

## Primary colonisation of newly formed soils by actinedid mites

David J. Russell<sup>1</sup>, Karin Hohberg<sup>1</sup> & Michael Elmer<sup>2</sup>

<sup>1</sup> Senckenberg Museum of Natural History, Postfach 300 154, 02806 Görlitz, Germany  
david.russell@senckenberg.de

<sup>2</sup> Brandenburg University of Technology, Postfach 101 344, 03013 Cottbus, Germany

### Abstract

In the brown-coal open-cast mining district near Cottbus, Germany, an artificial, experimental water-catchment system was constructed in 2005. The purpose of the experiment is to observe the development of the soil ecosystem during simulated primary succession. Within these studies the development of the soil fauna has been monitored since late 2005, of which the results regarding actinedid mites are presented here. Actinedida represented the major microarthropod group colonising the newly developing soils, having been present within months after exposition of the substrates to the surface, albeit in very low densities and only in sporadic samples. Initially, species richness was also extremely low, with practically only *Nanorchestes* sp. und *Speleorchestes* sp. present. Three years after site initiation, the abundances and species richness increased significantly, although they were still low compared to mature soils. The microarthropod communities continued to be strongly dominated by actinedid mites and colonisation of the soils remained spatially heterogeneous. The sporadic individual-richness was mostly caused by strong population development of single species in a few samples, e.g., *Siteroptes* sp. and *Bakerdania* sp. The abundance and distribution of *Nanorchestes* sp. originally increased strongly in the first two years. However, as many more species were found thereafter, the density of this species decreased briefly; dramatically in samples containing high densities of *Siteroptes* sp., indicating successional species replacement. Remarkable is the occurrence of species such as *Cheletomimus vesicus*, *Hawaii eupodes thermophilus* and *Xerophiles ereynetoides*, which are rare, most likely xerothermophilous species adapted to nutrient-poor soils. The results described here represent only those of the first 2.5 years and sampling and evaluation will continue.

**Keywords:** Actinedida, succession, sand, colonisation

### 1. Introduction

The soil fauna plays an important role in primary succession as it is present almost immediately after exposure of new land surfaces, facilitating the establishment of other biota (Hodkinson et al. 2004, Frouz et al. 2007, Wanner et al. 2008). On the other hand, vegetation development is an important determinant of the structure and function of the soil food web. Plant species' effects on soil development, decomposer organisms and processes are especially apparent in the course of ecosystem development (Wardle 2002). Changes in species composition during succession are controlled by biotic interactions, i.e. facilitation, competition and inhibition as well as tolerance. Many studies have followed secondary succession of soil-fauna (e.g. during recovery after disturbance), showing important effects of

regional species pool as well as species' disturbance tolerance and abiotic adaptation on colonisation, founder effects on community composition and structure etc. (Koehler & Born 1998, Dunger et al. 2002, Berg & Hemerik 2004, Wanner & Xylander 2005, Russell & Griegel 2006). However, very little is known about soil-faunal colonisation and community establishment during primary succession. In one of the few studies, Dunger et al. (2001, 2004) and Hohberg (2003) could show, in chronosequences of gradually reclaimed post-mining sites including initial substrates, regular patterns of colonisation by soil-faunal species as well as soil food-web development that paralleled soil maturation and was dependant on site conditions and amelioration (afforestation) methods. Even after 50 years of succession, initial ecosystem sites did not nearly approach soil-faunal climax conditions. Very few studies have investigated the interaction between vegetation and the soil food web or between soil food-web components during the initial stage of ecosystem development. This holds true, especially, with regard to the influence of interactions on the temporal and spatial variability of the soil fauna (Wardle 2002, Walker & del Moral 2003).

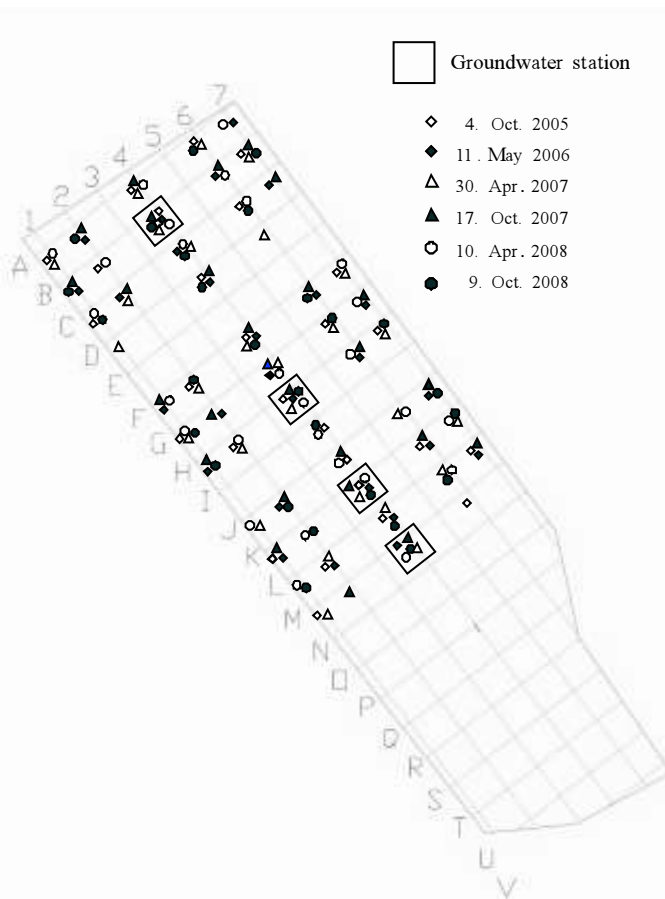


Fig. 1 Sketch of the study area with the plot coordinates and position of the individual samples at the different sampling dates.

Thus, within the framework of a multidisciplinary project of the BTU Cottbus, an artificial water-catchment area ('Chicken Creek') was created in order to study the ecological structures, processes and interactions during initial ecosystem development (Gerwin et al. 2009). In contrast to the study sites mentioned above, this area was left without further human interference, thus providing the opportunity to investigate undisturbed, natural primary succession during initial ecosystem development. The goal of this project is the study of the spatio-temporal succession of soils, soil microbiology, soil fauna, vegetation and their interactions during initial phases of ecosystem development.

Within these studies, the spatial and temporal development of several components of the soil-faunal food web is being investigated in detail during the initial stages of primary succession in the water-catchment area. Actinedid mites (in the sense of the paraphyletic group comprising Prostigmata and 'Endeostigmata'; OConnor 1984, Norton et al. 1993) are well known to be the dominant microarthropod group in nutrient- and structurally poor (e. g. sandy) soils around the world (i.e., Santos et al. 1978, Steinberger & Whitford 1984, Kinnear 1991, Cepada-Pizzaro et al. 1996, Noble et al. 1996). Therefore, this soil-animal group was expected to play an important role during initial developmental phases in the experimental ecosystem and is being intensively studied within the soil-biological investigations. Since only preliminary data regarding soils, soil microbiology and vegetation are becoming available and the soil-fauna studies are still ongoing, a comprehensive analysis of interrelations and interactions is not yet possible. Nonetheless, clear patterns of initial colonisation and community development are already emerging after only the first 2.5 years of primary succession. Therefore, the present report describes results concerning the actinedid fauna obtained during the initial period of soil-faunal colonisation and establishment in the artificial water-catchment area 'Chicken Creek'.

## 2. Materials and methods

The study was carried out at the artificial, approximately 6-ha large catchment area 'Chicken Creek' (Fig. 1). The site is located in the open-cast mine site Welzow-South (20 km south of Cottbus, Lower Lusatia, Germany; 51°36'18" N; 14°15'58" E). The catchment was constructed as a small hill with an altitude difference of approximately 10 m and an approximate slope of 2 %. In the winter of 2004/2005, a packed bed was produced and covered with a 2- to 3-m basal layer of clay to allow development of a groundwater table. Sandy quaternary substrate (85 % sand, 9 % silt, 6 % clay) taken from 20- to 30-m depth were then deposited on the surface to create a 2- to 3-m deep initial surface substrate (Gerwin et al. 2009). Construction of the area was finished in September 2005 and subsequently fenced to prevent disturbance by large vertebrate animals. Besides levelling and planning the area, no amelioration measures were taken and the area was allowed to undergo primary succession. For further information of the site see Gerwin et al. (2009). Soil parameters were measured by the BTU Cottbus for initial site conditions (in 2005), which are given in Tab. 1.

Tab. 1 Mean values and standard deviations of various soil parameters of the upper 30 cm of substrate after construction of the 'Chicken Creek' catchment area. From Gerwin et al. 2009.

Parameter	pH (H <sub>2</sub> O)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	C <sub>tot</sub> (mg g <sup>-1</sup> )	C <sub>org</sub> (mg g <sup>-1</sup> )	N <sub>tot</sub> (mg g <sup>-1</sup> )	CaCO <sub>3</sub> (%)
Mean	8.05	14.5	84.8	9.1	6.1	2.7	1.6	0.1	0.87
Std Dev.	0.43	6.6	5.4	3.4	2.1	1.5	1.0	<0.01	0.66

Vegetation was allowed to spontaneously colonise the 'Chicken Creek' site with no anthropogenic influence. Floral monitoring (by the Tech. Univ. Munich) documented a rapidly increasing vegetation cover and number of plant species. In the first year, a total of 18 plant species was found. The number of species increased to 130 in 2008. The two most dominant plant species were *Cirsium arvense* and *Chenopodium album* (2005), *Ch. album* and *Coryza canadensis* (2006), *C. canadensis* and *Echinochloa crus-galli* (2007) and *Trifolium arvense* with *Tussilago farfara* (2008). As one of the first woody plants, *Robinia pseudoacacia* was represented by a total of 88 individuals in 2008. Other pioneer tree species were also present in the catchment, e.g. *Pinus sylvestris*. However, their abundances and growth was much weaker than *Robinia* (Gerwin pers. comm.).

Sampling of the endogenous soil microarthropods took place via soil cores (6.4 cm in diameter, 5 cm depth) from the catchment area. Preliminary sampling was undertaken in October 2005 and May 2006 to assess initial soil-fauna development. Regular soil-faunistic sampling began in 2007 and took place at usual times of peak abundances, namely in April and October of each year. At each sampling date, 27 soil cores, distributed evenly throughout the catchment area, were taken. To prevent undue emphasis of single coordinate points as well as to avoid undue destructive sampling, the sampled points were rotated slightly from sampling date to sampling date (see Fig. 1). Solely permanent groundwater measurement stations were sampled at every date to ensure direct correlations between soil-fauna and hydrological or soil data. The cores were removed intact, transferred to size-matched transportation containers and taken to the laboratory, where the animals were driven from the cores via an increasing temperature and desiccation gradient in a Macfadyen-type, high-gradient extractor (Macfadyen 1961, Bieri et al. 1978).

Extraction took place with soil cores placed intact and inverted onto metal nets (2 mm mesh size) above funnels and continued for an average of 10 days. Temperatures in the heating chamber continually increased from approximately 20 °C to 50 °C with a temperature gradient within the cores increasing from approximately 5 °K to 20 °K. Extraction ended with total desiccation of the soil. The animals were caught in 30-ml reception jars containing von-Törne's conservation medium (50 % isopropanol with 3 % glacial acetic acid and 0.3 % formalin; Dunger and Fiedler 2000).

After extraction, the collected animals were transferred sample-specifically into 70 % ethanol and stored for approximately three weeks to allow total fixation and conservation. The microarthropods were subsequently sorted into higher-level taxon groups under a stereomicroscope at maximally 50× magnification, individual mites then mounted in Hoyer's medium and determined to species or generic level under a differential-interference microscope at up to 1000× magnification. Determination of Actinedida followed, e.g., Kazmierski (1998), Kethley (1990, and unpubl. manuscript), Khaustov (2008), Savulkina (1981), Volgin (1989), Zacharda (1978) as well as original descriptions and taxonomic generic and family reviews. However, due to lack of determination keys or unavailability of all species descriptions for some genera, not all taxa could be confidently determined to species level. As of yet, only the Actinedida from samples taken until April 2008 have been completely determined.

The number of individuals as well as of species present in each sample was summed into sampling-date averages for the total catchment area in order to assess temporal faunistic development during primary succession. Average densities were calculated and standardised

into individuals  $m^{-2}$  from the total individuals of all 27 samples per sampling date. Total species numbers were determined as sampling-date sums. In order to characterise the actinedid communities, the community composition (= species composition) and community structure (= relative proportion of each species in the total community; 'dominance' in %) was determined.

To test for significant temporal developments in the actinedid communities, the data were submitted to a variance analysis with sampling date as the main factor. Due to the non-normal distribution of soil animals, differences in the densities and species richness (as individuals and species per sample, respectively) between sampling dates were tested for significance using a non-parametric one-way ANOVA for multiple observations (= samples) per cell (= sampling date) (modified Friedman test; Zar 1999, Schöps and Russell 2004). This ANOVA is based on ranked per sample data for each sampling date and on the  $\chi^2$  rather than the F distribution. A post-hoc Tukey-like multiple comparison procedure for this non-parametric ANOVA (Zar 1999) tested for significant differences between sampling dates.

In a first step towards evaluating possible interactions with soil or vegetation parameters during temporal changes of the actinedid fauna, for each species non-parametric Spearman correlations were carried out between total individual numbers occurring in a sample and data for soil parameters of the same sample. Core-by-core soil data was available particularly for soil moisture and pH. Contents of C and N apparently did not change appreciably during this initial study period. However, slight increases were associated with developing vegetation structures – resulting in, i.e., patchy colonisation processes of protists (Wanner & Elmer, 2009). The correlations were undertaken for all sampling dates together as well as for each sampling date individually. Furthermore, correlations were carried out between species abundance and vegetation ground cover (as an indicator of ecosystem development during primary succession). However, this was only carried out for data from 2007, after vegetational succession had noticeably progressed and for which comprehensive vegetational data were available. Vegetation ground cover was estimated in categories as 0 %, 10 %, 20 % or 50 %.

### 3. Results

At all sampling dates, Actinedida represented the absolutely dominant group, often constituting more than 90 % of all microarthropods (Fig. 2). During initial development from 2005 to early 2007, only very low densities were registered ( $< 5000$  ind.  $m^{-2}$ ; Fig. 3). Distribution was very heterogeneous especially in the years 2005 and 2006, where many samples (25–50 %) contained only single individuals or no Actinedida at all. Accordingly, the variability of densities was very high, extraordinarily so in 2007, when single samples contained more than 2000 individuals, while others contained none. The number of samples with actinedid mites increased steadily from sampling date to sampling date until 2008, when numerous Actinedida were present in every sample and total variability was much lower. The increases in density were significant as of autumn 2007 ( $X^2 = 51.226$ ;  $P < 0.001$ ; Fig. 2). Although the highest average densities were found in October 2007, the statistically highest densities were recorded in April of 2008, due to very high individual numbers in only single samples in 2007 and a more homogeneous distribution among the samples in 2008.

Total species numbers were also very low (3–4 species) during initial ecosystem development (Fig. 4), with most individuals representing *Nanorchestes* sp. und *Speleorchestes* sp. (s. Appendix). Total species richness increased significantly as of October 2007

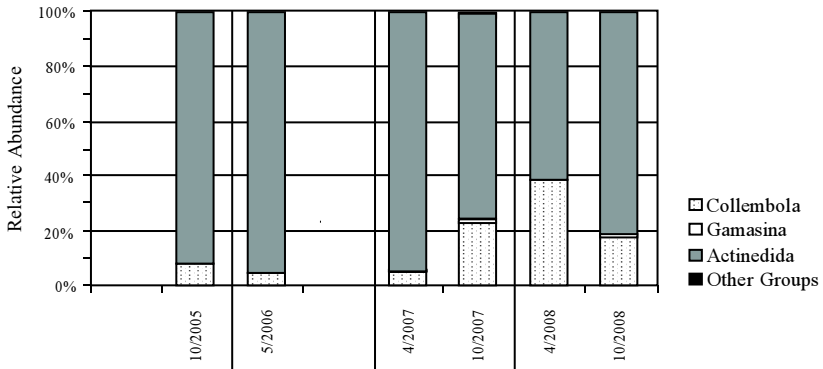


Fig. 2 Composition of the major microarthropod groups found in the experimental catchment area ‘Chicken Creek’ at the various sampling dates.

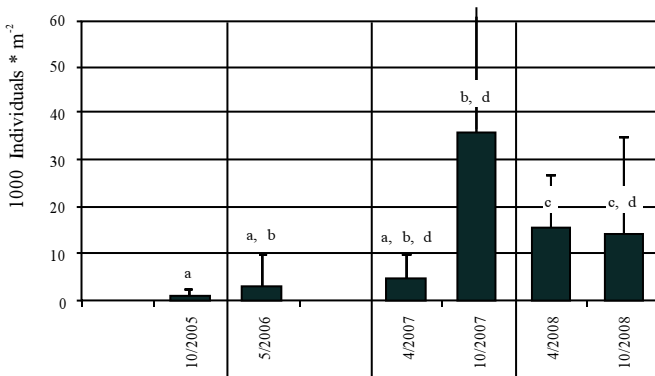


Fig. 3 Temporal development of actinidid species richness in the study site (total registered species number as well as average species number per sample + standard error at the different sampling dates). Different letters denote significantly different species richness between sampling dates.

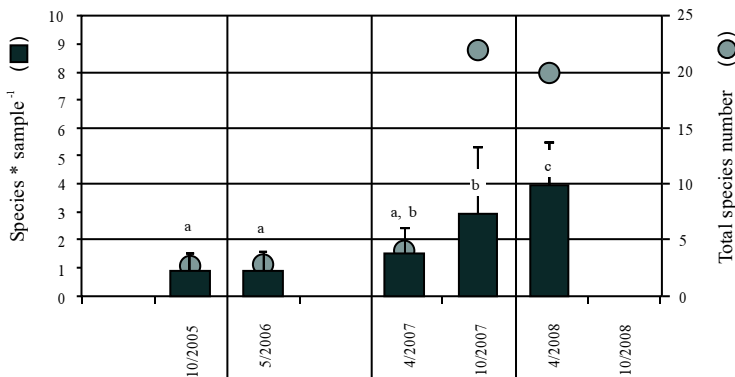


Fig. 4 Temporal development of actinidid species richness in the study site (total registered species number as well as average species number per sample + standard error at the different sampling dates). Different letters denote significantly different species richness between sampling dates.

( $Xr^2 = 60.206$ ;  $P < 0.001$ ; Fig. 4), when 23 (October 2007) and 19 different taxa (April 2008) were identified. Except for heterostigmatid taxa (i.e., *Siteroptes* sp. and *Bakerdania* sp.), most of the additional species in October 2007 were only registered as one or two individuals. The exceedingly high densities in single samples in October 2007 were mostly caused by highly individual-rich populations of *Siteroptes* sp. in these samples. This taxon was no longer registered in April 2008 (but again in October 2008, data not shown), where the populations of many other species were found to be somewhat more individual-rich.

Whereas the most common taxon, *Nanorchestes* sp., was found in only 75 % of the samples in low individual numbers in 2005, its abundance and spatial distribution (= occurrence in number of samples) increased steadily from 2005 to 2008. Its population densities were then significantly higher at each sampling date as of 2007 ( $Xr^2 = 50.994$ ;  $P < 0.001$ ) and it was found in all samples in high individual numbers in 2008. Its densities decreased briefly only in autumn 2007, dramatically in samples containing high densities of *Siteroptes* sp. Also *Speleorchestes* sp. was registered at every sampling date, albeit in very low individual numbers in 2005 and 2006 ( $< 5$ ). Its densities similarly increased significantly as of 2007 ( $Xr^2 = 40.999$ ;  $P < 0.001$ ), but also with a reduction in October 2007.

Remarkable was the occurrence of species such as *Xerophiles ereynetoidales* (2006–2008), *Cheletomimus vesus* (2007 and 2008) as well as *Hawaiieupodes thermophilus*, *Claveupodes delicatus* or Iolinidae taxa (all in Oct. 2007 and 2008). Although most were only found in few individuals, the populations of these species all increased in the later sampling dates. Especially the development of *Xerophiles ereynetoidales* was conspicuous. Found only as occasional individuals as of 2006, its density and distribution increased sharply as of October 2007 (Fig. 5). In general, with increasing species richness, the proportion of purely carnivorous species (i.e., species of Rhagidiidae, Cunaxidae, Bdellidae, Stigmaeidae, Cheyletidae) also increased. Whereby no exclusively carnivorous taxa were registered in 2005 and 2006, they accounted for  $> 25$  % of all species as of October 2007, albeit still less than 5 % of all individuals.

The changes described above did not relate to changes in soil parameters. Only soil moisture correlated with a few species (Tab. 2). However, this appears to be a statistical artefact occurring when all sampling dates are taken into account: these species increased in density only at later sampling dates, when higher soil moistures were also measured (Fig. 5). A true parallelism between species' densities and soil moisture could not be observed and no significant correlations were present at single sampling dates. Furthermore, it must be noted

Tab. 2 Spearman correlations of species' abundances and soil moisture (all sampling dates) as well as vegetation cover (data from October 2007). Only significant correlations are shown.  
\*  $P < 0.05$ ; \*\*  $P < 0.01$

Taxon	Correlation coefficient (Spearman's R) Soil moisture
<i>Alicorhagia</i> sp.	0.291**
<i>Xerophiles ereynetoidalis</i>	0.252**
<i>Speleorchestes</i> sp.	0.188*
<i>Claveupodes delicatus</i>	0.183*
<i>Tydaeolus</i> sp.	0.179*
	Ground vegetation cover
<i>Siteroptes</i> sp.	0.572**
<i>Tydeus</i> sp.	0.503**
<i>Xerophiles ereynetoidalis</i>	0.399*

that the occurrence of all these species was in cores with very low soil moistures (i.e. 2–6 %). However, three species, *Siteroptes* sp., *Tydeus* sp., and *Xerophiles ereynetoidalis*, did correlate with vegetation ground cover when the data of single sampling dates was analysed (Tab. 2). Higher densities or a more frequent occurrence were observed for these species in cores taken from areas with a higher vegetation cover (Fig. 6).

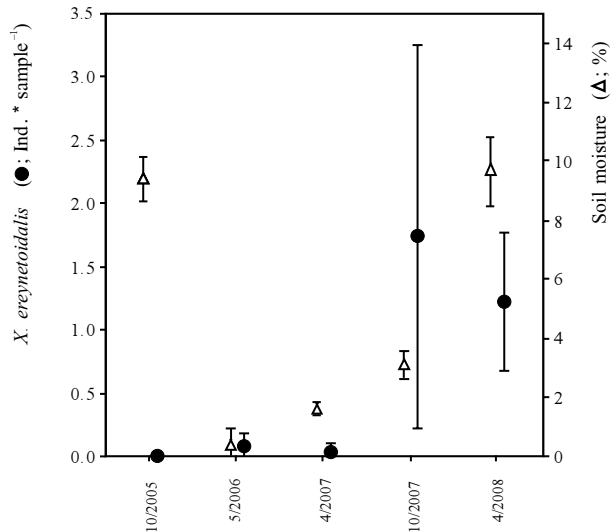


Fig. 5 Development of individual richness of *Xerophiles ereynetoidalis* and soil moisture at the different sampling dates. Although both increase with time and thus are positively correlated (see text), a strict parallelism suggestive of a causal relationship is not observable.

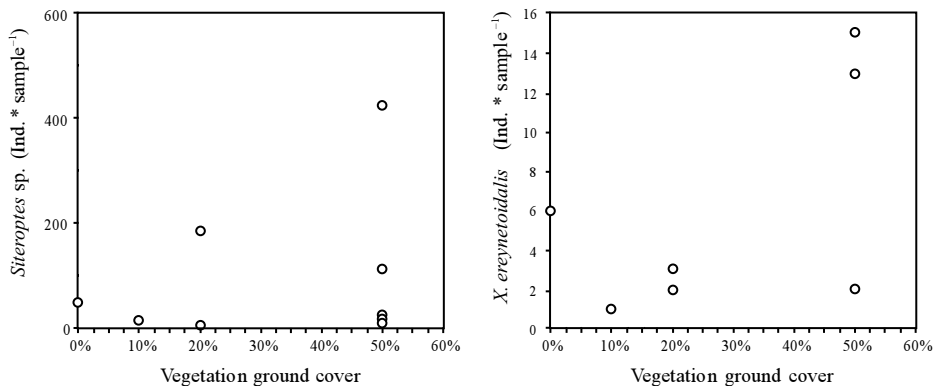


Fig. 6 Densities in individual samples of *Siteroptes* sp. and *Xerophiles ereynetoidalis* in relationship with the vegetational ground cover of the respective sample (data from October 2007). Only samples with individuals of the respective taxon are shown. Higher individual densities or more samples containing individuals were found in cores taken under higher vegetation cover.



#### 4. Discussion

It is most remarkable that one month after construction of the artificial catchment the initial substrates were already colonised by Actinedida, even if by only two major species in only few, very patchily distributed individuals. It could not be ascertained whether these species were already present in the deep sands before being transported to the surface, were anthropogenically introduced during site construction or were passively transported to the site by wind or animals. Active immigration is highly unlikely since developed soils were many kilometres distant from the study site.

The early presence of these species makes obvious that nutrient resources needed for population establishment were almost immediately available in the newly formed soils. Single-celled algae were observed in substrate samples and an individual-rich nematode fauna predominated by bacterial feeders as well as a strong development of algal-feeding tardigrades were recorded in the study site during early succession (Elmer et al., in press; Hohberg et al., in press). This is indirect proof that microbial and soil-algal communities were present early in ecosystem development and were available as faunal nutrient resources.

The two main, early colonising taxa, *Nanorchestes* sp. und *Speleorchestes* sp., are common throughout the world in sandy or newly formed soils poor in organic matter (Franco et al. 1979, Whitford & Santos 1980, Santos & Whitford 1983, Steinberger 1990, Kinnear 1991, Cepeda-Pizzaro et al. 1996) and are most likely microbivore, algivore and possibly nematophageous (Walter 1988). The study area was also colonised early by the widespread, microbivore/algivore collembolan *Mesaphorura macrochaeta* in a similarly individual-poor, patchy manner (Elmer et al., in press). Thus, in the first two years, the catchment area was only sporadically colonised by few individuals of common microarthropod species that occupy basal positions in the soil food web and are known to regularly inhabit primary soils and nutrient-poor conditions.

Throughout the first years, all of these species steadily increased their populations and distribution throughout the study site until, after 2.5 years, a 'homogeneous' distribution was attained. Their populations can thus be considered to have become established during early succession. Ufer (1993) observed recolonisation of totally defaunated agricultural soils by endogenous species to proceed via 'initial nuclei', spreading throughout a site from there. Thus, this form of colonization mechanism appears to be common among endogenous microarthropods in newly formed soils.

In late 2007, two years after site construction, individual densities and species richness increased dramatically, indicating a successional jump in the development of the actinedid communities. Data are not yet available to ascertain whether this was due to a qualitative change in the soil conditions, allowing colonisation by further actinedid species. That the few species correlating positively with vegetation cover first occurred in higher densities or at all on this date is, however, indicative of this. Alternatively or concurrently, species previously present and already finding adequate conditions increased their population size and spatial distribution throughout the site. Furthermore, the increased number of predator species observed in 2007 indicate a successional development of the trophic complexity in the communities.

The variances of the abundances were very high during early succession, due to many samples containing few individuals while some included many hundreds or even thousands. This indicates that colonisation of the soils was still very heterogeneous. This sporadic

individual-richness in October 2007 was mostly caused by strong populations of single species, e.g., the heterostigmatid species *Siteroptes* sp. and *Bakerdania* sp. These species are probably micro- and fungivore (Suski 1973, Greenslade & Cliff 2004) and can be distributed phoretically (Rack & Vercammen-Grandjean 1979, Masan 1993, Kurosa 2002), allowing strong population development if appropriate habitat and nutritional resources are found. Interestingly, *Nanorchestes* decreased dramatically at this date in samples containing high densities of *Siteroptes* sp., indicating first successional species replacement. However, especially *Siteroptes* was not found in spring of the following year (although individuals were again recorded in the following autumn; data not shown), showing that an overwintering was not yet assured and that population establishment of these species had not yet fully occurred. In 2008 *Nanorchestes* again increased in abundance, indicating an oscillation in species occurrence and population sizes during these early successional stages.

In 2008, based on reduced abundance variability and steadying species numbers, the densities and species richness of the actinedid communities apparently began to stabilise. Compared to mature soils, however, where total actinedid densities can reach 50-200,000 individuals m<sup>-2</sup> (Peterson & Luxton 1982, Curry 1994), the densities found in the 'Chicken Creek' catchment area must still be considered low. Nonetheless, the communities attained densities commonly found in sandy, nutrient-poor xerothermic habitats (1000-32,000 ind. m<sup>-2</sup>; Lussenhop 1970, Wood 1971, Edney et al. 1975, Franco et al. 1979, Steinberger et al. 1990), indicating that colonisation and succession had attained a stage common for nutrient-poor, xerothermic habitats less than three years after site initiation.

Notable was the occurrence of species such as *Cheletomimus vescus*, *Hawaiieupodes thermophilus*, *Xerophiles ereynetoides* and *Neonanorchestes ammolitoreus*, which are all rare, often xero-thermophilous species probably adapted to sandy and/or nutrient-poor soils (McDaniel & Bolen 1981, Jesionowska 2003, 2008). Almost all of these species are reported here for the first time in Germany; *C. vescus* has only been recorded in desert habitats of Iran or Pakistan (Bochkov et al. 2005). This raises important questions regarding the distribution and means of dispersal of these species. It is likely that these species are more widely distributed than presently known, but have not been recorded due to the lack of studies of Actinedida in such habitats. Although still present in low densities in the study area, the populations of these species have been steadily increasing from sampling date to sampling date, indicating population establishment also of these species. The established presence of these species – together with *Nanorchestes*, *Speleorchestes* etc. suggests an actinedid community specialised to xero-thermophilic habitat conditions already 2.5 years after ecosystem initiation.

Thus, as of October 2007, a marked development in the actinedid communities could be observed. Beyond increased densities and species richness, the proportion of purely carnivorous species also increased as of late 2007, although their populations are most likely not thoroughly established. Whereby microbivore species originally represented almost 100 % of the community, in autumn 2007 and spring 2008 (2–2.5 years after ecosystem initiation) purely predaceous species accounted for more than 25 % of the species, if still less than 1–5 % of the individuals. At this time, also the first gamasid species began to show established populations, albeit still in very low individual numbers (Elmer et al., in press). This indicates a development of the soil food web beyond basal trophic levels of micro- and algivore species, which alone were found in 2005 and 2006. This concurs with the herbaceous plant

society becoming richer and more diverse, thus providing an increasing supply of nutrient resources and niches. Nonetheless, according to the microarthropod fauna (within which Oribatida were still lacking), ‘Chicken Creek’ soil food webs in 2008 were apparently still poorly structured, species-poor and dominated by basal trophic levels (Elmer et al., in press). It is expected that, during soil succession, the food web structure should further increase from basal food webs, where only generalists can survive and reproduce, to mature food webs with a higher trophic diversity and multitrophic interactions.

A comprehensive analysis of the species of all faunal groups and their small-scale spatio-temporal distribution in relation with soil and vegetation parameters still remains to be undertaken in order to fully understand these developmental patterns. Especially in such nutrient-poor initial habitats, minor differences in vegetation, soil organic matter and the related nutritional resources can play an important role in colonisation, the population development of individual species and community assembly. As the background data become more available for the study site and the soil-faunistic studies progress, a spatial point-by-point analysis of all these factors should help understand the ecosystem interactions structuring community establishment, assembly and succession in the study area.

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**Appendix** List of the registered taxa with their observed densities (in average ind. \* m<sup>-2</sup> [rounded values]) at the different sampling dates. Dominant taxa in bold type.

	10/2005	05/2006	04/2007	10/2007	04/2008
<b>Endeostigmata</b>					
Nanorchestidae					
<b><i>Nanorchestes Topsent &amp; Trouessart, 1890 sp.</i></b>	990	3,170	3,780	1,120	12,790
<i>Neonanorchestes ammolioreus</i> McDaniel & Bolen, 1981					35
<b><i>Speleorchestes Trägårdh, 1909 sp.</i></b>	60	25	830	265	1,290
Alicorhagiidae					
<b><i>Alicorhagia Berlese, 1910 sp.</i></b>					450
<b>Prostigmata</b>					
Bdellidae					
<i>Bdella</i> Latreille, 1795 sp.					10
<i>Spinibdella</i> Thor, 1930 sp.				25	
Cunaxidae					
<i>Pseudobonzia</i> Smiley, 1975 sp.				10	10
Eupodidae					
<b><i>Claveupodes delicatus</i> Strandtmann &amp; Prasse, 1976</b>	10			10	115
<i>Cocceupodes</i> Thor, 1934 sp.					25
<i>Eupodes</i> C. L. Koch, 1835 sp.				25	25
<i>Hawaiieupodes thermophilus</i> Strandtmann & Goff, 1978				10	35
<i>Protoreunetes</i> Berlese, 1923 sp.				10	
<b><i>Xerophiles ereynetoidalis</i> Jesionowska, 2003</b>		25	10	540	380
Penthalodidae					
<i>Penthalodes ovalis</i> (Dugès, 1834)				10	
Rhagidiidae					
<i>Parallelorhagia evansi</i> Strandtmann & Prasse, 1976				10	10
Gen. II sp. juv.				10	
Iolinidae					
<i>Coccotydaeolus</i> Baker, 1965 sp.					12
<i>Tydaeolus</i> Berlese, 1910 sp.				100	90
cf. <i>Tyndareus</i> Livshitz & Kuznetsov, 1972 sp.				10	
Tydaecidae					
<i>Pseudolorryia</i> Kazmierski, 1989 sp.				10	
<i>Tydeus</i> C. L. Koch, 1835 sp.				60	
Stigmaeidae					
Gen. sp. LV				10	
Cheyletidae					
<i>Cheletomimus</i> cf. <i>vescus</i> Qayyum & Chaudhri, 1979			10	25	70
Siteroptidae					
<b><i>Siteroptes Amerling, 1861 sp.</i></b>				31,900	
Pygmephoridae					
<b><i>Bakerdania</i> Sasa, 1961 sp.</b>				1,390	25
<b><i>Brennandania</i> Sasa, 1958 sp.</b>				207	80
<i>Pediculaster</i> Vitzthum, 1931 sp.					10
Scutacaridae					
<i>Scutacarius</i> cf. <i>wasyliki</i> Mahunka, 1977				50	50
Tarsonemidae					
<i>Dendroptus</i> Kramer, 1876 sp.				25	