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Beech and spruce forest stands conditions in the area of the Moravian-Silesian Beskids and soil zoocenosis

DIPLOMA THESIS

2016/2017 Jakub Bayer

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Poděkování

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Author: Jakub Bayer

Title: Beech and spruce forest stands conditions in the area of the Moravian-Silesian Beskids and soil zoocenosis

Abstract: Soil epigeal fauna of beech and spruce forest stands had been monitored for 8 years (2007–2014) in 37 selected research area in the Moravian-Silesian Beskids. Collection of material carried out twice per year in spring and autumn aspects. Site characteristics of research localities were characterized by high variability while 4 vegetation altitudinal zones, 8 edaphic categories and 12 forest site types had been distinguished. Soil fauna was extracted by Tullgren devices. Within the monitoring, 11 target animal groups were engaged in: mites, springtails, larvae stages of ground beetles, symphylans, diplurans, proturans, centipedes and millipedes, larvae stages of rove beetles, adults of rove beetles, earthworms, larvae stages of click beetles (wireworms). Earthworm´s and wireworm´s cenosis were deterimined into species and genera, respectively. Remaing groups of soil fauna had been studied within larger systematic categories. Subsequently, abundance and dominance of the particular groups of soil epigeal fauna. The outputs had been compared each other and potential relations between particular animal groups to the specific site properties, vegetation altitudinal zones, edaphic categories and forest site types had been assessed thereby. Overall, 274 015 individuals were captured within the monitored soil animal groups. Several groups of soil cenosis were disvored specific relations to the site conditions. Additionally, 12 species of earthwomrs were distinguished while Dendrobaena octaedra seemed to be significantly dominant species representing 68,33 % of total earthworm´s species spectrum. Larvae stages of wireworms were determined into 5 genera. Representatives of Athous genera formed almost 86 % of the population of wireworms.

Keywords: abundance, earthworms, edaphic category, forest site type, the Moravian-Silesian Beskids, soil fauna, tullgren, vegetation altitudinal zone, wireworms

Autor: Jakub Bayer

Název: Půdní zoocenóza a stanovištní podmínky bukových a smrkových porostů na území Moravskoslezských Beskyd

Abstrakt: Půdní epigeická fauna bukových a smrkových porostů byla sledována po dobu 8 let (2007–2014) na 37 vybraných výzkumných plochách v Moravskoslezských Beskydech. Odběr materiálu probíhal 2x ročně v jarním a podzimním aspektu. Stanovištní podmínky výzkumných ploch byly charakteristické poměrně vysokou variabilitou, přičemž byly rozlišeny 4 vegetační stupně, 8 edafických kategorií a 12 souborů lesních typů. Půdní fauna byla extrahována prostřednictvím tullgrenů. V rámci monitoringu bylo sledováno celkově 11 cílových skupin půdní fauny: roztoči, chvostoskoci, larvy střevlíkovitých, stonoženky, vidličnatky, hmyzenky, stonožky a mnohonožky, larvální stádia drabčíků, imaga drabčíků, žížaly a larvální stádia kovaříků (drátovci). Cenóza žížal a drátovců byla determinována do druhů, respektive rodů. Ostatní cílové skupiny půdní fauny byly pozorovány v rámci vyšších systematických jednotek. Byla stanovena abundance, případně dominance jednotlivých skupin půdní epigeické fauny. Výstupy byly porovnávány a následně byly odvozovány možné vazby jednotlivých živočišných skupin na půdní prostředí, lesní vegetační stupně a soubory lesních typů. Celkově bylo odchyceno 274 015 jedinců v rámci všech sledovaných skupin půdních živočichů. Pro určité skupiny půdní fauny byly zjištěny specifické vazby na stanovištní podmínky. Bylo monitorováno 12 druhů žížal, přičemž druh *Dendrobaena octaedra* se jevil jako výrazně dominantní a tvořil 68,33 % druhového spektra žížal. Larvální stádia drátovců byly determínovány do 5 rodů. Zástupci rodu *Athous* tvořili téměř 86 % populace drátovců.

Klíčová slova: abundance, žížaly, edafická kategorie, soubor lesních typů, Moravskoslezské Beskydy, půdní fauna, tullgren, lesní vegetační stupeň, drátovci

List of Abbreviations

EC – Edaphic category

FST – Forest site type

VAZ – Vegetation altitudinal zone

K-W test – Kruskal-Wallis test

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1. Introduction

Soil organisms provide numerous ecosystem services upon which all life on Earth depends (Coleman et al., 2004). Biomass of soil fauna reaches tens and even hundreds kilograms per hectare, therefore it is an integral part of soil environment (Gryndler, 2013).

The roots of human understanding of soil biology and ecology can be traced into antiquity and probably even beyond the written word. Soil is so fundamental to human life that it has been reflected for millennia in different languages (Coleman et al., 2004). The term edaphon was officially introduced by German scientist Raoul Heinrich Francé by publishing the first title dealing with soil organism items in 1913. However, the first attempts for proceeding and reaching new knowledges about soil fauna were done by K. Diem in 1903 (Tuf, 2013).

The diversity of animal life in soil and litter is far greater than might generally be believed, and many groups frequently encountered are unfamiliar even to the trained zoologist this particularly so in the case immature forms (Gobat et al, 2004).

Thus did André et al. (1994) describe the soil fauna while deploring the lack of knowledge about soil animals, despite appereances to the contrary. The recent application of new techniques for extraction of the soil fauna shows that the systematic picture we still have today of certain groups is very incomplete, to say nothing of their functional aspects. (Gobat et al, 2004).

However, by their various capacities, animals are essential role-players in all soils of the world: macroarthropods of the litters of temperate countries, termites of tropical soils, microarthropods of peaty soils, earthworms of all climates, each group intervening in transfer of matter and energy in the soil. Relative ignorance about them is chiefly due to lack of specialists in systematics: only correct identification of organisms can enable us to proceed to the next step, that of their ecology and the role of each plays in the soil (Gobat et al. 2004).

Soil is the basic subsystem of the geobiocenosis and is significantly formed and affected by biota which the soil fauna is partially represented in. Soil and epigeic fauna biodiversity might be a tool for an assessment of disturbance scale and ecosystem stability or even a tool useful while evaluating methods and processes leading to the elimination of negative impacts, i.e. climatic changes and anthropogenic affects, to the forest ecosystems (Kula, 2009).

Indeed, it is necessary to get familiar with composition of the geobiocenosis, compounds of live nature biocenosis, that consists of the botanical elements (fythocenosis) and animal elements (zoocenosis) (Beránek, 2008). Botanical part has been researched much more detailed so far than the animal part, added Beránek.

For the further objectification of the Czech typological classification system will be required to verify biondicating importance of animal components that has not been utilized. Therefore, the aim is to identify certain animal groups which will be further available for classification of (relatively) sustainable ecological conditions according to Czech forestry typological classification system (Kula, 2009).

Soil fauna is important in terms of outstanding pedogenic functions and maintaining of biological diversity and stability of geobiocenosis. Site conditions are not stable but are influenced depending on soil, geological, climatic and ecological features being changed continuously. Detail knowledge of soil and epigeic fauna is important for cognition of the researched sites.

2. Objectives of the thesis

Complex researches and studies of soil and epigeic fauna and their relations and dependencies on sustainable ecological conditions being defined by Forest site type (FST) enable to establish the processes of selected animal group utilization for the forest stand characteristics (Kula, 2009).

The aim of this diploma thesis is to characterize selected habitat conditions (i.e. soil pH, soil type, tree layer, exposition, altitude, vegetation altitudinal zone, forest site type, volume of selected nutrients within the soil etc.) significantly affecting soil environment and local soil invertebrate animal individuals participating in pedogenic processes (Collembola, Lumbricidae) or acting as the pets of root plant system (especially larvae of Elateridae family) in the selected researched spots of the Moravian-Silesian Beskids.

Next aim is to describe the representation of individual animal groups in the level of larger systematic categories (i.e. Acari, Collembola, Diplura, Protura, Symphyla, Elateridae and larvae stages of selected Coleoptera) in a relation to the habitat conditions in beech and spruce forest stands and to the forest altitudinal zones and forest site types, eventually.

Moreover, the thesis was engaged in expressing the possible relation between abundances of particular animal groups and the conditions of specific forest sites.

The diploma thesis focuses on more detailed evaluation of Lumbricidae and Elateridae (in larvae stages) cenosis. Additionally, the relations between cenosis of Lumbricidae and Elateridae to the site conditions of researched localities were studied in the part of the diploma thesis.

3. Literature overview

3.1. Current cognition of the Moravian-Silesian Beskids

The character of invertebrate fauna is conditioned by many factors. The area of Beskids is situated on the boundary with the Bohemic massif. Moravian-Silesian Beskids are almost fully afforested and involve many altitudinal zones and forest types. Fauna is not only the result of long-terming development but also the natural environment changes and under human being influences. The negative impacts are presented mainly by soil acidification and damages of forest stands in higher altitudes, predominantly in beech-fir stands and dwarf spruce stands with limited occurrence nowadays (Kula, 2009).

Forest geobiocenosis of Beskids mountains present outstanding area for invertebrate fauna, especially in consideration of relatively high stability of the forest stands conditions despite the local imission impact that have negatively influenced certain local forest locations (Kula, 2009). Kula was additionally deploring the lack of data about soil and epigeic fauna and mentioning the local fauna inadequately described and researched.

The initial researches of geobioceniss in the area of the Moravian-Silesian Beskids, Smrk peak, respectively had been carried out in 1952. Mr. A. Zlatník and Pelíšek had been working as leaders of research duration until 1955. In 1964, the revision of geobiocenosis mapping was done by J. Togner and M. Santora. Mr. Satora and Král had been revising local geobiocenosis mapping since 1973 to 1974 (Holuša, 2001).

The most detailed described group of invertebrate animals of Beskids is represented by Carabidae family (Stanovský and Pulpán, 2006). However, Heteroptera suborder, Curculionidae family, Staphylinidae family, Sylphidae family, Lumbricidae family and Psocoptera order had been studied and monitored too in the area of Beskids mountains (Boháč, Roháčová, 2001, Holuša, 2001, Kula, 2009).

3.2. Roles of soil fauna in soil environment

1. Soil formation and maitenance of soil structure

2. Decomposition and nutrient release

3. Biological control and beneficial effets

4. As petsts

1. Soil formation and maitenance of structure

Soil animals directly and indirectly affect the transport of organic and inorganic materials within and between soil systems. Feeding and burrowing activities of larger soil invertebrates, such as earthworms and termites, substantially mix organic matter and mineral particles and modify the physical properties of soil, which in turn affects water balance in soil, water infiltration rates, and the production of water-stable aggregates. Insect larvae, collembola, millipedes, and mites feed directly on decomposing leafy or woody vegetation, shred the plant fragments and reorganize humic and fine mineral material into dicrete pellets, vhich help develop microstructrure in soil (Chesworth, 2008).

2. Decomposition and nutrient cycling

The importance of soil fauna in decomposition and nutrient cycyling has been the subject of extensive reserach, and has been reviewed by many scientists, i. e. Seastedt (1984), Lavelle (1997) and van der Putten (2002). Ecosystem studies demonstrate that 40 to 90 % of net primary productivity is metabolized by decomposers. Some small soil animals, particularly mites and collembola, stimulate and control fungal growth in soil environment. In addition, they stimulate microbial activity by supplying nutrients in their feces and urine. These facts affect the rate of decomposition and thus nutrient content in soil which have positive effect on plant growth (Chesworth, 2008).

3. Biocontrol and beneficial effects

The beneficial effects of soil animals are multiple, but few have been quantified, although more than 90 % of pest insects have a stage in soil, potentially the object of biocontrol. Mites and collembola that feed on bacteria and fungi carry beneficial fungal and bacterial iniculum to roots, and they can do this through sterile soil. Many soil arhtropods are nematophagous and are potential biocontrol agents for plant parasitic nematodes. In future it should be feasible to manipulate nonphytophagous soil fauna and fungal biocontrol agents for optimum protection of plants from root pests, including nematodes and insects. In general, soil fauna has a positive impact on plant productivity (Chesworth, 2008).

Earthworms have been introduced into soils for their beneficial effects on soil structure. For example, in the Netherlands they were introduced into reclaimed polder to ameliorate wrowing conditions, and in New Zealand they were introduced into grassland to iprove its productivity (Paoletti, 1999).

4. Pests

Soil animals can have detrimental effects on the soil system in various ways. For example, Collembola individuals may injure germinationg of seeds and seedling roots of some specific plant species. Larvae stages of Elateridae have negavive impacts on root system of the tree species but even harm in agriculture while damaging crops (Chesworth, 2008).

3.3. Soil fauna distribution

1. According to the activities and distribution in soil

a) Epigeics fauna – process organic matter on or near to the soil surface
b) Endogeics fauna – live in the mineral part of soil and feed on humus
c) Anecics fauna – transfer materials between the soil and litter habitats (Abott, Murphy, 2007)

2. According to the body size

a) Microfauna – body size less than 0,2 mm (Protozoa)
b) Mesofauna – body size in interval 0,2–4 mm (i.e. Collembola, Acari)
c) Macrofauna – body size over 4 mm (i.e. Lumbricidae, Coleoptera) (Coleman et al., 2004)

3.4. Characteristics of selected animal groups

3.4.1. Acari

The soil mites, Acari are the most abundant microarthropods in many types of soils. In rich forest soil, a 100g sample extracted on a Tullgren funnel may contain as many as 500 mites representing almost 100 genera. This much diversity includes participants in three or more trophic leves and varied strategies for feeding and reproduction. Identification of mites to the family level is a sklil readily learned under the tutelage of an acarologist Expert assistance is necessary for identifications of soil mites to genus or species (Coleman et al., 2004).

Four suborders of mites occur frequently insoils: the Oribatei, the Prostigmata, the Mesostigmata, and the Astigmata. Among the four mige groups, the oribatids are the characteristic mites of the soil and are usually fungivorous, detrivorous, or both. Mesostigmatid mites are nearly all predators on other small fauna, although some few species are fungivores and these may become numerous in some situations. Acarid mites are found associated with rich, decomposing nitrogen sources and are seldom abundant except in agricultural soils. The prostigmata contains a broad diversity of mites with a variety of feeding habits and strategies. Very little is known of the niches or ecological requirements of most soil mite species. Mites play significant roles as consumers of plant pathogenic fungi. In ecosystems where most primary productivity occurs below ground, where nematode biomas sis high in root rhizospheres, nematophagous arthropods (including mites) could be significant predators of plant-feeding nematodes (Coleman et al., 2004).

3.4.2. Collembola

Collembolans are very tiny animals included in microarthropods with worldwide distribution They occur in all biomes, from tropic to arctic and from forest to grassland and desert and throughout the soil profile (Coleman et al., 2004). Collembola animal group is formed by very tiny or tiny animals with high variation of its sclerotization and pigmentation (Křístek, Urban, 2013). Collembolans have the common name of „springtails“ from the fact that many of the species are able to jump due to the special apparatus in the bottom of the abdomenal part of theirs body. They are very densely represented in soil environment, thus the abundance may reach 100 000 Collembola individuals per square meter. They occur throught the upper soil profile, where their major diet appears to be fungi associated with decaying vegetation. In the rhizosphere, they are often the most numerous of the microarthropods. Deeper parts the Collembolans are dwelling, the lack of pigmentation they have (Coleman et al., 2004). They are cosmopolitan, very well resistant against soil changes or their food spectrum is veryvaried and contain tiny soil animals, detritus and dead plant bodies or pollen fluctuations (Nosek, 1954).

3.4.3. Protura

Proturans are small, wingless, primitive insects readily recognized by their lack of antennaea and eyes. Seldom as numerous as the other microarthropods, proturans occur in a variety of soils worldwide, often associated with plant roots and litter (Coleman et al., 2004). The length of their body ranges from 0,5 to 2,5 mm (Tuf, 2013). Numbers reported in the literature range between 1000 and 7000 individuals per square meter. They penetrate the soil to surprising depths (25 cm), considering that they do not appear to be adopted for burrowing. Their feeding habits remain unknown. Observations that they feed on myccorhizae have not been verified according to Sturm´s observations (Coleman et al., 2004).

3.4.4. Diplura

Diplurans are small, elongate, delicate, primitive insects. They have long antennae and two abdominal cerci. They occur in tropical and temperate soils in low densities. Their population reaches approximately 50 individuals per square meter (Coleman et al., 2004). Length of the body varies from 2 to 5 mm (Tuf, 2013). They have long antennae with 10 or more segments projecting forward from the head and pair of cerci projecting backward from abdomen. Diplurans are common rather in moist soil, leaf litter or humus. They feed on dead organic matter predominantly (Ferguson, 1990a).

3.4.5. Symphyla

Symphylids are small, white, eyeless, elongate many–legged invertebrates, 2–10 mm long, that resemble tiny centipedes. They differ from centipedes in several characteristics, but superficially symphylids have 12 body segments and 12 pairs of legs, whereas centipedes have at least 15 pairs of legs, the first pair modified as fangs (Coleman et al., 2004). They can move rapidly through the pores between soil particles, and are typically found from the surface down to a depth of about 50 cm. They are omnivorous and can feed on the soft tissues of plants or animals (Edward, 1959). Some species act as pests in agriculture soils where they feed on roots of seedlings (Coleman et al., 2004). Some species of Symphyla cause damages even in forestry by feeding on seeedlings and root system of plants (Tuf, 2013).

3.4.6. Diplopoda

Millipedes are a group of widely distributed saprophages. They are major consumers of organic debris in temperate and tropical hardwood forests, where they feed on dead plant materials (Coleman et al., 2004). In the Czech Republic, about 80 species of Diplopoda have been monitored so far. Their body length ranges from 1 to 2 cm. In some cases, millipedes can feed on root systems of seedlings and thus act as pest in forest ecosystems. Millipedes are dependent on moisture while their prefer mositure soil (Tuf, 2013). Moreover, Coleman et al., 2014 add that millipedes become abundant in calcium rich soils. They have a calcareous exoskeleton, and because of their high densities they can be a significant sink for calcium. Indeed, they are major consumers of fallen leaf litter and may process some 15–25 % of calcium input into hardwood forest floors (Coleman, 2004).

3.4.7. Chilopoda

Centipedes are common predators in soil and litter. They are elongate, flattened with normal body length of 1,5–2 cm, but sometimes, according to Shelley, 2002, the length of Chilopoda´s bodies can exceed 30 cm. Indeed, our local Chilopoda species are rather long with body length about 3,5 cm in case of our common species *Lithobius forficatus* (Tuf, 2013). Some of them, euedaphic species mainly prey on earthworms and Diptera larvae stages. Like the millipedes, centipedes lose water through their cutiles at low relative humidities, therefore they seek moist habitats (Coleman et al., 2004). Millipedes and centipedes are supposed to be found suitable soil animals groups for quality evaluation of certain biotops (Kula, 2009).

3.4.8. Carabidae

Carabidae families represent an important predatory epigeal part of soil fauna that contributes to support the stability of forest geobiocenosis. The importance of Carabidae family is considerable in forest ecosystems (Hůrka, Farkač, Veselý, 1996). They feed on various species of invertebrate communities. They serve as a model groups of soil animals for many ecological studies (Butterfield, 1995).

Species of Carabidae family react very sensitively on toxic substance treatment (insecticides, herbicides). Many of ground beetles are affected by pH and moisture diversions in soil environment. Thus, they can be utilized as bioindicators of these soil environmental changes (Coleman et al., 2004). The abundance of ground beetle was assumed about 13 000–27 000 individuals per 10 hectares and 1–50 individuals in case of tiny Carabidae species.

Most known carabid larvae are terrestrial. Most of larvae are carnivorous, feeding on other insects and small invertebrates, often earthworms. Summer larvae are much shorter-lived, occuring in the first instar in April, May or June, and reaching the pupal stage by June, July or August of the same year. Winter larvae must survive food shortage, low temperatures and exposure to natural enemies. In general, species of shaded habitats such as forests are often autumn breeders with higher occurrence of larvae stages (Luff, 1993).

3.4.9. Staphylinidae

The rove beetles are a family of beetles, primarily distinguished by their short elytra (wing covers) extending the half of their abdomens (Boháč, Matějíček, Rous, in press). Sizes range from <1 to 35 mm, with most time in the 2–8 range, and the form is generally elogated. Their diets include just about averything excepth the living tissues (Křístek, Urban, 2013).

Almost all larvae are elongate and campodeiform, their antennae with three or four articles. Adults and larvae occur in leaf litter, decaying fruits, moss, and under bark of dead trees. Staphylindae are bionomically a very heterogeneous group occuring virutally in all types of terestric habitats. A considerable part of Staphylinidae (about 20 % species of our fauna) can be characterizes as mycetophagous or saprophagous. Smaller part of Staphylinidae (about 10 % species of our fauna) may be characterized as phytophagous or myrmecophilous.

Main abiotic and biotic factors influencing the structure of communities of Staphylinidae in central European cultural landscape are given (moisture, vegetation cover, temperature, geological substrate, dispersion abilities, predation and competition). This allows a better interpretation of ecological research of the communities of Staphylinidae. The spectrum of life forms of imago Staphylinidae indicates a variety of ecological characteristics environment and anthropogenic interference of the habitats and landscape. Higher number of life form occur in semi natural habitats less effected by man. Moreover, Staphylinidae rather occupy soils with non-acid character (Boháč, 1999).

3.4.10. Elateridae

The body is more or less convex, elongate or ovoid, often oblong, wide or flat. The length of European species is quite various. The colour is mostly inconspicuous, of dark, occasionally yellow, red and orange. The body surface is almost always punctate. The head is usually of the prognathous type (mouth parts projecting anteriorly), less often hypognathous (mouth parts projecting downwards), convex or flat. Eleven or rarely seemingly twelve-segmented antennae are inserted in front of the eyes (Laibner, 2000). They are called as „click beetle“ because of their specific click mechanism. A spine on the prosternum can be snapped into a corresponding notch on the mesosternum, producing a violent "click" that can bounce the beetle into the air. Clicking is mainly used to avoid predation, although it is also useful when the beetle is on its back and needs to right itself (Tuf, 2013).

The larvae is oligopodous (wire-worm type), cylindrical, usually light yellow to dark brown, sometimes green, composed of 13 segments. The head is prognathous, equipped with a strongly sclerotized case and three antennomeres behind which there may be small larval eyes (stemmata), that, however, are often absent. Larvae has three pairs of legs typically ended by a claw. The ninth segment, the rearmost, is pointed in larvae of Agriotes, Dalopius and Melanotus, but is bifid due to a so-called caudal notch in (formerly Ctenicera, Limonius, Hypnoides and Athous species (Laibner, 2000).

Most European Elateridae inhabit forest and forest-steppe formations, however many species also occur in open habitats including agricultural areas. Individual species are encountered in all altitudes including the alpine zone. Adults live two of four weeks and are agile either on on warm sunny days or in the evening, or rarely at night. Most often they occur on herbs, bushes, trees, under bark, in tree hollows, under stones, in detritus or in gravel. They feed on pollen, nectar, flower parts, buds or young plants (Laibner, 2013). Adults winter living out individuals appear in April or May normally. Since second decade of May females oviposit 100–200 eggs to the soil substrate. The development of juvenile stages is conditioned by sufficient of soil moisture (Tuf, 2013). The cycle from the egg to the adult takes from two to four years. The egg first takes in water and enlarges up to 1,5 times. The embryonic stage lasts three to five weeks. The hatched larvae briefly feed on yolk before switching to their normal food, and by the end of the growing season they reach 3 to 6 mm in length. Sometimes the larvae hibernate as deep as 50 cm (Laibner, 2000).

Significance of click beetles

From the economic standopoint, most species are inconsequantial. Larva of a few species prey on some forest pests and can be considered useful, e.g. *Athous subfuscus.* In the Czech Republic and Slovakia there is a group of approximately 15 species whose larvae (wire-worms) can unfavourably affect crops and root systems of some tree species in silvicuture. They attack radicles and young roots, thus preventing germination or causing weakness of the plant, or they bore into potato tubers and beets and so contribute to the spread of fungal, viral and bacterial diseases. Most affected are cereals, maize and root crops. Four to five wire-worms per square metre can cause as much as 5 % damage and if more than 15 wire-worms the damages are considered to be serious. In forest cultures, expecially nurseries, they damage seeds and seedlings; *Ectinus aterrimus* also damages acorns and beechnuts (Laibner, 2000).

3.4.11. Lumbricidae

Monitoring and study of Lumbricidae family has long-term tradition while the first study of earthworms in the Czech Republic area was published in 1874 by Mr. Vejdovský. Further, Mr. Černosvitov performed detailed studies of Lumbridae family in 30s of last century. Mr. Ivo Zajonc enriched the infomations about Eartworm´s occurrence in the area of Moravia and specific places in Bohemia. In 70s of 20th century, earthwomrs had been researched by Ms. Mikulová and Houšková (Pižl, 2002). Recently, RNDr. Václav Pižl, CSc. acts as the most important researcher of Lumbricidae family within the whole area of the Czech Republic (Kula, 2011).

Ecology of earthworms

Lumbricidae members are saprophagous animals representing the most important community of soil macrofouna (soil invertebrates of body size over 10 mm). Several species of earthworm may occupy a freshwater ecosystem or above-ground parts of terrestrial ecosystems (Pižl, 2002).

The main resource of nourishment for eartworm species consits of organic matter of plants and animals occasionally. In term of food preferences earthworms are distinguished in two groups – detritophagous (feeding on plant residuals, fecal matter of mammals, appearing nearby soil surface) and geophagous (devouring huge amount of soil matter and digesting contained organic remains and microflora, penetrating throught to upper parts of soil to the lower ones). The most important requirements of earthworms in case of site conditions is enough and quality of food sources, adequate moisture and tepmerature, soil reactions and soil testure (Pižl, 2002). Due to the limited locomotion properties of earthworms, their occurrence and total abundance are conditioned by food suitability. Earthworms are considerated to be sensitive in case of sudden and long-term changes of soil environmental properties. In case of serious lack of nourish resources, the total absence of earthworm individuals may occur inthere. Conversely, abundance of earthworm is supposed to be very high in case of sufficient organic matter in soil (Edward, Bohlen, 1996).

Earthworm´s classification according the way of life:

1**) Deep-living** (anectic) – occuring in lower parts of soil. Anectic earthworms create huge, up to 3 m long systems of deep corridors in soil. Due to the lack of the nourish resources in low soil parts, they excavate the vertical corrdirs which are terminated in to soil surface. Anectic earthworms are typical for the night activity while they search for the litter being retracted into soil corridors. Corridors are stiffened by their own fecals, therefore they are much more resistant against the destruction (Tuf, 2013). Deep-living group of earthworms is typically represented by *Lumbricus terrestris* and *Aporrectodea longa* etc. Those species of Lumbricidae are rahter long, dark colour in front and dorsal part of the body (Römbke, Jänsch, Didden, 2005). Anectic species are slower than epigeic species but are able to hide into soil corridors very nimbly (Pižl, 2002). They face low predation pressure because they occur in low parts of soil in the corridors (Römbke, Jänsch, Didden, 2005). They participate in formation of mull type of humus form. The corridor systems in soil improve the soil aeration and rooting of plants and infiltration of soil (Tuf, 2013).

2) **Living in litter layer on the soil surface** (epigeic) – *Dendrobaena octaedra, Dendrodrillus rubidus, Lubricus rubellus* can be classifed in epigeic form of earthworms. Epigeic species do not build the corridor system in soil (Römbke, Jänsch, Didden, 2005). They feed on partially decomposed organic remains on soil surface (Pižl, 2002). Epigeic species are rather small, red coloured, typically agile in locomotions with short life cycle. Due to the surface occurrence, they are forced to resist strong predating pressure (Römbke, Jänsch, Didden, 2005).

3) **Subsurface living** (endogeic) – form specific horizontal (unstable) corridors below the soil surface, often without any connection with soil surface (Pižl, 2002). Endogeic species of earthworms occupy the mineral soil within profile of 10–15 cm. Following Lumbricidae species are included: *Aporrectodea caliginosa, Octolasion lacteum* etc. Pigmenation is very weak in case of endogeic species, therefore the colour of their body is usually white. The locomotion is very slow and lenght of life cycle is medium (Römbke, Jänsch, Didden, 2005). They feed on organic materials with an admixture of mineral soil. They face medium predation pressure (Pižl, 2002).

Soil environmental requirements and population influencing factors of earthworms

1. **Soil moisture**

Considerable part of earthworm´s body is composed from water (75–95%). Earthworm´s respiration is performed by the body surface respiration and nitrogen elements are released in form of urea. Therefore, soil moisture is very important for the occurrence of earthworms. The optimal moisture conditions in soil environment are given by 40–60 % of maximal water capacity of soil (Pižl, 2002). Majority of earthworm species are well-adapted for a water surplus in soil. For example Octolasion tytraeum and Eiseniella tetraedra present typical species with predomination in very moist soils (Luthart et al., 2006). The situation in floodplain forest is little bit different - the occurrence and survival of earthworms is limited by the sufficient of oxygen and UV radiation (Pižl, 2002).

2. **Temperature**

Optimal temperature for earthworm´s development ranges from 10 to 15°C (15–20°C in case of epigeic species). In general, the most important is the combination of temperature and moisture. It is known, that more moisture conditions are the higher temperatures can earthworms resist. Limiting temperature is 0°C while the soil is getting frost (Pižl, 2002).

3. Soil reactions

Majority of earthworm species are neutrophilous but the optimal soil reaction varies from pH 6–7. Many of species tolerate acidic soil environment. Certain species are dwelling very acidic soil (pH approximately 3) or alkaline soils (pH over 8).

Earthworms can be distinguished according to the tolerance range against acidic soil environment:

a) Acid-tolerant- appear in soil with low pH capacity (3–5); *Dendrobaena octaedra, Dendrobaena Attemsi, Dendrobaena vejdovskyi, Allolobophora eiseni*

b) Tolerant – appear in soil with pH capacity (5–7); *Lumbricus rubellus, Octolasion lacteum*

c) Acid-intolerant – they do not either appear in acidic soils, or their occurrence is limited; *Allolobophora hrabei* (Pižl, 2002).

4. Soil texture

Population of Lumbricidae is also influenced by soil texture. Most of Lumbricidae species prefer fine soils with clay or sand admixture. The occurrence in rocky soils or pure sand soils is limited because of the possibility of soil drying. Abundance of earthworms is negligent in the soils with high content of loam and floodplain forest soils due to the anaerobic conditions inthere (lack of oxygen) (Pižl, 2002).

5. Other factors

Content of nitrogen is considered as one of the main factor influencing population of earthworms (Hendrix et al., 1992). Abundance of Lumbricidae family is positively affected by increasing volume of microbial biomass which is dependent on C:N ratio (Lee, 1985).

Vegetation cover can also affect the population of earthworms while the reduction of site vegetation leads to drop of suitable food resources (Zaler, Arnone, 1999).

Natural enemies present the next influencing item in case of earthworm population. We can distinguish various earthworm predators, the most common are represented by birds, frogs, moles from vertebrates and ground beetles, ants and centipedes from invertebrates (Kula, 2011).

Earthworm´s effects on soil and soil fertility

Importance of earthworm´s on pedogenesis, soil structure, decomposition of organic matter and nutrient cycling has been monitored since Darwin´s times. Nowadays, earthworms are sometimes called as the „ecosystem´s ingeneers" because they can rebuild the environment by their activities and processes (Pižl, 2002).

One of the earthworm´s benefits consist of complex organic compounds conversion the simple form capable for plants (Kula, 2011). They influenced the soil environment by excrement production where the mineral elements are mixed in with decayed organic remains and microflora. In local conditions, it was found that earthworms produce 40–50 tons of excrements within 1 hectare of soil, it is adequate to 4–5 cm thick layer (Pižl, 2002).

Earthworms as the bioindicators of natural environment

Earthworms are considered as the sensitive indicators of anthropogenic stress factors, especially chemical features. They were utilized while pesticides indication (Edward, Böhlen, 1996), heavy metals (Carter, Heinonen, Linder, 1982), physics properties – compactness, soil hydrology (Pižl, 2002). Decline of earthworm´s occurence indicates dererioration of local soil environmental properties (Eisenhauer, 2010). The relations among earthowrms and deterioration within soil properties had been monitored in several studies. Earthworm´s decreasing abundance is affected by heavy metals, whereas earthworms may be absent in case of serious heavy metal effecting. Several Lumbricidae species had been identified as very sensitve under heavy metals influencing – *Aporectodea rosea, Allolobophora chlorotica, Lumbricus rubellus, Lumbricus terrestris* (Spurgeon, Sandifer, Hopkin, 1996). In general, earthworms are supposed to be appropriate organisms for soil environmental conditions evaluating and soil contamination eventually (Christensen, Mather, 1994).

Characteristics of monitored Lumbricidae species within research area

Allolobophora eiseni – epigeic species with 3–6 cm of body lenght, red-violet coloured. This species occupies mainly deciduous forests, pure beech stands or floodplain forests.

This species is considered as acid-tolerant species with occurence in the Šumava mountains and the Beskids mountains (Pižl, 2002).

Aporrectode rosea – subsurface living species, body lenght reaches from 2,5 to 15 cm, pink colour, neutrophilous, acid-tolerant. Extension of this species is various – occupy distinct types of ecosystems. The highest abudances reaches in mixed forest, floodplain forests and meadows. It is cosmopolitan species extended in the whole area of the Czech Republic (Pižl, 2002).

Dendrobaena attemsi – epigeic species, body length 2,2–7 cm, pink or brown-red coloured. This species occupies different types of forests; decidous forest or spruce forest stands. It is acid-tolerant species with its extension in the Krkonoše mountains and the Šumava moutains predominantly (Pižl, 2002).

Dendrobaena octaedra – epigeic species with body length 1,5–6 cm, red-violet colouring. This is euryoecious species with occurence in almost all types of ecosystems (coniferous and deciduous forests, meadows, all types of agro-ecosystems). *D. octaedra* is considered as the most frequent species of Lumbricidae family in acid soils and peats. It can be found mainly in surface litter. This cosmopolitan species is classified in acid-tolerant species with its occurence in distinct ecosystems of the Czech Republic (Pižl, 2002).

Dendrodrilus rubidus – epigeic species, 3,5–6 cm long, red-brown coloured. This species is cosmopolitan with occurence in the distinct ecosystems within the Czech Republic area (Pižl, 2002).

Dendrodrilus rubidus tenuis – epigeic species, 1,5–6 cm long, red or red-brown colour. This is acid-tolerant species with preference of acid forest stands. It occupies all types of ecosystems, therefore is being considered as cosmopolitan species (Pižl, 2002).

Eisenia lucens – length of body ranges from 4,5 to 18 cm. *E. lucens* has typical „tiger“ colouring with significant dark (red-brown) transverse stripes in the middle of every body segment. I tis epigeic species living in surfaces layers composed of deciduous litter or coniferous litter. This species prefers loamy soils with high content of moisture. *E. lucens* individuals are typical for the ability of bioluminiscence. This species is extended in Krkonoše mountains and the Beskids mountains (Pižl, 2002).

Eiseniella tetraedra tetraedra – 3–6 cm long, brown-green coloured. This species is able to live in terrestrial or water environment. It can be found in the bottom of water resources, under the stones and mostly in moist sandy or loamy soils. It is cosmopolitan species extended in the whole area of the Czech Republic (Pižl, 2002).

Lumbricus rubellus – 6–15 cm long, red-violet coloured, epigeic species occuring in the distinct types of ecosystems. It is acid-tolerant species. *L. rubellus* is cospomolitan species and belong between the most common species in the Czech Republic (Pižl, 2002).

Octolasion lacteum – endogeic species with body length of 2,5–18 cm, white or slightly yelllow coloured. This species has wide ecological amplitude while it can be found mostly in loamy and sandy soils. I tis cosmpolitan species with occurence in the whole area of the Czech Republic (Pižl, 2002).

Octolasion tytraeum – endogeic species, 2,2–16 cm long, white coloured, in front part of body brown coloured. In comparison with morfologically related species *Octolasion lacteum*, this species occupies water influenced localities predominantly. This species can be monitored in distinct places with required conditions (Pižl, 2002).

3.5. Characteristics of represented vegetation altitudinal zones

4th - Beech zone (*Fagus sylvatiaca*)

Climatic characteristics: mean annual temperature 6,0 to 6,5°C; mean annual precipitation 700 to 800 mm; growing season 140 to 150 days. This zone, represnting the climatic optimum for *Fagus sylvatica*. *Quercus petraea* and *Abies alba* may be minor associates in the lower tree layer. Beech zone covers 5,7 % of the forested area in Czech Republic (Viewegh, 2013).

5th - Fir–Beech zone (*Abies alba–Fagus sylvatica*)

Climatic characteristics: mean annual temperature 5,5 to 6,0°C; mean annual precipitation 800 to 900 mm; growing season 130 to 140 days. Depending on local conditions, either *Fagus sylvatica* or *Abies alba* are dominant species in forests stands, while *Quercus petraea* agg. is absent. Abies alba occurs more frequently on fine-textured soils and ridges where beech litter does not accumulate. Conversely, habitats with beech litter accumulation and hence with compacted forest floor are more suitable for *Fagus sylvatica.* Also present, albeit to a much greater extent than in the past, is *Picea abies* who reaches a production optimum in the Fir–Beech zone. Throughout the zone, *Fagus* *sylvatica* is accompanied by several Fir–Beech zone covers 30 % of the forested area in Czech Republic (Viewegh, 2013).

6th - Spruce–Beech zone (*Picea abies–Fagus sylvatica*)

Climatic characteristics: mean annual temperature 4,5 to 5,5°C; mean annual precipitation 900 to 1,050 mm; growing season 115 to 130 days. Three dominant tree species, i.e. *Fagus sylvatica, Abies alba*, and *Picea abies,* are referred to as a 'hercynian mixture'. *Fagus sylvatica*, however, does not occur on water-surplus sites. Several understory species considered to be companions of *Picea abies* occur sporadically the in herb layer, such as *Prenanthes purpurea* (ascended from relatively wetter sites in the Fir–Beech zone and yet wetter in the Beech zone to relatively drier sites in this zone), Spruce–Beech zone covers 12 % of the forested area in Czech Republic (Viewegh, 2013).

7th - Spruce zone (*Picea abies*)

According to Plíva (1987), spruce vegetation altitudinal zone can be characterized by altitude gradient 900–1050 m a.s.l., average annual temperature 4,0–4,5°C, total annual precipitations scale 1050–1200 mm and length of vegetation zone 100–115 days. The dominant species become norway spruce (*Picea abies*) while beech (*Fagus sylvatica*) is rather found in understorey (Průša, 2001). Spruce zone covers 5 % of the forested area in Czech Republic (Viewegh, 2013).

3.6. Characteristics of represented edaphic categories

In case of edaphic categories, eight different edaphic categories had been monitored within the research area; A, B, F, L, O, O/R, S and Y edafic categories.

A - stony-colluvial

Category „A" is a transition to nutrient group with high content of stones or rocky elements in whole soil profile. Stony category is typical in steep terrains, ridges and occasionally in trenches. Soil type is undeveloped browns soil, rankers or rendzindas. Tree species compositon is rather poor (Průša, 2001). This EC is transient to F EC (Viewegh, 2013).

B – nutrient rich

Rich edaphic category is an initial category of nutrient group of edaphic categories. This category is characterised by rich or medium-rich mineral bedrock, non-exposed terrains (without any steep slopes). The soils are resisted against soil erosion and degradation. Forest stands are highly endangered by wind. Furhhermore, from 5th vegetation altitudinal zones, forests stands are threatened by snow cover, in lower elevetation by rots. Weed threaten rises up even if low lightening through forest stand. Main forest function is management, than infiltration function (Plíva, 1987).

F – slope-stony soils with ferns in the herb layer

Hillside edaphic category is typical for an unique occurence of high fern species, i.e. *Driopteris fillix mas*, *Athyrium filix femina* and *Athyrium distentifolium* in higher elevations. Ridge of the mountains, below slope trenchces (deluvium), sites with steep terrains. The sites of hillside category have favourable humidity properties but limited processes of humification. Soils are not well developed brown soils and occasionally rankers are found (Plíva, 1987).

L – alluvial soils of floodplains

Floodplain category is characterized by typical floodplain communities. Alluvial soils are monitored predominantly with semigleys or gleys. This edaphic cathegory can be climaticaly contioned by average annual temperature 8–9°C. Total precipitation ranges 500–600 mm. Management functions is performed by lowland floodplain areas. Production is higher than average, main proble causes agressive weed (Plíva, 1987).

O – nutrient-medium stagned soils

Is a transient cathegory distinguishing from pure pseudogley cathegory which is typical for changing of soil humidity. Grass community with dominance of *Calamagrostis arundinacea* is very common (Plíva, 1987).

O/R – gley-peat transitional

Gley-peat edaphic cathery include two subcathegories; poorer – R and medium-rich +R. Tree species composition of peat poorer subcathegory ivolve spurce, pine and dwarf pine (*Pinus mugo*) in the highest elevations. Soil type is oligotrophic peat or gley of peat type. In the dwarf stands mosses are dispered (Plíva, 1987).

S - nutrient-medium

Nutrient-medium, sometimes identified as „fresh“ is a transational category between nutrient-rich and acidic categories. This EC is characterized by brown soils and moder form of humus with loamy soils in the highest elevations (Plíva, 1987).

Y – skeletal

Skeletal category is spread mostly in mountain areas with low weathering ability of bedrock. Protected forests can be found with slighthly deep, acidic, boulder soils or antropenic heaps where the dwarf species are missing. The stands are rather opened than dense (Plíva, 1987).

3.7. Characteristics of represented forest site types

FST code	Latine title	Extension	Geology	Soil	Natural tree species composition	Target tree species composition	Risks
4S	*Fagetum mesotrophicum*	slopes, ravines	different type of bedrock, aluminum overlay	deep, fresh	beech 8, fir 2	spruce 7, bk2, md1, oak,fir	negligible
4Y	*Fagetum saxatile*	mountains areas, steep terrains	rocky soils, rather dry	boulder, slightly dry, moderately deep	beech 6, oak 2, fir 1, (pine, birch)1	pine 7, beech 3, spruce , (beech 10)	serious erossions, degratation, soil dessication
5A	*Acereto-Fagetum lapidosum*	highlands or lower altitudes, mountain ridges, moderate slopes	Rich or middle rich bedrock (soil)	fresh and moist, middle deep or deep, hight content of rocky elements, well-humused	beech 5, fir 3, spruce 1, acer 1	spruce 5, fir 2, beech 2, acer 1	serious erossions, agressive weed
5B	*Abieto-Fagetum trophicum*	from highlands to mountain areas, slopes but also tablelands	rather rich bedrock	moist, permeable, deep, slightly gravelly	beech 6, fir 4, acer	spruce 4, fir 2, beech 4	agressive weed, snow cover, rootstock due strong winds
5F	*Abieto-Fagetum lapidosum mesotrophicum*	rocky slopes in mountains, ridges, highlands	different, middle rich	hight content of stones or even boulders	beech 6, fir 4, acer, elm	beech 6, fir 4, acer, elm	winds, weed, snow cover, serious erossions
5L	*Fraxineto-Alnetum montanum*	from highlands to mountain areas	different, middle rich	influenced by water	alder predominatly	alder predominatly	waterlogging
5S	*Abieto-Fagetum mesotrophicum*	from highlands to lower mountain areas, slope shaped, ravines	different bedrock	deep, fresh, good aeration	fir 5, beech 5, acer	spruce 7, fir1, beech2	wind, snow cover predominantly , weed
5Y	*Abieto-Fagetum saxatile*	highlands, lower mountain areas, boulder slopes, rocky protrusions	undeveloped soil, rocky protrusions in surface	partly developed or undeveloped	beech 7, fir 2, birch 1, pine, spruce	spruce 5, beech 3, fir 1, birch 1	serious erossions, snow cover, degradation of soil
6O	*Piceeto-Abietum variohumidum trophicum*	highlands, without steepness, tablelands	different bedrock, aluminum overlays	deep, clay in lower parts	beech 2, fir 5, spruce 3	spruce 7, fir 3, beech	wind, snow cover, waterlogging, weed
6O/R	*Piceeto-Abietum variohumidum trophicum/Piceetum turfosum mesotrophicum*	highlands, mountains, spring area	water influenced soils	high ground water level (0,3 - 0,5m), in basement of peat with thickness of 50 cm	spruce 10, jd, ol	spruce 10, (alder, fir)	serious waterlogging, wind, agressive weeed, frost, snow cover
6S	*Piceeto-Fagetum mesotrophicum*	highlands, mountain areas, slopes, ridges, ravines	different bedrock	deep, permeable	spruce 3, bk4, jd3	spruce 7, fir 2, beech 1	wind and snow cover predominantly , weed
7S	*Fageto-Piceetum mesotrophicum*	mainly in mountain areas, slopes	different bedrock	deep, permeable	spruce 7, bk2, jd1, kl	spruce 8, fir 1, beech 1	wind, tootfish predominantly , weed

(Viewegh,2013)

4. Description of researched area

Indeed, all the information for a general description of researched are of the diploma thesis had been gathered from the forest management plan of Ostrava-Opava bishopric forest management unit (forest management unit Ostravice in past).

4.1. Localization

Area of interest is found in the east-northern parts of Moravia in central part of the Moravian-Silesian Beskids. The locality is part of the Natural Forest Area no. 41 called Moravian-Silesian Beskids and belongs to the cadastre of Čeladná village and Frýdek-Místek district.

4.2. Orographic conditions

Western part of the area is occupied mainly by Smrk massif (1276 m a.s.l.) while Kněhyně massif dominates in eastern part (1257 m a.s.l.). These massifs form Radhošť ridge that is located by the right sight of river Ostravice. The average altitude reaches 702 m a.s.l. and the average slope of the terrain achieves 16°.

4.3. Hydrologic conditions

Local area is dewatered by Ostravice river which belongs to Odra basin and Baltic sea drainage area. Northern part of the area is dewatered by Bílá Ostravice stream, and the western part is dewatered by Čeladenka stream. Furhtermore, Šance dam is situated in target area.

4.4. Geologic and pedologic conditions

Bedrock of the Moravian-Silesian Beskids is formed mainly by claystone, sandstone and conglomerates. These sedimentary bedrocks layer in line-shaped formations. Local landscape is very structurally composed.

In case of soil type, cabisols are found as the most obvious soil type in local area with percentage values of 86 %. Podsosl, psudogleys, fluvisols, rankers and gleys are represented additionally.

4.5. Climatic conditions

The differentiation of climatic conditions in the monitored area is given by high variability of relief segmentation and significant difference of the altitudes. The higher elevations the higher content of snow cover and precipitations, therefore. The content of snow cover in higher elevation might reach 16 % of the whole annual precipitation scale. However, an important role in case of increasing of water balance, have horizontal precipitations (fogs), especially in higher elevations. Horizontal precipitations might increase water balance even by 15 %.

Important local climatic facts:

Average annual temperature: 2,3–7,2 °C

Average annual precipitations: 1000–1565 mm

Average air temperature within vegetation period: 10–13 °C

Average precipitations within vegetation period: 700–900 mm

Duration of vegetation period: 100–140 days

Average annual amount of summer days: 10–40 days

Annual amount of days with snow cover per year: 80–160 days

Average thickness of snow cover: 35–120 cm

In model area of the Moravian-Silesian mountains, some of the target plots are involved in Nature Reserve (NR) area – NR Smrk, NR Bučačí potok, NR Studenčany and NR V Podolánkách. In summary, 7 partial spots from total amount of 37 spots are situated in Nature Reserve area (see Tab.1).

5. Methodology

5.1. Selection of researched localities

The aim of the selection of researched localities was to incorporate maximal available spectrum of meso-climatic conditions in the area of Smrk and Kněhyně massifs in Moravian-Silesian Beskids mountains. Therefore, the proposed net of researched spots consists of elevation gradient, reaching 540 to 1200 m.a.s.l. Several types of soil can be found there – oligobasic soils (cryptopodsols, podsols) or even eu-mesobasic soils (cambisoils, rankers). In the location of interest, the soils are characterized by different hydromorphic properties - the soils with permanently affected by water (organosoils) and other soil types without any water influences. Indeed, the geomorphologic features and terrain expositions with two different forest habitat types (beech and spruce) of distinguish age structure, are located in the area of interest (Kula, 2009).

5.2. Soil samples collection

The collection of soils samples in the area of interest in beech and spruce forest stands in Moravian-Silesian Beskids mountains had been lasting for 8 years, since 2007 to 2014, respectively. Researched area is occupied by Smrk and Kněhyně massifs in the area of Čeladenka stream in Podolánky village. Soil sample collections had been carried out in regular intervals within 37 researched plots (4 sample spots in every selected forest stand). Selected researched plots are represented by 4 various altitudinal zones while the elevation gradient is 670 meters in total with the highest point 1210 m a.s.l. and the lowest situated point with elevation of 540 m.a.s.l. In the case of forest site types, the monitored area of Beskids mnt. Is characterized by 12 different forest site types (FST) and 8 edaphic categories (see Tab.3).

From the tree species composition point of view, the researched plots may be classified by 2 dominant composition species, beech and spruce. Spruce forest stands included 26 localities from the total amount of 37 while beech forest stands involved remaining 11 localities.

Annually, two soil sampling activities had been accomplished regularly, while the first sampling was carried out in spring aspect (April – June) and the second one was performed in autumn aspect (September – November). Only the exception was in 2007 when only one soil sampling activity was done in autumn aspect.

Each of the soil samples was taken from the soil as a compact block with identic diameters 25 x 25 x 15 cm by spade. Removed soil sample was placed to polyethylene bag with for transport purposes. Inside the polyethylene bag was inserted label with an appropriate indication items (number of forest stand and soil spot) in order to prevent any sample exchanges. All the collected soil samples were transported to the cellar of Mendel University where they had been stored for further extraction. Storing processes were limited by 24 hours since the soil sample was taken from the soil because of a possibility of evaporation.

Indeed, Tullgren method was used for the extraction of soil organisms from soil samples.

5.3. Tullgren device

Tullgren, also known as Berles´s extractor, is considered as one of the most effective method for extraction of invertebrate animal organisms from soil samples in general (Anderson et al., 2013).

Tullgren is a specific device consisting of these components: cover with a source of thermal energy (bulb), adapted plastic container of cone shape (bucket with released bottom) with 10 dm^3 volume, wire net with partial diameters, collecting plastic bowl with the content of formaldehyde (0,5% concentration).

5.4. Tullgren processes of extraction

The principle of Tullgren method is based on a hydrotaxion an positive geotrophism (Kula, 2009).

Soil sample is placed on wire net with spots dimensions of 25 mm x 25 mm. Wire net is anchored into the plastic bucket approximately 10 cm from the bottom. Plastic bucket is enclosed by the cover where the thermal energy source is placed (60W bulb). Thermal radiation is produced by a bulb and the soil sample is getting dried from the upper parts to the lower parts of soil profile. Therefore, the soil organisms are forced to migrate from the upper (dried) parts to the lower parts of soil sample where a humid concentration is higher. As far as the whole profile of soil simple is dried, the soil organisms are finally leave from the soil – they are extracted in a fixing solution of formaldehyde with 0,5% concentration for the further detailed elaboration.

5.5. Tulgren processing

Tulgren extraction had been lasting for 3 or 4 weeks depending on drying process of the soil samples. Extracted soil organism had ben conserved in 75% ethanol solution as long as the soil fauna is sorted out in laboratory. Moreover, each of the extracted samples was identified by special label with following data: method, area of collection, number of locality, number of soil spot, date of collection (e.g. TULL-Beskydy-38/1-26.04.2014).

5.6. Sorting out of extracted soil organisms

Sorting out and treating of soil samples (organisms) had been performed in the entomologic laboratory of Mendel University via luminary microscope. Before sorting out of soil samples, It was supposed to study all the characteristic properties of each animal group that had been monitored. Initial sorting out of soil samples had been carried out with an assistance of diploma thesis supervisor in order to prevent any sampling mistake. Following groups of soil animals had been monitored within sorting out processes: Staphylindae and it larvae stages (wireworms), Elateridae and its larvae stages, Carabidae and its larvae stages, Protura, Symphyla, Diplura, Araneae, Acari, Collembola and Lumbricidae. These mentioned animal groups of soil fauna had been classified into larger systematic categories, except of Elateridae larvae (wireforms) and Lumbricidae individuals that had been determined in appropriate genera. Exact determination of Lumbricidae family was done by Ing. Petr Švarc.

Moreover, larvae stages of Elateridae family had been determined in detailed taxonomic categories, genera, respectively. Classification of wireworms was performed for within one year (2014) of the research duration, in both, spring and also autumn aspect. Determination of wireworms was done according to the Dolin V. G., 1978 dealing with determining signs of Elateridae larvae and also according the previous determinations of wireworms within the research.

Larvae stages of Elateridae had been also measured by digital caliper with accuracy 0,01 cm of accuracy and were subsequently classifed in 3 size categories:

A category: 0,40–0,90 cm

B category: 0,91–1,40 cm

C category: > 1,40 cm

The abundance of target animal groups was asses within soil samples processing and further, the values of abundance of each animal groups were written in the recording sheets from which the final database was made from.

5.7. Database forming

Final summary database was created in Microsoft Excel 2010. The recording sheets consisting of the abundance of each target animal group were transformed into the electronic (pc) form. The evaluation and summarization of partial abundance values was performed by contingency tables functions.

5.8. Soil analysis

Soil analysis had been carried out individually on each of the represented forest site. Soil analysis were done by doc. Mgr. Aleši Bajerovi, Ph.D. Soil analysis consisted of pH/KCl, volume of Ca^{2+}, Mg^{2+}, K^{+}, Al^{3+}. According to the specific volume of individual elements, soils had been classified in accordance with classification tables for the evaluation of forest soil quality by Šály 1978, Rejšek 1999, Sáňka, Materna 2004 (see Tab.2).

5.9. Statisitcal evalutation of results, charts formation

Parameters of the research experiment and results were subject to statistical analysis at the level of significance ($\alpha=0.05$) in the STATISTICA 12 software (StatSoft, Inc.; www.statsoft.cz). Taking into account the result of Shapiro-Wilk´s test of normality and value of p ($p<0,05$) parameter, it was decided about non-parametric statistical surveys for further processing of statistical analysis. Normal distribution of data was refused based on quantile quantile plot analysis.

In the rest of the statistical investigation, a non-parametric method (the Kruskal-Wallis test hereafter K-W test and Dunn´s test) was applied. All figures and charts were generated by STATISTICA 12 as well by 2D mean charts with confidence interval of „box“ type utilization.

In case of wireforms (Elateridae larvae stages) and Lumbricidae statistical evaluation, principal component analysis (PCA) was used in order to provide the general overview for displaying partial relations within evaluating components.

The objective of this analysis is to reduce the original number of described variables by new quantities (artificial) marked as components that summarize the information on original variables at the cost of minimal information loss. These components are mutually independent and they are arranged according to their contribution to explaining the total dispersion of observed variables (Hendl, 2006).

The principal components analysis can be understood as a linear transformation of the original dependent variables into new uncorrelated variables called principal components. The basic characteristic of each principal component is its level of variability – in other words dispersion.Principal components are arranged according to their importance, so according to decreasing dispersion. The most of the information on the variability of original data concentrates in the first component, the least is in the last component (Hendl, 2006).

5.10. Calculations

Abundance – defines the density of any community. Abundance is a scale expressing the numbers of individuals of all species populations occupying unit of area or unit of volume. Accuracy of abundance assessment depends on representative composition of collection localities in monitored biotope. Value of abundance can be expressed in absolute values (real number) or in relative values (indexes, percentages, etc.).

Abundance was calculated for each of the soil sample however the values had to be recalculated in average abundance for partial FAL, FST, EC, etc.

Calculation of one sample plot area (SSP= 25x25 = 625 cm^2).

Dominance – is the percentage representation in population. Dominance is influenced by amount of species in zoocenosis while the value of dominance is decreasing in accordance with increasing number of present species (Laštůvka, 2000).

Calculation of dominance:

$$D = \frac{n_i}{n} * 100 \ (\%),$$

Description of formula:

ni – number of specific species individuals

n – number of all the individuals within zoocenosis

Tishler´s (1949) classification of dominance assessment was used for dominance evaluation of earthworms:

Eudominant species > 10 %

Dominant species 5–10 %

Subdominant species 2–5 %

Recedent species 1–2 %

Subrecedent species < 1 %

6. Results

Soil founa of the target territory of the Beskids Mountains had been monitored since 2007 to 2014. Totally, 274 015 individuals were recorded within the whole spectrum of target animal groups. I tis necessary to mention, that detailed classification of specific monitored soil animal is very complicated or even impossible (springatails, mites), therefore the target soil animal groups are determined in the level of larger systematic categories (except of earthwomrs, Lumbricidae members and larva stages of Elateridae family).

In initial phase of monitoring, 20 animal groups had been dealt with in the diploma thesis. Some animal groups were represented in very low density or their monitoring had been engaged in distinct researches, thus the final target animal group composition was reduced in 10 animal groups; Collembola, Carabidae(larvae stages), Diptura, Elateridae (larvae stages), Chilopoda + Diplopoda, Lumbricidae, Protura, Symphyla, Staphylinidae (adults), Staphylinidae (larvae stages).

While comparing partial initial research plots, it was found, that the most significant deviations and differences were found in locality no (O/R EC). 23. First of all, it should be noted, that this locality is very specific and its characteristcs (soil and environmental) differ from the other localities included in research. The locality is considered to be azonal, however the evaluation of this locality was included in statistical analysis and other further evaluation

6.1. Acari

Tullgren´s extraction found the Acari being the second most represented animal group with total record of 107 414 individuals. However, it should be noted, that final abundance of acari would be affected by the method of Tullgren and also by the size of soil samples. Several inexactnesses in acari evaluation may occured due to the high abundance of mites and also while extracting the soil samples. Abundance of mites was higher in forest stands with spruce dominance (889 ex.m^2) than beech dominance (711 ex.m^2).

In case of vegetation altitudinal zones, there was releaved no statictically significant diversity based on Kruskal-Waliss test: H (3, N=2056)=6,317364; p=0,177 evaluation. Average abundance is quite equally distributed with no serious deviations. The values of abundance among partial vegatation altitudinal zones ranges from 882 ex.m^2 (spruce VAZ) to 737 ex.m^2 (spruce-beech VAZ) (see Fig.1a).

KW test: H (7, N=2056)=36,24826; p=0,000) displayed the presence of statistical differences among partial edaphic categories while the most distinct category was O/R category. Taking in consideration the average abundace of mites, this category was found as the poorest one with total average abundance of 405 ex.m^2. The Dunn´s test (p<0,022) proved a statistically significant differences in these paires of edaphic cathegories (except of O/R): YxB, YxF while EC Y indentified the highest average abundance (1073 ex.m^2) (see Fig.1b).

Statistical evaluation of mite´s abundance in represented forest site types displayed the statistically important deviations by K-W test: H(11, N=2056)=49,31495; p=0,000). Absolutely lowest value of average abundance was investigated in 6O/R (405 ex.m^2), therefore this forest site type differ predominantly. By the subsequent multiple comparison test (Dunn´s test p<0,034), it was confirmed that average abundance of mites statistically differ between the FST 5Sx5B and 5Sx5F. Population of mites was the most abundant in 4Y and 5Y where the values of average abundance exceeded level of 1000 ex.m^2 (see Fig.1c).

Abundance of mites was different also in case of pH/KCl evaluation (K-W test: H (2,N=2056)=8,388835; p=0,015). The highest average abundance was found out in A pH/KCl category (960 ex.m^2). Devation in abundance within remaining categories B and C was rather negligent (43 ex.m^2) (see Fig.1d).

In case of reaction of mites on Ca^{2+}, K-W test: H(2, N=2056)=3,882439; p=0,144) did not find out any statistically significant differences. Therefore, content of Ca^{2+} was not taken into accoun in he following investigation (see Fig.1e).

Kruskal-Wallis test: H(2, N=2056)=0,5401235; p=0,763) did not recognize statistically significant deviations within Mg^{2+} evaluation in realation to the abundances. However, according to the Fig.1f) we can observe that mite´s abundance is slightly decreasing with increasing content of magnesium.

K-W test: H(2, N=2056)=4,925253; p=0,085) did not indicate any statistically important differences in accordance to K^+. Average abundance of mites varies from 892 ex.m^2 (B category) to 740 ex. ex.m^2 (C category) (see Fig.1g).

6.2. Collembola

Community of springtails was evaluated as the most numerous group of target soil animals with total amount of 120 370 individuals. At the beggining of sprintail´s evaluation, one important fact must be mentioned. Tullgren extraction method and size of soil samples could negatively affected final accuracy in evaluations of abundances. Several inaccuracies might been carried out while extraction via Tullgren devices or while laboratory processing of soil samples. Neverthless, its evaluation has the substantiation because of the unique method of soil fauna monitoring.

Hihger abundance was monitored in forest stands witch dominance of spruce (971 ex.m^2) than beech (856 ex.m^2).

Stastically significant differences among the springtail´s abundance within represented vegetation altitudinal zoneswere not determined by K-W test: H(3, N=2056)=2,374824; p=0,498. Average abundance distribution refered minor differences through the VAZ. Values of average abundance varied from 966 ex.m^2 (fir-beech VAZ) to 864 ex.m^2 (beech VAZ) (see Fig.2a).

Statistically significant differences had been releaved by K-W test: H(7, N=2056)=30,65870; p=0,001 while evaluating abundance within represented edaphic categories. Dunn´s test (p<0,044) found O/R category as the most statistically distinct with the lowest abundance counting 481 ex.m^2. Except of O/R, significant deviation was monitored between FxY edaphic categories. Average abundance exceeded level of 1000 individuals per square meter at skeletal (Y) edaphic category (1135 ex.m^2), gley medium-rich (O) edaphic category (1094 ex.m^2) and stony (A) edaphic category (1059 ex.m^2). Abundance at remaing edaphic categories varies between 918 and 798 ex.m^2 (see Fig.2b).

Significant differences within represented forest forest site types were determined statistically by K-W test: H(11, N=2056)=42,08333; p=0,000. Only azonal site coded by 6O/R was shown different according to Dunn´s test (p<0,011) evulation while there was monitored the lowest average abundance (481 ex.m^2). In general, the values of abundance seemed to be relatively balanced (see Fig.2c).

K-W test: H(2, N=2056)=6,763467); p=0,034 proved statistically significant differences in case of springtail´s reaction connected to pH/KCl changes. However no relevant trend was found out while the average abundance was highest within A pH/KCl category (1073 ex.m^2) and lowest in B category (872 ex.m^2) (see Fig.2d).

Statistical evaluation based on K-W test: H(2, N=2056)=1,489164; p=0,475 did not confirm statistically important deviations in relation between springail´s abundance and distinct Ca^{2+} conditions. Anyway, the Fig.2e) show rather decreasing trend with increasing content of Ca^{2+} in soil.

Mg^{2+} concetration and abundance of Collembolans did not prove important statistically significant differences based on K-W test: H(2, N=2056)=0,0937688; p= 0,954 result. Average abundances were almost equal in A and B categories (958, 969 ex.m^2) (see Fig.2f).

Similar results were found out in case of conncection between abundances and K^+. K-W test: H(2, N=2056)=5,6611891; p=0,590 did not traced out any statistically significant deviations (Fig.2g).

6.3. Carabidae larvae

Overall, 5148 larvae of Carabidae family had been monitored. Greater abundance was found out in spruce forest stands (46 ex.m^2) than in beech stands (26 ex.m^2).

Abundance of larvae stages of Carabidae family was statically different by K-W test: H(3, N=2056)=13,36784; p=0,004 evaluation within vegetation altitudinal zones. Moreover, Dunn´s test (p<0,010) releaved differences between beech and fir-beech VAZ. According to the Fig.3a) we can distinguish decline of average abundance with increasing altitude. Beech VAZ demonstrated the highest abundance (63 ex.m^2).

In case of partial edaphic categories, statistically significant differences were indetified by K-W test: H(7, N=2056)=54,22797; p=0,000). The lowest abundances had been found out in O (24 ex.m^2) and O/R (14 ex.m^2) edaphic categories and the highest ones in L (61 ex.m^2) and Y (57 ex.m^2) (see Fig.3b). Dunn´s test (p<0,032) showed significant deviations between Y and A, B, F, O, O/R categories, also between S and B edaphic categories. Moreover, O and O/R categories were the most different in additional comparison of Dunn´s analyse.

K-W test: H(11, N=2056)=60,73193; p=0,000) proved statistically significant distinctions while evaluating average abundance of ground beetles larvae stages in correlation to forest site types. Dunn´s test (p<0,041) releaved 4Y and 5Y FST as the most different comparing with remaining FST. The highest average abundance was clearly monitored in 4Y FST with 93 ex.m^2 while the lowest abundance was in 6O/R (14 ex.m^2) (see Fig.3c).

Taking in consideration correlation between pH/KCl categories and values of abundance, statistically significant deviations were confirmed by K-W test: H(2, N=2056)=12,24033; p=0,002 assessment. According to the Fig.3d) we can observe declining trend of abundances with increasing pH/KCl values.

Abundance of Carabidae larvae stages did not significinatly differ in connection with represented intervals of Ca^{2+} content, K-W test: H(2, N=2056)=1,512902; p=0,469. Therefore, it was not submitted for further ivestigation (see Fig.3e).

No relevant correlation was detected in case of Mg^{2+} content despite the fact, that K-W test: H(2, N=2056)=22,57230; p=0,000 investigated significant differences. Average abundaces fluctuated through the selected categories of Mg^{2+} content (see Fig.3f).

Similar result was achieved while evaluating abundances with K^- content. Further investigations had been rejected on te basis of result of K-W test: H(2, N=2056)=3,884329; p=0,143. Average abundaces fluctuated through the selected categories of K^+ content (see Fig.3g).

6.4. Symphyla

This group of soil animals belong among the most common species of soil animals while the total amount of Symphyla individuals counts 14297 individuals. It was the third most represented animal group within the whole animal group spectrum. Average abundance in forest stands with dominance of spruce was brightly higher (116 ex.m^2) than average abundance in beech stands (99 ex.m^2).

Statistical evaluation of abundance did not identify any significant differences among the represented vegetation altitudinal zones; K-W test: H(3, N=2056)=6,803788; p=0,784. The hightest average abundance was monitored in 7^{th} VAZ (127 ex.m^2) and the lowest one was in 6^{th} VAZ (93 ex.m^2) (see Fig.4a).

K-W test: $H(7, N=2056)=41,19390$; $p=0,000$ registered statistically important distinctions within evaluation of Symphyla´s abundance in connection to edaphic categories. Distribution of abundance within EC was very unequal. Dunn´s test ($p<0,032$) proved statistical differences while edaphic category Y seemed to be distinct from F and A EC. Moreover, EC O/R had a lowest average abundance (58 ex.m^2) and was the most distinct in statistical comparison. The highest average abundance was monitored within Y edaphic category (174 ex.m^2) (see Fig.4b).

Significant deviations were found out in case of forest site types evaluation on the basis of K-W test: $H(11, N=2056)=57,11294$; $p=0,000$. By the subsequent multiple comparison test (Dunn´s test: $p<0,017$), it was confirmed that abundances within FST differ mostly in 5Y which had clearly refered the highest number of average abundance (197 ex.m^2). This code of FST was distinct from 5A, 4S, 6S, 5F, 5L and 6O/R. In general, distribution of particular abundances within FST releaved irregular fluctuations (see Fig.4c).

Statistically significant differences had been proved by K-W test $H(2, N=2056)=15,08379$; $p=0,001$ within evaluation of pH/KCl. Despite this fact, no relevant relation between abundances and pH/KCl changes had been found out. In general, average abundance was the highest in B category (104 ex.m^2), similar abundances were monitored in A and C pH/KCl categories (124 ex.m^2, 123 ex.m^2) (see Fig.4d).

Abundance of Symphyla did not significinatly differ in connection with represented intervals of Ca^{2+} content, K-W test: $H(2, N=2056)=0,5928217$; $p=0,744$. However, we can distinguish that average abundances are gradually increasing with increasing content of Ca^{2+} while the highest abundances was in C^{2+} category (137 ex.m^2) (see Fig.4e).

K-W test: $H(2, N=2056)=10,28204$ proved statistically significant differences among the represented Mg^{2+} categories and the abundances. According to the Fig.4f) we can see irregular distribution of abundances; A 115 ex.m^2, B 91 ex.m^2, C 121 ex.m^2.

Statistical analysis based on K-W test: $H(2, N=2056)=2,424427$; $p=0,298$ did not releave any important deviations in case of K^+ evaluation. The average abundances were almost equal with negligent (1 ex.m^2) differences within represented K^+ classes (see Fig.4g).

6.5. Diplura

Total number of monitored Diplurans counted 3901 individuals. Average abundance in forest stands with dominance of spruce was higher (32 ex.m^2) than average abundance in beech stands (25 ex.m^2).

In case of vegetation altitudinal zones, K-W test: H(3, N=2056)=1,399151; p=0,796 did not found out any statistically significant differences. Average abundance of Symphyla animal group reached from 33 ex.m^2 (fir-beech VAZ) to 23 ex.m^2 (spruce VAZ) (see Fig.5a).

K-W test: H(7, N=2056)=29,96616; p=0,001 detected statistically significant differences among the represented edaphic categories and average abundances of Diplurans. On the basis of Dunn´s test (p<0,021) we can distinguish deviations between Y EC x F and O/R EC. The highest values of average abundances were monitored in B (47 ex.m^2) and Y (44 ex.m^2) EC. Taking in cosideration remaining values of abundances (expect of O/R), there were no significant deviations (see Fig.5b).

Statistically important distinctions had been observed within evaluation of particular forest site types and abundances by K-W test: H(11, N=2056)=33,88184; p=0,000. Dunn´s test (p<0,003) proved significant differences between 5Y and 5F. In general, distribution of abundance in case of FST releaved fluctuations in abundances (see Fig.5c).

Statistically significant differences had been proved by K-W test H(2, N=2056)=18,02232; p=0,000 within evaluation of pH/KCl in relation to abundance of Diplurans. The highest average abundance was monitored in A pH/KCl category (41 ex.m^2). Values of abundances in B and C category had been almost the same (deviation of 2 individuals per square meter) (see Fig.5d).

Statistical analysis did not releaved existence of a statistically significant difference in relation to Ca^{2+} and particular abundances; K-W test: H(2, N=2056)=4,572779; p=0,102. According to the chart of Ca^{2+} evaluation we can see decreasing trend in connection to increasing content of Ca^{2+} in soil (see Fig.5e).

In case of Mg^{2+}, statistical evaluation based on K-W test: H(2, N=2056)=5,177609; p=0,075 did not found out any significant differences. Therefore, further investigation was not enegaged in (see Fig.5f).

Statistical analysis releaved existence of a statistically significant difference in relation to K^- and particular abundances; K-W test: H(2, N=2056)=10,23163; p=0,006. Dunn´s test (p<0,042) found out A category being statistically distinct comparing to B and C within K^+ classification groups. Abundances of Diplurans was decreasing with increasing content of K^+ in soil environment (see Fig.5g).

6.6. Protura

In total, 3352 individuals of Protura family had been trapped within soil fauna research. The average abundance was slightly higher in beech forest stands (27 ex.m^2) than spruce stands (26 ex.m^2).

K-W test: H(3, N=2056)=12,23074; p=0,007 found out statistically significant deviations in abundance within the vegetation altitudinal zones. Despite, no eminent relations were identifed due to the irregular fluctuations within particular abundances in VAZ (see Fig.6a).

Important statistical differences were proved by K-W test: H(7, N=2056)=39,45893; p=0,000 while analysing average abundance in particular edaphic categories. The highest average abundance was in skeletal category (49 ex.m^2) and this EC was identifed as a most distinct by Dunn´s test evaluation (p<0,027). Y EC was staticially distinct from F, L, O, O/R and S EC. Low average abundances were in L (15 ex.m^2), O (14 ex.m^2) and O/R (12 ex.m^2) EC (see fig.6b).

Statistical analysis releaved existence of a statistically significant difference in relation to forest site types and particular abundances of Proturans; K-W test: H(11, N=2056)=49,16070; p=0,000. Dunn´s test confirmed that only 5Y is statically distinct in comparison with remaing FST while the distinctions were monitored between 5Yx6O, 6S, 6O/R. The highest value of average abundance was in 5Y (53 ex.m^2) (see Fig.6c).

K-W test: H(2, N=2056)=4,593741; p=0,100 did not suggested any significant differences in case of pH/KCl evaluation in relation to average abundance of Proturans. According to the Fig.6d) we can the greatest number in case of C pH/KCl category with total average abundance consisted of 36 ex.m^2.

Similar situation was observed in case of statistical analysis within Ca^{2+}categories and abundances. K-W test: H(2, N=2056)=1,1044416; p=0,576 did not revealed any important differentiations among the abundances. Average abundances did not suggest serious devaitons in case of A and B Ca^{2+} categories (26, 22 ex.m^2) but C category was clearly represented by the highest average abundance (36 ex.m^2) (see Fig.6e).

While evaluating abundance in particular Mg^{2+} categories, no statistically significant differences had been found out by K-W test: H(2, N=2056)=1,565683; p=0,925. Average abundances were fluctuating without any relevant relation (see Fig.6f).

K-W test : H(2, N=2056)=8,406985; p=0,015 identified deviations in relation between abundances of Proturans and distinct K^+ categories with no implying binding. Average abundances had irregular character throughout statistical analysis (see Fig.6g).

6.7. Chilopoda, Diplopoda

It was captured totally 3216 individuals of Chilopoda and Diplopoda. Higher abundance was monitored within beech forest stands (26 ex.m^2) than spruce stands (23 ex.m^2).

K-W test: H(3, N=2056)=55,96884; p=0,00 releaved statistically significant differences among the abundances and particular vegetation altitudinal zones. Dunn´s test (p<0,027) identified deviations between all the represented VAZ. As we can see in the Fig.7a), the highest abundances had been figured out within 4th VAZ (21 ex.m^2) and 5th VAZ (27 ex.m^2). Thereafter, average abundances were descending while the lowest abundance was in 7th VAZ (13 ex.m^2).

Statistically imporant differences were found out within average evaluation in relation to edaphic categories by K-W test: H(7, N=2056)=29,29957; p=0,001. Average abundances were relatively equally distributed within particular EC and its values range from 31 ex.m^2 (Y, B) to 21 ex.m^2 (O). Dunn´s test (p<0,035) found O/R edaphic category out of normality with average abundance of 8 ex.m^2 (see Fig.7b).

Statistically significant differences were releaved by K-W test: H(11, N=2056)=74,19184; p=0,000 while evaluating average abundance of millipedes and centipedes within particular FST. Cosequently, Dunn´s test (p<0,039) found out statistical deviations predominantly in 6O/R and 7S while in these FST were the poorest populations. The highest abundance was monitored in 5Y (35 ex.m^2) (see Fig.7c).

K-W test: $H(2, N=2056)=4,593741$; $p=0,287$ did not suggested any significant differences in case of pH/KCl evaluation in relation to average abundance of Chilopoda and Diplopoda. We can see negligent deviations of abundaces among particular pH/KCl categories (see Fig.7d).

Significant statistical distinctions were figured out by K-W test: $H(2, N=2056)=14,43944$; $p=0,001$ in case of Ca^{2+} evaluation. Statistically significant differentiantions had been monitored by Dunn´s test ($p<0,005$) between each of represented Ca^{2+} categories. In Fig.7e) we can see icreasing tendency in response to rising level of Ca^{2+}.

No statistically significant differences were found out within statistical analysis for abundances of Chilopoda and Diplopoda binding on Mg^{2+} level in soil based on K-W test $H(2, N=2056)=6,56843$; $p=0,375$ evaluation. Both, A and B categories were represented by equal value of average abundance (23 $ex.m^2$) while the average abundance in C category was clearly the highest (28 $ex.m^2$) (see Fig.7f).

In case of K^+ evaluation in relation to average abundances, no statistically significant differences were found out; K-W test: $H(2, N=2056)=5,116182$; $p=0,775$. Values of average abundances of Chilopoda and Diplopoda seemed very evenly distributed (see Fig.7g).

6.8. Staphylinidae – larvae

Total amount of larvae stages of Staphylinidae family was 2813 individuals. They were more densely represented in forest stands with dominance of spruce (23 $ex.m^2$) than beech (19 $ex.m^2$).

Essential statistical differences had been found in average abundance binding to vegetation altitudinal zones by K-W test: $H(3, N=2056)=60,02144$; $p=0,000$. Dunn´s ($p<0,000$) test indetified statistically significant differences while 7th VAZ differed from 4th, 5th and also 6th VAZ. Average abundances in 4th, 5th, 6th VAZ were almost equal (22, 20, 21 $ex.m^2$) meanwhile average abundances (46 $ex.m^2$) in 7th VAZ was clearly dominant (see Fig.8a).

K-W test: $H(7, N=2056)=43,72967$; $p=0,000$ figured out statistically significiant deviations in abundances of Staphylinidae larvae within represented edaphic categories.

By the subsequent multiple comparison test (Dunn´s test $p<0,041$) it was identified statistical difference between L and F EC, B and S EC. Generally, Average abundace was very irregularly distributed. Values of average abundances range from 14 $ex.m^2$ by O/R category and 33 $ex.m^2$ by L edaphic category (see Fig.8b).

Statistically significant differentials by K-W test: $H(11, N=2056)=94,38312$; $p=0,000$ were proved in case of forest site types evaluation. FST 7S was distinct compared with remaing FST. This fact was proved by Dunn´s test ($p<0,035$). Moreover, 5F was different to 5L and 5S simultaneously. Average abundance exceeded level of 30 individuals per square meter in 7S (46 $ex.m^2$) and 5L (33 $ex.m^2$) (see Fig.8c).

Occurence of statistically significant differences within abundances of larvae stages of Staphylinidae and pH/KCl categories was refused by K-W test: $H(2, N=2056)=2,77441$; $p=0,249$. The highest average abundance was in A (23 $ex.m^2$) category while abundances in B and C categories had decreasing trend (22, 18 $ex.m^2$) (see Fig.8d).

Very similar situation appeared in case of Ca^{2+} statistical evaluation on the basis of

K- W test: $H(2, N=2056)=0,25976$; $p=0,878$. Average abundaces were almost indentical as in pH/KCl evaluation (see Fig.8e).

K-W test: $H(2, N=2056)=6,11468$; $p=0,471$ did not figured out any statistical important deviations in abundances within Mg^{2+} categories. Average abundace fluctuated within pafticular Mg^{2+} categories (see Fig.8f).

Significant differences were not found out among abundances within K^+ evaluation based on K-W test: $H(2, N=2056)=1,18281$; $p=0,554$. Average abundances had been fluctuating without any proposed relation (see Fig.8g).

6.9. Staphylinidae – adults

In total, 2459 rove beetles had been captured. The average abundance in beech forest was 21 $ex.m^2$ and 19 $ex.m^2$ in forest stands with dominance of spruces.

K-W test: $H(3, N=2056)=36,0160$; $p=0,000$ found out statistically significant differences in average abundances within particular vegetation altitudinal zones. Dunn´s test ($p<0,044$) indentified 7^{th} VAZ as the most different while it was characterized by the highest value of average abundance (40 ex.m^2). The lowest value of average abundance(15 ex.m^2) of rove beetle was monitored in 5^{th} VAZ (see Fig.9a).

Statistical evaluation in represented forest site types displayed the statistically important deviations by K-W test: H(7, N=2056)=31,7717; p=0,000). The lowest value of average abundance was investigated in 6O/R (5 ex.m^2) and L (9 ex.m^2). By the subsequent multiple comparison test, Dunn´s test (p<0,030), it was confirmed that average abundance of rove beetles statistically differ between A and L, O/R EC. Average abundances within remaining EC varied from 16 ex.m^2 to 24 ex.m^2 (see Fig.9b).

There were found out statistical differences while evaluating abundance of rove beetles binding on forest site types on the basis of K-W test: H(11, N=2056)=75,6066; p=0,000. Consequently, Dunn´s (p<0,246) test proved presence of significant differences mainly in case of 7S FST while its average abundance was the highest (40 ex.m^2) inthere. 4Y FST exeeded level of 30 ex.m^2. Remaining FST releaved quite similar values of average abundances (see Fig.9c).

While evaluating relation between average abundance and pH/KCl categories, no stasticially significant differences were found out by K-W test: H(2, N=2056)=8,3071; p=0,157. Slightly increasing values of average abundances in accordance to enhancing pH/KCl level (see Fig.9d).

No significant differences between average abundance and Ca^{2+} had been found by K-W test: H(2, N=2056)=2,1239; p=0,346. No relevent relation betwenn Ca^{2+} and average abundances were identified according chart. (see Fig.9e).

Statistical evaluation performed by K-W test: H(2, n=2056)=8,76396; p=0,013 figured out statistically significant differences withing abundances in relation to Mg^{2+} level captured in soil. Dunn´s test (p<0,0499) found out statistical differences between C (26 ex.m^2) and A (17 ex.m^2) Mg^{2+} categories. Average abundance within particular Mg^{2+} categories was increasing in relation to increasing content of Mg^{2+} (see Fig.9f).

Statistical differences were present in case of evaluating abundances of rove beetles in relationship to ration of K^+ on the basis of K-W test: H(2, N=2056)=14,21755; p=0,008. Category C seemed to be the most densely represented with the highest value of average abundance of 29 ex.m^2 (Fig.9g). Therefore, this category was found the most distinct compared to the remaing categories by Dunn´s test (p<0,012).

6.10. Lumbricidae

Community of Lumbricidae consisted of 1765 captured individuals. Higher average abundance was monitored in forest stands with beech dominance (16 ex. m^2) than in forest stands with dominance of spruce (12 ex. m^2).

Family of Lumbricidae was determined in species while 12 distinct species had been monitored: *Allobophora eiseni, Aporrectodea rosea, Dendrobaena attemsi, Dendrobaena octaedra, Dendrobaena vejdovksyi, Dendrodrilus rubidus, Dendrodrilus rubidus tenuis, Eisenia lucens, Eiseniella tetraedra tetraedra, Lumbricus rubellus, Octolasion lacteum* and *Octolasion tyrtaeum*. Composition of Lumbricidae species was characterized for its variety and diversity in term of particular representation.

6.10.1. Evaluation by PCA

PCA method with projection of the varibles on the factor-plan was used for Lumbricidae in order to express the ralations among particular variables included in the research. Two main components had been distinguished. The first component represented approximately 46 % of data variability and the second main component expressed about 21 % of variability of data structure. First component is positively correlated with Al^{3+} and negatively by Mg^{2+} and Ca^{2+}. It can be note, that first component corresponds mainly with soil properties being monitored. Second component correlated mainly with altitude (Fig.10).

According to the Fig.10 we can also find out significant linkage between amount of earthworms and pH/KCl while the more acid (low number of pH/KCl value) soil environment is the poorer abundance of earthworms and vice versa. Abundance of wireworms was positively correlated with basic ions content (Mg^{2+} and Ca^{2+}) however this correlation is not so substantial as in the case of pH/KCl. Basic ions seemed to be independent of altitude. Moreover, there was found no significant correlation beween K^+ content earthworm´s abundance. Negative correlation was found between Al^{3+} and pH/KCl, it means, the higher content of Al^{3+}, the more acidic soil with low abundance of earthworms, respectively (Fig.10).

6.10.2. Subsequent statistical analysis

K-W test: H(3, n=2056)=20,6606; p=0,001 suggested statistical differences while evaluating average abundances of eartworms in connection to vegetation altitudinal zones. Dunn´s test (p<0,022) found out statistical difference between spruce and fir-beech VAZ. The values of abundances in 4th, 5th and 6th VAZ did not differ considerably, however the lowest average abundance (8 ex.m^2) was manitored within 7th VAZ (see Fig.11a).

Statistical significant differences had been distinguished by K-W test: H(7, n=2056)=26,7089; p=0,039 when the average abundance of earthworms was compared to distinct edaphic categories. EC O/R was significantly the most diverse and this fact was confirmed by Dunn´s test (p<0,041). Average abundance was relatively equally composed except O/R where the average earthworm´s abundance reached 32 ex.m^2 (see Fig.11b).

K-W test: H(11, N=2056)=46,8033; p=0,042 found out statistical deviations in abundances of earthworms with the forest site types. Dunn´s test (p<0,046) found out statistical variance mainly in case of 6O/R. This FST was different by the highest average abundance of 32 ex.m^2 (see Fig11c).

K-W test: H(2, n=2056)=28,2420; p=0,000 revelead statistically significant differences between pH/KCl categories in connection to average abundance of earthworms. Dunn´s test (p<0,001) found out statistically signifiant deviations among all the represented categories while the average abundance of earthworms was the lowest in A pH/KCl category (10 ex. m^2) and the hihghest in C category with the value 22 ex. m^2 (see Fig.11d).

Statistical evaluation of relation between Ca^{2+} and average abudance of earthworms indetified statistical differences based on K-W test: H(2, n=2056)=41,20275; p=0,000. C category with the highest content of Ca^{2+} was found as statistically different comparing to A and B categories according to Dunn´s test (p<0,000). Average abundance (38 ex. m2) was highly the most significant within C category (see Fig.11e).

Similar situation was observed in case of Mg^{2+} and average abundance of Lumbricidae family. Although, K-W test: H(2, n=2056)=8,20272; p=0,0624 did not find statistically significant differentiations, the abundance was increasing dependently to Mg^{2+} (see Fig11f).

No statistically important differences had been figured out by K-W test: $H(2, n=2056)=2,71725$; $p=0,257$ while evaluating average abundance and K^+. Distribution of abundances were quite equal among the represented categories (see Fig.11g).

6.10.3. Dominance of earthworms

VAZ

In 4th vegetation altitudinal zones, there were monitored two eudominant spices, *Dendrobaena octaedra* (62,99 %) and *Dendrobaena attemsi* (16,23 %). Three other species were found out to be dominant, *Aporectodea rosea* (6,49 %), *Eisenia lucens* (8,44 %) and *Dendrodrilus rubidus* (5,84 %). Beech altitudinal zone did not be represented by any other species (see Tab.4).

Two species of Lumbricidae family had been investigated to be eudominant within 5th VAZ, *Dendrobaena octaedra* (74,00 %) and *Dendrobaena attemsi* (17,23 %). *Dendrodrilus rubidus* (4,78 %) and *Eisenia lucens* (2,74 %) were classified as subdominant species. Moreover, six other species had been represented occasionally, thus *Allolobophora eiseni*, *Dendrobaena vejdovskyi*, *Dendrodrilus rubidus tenuis*, *Lumbricus rubellus*, *Octolasion lacteum* and *Octolasion tyrtaeum* had been distinguished as subrecedent species (se Tab.4).

In case of 6th vegetation altitudinal zone, eight distinc species had been found out inthere. *Dendrobaena octaedra* (45,42 %) and *Eisenia lucens* (32,35 %) seemed to be represented mostly, therefore were classified as eudominant species. *Dendrobaena attemsi*, with dominance of 8,82 % and Eiseniella tetraedra tetraedra (5,88 %) were dominant species. *Aporrectodea rosea* and *Lumbricus rubellus* were found subrecedent with the same value of dominance (0,33 %) (see Tab.4).

Only four species of Lumbricidae family were represented while evaluating dominance of earthworms within 7th VAZ. *Dendrobaena octaedra* was signifinatly eudominant (89,29 %) while *Allobophora eiseni*, *Eisenia lucens* and *Dendrobaena attemsi* were subdominant with an united value of dominance (3,57 %) (see Tab.4).

EC

Edaphic category A was represented by 7 species of earthworms while 2 species, Dendrobaena octaedra (72,51 %) and Dendrobaena attemsi (15,20 %), were found as eudominant species. No dominant species was found. Group of subdominant species included 3 species of Lumbricidae family: *Dendrodrilus rubidus* (4,68 %), *Eisenia lucens* (4,09 %) and *Lumbricus rubellus* (2,34 %). *Allobophora eiseni* was captured very rarely, therefore it was classifed as subrecedent species (see Tab.5).

Five Lumbricidae species were investigated within B EC. *Dendrobaena octaedra* (65,19 %) and *Dendrobaena attemsi* (18,99 %) were classified as eudominant species. Dendrodrilus rubidus was incorporate into dominant species with dominance of 9,49 %. Category of subdominant species was represented by *Dendrobaena vejdovskyi* (2,53 %). No recedent and subrecedent species had been figured out (see Tab.5).

Slope-stony (F) edaphic category was represented by 5 different earthorm´s species. There were investigated 2 eudominant species, *Dendrobaena octaedra* (66,56 %) and *Dendrobaena attemsi* (21,97 %), 1 dominant species, *Dendrodrilus rubidus* (8,85 %), 1 subdominant species, *Eisenia lucens* (2,30 %) and 1 subrecedent species, *Dendrodrilus rubidus tenuis* (0,33 %) (see Tab.5).

Distribution of dominance within L edaphic category was quite various. This EC was represented by 8 species of Lumbricidae family. *Dendrobaena octaedra* (64,91 %) and *Dendrobaena attemsi* (28,07 %) demonstrated the highest dominance, and were classified into eudominant group of species therefore. No dominant species was figured out. *Eisenia lucens* with final dominance of 2,63 % was incorporated into subdominant group. *Dendrobaena vejdovksyi, Dendrodrillus rubidus, Lumbricus rubellus, Octolasion lacteum* and *Octolasion tyrtaeum* were captured in low densities and seemed to be subrecedent (see Tab.5).

EC O was the poorest in term of eartworm´s representation within edaphic categories. represented by eartworms. It was represented by 3 species while *Dedndrobaena octaedra* had the absolute highest value of dominance (68,97 %) and was classified as eudominant also with *Eisenia lucens* (29,14 %). *Dendrobaena attemsi* decreased its value of dominance (6,90 %) in this EC (see Tab.5).

Transient edaphic category O/R was represented by 6 species of eartworms while 4 of them were classified as eudominant. The highest dominance had *Eisenia lucens* (46,32 %), *Eiseniella tetraedra tetraedra* (18,95 %), *Dendrobaena octaedra* with *Octolasion tyrtaeum* with total dominance value of 14,74 %. *Dendrodrillus rubidus* with dominance of 4,21 % was subdominant and *Aporrectodea rosea* was recedent species (1,05 %) (see Tab.5).

Edaphic category S was represented by 7 species of Lumbricidae family. *Dendrobaena octaedra* was hihgly eudominant with 80,45 %. *Eisenia lucens* was the second eudominant species with 11,34 % of dominance. Dominances of *Aporrectodea rosea* and *Dendrodrillus rubidus* range between 1–2% (see Tab.5).

Skeletal edaphic kategory (Y) was quite sparsely represented by earthworms while 4 different species had been distinguished. Eudominant species consisted of *Dendrobaena octaedra* (64,26 %) and *Dednrobaena attemsi* (29,55 %). Dominant species had been represented by Eisenia lucens (9 %) and Dendrodrilus rubidus (5,50 %). Neither subodominant, recedent nor subrecedent species were monitored within Y EC (see Tab.5).

FST

Forest site coded by 4S was represented by 5 different species of earthworms. There were two species eudominant with predominance of *Dendrobaena octaedra* (76,32 %), then *Eisenia lucens* (11,40 %). *Aporrectodea rosea* was identified as dominant species with 8,77 % of dominance. In 4S FST, *Dendrobaena attemsi* and *Dendrodrilus rubidus* were found the recedent species (see Tab.6).

FST 4Y was one of the poorest forest stand types in term of eartworm´s representation while 3 distinct species had been distinguished and classified into eudominant group of species; *Dendrobaena attemsi* (57,50 %), *Dendrobaena octaedra* (25 %) and *Dendrodrilus rubidus* (17,50 %) (see Tab.6).

Forest site 5A was the second forest stand type with the highest number (7) of Lumbricidae distinct species. Dendrobaena octaedra formed the highest content of species composition, thus was included in eudominant class of species with dominance of 72,51 %. Dendrobaena attemsi was represented by 15,20 % as eudominant species too. *Dendrodrilus rubidus* (4,68 %), *Eisenia lucens* (4,09 %) and *Lumbricus rubellus*

(2,34 %) seemed as subdominant species. Subrecedent group of earthworms was represented by *Allobophora eiseni* and *Dendrobaena vejdovskyi* (see Tab.6).

Population of earthworms consisted of five distinc species in 5B FST while the most common species was presented by *Dendrobaena octaedra* (65,19 %) and *Dendrobaena attemsi* (18,99 %). Thus, these species belonged to eudominant group. *Dendrodrilus rubidus* acted as dominant species with 9,49 %. Value of dominance of *Dendrobaena vejdovskyi* and *Eisenia lucens* ranged in the interval of subdominant species (see Tab.6).

Forest site type coded by 5F was represented by 5 different species of earthworms. *Dendrobaena octaedra* (66,56 %) and *Dendrobaena attemsi* (21,97 %) had been found out as eudominant species while *Dendrodrilus rubidus* (8,85 %) belonged to dominant species. *Eisenia lucens* fulfilled the value of dominance for subdominant species and *Dendrodrilus rubidus* tenuis was monitored occasionally (see Tab.6).

FST of alluvial floodplain soils of 5th vegetation tier included 8 distinct species of Lumbricidae family, therefore was the most various FST while evaluating eartworm´s represenation. *Dendrobaena octaedra* (64,91 %) and *Dendrobaena attemsi* (28,07 %) were found as eudominant species. No dominant species had been represented inthere. *Eisenia lucens* seemed to be subdominant species and *Dendrobaena vejdovskyi, Dendrodrilus rubidus, Lumbricus rubellus, Octolasion lacteum* and *Octolasion tyrtaeum* were classified as subrecedent species while the value of dominance did not exceed 1 % (see Tab.6).

5S forest site type was specific for its significant dominance of *Dendrobaena octaedra* (94,96 %) however 4 other species had been found out. *Eisenia lucens* with total dominance of 3,60 % was classified as subdominant species. *Dendrobaena attemsi, Dendrobaena vejdovskyi* and *Dendrodrilus rubidus* were subreedent species (see Tab.6).

Population of Lumbricidae within 5Y FST was formed by 4 species. Eudominant group comprised of *Dendrobaena octaedra* (70,52 %) and *Dendrobaena attemsi* (25,10 %), subdominant group consisted of one species, *Dendrodrilus rubidus* (3,59 %) and *Eisenia lucens* with 0,8 % of dominance seemed as subrecedent species (see Tab.6).

Earthworm´s representation within 6O was poor with occurence of 3 distinct species. *Dendrobaena octaedra* (68,97 %) and *Eisenia lucens* (24,14 %) were eudominant while

Dendrobaena attemsi with total dominance of 6,90 % was classified as dominant. Neiter subdominant, recedent nor subrecedent species had been monitored (see Tab.6).

Dominance of earthworms was divided among 6 distinct species in case of 6O/R FST. Four species, *Dendrobaena octaedra* (14,74 %), *Eisenia lucens* (46,32 %), *Eiseniella tetraedra tetraedra* and *Octolasion tyrtaeum*, were distinguished as eudominant species. *Dendrodrilus rubidus* (4,21 %) was classified in subdominant species and *Aporectodea rosea* (1,05 %) was recedent (see Tab.6).

6S FST was represented by 5 species of earthworms. *Dendrobaena octaedra* (55,56 %), *Eisenia lucens* (26,80 %) and *Dendrobaena attemsi* seemed eudominant. *Dendrodrilus rubidus* was classified as recedent with dominance of 1,96 % and *Lumbricus rubellus* was subrecedent (see Tab.6).

Dominance of Lumbricidae family in 7S was represented by 4 distinct species. *Dendrobaena octaedra* was highly eudominant (89,29 %). Value of dominance by *Allobophora eiseni, Dendrobaena attemsi* and *Eisenia lucens* was indentical (3,57 %) (see Tab.6).

6.11. Elateridae larvae

Larvae stages of Elateridae family called as wireworms were relatively densely represented. Total population involved 7366 individuals of wireworms. Average abundance per 1 square meter was siginificantly higher within spruce forest stands with 65 individuals in average while the average abundance in beech stands counted 39 ex.m^2.

6.11.1. Evaluation by PCA

PCA method with projection of the variables on the factor-plan was used in order to find out the reltions among particular variables being monitored within the research. Two main components had been defined while the first component expressed about 41 % of variability within data and the second component interpreted approximately 21 % of variability within data structure. First main component highly negatively correlated with pH/KCl variable while the most important positive correlation was monitored in connection to Al^{3+}. Second main component is quite significantly negatively correlated with value of altitude, therefore it correseponds with altitudinal zonation of the particular research locallities (see Fig.12).

Specific relations of variables are displayed in chart 1 where we can distinguish positive correlation between pH/KCl and concetration of basic ions (Ca^{2+}, Mg^{2+}). Abundance of wireworms was higher with lower values of pH/KCl within soil environemnt, the more acidic soil, the higher abundance of Elateridae larvae stages, respectively. Similar connection was observed in case of pH/KCl and size of wireworms, however correlation was not so significant in this case. Moreover, these basic cations are negatively correlated with concentration of aluminum ions (Al^{3+}) in the soil substrate. Size of eartworms was positevly influenced by the increasing content of Ca^{2+}, Mg^{2+} in the soil envrionment. Abundance of wireworms was correlated neither with ions of Ca^{2+}, nor Mg^{2+}. However, abundance of Elateridae larvage stages seemed to be very positevely correlated with concentration of K^{+}. Total abundance of wireworms was slightly positively correlatted with altitude (see Fig.12).

6.11.2. Subsequent statistical analysis

K-W test: H(3, N=2056)=14,7202; p=0,021 revealed statistically significant differences while evaluating average abundances of wireworms with vegetation altitudinal zones. Subsequent muliple comparison test, Dunn´s test (p<0,038) figured out considerable differentions especially in the 7th VAZ which had been dissimilar to 4th and 5th VAZ simultaneously. In fig…, there is displayed increasing volume of wireworm´s abundance in connection with higher vegetation eltitudinal tiers. Average abundance varied from 50 ex.m^{2} (4th VAZ) to 72 ex.m^{2} (4th VAZ) (see Fig.13a).

Statistically important differences were found out by K-W test: H(7, N=2056)=94,13655; p=0,000 in connection between represented edaphic categories and average abundances of wireworms. Dunn´s test (p<0,038) found out statistically significant differences between these paires of EC: YxA, B, F, O, O/R, Sx A, B, F. Average abundance of wireworms differed considerably while the lowest average abundance was monitored in trasient O/R EC (10 ex.m^{2}). EC S (66 ex.m^{2}) and Y (78 ex.m^{2}) seemed to be occupied the most densely (see Fig.13b).

Statistically significant deviations had been monitred also within distinct forest site types. It was proved by K-W test: $H(11, N=2056)=119{,}7277$; $p=0{,}000$. Dunn´s test ($p<0{,}042$) found out essential differences in average wireworm´s abundances between several FST. Forest site type coded by 6O/R seemed to be highly different comparing to other FST. Statistical differences were monitored also in other cases of FST, therefore final distribution of average abundances within FST was fluctuating (see Fig.13c).

K-W test: $H(2, N=2056)=74{,}66160$; $p=0{,}000$ found out statistically significant differences while evaluating average abundance of wireworms with pH/KCl. Dunn´s test ($p<0{,}000$) indetified statistical deviations among each of the represented pH/KCl category. In the Fig.13d) we can infer, that average abundance of wireforms was higher in more acidic soils, therefore value of average abundance in case of A category is the highest (77 ex.m^2) and the lowest in C pH/KCl category (44 ex. m^2) (see Fig.13d).

Significant differentions were found on the basis of K-W test: $H(2, N=2056)=9{,}84249$; $p=0{,}073$ evaluation between average abundance of wireworms and concetration of Ca^{2+}. By the subsequent multiple comparison test (Dunn´s test $p<0{,}008$) it was identified statistical difference between C and A Ca^{2+}. We can see increasing trend of abundance in connection to increasing contration of Ca^{2+} ions in soil while the average abundance ranges from 59 ex.m^2 in A to 46 ex.m^2 in B category (see Fig.13e).

No statistically significant difference had been figured out by K-W test: $H(2, N=2056)=9{,}09576$; $p=0{,}635$ between average abundance and concentration of Mg^{2+}. Average abundance was distributed quite equaly within represented Mg^{2+} categories (see Fig.13f).

K-W test: $H(2, N=2056)=6{,}884753$; $p=0{,}032$ identified significant statistical differences within abundance of wireworms and concetration of K^+ in soil. Statistical deviations had been displayed by Dunn´s test ($p<0{,}030$) between C and B category. As we can see in Fig.13g), average abudances of wireworms seemed to be identical, however the value of average abundance was significantly ingreasing simultaneously wih rising level of K^+, therefore wireworm´s abundance was the highest in C category (64 ex.m^2).

6.11.3. Genera composition

Wireworms had been determined in genera systematic categories. Five distinct genera had been distinguished: *Athous, Ctenicera, Dalopius*, *Denticollus* and *Limonius*.

Composition of wireworm genera seemed to be disproportionately distributed (see Tab.8).

Athous

This genera of wireworms seemed to be significantly dominant with total representation of 85,74 % which corresponds to 469 captures individuals. The average size of the larvae was 1,13 cm and maximal 1,94 cm. Minimal size of this genera was 0,41 cm (see Tab.8).

Ctenicera

Ctenicera was represented quite rarely on the basis of determination with total finding of 14 individuals and 2,56 % of dominance, respectively. The average larvae size was 0,94 cm while the maximal size was 1,29 cm and minimal size 0,64 (see Tab.8).

Dalopius

This genus was found as the second most abundant genus of Elateridae larvae stages with total dominance of 8,96 %. In summary, 49 larvae stages had been distinguished. *Dalopius* genus involved the largest body size of 2,53 cm while the minimal larvae size was 0,59 cm. Average size was 1,23 cm (see Tab.8).

Denticollis

This genus consisted of the lowest amount of Elateridae larvae stages (7 ex., 1,28 % of total dominance). Average larvae size was 1,06 cm, minimal size 0,68 cm and maximal size 1,43 cm (see Tab.8).

Limonius

Population of Limonius genus consisted of 8 larvae with total percentage represetion of 1,46 %. The average larvae size was 0,76 cm, while the maximal was 1,05 cm and minimal size 0,46 cm (see Tab.8).

7. Discussion

Aim of this diploma thesis was to monitore the representation and abundance of selected animal group in order to define the potential relation of their abundance to the specific habitat conditions within the model area of the Moravian-Silesian Beskids. It is neccessary to notice, that the model area of this diploma thesis consisted of 4 vegetation altitudinal zones, 8 edaphic categories and 12 forest site types, thus this unequal composition research localities could cause specific inacuraccies while evaluating the abundances of particular soil animal groups. Most of the engaged soil animal groups were monitored within larger systematic categories because the detail determination is very complicated and sometimes almost impossible to perform (*Collembola, Acari*). Moreover, Tullgren method of extraction and the size of soil samples could influence their ability to permeate through the soil samples. Despite, this uniform method of soil fauna extraction by Tullgren method has certain importance. However,the Tullgren method is fully suitable for extraction of earthworms and larvae stages of Elateridae. These groups of soil fauna occupy both surface and deeper parts of soil profile and even their detail classification is possible to be carried out, therefore this diploma thesis deals with earthworms and wireworms in more details.

It was proved, that site conditions, soil and environmental conditions, have considerable influences on soil fauna and ther population densities. The scale of influence can not be defined generally for the whole spectrum of soil animals because each of the monitored group of soil epigeal animals responded very specifically to the distinct site conditions.

Acari, Collembola

Both Acari and collembolans were found as the most abundant groups of soil fauna. Their average abundance was more significant in forest stands with dominance of spruce (approximately 900 ex.m^2) than beech (approximately 700 ex.m^2). This fact was proved by Kula and Matoušek (2004). The absolute lowest of Collembolans was monitored in O/R EC (see Fig.2b) while there is serious influence by water regime. This situation corresponds with the statement of Resh and Cardé (2009) who found out that excessive humidity is seldom a problem for Collembolans however the desiccation of soil is also often serious. Resh and Cardé (2009) add that Collembola resist desiccation by moving into imcroenvironments of enough humidity especially into skeletal parts of soil or even under stones. This may bet he reason why the average abundance of Collembolans was the highest in case of Y (skeletal) edaphic category but even in A EC (see Fig.2b). Very similar situation was observed within evaluation of Acari (see Fig.1b). No relevant relation had been monitored while evaluating abundances of Acari and Collembola in reaction to pH/KCl and Ca^{2+} (see Fig.1d,1e, Fig 2d, 2e). Thie same was claimed also by Kula and Matoušek (2004) indicating no increases of Collembola abundance while liming and acidification of soil.

Carabidae larvae

Abundance of larvae stages of Carabidae differed within represented vegetation altitudinal zones while the highest value of average abundances was figured out in 4th VAZ (see Fig.3a). Ball et al. (1960) noticed, that temperature requirements for carabid larvae ranges between around 13° C, therefore there is possible relation to the lower altitudes.

Symphyla

It was found out, that abundance of Symphylans might correlated with volume of Ca^{2+} in the soil environemnt. This fact is supported by evaluation (Fig.4e) where there can be observed how the average abundance of Symphylans grew up in accordance with increasing content of Ca^{2+} despite the differences among the abundances were not statistically significiant (see 6.4. Symphyla). Zambonelli et al. (2016) monitored higher abundances of Symphylans between pH 5 – 6. This fact was partly found out in the thesis while the average abundance was relatively high in C pH/KCl category with pH > 4 (see Fig.4d).

Diplura

Population density of Diplura individals was rather low while the higher average abundance (32 ex.m^2) was in spruce stands. Statistical investigations did not releave any differences in relation to VAZ and even the relations binding on EC or SLT did not indicate any relevant sign. However, the highest abundance was monitored in pH/KCl category A (see Fig.5d). This was proved also by Kula (2010). In the Fig.5e), 5g) the decreasing tendency of abundances binding on increasing saturation of Ca^{2+} and K^+ is displayed. Moreover, Kula (2010) monitored this trend as well.

Protura

In case of Protura, no relevant indications were found out between abundances and VAZ, EC, SLT. Kula (2010) pointed out, that the low population density (20-50 ex.m^2) were monitored in soils without any application of dolomitic limestone and the abudance of Proturans was the higer with increasing content of Ca^{2+}. According to Fig.6e) we can see trend characterized by growing abundance with increasing content of Ca^{2+}. Additionally, it was noticed, that population of Proturans was the highest at pH > 4, however Kula (2010) found out decreased abundance at pH > 4,5.

Chilopoda, Diplopoda

Centipedes and Millipedes are no probrably in correlation with VAZ (see Fig.7a) The abundance was relatively equally distributed in case of EC while the lowest density in O/R (see Fig.7b). Neverthless, Tuf (2013) noticed that Millipedes and Centipedes are dwelling rather soil with high moisture. Indeed, considerably strong relation is dispayed in Fig.7e) where the abundance is growing in accordance with increasing content of Ca^{2+} in the soil environment. According to Tuf (2013), their body involved high content of calcium and they can themselves influence the input of calcium into the soil profile. This can be the reason why the abundance of Chilopoda and Diplopoda individuals grows conseqently with the content of calcium.

Staphylinidae larvae, Staphylinidae adults

The abundance of Staphylindae larvae stages and even Staphylindae adults seemed to be denser in relation to higher elevations while the most abundant population was monitored in 7th VAZ (see Fig.8a), Fig.9a). This fact is in accordance with Boháč and Roháčová (2001) who proved the trend of increasing abundance in connection to higher elevation. Boháč and Roháčová (2001) add, that denser population both rove beetle adults and larvae stages prefer spruce stands while it was verified in the thesis as well (see 6.8. Staphylinidae – larvae, 6.9. Staphylinidae – adults). Considerably high abundances of Staphylinidae larvae stages were found in case edaphic categoris influenced by water, L and O EC (see Fig.8 b). It corresponds with Boháč (2007) being in accordance with the fact that Staphylinidae often occupy soils with high moisture.

Lumbricidae

PCA method was used in order to identify general relations among the particular habitat characteristics. It was found out, that abundances of the acidity of p/H affect the Lumbricidae population while the more acidic soil environment is, the lower abundances is supposed to be. This fact was confirmed by both PCA and nonparametric statistical analysis. However, the sensitivity of earthworms connected to pH is very specific and Pižl (2002) notice, that optimal soil reaction is while pH 6–7. This clarification was proved by Kula (2010) as well.

PCA and subsequent statistical analysis based on K-W test and Dunn´s test found out the relation in case of Lumbricidae abundance and content of Ca^{2+} while the abundance of earthworms was greater based on the increasing volume of calcium within soil environment. This was also proved by Kula (2011). Similar reaction of Lumbricidae was observed in term of Mg^{2+} while the abundance was increasing proportionately with enhancing level of Mg^{2+} within the soil. Kula and Švarc (2011) found the identical reaction as well.

It is generally known, that population of Lumbricidae is negatively influenced by the occurrence of heavy metals in soils (Al). Kula and Švarc (2011) proved decreases of Lumbricidae populations in contaminated soils. Moreover, Pižl (2002) supported this fact. Indeed, the negative impact of toxicity in relation to Lumbricidae population was confirmed in the thesis by principal component analysis (see Fig.10).

Dendrobaena octaedra was appearing as the most abundant species compared to the remaining species being represented (see Tab.7). This species was eudominant in all the VAZ, EC and even SLT. Pižl (2002) considered *Dendrobaena octaedra* being cosmopolitan with occurrence in both spruce and beech forest and acidotolerant. This fact was found out as well in the thesis. Moreover, Kula (unpublished) further remarked, that monitored in the area of the Ore mountains but the considerably higher representation of this species was monitored in the area of the Moravian-Silesian Beskids.

Dendrobaena attemsi was the second most represented species of Lumbricidae family (see Tab.7). This species was represented in all the EC (see Tab.5) while the most abundant was in 4th and 5th VAZ (see Tab.4). *Dendrobaena attemsi* was eudominant in these mentioned VAZ. This may corresponds with Rota and Erséus (1997) who noted, that this species occurred predominantly in the southern parts of Europe, therefore is more tolerant to the drier soil environment. This species had been monitored quite densely in all the research spots (see Tab.4, Tab.5, Tab.6). Moreover, Kula and Švarc (2011) found out this species as considerably densely represented within the researches in the area of the Ore mountains and the Moravian-Silesian Beskids mountains.

Allolobophora eiseni was represented in low densities (see Tab.7) in VAZ 5 and 7 (se Tab.4) and A and S EC (see Tab.5) within the research spots 26 and 32 where the spruce was dominating (see Tab.3). Neverthless, Pižl (2000) found out this species to be occupying beech stands and floodplain forests. Moreover, Kula and Švarc (2010) monitored this species in the forest stands of *Picea pungens*.

Dendrobaena vejdovskyi, *Dendrodrilus rubidus tenuis* and *Eiseniella tetraedra tetraedra* were monitored very sparsely (see Tab.7). Furthermore, habitat requirements of *Eiseniella tetraedra tetraedra* and *Octolasion tyrtaeum* seemed to be similar while their occurrence was conditioned by soils being influenced by water regime (see Tab.5). This fact is in correspondence with Karaca (2010) who mentioned, that these species prefer swampy stands and soils with affected by water in general.

According to the statement of Pižl (2002), *Eisenia lucens* prefer predominantly soils with high moistures. This was proved in the thesis based on the evaluation of Lumbricidae dominances within EC and SLT where we can found high values of dominance in case of water influenced stands, O and O/R, respectively (see Tab.5, Tab.6).

Elateridae larvae

Larvae stages of Elateridae family are considered to be engaged in all the parts of soil profile. First of all, it should be noted, that the resource of information dealing with larvae stages of Elateridae family is limited or even deficient. PCA evaluation was used in order to express the particular relations among all the site characteristics. Elateridae larvage stages, wireworms, respectively seemed to have specific and rather different environmental and soil requirements compared with Lumbricidae. According to the PCA evaluation of Elateridae larvae (see Fig.12) it was found out, that wireworms are more capable to resist the occurrence of soil heavy metals (Al) than the Lumbricidae. Moreover, population of wireworms was positively influenced by K^+ (see Fig.12). The average abundances of wireworms significantly differed in spruce and beech stands. Wireworms appeared as more abundant in the habitats with dominance of spruce while the average abundance was 65 ex.m^2 while the average abundance in beech stands was 39 ex.m^2 (see

6.11. Elateridae larvae). Taking in consideration the soil pH reaction wireworms seemed to be occupying more acidic soils. It was confirmed by PCA evaluation (see Fig.12) and subsequent statistical analysis based on K-W test evaluation (see 6.11.2. Subsequent statistical analysis).

Five distinct genera had been monitored while *Athous* genera seemed to be significantly dominating with the total representation of almost 86 % within the whole spectrum of Elateridae genera.

Diploma thesis also dealt with the size of Elateridae larvae stages being measured by digital caliper while the sizes had been assessed within the year of 2014. Three size categories of wireworms were distinguished in order to find out the possible ratio among the developmental stages of Elateridae. Laibner (2000) noted, that amount of developmental stages is various and may reach up to 6 particular developmental stages. Taking in consideration the final evaluation of wireworm´s size categories (see Tab.9), no conclusive ration among the developmental stages can be identified. Therefore, it would be noticed, that there is the overlay of developmental stages of Elateridea family.

8. Conclusion

Diploma thesis had been dealing with soil fauna of beech and spruce stands in the model area of the Moravian-Silesian Beskids. Overall, 11 soil animal groups had been monitored in the level of larger systematic catagories while the population of earthworms and larvae stages of Elateridae had been investigated in more details. Thesis was focused on monitoring of abundance within particular groups of soil animals and inference of possible relations between the animal groups of soil fauna in relation to vegetation altitudinal zones, edaphic categories, forest site types and habitat conditions, respectively.

In total, 274 015 individuals within all selected animal groups were extracted while the highest values of abundances were figured out in case of Collembola, Acari and Symphyla. Collembolans seemed to be more abundant in forest stands with spruce dominance, nevertheless no significant relation to soil reaction pH was found out.

Higher abundance of Symphylans in connection to increasing content of calcium captured in soil was investigated.

Growing populations in relation to increasing the level of calcium in soil was observen in case of Chilopoda and Diploda. Indeed, these soil animals have an impact on increases of calcium level in soil.

Adults and larvae stages of Staphylinidae positively correlated with increasing elevations while the higher elevation the more abundante community of Staphylinidae.

While evaluating abundance of Lumbricidae, it was found out, that earthworms prefer rather neutral soils. Moreover, earthworm´s population was positively influenced by increasing level of calcium in soil while the occurence of heavy metals in soils caused decreases of their abundance.

Lumbricidae were determined into 12 distinct species. Dendrobaena octaedra widely represented in all the monitored localities. This species acted very dominantly and involved more than 68 % of Lumbricidae species spectrum. Therefore, its cosmopolitan extension and acidotolerance was proved.

Eiseniella tetraedra tetraedra and *Octolasion tyrtaeum* demonstrated the relation to soils influenced by water regime.

Specimen of *Allolobophora eiseni* was monitored within 7th altitudinal vegetation zone with altitude of 1190 m a.s.l. in spruce stand. Occurence of this species is desribed predominantly in beech stands with low elevations.

Habitats requirements of larvae stages of Elateried seemed to be different compared to Lumbricidae habitat demands. Wireworms´s ability to resist heavy metals appereances was proved as well. They abundances seemed to be independent of Ca^{2+} and Mg^{2+} ions, nevertheless the population was higher in sites saturated by K^{+}.

Specimens of wireworms were determinated into 5 distinct genera while *Athous* formed almost 86 % of the genera spectrum. Elateridae larvae developmental stages overlays were investigated on the basis of the unequal representation of particular size categories.

Furthermore, I would propose to focus on monitoring of the larvae stages of Elaterida within the additional researhces of soil fauna in the Moravian-Silesian Beskids model area. For these purposes, larvae stages of Elateridae were preserved and stored.

9. Závěr

Diplomová práce se zabývala půdní faunou bukových a smrkových porostů v modelovém území Moravskoslezských Beskyd. Celkově bylo sledováno 11 skupin půdních živočichů na úrovni vyšších systematických kategorií, přičemž populace žížal a larválních stádií čeledi Elateridae byly sledovány detailněji. Práce byla zaměřena na monitoring abundance v rámci jednotlivých skupin půdních živočichů a odvození možných vztahů mezi živočišnými skupinami půdní fauny ve vazbě na lesní vegetační stupně, edafické kategorie, soubory lesních typů, respektive stanovištní podmínky.

Celkem bylo extrahováno 274 015 jedinců ze všech cílových živočišných skupin, přičemž nejvyšší abundance byla pozorována u chvostoskoků, roztočů a následně stonoženek. U chvostoskoků byla pozorována vyšší abundance ve smrkových porostech, přičemž nebyla odvozena signifikantní vazba na půdní reakci pH.

V rámci hodnocení abundance stonoženek byla pozorována zvyšující se početnost s rostoucím obsahem vápníku v půdě.

Zvyšující se abundance ve vazbě na rostoucí hladinu vápníku v půdě byla pozorována u stonožek a mnohonožek, přičemž je známo, že tyto skupiny půdní fauny zvyšují obsah vápníku v půdě.

U dospělců čeledi drabčíkovitých a jejich larvální stádií byla pozorována korelace jejich početností s nadmořskou výškou, přičemž abundance se s rostoucí nadmořskou výškou poměrně značně zvyšovala.

V rámci hodnocení abundance žížal bylo zjištěno, že zástupci čeledi Lumbricidae preferují spíše neutrální půdy. Dále bylo investigováno, že populace žížal je pozitivně ovlivněna zvyšujícím se obsahem vápníku v půdě, zatímco obsah těžkých kovů v půdě má za následek značný pokles jejich početnosti.

Cenóza žížal byla determinována do druhů, přičemž bylo zjištěno 12 druhů. Druh *Dendrobaena octaedra* byl hojně zastoupený na všech pozorovaných lokalitách. Tento druh se jevil zcela dominantně a tvořil víc než 68 % celkové druhové spektra žížal, čímž bylo potvrzeno, že se jedná o kosmopolitní acidotolerantní druh.

Druhy *Eiseniella tetraedra tetraedra* a *Octolasion tyrtaeum* prokázaly vazbu na vodou ovlivněná stanoviště.

Exemplář druhu *Allolobophora eiseni* byl nalezen na stanovišti v 7. vegetačním stupni s nadmořskou výškou 1190 m n.m. ve smrkovém porostu, zatímco jeho výskyt je popisován výhradně v níže situovaných bukových porostech.

Stanovištní nároky larválních stádií kovaříkovitých se jevily značně odlišně ve srovnání s žížalami. Drátovci naznačili vyšší schopnost odolávat přítomnosti těžkých kovů v půdním prostředí. Bylo zjištěno, že jejich početnost pravděpodobně nesouvisí s množství iontů Ca^{2+} a Mg^{2+} obsažených v půdě, zatímco jejich abundance byla vyšší na stanovištích s vysokým obsahem K^{+}.

Drátovci byli determinováni do 5 odlišných rodů. Signifikantně byl zastoupen rod *Athous*, který tvořil téměř 86 % rodového spektra drátovců. Na základě nerovnoměrného zastoupení jednotlivých velikostních kategorií drátovců bylo stanoveno, že populace jednotlivých vývojových stádií kovaříků se překrývají.

V rámci dalšího průzkumu půdní fauny v modelovém území Moravskoslezkých Beskyd bych navrhoval zaměřit se především na monitoring larev kovaříkovitých. Pro tyto účely byla larvální stádia kovaříků konzervována a uložena.

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11. Annexes

11.1. List of tables

Tab.1: Overviw of research plots within Nature reserve

Name of Nature Reserve	**Amount of target plots**	**No. of partial target plot**
Smrk	4	7, 31, 32, 35
Bučačí potok	1	12
Studenčany	1	6
V Podolánkách	1	19

Tab.2: Evaluation of forest soil quality by Šály 1978, Rejšek 1999, Sáňka, Materna 2004

Soil reaction	Extremely acid	Very heavily acid	Heavily acid	Acid
pH (H_2O)	< 3.5	3.5–4.5	4.5–5.5	5.5–6.5
pH (KCl)	< 3.0	3.0–4.0	4.0–5.0	5.0–6.0
Sorption complex	very low, low	medium	high (very high)	
T (mmol·kg^{-1})	(< 80) 80–130	130–240	240–300 (> 300)	
S (mmol·kg^{-1})	< 120	120–180	> 180	
Sorption complex saturation	very low, low	medium	Higher	high (very high)
V (%)	(< 5) 15–30	30–50	50–70	70–85 (>85)
Content of available nutrients*	very low, insufficient	optimum	excessive (very high)	
P (mg·kg^{-1})	(< 5) 5–10	10–30	30–60 (> 60)	
Mg (mg·kg^{-1})	(< 20) 20–40	40–60	60–80 (> 80)	
Ca (mg·kg^{-1})	(< 150) 150–300	300–500	500–800 (> 800)	
K (mg·kg^{-1})	(< 20) 20–50	50–90	90–140 (> 140)	

*Criteria of the evaluation of available nutrients are determined according to analyses using the procedure of Mehlich II, III.

Tab.3: Overview of research localities and site characteristics

Locality	FST	VAZ	EC	Altitude	Tree	pH/KCL	Cat. pH/KCL	Al3-	Ca^{2+}	Ca2+ Category	Mg^{2+}	Mg2+ Category	K^{+}	K+ Category	Soil type
1	5Y	5	Y	580	SM	2,80	A	12,40	191,00	A	46,00	A	112,00	B	Leptosols (RN)
2	5F	5	F	800	BK	3,50	B	2,61	205,00	A	52,00	A	62,00	A	Leptosols (RN)
3	5S	5	S	870	BK	3,47	B	2,63	236,00	A	62,00	B	102,00	B	entic Podzols (KP)
4	5S	5	S	880	SM	3,02	B	7,25	192,00	A	51,00	A	111,00	B	haplic Podzols (PZ)
5	5S	5	S	850	BK	3,32	B	2,09	177,00	A	62,00	B	118,00	B	haplic Podzols (PZ)
6	5B	5	B	900	BK	4,29	C	1,11	216,00	A	49,00	A	79,00	A	Cambisols (KA)
7	5A	5	A	820	BK	3,75	B	1,64	279,00	A	64,00	B	118,00	B	Leptosols (RN)
8	6S	6	S	1000	SM	2,99	A	7,99	181,00	A	52,00	A	79,00	A	haplic Podzols (PZ)
9	6S	6	S	1030	SM	2,74	A	10,80	229,00	A	57,00	A	106,00	B	Cambisols (KA)
10	5S	5	S	840	SM	3,15	B	11,12	214,00	A	50,00	A	75,00	A	Leptosols (RN)
11	5F	5	F	860	SM	2,95	B	9,44	182,00	A	46,00	A	74,00	A	Leptosols (RN)
12	5F	5	F	800	BK	3,31	B	7,40	557,00	C	87,00	C	137,00	B	entic Podzols (KP)
13	5F	5	F	850	SM	2,78	B	6,98	222,00	A	57,00	A	108,00	B	Leptosols (RN)
14	5B	5	B	820	SM	3,41	B	10,08	258,00	A	64,00	B	115,00	B	Cambisols (KA)
15	5Y	5	Y	790	SM	4,43	C	1,09	643,00	C	480,00	C	175,00	C	Leptosols (RN)
16	5Y	5	Y	800	SM	3,11	B	6,22	350,00	B	112,00	C	120,00	B	Leptosols (RN)
17	5L	5	L	590	SM	3,07	B	13,33	175,00	A	59,00	A	110,00	B	Fluvisols (FL)
18	5L	5	L	600	SM	3,13	B	11,89	169,00	A	53,00	A	85,00	A	Fluvisols (FL)
19	6O	6	O	630	SM	3,03	B	0,73	233,00	A	49,00	A	98,00	B	Gleysols (GL)
21	5B	5	B	720	BK	3,95	B	2,47	479,00	B	102,00	C	221,00	C	Cambisols (KA)
22	5B	5	B	680	SM	2,97	A	7,53	170,00	A	48,00	A	85,00	A	Cambisols (KA)
23	6O/R	6	O/R	540	SM	3,77	B	7,60	230,00	A	46,00	A	77,00	A	Histosols (OR)
24	6O	6	O	540	SM	3,34	B	23,49	220,00	A	47,00	A	79,00	A	Stagnosols (PG)
25	5A	5	A	850	BK	4,11	C	1,76	278,00	A	65,00	B	100,00	B	entic Podzols (KP)
26	5A	5	A	850	SM	3,00	A	10,70	267,00	A	70,00	B	108,00	B	Leptosols (RN)
27	6S	6	S	1000	BK	3,18	B	7,86	410,00	B	93,00	C	163,00	C	Cambisols (KA)
28	6S	6	S	1020	BK	3,29	B	9,56	479,00	B	153,00	C	191,00	C	Cambisols (KA)
29	4Y	4	Y	600	SM	3,05	B	8,00	258,00	A	50,00	A	81,00	A	Leptosols (RN)
30	4S	4	S	620	SM	2,98	A	9,73	175,00	A	41,00	A	64,00	A	Cambisols (KA)
31	6S	6	S	1100	SM	2,74	A	12,86	242,00	A	79,00	B	155,00	C	Cambisols (KA)
32	7S	7	S	1190	SM	3,14	B	7,72	161,00	A	49,00	A	151,00	C	Leptosols (RN)
33	7S	7	S	1210	SM	2,79	A	12,61	164,00	A	46,00	A	119,00	B	haplic Podzols (PZ)
34	6S	6	S	1090	SM	3,00	A	7,36	256,00	A	82,00	C	177,00	C	haplic Podzols (PZ)
35	4S	4	S	620	BK	4,04	C	1,37	222,00	A	51,00	A	142,00	C	Cambisols (KA)
36	5S	5	S	640	SM	3,09	B	10,41	220,00	A	82,00	C	102,00	B	Cambisols (KA)
37	5S	5	S	630	SM	2,87	A	9,66	216,00	A	69,00	B	119,00	B	Cambisols (KA)
38	4S	4	S	620	SM	3,12	B	8,01	311,00	B	98,00	C	144,00	C	haplic Podzols (PZ)

Tab.4: Dominance of Lumbricidae in VAZ

VAZ	*Allolobophora eiseni*	*Aporrectodea rosea*	*Dendrobaena attemsi*	*Dendrobaena octaedra*	*Dendrobaena vejdovskyi*	*Dendrodrilus rubidus*	*Dendrodrilus rubidus tenuis*	*Eisenia lucens*	*Eiseniella tetraedra tetraedra*	*Lumbricus rubellus*	*Octolasion lacteum*	*Octolasion tyrtaeum*
4	x	6,49	16,23	62,99	x	5,84	x	8,44	x	x	x	x
5	0,08	x	17,23	74,00	0,55	4,78	0,08	2,74	x	0,39	0,08	0,08
6	x	0,33	8,82	45,42	x	2,29	x	32,35	5,88	0,33	x	4,58
7	3,57	x	3,57	89,29	x	x	x	3,57	x	x	x	x

Tab.5: Dominance of Lumbricidae in EC

EC	*Allolobophora eiseni*	*Aporrectodea rosea*	*Dendrobaena attemsi*	*Dendrobaena octaedra*	*Dendrobaena vejdovskyi*	*Dendrodrilus rubidus*	*Dendrodrilus rubidus tenuis*	*Eisenia lucens*	*Eiseniella tetraedra tetraedra*	*Lumbricus rubellus*	*Octolasion lacteum*	*Octolasion tyrtaeum*
A	0,58	x	15,20	72,51	0,58	4,68	x	4,09	x	2,34	x	x
B	x	x	18,99	65,19	2,53	9,49	x	3,80	x	x	x	x
F	x	x	21,97	66,56	x	8,85	0,33	2,30	x	x	x	x
L	x	x	28,07	64,91	0,88	0,88	x	2,63	x	0,88	0,88	0,88
O	x	x	6,90	68,97	x	x	x	24,14	x	x	x	x
O/R	x	1,05	x	14,74	x	4,21	x	46,32	18,95	x	x	14,74
S	0,17	1,75	4,89	80,45	0,17	1,05	x	11,34	x	0,17	x	x
Y	x	x	29,55	64,26	x	5,50	x	9,00	x	x	x	x

Tab.6: Dominance of Lumbricidae in FST

FST	*Allolobophora eiseni*	*Aporrectodea rosea*	*Dendrobaena attemsi*	*Dendrobaena octaedra*	*Dendrobaena vejdovskyi*	*Dendrodrilus rubidus*	*Dendrodrilus rubidus tenuis*	*Eisenia lucens*	*Eiseniella tetraedra tetraedra*	*Lumbricus rubellus*	*Octolasion lacteum*	*Octolasion tyrtaeum*
4S	x	8,77	1,75	76,32	x	1,75	x	11,40	x	x	x	x
4Y	x	x	57,50	25,00	x	17,50	x	0,00	x	x	x	x
5A	0,58	x	15,20	72,51	0,58	4,68	x	4,09	x	2,34	x	x
5B	x	x	18,99	65,19	2,53	9,49	x	3,80	x	x	x	x
5F	x	x	21,97	66,56	x	8,85	0,33	2,30	x	x	x	x
5L	x	x	28,07	64,91	0,88	0,88	x	2,63	x	0,88	0,88	0,88
5S	x	x	0,72	94,96	0,36	0,36	x	3,60	x	x	x	x
5Y	x	x	25,10	70,52	x	3,59	x	0,80	x	x	x	x
6O	x	x	6,90	68,97	x	x	x	24,14	x	x	x	x
6O/R	x	1,05	x	14,74	x	4,21	x	46,32	18,95	x	x	14,74
6S	x	x	15,03	55,56	x	1,96	x	26,80	x	0,65	x	x
7S	3,57	x	3,57	89,29	x	x	x	3,57	x	x	x	x

Tab.7: Total representation of Lumbricidae

Total representation	*Allobophora eiseni*	*Aporrectodea rosea*	*Dendrobaena attemsi*	*Dendrobaena octaedra*	*Dendrobaena vejdovskyi*	*Dendrodrilus rubidus*	*Dendrodrilus rubidus tenuis*	*Eisenia lucens*	*Eiseniella tetraedra tetraedra*	*Lumbricus rubellus*	*Octolasion lacteum*	*Octolasion tyrtaeum*
Total representation (ex)	2	11	273	1206	7	77	1	148	18	6	1	15
Total representation (%)	0,11	0,62	15,47	68,33	0,40	4,36	0,06	8,39	1,02	0,34	0,06	0,85

Tab.8: Genera representatiton of Elateridae larvae

	Athous	*Ctenicera*	*Dalopius*	*Denticollis*	*Limonius*
Total representation (ex)	469	14	49	7	8
Total representation (%)	85,74	2,56	8,96	1,28	1,46
Average size (cm)	1,13	0,94	1,23	1,06	0,76
Maximal size (cm)	1,94	1,29	2,53	1,43	1,05
Minimal size (cm)	0,41	0,64	0,59	0,68	0,46

Tab.9: Elateridae larvae size categories

	Athous	*Ctenicera*	*Dalopius*	*Denticollis*	*Limonius*	**In total (ex)**
Size category A (ex)	130	7	13	3	5	158
Size category B (ex)	240	7	23	3	3	276
Size category C (ex)	99	0	13	1	0	113
In total (ex)	469	14	49	7	8	547

11.2. List of figures

Fig.1: Abundance of Acari in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

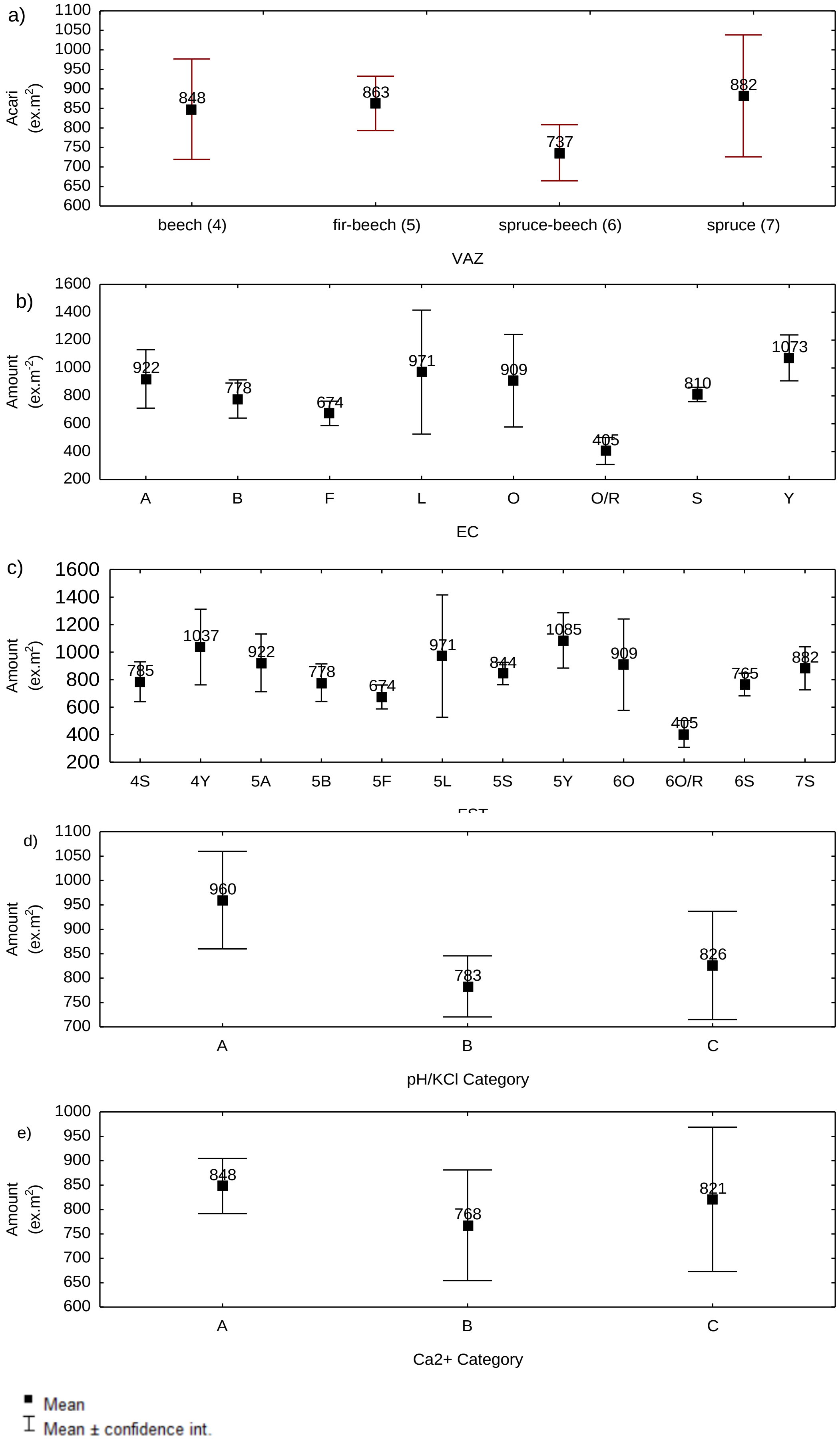


Fig.1(cont.): Abundance of Acari in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

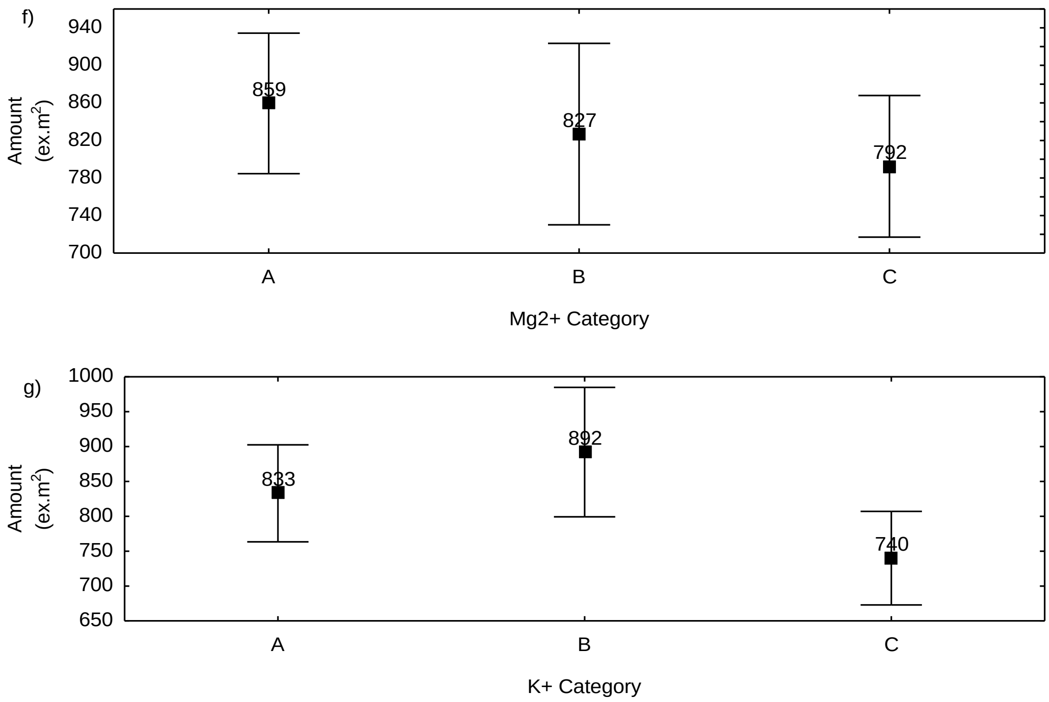


Fig.2: Abundance of Collembola in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

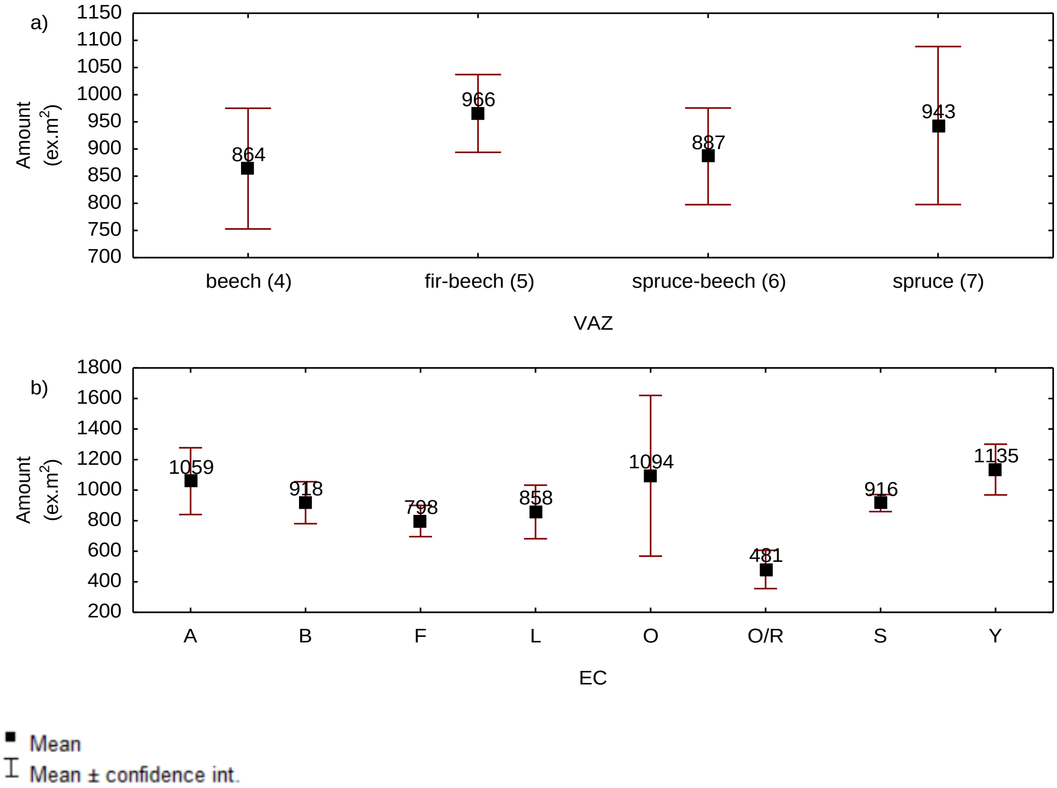


Fig.2(cont.): Abundance of Collembola in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

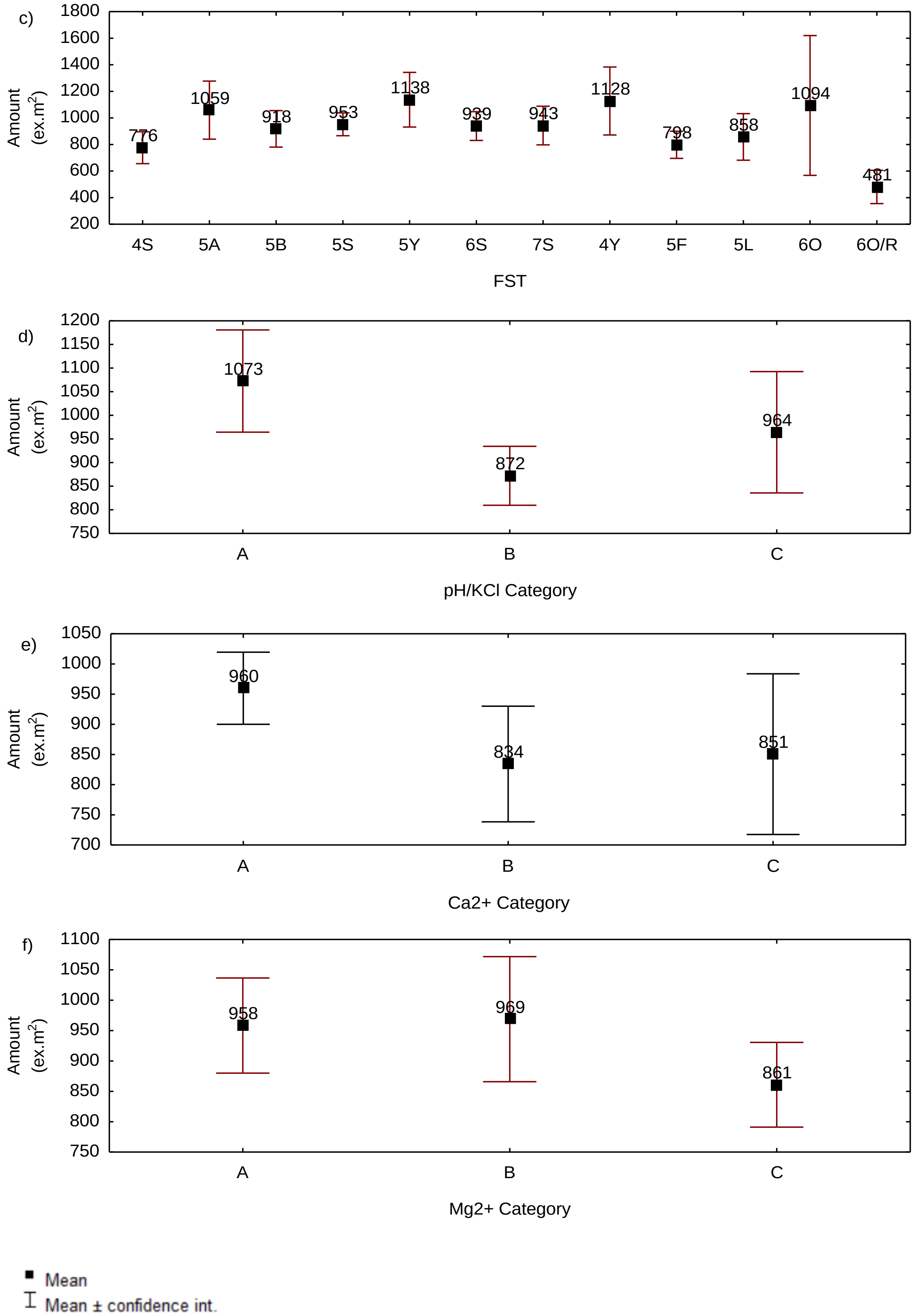


Fig.2(cont.): Abundance of Collembola in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

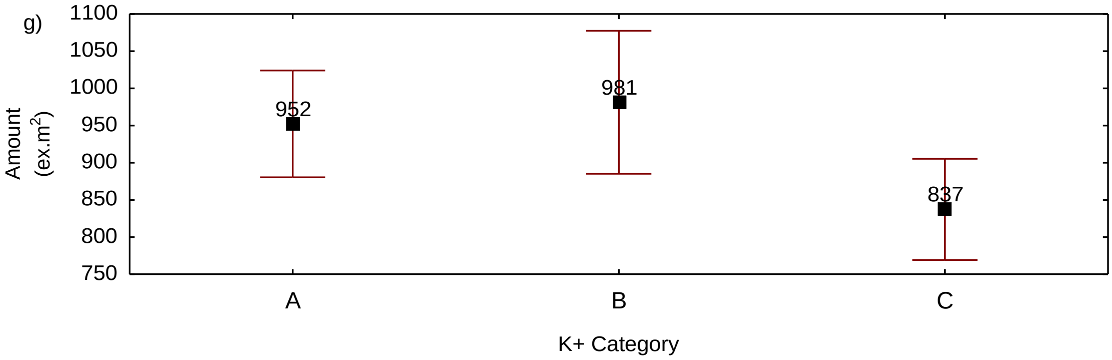
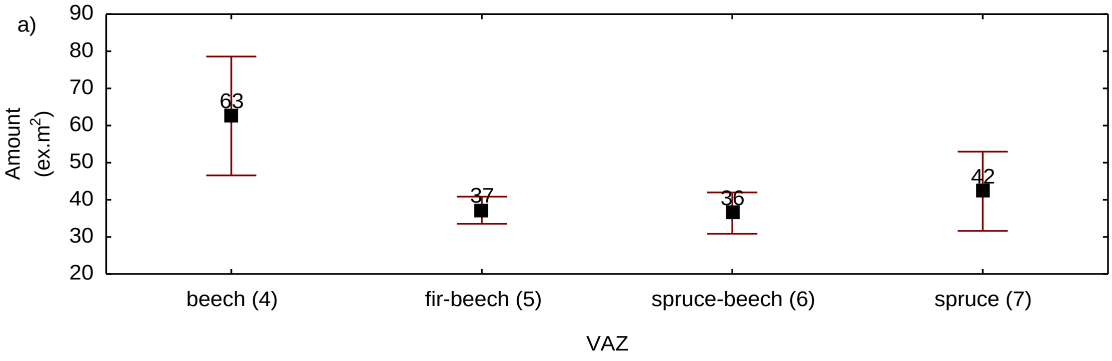


Fig.3: Abundance of Carabidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



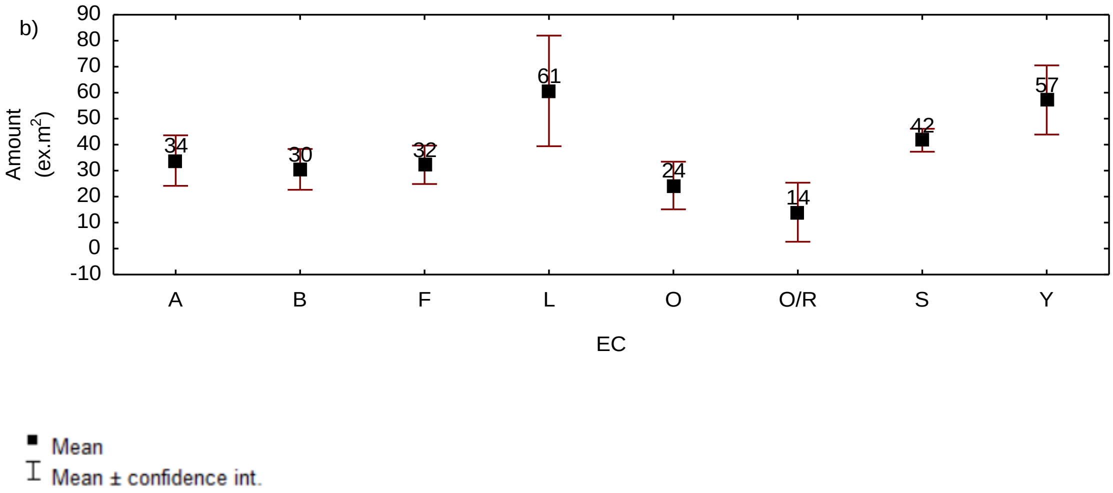


Fig.3(cont.): Abundance of Carabidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

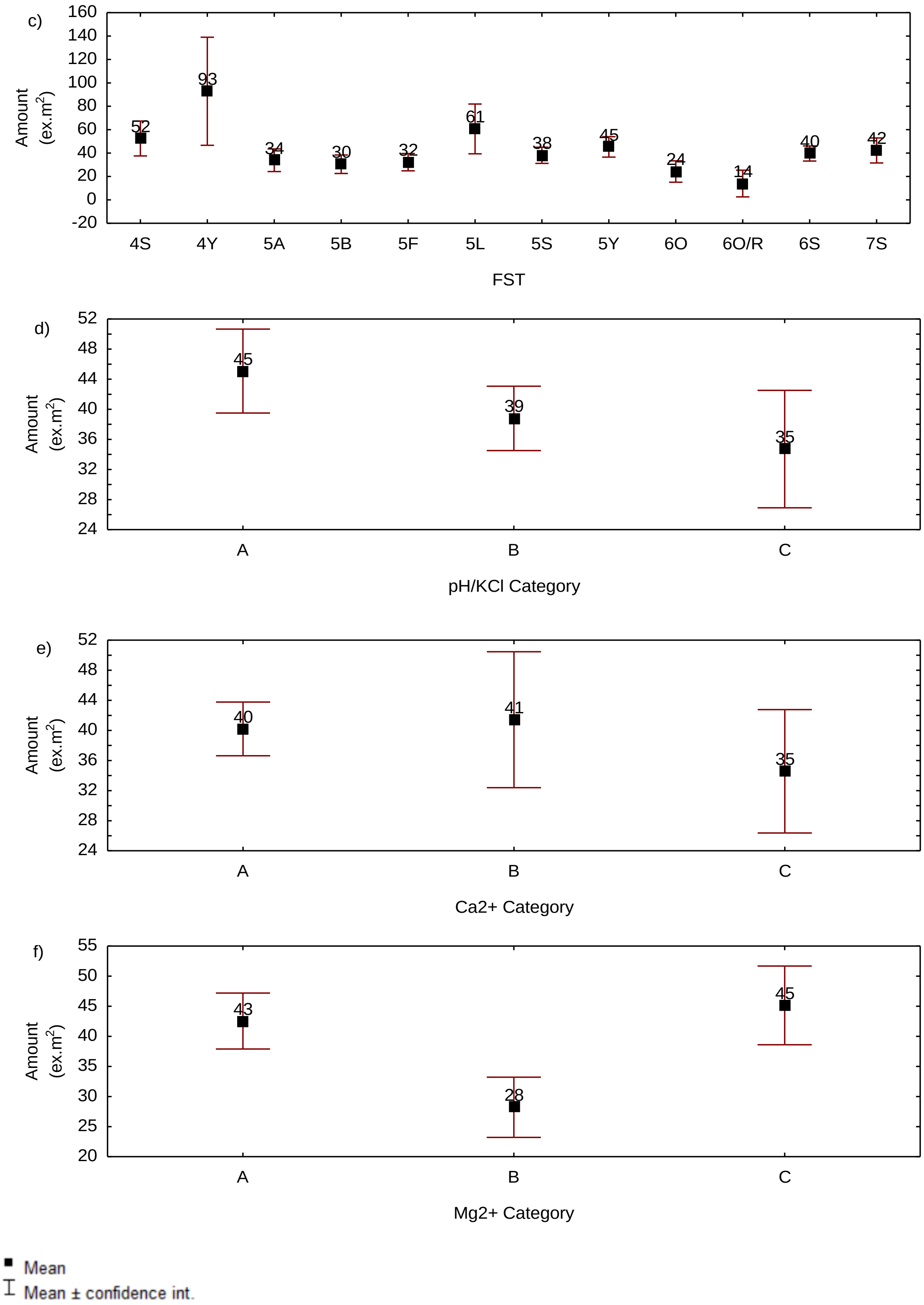


Fig.3(cont.): Abundance of Carabidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

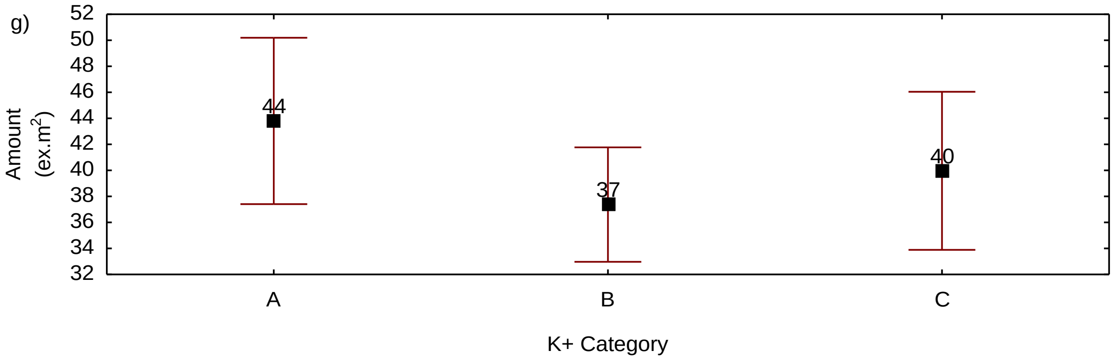
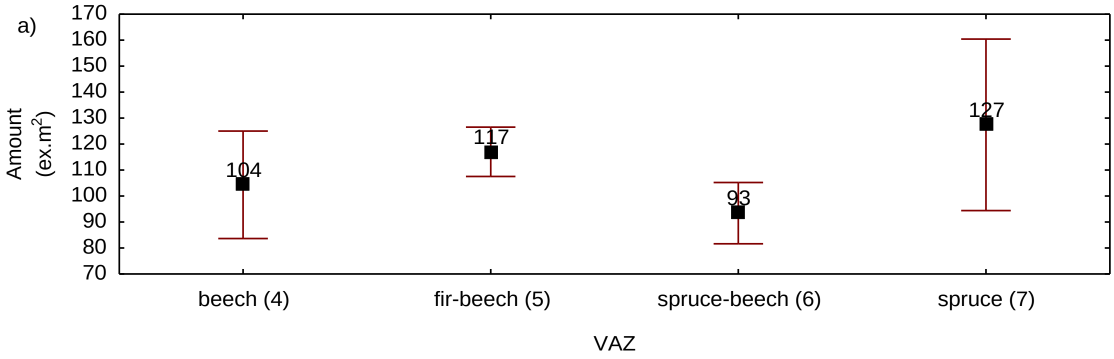


Fig.4: Abundance of Symphyla in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



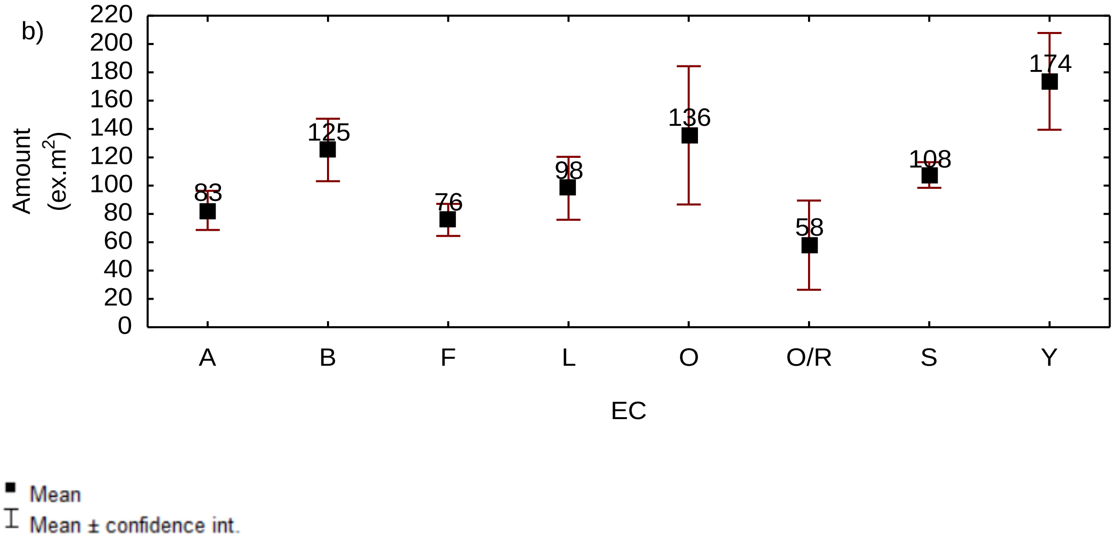


Fig.4(cont.): Abundance of Symphyla in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

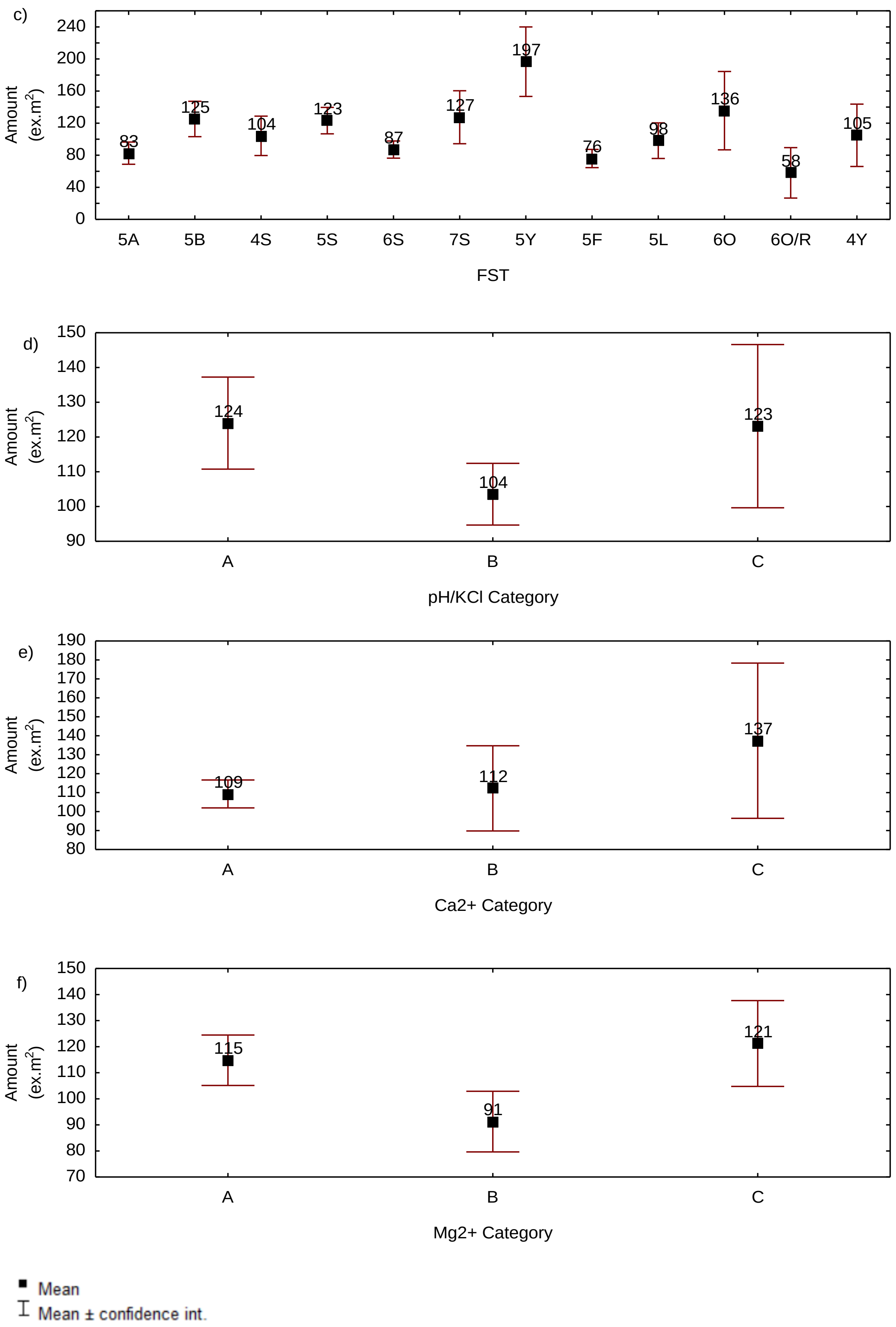


Fig.4(cont.): Abundance of Symphyla in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

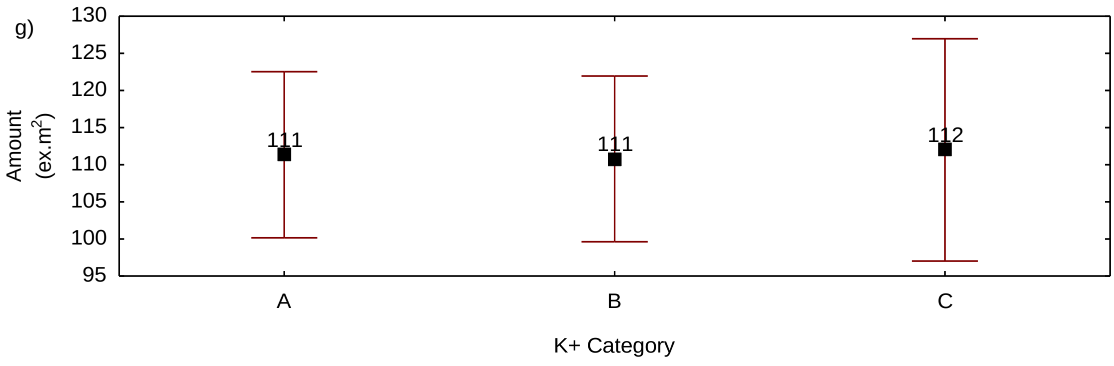
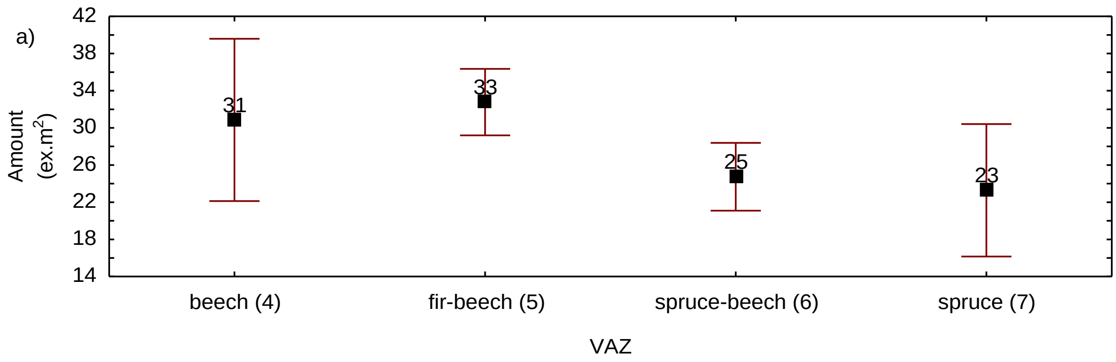


Fig.5: Abundance of Diplura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



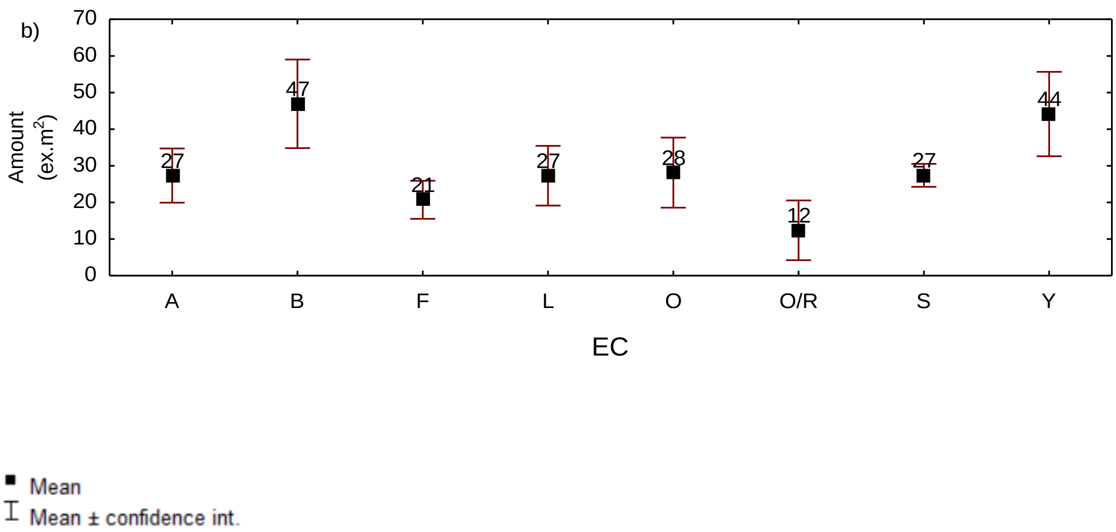


Fig.5 (cont): Abundance of Diplura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^+ g)

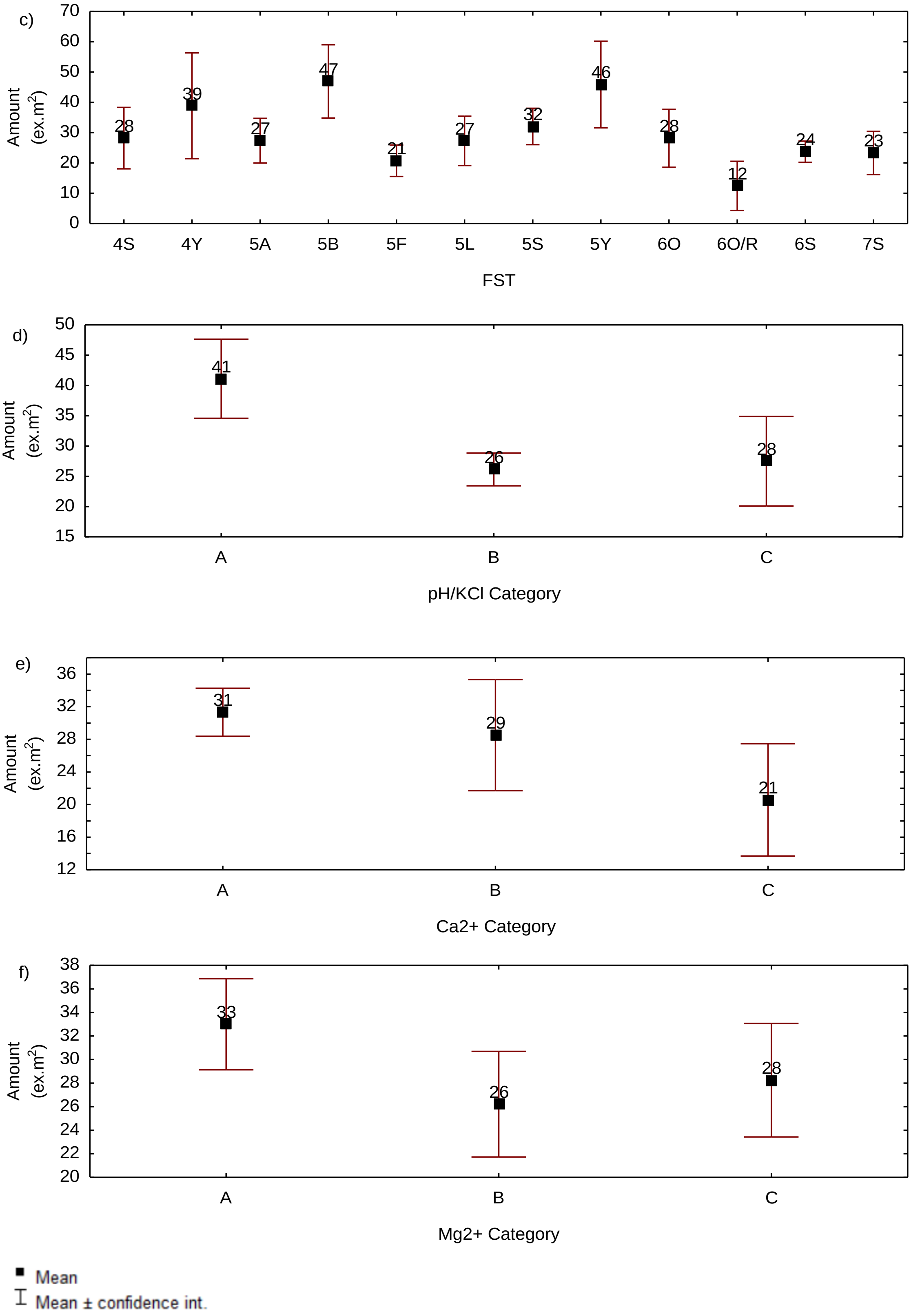


Fig.5 (cont): Abundance of Diplura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

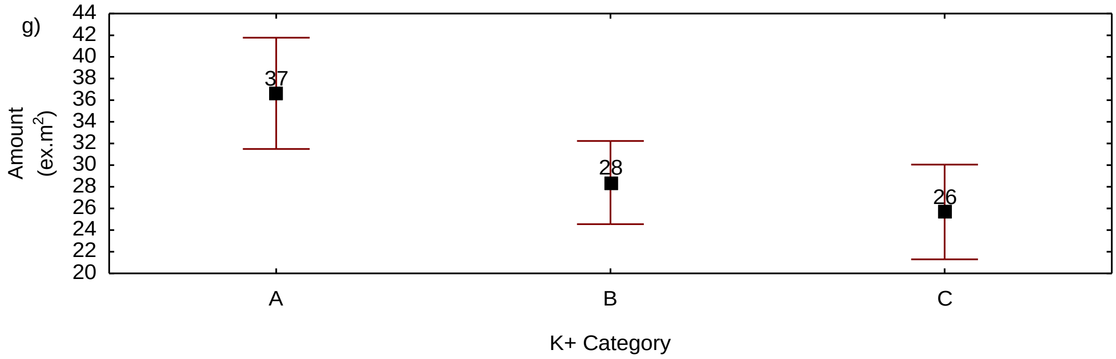
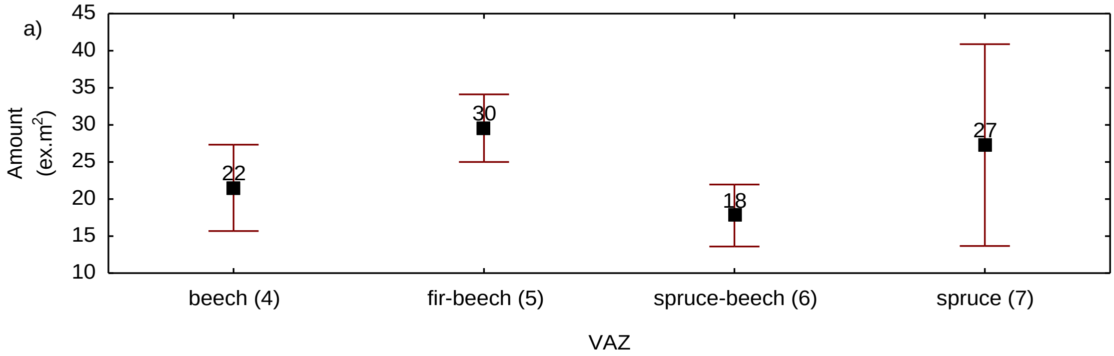


Fig.6: Abundance of Protura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



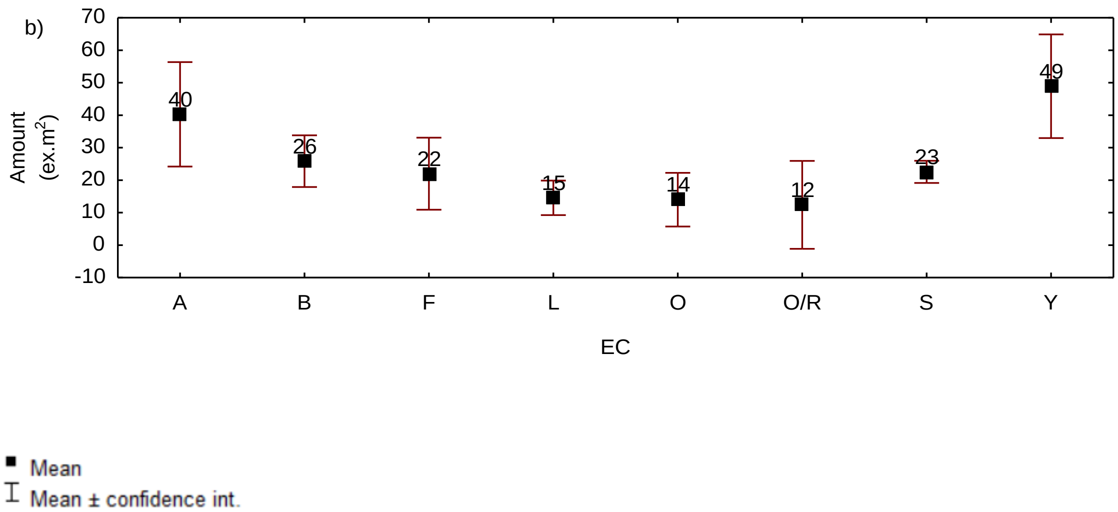


Fig.6(cont.): Abundance of Protura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

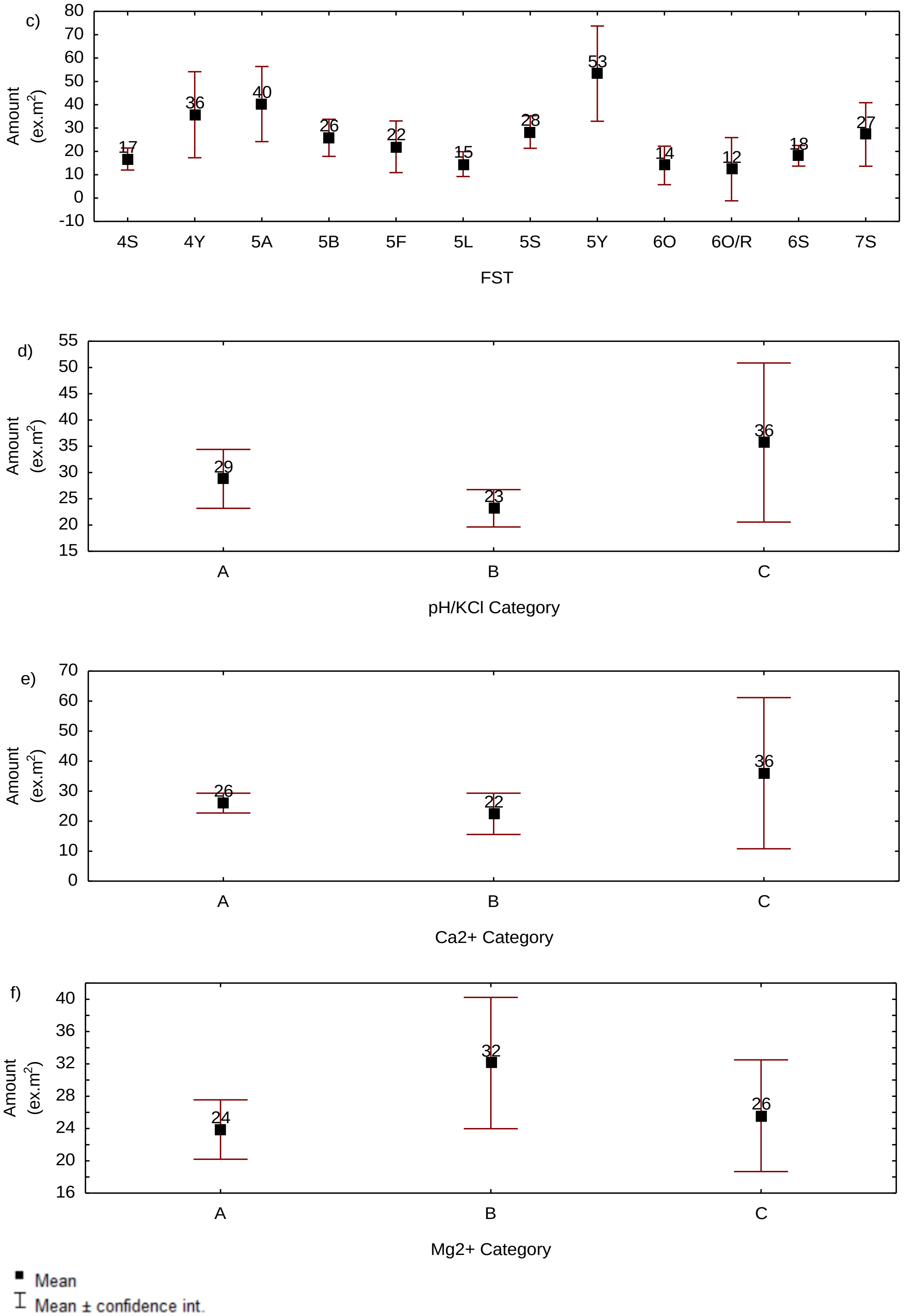


Fig.6(cont.): Abundance of Protura in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

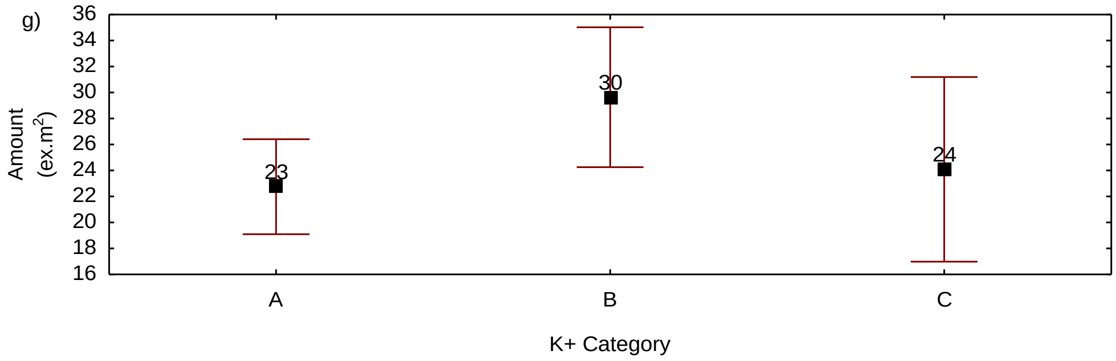
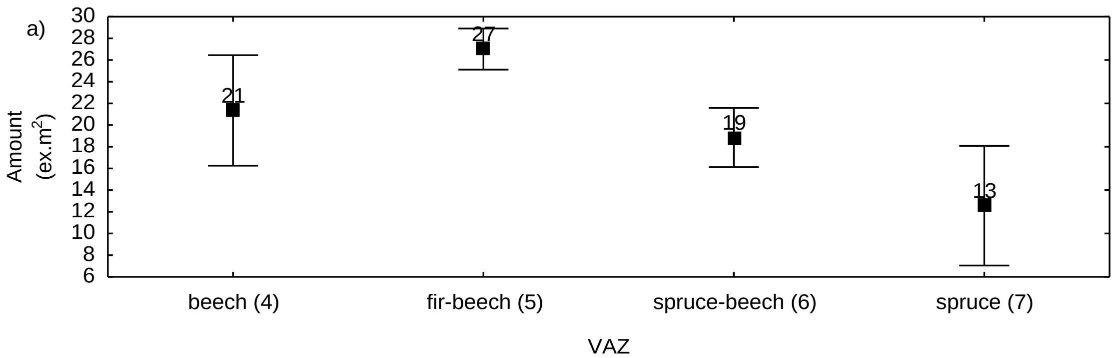


Fig.7: Abundance of Chilopoda, Diplopoda in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



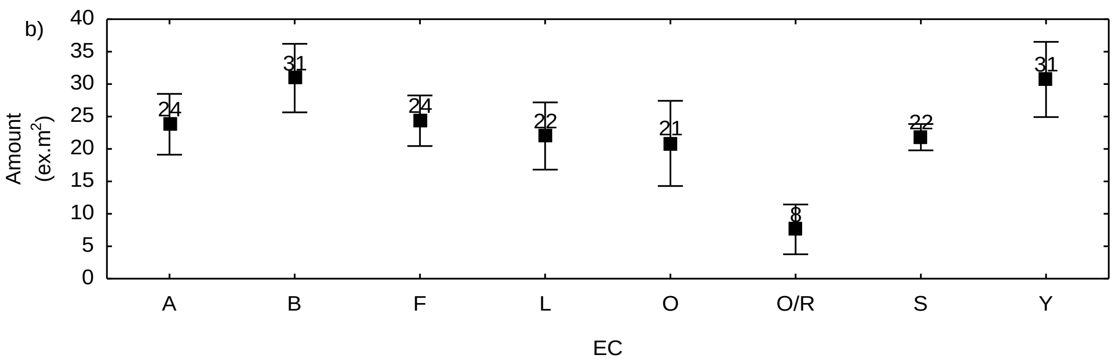


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Fig.7 (cont.): Abundance of Chilopoda, Diplopoda in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

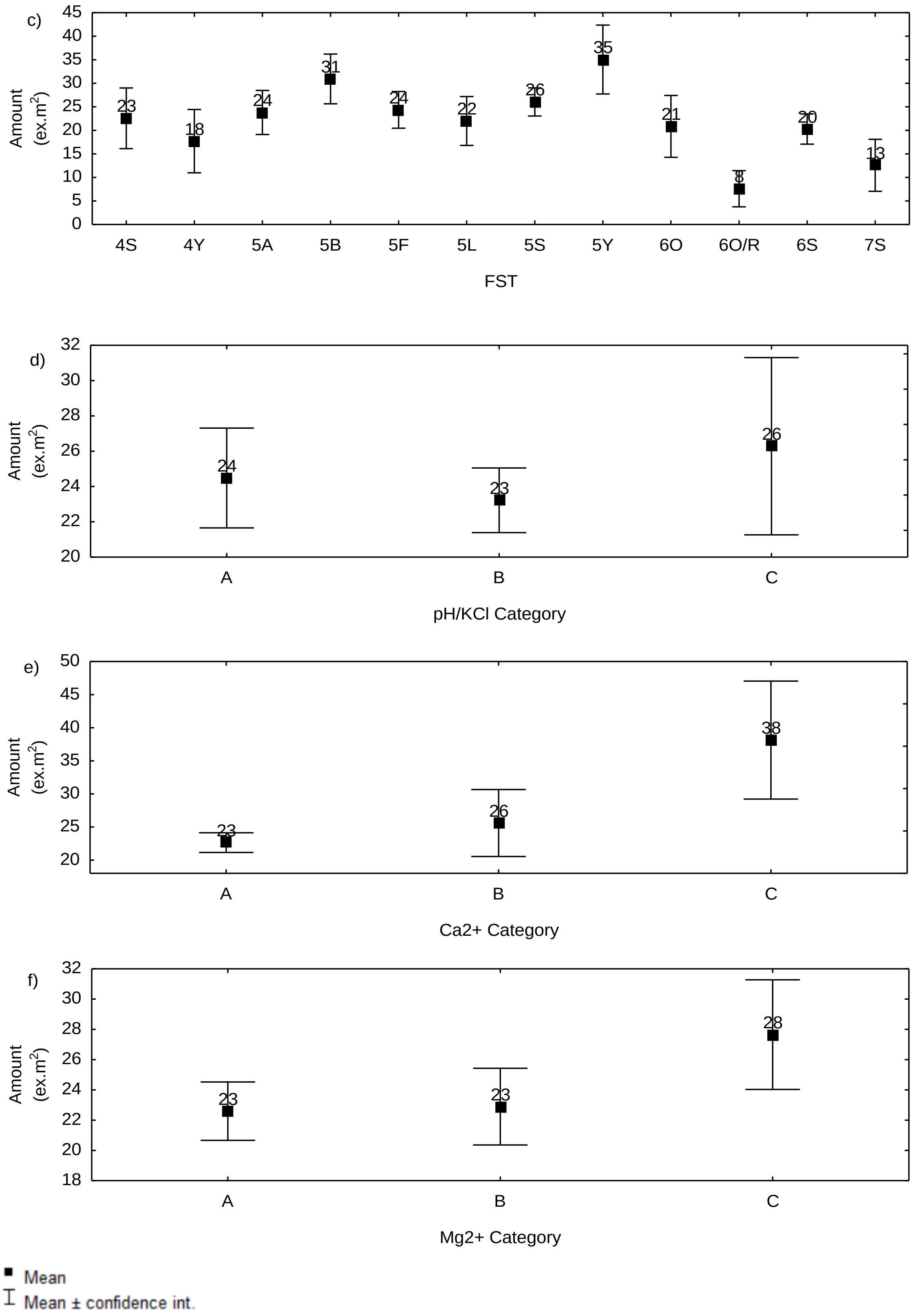


Fig.7 (cont.): Abundance of Chilopoda, Diplopoda in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

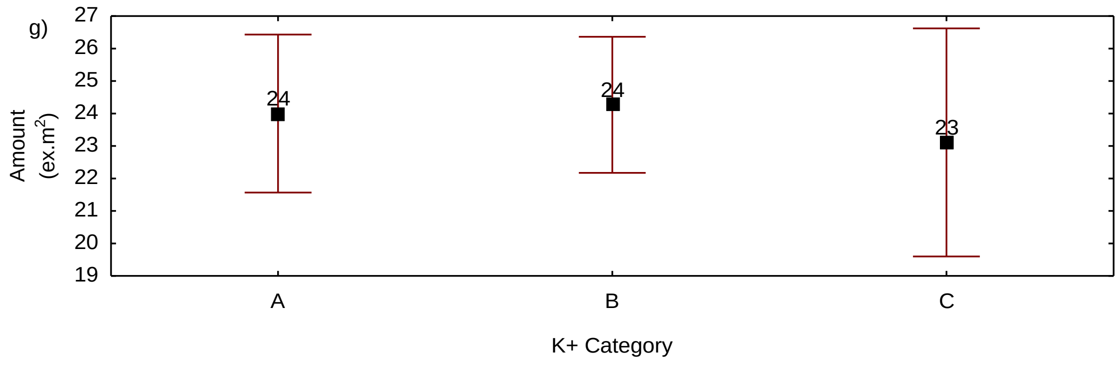


Fig.8: Abundance of Staphylinidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

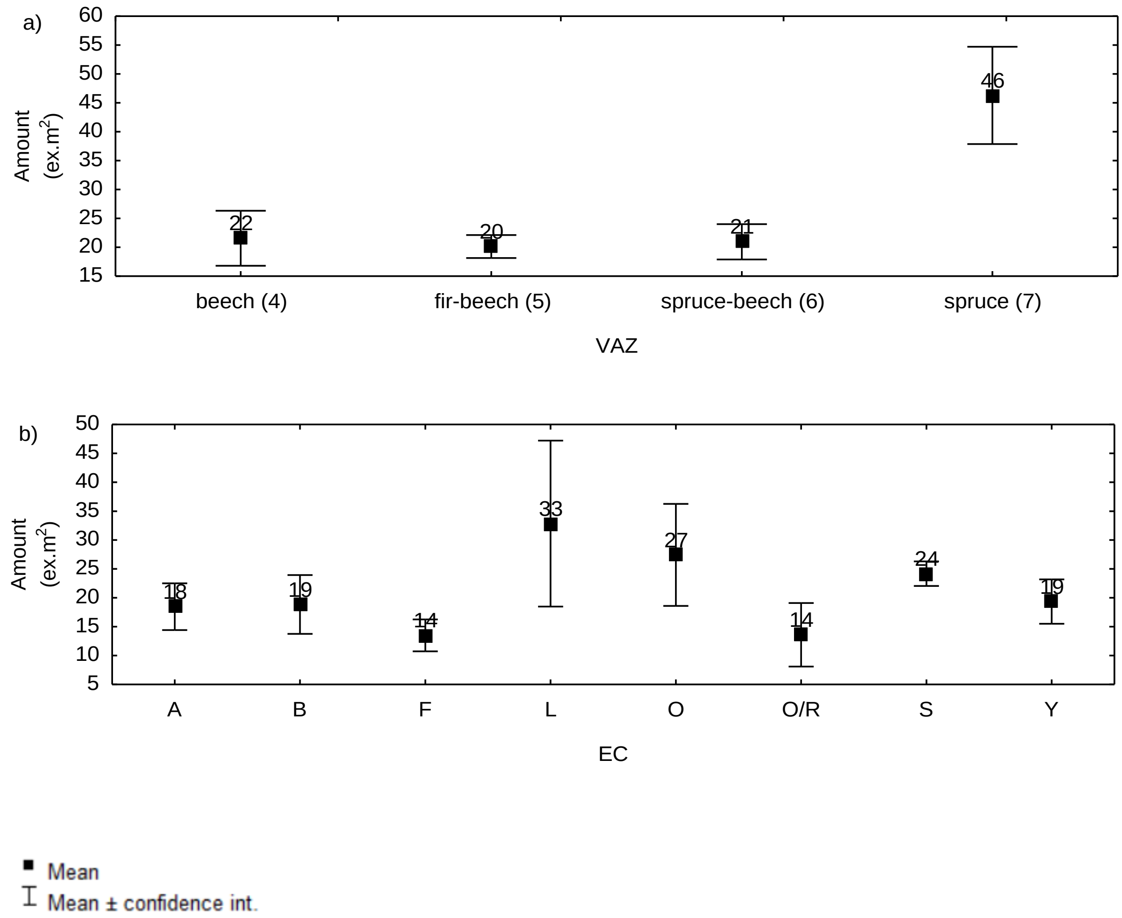


Fig.8 (cont.): Abundance of Staphylinidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

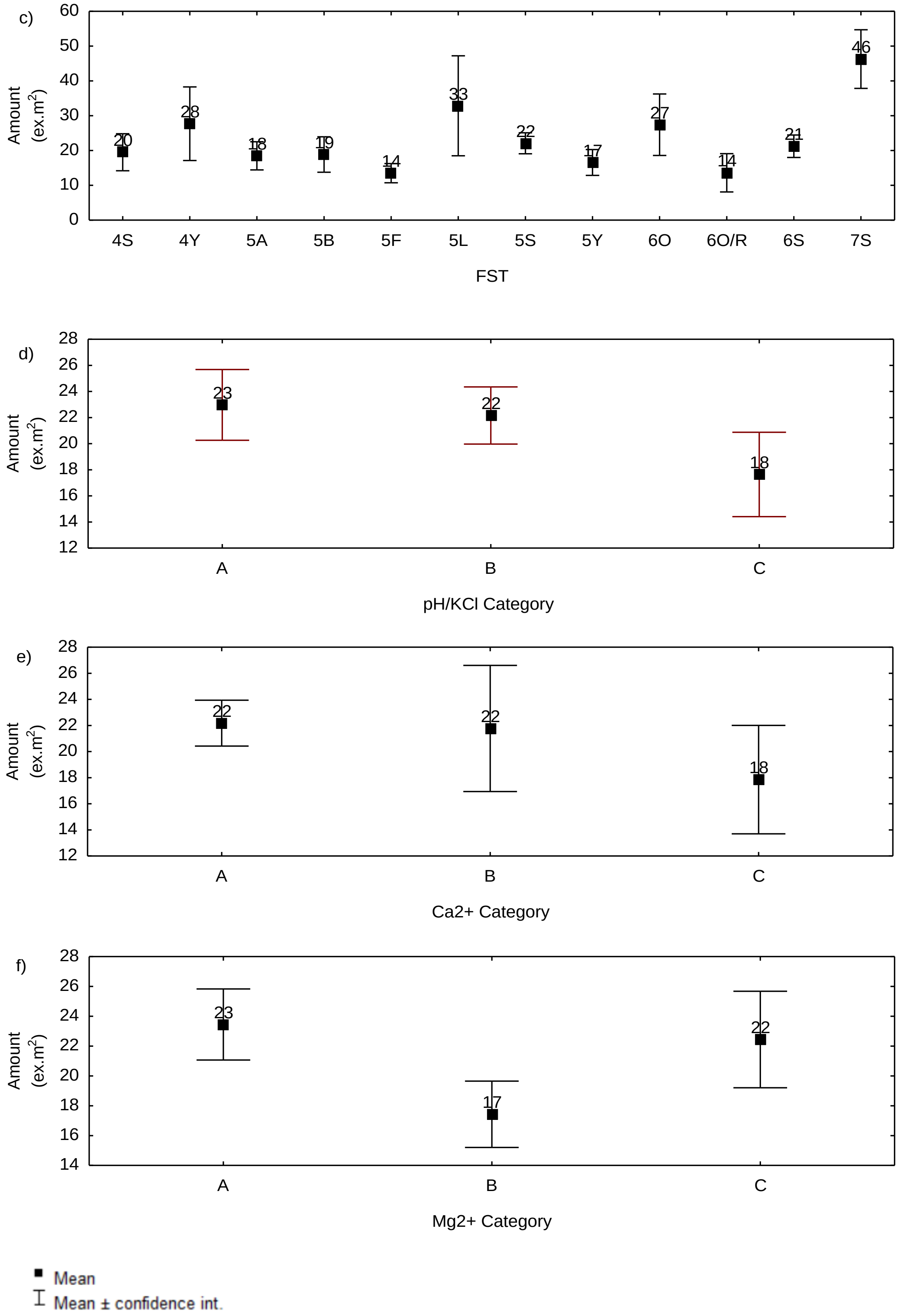


Fig.8 (cont.): Abundance of Staphylinidae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

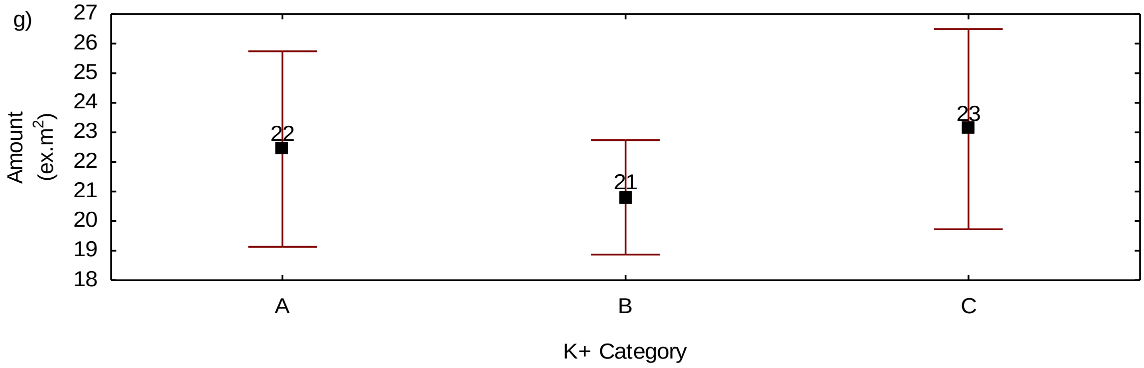
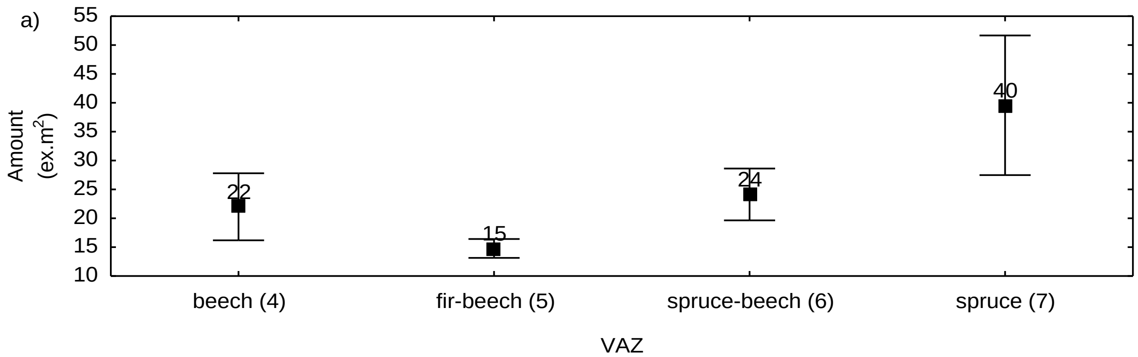


Fig.9: Abundance of Staphylinidae adults in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



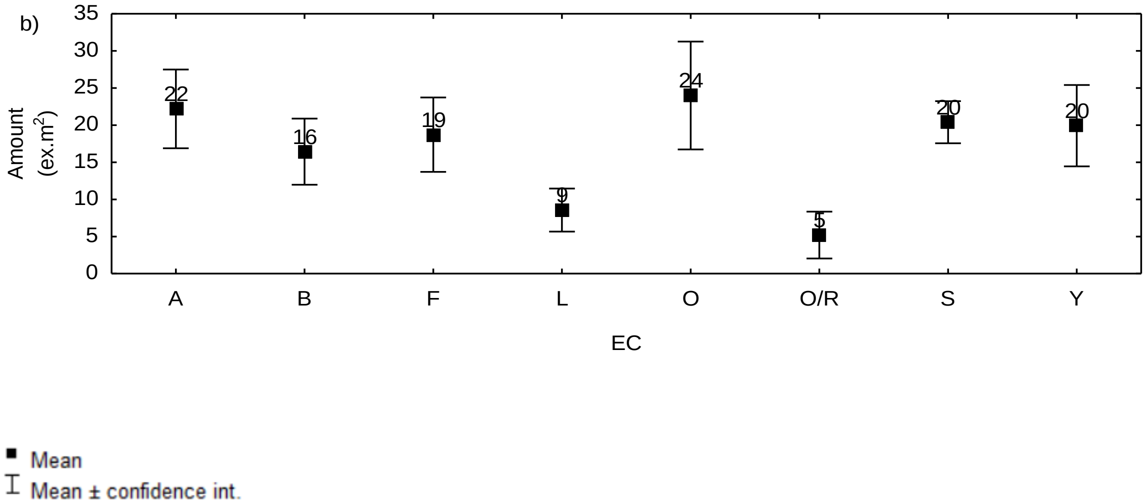


Fig.9 (cont.): Abundance of Staphylinidae adults in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^+ g)

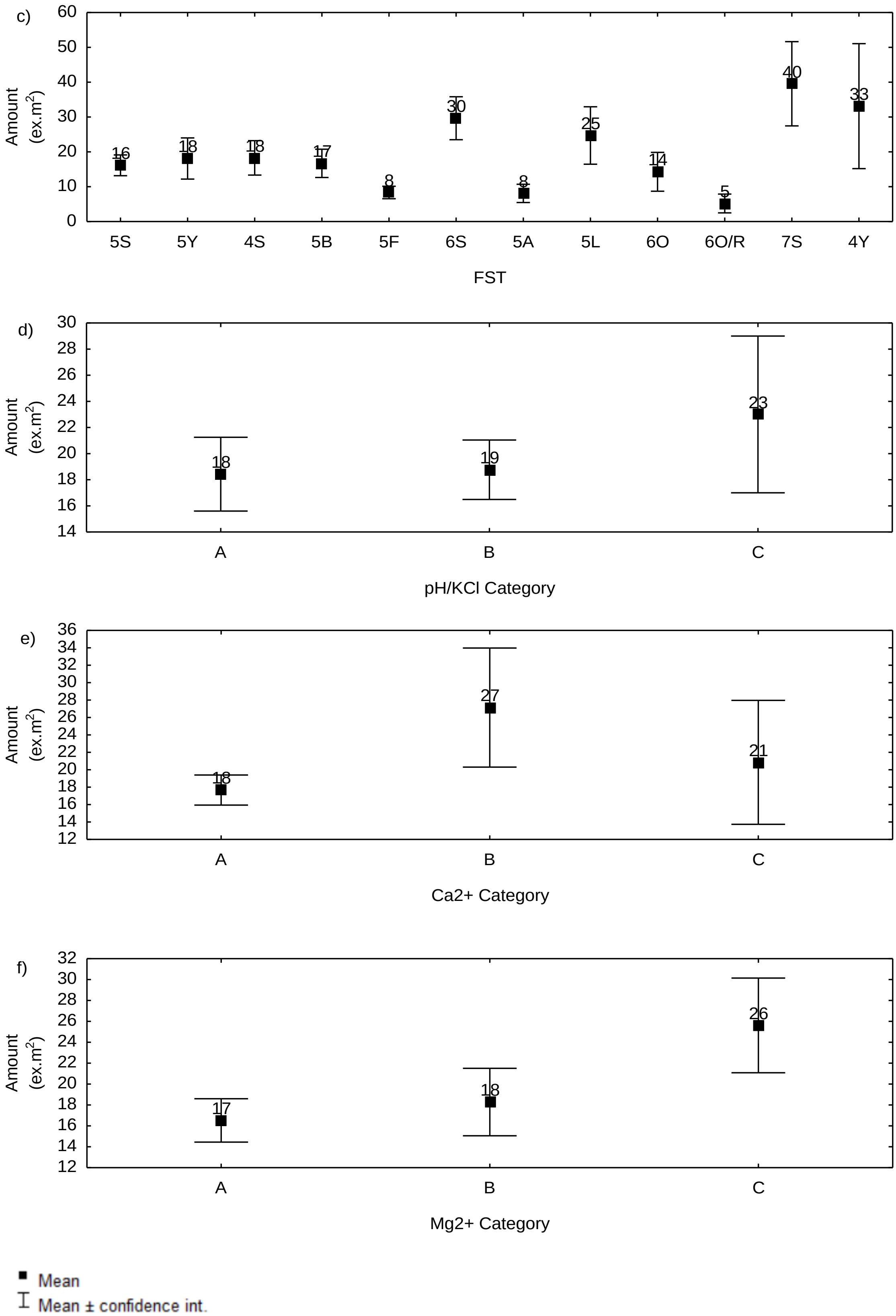


Fig.9 (cont.): Abundance of Staphylinidae adults in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^+ g)

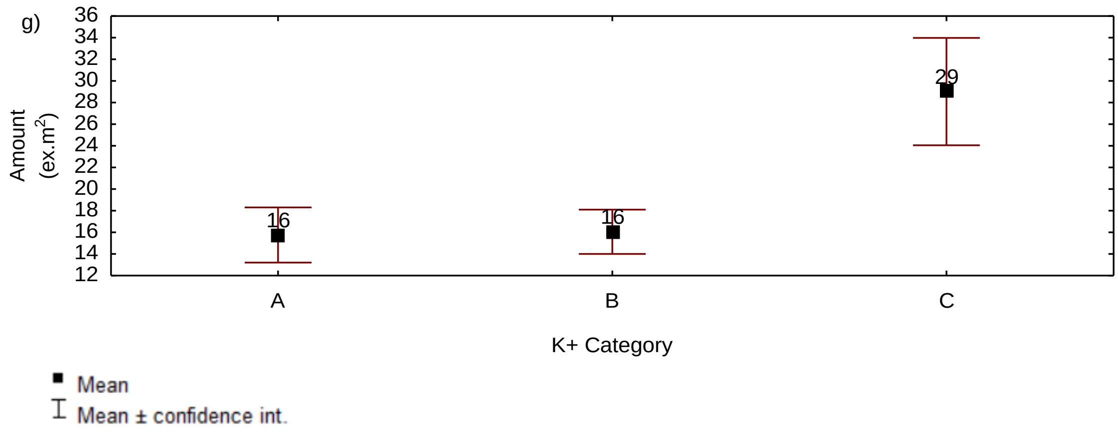


Fig.10: Projection of the variables to the factor-plane (1 x 2) for Lumbricidae

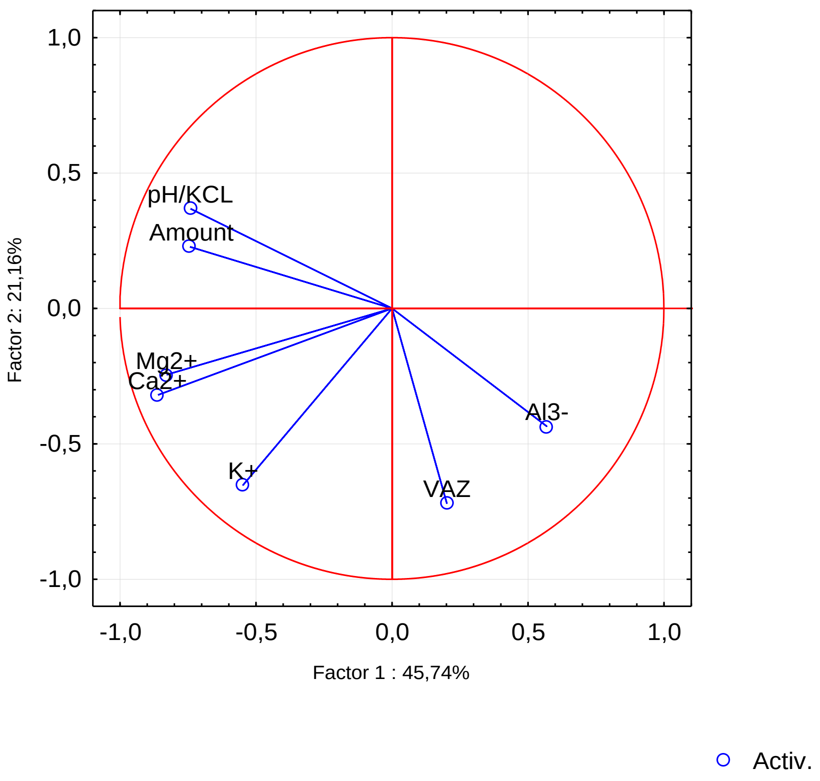


Fig.11: Abundance of Lumbricidae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

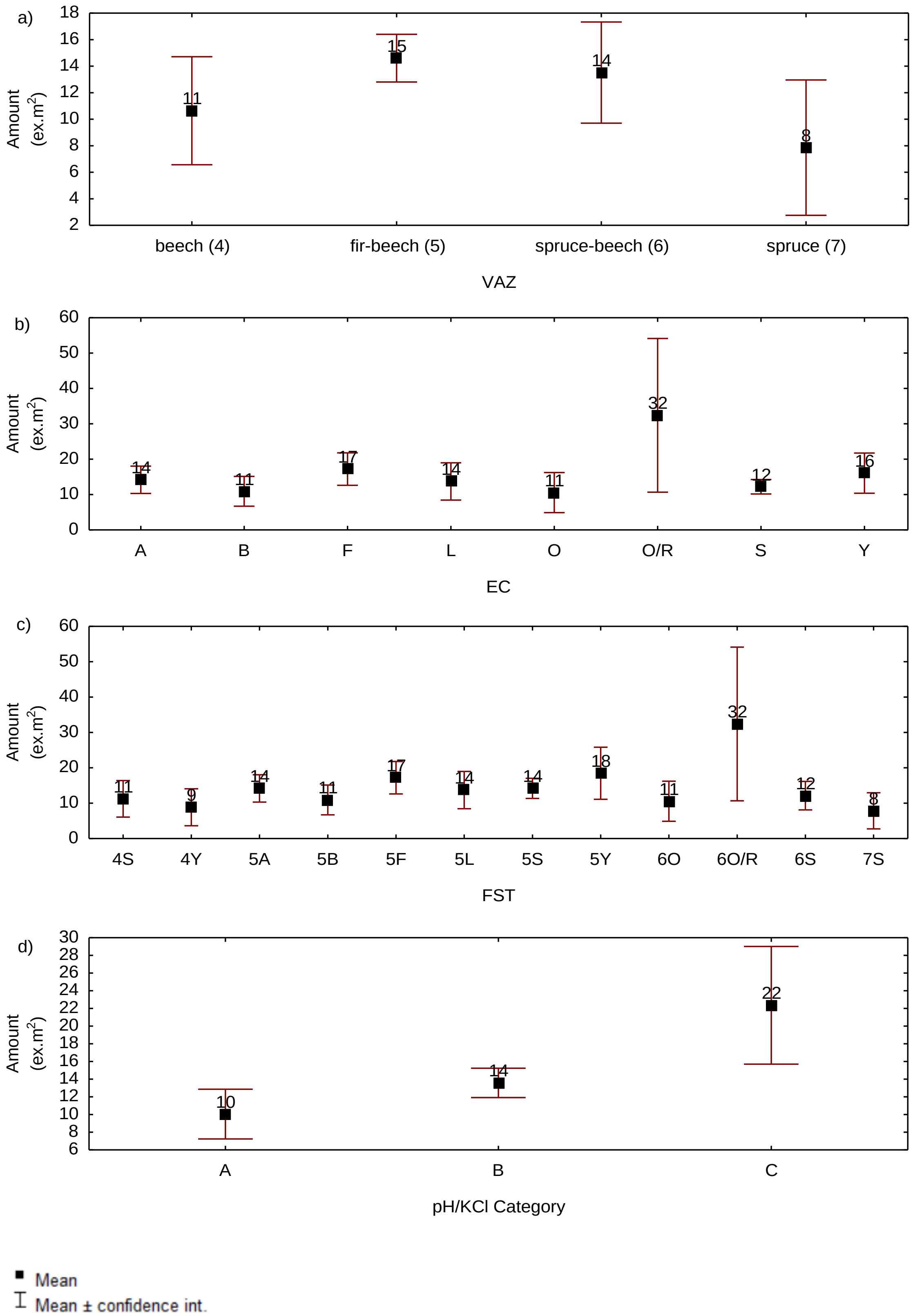


Fig.11(cont.): Abundance of Lumbricidae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

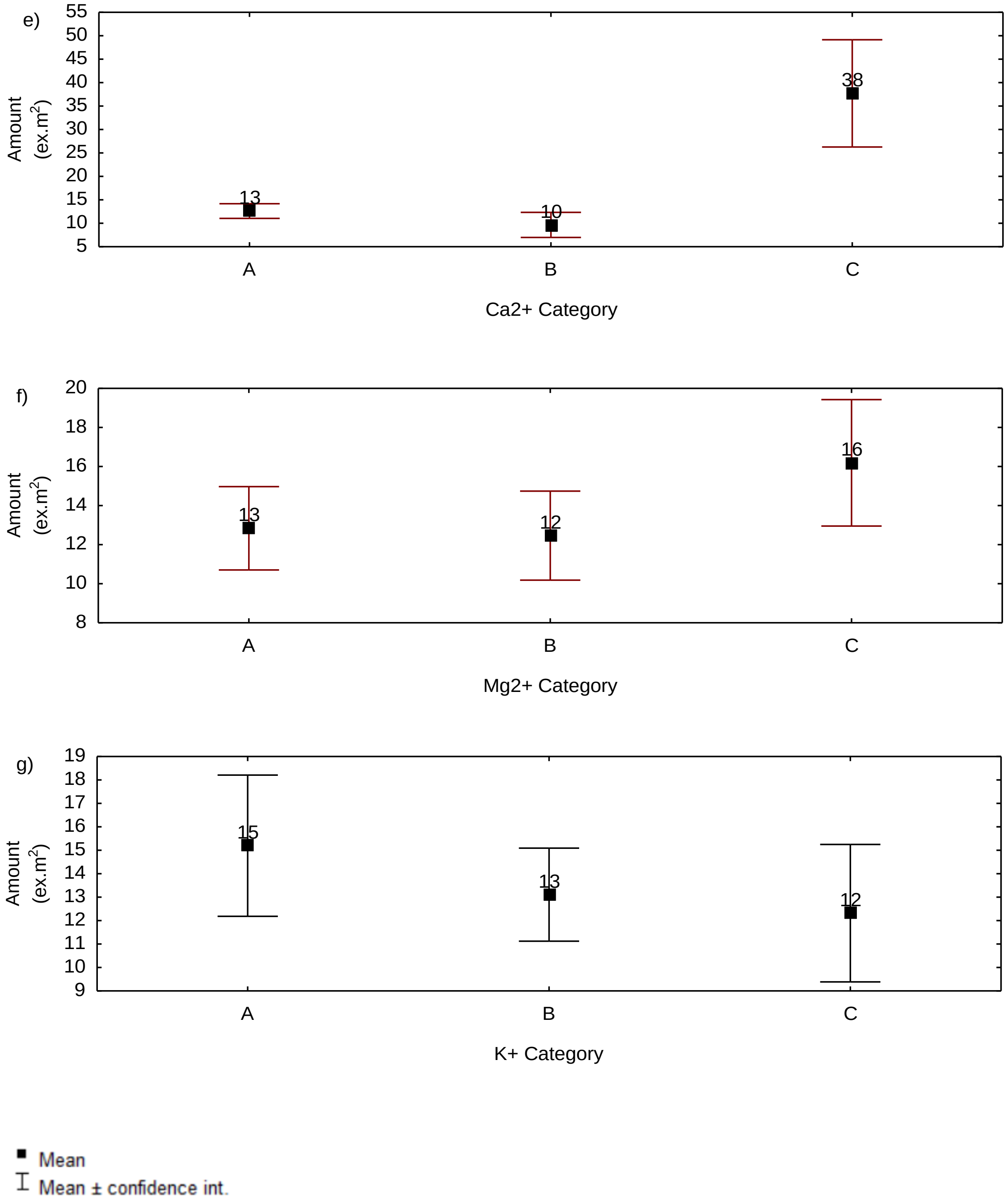


Fig.12: Projection of the variables to the factor-plane (1 x 2) for Elateridae larvae

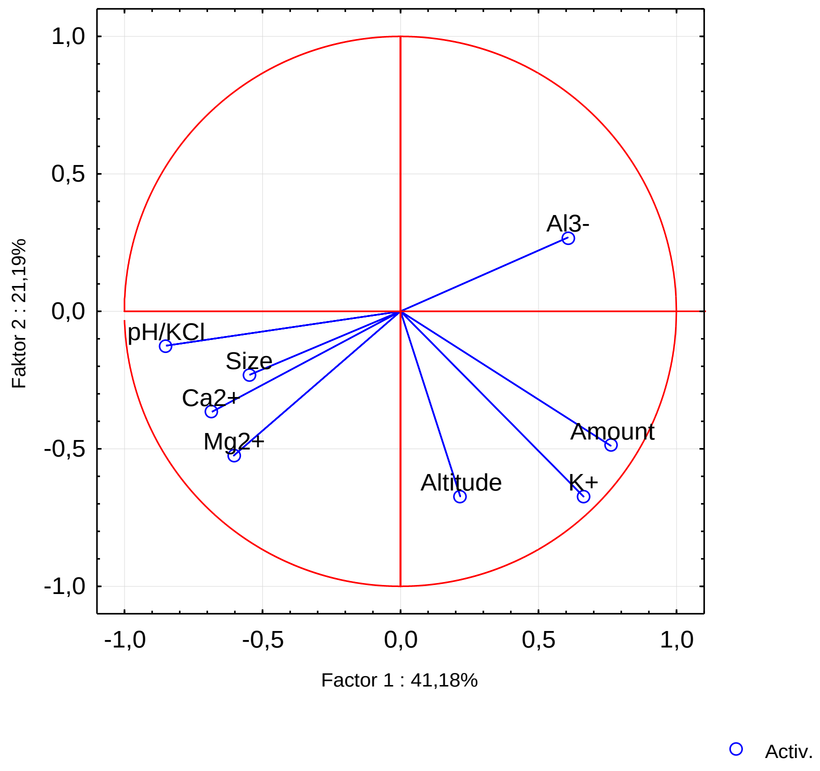


Fig.13: Abundance of Elateridae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

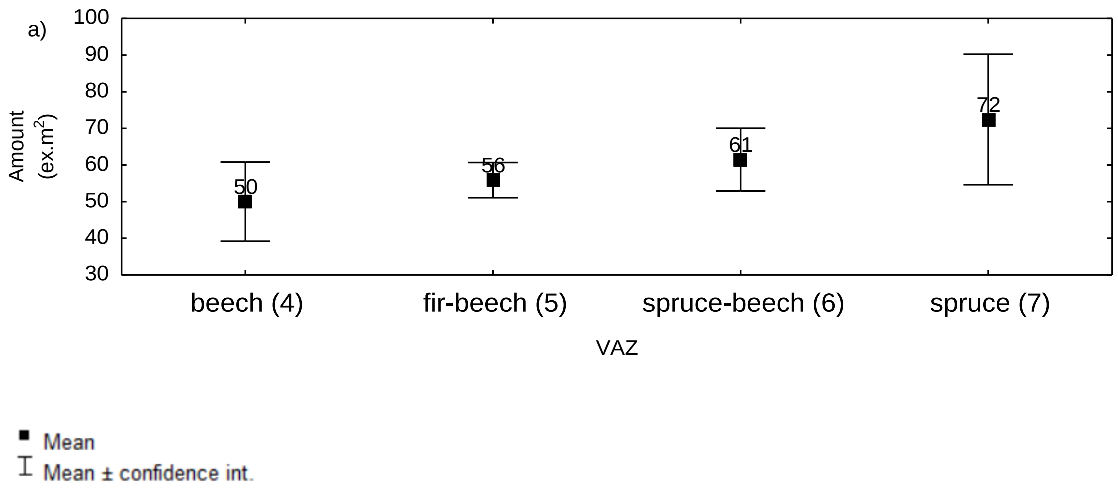


Fig.13(cont.): Abundance of Elateridae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)

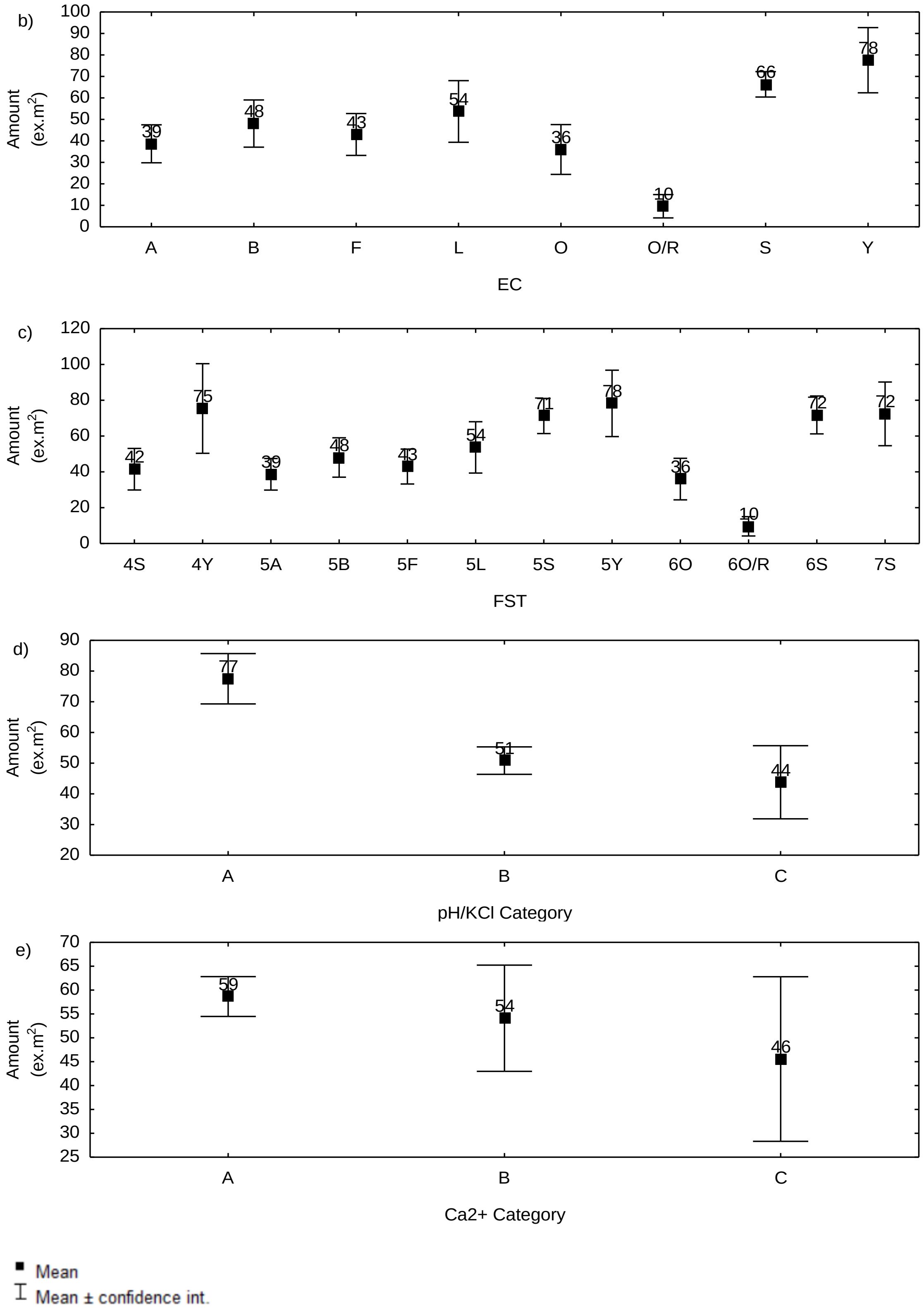
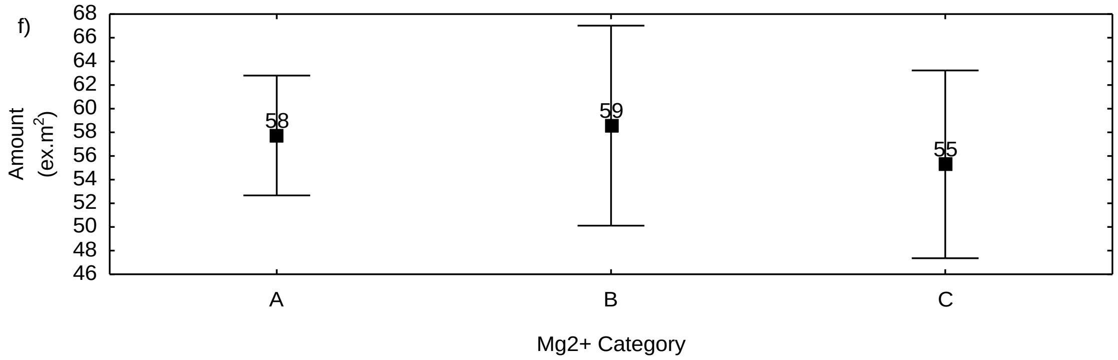


Fig.13(cont.): Abundance of Elateridae larvae in VAZ a), EC b), FST c), pH/KCl d), Ca^{2+} e), Mg^{2+} f), K^{+} g)



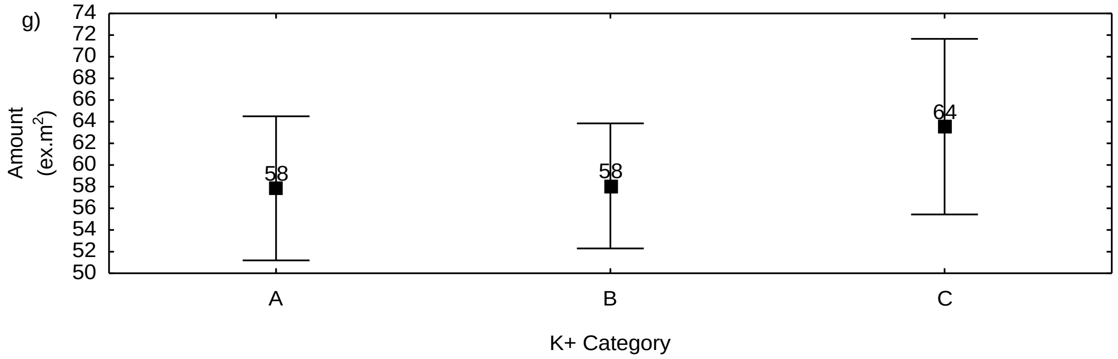


Fig.14: Tullgren