EKOLOGIJA. 2004. Nr. 4. P. 32–39

Comparison of three methods of sampling wild bees (Hymenoptera, Apoidea) in Èepkeliai Nature Reserve (South Lithuania)

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In 1979–1985 and 1997–2001, in the Èepkeliai nature reserve by three methods a total of 25627 wild bee specimens were collected. The samples collected with a entomological sweep-net and Moericke type yellow coloured traps by diversity, sex and family ratio were comparable and rather exactly represented the local wild bee populations. A significant part of Söderman's yellow trap samples contained representatives of the family Apidae (various bumblebee species). The Söderman's yellow traps hanged about 1 m above the ground can be used only for bumblebee (genus Bombus Latr.) population dynamics monitoring. The service of this type of traps is very simple and the collected material is in a very good condition. The Moericke's yellow traps can be used for a long-term monitoring of local population dynamics of most wild bee species. The use of these traps for studying wild bee ecology must be cautious, because attractiveness of particular species to yellow-coloured traps can be abnormal.

Key words: wild bees, Apoidea, sampling methods, yellow coloured traps, monitoring, Lithuania

INTRODUCTION

For many years apidologists in various countries had used a very simple method of sampling wild bees – collecting them with an entomological sweep-net. This classical method is indispensable for studying the trophic links and some other ecological features. For a long-term monitoring of local wild bee populations more preferable are trap-based sampling methods. The simplest and most popular is the method based on colour attraction trapping. Traps of various constructions and different colours are used. The trap colour influences the number and differentiation of caught bees (Banaszak, 1991; Banaszak et al., 1994; Söderman, 1999).

For monitoring a long-term local population dynamics rather simple but effective sampling methods are required. Is it possible with traps of one type and one colour to ensure the monitoring of the whole wild bee systematic group?

The aim of the present study was to determine the representativeness degree of Moericke's type yellow coloured trap samples with regard to local wild bee fauna and herewith to substantiate their suitability for a long-term monitoring of local wild bee populations.

MATERIALS AND METHODS

The investigation was carried out in the Èepkeliai strict nature reserve (South Lithuania). In the first stage of study (1979–1985) the material was sampled using an entomological sweep-net (total 2941 specimens). All material was gathered with keeping to the rule: all noticed wild bees where captured. So the number of collected specimens was more or less in conformity with the density of the species. In the second stage (1997–2001) the material was sampled with Moericke's yellow traps (Moericke, 1951). They were plastic bowls 20 cm in diameter and 10 cm deep, filled with a preserving liquid of the following composition: ethylene glycol 10%, detergent (washing powder) 0.2% and the rest part was water. The traps were placed in a grass layer directly on the ground, in clusters of three in each site (the total number of sites 14). They were emptied from insects every seven days. A total of 21969 specimens of wild bees were collected with these traps. In 1998, in parallel to Moericke's traps, at one site three Söderman's yellow traps were placed (Söderman et al., 1997). They were plastic pheromone traps, manufactured by Russells Chemicals Ltd, with killing strips (DDVP) inside. They were hung about 1 m above the ground and emptied from insects every seven days together with Moericke's traps. Using these traps, 717 specimens of wild bees were sampled.

The material have been managed with Microsoft Access 2000 software. The statistical indices were computed using Statistica 5.5 A software.

RESULTS AND DISCUSSION

The evaluation of wild bee sampling methods in the Èepkeliai nature reserve are presented in Table 1. The material sampled by means of the entomological sweep-net embraces 128 bee species (Monsevièius, 1988) and with Moericke's yellow traps even 221 species. Of course, these two numbers prove nothing yet: the size of samples is rather different. But if you consult Fig. 1, you can see the conformity of the entomological sweep-net sampling data with the curve of diversity – sample size dependence of Moericke's trapping data.

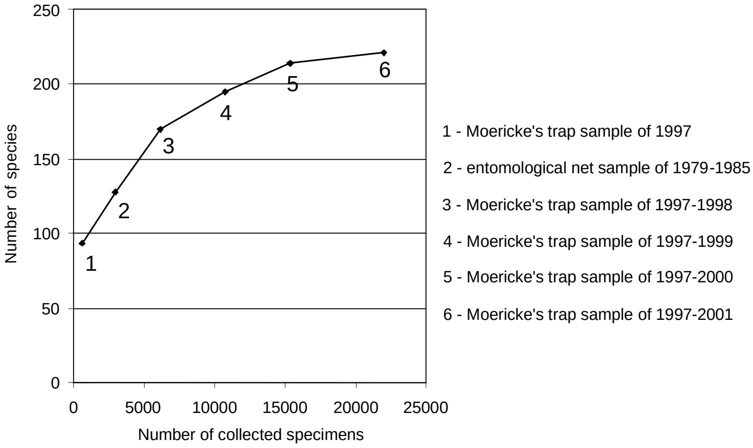

Fig. 1. Diversity of wild bee samples according to their size in Èepkeliai nature reserve (South Lithuania)

The Shannon diversity index counted from the material of entomological sweep-net sampling (3.78) was only fractionally higher than the index counted from the material of Moericke's yellow trap samples (3.58). According to species diversity estimation, both methods are approximately equal. It has been found that oligolectic species that are indifferent to yellow-flowered plants were interested in yellow traps. Such species collected with yellow traps are *Andrena fuscipes* and *Colletes succinctus* which usually are found on *Calluna vulgaris* (L.) Hill; *Andrena proxima* – on Umbelliferae sp.; *Nomada armata* – on *Knautia arvensis* (L.) Coult.; *Andrena paucisquama*, *A. curvungula* (Soderman 1999 and author's data from Lithuania), *Chelostoma campanularum* – on *Campanula* sp. In total, only 4 species (*Chelostoma rapunculi*, *Hylaeus styriacus*, *Lasioglossum laeve* and *Psithyrus norvegicus*) from the sweep-net sample don't fall into traps. However, they are rare species in the area, and this may be the main reason for their absence in Moericke's traps.

Table. **Species composition and number of wild bee individuals collected by two methods in Èepkeliai nature reserve**

Species	Number of individuals collected with sweep-net				Number of individuals collected with Moericke's traps			
	Spcm	Fem	Mal	Work	Spcm	Fem	Mal	Work
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Andrena alfkenella Perkins					10	9	1	
Andrena apicata Smith	74	69	5		47	29	18	
Andrena argentata Smith					75	53	22	
Andrena barbilabris (Kirby)	13	10	3		22	10	12	
Andrena bicolor Fabricius					1	1		
Andrena bimaculata (Kirby)	2		2		13	8	5	
Andrena carbonaria Fabricius	2		2		41	37	4	
Andrena chrysosceles (Kirby)					8	4	4	
Andrena cineraria (Linnaeus)	85	28	57		3421	148	3273	
Andrena clarkella (Kirby)	20	20			8	6	2	
Andrena denticulata (Kirby)					52	48	4	
Andrena dorsata (Kirby)	2	1	1		27	13	14	
Andrena falsifica Perkins					1	1		
Andrena flavipes Panzer					21	6	15	
Andrena fucata Smith					5	3	2	
Andrena fulvago (Christ)	1	1			12	6	6	
Andrena fulvida Schenck	5	5			150	147	3	

Table (continued)

1	2	3	4	5	6	7	8	9
Andrena fuscipes (Kirby)	44	11	33		174	74	100	
Andrena gelriae Vecht	9	7	2		10	9	1	
Andrena haemorrhoa (Fabricius)	103	42	61		327	162	165	
Andrena humilis Imhoff	20	13	7		10	5	5	
Andrena jacobi Perkins					5	2	3	
Andrena labialis (Kirby)					1	1		
Andrena labiata Fabricius					6	5	1	
Andrena lapponica Zetterstedt	34	16	18		476	292	184	
Andrena minutula (Kirby)					2	1	1	
Andrena morawitzi Thomson					3	3		
Andrena nigriceps (Kirby)	1	1			3	3		
Andrena nigroaenea (Kirby)					11	10	1	
Andrena nitida (Muller)	38	28	10		76	41	35	
Andrena ovatula (Kirby)	1	1			2	2		
Andrena paucisquama Noskiewicz					1	1		
Andrena pilipes (Fabricius)					9	8	1	
Andrena praecox (Scopoli)	14	12	2		33	20	13	
Andrena propingua Schenck	2	1	1		3	2	1	
Andrena proxima (Kirby)					1	1		
Andrena ruficrus Nylander	39	7	32		87	65	22	
Andrena semilaevis Perez					1	1		
Andrena simillima Smith					1	1		
Andrena subopaca Nylander	41	34	7		66	54	12	
Andrena tarsata Nylander	1		1		4	2	2	
Andrena thoracica (Fabricius)					3	1	2	
Andrena tibialis (Kirby)	3	1	2		42	3	39	
Andrena vaga Panzer	81	40	41		192	94	98	
Andrena varians (Rossi)					6	1	5	
Andrena ventralis Imhoff	158	31	127		336	216	120	
Andrena wilkella (Kirby)	5	3	2		5	3	2	
Anthidiellum strigatum (Panzer)	1	1			3	2	1	
Anthidium manicatum (Linnaeus)					2	1	1	
Bombus confusus (Schenck)					1	1		
Bombus cryptarum (Fabricius)	173	37	18	118	3214	1245	249	1720
Bombus distinguendus Morawitz					6	6		
Bombus hortorum (Linnaeus)	4	3		1	93	68	7	18
Bombus humilis Illiger	3	3			5	1	2	2
Bombus hypnorum (Linnaeus)	26	4	3	19	19	9	2	8
Bombus jonellus (Kirby)	202	9	26	167	189	99	12	78
Bombus lapidarius (Linnaeus)	3		1	2	145	11	60	74
Bombus lucorum (Linnaeus)	80	18	9	53	2030	1073	132	825
Bombus magnus Vogt	33	2	10	21	211	59	53	99
Bombus muscorum (Linnaeus)	12	1	3	8	78	53	8	17
Bombus pascuorum (Scopoli)	212	19	50	143	752	98	146	508
Bombus pratorum (Linnaeus)	83	12	12	59	214	96	3	115
Bombus ruderarius (Mueller)	7	3		4	14	10		4
Bombus schrencki (Morawitz)	257	24	21	212	1697	131	261	1305
Bombus semenoviellus (Skorikov)	1			1	135	54	7	74
Bombus soroeensis (Fabricius)					78	5	6	67
Bombus subterraneus latreillellus (Kirby)	4	2	2		77	49	21	7
Bombus sylvarum (Linnaeus)	1			1	26	7	11	8
Bombus terrestris (Linnaeus)	2	2			120	110	3	7
Bombus veteranus (Fabricius)					13	6	1	6
Ceratina cyanea (Kirby)	2	2			15	9	6	

Table (continued)

1	2	3	4	5	6	7	8	9
Chelostoma campanularum (Kirby)					1	1		
Chelostoma florisomne (Linnaeus)	13	11	2		8	1	7	
Chelostoma rapunculi (Lepeletier)	1		1					
Clisodon furcatus (Panzer)	3		3		52	41	11	
Coelioxys alata Foerster					5	5		
Coelioxys conoidea (Illiger)					3	3		
Coelioxys inermis (Kirby)					4	2	2	
Coelioxys mandibularis Nylander					4	3	1	
Coelioxys quadridentata (Linnaeus)	8	4	4		1	1		
Coelioxys rufescens Lepeletier	2		2		1	1		
Colletes cunicularius (Linnaeus)	2		2		9	2	7	
Colletes daviesanus Smith	13	7	6		6	5	1	
Colletes fodiens (Fourcroy)	19	13	6		4	4		
Colletes similis Schenck					9	9		
Colletes succinctus (Linnaeus)	3	1	2		133	98	35	
Dasypoda altercator (Harris)					313	290	23	
Dufourea vulgaris Schenck					3	3		
Epeoloides coecutiens (Fabricius)	3	3			146	88	58	
Epeolus cruciger (Panzer)	4	3	1		1		1	
Epeolus variegatus (Linnaeus)					2	2		
Eucera longicornis (Linnaeus)					1		1	
Halictus confusus perkinsi Bluthgen	17	16	1		97	89	8	
Halictus leucaheneus arenosus Ebmer					5	5		
Halictus maculatus Smith					5	3	2	
Halictus quadricinctus (Fabricius)					2	2		
Halictus rubicundus (Christ)	44	39	5		75	61	14	
Halictus sexcinctus (Fabricius)	3	3			10	10		
Halictus subauratus (Rossi)					2	2		
Halictus tumulorum (Linnaeus)	12	8	4		229	213	16	
Heliophila bimaculata (Panzer)					3	3		
Heriades truncorum (Linnaeus)					17	12	5	
Hoplitis claviventris (Thomson)	3	2	1		16	10	6	
Hoplitis tuberculata (Nylander)					2	1	1	
Hylaeus angustatus (Schenck)					3	2	1	
Hylaeus annularis (Kirby)					1	1		
Hylaeus brevicornis Nylander	1	1			22	20	2	
Hylaeus cardioscapus Cockerell					96	77	19	
Hylaeus communis Nylander	50	39	11		240	220	20	
Hylaeus confusus Nylander	10	9	1		575	415	160	
Hylaeus difformis (Eversmann)	1		1		2	1	1	
Hylaeus gibbus Saunders	1	1			20	14	6	
Hylaeus gracilicornis (Morawitz)	2	2			18	16	2	
Hylaeus gredleri Foerster	1	1			14	9	5	
Hylaeus nigritus (Fabricius)					9	1	8	
Hylaeus pectoralis Foerster					97	89	8	
Hylaeus pfankuchi (Alfken)	2	2			34	30	4	
Hylaeus rinki Gorski					60	54	6	
Hylaeus sinuatus (Schenck)	10	1	9		2	1	1	
Hylaeus styriacus Foerster	1		1					
Lasioglossum (Evylaeus) sp. 1	7	7			121	118	3	
Lasioglossum aeratum (Kirby)					46	45	1	
Lasioglossum albipes (Fabricius)	230	226	4		531	515	16	
Lasioglossum brevicorne (Schenck)	22	22			20	20		
Lasioglossum calceatum (Scopoli)	19	16	3		159	136	23	

Table (continued)

1	2	3	4	5	6	7	8	9
Lasioglossum fratellum (Perez)	16	16			325	302	23	
Lasioglossum fulvicorne (Kirby)	5	5			198	193	5	
Lasioglossum laeve (Kirby)	1	1						
Lasioglossum lativentre (Schenck)					7	5	2	
Lasioglossum leucopus (Kirby)	30	30			96	92	4	
Lasioglossum leucozonium (Schrank)	60	60			147	119	28	
Lasioglossum lucidulum (Schenck)					9	9		
Lasioglossum majus (Nylander)					2	2		
Lasioglossum minutissimum (Kirby)					11	10	1	
Lasioglossum morio (Fabricius)	1		1		21	19	2	
Lasioglossum pallens (Brulle)					1	1		
Lasioglossum pauxillum (Schenck)					5	3	2	
Lasioglossum prasinum (Smith)					1	1		
Lasioglossum punctatissimum (Schenck)	20	20			410	398	12	
Lasioglossum quadrinotatulum (Schenck)	10	9	1		22	21	1	
Lasioglossum quadrinotatum (Kirby)	3	3			13	11	2	
Lasioglossum rufitarse (Zetterstedt)	23	19	4		29	25	4	
Lasioglossum semilucens (Alfken)					8	8		
Lasioglossum sexmaculatum (Schenck)	7	7			72	71	1	
Lasioglossum sexnotatum (Kirby)					2	2		
Lasioglossum sexstrigatum (Schenck)	56	56			90	85	5	
Lasioglossum villosulum (Kirby)	4	4			55	50	5	
Lasioglossum zonulum (Smith)					102	91	11	
Macropis europaea Warncke	1	1			154	123	31	
Macropis fulvipes (Fabricius)	13	9	4		125	87	38	
Megachile alpicola Alfken	2	1	1		26	21	5	
Megachile centuncularis (Linnaeus)					3	3		
Megachile circumcincta (Kirby)	13	9	4		1		1	
Megachile genalis Morawitz					1		1	
Megachile lapponica Thomson					17	14	3	
Megachile ligniseca (Kirby)					104	84	20	
Megachile maritima (Kirby)					2	2		
Megachile nigriventris Schenck					1	1		
Megachile versicolor Smith					39	29	10	
Megachile willughbiella (Kirby)	2	1	1		6	2	4	
Melitta leporina (Panzer)					3		3	
Melitta tricincta Kirby					1	1		
Nomada armata Herrich-Schaeffer					1	1		
Nomada baccata Smith					1		1	
Nomada bifida Thomson	9	1	8		7	4	3	
Nomada fabriciana (Linnaeus)					10	6	4	
Nomada femoralis Morawitz	1	1			3	3		
Nomada ferruginata (Linnaeus)					13	4	9	
Nomada flava Panzer					2		2	
Nomada flavoguttata (Kirby)	1		1		16	6	10	
Nomada flavopicta (Kirby)					11	11		
Nomada fucata Panzer					6	3	3	
Nomada fulvicornis Fabricius	2	1	1		5	3	2	
Nomada fuscicornis Nylander					4	3	1	
Nomada goodeniana (Kirby)	40	20	20		6	1	5	
Nomada guttulata Schenck					3		3	
Nomada integra Brulle	1	1			2	1	1	
Nomada lathburiana (Kirby)	13	10	3		51	32	19	
Nomada leucophthalma (Kirby)	2	2			86	50	36	

Table (continued)

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Nomada marshamella (Kirby)					1	1		
Nomada moeschleri Alfken	4		4		46	22	24	
Nomada mutabilis Morawitz					2	1	1	
Nomada obscura Zetterstedt	1	1			17	13	4	
Nomada ochrostoma Zetterstedt	3	2	1		18	9	9	
Nomada opaca Alfken					3	2	1	
Nomada panzeri Lepeletier	22	11	11		134	68	66	
Nomada roberjeotiana Panzer					8	8		
Nomada rufipes Fabricius	21	11	10		53	43	10	
Nomada striata Fabricius					1		1	
Nomada trapeziformis Schmiedeknecht					1	1		
Nomada zonata Panzer					3	2	1	
Osmia (Melanosmia) sp. 1					10	1	9	
Osmia bicolor (Schrank)					10	6	4	
Osmia fulviventris (Panzer)					1	1		
Osmia inermis (Zetterstedt)	4	4			4	2	2	
Osmia leaiana (Kirby)	9	8	1		7	4	3	
Osmia nigriventris (Zetterstedt)	8	6	2		15	8	7	
Osmia parietina Curtis	3		3		8	5	3	
Osmia pilicornis Smith	2	1	1		5	4	1	
Osmia rufa cornigera Linnaeus	1	1			48	3	45	
Osmia uncinata Gerstacker	2	2			38	25	13	
Panurgus calcaratus (Scopoli)	3	3			449	194	255	
Psithyrus barbutellus (Kirby)					1	1		
Psithyrus bohemicus (Seidl)	23	12	11		241	172	69	
Psithyrus campestris (Panzer)	3	1	2		15	3	12	
Psithyrus norvegicus Schneider	6		6					
Psithyrus rupestris (Fabricius)	7		7		68	8	60	
Psithyrus sylvestris Lepelletier	16	4	12		21	14	7	
Sphecodes albilabris (Fabricius)					1	1		
Sphecodes crassus Thomson	1	1			3	2	1	
Sphecodes ephippius (Linnaeus)	3	1	2		32	28	4	
Sphecodes ferruginatus Hagens					6	4	2	
Sphecodes geoffrellus (Kirby)					9	9		
Sphecodes gibbus (Linnaeus)	1	1			5	5		
Sphecodes hyalinatus Hagens					28	27	1	
Sphecodes longulus Hagens	5	4	1		22	18	4	
Sphecodes marginatus Hagens	1	1			33	28	5	
Sphecodes miniatus Hagens	4	4			18	18		
Sphecodes monilicornis (Kirby)	5	4	1		26	25	1	
Sphecodes niger Hagens					1	1		
Sphecodes pellucidus Smith	30	30			24	24		
Sphecodes puncticeps Thomson					2	2		
Sphecodes reticulatus Thomson	6	6			5	5		
Stelis breviuscula (Nylander)					1	1		
Trachusa byssina (Panzer)					3		3	
Total individuals	2941	1367	765	809	21969	10401	6626	4942
Total species	128	110	81	14	221	213	166	21

The sex ratio of wild bee samples collected by both methods is comparable also (Fig. 2). The females' weight in the Moericke's trap sample is even higher than in the entomological sweep-net sample. The distribution of all sex forms seems rather normal and maybe is close to the natural distribution.

The wild bee family ratio in the Moericke's yellow trap sample (Fig. 3) is perhaps even more rep-

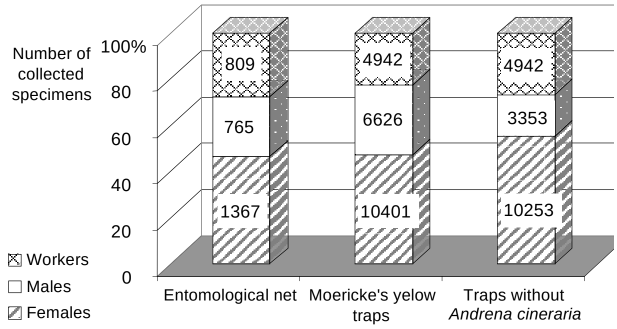

Fig. 2. Sex ratio of wild bees samples collected by two methods

resentative. Some species of the family Apidae are very common (*Bombus lucorum*, *B. cryptarum*, *B. pascuorum*, etc.) and maybe not all noticed individuals were captured by entomological sweep-nets. Thought the differences between the distribution of individuals of various families in each sample were statistically significant ($\chi 2$ = 226.25 $p < 0.0001$), in view of a great time-lag between the two stages of study, in which considerable changes took place in the area, these distinctions seem not significant. Especially the family ratio of samples obtained by these two methods seems similar if to compare them with data of the third method.

The species dominance structure of samples collected by both methods is rather distinct (Table). The differences in the distribution of individuals of each species in each sample were statistically significant ($\chi 2$ = 6618.15, $p < 0.0001$). The proportion of particular species in the material of both samples could have been modified not only by the method of sampling, but also by population dynamics, since sampling took place in different years. But in some cases it was more evident that the type of the method was the prior factor. For example, a tremendous amount of males of *Andrena cineraria* in Moericke's yellow traps seems abnormal and maybe was determined by the extreme attractiveness of this type of traps.

The results of the third wild bee sampling method (Söderman's yellow traps) are distinctly divergent from both foremost. A significant part of Söderman's trap samples were representatives of the family Apidae (various bumble-bee species) (Fig. 4). The ratio of solitary / social bee individuals in Söderman's trap one cluster sample in the Èepkeliai nature reserve was 1:16. In the large more northern region of Eastern Fennoscandia and Eastern Baltics this proportion is even higher, reaching on average 1:29 (data counted by V. M. from Söderman 1999), while Moericke's traps the ratio of solitary / social bee individuals in one cluster sample of the same site in the Èepkeliai reserve was 1:1.05 (average of all sites 1:0.76). Maybe this result depends not only on the type of trap, but also on the traps hanging above the ground.

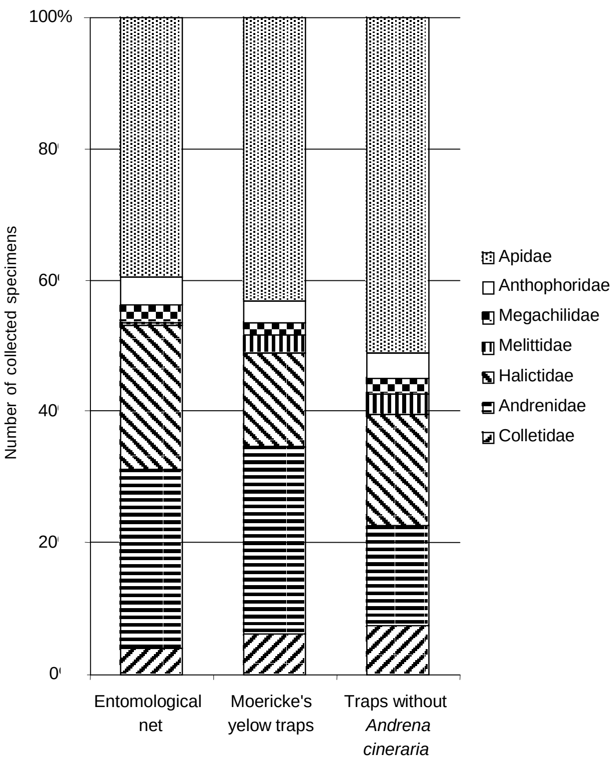

Fig. 3. Family ratio of wild bee samples collected by two methods in Èepkeliai nature reserve

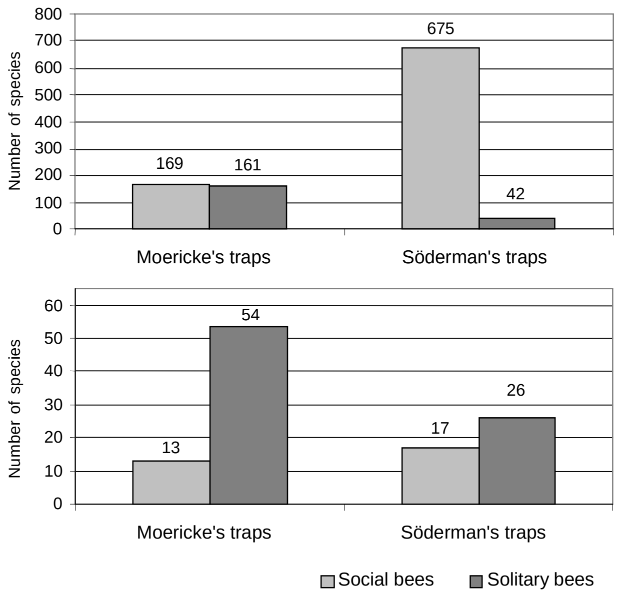

Fig. 4. Comparison of wild bee material collected by Moericke's and Söderman's traps in 1998

CONCLUSIONS

The Moericke's yellow trap samples rather accurately reflect the diversity, sex and family ratio of local wild bee populations. This is confirmed by the high number of species collected with yellow traps in the Èepkeliai nature reserve (66% of the total number of wild bee species known to occur in Lithuania) (Monsevièius, 2003) and a certain analogy of the two methods. Trap methods are not subjected to human artefacts. Therefore, Moericke's yellow traps can be used for a long-term monitoring of local population dynamics of most wild bee species. The quality of collected material is right enough for determination. These traps for studying wild bee ecology should be used cautiously, because attractiveness of a particular species to yellow traps can be abnormal.

Söderman's yellow traps, hanged about 1 m above the ground, can be used for monitoring the dynamics of bumble-bee (genus *Bombus* Latr.) population. The handling of this type of traps is very simple, and the collected material is in very good condition.

Received
20 May 2003

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LAUKINIØ BIÈIØ (HYMENOPTERA, APOIDEA) TRIJØ RINKIMO METODØ PALYGINIMAS ÈEPKELIØ REZERVATE

S a n t r a u k a

Èepkeliø rezervate 1979–1985 ir 1997–2001 m. trimis skirtingais metodais surinkta 25627 laukinës bitës. Kolekcijos, surinktos entomologiniu tinkleliu ir Miorikës geltonomis gaudyklëmis, yra panaðios tiek pagal rûðinæ ávairovæ, tiek pagal lyèiø bei ðeimø santyká ir pagal ðiuos rodiklius gana tiksliai reprezentuoja vietines laukiniø bièiø populiacijas. Siodermano geltonos gaudyklës pasiþymëjo padidintu atraktyvumu kamanëms ir sumaþintu atraktyvumu pavienëms bitëms. Jos tinka tik kamaniø populiacijø dinamikos monitoringui. Teigiamos jø savybës – aptarnavimo paprastumas ir surinktos kolekcinës medþiagos kokybiðkumas identifikacijos atþvilgiu. Miorikës geltonos gaudyklës gali bûti naudojamos daugelio laukiniø bièiø rûðiø vietiniø populiacijø dinamikos monitoringui. Taèiau jø aptarnavimas yra gana sudëtingas, o surinkta kolekcinë medþiaga sunkiau identifikuojama. Laukiniø bièiø ekologijos tyrimams geltonàsias gaudykles reikia naudoti atsargiai, nes kai kuriø rûðiø atraktyvumas joms gali bûti nenormalus.

Raktaþodþiai: laukinës bitës, Apoidea, bandiniø ëmimo metodai, geltonos gaudyklës, monitoringas, Lietuva