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Review Article

The family Paratylenchidae Thorne, 1949 in the rhizosphere of grass and woody species in Europe: a review of the literature

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Summary

The family Paratylenchidae (*Paratylenchus*, *Gracilacus*) belonging to the suborder Criconematina Siddiqi, 1980 including several others families: Criconematidae Taylor, 1936, Hemicycliophoridae Skarbilovich, 1959, Shaeronematidae Raski & Sher, 1952 and Tylenchulidae Skarbilovich, 1947. Members of these families are parasites of higher plants with a higher abundance in perennial cultural plants. Generally we can consider members of the suborder Criconematina as numerous, adaptable, more or less specialized plant parasitic nematodes occurring worldwide. The main common features of specimens of this suborder are relatively long and robust stylet and small body size. This combination enabled them to inhabit also very poor sites in considerable numbers where other nematodes have no chance. A stylet of *Paratylenchus* nematodes is from 10 to 40 μm of length, the *Gracilacus* nematodes from 40 to 120 μm of length. The nematodes of the genus *Paratylenchus* with shorter stylet attack and damaged the cuticular cells of host roots, however, the nematodes of the genus *Gracilacus* with the longer stylet are able to damage a deeper level of plant roots. Presented review should serve as a list and an outline of what was by some members of the genera *Paratylenchus* and *Gracilacus* previously published in connection with trees and grassland.

Keywords: Paratylenchidae; *Paratylenchus*; coniferous tree; foliaceous tree; grass; occurrence

Introduction

Andrássy (2007) integrated about 122 species to the family Paratylenchidae Thorne, 1949. In Europe, only 31 species belong to the two genera: *Paratylenchus* Mikoletzky, 1922 and *Gracilacus* Raski, 1962 are present. They are obligate ectoparasites of plants with a higher abundance in perennial cultural plants, all above grass stands (Jordan & Mitkowski, 2006; Háněl & Čerevková, 2006; Čerevková, 2006); hop gardens (Lišková & Renčo, 2007; Čermák *et al*., 2009), orchards (Erbenová, 1976) or forest trees and shelterbelts (Háněl, 2000a Wasilewska, 2004; Čerevková & Renčo, 2009). For example, the species *Paratylenchus concavus* Eroshenko, 1978 was found in the rhizosphere of 14 plant hosts belonging to 7 families (*Abies neophrolepis* Maxim., *Artemisia stolonifera* Kom., *Calamagrostis angustifolia* Kom., C. langsdorffi Trin., *Poa pratensis* L., *Potentilla* sp., *Phleum pratense* L., *Pinus silvestris* L., *Convallaria keikse* Miq., *Larix dahurica* Turcz., *Euonymus* sp., *Picea ajanensis* Fisch., *Salix* sp. (Eroshenko & Volkova, 2005). As stated Corbett (1978), in the rhizosphere of perennial plants, particularly orchards, it is possible to find an enormous population up to 250 thousand of *Paratylenchus* specimens per a litre of soil. Missing of comprehensive summary of dates from the literature, despite the common occurrence, high densities and plant parasitic potential of species of the family Paratylenchidae on many localities and host plants all over the Europe. The review can serves as complex source of information for quick orientation in the distribution, hosts range and occurrences of several species of the family Paratylenchidae on grasses, trees and shrubs. The species of *Paratylenchus* nematodes and their hosts are given in Table 1.

Occurrence of *Paratylenchus* in the rhizosphere of grass

In the nature, there are different types of grassland with many kinds of grass species covering the soil surface and the amount of grass roots to produce suitable environment for the life of soil nematodes including plant parasites. Also plant parasitic nematodes of the genus *Paratylenchus* are common members of nematodofauna of grass rhizosphere (Wasilewska, 1991; Verschoor *et al.,* 2001a; Háněl & Čerevková, 2006; Háněl, 2009). That grasses are good hosts of these nematodes is confirmed by results of Viketoft *et al.* (2005) or Viketoft (2008) as well, who

Table 1. The list of *Paratylenchus* nematode species and their occurrence (ecosystem) or preferred hosts

Species	Host (ecosystem)	References
P. arculatus	olive tree nursery	Brzeski *et al.,* 1999
	pine forest	Nguyen *et al.,* 2004
P. aculentus	pine forest	Nguyen *et al.,* 2004
P. audriellus	meadow-spruce forest	Háněl, 1992 – 1993
P. bukowinensis	meadow	Háněl & Čerevková, 2006
	birch forest	Háněl, 2000b
	fruit nurseries	Lišková *et al.,* 2007
P. ciccaronei	grassland	Talavera & Navas, 2002
	oak-poplar forest	Gomez-Barcina *et al.,* 1990
P. colbrani	pine forest	Nguyen *et al.,* 2004
P. corbetti	pine forest	Nguyen *et al.,* 2004
P. costatus	pine forest	Nguyen *et al.,* 2004
P. dianthus	pine forest	Nguyen *et al.,* 2004
P. discocephalus	pine forest	Nguyen *et al.,* 2004
P. elachistus	fruit nurseries	Lišková *et al.,* 2007
	pine forest	Nguyen *et al.,* 2004
P. epicotylus	pine forest	Nguyen *et al.,* 2004
P. goodey	meadow	Háněl & Čerevková, 2006
	lime plantation	Háněl, 2008
	apple, pear, plum, apricot, peach, quince tree nursery	Stollárová, 1999
P. hamatus	peach trees	Lownsbery *et al.,* 1974, Kotcon, 1990
	plum, prune trees	Lownsbery *et al.,* 1974
	asch, alder, elm seedlings nursery	Stollárová, 1999
P. laocaiensis sp. n	pine forest	Nguyen *et al.,* 2004
P. macrophalus	birch-alder forest	Šály, 1980
P. microdorus	grassland	Popovici, 1974; Talavera & Navas, 2002
		Háněl, 1992-1993
	meadow-spruce forest	Háněl, 1994a; Háněl & Čerevková, 2006
	meadow	Háněl,1998a
		Háněl, 2000b
	flooplain meadow	Talavera & Jiménez, 1997
	birch forest	Háněl, 1992
	olive trees	Čerevková & Renčo, 2009
	spruce forest	
	spruce-pine forest	
P. nanus	*Dactylis glomerata, Phleum pratense, Trifolium repens, Rumex acetosa* (as preffered hosts)	Viketoft *et al.,* 2005, Viketoft, 2008
	grassland	Verschoor *et al.,* 2001a
	meadow	Háněl, 1994a
	lime plantation	Háněl, 2008
	olive trees	Talavera & Jiménez, 1997
	fruit nurseries	Lišková *et al.,* 2007
	spruce forest	Háněl, 1992
P. nawadus	pine forest	Nguyen *et al.,* 2004
P. neoamblycephalus	apple, apricot, peach, plum trees	Braun & Lownsberry, 1975
P. pandatus	pine forest	Nguyen *et al.,* 2004
P. perlatus	pine forest	Nguyen *et al.,* 2004
P. projectus	meadow-spruce forest	Háněl, 1992-1993
	meadow	Háněl, 1996b
	flooplain meadow	Háněl,1998a
	oak forest	Háněl, 1994b; Háněl, 2000b
	fruit nurseries	Lišková *et al.,* 2007
P. serrcaudatus	pine forest	Nguyen *et al.,* 2004
P. sheri	oak- poplar forest, pine forest	Gomez-Barcina *et al.,* 1990
	olive trees	Talavera & Jiménez, 1997
P. similis	grassland	Talavera & Navas, 2002
	meadow	Háněl & Čerevková, 2006
P. steineri	meadow	Háněl & Čerevková, 2006
P. straeleni	meadow	Háněl & Čerevková, 2006
	oak-lime forest	Háněl,1998a
	foodplain lime-oak forest	Háněl,1998a
	foodplain hornbeam-lime forest	Háněl,1998a
	birch, alder, oak forest	Háněl, 2000b
	lime plantation	Háněl, 2008
P. veruculatus	grassland	Verschoor *et al*., 2001a
	birch, alder forest	Háněl, 2000b

found grass species *Dactylis glomerata* and *Phleum pratense* as the best hosts of *P. nanus* Cobb, 1923.
Háněl (1992 – 1993) detected three *Paratylenchus* species: *P. audriellus* Brown, 1959; *P. microdorus* Andrássy, 1959 and *P. projectus* Jenkins, 1956 during his investigation of the soil nematode communities in a meadow-spruce forest ecotone in Central Bohemia. The abundance of these nematodes decreased from meadows soil to forest soil. Talavera and Navas (2002) observed the four *Paratylenchus* species: *P. microdorus, P. similis* Khan, Prasad & Mathur, 1967*, P. nanus* and *P. ciccaronei* Raski, 1975 in the natural mountain grassland of southern Spain, where those nematodes were the most abundant and prevalent from plant parasitic nematodes found.
Háněl (1996b) studied the seasonal changes of the soil nematode communities in the eight-year-old meadow in the southern Bohemia. The dominance of *Paratylenchus projectus* with abundance of (80.1 x 10^3 ind.m^{-2}) he observed in the first years of investigation. In subsequent years, *Paratylenchus projectus* was observed as subdominant nematode species (23.3 x 10^3 ind.m^{-2}) among the plant parasites with the prevalence of the species *Filenchus vulgaris* (Brzeski, 1963) Lownsbery & Lownsbery, 1985 at abundance of 62.3 x 10^3 ind.m^{-2}.
Háněl (1997) investigated nematodes of peaty and cultivated drained meadows in the Novobystřická vrchovina highlands. The two *Paratylenchus* species: *P. dianthus* Jenkins & Taylor, 1956 and *P. veruculatus* Wu, 1962 were found. The population densities of *Paratylenchus* nematodes tended to increase in drained soils which agree with the results of Wasilewska (1991a, 1991b) in Poland. A maximum abundance of these nematodes (19.1 x 10^6 ind.m^{-2}) was observed at 50.3 % soil moisture content. However, Wasilewska (2006) stated, that increasing effect of drainage on *Paratylenchus* nematodes is only temporal (first 10 years after draining) followed by a decreasing trend during the course of succession.
As stated Verschoor *et al.* (2001a) in the study about the changes in the composition of plant parasitic nematodes after cessation of fertilizer, the presence and number specimens of several *Paratylenchus* nematode species in grassland depends on nutrient content. In the grassland rich in nutrient (6 years after cessation of fertilization) the *P. nanus* species dominated and later was completely missing, however species *P. veruculatus* reached maximum abundance 23 and 28 years after the end of fertilization in the nutrient-poor sites.
Soil nematode community structure on meadows in the Biosphere reserve Pálava was studied by Háněl (1998a) and found the two *Paratylenchus* species: *P. microdorus* in floodplain meadows (oaM) with dominance *Carex gracilis*, *Phalaris arundinacea* and *Thalictrum flavum* at abundance 1 x 10^3 ind.m^{-2}, *P. projectus* in floodplain meadows (oaM) at abundance 1 x 10^3 ind.m^{-2} and on anthropogenic destroyed locality with weedy vegetation (hdM) with dominance of *Poa palustris*, *Ranunculus repens*, *Alopecurus pratensis*, *Potentilla reptans*, *Inula britanica* and *Cirsium arvense* at abundance 1 x 10^3 ind.m^{-2}.
The species *P. curvitatus* Van der Linde*,* 1938; *P. microdorus; P. projectus* Jenkins, 1956*; P. neoamblycephalus* Geraert, 1965; *Gracilacus acicula* Brown, 1959 (Raski, 1962) recorded Popovici (1974, 1993, 1998) and Ciobanu *et al.* (2003) from grassland in Romania. The nematodes of the genera *Paratylenchus* dominated in alpine grassland (*Violo declinatae-Nardetum* and *Primulo-Caricetum curvulae*), subalpine and mountainous grasslands as well (Popovici & Ciobanu, 2000). But, their dominance were also found in undegraded, degraded and improved grassland with the dominance of *Aneurolepidium chinense*, *Arundinella hirta*, *Spodiopogon sibiricus, Phragmites communis, Hemarthria japonica, Adenophora tetraphylla* in Northeast China (Liang *et al.,* 2007).
The highest number of *Paratylenchus* nematode species in grass stands was found by Háněl and Čerevková (2006), during the investigation of eleven meadows in the White Carpathian, Czech and Slovak part. Seven species were identified there: *P. bukowinensis* Micoletzky, 1922 (Dominance = 0.78 %, Frequency of occurrence = 23.53 %), *P. goodeyi* Oostenbrink, 1953 (D = 0.04 %, F = 5.88 %), *P. microdorus* (D = 0.09 %, F = 5.88 %), *P. similis* (D = 0.02 %, F = 5.88 %), *P. steineri* Golden, 1961 (D = 0.33 %, F = 23.53 %), *P. straeleni* (de Coninck, 1931) Oostenbrink, 1960 (D = 0.16%, F = 5.88 %) and *P.* spp. (D = 0.04 %, F = 5.88 %). The presence of *P. straeleni* in meadows was confirmed also by Háněl (2003b) although this species prefer forest habitats (Brzeski, 1998).

Occurrence of *Paratylenchus* in the rhizosphere of foliaceous trees

As Yeates and Bongers (1999) wrote, forest soils have different quantity and quality of organic material over mineral soil, and various organic mineral horizons have different physical, chemical and biological properties, which affect the nematode occurrence. However, the type of trees, overground vegetation in forest or changes in forest vegetation (management, natural changes) influenced the nematode presence as well.
During the study of nematodofauna of forest ecosystems in the Biosphere reserve Pálava Háněl (1998a) identified the nematode species *P. streaeleni* at four localities - oaM (1 x 10^3 ind.m^{-2}); in floodplain oak-lime forest on alluvial plain, drained without stream (olF) (6 x 10^3 ind.m^{-2}) with the dominance of *Quercus robur*, followed by *Tilia cordata*, *Fraxinus angustifolia* and *Loranthus europaeus* with rare undergrowth of *Impatiens parviflora* and *Urtica dioica*; in floodplain lime-oak forest on alluvial plain, medium drained and permanently flooded (35 x 10^3 ind.m^{-2}) with the dominance of *T. cordata* followed by *Q. robur* and *Acer campestre*; in floodplain hornbeam-lime forest on alluvial plain permanently strongly flooded (1 x 10^3 ind.m^{-2}) with the dominance of *Carpinus betulus* followed by *T. cordata*, *F. angustifolia* and *Q. robur.*
The nematodes of the species *Paratylenchus* were also found in the soil of *Quercus rubra* L., the covered by dry leaves without undergrowth in abundance 20 x 10^3 ind.m^{-2}

and in the soil with *Alnus glutinosa* growth, undergrowth of *Calamagrostis villosa* (Chaix) Gmel., *Aegopodium podagraria* L., *Artemisia vulgaris* L., *Sonchus* spp. and *Rubus* spp. in the abundance of 10 x 10^3 ind.m^{-2} (Háněl, 2003a) These findings are in agreement with results of Wasilewska (2004) obtained during the examination of soil samples from 170 years old windbreak of *Robinia pseudoakacia* and *Quercus* spp. with unlisted undergrowth around the maize fields. She found that nematode abundance of *Paratylenchus* in this ecosystem was 100 x 10^3 ind.m^{-2}. Opposite, in the 6-year-old windbreak characterized by occurrence of 10 woody species and a high species diversity of grasses was the abundance of the *Paratylenchus* nematodes less than 50 x 10^3 ind.m^{-2}.

In the Slovak Republic Šály (1980) found in soil samples collected from 60-year-old birch-alder forest the species *Paratylenchus macrophallus* (De Man, 1880) Goodey, 1934 with occurrence during whole year. The species *Paratylenchus projectus* (0.2 x 10^3 ind.m^{-2}) was found in the oak forest with the dominance of *Quercus robur* L. and rare occurrence of *T. cordata* Mill., *Fraxinus excelsior* L., *Picea abies* (L.) Karst., *Acer pseudoplatanus* L. and *Fagus silvatica* L. with undergrowth of *Oxalis acetosella* L., *Sanicula europaea* L., *Viola reichenbachiana* Jord. and *Veronica chamaedrys* L. (Háněl, 1994b). Gomez-Barcina *et al.* (1990) recorded the occurrence of *P. ciccaronei* and *P. sheri* (Raski, 1973) Siddiqi, 1986 in the soil around the root of *Quercus rotundifolia* Lam. and *Populus nigra* L. in southeastern Spain. The species *P. sheri* they also found in the root rhizosphere of *Q. faginea* Lam., *Rosmarinus officinalis* L. or coniferous tree (see next capture).

In the State Natural Reserve Jeseníky two species *P. nanus* and *P. microdorus* were identified by Háněl (1994a). The highest abundance (184 and 189 ind. x 10^3 ind.m^{-2}) of *P. microdorus* on two localities was found. The first locality was characterized as the meadows communities of Thesio alpini-Nardetum with the occurrence of *Nardus stricta* L., *Anthoxanthum odoratum* s.l., *Crepis conyzifolia* (Gouan) Kern, *Viola sudetica* (Willd.) Becker, *Potentilla aurea* L., *Rhinanthus pulcher* Schummel, *Thesium alpinum* L., 1425 m.a.s.l.. The second locality was characterized as Salici silesiaceae-Betuletum carpaticae, birch wood on moraine with dominant shrubs *Betula carpatica* W. et K. in undergrowth of *Calamagrostis* spp., *Luzula* spp., *Vaccinium myrtillus* L., 1125 m.a.s.l.. The species *P. nanus* was found only at one locality of Festuco supinae-Vaccinietum myrtili plant community, dominance of *Vaccinium myrtillus* L., *Festuca supina* Schur, *Calamagrostis villosa* (Chaix) J. F. Gmel. and *Deschampsia flexuosa* (L.) Trin., 1350 m.a.s.l.

The five *Paratylenchus* species were isolated by Háněl (2000b) from alder (AF), birch (BF) and oak (OF) during the investigation of soil nematodes in south and western Bohemia, the Czech Republic. The species *P. bukovinensis*, *microdorus, straeleni* and *verculatus* occurred in the BF, *P. straeleni* and *verculatus* in the AF and *P. projectus* and *straeleni* in the OF. Pavljuk (1983) also recorded the occurrence of *P. straeleni* in the soil of *Betula pendula* wood near Moscow. As stated Háněl (2000b) the species *P. straeleni* is probably a typical species of soil fauna under *Betula pendula* because it occurs numerously in birch rhizosphere of wet as well as dry soils in South Bohemia. It corresponds to our results, where the species *P. straeleni* dominated from phytophageous nematodes in the wet birch wood of Slovak and the Czech Republic (unpublished data). Also Boag (1974) observed high population densities of *Paratylenchus* species in the *Quercus* spp. rhizosphere in Scotland.

The presence of four *Paratylenchus* species was confirmed by Háněl (2008) also in the tree plantations on colliery soil near Sokolov. The species *P. goodeyi, P. nanus* and *P. straeleni* were found only in soil with (T) *T. cordata* growth. The species *P. similis* was observed only on locality with a spontaneous succession of *Salix caprea*, *Populus tremula* and *Betula* spp. The species *P. nanus* is probably more resistant to stress and competition because it was found on all investigated localities. The length of stylet of *P. nanus* is 28.5 µm (23 – 34 µm) (Brzeski, 1998) seems to be optimal to attack a wide range of the host plants, similar to several others potentially wide occurrence ectoparasitic nematode species: *Rotylenchus goodeyi* Loof and Oostenbrink, 1958 - 31µm (28.5 – 35 µm), *Rotylenchus robustus* (de Man, 1876) Filipjev, 1936 – 34 µm (32 – 38 µm), *Helicotylenchus varicaudatus* Yuen, 1964 – 28 µm (25 – 33 µm) or *Helicotylenchus vulgaris*, Yuen, 1964 – 31 µm (27 – 34 µm). Each of these plant parasitic nematodes has very similar characteristics such as length of stylet, rare or absent male occurrence or parthenogensis and was found separately or in different combinations on soil samples. Yeates (1986) indicated the length of stylet as decisive factor for determination of food niches. This is the reason why the food niches at nematodes with a similar length of stylet are overlapped. However, the different body size of *Paratylenchus* compared to *Helicotylenchus* or *Rotylenchulus* nematodes and partially different form of root attack (*Paratylenchus* – ectoparasite vs. *Rotylenchus* and *Helicotylenchus* - ecto to semiendoparasite) can by the reason for co-existence of these nematodes in high abundance.

Nyczepir and Halbrendt (1993) considered the species of the genus *Paratylenchus* as pests of several fruit trees with the possibility of damage of their root systems. For example, Braun and Lownsberry (1975) observed the species *Paratylenchus neoamblycephalus* in the root rhizosphere of apple trees, apricot and peach trees or herbs and head of specimens of this species was found a deep in root of plums. The root systems of infested plum seedlings were reduced, darker and smaller. Lownsbery *et al.* (1974) recorded *P. hamatus* Thorne & Allen, 1950 as parazitized peach, plum and prune trees, reducing vigour and yield.

Brzeski *et al.* (1999) found the species *Paratylenchus arculatus* Luc & Guiran, 1962 in the soil sample from olive tree nursery in the south of Spain. The population density varied from 0.03 to 2.49 of nematode per cm^3 of soil. During the examination of olive root the author found a lot of females on olive trees roots. Talavera and Jiménez

(1997) recorded the presence of *Paratylenchus* nematodes in the olive trees root rhizosphere in Alhama region (south-eastern Spain). Specifically, they were a species *P. microdorus, P. nanus* and *P. sheri.* The soil around the root of fig trees was highly infested *Paratylenchus* sp. as well (Abrantes *et al.,* 2008).
Stollárová (1999) recorded the species *P. goodeyi* in the Slovak fruit nurseries with dominance seedling of *Malus nitis* (apple)*, Pyrus communis* (pear)*, Prunus domestica* (plum)*, Persica vulgaris* (peach)*, Armeniaca vulgaris* (apricot) and *Cydonia oblonge* (quince). The species *P. hamatus* in the *Fraximus excelsior* (ash), *Alnus glutinosa* (alder) and *Ulmus laevis* (elm) seedling nurseries she found. Lišková *et al.* (2007) found the *Paratylenchus bukowinensis*, *P. nanus, P. projectus* and *P. elachistus* Steiner, 1949 in fruit orchards of the Danube Lowlands and East Slovak Lowland without giving trees species.

Occurrence of *Paratylenchus* in the rhizosphere of coniferous trees

In the Czech Republic, the nematodes of the genus *Paratylenchus* were isolated from the soil samples collected from the root rhizosphere of trees, shrubs and grass where are many times dominant. For example, Háněl (1998b) during the study of micorrhizal and nonmicorrhizal communities of spruce trees in Boubín Mount found a frequent colonization of spruce roots by *Paratylenchus* nematodes. Their abundance had an increasing tendency from micorrhizal (14.36×10^3 ind.m^{-2}) to nonmicorrhizal (108.29×10^3 ind.m^{-2}) spruce roots, however, on micorrhizal roots the highest frequency of occurrence of the *Paratylenchus* nematodes was observed. As stated Háněl (1995), the nematodes of the genus *Paratylenchus* are on the fifth place in the abundance in the Czech spruce forest with an average abundance (35.7×10^3 ind.m^{-2}).
The most found species of the genus *Paratylenchus* in the Czech spruce forest are *P. nanus* and *P. microdorus* (Háněl, 1992; Háněl, 1996a). This confirms also the results from two soil samples collected from Protected Lanscape Area Beskydy where *P. nanus* dominated (Háněl, 1992). One of the soil samples was collected from a 105-year-old spruce forest with shrubs layer of *Picea abies* L., and *Betula pubescens* Ehrh., herb layer of *Rubus ideaeus* L., *Luzula silvatica* (Huds.) Gaud., *Calamagrostis villosa* (Chaix) Gmel., *Vaccinium myrtillus* L. and *Avenella flexuosa* (L.) Parl.. The second soil sample was collected from a 5-year-old spruce forest adjacent to the previous 105-year-old forest, characterized by the occurrence of *Betula pubescens* and *Fagus silvatica*, *Calamagrostis villosa, Avenella flexuosa, Vaccinium myrtillus,* rarely *Rubus ideaeus*. Ruess (1995) found the *Paratylenchus* spp. in subalpine 60 – 80-year-old spruce forest (*Piceetum subalpinum*) where these were dominant. The species *P. sheri* was identified in the soil around the root of *Pinus pinaster* Aiton and *Pinus nigra* in Spain (Gomez-Barcina *et al.,* 1990).
As referred Háněl (1993) or Háněl (2002) the nematode abundance of *Paratylenchus* species decreased with the rate of trees damage and mycorrhizal communities of fungus. In the undamaged forests the *Paratylenchus* nematodes similar to *Filenchus* nematodes reached the highest nematode abundance in the ectomycorrhizal communities (Háněl, 1998b). The different nematode abundance of *Paratylenchus* found in soil of clear cutting spruce forest (Háněl, 2002) compared to intact forest (Háněl, 1998a) reflects the changes in nutrient cycling in the soil caused by an extreme biotope change. However, it depends on several species of *Paratylenchus* nematodes which are present in the investigated damaged coniferous forests. Čerevková and Renčo (2009) observed the highest abundance of *Paratylenchus microdorus* in the damaged and extracted plane of *Lariceto-Piceetum* forest (D% = 13.43), compared to non-extracted (D% = 2.38), intact (D% = 1.97) and burnt plane (D% = 0.28) of this forest ecosystem. The species *Paratylenchus projectus* was observed only on intact plane of this forest at low dominance (D% = 0.48).
The highest number of *Paratylenchus* nematodes in pine natural forest recorded Nguyen *et al.* (2004), but it was no in Europe. Fourteen species they found: *P. arculatus* Luc & de Guiran, 1962; *P. aculentus* Brown, 1959; *P. colbrani* Raski, 1975; *P. corbetti* Ganguly & Khan 1990; *P. costatus* Raski, 1976; *P. dianthus P. discocephalus* Sidiqqi, Khan & Ganguly, 1990; *P. elachistus; P. epicotylus* Sidiqqi, Khan & Ganguly, 1990; *P. nawadus* Khan, Prasad &Mathur, 1967; *P. pandatus* (Raski, 1976) Sidiqqi, 1986; *P. perlatus* Raski, 1975; *P. serricaudatus* Raski, 1975 and *P. laocaiensis* sp. nov.
Although, the *Paratylenchus* nematodes are polyfagous, they are not essentially limited by the soil environmental conditions such as pH, temperature or humidity (Bell and Watson, 2001a). But the abundance of *P. nanus* was positively correlated with soil temperature and negatively with soil moisture (Bell and Watson, 2001b). Despite of this, it seems that restricting factor for their occurrence are body parameters, especially the long stylet enabling the parasitizing deep root tissues of trees and shrubs. On the basis of these behaviours *Paratylenchus* nematodes can change the host plant, from woody species to several species of grass and herb after the change in the soil ecosystems and nutrient cycling. There are a several other factors which can influence their occurrence on locality. Matthew *et al.* (1991) referred the nutrient purchase of food source as the important factor influencing nematode abundance. Bell and Watson (2001c) stated, that the biggest food competitor of the species *P. nanus* are nematodes of the genus *Pratylenchus* Filipjev, 1936 because they have a common food niche and are anatomically similar. Reversal with the species *Paratrichodorus minor* (Colbran, 1956) are not in a competitive relation for their anatomical differences (Bell and Watson, 2001a). Additional factors which influenced the occurrence of *Paratylenchus* nematodes in soil sample is time, the soil collection and depth of collection as well, related to the presence of nonspecific pathogenic microorganisms e.g. fungus (predators) (e.g. *Arhrobotrys* and *Monacrosporium*) and the fact that plant parasitic nema-

todes are present in the highest abundance in mineral soil layers (Magnusson, 1983). The highest abundances are in spring and autumn sampling dates (Háněl, 2002; Bell & Watson, 2001a).

Conclussion

Members of the family Paratylenchidae belong to the most widespread species of nematodes in soil in the temperate areas. They are currented in the most types of soil, feed on a wide range of host plants, some species bear the label of pests of plants and through a combination of features described above are very well specialized to live on very poor sites, which unlike other species can reach large population densities. In spite of this, many more about most species of these genera with few exceptions not know. However, as stated Háňel or Verschoor in their works cited above, both genera can be used to study of human impacts on the soil as indicators of changes in soil. Presented review should serve as a list and an outline of what was by some members of the genera *Paratylenchus* and *Gracilacus* previously published in connection with trees and grassland. The biggest objection during studies of the representatives of the genera discussed is their small size, which can be related in part to their absence in some localities studied, the losses caused by the small size fraction of nematodes during the extractions of the soil samples and the relatively difficult diagnosis depends on the presence of adult males and sometimes even in populations which for mass occurrences of juvenile stages at the sites during very difficult and prolonged work.

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