of communities similar to the second model in the close vicinity of the dump or in the strong anthropogenically modified urban ecosystems and the high resistance and expansivity of *Harpalus rufipes* confirm the reality of the second model. As the second model shows, the observed state of communities in the surroundings of the nickel leaching dump seems to be rather stable. On the one hand this stability could be negatively influenced by the accumulation of the nickel leaching rest in the soil if the dump surface is not stabilized in the future, on the other hand, intensive migration ability of individual species, which is characteristic of the typical field species, will compensate for the negative effect of pollution by the nickel leaching rest will.

Discussion and conclusions

Changes in the studied taxocoenoses on individual levels of bioindicative criteria provoked by fall of the nickel leaching rest provoked reflected clearly the different intensity of the fall. Along the whole gradient of the fall intensity no significant changes in the cumulative abundance and biomass of the studied taxocoenoses caused by the fall intensity were observed. The observed differences were mostly caused by the different vegetation structures at individuals sampling sites, or by competitive pressure of similarly sized species. The species number decreased in the zone of fall intensity exceeding 800 t km^{-2}year^{-1} by approximately five species. In the same zone the alpha diversity sank approximately by one bit, whereas a visible tendency to its decrease was already evident already in the zone of fall intensity exceeding 500 t km^{-2}year^{-1}. In the centre of the most polluted area the species Harpalus rufipes tended to reach an extremely high relative abundance of 90% and relative biomass of 97%. The impoverishment of the community was also clearly documented by the simplification of the body size structure in the zone of the fall intensity exceeding 500 t km^{-2}year^{-1}. The sex ratio of individual species was the most sensitive bioindicative criterium. It already already in the zone of the fall intensity exceeding 300 t km^{-2}year^{-1} in *Agonum dorsale*. A tentative estimate of the population growth of the seven most abundant species during ten years after the investigation shows that the community in less polluted parts of the transection tended to the state found in the most polluted part in the closest vicinity of the pollution source. The colonization of the actual dump was strongly dependent on the presence of the sparse vegetation in the places where the nickel leaching rest was admixed with loam.

A comparison of the effects of pollution by nickel leaching rest with the effects of other types of industrial imissions on Carabidae, Silphidae and Staphylinidae is rather contradictory. No effect of pollution on cumulative abundance and biomass

in pine forests was found by FEILER and HIEBSCH (1968) during one year of observation while as late as after three year of observations they found a higher cumulative abundance of Carabidae in less polluted stands. On the contrary, a higher cumulative abundance of carabids in the fields polluted by dust containing lime or sulphuric substances was found by PUSZKAR (1979 d-f). KHOT'KO et al. (1982) reported rather contradictory results about abundance changes of the soil mesofauna in forests in areas polluted by various kinds of chemicals. In approximately one half of cases, she found insignificant differences while in the remaining cases abundance fluctuated without any obvious relation to the degree of pollution. TOBISCH and DUNGER (1973) found no changes in the species diversity and activity abundance in the polluted areas. KABACYK-WASYLIK (1980) found about one-third fewer species of Carabidae in the potato fields in polluted area than in less exposed fields.

The changes in body size structure and in sex ratio along pollution gradients have rarely been studied. The patterns exhibited by both bioindicative criteria are rather similar to those found along an idealised urbanisation gradient in the cities of Bratislava and Brno (ŠUSTEK, 1986, 1987, 1994). The patterns found in wider surroundings of the dump corresponds with those in large parks or in the peripheries, while those found on the proper dump corresponds with the patterns found in small flower beds in the city center. The predominance of males in the strongly polluted or otherwise anthropogenically disturbed areas as a result of immigration from less exposed surroundings is indirectly confirmed by higher phenotypical heterogeneity in the populations of *Pterostichus oblongopunctatus* in the recreation zones (EMEC, 1984).

STUBBE and TIETZE (1982) concluded that the influence of various noxious factors is usually minor compared to the influence of microclimatic factors. They generalized this conclusion so far that the carabids are to be taken as indirect bioindicators. Although this generalization seems to be somewhat exaggerated, their finding is highly compactible with my results and, at the same time, can be considered to be the main cause of the contradictory results presented by other authors who focused in their interpretations predominantly on the pollution and omitted other differences between the studied habitats or possible influence of competitive relationships of trophically related groups.

It is evident that an occasional coincidence of various natural gradients in community structure with an expected trend provoked by a pollution gradient can lead in such cases to serious misinterpretations of results.

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