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Characterization of the lumbricid fauna in alluvial soils in the Danube River floodplain area east of Vienna

R. BAUER, K. KÜPPER & H.W. MÜLLER

A b s t r a c t : In the Danube River floodplain east of Vienna, the structure of the earthworm community - abundance, biomass and dominance - was studied at two transects which varied in the distance to the river and in the type of vegetation. Eleven earthworm species were found, most of them being widespread. Higher species number, abundance and biomass were recorded in the softwood forest by the river than in the hardwood forest zone. Differences are significant for the epigeic species *Lumbricus rubellus* and *Dendrodrilus rubidus tenuis* and the total number of juvenile individuals. The amount and chemical composition of the leaf litter, the soil texture and the impact of inundations are discussed as possible factors causing these differences.

K e y w o r d s : Lumbricidae, Danube, alluvial soils, floodplain

Introduction

The „Stopfenreuther Au", situated along the Danube River east of Vienna, is among the largest coherent natural floodplain areas in Central Europe. Ecological processes in the river-adjacent woodland are heavily influenced by submersion dynamics and the fluctuating groundwater level. Inundations not only affect erosion and sedimentation of soil material, but also provide a high amount of nutritive substances. On one hand, the plants and soil fauna inhabiting floodplains are therefore favoured by an abundant food supply, while on the other hand they must withstand disturbances caused by continuing changes of sedimentation and soil formation.

Depending on the distance to the Danube and on the formation of soil strata, a great variety of biocenoses have developed. Like the vegetation, which shows a typical zonation from pioneer communities over the softwood forest near the river to the hardwood forest, soil animal communities are composed of differing portions of aquatic, inundation-tolerant and terrestrial species (DUNGER 1983). ZULKA (1989, 1991) studied the distribution of soil arthropods in flooded and non-flooded areas at the Morava River (March) in Lower Austria for several years and found conspicuous differences of the species composition. The macrofauna (Isopoda, Diplopoda, Lithobiomorpha) showed a higher density and diversity in the non-flooded terraces. Floodplains house earthworms in comparatively great individual and species numbers (EMMERLING 1995). The occurrence of particular lumbricid species depends both on physicochemical factors such as humidity, temperature, acidity, carbon dioxide concentration, oxygen pressure etc. and on the supply of food (EDWARDS & LOFTY 1972; LEE 1985). HÖSER (1990) pointed to the importance of the nutrient usability, i.e. the quality (stage of decomposition) and dispersion (concentration) of food items in the soil. This usability is affected chiefly by the nature and composition of leaf litter and by sedimentation and stratification processes.

In the "Stopfenreuther Au", lumbricid community structure, abundance, biomass and life-form

spectrum (according to BOUCHÉ 1972) were determined along two transects which varied with respect to the distance to the river and the type of vegetation. Being possible determinants, soil texture, pH, as well as the amount of litter and its nitrogen and phosphorous content were measured.

Materials and Methods

S t u d y a r e a : The "Stopfenreuther Au" is situated along the Danube River, about 50 km east of Vienna, 48°08'N/16°52'E, 141-144 m a.s.l. The long-term average air temperature was 9.5°C, the average precipitation was 541 mm per year (1961-1990). Two transects (D and E) were investigated (Fig. 1). Transect D is situated 400 m north from the river bed. The northern part is flat and to the south there is a periodically water-filled trough. The groundwater table oscillates between 1.5 and 3.5 m under the terrace level (Fig. 2). The vegetation is a riverine softwood forest composed of *Populus alba, P. nigra, Fraxinus excelsior, Alnus incana, Ulmus laevis, Cornus sanguinea, Juglans nigra, Corylus avellana, Sambucus nigra* and *Allium ursinum.* Transect E, about 700 m north of transect D, is less exposed to flooding. The vegetation is a riverine hardwood forest composed of *Quercus robur, Acer campestre, Populus canescens, Ulmus laevis, Cornus mas, Crataegus, Cornus sanguinea, Ligustrum vulgare,* and *Rubus caesius,* with *Allium ursinum* and *Galanthus nivalis* in the undergrowth.

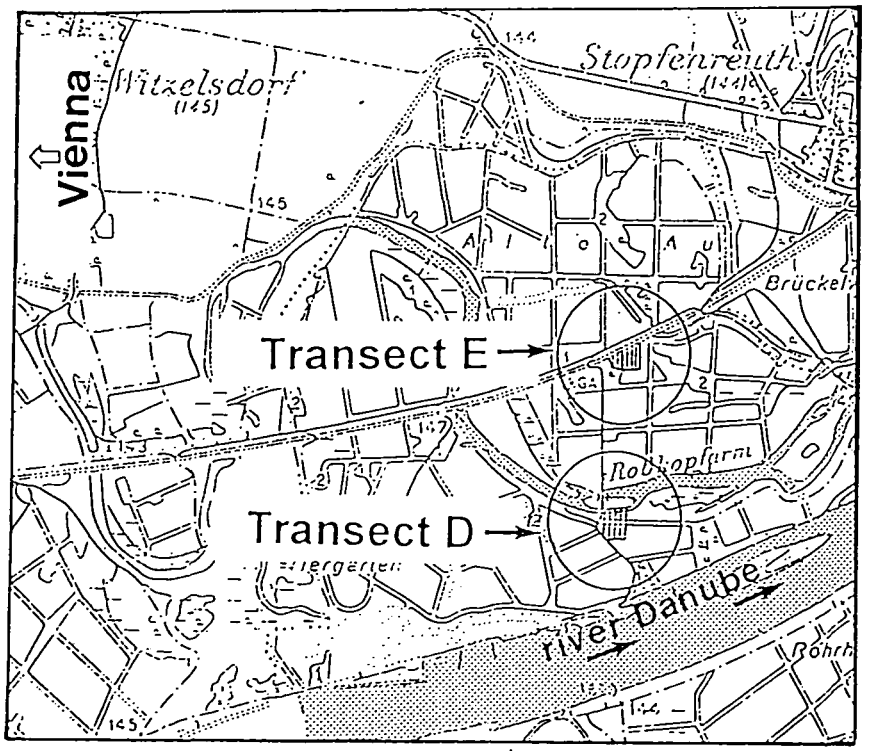

Fig. 1: Location of the „Stopfenreuther Au" and of the transects in the floodplain along the Danuber River.

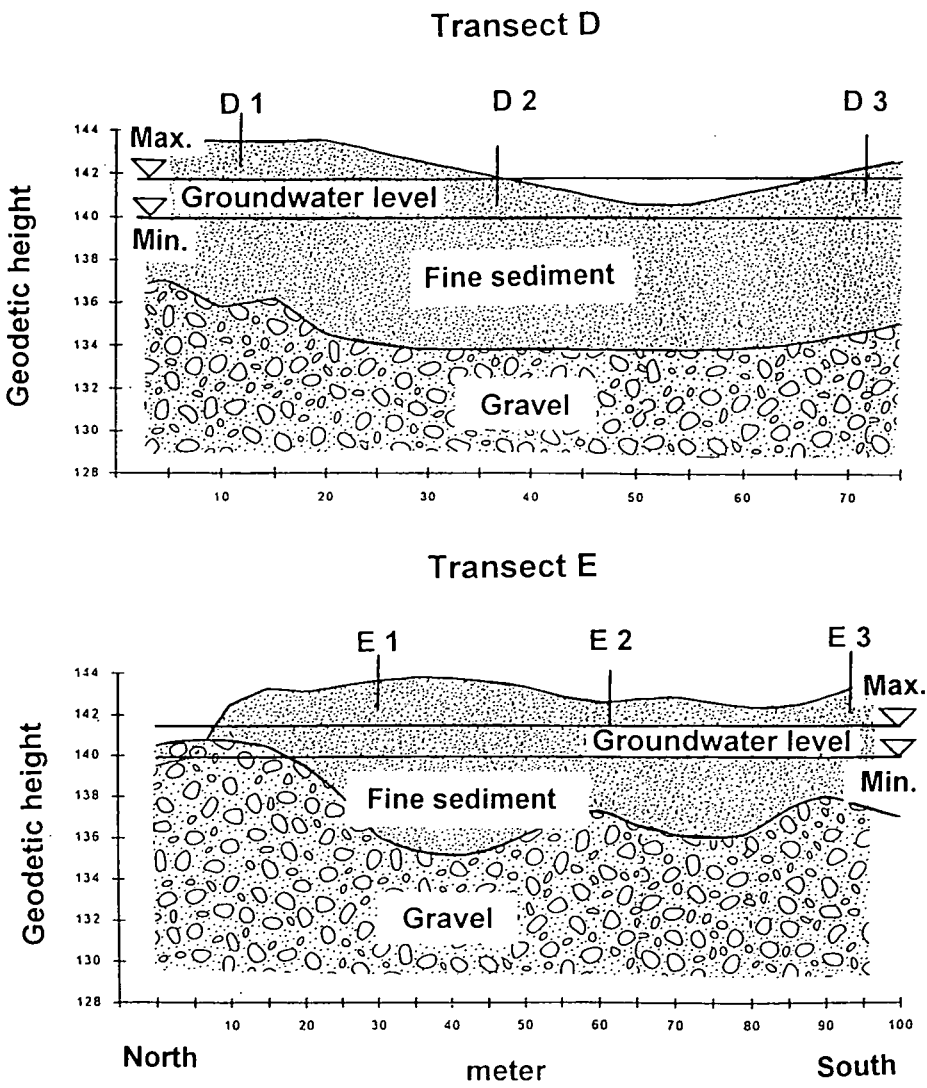

Fig. 2: Cross section through the transects, location of the investigated plots groundwater amplitude during the study period.

Soil texture and leaf litter: The soils of both transects are typical clay loam fluvisols (FAO) with a clay-horizon at 1.6 m. The texture is loam, silt loam and silty clay loam (Tab. 1). The mineral content is characteristic of the inundation areas of the Danube east of Vienna. The pH (KCl) values ranged from 6.7 to 7.3 in both transects. The average dry mass of the leaf litter amounted to 2.81 t ha^{-1} in transect E and 3.05 t ha^{-1} in transect D. C-, N- and P-contents of the leaves were determined in extracts made with HNO_3 + $HClO_4$ and H_2SO_4 (Kjeldahl) for total nitrogen. N-content was 45.75 kg ha^{-1} (transect D) and 37.94 kg ha^{-1} (transect E). P-content amounted to 2.14 kg ha^{-1} (transect D) and 1.41 kg ha^{-1} (transect E). The C/N-ratio in both transects was between 10 and 11.

Earthworms: In May and October 1994, on three plots each on transects D and E (Fig. 2: D1, D2, D3 and E1, E2, E3), seven samples were taken using the formaldehyde method according to RAW (1959). Squares of 25 x 25 cm were fenced in by a frame of steel. A total of 5 l of 0.5% aqueous formaldehyde solution was poured twice with an interval of 15 minutes on each square. The earthworms were killed in 70% alcohol, fixed in a 4% formaldehyde solution for two days, and stored in 70% alcohol. Biomass was determined according to SATCHELL (1970) und SENAPATI & DASH (1980). The worms were weighed after blotting on filter paper. As the fixation process leads to a weight loss of about 10%, this difference was added to the balance values. 20% of this value was deducted in order to compensate the weight of gut contents. Multiplication by the factor 0.16 provides the individual dry mass with empty gut (RÖMBKE 1985).

Only mature individuals were identified to species according to ZICSI (1965, 1994) and SIMS & GERARD (1985), the nomenclature follows EASTON (1983). Individual and biomass dominance were divided according to ENGELMANN (1978): eudominant (ed) = 32 - 100%, dominant (d) = 10 - 31.9%, subdominant (sd) = 3.2 - 9.9%, recedent (r) = 1.0 - 3.19%, subrecedent (sr) = 0.32 - 0.99%, sporadic (s) = < 0.32%.

SØRENSEN- and RENCONEN-indices were calculated to compare the species composition of the two transects. For statistical evaluation the nonparametric U-Test (MANN & WHITNEY) was applied.

Results

Eleven lumbricid species were found in the "Stopfenreuther Au" (Tab. 3). The species composition of transect D resembled that of transect E: the SØRENSEN-quotient 80 (May) and 67 (October); the RENKONEN-index 63.7 (May) and 50.6 (October). On transect D more species were found, both in spring and in autumn: 11 species on transect D vs. 8 species on transect E.

Abundance, dry mass and dominance of the epigeic, endogeic and anecic earthworm species are listed in Tables 3 and 4. The total number and dry mass on transect E is significantly lower than on transect D. The differences are caused by the epigeic *Lumbricus rubellus* (May: U-Test, α = 0.879 %), and by the juveniles (May: U-Test, α = 1.389 %, October: α = 0.308 %). Juveniles formed the decisive portion of earthworm abundance and biomass on both transects. The total number decreased in autumn. In October adult epigeic species were completely missing on transect E.

No differences in abundance are shown by the endogeic and anecic lumbricid species between both transects in May and October. Whereas the anecic earthworms occurred in high abundance and biomass in autumn too, the abundance of the endogeic species decreased significantly (α < 5 %).

Discussion

The soil of the "Stopfenreuther Au" houses a comparatively diverse lumbricid fauna. All recorded earthworm species are common in many habitats and widespread. Though only one extraction method was used, members of all life-forms (BOUCHÉ 1972) were found.

Lumbricus rubellus, colonizing the litter and the uppermost soil layer, has already been found in various floodplains (DUNGER 1958; FRANZ et al. 1959; VOLZ 1962; HÖSER 1990). It is among the most frequent species in Germany. *L. rubellus* is dominant in a beech forest (Black forest, Germany), where it shows characteristic seasonal population dynamics with a peak in spring (RÖMBKE 1985). Accordingly, in the "Stopfenreuther Au" significantly more mature individuals occurred in May than in October 1994. *Dendrodrilus rubidus tenuis*, living mainly in decaying organic matter, in rotten wood and in moss, belongs to the epigeic species as well (ZICSI 1965).

The endogeic species *Aporrectodea rosea* shows a wide distribution. The habitat requirements resemble those of *A. caliginosa*, although, *A. rosea* prefers more stable humidity conditions and a higher humus content in the mineral soil (HÖSER 1994). *A. rosea* occurs in the "Stopfenreuther Au" in a higher density than *A. caliginosa*. *A.caliginosa* has been recorded from various floodplains (DUNGER 1958; VOLZ 1962; HÖSER 1990) and is the most abundant species in the flooded areas investigated by EMMERLING (1995). The occurrence of this species is characteristic of soil profiles developed by rearrangement processes (HÖSER 1994). The small endogeic earthworms *Aporrectodea georgii* and *Kritodrilus auratus* colonize wet habitats close to waters (ZICSI 1965; HÖSER 1994). *Octolasion lacteum*, inhabiting the mineral horizon near the soil surface, prefers moist soils. HÖSER (1994) found *O. lacteum* in wooded stratified mineral soils with a raw humus layer.

Fitzingeria platyura platyura colonizes moist floodplain forests and was often found in soils by the Danube River east of Vienna (FRANZ et al. 1959; ZICSI 1994). This large anecic worm constructs deep vertical burrows in the soil – just as the subspecies *F. pl. depressa* – and feeds on leaf litter. *F. pl. platyura* and *F. pl. depressa* resemble each other morphologically and live syntopically in the "Stopfenreuther Au", *F. pl. depressa* being larger than *F. pl. platyura*. The anecic *Lumbricus polyphemus* is the largest earthworm species in Austria, mainly colonizing forests but also living in gardens and parks. *Octodrilus* sp. was found in a small individual number only in October 1994 and a clear assignment to the species *O. hemiandrus* or *O. transpandanus* was not possible.

The species composition of transect D and E are very similar. Earthworm density and biomass, however, were significantly higher in the softwood forest, both in May and October. The higher numbers of the endogeic *Lumbricus rubellus* and juvenile individuals in the soil of transect D may be due to the greater amount of leaf litter and higher nitrogen and phosphorus content, as soil texture and pH are almost the same. HÖSER (1994) stated that the occurrence of *L. rubellus* in a floodplain depends on litter supply. This species shows the highest reproduction rate within the genus: about 100 cocoons per year (with one worm each) are deposited in the uppermost litter layer (GRAFF 1953). *L. rubellus* is therefore "r-selected", contrary to the other lumbricid species found in the "Stopfenreuther Au" which are mainly "K-selected" (SATCHELL 1980). According to SOUTHWOOD et al. (1974) the stability of the environment represents the main factor for the occurrence of "K-strategists", the food source playing an important role. In the "Stopfenreuther Au" a diverse earthworm fauna has been become established with respect to both, species and life-form composition. High decomposition is characteristic for these habitats, in which the macrofauna (Lumbricidae, Isopoda, Diplopoda, Gastropoda) play an important part (DUNGER 1958). Although both transects D and E are rarely affected by inundation today, submersion dynamics and fluctua-

ting groundwater level have led to the formation of various vegetation zones whose plant and leaf litter composition may influence the earthworm diversity, abundance and biomass considerably.

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Address of the authors: Dr. Roswitha BAUER
Institute of Zoology, University of Agricultural Sciences, Vienna, Gregor-Mendel-Straße 33, 1180 Vienna, Austria.

DI Karl KÜPPER, Univ.Doz. Dr.Harald W. MÜLLER
Institute of Applied Geology, University of Agricultural Sciences, Vienna, Peter-Jordan-Straße 70, 1190 Vienna, Austria.

Table 1. Particle size distribution (%), total mineral content (%) and clay mineral content (%) in the soils of the transects D and E.

Particle size distribution (%)

	Plots D1 and D3			Plot D2			Plots E1, E2 and E3		
Horizon	sand	silt	clay	sand	silt	clay	sand	silt	clay
A	33.5	50.5	16.0	16.9	61.1	22.0	17.9	51.0	31.1
AC	38.0	48.3	13.7	15.0	56.3	27.7	18.8	52.7	28.5
C	43.0	43.9	13.1	14.2	64.2	21.6	24.2	52.8	23.0

Total mineral content (%)

	quartz	feldspar	calcite	dolomite	chlorite	mica (and clay minerals)
Transect D	32	8	10	17	8	25
Transect E	26	9	9	24	4	28

Clay minerals (%)

	smectite	illite	kaolonite	chlorite	vermiculite
Transect D	5	59	10	26	sp
Transect E	19	53	7	21	sp

Table 2. Distribution of the earthworm species on the transects D and E in May and October 1994 and their dominance classification according to Engelmann (1978): ed = eudominant (32 - 100%), d = dominant (10 - 31.9%), sd = subdominant (3.2 - 9.9%), r = recedent (1.0 - 3.19%), sr = subrecedent (0.32 - 0.99%), s = sporadic (<0.32%)

	D				E			
	May		October		May		October	
	%		%		%		%	
Aporrectodea caliginosa (SAVIGNY 1826)	2.8	r	2.8	r	1.8	r	0	
A. georgii MICHAELSEN 1890	6.6	sd	10.9	sd	0		2.4	r
A. rosea (SAVIGNY 1826)	13.2	d	26.8	d	17.2	d	2.4	r
Dendrodrilus rubidus tenuis (EISEN 1874)	0		2.8	r	0		0	
Fitzingeria platyura platyura (FITZINGER 1833)	20.8	d	24.3	d	41.4	ed	57.9	ed
F. pl. depressa (ROSA 1893)	9.4	sd	13.4	d	5.2	sd	16.2	d
Kritodrilus auriculatus (ROSA 1897)	1.9	r	0		0		2.4	r
Lumbricus rubellus HOFFMEISTER 1843	32.1	ed	2.8	r	12.0	d	0	
L. polyphemus (FITZINGER 1833)	0		8.1	sd	0		0	
Octolasion lacteum (ÖRELEY 1885)	8.5	sd	8.1	sd	22.4	d	18.7	d
Octodrilus sp.	4.7	sd	0		0		0	

Table 3. Individual number per m^2 (mean and standard deviation: * [S.D.]) and dominance (%) of the earthworm species arranged according the epigeic, endogeic and anecic life-forms (BOUCHÉ 1972).

	Transect D				Transect E			
	May		October		May		October	
	* [S.D.]	%	* [S.D.]	%	* [S.D.]	%	* [S.D.]	%
Epigeic species:								
Dendrodrilus rubidus tenuis	0	**0**	0.8 [3.4]	**0.6**	0	**0**	0	**0**
Lumbricus rubellus	25.9 [29.4]	**8.7**	0.8 [3.4]	**0.6**	5.3 [10.3]	**2.7**	0	**0**
Endogeic species:								
Aporrectodea rosea	10.7 [14.3]	**3.6**	7.6 [0.8]	**6.1**	7.6 [10.6]	**3.9**	0.8 [3.4]	**0.9**
A. caliginosa	2.3 [5.6]	**0.8**	0.8[3.4]	**0.6**	0.8 [3.4]	**0.4**	0	**0**
A. georgii	5.3 [17.3]	**1.8**	3.1 [8.0]	**2.5**	0	**0**	0.8 [3.4]	**0.9**
Kritodrilus auriculatus	1.5 [6.8]	**0.5**	0	**0**	0	**0**	0.8 [3.4]	**0.9**
Octolasion lacteum	6.9 [9.3]	**2.3**	2.3 [8.2]	**1.8**	9.9 [11.6]	**5.1**	6.1 [12.6]	**6.8**
Anecic species:								
Fitzingeria pl. platyura	16.8 [18.1]	**5.6**	6.9 [9.3]	**5.5**	18.3 [22.8]	**9.5**	19.0 [25.9]	**21.1**
F. pl. depressa	7.6 [11.7]	**2.5**	3.8 [6.8]	**3.0**	2.3 [5.6]	**1.2**	5.3[10.3]	**5.9**
Lumbricus polyphemus	0	**0**	2.3 [5.6]	**1.8**	0	**0**	0	**0**
Octodrilus sp.	3.8 [9.8]	**1.3**	0	**0**	0	**0**	0	**0**
Juveniles	217.9 [59.3]	**72.9**	96.8 [35.4]	**77.5**	149.3 [57.2]	**77.2**	57.1 [56.9]	**63.5**
Total	**298.7 [125.2]**		**125.2 [48.8]**		**193.5 [56.5]**		**89.9 [66.9]**	

Table 4. Earthworm dry mass g m^{-2} (mean and standard deviation: * [S.D.]) and dominance (%) of the species arranged according the epigeic, endogeic and anecic life-forms (BOUCHÉ 1972)

	Transect D				Transect E			
	May		October		May		October	
	* [S.D.]	%	* [S.D.]	%	* [S.D.]	%	* [S.D.]	%
Epigeic species:								
Dendrodrilus rubidus tenuis	0	**0**	0.1 [0.0]	**0.1**	0	**0**	0	**0**
Lumbricus rubellus	2.27 [2.35]	**13.8**	0.04 [0.19]	**0.5**	0.66[1.28]	**5.6**	0	
Endogeic species:								
Aporrectodea rosea	0.49[0.66]	**3.0**	0.21 [0.30]	**2.6**	0.4 [0.54]	**3.4**	0.03 [0.14]	**0.4**
A. caliginosa	0.22 [0.56]	**1.3**	0.07 [0.31]	**0.9**	0.09 [0.4]	**0.8**	0	**0**
A. georgii	0.14 [0.43]	**0.8**	0.06 [0.16]	**0.8**	0	**0**	0.02 [0.09]	**0.3**
Kritodrilus auriculatus	0.003 [0.01]	**0.02**	0	**0**	0	**0**	0.01 [0.03]	**0.1**
Octolasion lacteum	0.42 [0.61]	**2.6**	0.23 [0.75]	**2.9**	1.15 [2.1]	**9.8**	0.35 [0.74]	**4.5**
Anecic species:								
Fitzingeria pl. platyura	3.41 [3.75]	**20.7**	1.06 [1.55]	**13.3**	3.67 [4.9]	**31.1**	3.24 [4.22]	**41.9**
F. pl. depressa	2.32 [3.67]	**14.1**	0.93 [1.72]	**11.6**	0.93 [2.29]	**7.9**	1.42 [2.79]	**18.4**
Lumbricus polyphemus	0	**0**	1.61 [4.22]	**20.1**	0	**0**	0	**0**
Octodrilus sp.	0.43 [1.1]	**2.6**	0	**0**	0	**0**	0	**0**
Juveniles	6.76 [4.5]	**41.1**	3.78 [1.92]	**47.2**	4.89 [3.5]	**41.4**	2.66 [3.79]	**34.4**
Total	**16.46 [8.24]**		**8.0 [6.76]**		**11.79 [5.94]**		**7.73 [6.98]**	