Phenological activity patterns of imaginal Heteroptera in the canopy of different tree species in Bavaria, Germany[1]

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Abstract: Heteroptera were caught by flight-interception and branch traps between 1996 and 2004 during canopy research projects in Bavaria, Germany. Activity patterns focusing on seasonality and annual fluctuations as well as differences between tree species, sites, and sexes are analysed. Phenological data of the 21 most abundant species are presented. Heteroptera species exhibited conspicuously different phenological patterns which can be explained by specific ecological traits. The general outcome of present study was that 1) seasonality of phytophagous specialists is determined by phenology of their host plants; 2) spatial pattern of zoophagous species is influenced by prey availability; 3) annual fluctuations can be explained by several climatic conditions as well as differences in prey density. Furthermore, males of most species appear previous to females and have a shorter life span. Sex ratios differ greatly between Heteroptera species.

Key words: Heteroptera, activity densities, annual variation, seasonality, sex ratio, site differences, tree specificity.

Introduction

Tree crowns include the main part of above ground photosynthetic active leaf tissue in most forest ecosystems (SONG 1998; VAN PELT & FRANKLIN 2000) and are highly structured (PARKER 1995; MOFFET 2001). As a consequence, canopy insect diversity is very high (STORK et al. 1997; WINCHESTER & RING 1999) and a significant proportion of all terrestrial animals are expected to inhabit this extremely high spatial system (ERWIN 1983; BASSET 2001). Nevertheless, research on canopy insect communities is a young science. Thus, ERWIN (1983) called it "the last biotic frontier". After the 1970's, an explosion of tree crown projects occured in the tropics (e.g. BASSET 2001). This may be mainly traced back to the development of new ground-based sampling methods: canopy fogging (ROBERTS 1973; ERWIN & SCOTT 1980; GAGNÉ & HOWARTH 1981); light-trapping (SUTTON 1979; WOLDA 1979; SUTTON & HUDSON 1980; SMYTHE 1982) as well as canopy access techniques: walkways (MUUL & LIM 1970; SUGDEN 1985; MUUL 1999); single rope techniques (PERRY 1978); cranes (PARKER et al. 1992); rafts, etc. (HALLÉ & BLANC 1990; see also BARKER & PINARD 2001; MITCHELL et al. 2002, BASSET et al. 2003a, 2003b). Compared to the tropics, canopy research in temperate regions made much slower progress. Simply because many scientists did not expect to uncover any genuine new data in tree crowns of those regions. While in North America in 1985 the installation of the "Wind River Crane" at Gifford Pinchot National Forest near the Columbia River Gorge was the starting point for initiating numerous tree crown projects (see SHAW et al. 2003), in Europe only isolated studies were conducted at that time. In 1996 only three of the 57 worldwide tree crown research stations were located in Europe (LOWMAN & WITTMAN 1996). Concurrent to this decent beginning of tree crown research in Europe the number of publications on tree crown dwelling arthropods is still subdued.

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[1] This article is dedicated to Ernst Heiss for his continuous and generous support of my research. He uniquely fosters enthusiasm for Heteroptera in young scientists.

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Neue Serie 50 (2006), 1055–1094

Fig. 1: **a)** Flight-interception trap in the canopy of *Pseudotsuga menziesii* and **b)** branch-trap in the canopy of *Quercus robur*.

Additionally, due to the low collection density and the lack of standardised studies on tree crown dwelling Heteroptera in forest ecosystems, our knowledge of seasonal and annual patterns of most arboreal Heteroptera species is still fractional. Several studies on tree crown dwelling Heteropteras have been conducted in the tropics (Casson & Hodkinson 1991; Paula & Ferreira 2000; Wagner 2001) as well as in North America (Wheeler 1991, 1999). In Central Europe, especially in managed forests with defined forest edges, trees with crowns reaching the ground are extremely rare. It makes it nearly impossible to measure the seasonal activity pattern of arboreal species from ground level. Most phenological information on Heteroptera is gained by means of light trapping in Great Britain (Southwood 1960), the Netherlands (Meurer 1956, 1957), Germany (Günther 1988; Göllner-Scheiding 1989), Switzerland (Göllner-Scheiding 1981; Göllner-Scheiding & Rezbanyai-Reser 1992), Turkey (Hoberlandt 1961; Önder & Adigüzel 1979; Önder et al. 1981, 1984), and Greece (Heiss et al. 1991). With light trapping only nocturnal flight-active species are collected – which are primarily males (Southwood 1960). Moreover, in most cases sampling was not carried out in the forest interior (light trapping) or restricted to the near-ground stratum as in the studies of Dorow (1999, 2001) in the forests of Hesse (Germany) using flight-interception traps. Therefore conclusions on activity patterns in tree crowns can not be drawn from this data. Southwood et al. (2004) studied the seasonality of phytophagous insects in Great Britain and France using insecticidal knockdown fogging and branch clipping. However, rather the seasonality of the sucking guild than of single Heteroptera species was analysed. The investigation of Heteroptera on urban trees by Göllner-Scheiding (1992) using branch beating and the study of Cmoluchowa & Lechowski (1993) in Poland in pine canopies using Moericke's yellow pan traps contributed to the knowledge of seasonal patterns of arboreal Heteroptera species. Nevertheless, continuous sampling in tree crowns in Central Europe using non-attractive trapping systems is scarce. Goßner (2006a) demonstrated different activity patterns of Heteroptera on different tree species separated by overwintering traits; however, the seasonality of single Heteroptera species was not analysed.

The aim of present study is to reveal phenological patterns of several Heteroptera species abundant in tree crowns in Bavaria (Germany) of different conifers (*Picea abies* L., *Abies alba* Mill., *Larix decidua* Mill., *Pseudotsuga menziesii* ((Mirb.) Franco)) and broad-leaved trees (*Quercus robur* L., *Q. petraea* (Matt.) Liebl., *Q. rubra* L., *Fagus sylvatica* L.). Present work mainly focuses on seasonal and annual patterns. In addition differences between tree species and sites are described. Data of two sampling methods, viz. flight-interception traps and branch traps, sampled between 1996 and 2004 are reanalysed.

Material and Methods

To describe phenological patterns of arboreal Heteroptera species data of several projects, conducted in Bavaria within the last decade, are reanalysed. The project designs are described in Table 1. All projects were performed in forest stands older than 100 years. The two lowland sites "**Fe**uchtwangen" and "**G**unzenhausen" (**FEG**) as well as the three mountainous sites "**R**eit im Winkl", "**I**nzell" and National Park "**B**ayerischer Wald" (**RIB**) from Goßner (2005) were pooled for analyses. Six indigenous (*P. abies*, *A. alba*, *L. decidua*, *F. sylvatica*, *Q. petraea*, *Q. robur*), and two introduced tree species (*P. menziesii*, *Q. rubra*) were included in present study. Table 2 shows the number of sampled trees per year.

Two trap types were used for the Heteroptera sampling: flight-interception traps (FIT) (Winter et al. 1999; Goßner 2004) for "flight-active" and branch traps (BT) (Koponen et al. 1997; Goßner 2004) for "surface-active" species (Fig. 1). The latter was only used in a broad-leaved tree stand (*F. sylvatica*, *Q. robur*, *Q. rubra*) at the Krumbach (KRU) site. The traps were installed in the center of each tree crown at heights from 18m to 32m. FIT consisted of one, BT of two traps per tree crown. Sampling jars were filled with 5 % Formaldehyde (HIE) or 1.5 % copper sulphate solution (all the other investigation sites). The traps were checked monthly from March to October either at the end of each month (HIE, EBE, FEG, RIB) or mid-month (OTT, KRU, FRE, UFF) (Tab. 1).

Species determination was done by T. Maier (HIE) and the author. Females of the *P. mollis*, *P. cruentatus*, and *P. confusus*-group were assigned to *P. mollis*, because only males of this species were found.

A Friedman ANOVA (F-ANOVA) and a Wilcoxon Matched Pair Test (WMP-Test) was performed to test the annual variation in activity densities. Differences between tree species were analysed using a Repeated-

Tab. 1: Description of study sites. Aa= *Abies alba*, Bp=*Betula pendula*, Cb=*Carpinus betulus*, Fe=*Fraxinus excelsior*, Fs=*Fagus sylvatica*, Ld= *Larix decidua*, Pa=*Picea abies*, Pav=*Prunus avium*, Pm=*Pseudotsuga menziesii*, Ps= *Pinus sylvestris*, Pt= *Populus tremula*, Qp=*Quercus petraea*, Qro=*Quercus robur*, Qru=*Quercus rubra*, Ti=*Tilia sp.*; FNR=Forest Nature Reserve.

Project site	Hienheim	Ottobeuren	Krumbach	Freising	Uffenheim	Ebrach / Eltmann	Feuchtwangen / Gunzenhausen	Reit im Winkl / Inzell / Bayer. Wald
abbreviation	HIE	OTT	KRU	FRE*	UFF	EBE	FEG	RIB
Project description	Schubert (1998), Maier (1997)	Ammer et al. (2002), Goßner et al. (2006)	Goßner (2004),		Müller et al. (2004)	Müller (2005)	Goßner (2005), Gauderer et al. (2005), Müller et al. (2005)	
Coordinates	10°47'E, 48°54'N	10°21'E, 48°06'N	10°24'E, 48°22'N	11°41'E, 48°24'N	10°12'E, 49°30'N	10°34'E, 49°55'N	10°21'E, 49°11'N / 10°47'E, 49°12'N	12°28'E, 47°41'N / 12°47'E, 47°46'N / 13°30'E, 48°54'N
Altitude a.s.l. [m]	400-475	620-645	520-535	480	340-390	325-520	500-510	720-960
Mean annual temperature [°C]	7.5-8	7-8	7-8	7-8	8-9	7-8	8-9	5.5-6.5
Precipitation [mm/a]	650-730	900-1,000	750-800	750-800	650-700	850	750	1,050-1,360
Year(s)	1996-1997	1999-2004	1999-2001	2000-2001	2002	2004	2004	2004
monthly sampling interval	beginning- end	mid-mid	mid-mid	mid-mid	mid-mid	beginning-end	beginning-end	beginning-end
Trap type	FIT	FIT	FIT, BT	FIT	FIT	FIT	FIT	FIT
Dominant tree species in studied stands (>5 %)	Fs, Pa, Qro, Ld	Pa, Fs, Pm	Fs, Qro, Pm, Pa	Qro / Qru	Qp, Ti, Cb, Fe, Bp, Pt	Fs, Qp	Pa, Aa, Qp	Pa, Aa, Fs
Sampled tree species	Fs, Pa, Qro, Ld	Fs, Pa, Pm	Fs, Pa, Pm, Qru	Qro, Qru	Qp	Fs, Qp	Pa, Aa, Qp	Pa, Aa
note	Close stands	Close stands, FNR	Close stand, Pm- stand more open	Close stand, close to forest edge or glade	Coppice-with-standards forestry	Close and more open stands, FNRs		
Size of forest area [ha]	2,000	400	400	1,400	330 / 430	16,000	100 / 150	1,000 / 10,000 / 65,000
Dominant tree species in forest area (>5 %)	Fs, Qro Pa, Ld	Pa, Fs, Pm	Pa, Fs, Qr	Pa, Fs, Qro, Ld	Qp, Cb, Pt, Fe, Bp, Pav, (Ps, Pa)	Fs, Qp, (Pa, Ps)	Pa, Aa, Ps (GUN),) Qp (FEU), Fs (GUN	Pa, Aa, Fs,

* two pure stands (Qro/Qru) in the same forest area were studied

Tab. 2: Number of sampled trees per site and per year, and number of used traps. Pa=*Picea abies*, Aa=*Abies alba*, Ld=*Larix decidua*, Pm=*Pseudotsuga menziesii*, Fs=*Fagus sylvatica*, Qp=*Quercus petraea*, Qro=*Quercus robur*, Qru=*Quercus rubra*; FIT=flight-interception traps, BT=branch traps.

Project site	**year**	**Trap type**	**Pa**	**Aa**	**Ld**	**Pm**	**Fs**	**Qp**	**Qro**	**Qru**	**N_{total}**
Hienheim	1996	FIT	9	/	6	/	15	/	9	/	39
	1997	FIT	9	/	6	/	15	/	9	/	39
Ottobeuren	1999	FIT	12	/	/	12	12	/	/	/	36
	2000	FIT	12	/	/	12	12	/	/	/	36
	2001	FIT	12	/	/	12	12	/	/	/	36
	2002	FIT	23	/	/	/	5	/	/	/	28
	2003	FIT	23	/	/	/	5	/	/	/	28
	2004	FIT	21	/	/	/	3	/	/	/	24
Krumbach	1999	FIT	21	/	/	12	12	/	9	/	54
	2000	FIT	15	/	/	6	12	/	12	6	51
	2001	FIT	6	/	/	6	6	/	6	6	30
Freising	2000	FIT	/	/	/	/	/	/	6	6	12
	2001	FIT	/	/	/	/	/	/	6	6	12
Uffenheim	2002	FIT	/	/	/	/	/	40	/	/	40
Ebrach/Eltmann	2004	FIT	/	/	/	/	36	27	/	/	63
Feuchtwangen/Gunzenhausen	2004	FIT	10	10	/	/	/	5	/	/	25
Reit im Winkl/Inzell/Bayer. Wald	2004	FIT	15	15	/	/	/	/	/	/	30
Total FIT			**188**	**25**	**12**	**60**	**145**	**72**	**57**	**24**	**583**
Krumbach	2000	BT	/	/	/	/	6	/	6	6	18
	2001	BT	/	/	/	/	6	/	6	6	18
Total BT							**12**		**12**	**12**	**36**

Tab. 3: Seasonal activity patterns of *Deraeocoris lutescens* on branches (BT) at Krumbach (KRU) site in 2000-2001; traps were emptied mid-month. / = no sampling.

	year	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**		**Σ**
males	2000	/	12	13	0	0	0	2	11	0	/	38
	2001	/	0	133	0	0	0	2	38	/	/	173
females	2000	/	1	0	0	1	1	0	12	0	/	15
	2001	/	0	0	0	0	0	0	22	/	/	22
total		/	13	146	0	1	1	4	83	0	/	248

Measure ANOVA (RM-ANOVA), followed by a Scheffé Post Hoc Test (PH-Test).

Commented species list

Section 1

Section 1 is dealing with the species collected by flight-interception traps in more than 350 specimens; branch trap results are given for species collected in at least 30 specimens; species are listed in order of decreasing abundance.

Deraeocoris lutescens (Schilling 1837) – Miridae (Fig. 21)

Material collected: Flight-interception traps = 3,182 specimens, 2,828♂♂ (89 %), 354 ♀♀ (11 %); branch-traps = 250 specimens, 212♂♂ (85 %), 38 ♀♀ (15 %).

Phenological activity: Males exhibited a distinct activity peak (FIT) at the end of April (Figs 2a, c, e, 3, 4, 5), which was independent of study site and year. During April the activity of *D. lutescens* reached mean values up to 24 specimens per tree crown (HIE1997; Fig. 2a). After mid-May, almost no males were captured by FITs (Figs 2a, c, e, 3, 4, 5). The males of the new generation occurring in August/September showed low flight-activity (Figs 2a, c, e, 3, 4, 5), but were more numerous on branches (Tab. 3). In females a less pronounced activity peak was observed (FIT) and the mean values were below three specimens per tree crown (Figs 2b, d, f, 4b). On branches, female activity of the new generation was relatively high, especially between mid-September and mid-October (Tab. 3).

The six-year study at site OTT revealed a high annual variation of male activity, at least at sites where almost no *Quercus* occur (Fig. 5). Activity in 2000 and 2002 was conspicuously higher than in 2001 and 2003 (in 1999 and 2004 sampling started not before mid-May). On *P. menziesii* the difference between 2000 and 2001 was significant (Wilcoxon Matched Pair Test: $p<0.05$). However, activity was quite low at this site (males, 5 specimens per tree crown between mid-April and mid-May on average). In the mountainous sites RIB (not shown) even lower activity was observed: During one year only 9 specimens were captured in 30 tree crowns.

Tree preferences: Activity of *D. lutescens* was much higher at sites were *Quercus* is the dominant tree species (HIE, KRU, FRE, UFF) (Figs 2, 4). Highest activity was found in the flight-interception traps on *Q. petraea* and *Q. robur* (Figs 2, 3a); significant values were obtained for HIE and KRU (RM-ANOVA, PH-Test: $p<0.05$). The preference for *Quercus* was also confirmed by branch trap samples where 66 % (164 specimens) of all specimens were captured on *Q. robur*. A comparable number of specimens was found on *F. sylvatica* and *Q. petraea* at site EBE in 2004 (FIT) (Fig. 3b). The activity of *D. lutescens* was also high on the exotic *Q. rubra* in the mixed broad-leaved site at KRU (Figs 2c, d), but not in pure stand at site FRE (Figs 2e, f). In the latter case only eight specimens were found on *Q. rubra* during the two years of investigation. The high activity on *Q. rubra* at site KRU was also con-

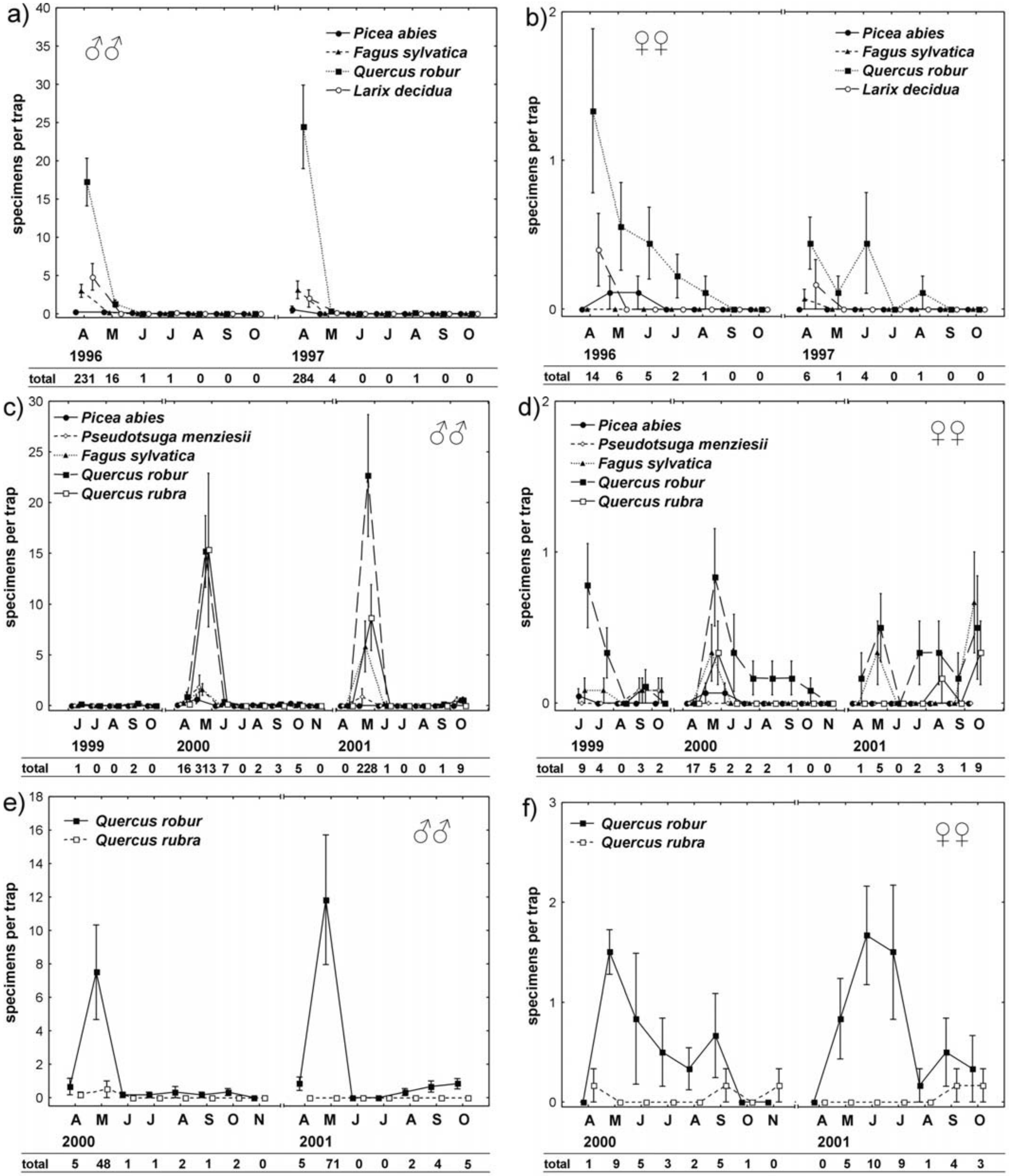

Fig. 2: Seasonal activity patterns of *D. lutescens* in the canopy (FIT) of different tree species at site HIE 1996-1997 (a, b), KRU 1999-2001 (c, d), and FRE 2000-2001 (e, f). Means and Standard error are shown. At site HIE traps were emptied at the end of each month, at sites KRU and FRE mid-month.

firmed by branch trap samples (61 → 24%). In KRU (Figs 2c, d) and OTT (Fig. 5) a high number of *D. lutescens* males were sampled on the exotic *P. menziesii* in the year 2000, compared to indigenous *F. sylvatica* and *P. abies*. Within the coppice-with-standards managed *Q. petraea* forest at site UFF no significant difference between the activity of *D. lutescens* in the three categories dense, medium dense, and sparse forest canopy were observed (RM-ANOVA: p>0.10) (Fig. 4).

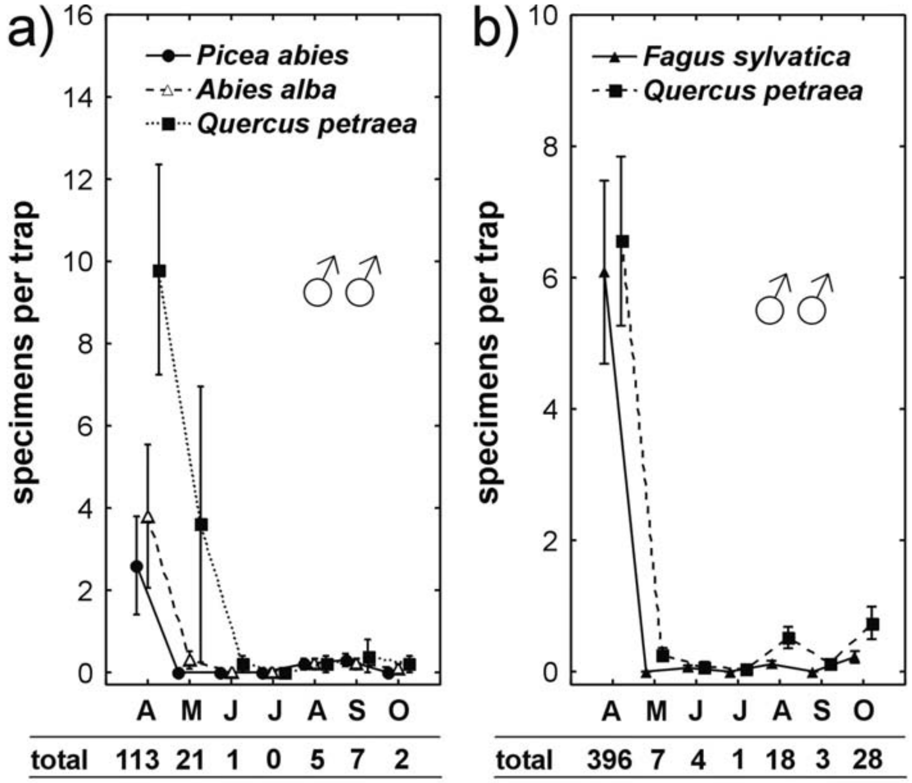

Fig. 3: Seasonal activity patterns of *D. lutescens* in the canopy (FIT) of different tree species at site FEG (a) and EBE (b) in 2004. Means and Standard error are shown. In all months average activity of females (not shown) was below one specimen per trap. The traps were emptied end of each month.

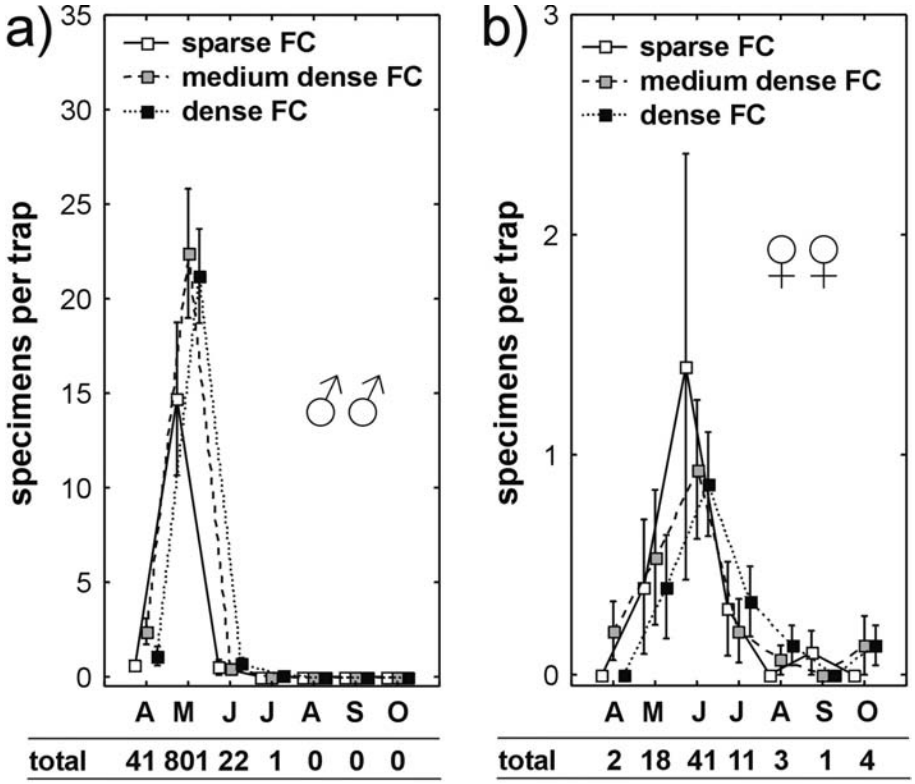

Fig. 4: Seasonal activity patterns of *D. lutescens* in the canopy (FIT) of *Q. petraea* in a coppice with standards forest at site UFF in 2002. Means and Standard error are shown. The traps were emptied mid-month. FC=forest canopy.

Discussion: *D. lutescens* was the most abundant species in the present study, occurring at all study sites (lowland and mountainous). This species has a west-palaearctic distribution and is common in Europe (KERZHNER & JOSIFOV 1999; GÜNTHER & SCHUSTER 2000). Generally the observed seasonal pattern confirms the current knowledge on this species. It overwinters as imago, the new generation occurs from mid-July on, and one generation per year is developed (EHANNO 1977; GOULA 1988; WACHMANN et al. 2004). As I could show, the activity of males compared to females is much higher in early spring. Males are active only during a small time interval in the end of April, probably during the search for food and mates. Later on, only females occured (see also EHANNO 1977). No difference in activity of males and females was observed in the new generation. Results from fogging of 30 *Q. petraea* tree crowns in the end of July 2004 and beginning of August 2005 near Werneck (Northern Bavaria) showed, that also densities of males (97 specimens) and females (107 specimens) of the new generation were comparable (Goßner unpubl. data). Similarly, SOUTHWOOD (1960) found a low number of males (seven specimens) and females (nine specimens) with suction traps in Britain (May, September, October). Therefore, either females were less flight-active in early spring or winter mortality in females is higher than in males. Sex-specific differences in winter mortality in insects were reported by RENAULT et al. (2002). If this applies for *D. lutescens* has to be verified by canopy fogging of *Quercus* in early spring.

WACHMANN et al. (2004) reported that *D. lutescens* occurs on several broad-leaved trees, mainly on *Tilia*, *Quercus*, *Acer*, *Corylus*, and *Ulmus* (see also STRAWIŃSKI 1936, 1964; SOUTHWOOD & LESTON 1959; LESTON 1961; WAGNER & WEBER 1964; WAGNER 1971; GÖLLNER-SCHEIDING 1974, 1992; EHANNO 1977; TAMANINI 1981, 1982; CHÉROT 1990). As MASSEE (1954) and SIMON (1992) demonstrated, *D. lutescens* is also found in high numbers on fruit trees (*Malus*, *Pyrus*, *Prunus*). The generally high abundance on indigenous *Quercus* (e.g. MASSEE 1954; VLACH 1994) could be confirmed in present study. In contrast, exotic

Q. rubra seems to be used as habitat only in mixed stands with indigenous *Quercus*.

Different explanations for the unequal distribution of *D. lutescens* on the studied tree species are possible: 1) differences in food supply and 2) differences in microclimatic conditions.

1) Predacious *D. lutescens* mainly feeds upon aphids and other small arthropods (STRAWIŃSKI 1964; TAMANINI 1982; WACHMANN et al. 2004). Differences in aphid densities could explain the high activity on *F. sylvatica* at site EBE in 2004, while at all other sites low activity was observed on this tree species. In 2004 mass occurrence of beech woolly aphid *Phylaphis fagi* (LINNAEUS 1767) (Homoptera: Phyllaphidinae) was observed in EBE (Müller pers. comm.). Another species of the same genus, *Deraeocoris fasciolus* KNIGHT 1921, is known to feed on *P. fagi* in North America, where it occurs on *Fagus grandifolia* EHRH. (WHEELER 2001). The high activity of *D. lutescens* on exotic *P. menziesii* might also be an effect of high food supply. Densities of introduced *P. menziesii* woolly aphid *Adelges cooleyi* (GILLETTE 1907) (Homoptera: Adelgidae) were high during the study period. During times of low native aphid abundance (year 2000) aphidophagous insects seemed to concentrate on this new food resource (see GOẞNER et al. 2005). Probably *D. lutescens* exploit *P. fagi* on *F. sylvatica* and *A. cooleyi* on *P. menziesii* in Central Europe. As LAMINE et al. (2005) pointed out searching behaviour of *D. lutescens* is influenced by resource availability.

2) DOROW (2001) described *D. lutescens* as a species inhabiting trees of open land and forest edges. The high activity on shade-intolerant species like *Quercus* and partly *L. decidua* compared to shade-tolerant *F. sylvatica* and semi shade-tolerant *P. abies* might therefore be explained by warmer and drier microclimatic conditions. This can also be seen as a reason for the high activity on exposed *P. menziesii* crowns overtopping the surrounding trees in present study. However, in *Q. petraea* no difference in activity in the canopies with dense, medium dense, and open forest canopy was observed. Therefore, differences in light and temperature might not be crucial for the abundance of *D. lutescens*. In contrast, activity of *D. lutescens* near ground in the forest interior seems to be low (DOROW 1999, 2001, Goßner unpubl. data). Therefore, food supply might be the most likely explanation for the occurrence pattern of *D. lutescens* in tree crowns. *D. lutescens* is known as a beneficial species in agriculture and forestry, e.g. attacking some pest species in orchards (FAUVEL & ATGER 1981; CHIRECEANU 2000; LINDSKOG & VIKLUND 2000). The fluctuation in aphid abundance might also explain the high annual fluctuation observed in present study, especially at site OTT.

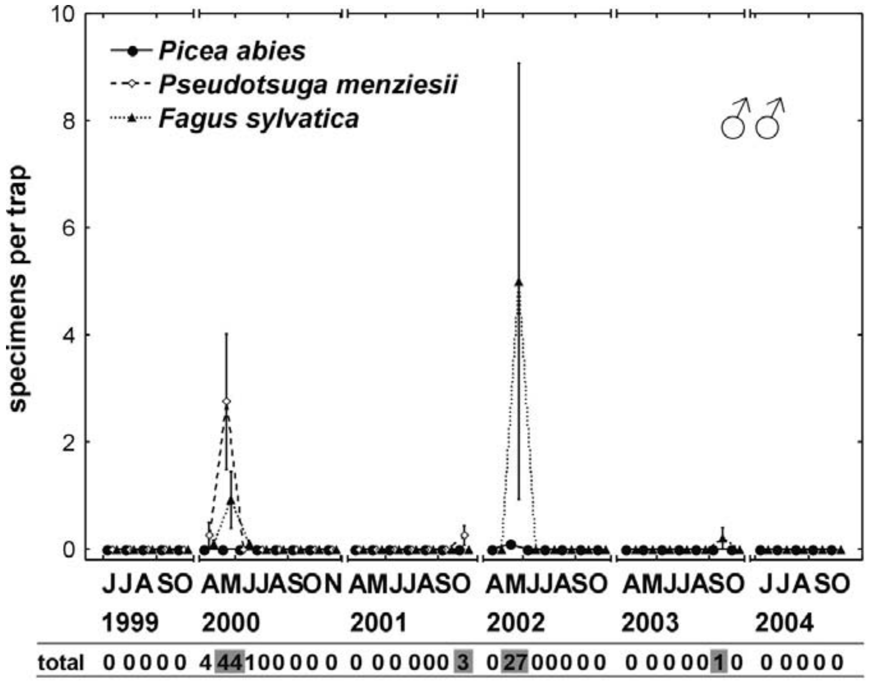

Fig. 5: Seasonal activity patterns of *D. lutescens* in the canopy (FIT) of different tree species at site OTT 1999-2004. The traps were emptied mid-month. In 1999 and 2004 sampling started in May.

Harpocera thoracica (FALLÉN 1807) – Miridae (Fig. 22)

Material collected: Flight-interception traps = 1,831 specimens, 836♂♂ (46 %), 995 ♀♀ (54 %); branch-traps = 33 specimens, 6♂♂ (18 %), 27 ♀♀ (82 %).

Phenological activity: Males and females showed a conspicuous activity peak in May (Figs 6, 7). While after mid-May almost no males were found at site KRU and FRE (2000-2001) (Figs 6c, e), at site UFF (2002) highest activity was observed between mid-May and mid-June (Fig. 8). At site KRU, females seemed to occur longer than males (Figs 6c, d). This was also confirmed by branch trap samples. While 30 % of females occured after mid-May, all males were sampled before that time. Differences in the occurrence of *H. thoracica* between

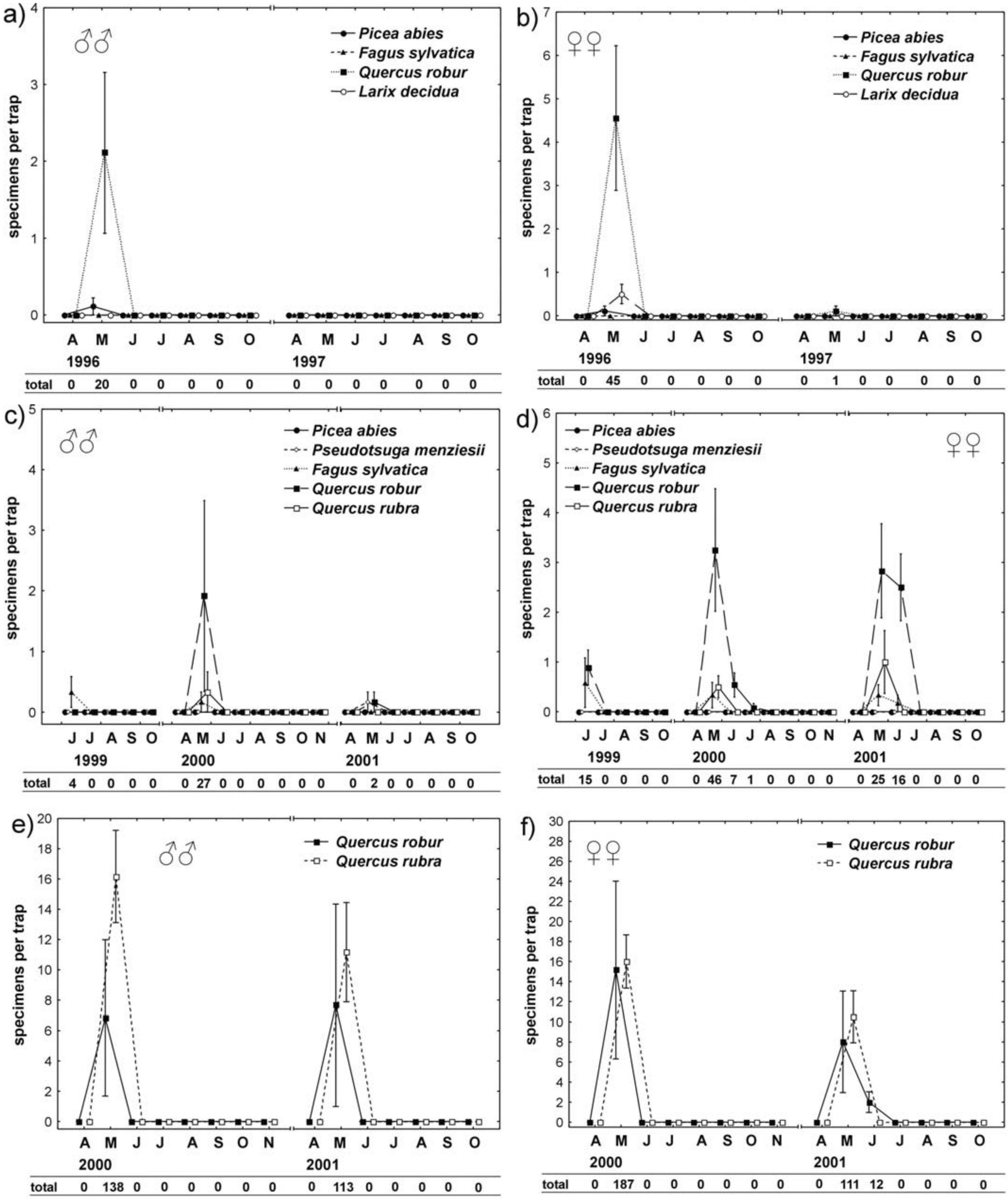

Fig. 6: Seasonal activity patterns of *H. thoracica* in the canopy (FIT) of different tree species at site HIE 1996-1997 (a, b), KRU 1999-2001 (c, d) and FRE 2000-2001 (e, f). Means and Standard error are shown. At HIE traps were emptied end, at sites KRU and FRE mid-month.

years became most obvious at site HIE (Figs 6a, b). While 65 specimens were sampled in 1996, only one female was captured in 1997. The difference was significant (Wilcoxon Matched Pair Test: p<0.01).

Tree preferences: Highest numbers of *H. thoracica* were found in the oak dominated stands of FRE and UFF (Figs 6e, f, 8). In beech dominated forests (HIE, EBE) the activity of *H. thoracica* was much lower (Figs 6a, b, 7c, d). At site OTT, were almost no *Quercus* occur, not a single specimen of this species was captured. The flight-acticity of *H. thoracica* was highest in *Quercus* canopies (Figs 6, 7) and this was significant at HIE, KRU, and EBE (RM-ANOVA, PH-Test: $p<0.05$). *H. thoracica* occured in high numbers on exotic *Q. rubra*, especially in the pure stand at site FRE (Figs 6e, f). Only from mid-May to mid-June 2001 a higher number of *H. thoracica* were sampled on indigenous *Q. robur*. The high numbers found on *P. abies* at site FEG were noticable (Figs 7a, b), but differences between tree species were not significant. In the coppice-with-standards managed oak forest at site UFF no significant difference between the activity of *H. thoracica* in the three categories dense, medium dense, and sparse forest canopy were observed (RM-ANOVA, $p>0.10$) (Fig. 8).

Discussion: *H. thoracica* showed its activity peak in early spring, in most cases before mid-May. WACHMANN et al. (2004) reported that within the zoophytophagous "early spring bugs" *H. thoracica* is the one with the fastest development. It requires only two weeks for nymphal development and this seems to be typical for catkin feeders (SOUTHWOOD & LESTON 1959). Climatic factors might have caused the later occurrence of this species at site UFF in 2002. The males have an especially short imaginal life span. SOUTHWOOD & LESTON (1959) and GROOVES (1968) reported longevity of males in *H. thoracica* of only one week in Britain. *H. thoracica* developed one generation per year. Eggs are inserted at the bud bases and stay there for around 11 months (SOUTHWOOD & LESTON 1959; SCHOPF & MITTERBÖCK 1991; SCHOPF et al. 1991). As for most species occurring in early spring on *Quercus*, this phenological pattern has to be seen as adaptation to its host plant. Nymphs suck on buds and pollen sacs of young blossoms of male *Quercus* (WACHMANN et al. 2004). The feeding habit of *H. thoracica* can cause a die off of young shoots (SCHOPF et al. 1991). Primarily, the results at site HIE indicate high fluctuation in population densi-

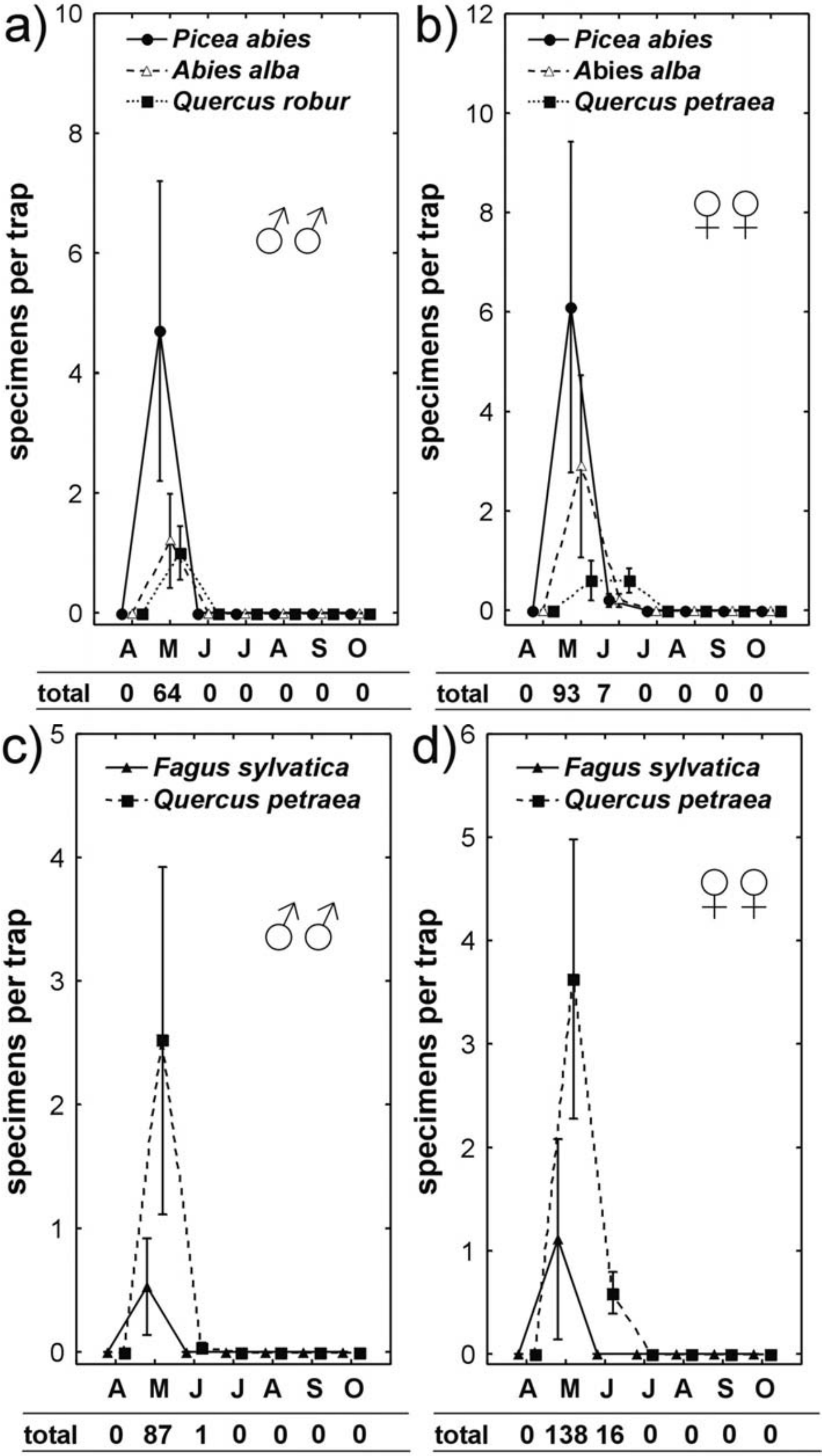

Fig. 7: Seasonal activity patterns of *H. thoracica* in the canopy (FIT) of different tree species at site FEG (a, b) and EBE (c, d) in 2004. Means and Standard error are shown. The traps were emptied end of each month.

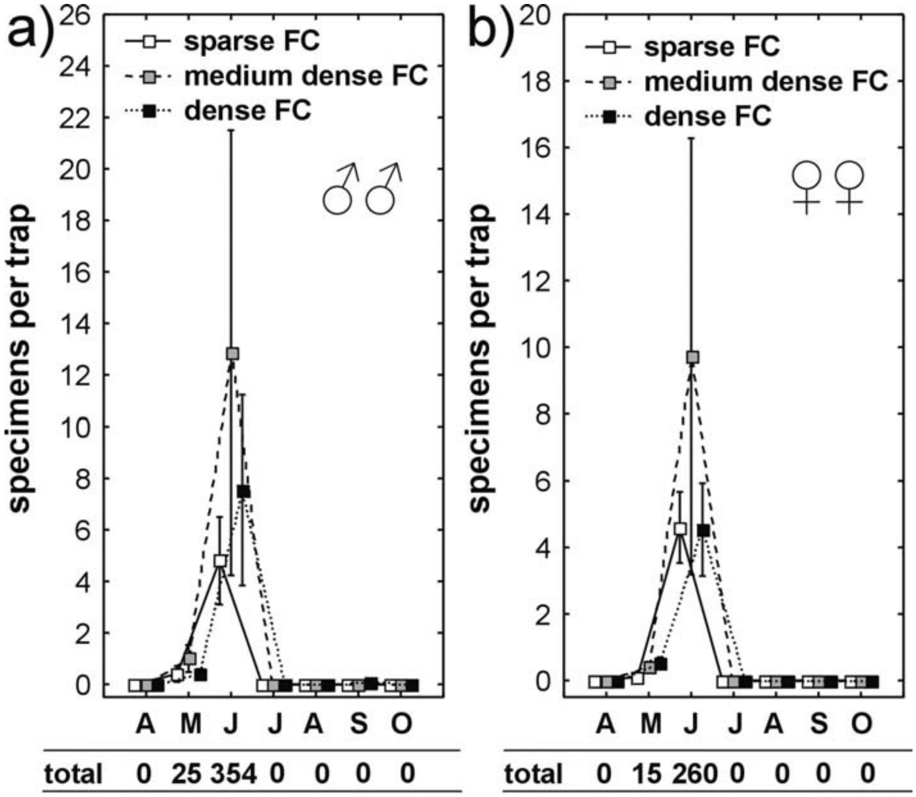

Fig. 8: Seasonal activity patterns of *H. thoracica* in the canopy (FIT) of *Q. petraea* in a coppice with standards forest at site UFF in 2002. Means and Standard error are shown. The traps were emptied mid-month. FC=Forest canopy.

ties. According to the present study, no clear difference in flight-activity of males and females in tree crowns are expected. In contrast, WACHMANN et al. (2004) reported about a high flight-activity of males only, flying to artificial light. Also SOUTHWOOD (1960) describes enormous catches of *H. thoracica* males during certain nights. However, females are attracted to light, too: thus, this phenomenon remains mysterious.

DOROW (2001) classified *H. thoracica* as *Quercus*-specialist. This is confirmed by the results of present study and by other studies (STRAWIŃSKI 1936; EHANNO 1965; GÖLLNER-SCHEIDING 1972; ŠTEPANOVIČOVÁ 1972; VLACH 1994; ŠTEPANOVIČOVÁ & BIANCHI 1999; WACHMANN et al. 2004; GOßNER 2006a). Present results indicate that this species exhibits high activity only in stands with a high proportion of *Quercus*. CMOLUCHOWA & LECHOWSKI (1990) classified *H. thoracica* to be typical for Tilio-Carpinetum in Poland. Interestingly, abundance of *H. thoracica* on introduced *Q. rubra* was also high and reached even higher values in a pure *Q. rubra* stand compared to an indigenous *Q. robur* stand (see GOßNER 2006b). Why *H. thoracica* showed high activity on conifers, specifically on *P. abies* at site FEG, cannot be explained by present autecological knowledge. Perhaps, *H. thoracica* is sometimes feeding on conifer aphids. WACHMANN et al. (2004) describe this species was already observed sucking on aphids. However, it is assumed that this species exclusively lives on *Quercus*.

H. thoracica is known to prefer sunny and dry sites (WACHMANN et al. 2004). Besides the high proportion of *Q. petraea*, this might explain the high activity of this species at coppice-with-standards managed forest site UFF, although within this site no difference between differently dense forest canopies was observed.

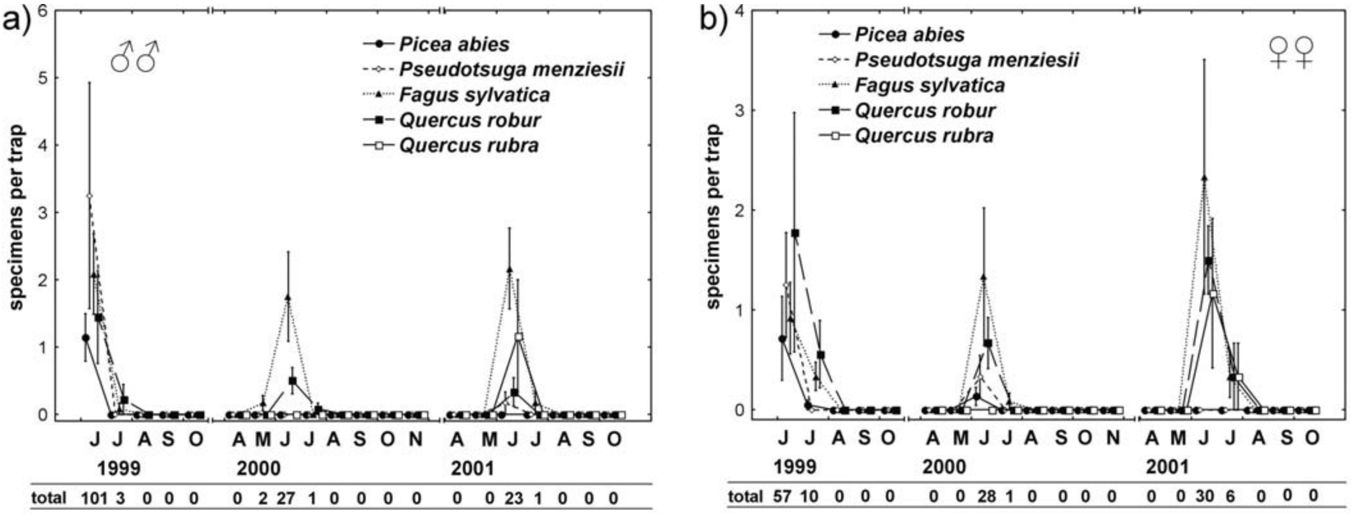

Fig. 9: Seasonal activity patterns of *P. varians* in the canopy of different tree species at site KRU 1999-2001. Means and Standard error are shown. The traps were emptied mid-month.

Psallus varians (HERRICH-SCHAEFFER 1841) – Miridae (Fig. 23)

Material collected: Flight-interception traps = 1,562 specimens, 615♂♂ (39 %), 947♀♀ (61 %); branch-traps = 120 specimens, 68♂♂ (57 %), 52♀♀ (43 %).

Phenological activity: Comparing activity patterns of different sampling intervals, main activity of *P. varians* in the first two weeks of June can be assumed, although at site OTT highest numbers of specimens were observed between mid-June and mid-July (Figs 9-11). Imagines were flight-active within a narrow time-interval (<1 month), although single captures were made until September. This was confirmed by branch trap samples: 90 % of all specimens occured between mid-May and mid-June in both study years. Not only seasonal, but also annual variation was high. This is illustrated by the six-year study at site OTT (Fig. 11). At this site, activity in 2001, 2003 and 2004 was conspicuously higher than in 1999, 2000, and 2002. Regarding *F. sylvatica* the between-year difference was significant (F-ANOVA: p<0.05).

Tree preferences: Interestingly, in the broad-leaved tree dominated site HIE (1996-1997) and in the *Quercus* stands of FRE (2000-2001) and UFF (2002) average number of sampled *P. varians* was below 1 per tree crown (which is therefore not shown). Generally, number of sampled specimens was higher on broad-leaved trees compared to *P. abies*. However, no clear preference of *P. varians* for *Quercus* or *F. sylvatica* could be observed. The activity of males in tree crowns of *P. menziesii* at site KRU in 1999 (Fig. 9) and on *A. alba* at site FEG (Figs 10a, b) was quite high. In mountainous stands (REW, NBJ) *P. varians* was found on *A. alba* (4♂♂ 6♀♀) and *P. abies* (1♂ 3♀♀).

Discussion: *P. varians* was by far the most abundant *Psallus* species and the third most abundant species in total at the various sites within present investigation. Near ground activity densities of *P. varians* were also high compared to other Heteroptera species in the study by DOROW (1999, 2001). In present study *P. varians* occured at both lowland and mountainous sites, confirming the studies of GÖLLNER-SCHEIDING & REZBANYAI-RESER (2000) who found this species between 530 and 1,200 m a.s.l. in southern Switzerland.

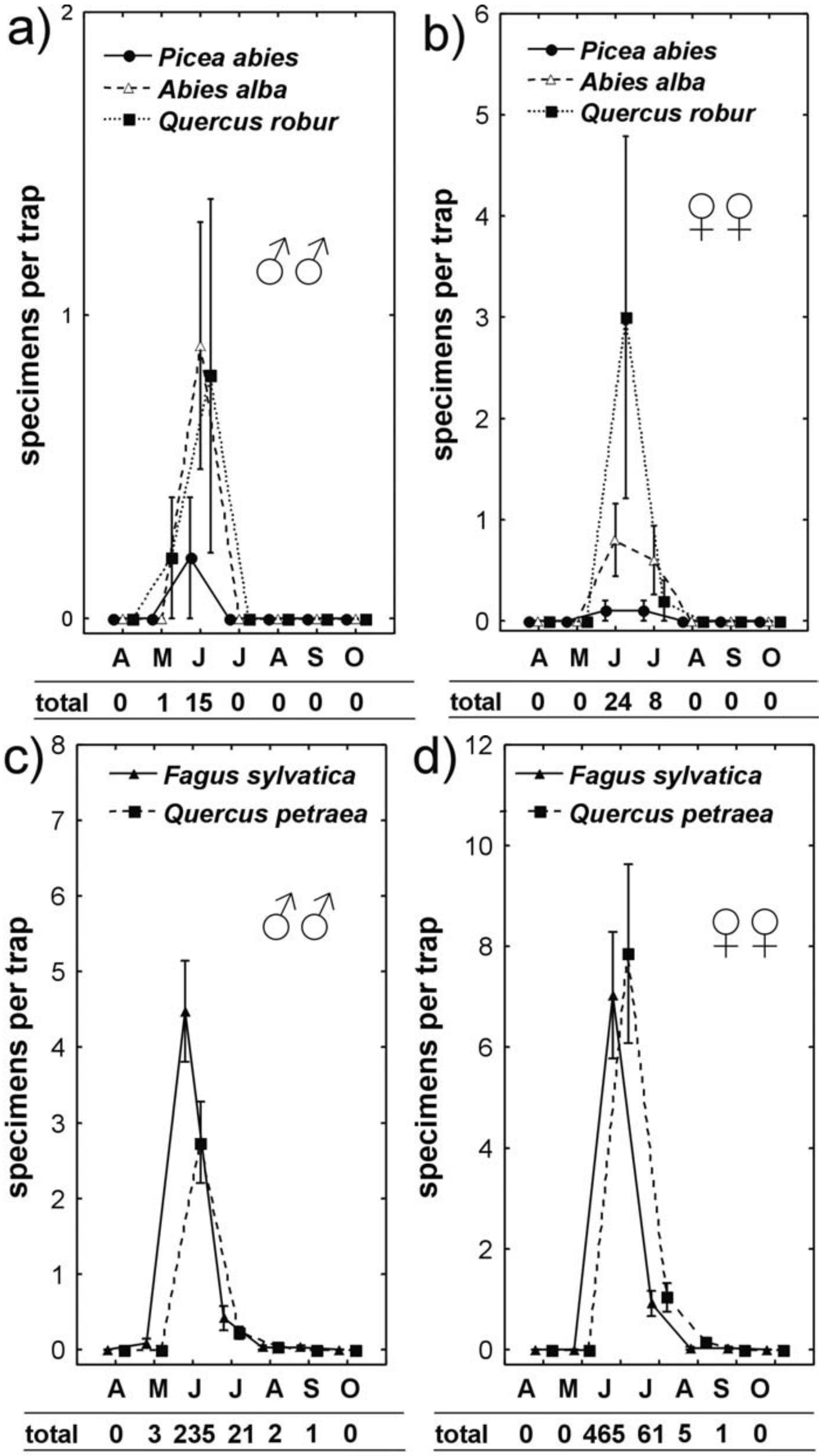

Fig. 10: Seasonal activity patterns of *P. varians* in the canopy (FIT) of different tree species at site FEG (a, b) and EBE (c, d) in 2004. Means and Standard error are shown. The traps were emptied end of each month.

The main activity time of imagines was observed during the first two weeks in June.

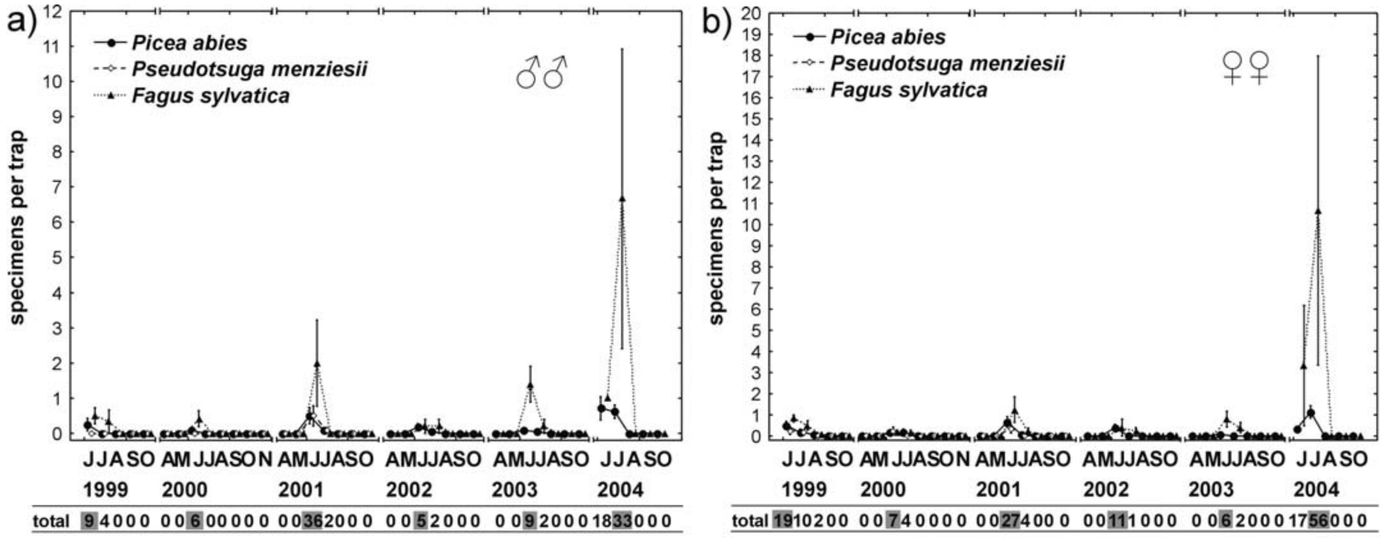

Fig. 11: Seasonal activity patterns of *P. varians* (left: males, right: females) in the canopy (FIT) of different tree species at site OTT (1999-2004). Means and Standard error are shown. The traps were emptied mid-month.

Therefore it seemed to be even shorter than the time of occurrence mentioned by GORCZYCA (1991) for Poland (June-July) and WACHMANN et al. (2004) for Germany and Austria (end of Mai to mid-July). However, in some years, e.g. in 2004 at site OTT, highest activities were observed between mid-June and mid-July. A similar pattern occured in 1991 (highest activity: mid-June to mid-July) compared to 1992 (highest activity: mid-May to mid-June) in the forest nature reserve Schönbuche in Hesse (DOROW 2001). This can probably be explained by differences in climatic conditions. Results indicate that females occur for a longer time than males. Interestingly, females showed higher flight-activity, but were less active on branches than males. Also, DOROW (2001) found a slightly higher flight-activity of females near ground. Observed seasonal pattern indicated that only one generation per year occurs, which overwinters in the egg stage (see also WACHMANN et al. 2004). A high annual fluctuation in abundance was observed and this concurs with results of DOROW (1999) and WACHMANN et al. (2004).

Its affinity with broad-leaved trees (STRAWIŃSKI 1964; TAMANINI 1981), but no clear preference for *Quercus*, as described by WACHMANN et al. (2004), could be confirmed by present study. No significant differences in activity were observed between *P. varians* specimens on *Quercus* and on *F. sylvatica*. Also, in urban areas (GÖLLNER-SCHEIDING 1992), in a beech forest in Denmark (NIELSEN 1974), and in a primary forest nature reserve in Slovenia (FLOREN & GOGALA 2002) high abundance of *P. varians* on *F. sylvatica* was documented. WAGNER (1952, 1962, 1975) and SCHUSTER (1995) note *Fagus sylavatica* and *Quercus* as main host trees for the Central European subspecies *P. varians varians*. GOẞNER (2006a) found a significant preference of *P. varians* for *F. sylvatica*, using a Monte-Carlo-Test. WAGNER (1962) argues that in many parts of Central and Northern Europe *F. sylavatica* is the main host tree, while in other regions *Quercus* species are more important hosts. Probably, in Central Europe a high overall abundance of *P. varians* occurs only in larger beech forests, like the Northern Steigerwald (EBE) and the beech forests of Hesse. According to my results, introduced *Q. rubra* is used as habitat by *P. varians*, too, at least in some years. REUTER (1908) pointed out, that a low number of *P. varians* successfully develop on conifers. In contrast, WACHMANN et al. (2004) assumes conifers not to be host trees of *P. varians*, although this species is found frequently on conifers. Therefore, the occurrence on *P. abies*, *A. alba*, and *P. menziesii* in present study remains unclear. STRAWIŃSKI (1964) observed *P. varians* sucking out aphids and insect eggs. Hence, it might be possible that zoophytophagous *P. varians* sometimes use conifer aphids as food resource.

Atractotomus magnicornis (FALLÉN 1807) – Miridae (Fig. 24)

Material collected: Flight-interception traps = 1,497 specimens, 612♂♂ (41 %), 885 ♀♀ (59 %).

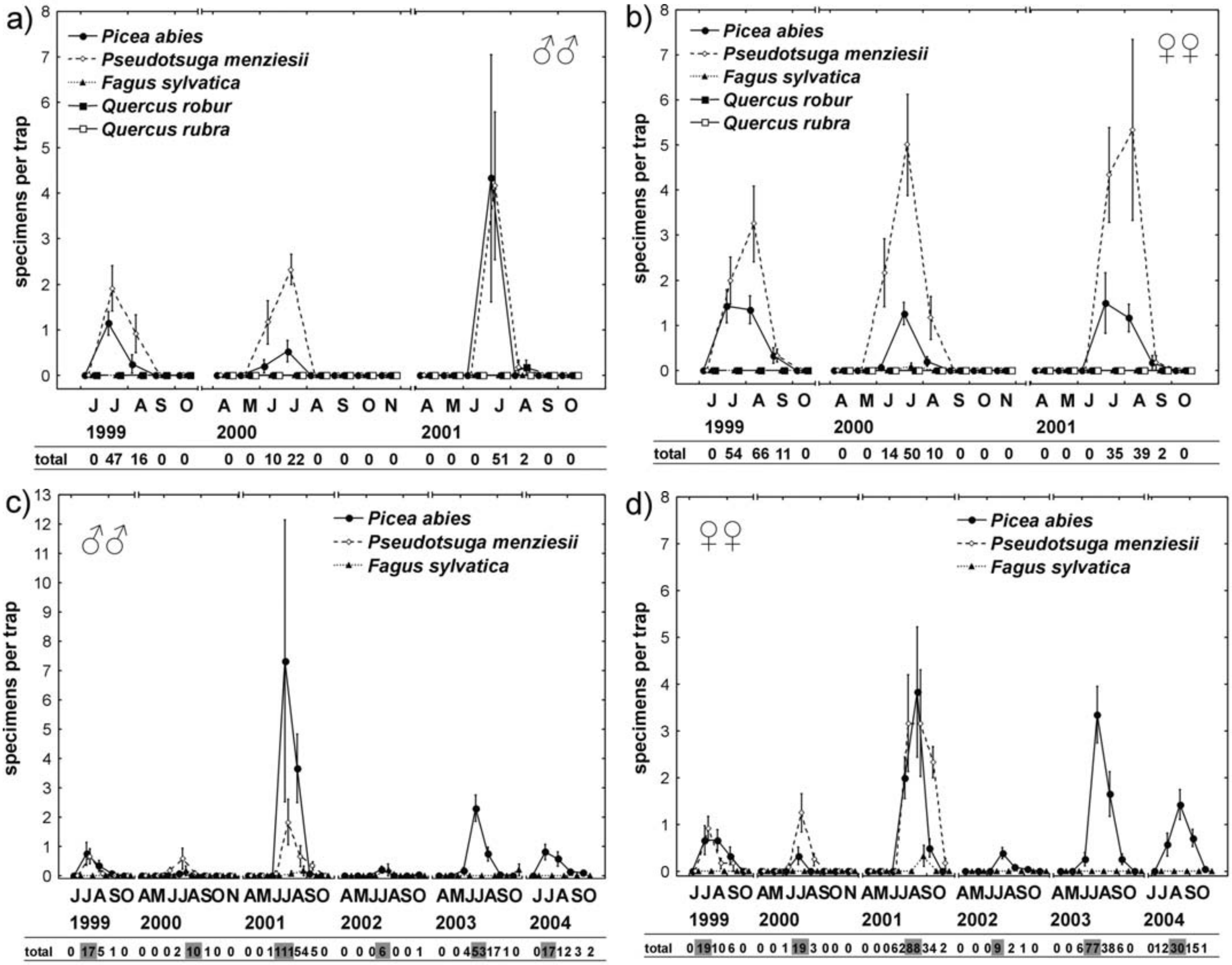

Fig. 12: Seasonal activity patterns of *A. magnicornis* in the canopy (FIT) of different tree species at site KRU 1999-2001 (a, b) and OTT 1999-2004 (c, d). Means and Standard error are shown. The traps were emptied mid-month.

Phenological activity: Highest activity of *A. magnicornis* was observed between mid-June and mid-July (Fig. 12). Females seemed to occur longer, still with high flight-activity between mid-July and mid-August. In the years 2001 and 2004 they even exhibited the activity peak during that time interval (Figs 12b, d). At the mountainous site (RIB) *A. magnicornis* occured later in the year and showed lower overall activity (Figs 13c, d). The six-year study at site OTT points out that seasonal as well as high annual fluctuation in flight-activity occured (Figs 12c, d). The latter was highly significant for *P. menziesii* (1999-2001) and *P. abies* (1999-2004) (F-ANOVA: p<0.001).

Tree preferences: Almost all specimens of *A. magnicornis* were sampled on coniferous trees, like *P. abies*, *P. menziesii*, and *A. alba*. The high numbers of specimens found on introduced *P. menziesii* are remarkable, especially at site KRU where a one hectare pure stand of *P. menziesii* was investigated (Figs 12a, b). At OTT and KRU the higher flight-activity of A. *magnicornis* on *P. menziesii* compared to other tree species was significant (RM-ANOVA, PH-Test: p<0.05). At sites FEG and RIB more specimens of A. *magnicornis* were captured on *A. alba* compared to *P. abies* (Fig. 13). However, this was not significant. No specimens were sampled on *Quercus*. At site HIE a low number of A. *magnicornis* were captured in total. All specimens were sampled on *P. abies*, except one (*L. decidua*).

Discussion: *A. magnicornis* occured within a large altitudinal range, which corresponds with previous publications (BÜTTNER & WETZEL 1964; TAMANINI 1982; WACHMANN et al. 2004). A clear influence

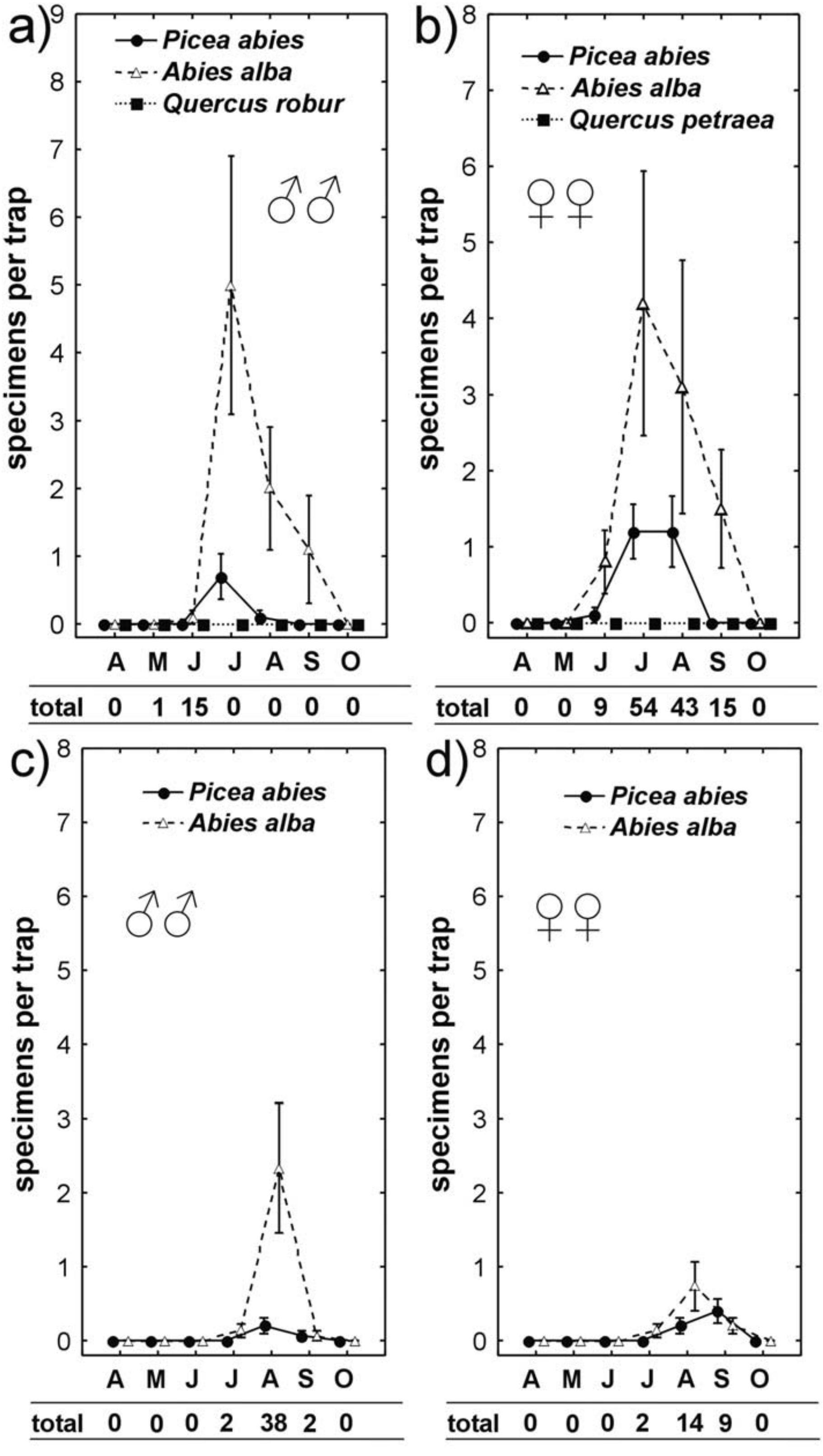

Fig. 13: Seasonal activity patterns of *A. magnicornis* in the canopy (FIT) of different tree species at site FEG (a, b) and RIB (c, d) in 2004. Means and Standard error are shown. The traps were emptied end of each month.

of climatic conditions on phenological data of *A. magnicornis* was observed in present study. While at lowland sites main activity of imagines occured between mid-June and mid-July, at mountainous sites abundance peak was around two weeks to one month later. This confirms the reports of GORCZYCA (1991) and WACHMANN et al. (2004) that the presence of this species depends on altitude. Overall activity at mountainous sites was smaller compared to lowland sites. Independent of altitude, *A. magnicornis* developed one generation per year and overwintered in the egg stage. Eggs might be deposited in bark cracks. GOẞNER & BRÄU (2004) observed high numbers of nymphs in arboreal photo eclectors, which were installed two meters above ground. They explained the high activity on stems by a migration of nymphs that hatched under the bark of stems up to the tree crown. The observed differences in annual activity clearly indicate high fluctuations in population densities between years.

A. magnicornis is exclusively found on conifers (REUTER 1908; WAGNER 1952; MASSEE 1954; STRAWIŃSKI 1964; TAKSDAL 1965; DIOLI 1975; TAMANINI 1982; STONEDAHL 1990; GORCZYCA 1991). WACHMANN et al. (2004) described *P. abies* as main host tree of *A. magnicornis* in Central Europe, which is rarely found on other conifers (*Abies*, *Pinus*, *Larix*, *Juniperus communis* L., *Thuja*). In contrast, significantly higher abundance was found on exotic *P. menziesii* compared to indigenous *P. abies* in particular years of present study. GOẞNER & BRÄU (2004) found also a higher density of this species in tree crowns of *P. menziesii* compared to *P. abies* using branch beating method. *A. magnicornis* feeds phytophagous on needles and buds of host plants as well as zoophagous on insects (Aphidina, Psocoptera) and mites (MASSEE 1954; SCHNEIDER 1962; THALENHORST 1962; STRAWIŃSKI 1964; WACHMANN et al. 2004). The zoophagous feeding habit of *A. magnicornis* was also demonstrated in North America, to where it was introduced (MCCLURE 1979, 1981; WHEELER & HENRY 1977, 1992). MCCLURE (1979) found *A. magnicornis* to be one of the predominant predators of helmlock scale (*Fiorinia externa* FERRIS 1942, Homoptera, Diaspididae) in a helmlock forest (*Tsuga canadensis* (L.) CARR.) of Connecticut. The most probable prey species in Europe is *A. cooleyi*, which was introduced together with *P. menziesii* from North America and reaches high densites on its host plant in Central Europe (STEFFAN 1972).

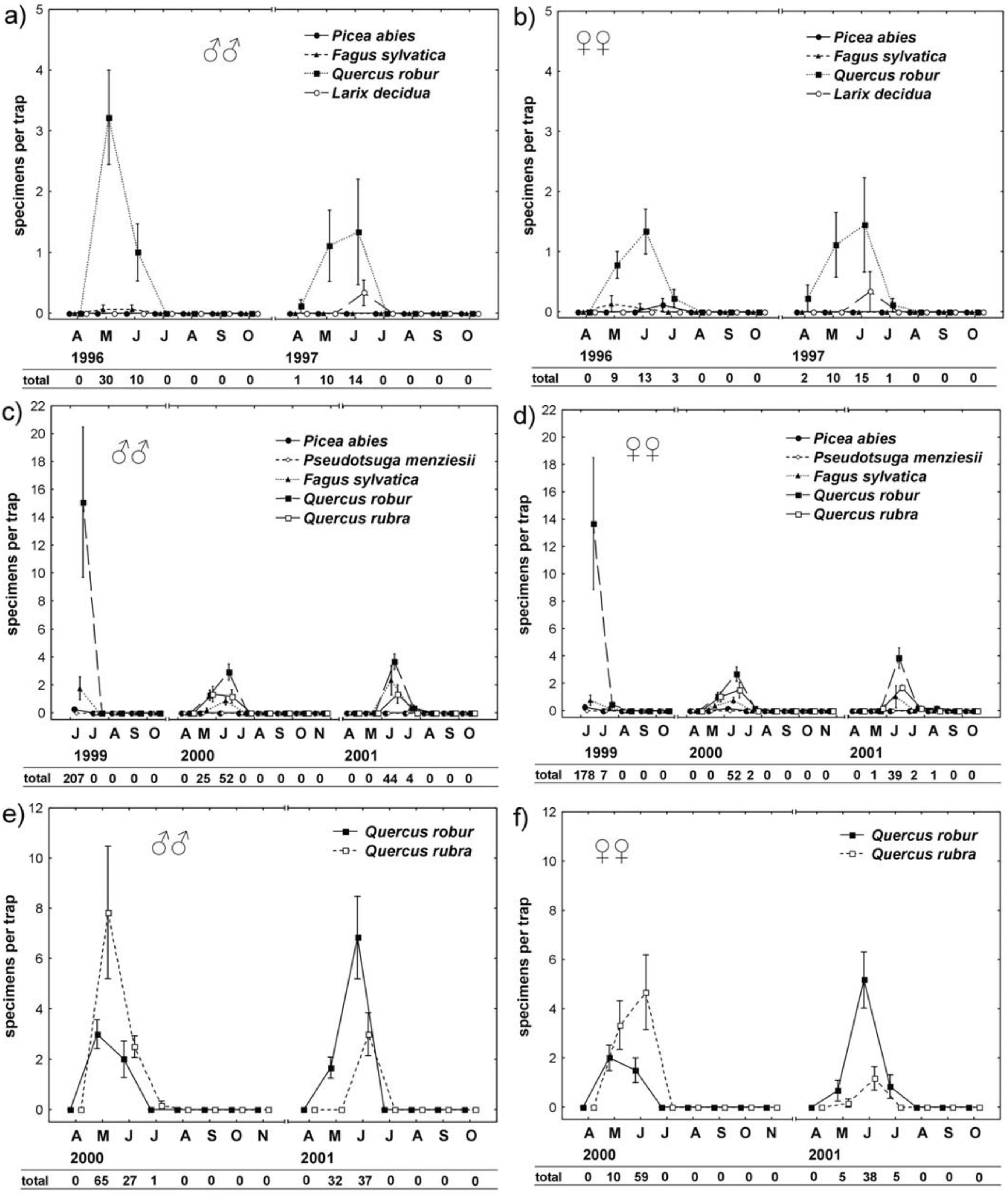

Fig. 14: Seasonal activity patterns of *R. striatellus* in the canopy (FIT) of different tree species at site HIE 1996-1997 (a, b), KRU 1999-2001 (c, d) and FRE 2000-2001 (e, f). Means and Standard error are shown. At HIE traps were emptied end, at sites KRU and FRE mid-month.

STEHLÍK (1998) investigated Heteroptera on introduced Cupressaceae in the Czech Republic and he found that *A. magnicornis* develops on introduced *Thuja occidentalis* L. and TAKSDAL (1965) found the species on

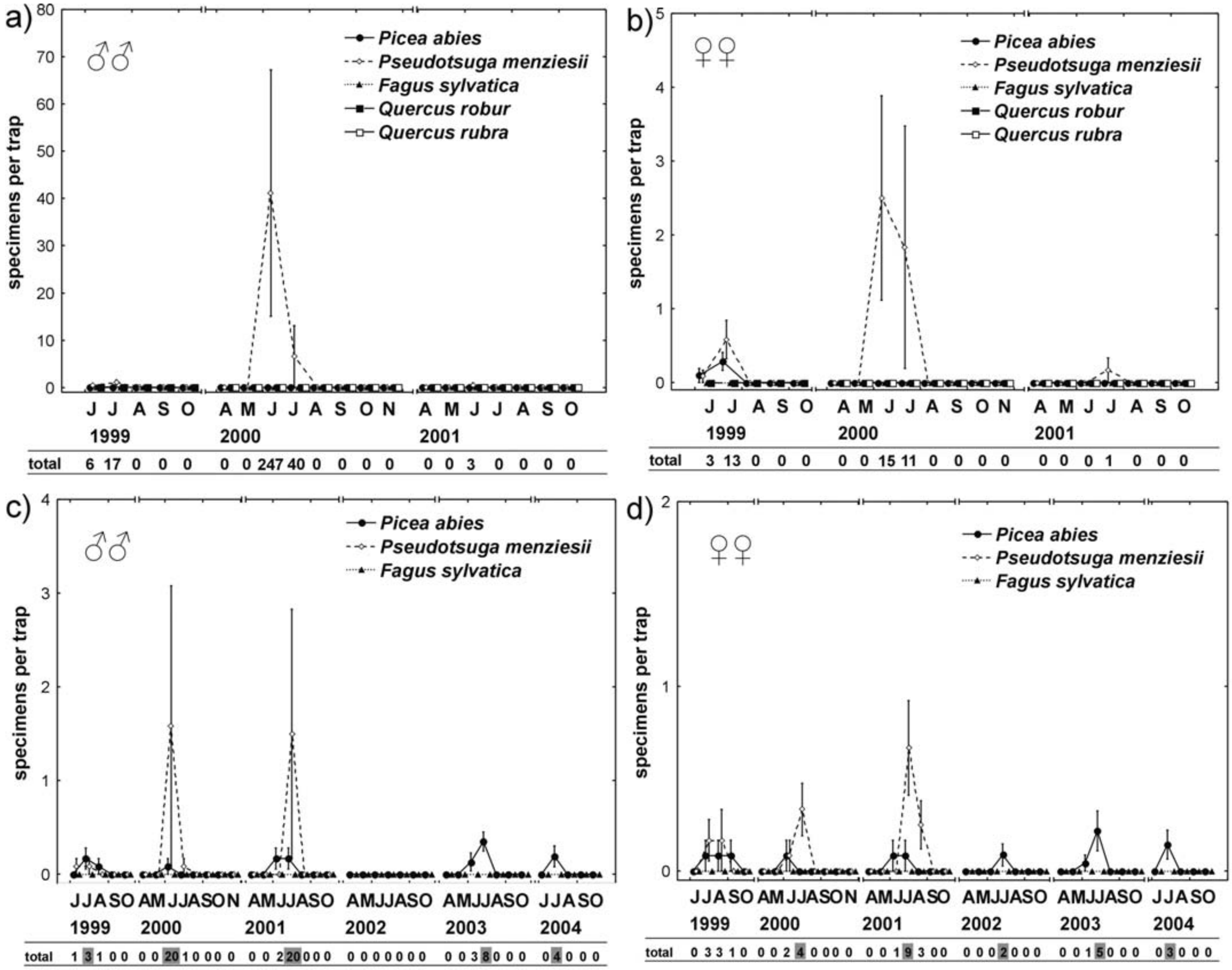

Fig. 15: Seasonal activity patterns of *C. alpestris* in the canopy (FIT) of different tree species at site KRU 1999-2001 (a, b) and OTT 1999-2004 (c, d). Means and Standard error are shown. The traps were emptied mid-month.

exotic tree species in his study on the Heteroptera of ornamental trees in Norway. In addition, my results indicate that abundance of *A. magnicornis* might be higher on *A. alba* compared to *P. abies*, but this was not statistically significant. Based on these results, *A. magnicornis* cannot be assigned as *P. abies* specialist as done by Dorow (2001). Probably, phenological patterns of *A. magnicornis* are highly influenced by fluctuations in prey densities.

Rhabdomiris striatellus (Fabricius 1794) – Miridae (Fig. 25)

Material collected: Flight-interception traps = 1,211 specimens, 655♂♂ (54 %), 556♀♀ (46 %); branch-traps = 91 specimens, 40♂♂ (44 %), 51♀♀ (56 %).

Phenological activity: *R. striatellus* exhibited highest flight-activity in May and June (Fig. 14). This was confirmed by branch trap samples: 27 % (25 specimens) of the collected specimens were sampled between mid-April and mid-May and 70 % (64 specimens) between mid-May and mid-June. Males occured slightly earlier than females, especially at site FRE in the year 2000 (Figs 14e, f) and at site HIE in the year 1996 (Figs 14a, b). Besides seasonal, also annual fluctuations in abundance were observed. This was most obvious at site KRU, where activity in the year 1999 was much higher than in 2000 and 2001 (Figs 14c, d). However, this was not significant (F-ANOVA: p>0.10).

Tree preferences: Highest flight-activity of *R. striatellus* was observed on *Quercus* (Fig. 14). This was significant at all sites (RM-ANOVA, PH-Test: p<0.05). Only at site KRU in 2001 the number of specimens found on *F. sylvatica* by FITs is worth mentioning. At site OTT where almost no *Quercus* trees occured in the studied stands, not a single specimen was found on *F. sylvatica*, *P. abies*, or *P. menziesii*. Interestingly, high numbers were found on introduced *Q. rubra* (Figs 14e, f). In addition, activity on branches of *Q. rubra* was higher than on *F. sylvatica.* In the pure stand of *Q. rubra* at site FRE in 2000 the activity of *R. striatellus* was even higher than in the pure stand of *Q. robur* (Figs 14e, f). The activity of *R. striatellus* in the oak forest at site UFF in 2002 was low with a mean peak in June of slightly more than one specimen per tree crown. In the beech forest of EBE and at site FEG in 2004, even lower activity on *Q. petraea* was observed. No specimen was sampled on *F. sylvatica* in EBE.

Discussion: *R. striatellus* is one of the mirid species that has a very fast development under ideal climatic conditions, as it was shown for *H. thoracica* (Wachmann et al. 2004). In 1996 at site HIE and in 2000 at site FRE especially males occured early in spring and reached their abundance peak already before mid-May. Favourite climatic conditions probably caused this early occurrence. In other years and at other sites males reached their activity peak between mid-May and mid-June, as females did in general. According to Wachmann et al. (2004), in June, eggs are deposited in female blossom buds, where they overwinter. However, in spring Goßner & Bräu (2004) found high numbers of nymphs in arboreal photo eclectors that were installed two meters above ground at site KRU. They assume that nymphs might hatch from eggs deposited in bark cracks and migrate up to the tree crown in spring. This corresponds with the results of Lapková (1989a, 1989b) and Vidlička (1993) in Slovakia. A slightly higher flight-activity of males in tree crowns can be assumed and this corresponds with results of light trapping (Göllner-Scheiding & Rezbanyai-Reser 2000). Only one generation per year is developed. The recorded high annual variation indicates high fluctuations in population densities of this species. This probably caused the low activity during the one-year study at sites UFF, EBE and FEG.

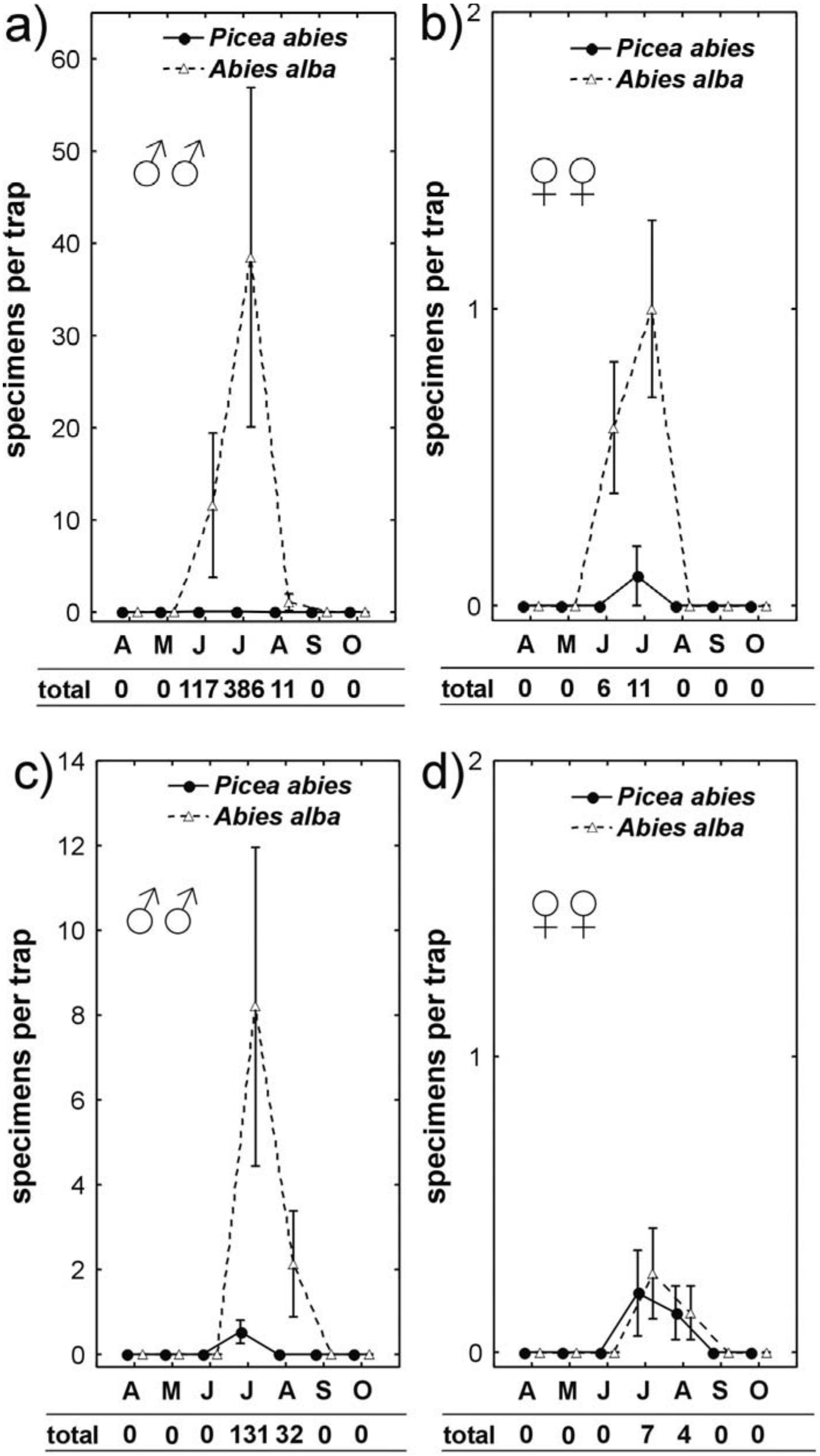

Fig. 16: Seasonal activity patterns of *C. alpestris* in the canopy (FIT) of different tree species at site FEG (a, b) and RIB (c, d) in 2004. Means and Standard error are shown. The traps were emptied end of each month.

Tab. 4: Number specimens of *P. rufipes* sampled by flight-interception traps. Highest numbers are bold (♂♂/♀♀). N=Number of traps.

Project site	year	N	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S	
HIE	1996	39	/	0/0	0/0	0/0	3/1	**10/4**	3/2	0/0	/	16/7	
	1997	39	/	0/0	0/0	0/0	9/**3**	**20**/1	0/0	0/0	/	29/4	
OTT	1999	36	/	/	/	0/0	1/0	0/0	**3**/0	0/0	-/-	/	4/0
	2000	36	/	0/0	0/0	0/0	**3**/0	**3**/2	**3**/1	0/0	0/0	/	9/3
	2001	36	/	0/0	0/0	0/0	0/**1**	**9**/0	5/0	0/0	/	/	14/1
	2002	28	/	0/0	0/0	0/0	3/0	**7/1**	1/0	0/0	/	/	11/1
	2003	28	/	0/0	0/0	0/0	1/0	7/**2**	**10**/0	3/0	/	/	21/2
	2004	24	/	/	/	0/0	0/0	**5**/0	3/0	1/0	/	/	9/0
KRU	1999	54	/	/	/	0/0	2/0	**22/4**	16/3	2/0	/	/	42/7
	2000	51	/	0/0	0/0	0/0	3/2	28/**9**	**42**/8	0/0	0/0	/	73/19
	2001	30	/	0/0	0/0	0/0	0/0	**11/6**	8/0	0/0	/	/	19/6
FRE	2000	12	/	0/0	0/0	0/0	0/2	6/1	**25/4**	4/2	0/0	/	35/9
	2001	12	/	0/0	0/0	0/0	0/0	10/**3**	**17**/2	0/0	/	/	27/5
UFF	2002	40	/	0/0	0/0	0/0	1/0	12/**4**	**21**/0	4/0	/	/	38/4
EBE	2004	63	/	0/0	0/0	0/0	3/0	**27/1**	20/**1**	3/0	/	53/2	
FEG	2004	25	/	0/0	0/0	0/0	0/0	1/**1**	**2**/0	0/0	/	3/1	
RIB	2004	30	/	0/0	0/0	0/0	2/**1**	**5/1**	2/0	0/0	/	9/2	
Total begin-end			/	0/0	0/0	0/0	17/5	**63/8**	27/3	3/0	/	110/16	
Total mid-mid							14/5	120/**32**	**154**/18	14/2			302/57

The present study confirmed the preference of *R. striatellus* for *Quercus*, as described by Strawiński (1964), Göllner-Scheiding (1970, 1972), Ribes (1982), Vlach (1994), Štepanovičová & Bianchi (1999), Dorow (2001), Wachmann et al. (2004), and Goßner (2005, 2006a). In present investigation, I document that preference of *R. striatellus* for *Quercus* includes not only indigenous oaks, but also exotic *Q. rubra*. The binding to *Quercus* probably is caused by the special feeding habit of the nymphs. Strawiński (1964) and Wachmann et al. (2004) reported that nymphs mainly suck on reproductive organs like female blossom buds and pollen sacs of *Quercus* host trees. Imagines, however, are mainly zoophagous (aphids, cicada nymphs, mirid nymphs, caterpillars) (see Jahn 1944; Kullenberg 1944; Southwood & Leston 1959; Putshkov 1961; Strawiński 1964; Starý et al. 1988; Hradil 2001; Wheeler 2001; Wachmann et al. 2004). This might explain why they were sometimes found on other tree species or in the herb layer, as reported by Wachmann et al. (2004).

Cremnocephalus alpestris Wagner 1941 – Miridae (Fig. 26)

Material collected: Flight-interception traps = 1,174 specimens, 1,059♂♂ (90 %), 115 ♀♀ (10 %). Phenological activity: Depending on the year, the activity peak of imagines was between mid-May and end of July (Figs 15, 16). In addition, fluctuations in total abundance between years occured (Fig. 15). This was most obvious regarding males on *P. menziesii* at site KRU (Figs 15a, b). While 40 males per tree crown were found between mid-May and mid-June in 2000, in total only 18 males were found in 1999 and three in 2001. This was statistically significant (F-ANOVA: $p<0.05$). At site HIE in 1996 and 1997 only 13 specimens of *C. alpestris* were captured.

Tree preferences: The majority of specimens was sampled in the crowns of conifers and only two on *F. sylvatica* at site HIE and one on *Q. robur* at site KRU. A much higher abundance of *C. alpestris* was observed on *P. menziesii* compared to *P. abies* at site KRU and OTT (Fig. 15). This was significant in 2000 at site OTT and in 2000 at site KRU (RM-ANOVA, PH-Test: $p<0.05$), a trend ($p=0.05$) was observed in 2001 at site KRU. A high variation in abundance between single trees of *P. menziesii* occured, regarding especially males at site OTT (Figs 15c, d). At site FEG and in the mountainous stands (RIB) the activity on *A. alba* was much higher than on *P. abies* (Fig. 16). In summary, *C. alpestris* exhibited high activity only on *P. menziesii* and *A. alba*.

Discussion: *C. alpestris* is known as species inhabiting Central and Southeast European mountainous landscapes, occurring mainly between 1,000 and 1,700 m a.s.l (Wagner 1952, 1973; Wagner & Weber 1964; Dioli 1975; Tamanini 1982; Gorczyca 1991). Büttner & Wetzel (1964) ob-

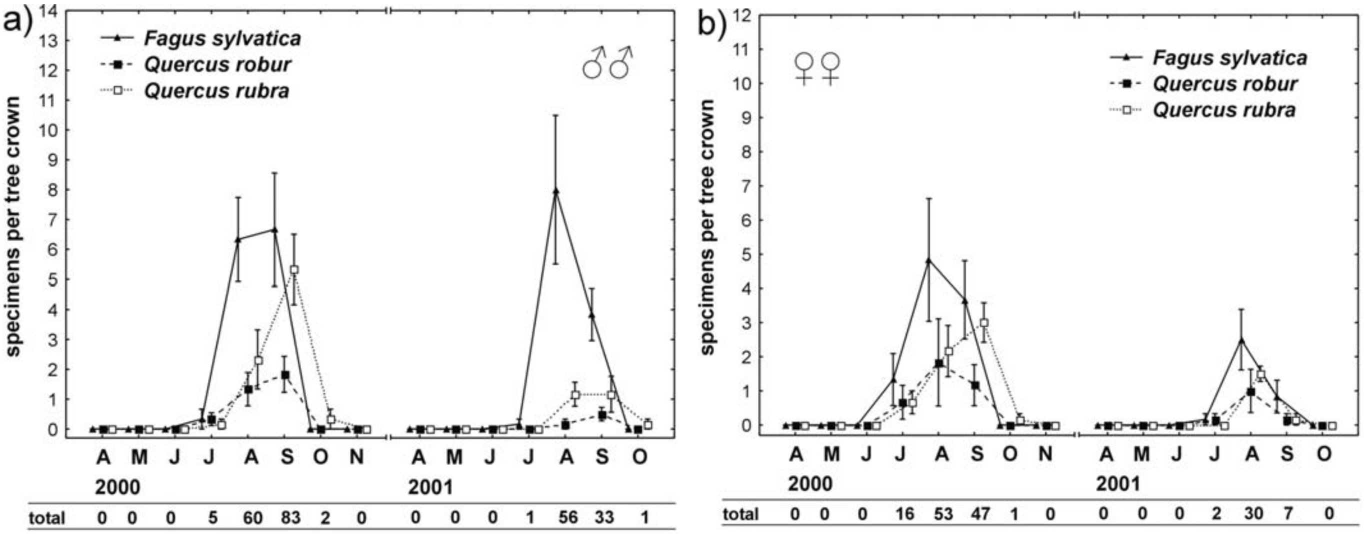

Fig. 17: Seasonal activity patterns of *P. rufipes* on branches (BT) in the canopy of different tree species at site KRU (2000-2001). Means and Standard error are shown. The traps were emptied mid-month.

served *C. alpestris* only obove 720 m a.s.l. in West Saxony. At lowland sites it was rarely found in previous investigations in Germany (SCHUSTER 1995; WACHMANN et al. 2004). Surprisingly, in present study *C. alpestris* was observed in high numbers at the lowland sites of KRU (620-645 m a.s.l.) and FEG (500-510 m a.s.l.) and the preference for mountainous sites, therefore, not confirmed by present study. A much higher number of males was noticed at all study sites. If males are more flight-active or male densities are higher than for females has to be verified by future investigations.

Depending on year and altitude activity peaks ranged from early June to mid-July and this goes along with the informations of WACHMANN et al. (2004). At mountainous sites flight-activity started around half a month later compared to lowland sites. The high variation in flight-activity of *C. alpestris* between years and single trees was conspicuous and this might be explained by fluctuations in prey availability. Only one generation per year occured at all sites. According to WACHMANN et al. (2004) females of *C. alpestris* insert their eggs at the base of the short shoots, where they overwinter.

The preference of *C. alpestris* for *P. abies* (DIOLI 1975; WACHMANN et al. 2004) was not confirmed by present study. A conspicuously higher activity occured on *P. menziesii* and *A. alba* (see also GOẞNER & BRÄU 2004; GOẞNER 2005). The zoophytophagous *C. alpestris* sucks on needles and buds of its host trees as well as on aphids and coccids (WACHMANN et al. 2004). Possibly, the high abundance of aphid prey (Douglas-fir woolly aphid *A. cooleyi* on *P. menziesii* – GOẞNER 2004; GOẞNER et al. 2005; Lachnidae on *A. alba* – MÜLLER et al. 2005, ZÖBL et al. 2005) can explain the high abundance compared to *P. abies*.

Pentatoma rufipes (LINNAEUS 1758) – Pentatomidae (Fig. 27)

Material collected: Flight-interception traps = 501 specimens, 429♂♂ (86 %), 72 ♀♀ (14 %); branch-traps = 397 specimens, 241♂♂ (61 %), 156 ♀♀ (39 %).

Phenological activity: Average flight-activity was not higher than one specimen per tree crown in most cases. The number of sampled specimens, separated by site and sex, is shown in Table 4, illustrating that *P. rufipes* exhibited the highest flight-activity between mid-July and mid-September. A similar seasonal pattern was observed by branch traps (Fig. 17).

Tree preferences: For *P. rufipes* no clear preference for a particular tree species was observed: The species occured on broad-leaved and coniferous tree species. In a few cases (OTT 2000, 2003, 2004, KRU 1999) a significantly higher activity on broad-leaved compared to coniferous trees was detected (RM-ANOVA, PH-Test: $p<0.05$). A higher number of *P. rufipes* combined with an earlier seasonal occurrence was observed on *F. sylvatica* compared to *Q. robur* branches (Fig. 17). However, this was only significant in 2001. The activity of *P. rufipes* on introduced *Q. rubra* was higher than on indigenous *Q. robur* (Fig. 17), but this was not significant.

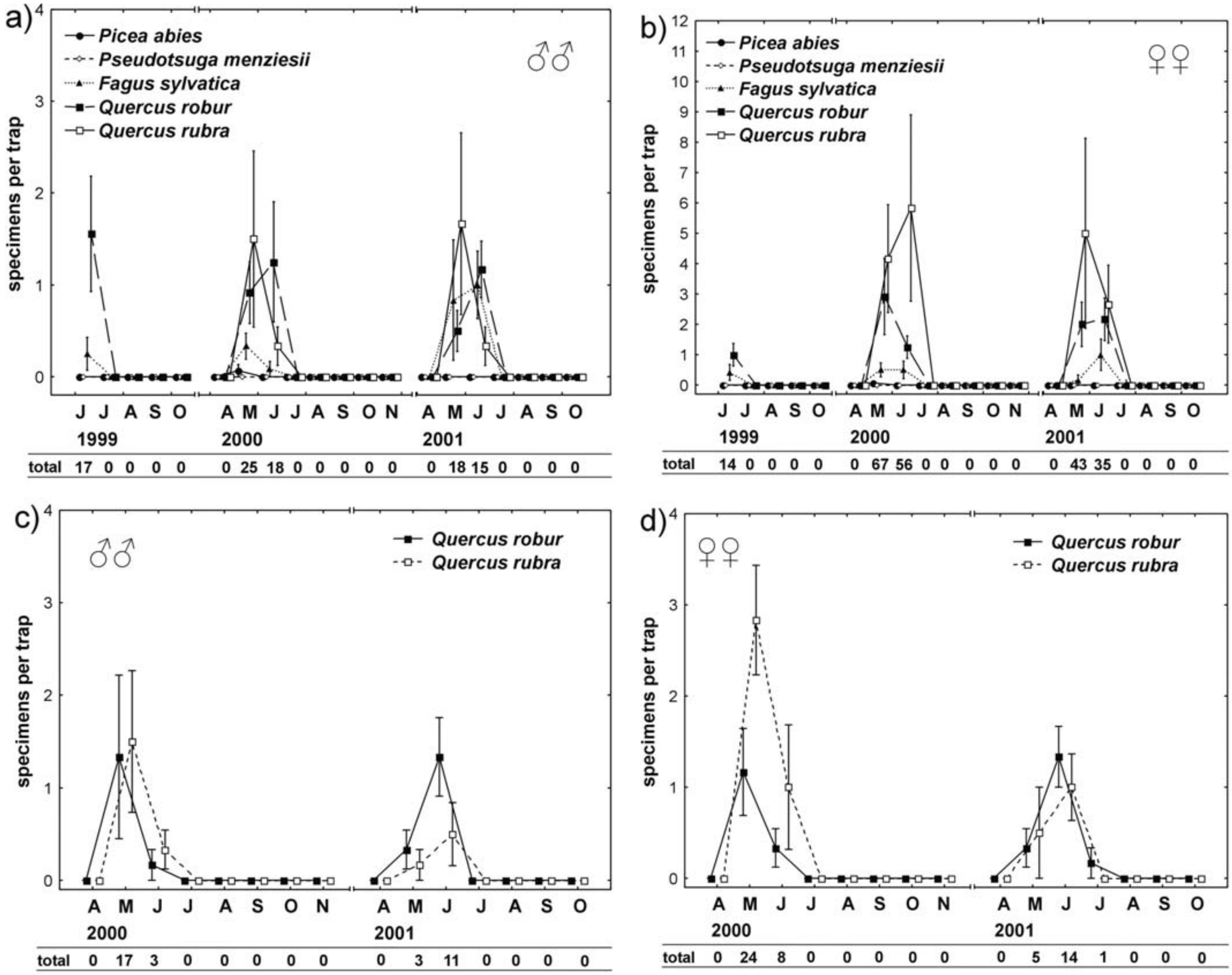

Fig. 18: Seasonal activity patterns of *D. flavoquadrimaculatus* in the canopy (FIT) of different tree species at site KRU 1999-2001 (a, b) and FRE 2000-2001 (c, d). Means and Standard error are shown. The traps were emptied mid-month.

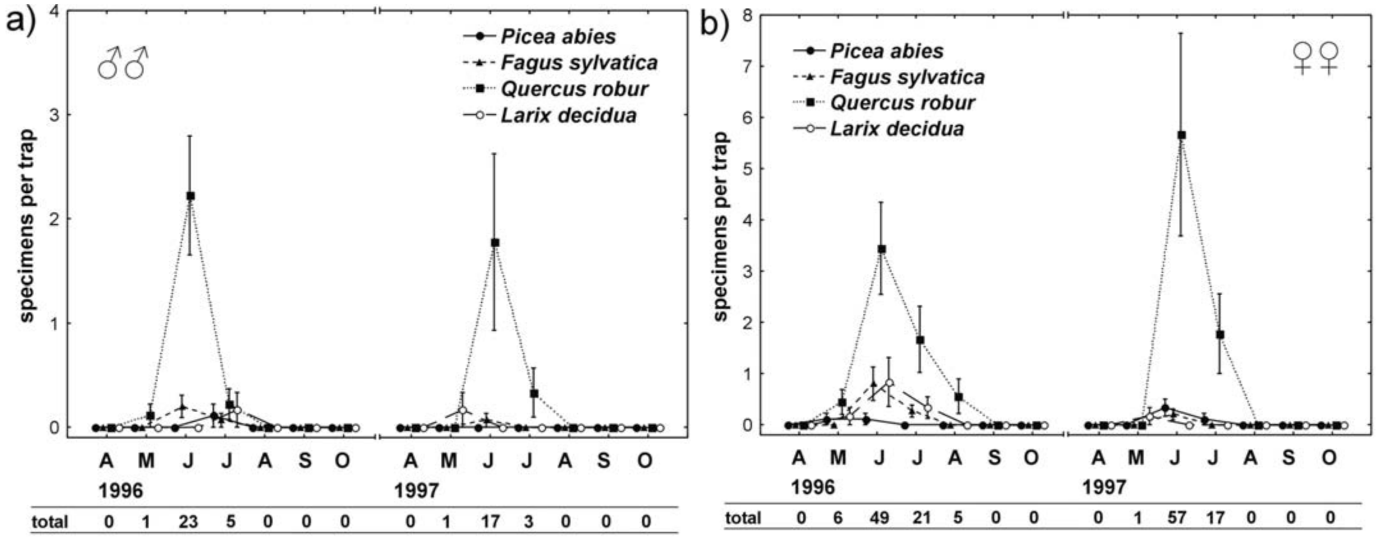

Fig. 19: Seasonal activity patterns of *P. mollis* in the canopy (FIT) of different tree species at site HIE (1996-1997). Means and Standard error are shown. The traps were emptied end of each month.

Discussion: *P. rufipes* is a very common species in Central Europe (WAGNER 1966; LANGE 1987). Results of present study indicate that in tree crowns flight-activity of this species is much lower than activity on the surface of branches. Number of males was much higher than number of females and this corresponds with results of light-trapping (GÖLLNER-SCHEIDING & REZBANYAI-RESER 2000). Interestingly, with fogging of 30 *Q. petraea* trees (July 2004/August 2005) near Werneck (Northern Bavaria) a comparable number of males (435) and females (415) were sampled (Goßner unpubl. data). Conclusively, activity, but not densities of males seem to be higher in the canopy of broad-leaved trees.

Highest activity of *P. rufipes* occured between mid-July and mid-September. Later, relatively few specimens were observed in tree crowns. In the near ground stratum DOROW (2001) documented high activity of *P. rufipes* until mid-October in the Forest Nature Reserve Schönbuche in Hesse, and Goßner (unpubl. data) at the sites of present study. WAGNER (1966) reported that *P. rufipes* overwinters as imago. Therefore, in October imagines of *P. rufipes* might be searching for overwintering habitats near the ground. However, MASSEE (1954), SOUTHWOOD (1960) and WACHMANN (1989) assume that young nymphal stages of this species overwinter. Because no imagines were found in November and between mid-March and end of June, it seems more plausible that this species overwinters as nymph.

P. rufipes occurs on several broad-leaved tree species (STRAWIŃSKI 1936; LANGE 1987; GÖLLNER-SCHEIDING 1992; VLACH 1994). In present investigation no preference neither for broad-leaved nor for conifer trees was observed. REUTER (1908) classified *P. rufipes* as "species that can be found on broad-leaved trees or herbaceous plants as well as on conifers during summer, but do not hibernate on conifers". STRAWIŃSKI (1964) described this species as optional zoophagous plant sap sucker, MASSEE (1954) as predacious species. If *P. rufipes* occurs on conifers because of feeding or as place for mating or resting remains unclear. The author observed mating only on broad-leaved trees.

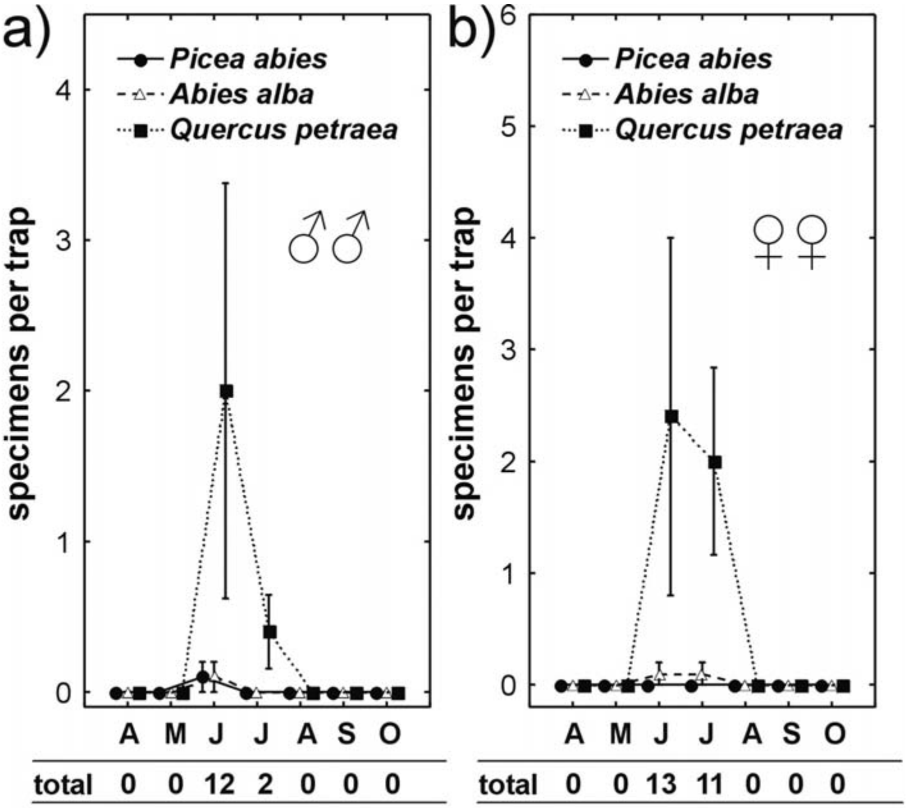

Fig. 20: Seasonal activity patterns of *P. mollis* in the canopy (FIT) of different tree species at site FEG. Means and Standard error are shown. The traps were emptied end of each month.

Dryophilocoris flavoquadrimaculatus (DE GEER 1773) – Miridae (Fig. 28)

Material collected: Flight-interception traps = 478 specimens, 173♂♂ (36 %), 305 ♀♀ (64 %).

Phenological activity: At site FRE the activity peak of *D. flavoquadrimaculatus* was between mid-April and mid-May in 2000, but between mid-May and mid-June in 2001 on indigenous *Q. robur* and on introduced *Q. rubra* (Figs 18c, d). At site KRU the observed seasonal pattern depended on year, tree species and sex (Figs 18a, b). However, in all cases the activity peak was between mid-April and mid-June.

Tree preferences: *D. flavoquadrimaculatus* was only found in stands where *Quercus* occured (HIE, KRU, FRE, UFF, FEG, EBE). Around 90 % of all specimens were sampled on *Quercus* and 9 % on *F. sylvatica*. At site KRU the higher abundance on *Quercus* compared to the other sampled tree species was significant (RM-ANOVA, PH-Test: $p<0.05$). In *Q. petraea* stands of UFF and in mixed stands of EBE, HIE and FEG average number sampled per tree crown at the seasonal activity peak was below one specimen. At site UFF, no difference in abundance of *D. flavoquadrimaculatus* between stands of dense, medium dense and sparse forest


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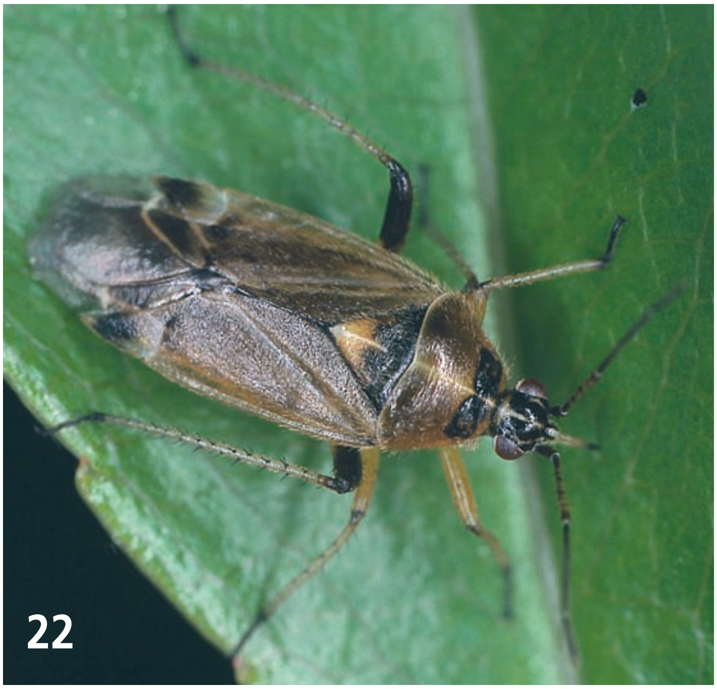
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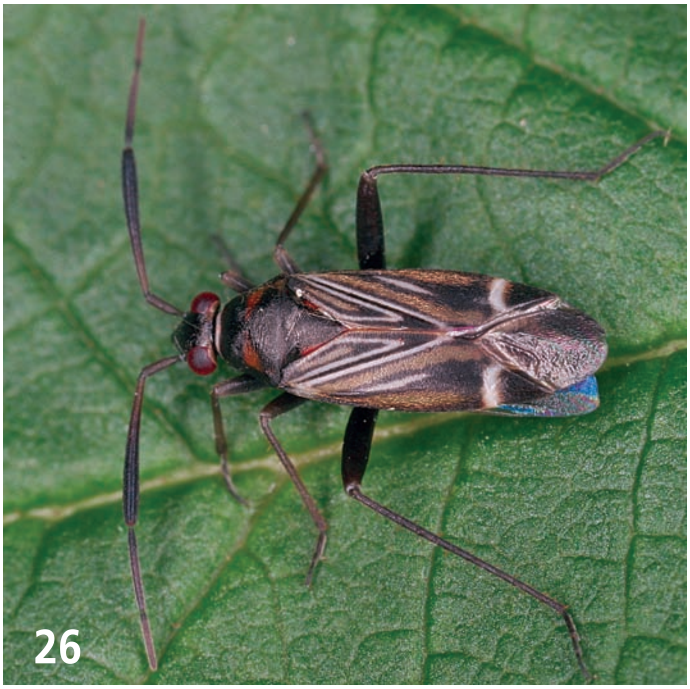
Figs 21-31: (**21**) *Deraeocoris lutescens* (Schilling 1837) (**22**) *Harpocera thoracica* (Fallén 1807) (**23**) *Psallus varians* (Herrich-Schaeffer 1841) (**24**) *Atractotomus magnicornis* (Fallén 1807) (**25**) *Rhabdomiris striatellus* (Fabricius 1794) (**26**) *Cremnocephalus alpestris* Wagner 1941 (**27**) *Pentatoma rufipes* (Linnaeus 1758) (**28**) *Dryophilocoris flavoquadrimaculatus* (De Geer 1773) (**29**) *Cyllecoris histrionius* (Linnaeus 1767) (**30**) *Phylus melanocephalus* (Linnaeus 1767) (**31**) *Kleidocerys resedae* (Panzer 1797)



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Figs 32-34: (**32**) *Phytocoris dimidiatus* KIRSCHBAUM 1856
(**33**) *Temnostethus gracilis* HORVÁTH 1907
(**34**) *Anthocoris confusus* REUTER 1884
(Photo: 21-25, 27-31, 33-34 E. Wachmann, 26, 32 I. Altmann).

canopy was observed. *D. flavoquadrimaculatus* exhibited a high activity on introduced *Q. rubra* (Fig. 18). In the time-interval between mid-May and mid-June 2000 activity was significantly higher on *Q. rubra* compared to all other tree species in the mixed broad-leaved tree stand at site KRU (RM-ANOVA, PH-Test: p<0.05).

Discussion: *D. flavoquadrimaculatus* is a very common species in Germany. WACHMANN et al. (2004) classified this species to the group of mirids that occur very early in spring on *Quercus*. In present study activity peak of imagines differed between years of investigations, but occured always between mid-April and mid-June. This confirms the informations given by WACHMANN et al. (2004). According to WACHMANN et al. (2004) males and females are very flight-active. Therefore, the higher flight-activity of females might reflect real density patterns. The observed seasonal pattern in present investigation indicates that only one generation per year occurs.

The preference of *D. flavoquadrimaculatus* for *Quercus* (LESTON 1961; STRAWIŃSKI 1964; EHANNO 1965; TAKSDAL 1965; GÖLLNER-SCHEIDING 1972; VLACH 1994; ŠTEPANOVIČOVÁ & BIANCHI 1999; DOROW 2001; WACHMANN et al. 2004) was confirmed by present study. Because of the high flight-activity of *D. flavoquadrimaculatus* this bug is found regularly on non-host tree species (WACHMANN et al. 2004). However, the high activity on *Q. rubra* in the pure stand of present study indicates that *D. flavoquadrimaculatus* colonised this introduced tree species (see also GOßNER & BRÄU 2004). *F. sylvatica* seems not to be a host tree of *D. flavoquadrimaculatus*. Nymphs suck on reproduction organs and buds of oaks and are therefore strongly associated with *Quercus* (WACHMANN et al. 2004). Imagines mainly feed on Aphidina, Lachnidae, Psyllidae, nymphs of other Miridae, and caterpillars (KULLENBERG 1944; SOUTHWOOD & LESTON 1959; PUTSHKOV 1961; STRAWIŃSKI 1964; WACHMANN et al. 2004) and occasionally might do this on other tree species.

WACHMANN et al. (2004) reported that *D. flavoquadrimaculatus* is mainly found at sunny sites, forest edges and solitary trees. No difference in abundance of this species was found between dense, medium dense, and sparse forest canopy at site UFF. This might be explained by the typically open structure of *Quercus* tree crowns. Abundance of *D. flavoquadrimaculatus* at the warmest and sunniest sites UFF and FEG was quite low. This might be a result of low population densities during the investigation. Nevertheless, no evidence was found for the preference of *D. flavoquadrimaculatus* for more open and sunnier sites.

Psallus mollis (MULSANT & REY 1852) – Miridae

Material collected: Flight-interception traps = 373 specimens, 103♂♂ (28 %), 270 ♀♀ (72 %).

Phenological activity: Males and females showed an activity peak in June. In July activity of females was higher than those of males. Later than July only a few *P. mollis* specimens were found (Figs 19, 20).

Tree preferences: Most specimens (84 %) were sampled on indigenous *Q. petraea/robur*, less on *F. sylvatica* (10 %), and only very few on other tree species. At sites HIE, FEG, and EBE this was significant (RM-ANOVA, PH-Test: p<0.05). However, also on *Quercus* average activity per tree crown was low, reaching less than one specimen per tree crown at sites KRU, FRE, UFF, and EBE. Only at site HIE in 1996 and 1997 (Fig. 19) and at site FEG in 2004 (Fig. 20) the average activity was higher.

Discussion: Activity of *P. mollis* differed greatly between investigated sites. WACHMANN et al. (2004) assumed that the distribution of this species in Germany is incompletely known. This fact and fluctuations in population densities between years might explain the observed pattern. Flight-activity was higher in females than males, as for *P. varians*. No data exist on densities of males and females. Therefore, it cannot be clarified, if either females are more flight-active or exhibit higher densities than males. Similar to *P. varians* females occured for a longer period than males. While males were active mainly in June, a quite high number of females were also found in July. The phenology in present study confirms informations given by WACHMANN et al. (2004).

Tab. 5: Seasonal activity patterns of *P. vitellinus* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		S
males	OTT	1999	/	/	/	0	6	1	0	0	/	/	7
		2000	/	0	0	0	5	2	0	0	0	/	7
		2001	/	0	0	0	5	10	0	0	/	/	15
		2002	/	0	0	0	2	0	0	0	/	/	2
		2003	/	0	0	0	8	3	1		/	/	12
		2004	/	/	/	0	0	5	0	0	/	/	5
	KRU	1999	/	/	/	0	24	16	1	0	/	/	41
		2000	/	0	0	0	6	1	0	0	0	/	7
		2001	/	0	0	0	4	3	0	0	/	/	7
	FEG	2004	/	0	0	12	2	1	0	0	/		15
	RIB	2004	/	0	0	0	1	0	0	0	/		1
females	OTT	1999	/	/	/	0	1	6	0	0	/	/	7
		2000	/	0	0	0	10	6	0	0	0	/	16
		2001	/	0	0	0	6	22	4	1	/	/	33
		2002	/	0	0	0	0	0	0	0	/	/	0
		2003	/	0	0	0	6	2	0	0	/	/	8
		2004	/	/	/	0	0	2	1	0	/	/	3
	KRU	1999	/	/	/	0	4	13	1	0	/	/	18
		2000	/	0	0	0	10	3	0	0	0	/	13
		2001	/	0	0	0	2	1	1	0	/	/	4
	FEG	2004	/	0	0	13	6	3	0	0	/		22
	RIB	2004	/	0	0	0	2	1	0	0	/		3
Total mid-mid			/	0	0	0	99	96	9	1	0	/	205
Total begin-end			/	0	5	39	16	5	0	0	/		65

Tab. 6: Seasonal activity patterns of *L. elegantula* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised. FIT=flight-interception traps, BT=branch traps.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		S
males	OTT-FIT	1999	/	/	/	0	1	0	0	0	0	/	1
		2000	/	0	0	0	6	0	0	0	0	0	6
		2001	/	0	0	0	6	1	0	0	0	/	7
		2002	/	0	0	0	4	0	0	0	0	/	4
		2003	/	0	0	0	3	0	0	0	0	/	3
		2004	/	/	/	0	4	1	0	0	0	/	5
	KRU-FIT	1999	/	/	/	1	4	0	0	0	0	/	5
		2000	/	0	0	11	4	0	0	0	0	0	15
		2001	/	0	0	0	6	1	0	0	0	/	7
	KRU-BT	2000	/	0	0	5	6	0	0	0	0	/	11
		2001	/	0	0	0	23	0	0	0	0	/	23
	FEG-FIT	2004	/	0	0	5	12	0	0	0	/		17
	RIB-FIT	2004	/	0	0	0	7	1	0	0	/		8
females	OTT-FIT	1999	/	/	/	0	0	0	1	0	0	/	1
		2000	/	0	0	0	0	1	0	0	0	0	1
		2001	/	0	0	0	1	11	0	0	0	/	12
		2002	/	0	0	0	1	0	0	0	0	/	1
		2003	/	0	0	0	3	1	0	0	0	/	4
		2004	/	/	/	0	3	4	0	0	0	/	7
	KRU-FIT	1999	/	/	/	0	0	1	0	0	0	/	1
		2000	/	0	0	2	5	2	0	0	0	0	9
		2001	/	0	0	0	3	6	0	0	0	/	9
	KRU-BT	2000	/	0	0	0	4	3	0	0	0	/	7
		2001	/	0	0	1	4	17	1	1		/	24
	FEG-FIT	2004	/	0	0	3	6	1	0	0	/	10	
	RIB-FIT	2004	/	0	0	0	4	4	0	0	/	8	
Total mid-mid			/	0	0	24	107	52	2	1	0	0	186
Total begin-end				0	0	8	35	21	0	0	0	/	64

Tab. 7: Seasonal activity patterns of *C. histrionius* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	HIE	1996	/	0	7	6	0	0	0	0	/	13
		1997	/	1	3	9	0	0	0	0	/	13
	KRU	1999	/	/	0	15		0	0	/		15
		2000	0	0	1	14	2	0	0	0		17
		2001	0	0	0	2	1	0	0	/		3
	FRE	2000	0	0	3	10	1	0	0	0		14
		2001	0	0	1	17	2	0	0	/		20
	UFF	2002	0	0	16	14	0	0	0	/		30
females	HIE	1996	/	0	6	3	2	0	0	0	/	11
		1997	/	0	0	8	0	0	0	0	/	8
	KRU	1999	/	/	0	9	2	0	0	/		11
		2000	0	0	4	12		0	0	0		16
		2001	0	0	0	2	1	1	0	/		4
	FRE	2000	0	0	2	4	2	0	0	0		8
	2001		0	0	0	7	3	0	0	/		10
	UFF	2002	0	0	14	14	1	0	0	/		29
Total mid-mid			0	0	41	120	15	1	0	0	0	177
Total begin-end			/	1	16	43	4	1	0	0	/	65

The preference of *P. mollis* for *Quercus* (Ehanno 1965; Göllner-Scheiding 1970, 1972, 1974; Schuster 1981; Aukema 1989; Gorczyca 1991; Heiss 2002; Wachmann et al. 2004) was confirmed by present study.

Section 2

Section 2 is dealing with the less abundant species collected by flight-interception traps in at least 30 specimens per investigation site; species are listed in order of decreasing abundance.

Plagiognathus vitellinus (Scholtz 1846) – Miridae

Material collected: Flight-interception traps = 270 specimens, 128♂♂ (47 %), 142 ♀♀ (53 %).

Phenological activity: Most specimens were observed between mid-June and mid-August, depending on year and site (Tab. 5).

Tree preferences: All specimens were sampled on coniferous trees, except three (HIE *F. sylvatica* 1♂; KRU *F. sylvatica* 1 ♀, *Q. robur* 1♂). The species occured on indigenous *P. abies* and *A. alba* as well as on introduced *P. menziesii* with no clear preference. At site HIE only 24 specimens were captured (9♂♂, 15 ♀♀) and with the exception of 3♂♂ (*F. sylvatica* 1, *P. abies* 2) and 2 ♀♀ (*P. abies*) all specimens were found on *L. decidua* (19 specimens).

Discussion: The occurrence of *P. vitellinus* between mid-June and mid-August in present study corresponds quite well with the description given by Gorczyca (1991) for Poland and Wachmann et al. (2004) for Germany, Austria and Switzerland. Depending on the year, abundance peak was found between mid-June and mid-August. This probably reflects different climatic conditions between years. Also, differences between altitudes were observed, with lower activity starting later in mountainous compared to lowland sites. *P. vitellinus* is known to have a broad altitudinal range (e.g. data of Büttner & Wetzel 1964 for West Saxony: 300-1,210 m a.s.l.). Observed activity pattern indicate that lifespan of *P. vitellinus* is short (probably < 1 month) and only one generation per year occurs. This confirms the informations given by Wachmann et al. (2004).

Almost all specimens of phytophagous *P. vitellinus* were found on conifers confirming previous studies on this species (Göllner-Scheiding 1972; Wachmann et al. 2004; Goßner 2006a). Gorczyca (1991) observed a preference for *Larix* in Poland; for Germany a preference for *Picea* and *Larix* is assumed (Schneid 1954; Wachmann et al. 2004). However, based on the present results no clear preference of *P. vitellinus* for a particular conifer species was observed. It occured frequently on indigenous *P. abies*, *A. alba*, *L. decidua* as well as on introduced *P. menziesii* (see also Goßner & Bräu 2004). Goßner (2005) found evidence that in particular years *P. vitellinus* might prefer *P. abies* over *A. alba*. Results of site HIE in present study indicate higher abundance on *L. decidua* compared to *P. abies*. Future autecological studies on this species should try to clarify tree species preference.

Loricula elegantula (Baerenspung 1858) – Microphysidae

Material collected: Flight-interception traps = 185 specimens, 98♂♂ (53 %), 87 ♀♀ (47 %); branch-traps = 65 specimens, 34♂♂ (52 %), 31 ♀♀ (48 %).

Phenological activity: *L. elegantula* exhibited highest activity between begin of June and mid-August (Tab. 6). Females seemed to occur later than males did. More specimens were caught by branch traps than flight-interception traps, when number of sampled trees is taken into account.

Tree preferences: No preference of a particular tree species was observed.

Discussion: Zoophagous *L. elegantula* inhabits lichens (*Parmelia*, *Cladonia*) and mosses covering the bark of stems and branches of trees (MASSEE 1954; PÉRICART 1972; NICOLAI 1986, 1987; BAUGNÉE 1999; PRINZING 2003; WACHMANN et al. 2004). ŠTEPANOVIČOVÁ & BIANCHI (1999), for example, found this species to be eudominant on stems of *Quercus*. Therefore, it is not surprising that branch traps captured more specimens than flight-interception traps. This is not only true for brachypterous females, but also for the macropterous males. No preference of *L. elegantula* for a particular tree species was observed, which corresponds with previous studies (GULDE 1921; PÉRICART 1972; SCHUSTER 1990; BAUGNÉE 1999; WACHMANN et al. 2004). GOẞNER & BRÄU (2004) found high activity on branches of *Quercus* and *F. sylvatica* as well as on stems of *P. abies* and *P. menziesii*. Males exhibited an earlier activity peak (mid-June to mid-July) than females (mid-July to mid-August). According to PÉRICART (1972) and WACHMANN et al. (2004) males die after copulation in June and July and therefore only females occur in August and September. In present investigation no specimen was observed after mid-October. This confirms the results of DOROW (1999, 2001) in Forest Nature Reserves of Hesse. Phenological patterns of previous and present studies indicate that this species has only one generation per year and overwinters in the egg stage. Eggs are deposit in bark cracks (MASSEE 1954; WACHMANN et al. 2004). This is confirmed by incubation of crown dead wood, harvested in March 2001 in KRU. A huge number of nymphs of *L. elegantula* hatched from the dead branches of *Q. robur* that were covered by mosses and lichens. Fewer nymphs were found on dead branches of *Q. rubra*, *P. menziesii* and *P. abies* (Goßner, unpubl. data).

Cyllecoris histrionius (LINNÉ 1767) – Miridae (Fig. 29)

Material collected: Flight-interception traps = 242 specimens, 137♂♂ (57 %), 105 ♀♀ (43 %).

Phenological activity: Between mid-May and end of June an activity peak was observed (Tab. 7). Males and females exhibited a similar seasonal pattern. At site UFF in 2002 the peak of abundance seemed to be earlier than at the other sites. At site EBE only 14 (9♂♂, 5 ♀♀) and at site FEG only six (3♂♂, 3 ♀♀) specimens were captured.

Tab. 8: Seasonal activity patterns of *K. resedae* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	UFF	2002	18	22	5	2	5	1	3	/		56
	EBE	2004	/	6	2	4	1	0	0	1	/	14
females	UFF	2002	12	21	5	7	1	1	1	/		48
	EBE	2004	/	9	9	5	2	0	0	0	/	25
Total mid-mid			38	62	14	10	6	4	6	1		141
Total begin-end			/	24	14	9	5	0	0	1	/	53

Tree preferences: More than 95 % of all specimens were found on *Quercus* (230 specimens). Interestingly, only 10 specimens occured on exotic *Q. rubra*. Two specimens were found on *F. sylvatica* (HIE 1♂, KRU 1 ♀) and one on *P. abies* (KRU 1 ♀).

Discussion: Imagines of *C. histrionius* occured mainly between mid-May and mid-July, depending on the climatic conditions. This corresponds with WACHMANN et al. (2004), who classified *C. histrionius* to the group of *Quercus* dwellers that occur in early spring. Seasonal patterns indicate that only one generation per year is developed and that *C. histrionius* overwinters in the egg stage.

The main activity of *C. histrionius* on indigenous *Q. robur* and *Q. petraea* confirms the preference for *Quercus* (STRAWIŃSKI 1936, 1964; TAKSDAL 1965; GÖLLNER-SCHEIDING 1972; VLACH 1994; ŠTEPANOVIČOVÁ & BIANCHI 1999; HRADIL 2001; WACHMANN et al. 2004), whereas introduced *Q. rubra* does not seem to be a suitable host plant for *C. histrionius* (see also GOẞNER & BRÄU 2004). As in other *Quer-*

Tab. 9: Seasonal activity patterns of *P. melanocephalus* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	HIE	1996	/	0	0	4	1	0	0	0	/	5
		1997	/	0	0	11	0	0	0	0	/	11
	UFF	2002	0	0	6	19	0	0	0	/		25
females	HIE	1996	/	0	1	5	2	0	0	0	/	8
		1997	/	0	0	7	0	0	0	0	/	7
	UFF	2002	0	0	4	16	0	0	0	/		20
Total mid-mid			0	1	37	54	0	0	0	/	/	92
Total begin-end			/	0	1	53	6	0	0	0	/	60

Tab. 10: Seasonal activity patterns of *P. perrisi* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		S
males	FRE	2000	/		0		1		1		0		0		0		0		0		/	2
		2001	/		0		0		6		2		0		0		0		/		/	8
	UFF	2002	/		0		0		13		5		0		0		0		/		/	18
females	FRE	2000	/		0		3		10		1		0		0		0		0		/	14
		2001	/		0		1		7		1		0		0		0		/		/	9
	UFF	2002	/		0		0		20		13		0		0		0		/		/	33
Total mid-mid			/		0		5		68		24		1		0		0		0		/	98
Total begin-end				/		0		1		30		12		1		0		0		/		44

cus specialists (e.g. *R. striatellus*, *D. flavoquadrimaculatus*), nymphs feed on reproduction organs and therefore depend on *Quercus*. The mainly zoophagous imagines, feeding on aphids, psyllids, insect eggs and caterpillars, are sometimes found on other tree species as well (WACHMANN et al. 2004). KULLENBERG (1944) and SOUTHWOOD & LESTON (1959) observed *C. histrionius* feeding on larvae in oak galls (probably Cynipidae), STRAWIŃSKI (1964) on oak aphids, and JAHN (1944) on pupae of *Tortrix viridana* L.

Kleidocerys resedae (PANZER 1797) – Lygaeidae (Fig. 30)

Material collected: Flight-interception traps = 194 specimens, 97♂♂ (50 %), 97 ♀♀ (50 %).

Phenological activity: *K. resedae* exhibited highest activity between mid-March and mid-May at sites UFF and EBE (Tab. 8), but imagines occured over the whole vegetation period. This is also confirmed by the few specimens found at the other sites: HIE (3♂♂, 2 ♀♀); OTT (5♂♂, 5 ♀♀); FRE (7♂♂, 9 ♀♀); FEG (7♂♂, 2 ♀♀); KRU (5♂♂, 6 ♀♀).

Tree preferences: Interestingly, most specimens were found on *Quercus* (140 → 72 %), although *K. resedae* was also captured on *F. sylvatica*, *P. abies*, *A. alba*, *L. decidua*, and *P. menziesii*.

Discussion: Imagines of *K. resedae* occured in tree crowns throughout the year. This confirms WAGNER'S (1966) assumption that imagines of this species overwinter in litter and under bark. In North America, where *K. resedae* was introduced, WHEELER (1976) observed overwintering nymphs in capsules of Ericaceae. In present study, highest activity of imagines was observed in early spring (before mid-May), when they feed on catkins and probably mating occured. Activity of the new generation was much lower, no clear second activity peak was observed. In contrast, in the Czech Republic KULA (1999) found *K. resedae*'s main activity in August and September in tree crowns of birch using a shaking method. In Europe, usually one generation per year is developed, but annual number of generations may vary due to climatic conditions (CARAYON 1989). In North America two and sometimes three generations were observed by WHEELER (1976).

WAGNER (1966) described *K. resedae* to occur mainly on birch, more scarcely on alder (see also MASSEE 1954; VLACH 1994; CARAYON 1989; GÖLLNER-SCHEIDING 1972; SCHUSTER 1995; FRIESS 2000; HEISS 2002). In the study of KULA (1999) *K. resedae* was the eudominant species on birch beside *Elasmucha grisea* (L.). However, *K. resedae* occurs also on other trees, shrubs, and even herbaceous plants (MASSEE 1954; WHEELER 1976; CARAYON 1989). Results of present study indicate that in managed forests, where birch and alder trees are rare, *K. resedae* is also found on other tree species, mainly on *Quercus*. However, highest abundance was observed at site UFF, where most birch trees occured in the forest area.

Phylus melanocephalus (LINNÉ 1767) – Miridae (Fig. 31)

Material collected: Flight-interception traps = 152 specimens, 84♂♂ (55 %), 68 ♀♀ (45 %).

Phenological activity: *P. melanocephalus* exhibited an activity peak in June (Tab. 9). It was found only at site HIE and site UFF with more than 30 specimens (Tab. 9). At site KRU 22 (10♂♂, 12 ♀♀), at site FRE 25 (13♂♂, 12 ♀♀), at site EBE 14 (10♂♂, 4 ♀♀) and at site FEG 15 (10♂♂, 5 ♀♀) specimens were captured.

Tree preferences: With four exceptions (*F. sylvatica*: 2♂♂, *Q. rubra* 1♂, 1 ♀) *P. melanocephalus* occured only on indigenous *Quercus petraea/robur* (97 %).

Discussion: *P. melanocephalus* is classified to the group of "early spring oak mirids" (WACHMANN et al. 2004). Results of present study indicate that this species occurs slightly later than *C. histrionius*, *D. flavoquadrimaculatus*, *H. thoracica*, and *R. striatellus*. Only one specimen of *P. melanocephalus* was found before mid-May. Moreover, no indication was found that imagines of *P. melanocephalus* live longer than other mirids of this group, as suggested by WACHMANN et al. (2004). No specimen was observed after July, probably not after mid-July. It is assumed that *P. melanocephalus* exhibit main activity in June, at least at the studied sites. The observed seasonal pattern indicates that one generation per year is developed, which overwinters in the egg stage.

The preference of *P. melanocephalus* for *Quercus* (LESTON 1961; EHANNO 1965; TAKSDAL 1965; GÖLLNER-SCHEIDING 1970, 1972, 1974; GORCZYCA 1991; SCHUSTER 1995; HRADIL 2001; WACHMANN et al. 2004) was confirmed by present study. Almost all specimens were found on *Q. petraea* and *Q. robur*. WACHMANN et al. (2004) suggest that *Quercus* is the exclusive host plant of this species, although STRAWIŃSKI (1964) found it also on other broad-leaved tree species. The facultative zoophagous feeding habit of the primarily phytophagous *P. melanocephalus* (STRAWIŃSKI 1964; WACHMANN et al. 2004) might explain that it occasionally occurs on other tree species.

Psallus perrisi (MULSANT & REY 1852) – Miridae

Material collected: Flight-interception traps = 142 specimens, 52♂♂ (37 %), 90♀♀ (63 %).

Phenological activity: Highest activity was observed between mid-May and mid-June (Tab. 10). Females seem to occur longer throughout the year. *P. perrisi* occured mainly in oak dominated stands at site FRE and UFF (Tab. 10). At site HIE 2♀♀, KRU 14 (6♂♂, 8♀♀), EBE 21 (9♂♂, 12♀♀), and FEG 21 (9♂♂, 12♀♀) specimens were observed.

Tree preferences: Most specimens were captured on indigenous *Q. petraea/robur* (128 → 90 %).

Discussion: *P. perrisi* was observed mainly between mid-May and mid-July. This corresponds well with the descriptions of GORCZYCA (1990, 1991) and WACHMANN et al. (2004). Similar to the other *Psallus* species (*P. varians*, *P. mollis*) females seem to occur longer than males. One generation per year and overwintering in the egg stage is indicated by the observed phenological pattern.

Tab. 11: Seasonal activity patterns of *P. atomarius* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	FEG	2004	/	4	1	0	0	1	0	2	/	8
	RIB	2004	/	36	3	0	0	0	0	2	/	41
females	FEG	2004	/	3	6	0	1	3	5	4	/	22
	RIB	2004	/	19	11	11	5	2	2	7	/	57
Total begin-end			/	63	21	11	6	6	8	15	1	131

Based on present data a strong affinity to indigenous oaks (*Q. petraea*, *Q. robur*) is assumed. Almost no specimen was found on other tree species, not even on introduced *Q. rubra* (see also GOßNER & BRÄU 2004). This corresponds with the documentations of AUKEMA (1981), RIBES (1982), REICHLING (1984), GORCZYCA (1991), and WACHMANN (2004). According to SOUTHWOOD & LESTON (1959) and WACHMANN et al. (2004) zoophytophagous *P. perrisi* is frequently found on other wood species, e.g. apple trees (JONNSON 1983), during the mating period, especially when colonised with potential prey like aphids (see KULLENBERG 1944). No evidence for this observation was found in present study.

Pinalitus atomarius (MEYER-DÜR 1843) – Miridae

Material collected: Flight-interception traps = 131 specimens, 50♂♂ (38 %), 81♀♀ (62 %).

Phenological activity: *P. atomarius* exhibited highest activity in early spring (April-May) and late autumn (October) (Tab. 11). The majority of specimens was collected at sites FEG and RIB, and only three specimens at other sites (UFF 2002: 1♀, KRU 2000: 1♂ 1♀). At site RIB the highest abundance was found in the "Nationalpark Bayerischer Wald".

Tree preferences: Almost all specimens (117 → 91 %) were found on *A. alba*.

Tab. 12: Seasonal activity patterns of *P. dimidiatus* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	HIE	1996	/	0	1	5	10	5	1	0	/	22
		1997	/	0	0	2	4	5	0	0	/	11
females	HIE	1996	/	0	0	2	4	1	0	0	/	7
		1997	/	0	0	2	6	6	0	0	/	14
Total mid-mid		/	0	0	10	16	10	14	2	0	/	52
Total begin-end			/	0	1	12	25	21	4	2	/	65

Tab. 13: Seasonal activity patterns of *T. gracilis* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	KRU-BT	2000	/	0	0	3	6	0	0	0	0	/	9
		2001	/	0	0	2	4	5	0	1	0	/	12
females	KRU-BT	2000	/	0	0	1	9	5	1	0	0	/	16
		2001	/	0	0	0	8	6	7	1	0	/	22
Total mid-mid			/	0	0	15	56	22	12	2	0	/	107
Total begin-end				/	0	0	3	4	2	0	0	0	9

Discussion: *P. atomarius* is rarely found in Central Europe (Rieger & Strauss 1992). In present study highest abundance was observed in early spring (April, May) and late autumn (October). The new generation seem to occur from July at lowland and from August at mountainous sites, depending on climatic conditions. Phenological pattern indicate that this species overwinters as imago and this corresponds with the description given by Southwood & Leston (1959), Wagner & Weber (1964) and Wachmann et al. (2004).

In Central and South Europe *P. atomarius* prefers mountainous areas (Wagner 1952; Stichel 1958; Josifov 1986; Wachmann et al. 2004). This is confirmed by the present study. More specimens where found at mountainous sites (especially in the "Nationalpark Bayerischer Wald"; see Goßner 2005) compared to lowland sites. However, also at the lowland site FEG it occured frequently. Because *P. atomarius* was sampled almost exclusively on *A. alba* it can be assumed that the restriction to mountainous sites is simply the result of the present distribution of its host plant (see also Goßner 2005). During the study of conifer trees in parks of Sweden, Lindskog & Viklund (2000) observed *P. atomarius* also exclusively and numerously on *A. alba*. Based on available data and the close correspondence between the zonal-geographic ranges of *P. atomarius* and *A. alba* in Central and South Europe they suggested *A. alba* as the primary and original host. This is clearly supported by present study.

Phytocoris dimidiatus Kirschbaum 1856 – Miridae (Fig. 32)

Material collected: Flight-interception traps = 117 specimens, 71♂♂ (61 %), 46♀♀ (39 %).

Phenological activity: *P. dimidiatus* exhibited highest activity between June and August (Tab. 12). It occured only at site HIE with more than 30 specimens. In OTT 17 (9♂♂, 8♀♀), KRU 24 (14♂♂, 10♀♀), FRE 11 (6♂♂, 5♀♀), FEG 3 (2♂♂, 1♀), and EBE 8 (7♂♂, 1♀) specimens were sampled. The pattern of occurrence at those sites confirmed the results from HIE.

Tree preferences: With a few exceptions all specimens were found on indigenous *Q. petraea/robur* and *F. sylvatica* (108 → 92 %).

Discussion: Imagines of *P. dimidiatus* were observed between May and October. This corresponds with the results of Dorow (1999, 2001) in forest Nature Reserves of Hesse as well as the description given by Wachmann et al. (2004) for Germany and Southwood & Leston (1959) for Great Britain. Wagner (1952, 1971) mentioned a much shorter imaginal period and one generation per year. In contrast, Wachmann et al. (2004) assumed that two generations per year develop because of the long occurrence of imagines. Data of the mid-month to mid-month interval in present study and Dorow (1999, 2001) give evidence for a second generation. In tree crowns of present study, males exhibited a higher flight-activity than females. By light trapping almost only males were observed (Göllner-Scheiding & Rezbanyai-Reser 2000). In addition, a higher number of males (12 specimens) than females (two specimens) were found by fogging tree crowns of *Q. petraea* in 2004/2005 (Goßner, unpubl. data). Therefore, not only a higher flight-activity but also a higher density of males might occur in tree crowns of managed forests. In contrast, on *F. sylvatica* stems Dorow (2001) found a higher number of females. Büttner & Wetzel (1964) and Göllner-Scheiding (1972) suggested that *P. dimidiatus* is absent in mountainous sites and no specimen was found at the mountainous site RIB in present study (but no broad-leaved trees were sampled there). Nevertheless, according to Wachmann et al. (2004) it occurs in the low mountain range.

The present study indicates a preference of *P. dimidiatus* for indigenous *Q. robur/petraea* and *F. sylvatica* in tree crowns of managed forests. Wagner (1952, 1971), Massee (1954), Southwood & Leston (1959), Göllner-Scheiding (1992) and Wach-

MANN et al. (2004) described *P. dimidiatus* as broad-leaved wood dweller (*Crataegus*, *Fagus*, *Malus*, *Prunus*, *Pyrus*, *Quercus*). However, WACHMANN et al. (2004) expect highest abundance of this species on old fruit trees with branches covered with lichens (e.g. WOODROFFE 1967; SIMON 1992). Nevertheless, in managed forests *Quercus* and *F. sylvatica* are supposed to be the main host trees.

Temnostethus gracilis HORVÁTH 1907 – Anthocoridae (Fig. 33)

Material collected: Flight-interception traps = 57 specimens, 22♂♂ (37 %), 35 ♀♀ (63 %); branch-traps = 59 specimens, 21♂♂ (36 %), 38 ♀♀ (64 %).

Phenological activity: *T. gracilis* was sampled most frequently in branch traps at site KRU (Tab. 13). Highest activity was observed between mid-June and mid-August. By flight-interception traps only a few specimens were captured: HIE 4 (2♂♂, 2 ♀♀), OTT 7 (2♂♂, 5 ♀♀), KRU 22 (10♂♂, 12 ♀♀), FRE 7 (2♂♂, 5 ♀♀), UFF 11 (4♂♂, 7 ♀♀), EBE 4 (1♂, 3 ♀♀), FEG 1 ♀, and RIB 1♂.

Tree preferences: Almost all specimens were sampled on broad-leaved trees, only two specimens were collected on *P. abies* and *A. alba*.

Discussion: Imagines of *T. gracilis* were found between mid-May and mid-October. This is surprising, because PÉRICART (1972) mentioned that imagines of this species occur throughout the year. Results of present study indicate that *T. gracilis* develops one generation per year and overwinters in the egg stage. With ground based trap systems (arboreal photo eclector, flight-interception traps, pitfall traps, ground photo eclector) no indication for a migration of imagines from the canopy to lower forest strata was found at the sites of present study (Goßner, unpubl. data). Therefore, it is very likely that in present study no imagines overwintered. So far, overwintering of *T. gracilis* in the egg stage has been observed only in Schleswig-Holstein (Remane, unpubl. data, cited in DOROW 2001).

T. gracilis predominantly inhabits stems and branches covered with mosses and lichens (MASSEE 1954; PÉRICART 1972; SCHUSTER 1990). Therefore, relatively higher numbers were found in branch traps compared to flight-interception traps. Almost all specimens were sampled on broad-leaved trees with no conspicuous preference for one particular tree species. This result corresponds with previous descriptions on the ecology of *T. gracilis* (STRAWIŃSKI 1964; PÉRICART 1972; SCHUSTER 1990). The crucial factor for colonisation is the coverage by epiphytes.

Tab. 14: Seasonal activity patterns of *A. confusus* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	EBE	2004	/	13	2	7	4	11	2	10	/	49
females	EBE	2004	/	4	1	3	2	5	0	7	/	22
Total mid-mid			/	6	7	2	1	1	1	5	0	/ 23
Total begin-end			/	22	4	11	6	18	2	18	/	81

Anthocoris confusus REUTER 1884 – Anthocoridae (Fig. 34)

Material collected: Flight-interception traps = 104 specimens, 63♂♂ (61 %), 41 ♀♀ (39 %).

Phenological activity: *A. confusus* occured in all months, with highest activity in April, June, August and October (Tab. 14). It was numerously collected only at the beech dominated site EBE in 2004 (Tab. 14). At site HIE 5 (3♂♂, 2 ♀♀), UFF 9 (3♂♂, 6 ♀♀), FEG 3 (1♂, 2 ♀), RIB 2 (1♂, 1 ♀), KRU 2♂♂, and OTT 12 (4♂♂, 8 ♀♀) specimens were captured.

Tree preferences: Imagines were equally distributed on *F. sylvatica* and *Quercus*.

Discussion: Imagines of *A. confusus* were observed throughout the year with four activity peaks (April, June, August, and October) (mainly at site EBE). This phenological pattern indicates that three generations per year occured and that imagines are overwintering. Under ideal conditions, four generations were developed in the laboratory (PÉRICART 1972). In Great Britain, SOUTHWOOD & LESTON (1959) observed two generations per year (in July and September). I assume that depending on climatic condi-

Tab. 15: Seasonal activity patterns of *P. dissimilis* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	FEG	2004	/	0	0	13	6	0	0	0	/	19
	RIB	2004	/	0	0	1	7	0	0	0	/	8
females	FEG	2004	/	0	0	15	9	0	0	0	/	24
	RIB	2004	/	0	0	2	9	0	0	0	/	11
Total begin-end			/	0	0	31	31	0	0	0	/	62

Tab. 16: Seasonal activity patterns of *D. annulipes* in tree crowns at sites where ≥30 specimens were sampled. Additionally, total number of specimens that were captured in all projects is summarised.

	site	year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	S
males	HIE	1996	/	0	1	11	2	0	0	0	/	14
		1997	/	0	0	5	0	0	0	0	/	5
females	HIE	1996	/	0	1	6	1	1	0	0	/	9
		1997	/	0	0	3	0	0	0	0	/	3
Total mid-mid		/	0	0	0	1	1	0	0	0	/	2
Total begin-end			/	0	2	25	4	1	0	0	/	32

tions and prey availability in situ 2-3 generations are developed.

A. confusus is known to inhabit broadleaved tree species (MASSEE 1954; STRAWIŃSKI 1964; TAKSDAL 1965; PÉRICART 1972; TAMANINI 1981, 1982), being particularly numerous on *F. sylvatica* (GÖLLNER-SCHEIDING 1992; NIELSEN 1974; SCHAEFER 1991). In present study comparable numbers were found on *F. sylvatica* and *Quercus* sp. Interestingly, high abundance was only found at the beech dominated site EBE. Because EBE was only investigated for one year, it remains unclear whether the dominance of *F. sylvatica* in this forest or the high abundance of *Phylaphis fagi* as food resource is the decisive factor for the high activity of *A. confusus*. The latter is supported by the study of EVANS (1976). He demonstrated that egg production of *A. confusus* females increase with prey densities. PÉRICART (1972) reported that *A. confusus* mainly feeds on aphids of the tribe Callaphidini. However, species of this tribe do not occur on *F. sylvatica* and other host trees of *A. confusus* (HANNEMANN et al. 2000; CHUMAK 2004). Therefore, it can be assumed that *A. confusus* feed on other aphid species when occurring on *F. sylvatica* and *Quercus* sp. (e.g. URBAN 2003a, 2003b). On *F. sylvatica*, *A. confusus* might feed on *P. fagi*, which had a mass occurrence during the year 2004 in the studied stands (Müller, pers. comm.). In the Czech Republic, ŠTEPANOVIČOVÁ & LAPKOVA (1986) found *A. confusus* to be the most important predator in *F. sylvatica* crowns, probably it preys mainly on *P. fagi*.

Phoenicocoris dissimilis (REUTER 1878) – Miridae

Material collected: Flight-interception traps = 62 specimens, 27♂♂ (44 %), 35 ♀♀ (66 %).

Phenological activity: *P. dissimilis* occured in June and July, with more specimens sampled at lowland site FEG in June and at mountainous site RIB in July (Tab. 15).

Tree preferences: *P. dissimilis* was exclusively found on *A. alba* in FEG and RIB.

Discussion: Only a very few records of *P. dissimilis* are known from Central Europe (GORCZYCA 1991; RIEGER & STRAUSS 1992; RABITSCH 1999; GÜNTHER & SCHUSTER 2000). In present study imagines exclusively occured in June and July, which corresponds with the information given in GORCZYCA (1991) and WACHMANN et al. (2004). Due to different climatic conditions, imagines were sampled earlier, and in higher abundance at lowland site FEG compared to mountainous site RIB. Phenological data indicate that one generation per year is developed and *P. dissimilis* overwinters in the egg stage.

P. dissimilis is known to inhabit conifers (*Pinus*, *Picea*, *Abies*, *Larix*) (GORCZYCA 1991; WACHMANN et al. 2004). Because this species was exclusively found on *A. alba* during the present study an affinity to this tree species can be assumed (see also GOßNER 2005). This is confirmed by another recent study in Southern Bavaria where SCHUSTER (2005) sampled numerous specimens from young *A. alba* trees in June and July 2004. He found no specimen on adjacent *P. abies* trees.

Deraeocoris annulipes (HERRICH-SCHAEFFER 1842) – Miridae

Material collected: Flight-interception traps = 34 specimens, 20♂♂ (59 %), 14 ♀♀ (41 %).

Phenological activity: The majority of specimens was sampled in June, primarily at site HIE (Tab. 16).

Tree preferences: *D. annulipes* was found exclusively on *L. decidua*, except three specimens: one ♀ on *F. sylvatica* and one ♂ on *P. abies* at site OTT where also *L. decidua* occured and one ♀ at site EBE on *Q. petraea*.

Discussion: Imagines of *D. annulipes* were found between May and August with one activity peak in June. This indicates that this species is univoltine and overwinters in the egg stage; this corresponds with the informations given by WACHMANN et al. (2004). GÖLLNER-SCHEIDING (1992) found this species on *L. decidua* in Berlin (Germany) from begin to mid-July. According to REUTER (1908) it is mainly found in the Alps, e.g. up to 1,650 m a.s.l in the canton Wallis (Switzerland), where it occurs later in the year (July, August). However, *D. annulipes* also occurs at lower altitudes: in present study it was observed at 400-475 m a.s.l. and BÜTTNER & WETZEL (1964) found a range between 320 and 580 m a.s.l. in West Saxony.

In present investigation *D. annulipes* was almost exclusively found on *L. decidua* and therefore primarily at site HIE. This confirms that *D. annulipes* is a specialist of *L. decidua* (REUTER 1908; SCHNEID 1954; GÖLLNER-SCHEIDING 1972; BOSMANS & CHÉROT 1995; DOROW 2001; WACHMANN et al. 2004). However, according to STRAWIŃSKI (1964) *D. annulipes* occasionally feeds on *P. abies*, too.

Discussion of Methods

The results demonstrate that flight-interception and branch traps are suitable methods to reveal characteristic phenological activity patterns of imaginal Heteroptera species in tree crowns of forest ecosystems. These methods have several advantages over light-trapping, the most common method used in the past for analysing seasonality (SOUTHWOOD 1960; GÜNTHER 1988; GÖLLNER-SCHEIDING 1989; HEISS et al. 1991): 1) by using non-attractive sampling fluid the activity in a defined system like a tree crown can be measured, 2) sampling include diurnal and nocturnal flight-activity, 3) acquiring continuous data sampling is less time-consuming, and 4) dependence on weather conditions (temperature, moonlight, cloud cover) and location (background illumination) is low. The two latter points also count when non-attractive trapping is compared with canopy fogging. Regarding weather conditions, wind is the decisive parameter influencing results of canopy fogging. Based on this advantages non-attractive traps are recommended by BASSET et al. (1997) for studying seasonal distribution in tree canopies, when emphasis is not placed on nocturnal arthropods. In contrast, precise resolution of seasonal patterns was not possible by using a four-week sampling interval as done in the present study. To reveal this, a two-week sampling interval is recommended. It has to be pointed to, that flight-activity, not density of species is measured in the present study. To measure real densities, methods like canopy fogging, branch beating or branch clipping are more suitable methods.

Conclusions

Analysed arboreal Heteroptera species exhibited different ecological traits, as for example overwintering stages. Although phenological patterns differed between species (see also GOẞNER 2006a), some general patterns were observed:

High annual fluctuations of activity occured in most species. However, this was species-dependent as abiotic and biotic factors effect species populations in different ways. As SOUTHWOOD (1960) pointed out differences in sampling abundance between years must not only be a consequence of fluctuations in population size. In addition, differences in flight-activity caused by different weather conditions and prey densities have to be taken into account.

In many species, males appeared before females and had a shorter lifespan. This confirms other studies on univoltine and multivoltine plant bug species (Miridae), conducted either in nature or in laboratory cultures (see WHEELER 2001). Males of some species live only for a very short time, e.g. *H. thoracica* for about one week (SOUTHWOOD & LESTON 1959; GROVES 1968). According to WHEELER (2001) mirid females typically live 25-40 days and die shortly after oviposition is completed.

Sex ratio differed greatly between species. Little is known about the fluctuations in sex ratio, specifically in predacious species (WHEELER 2001). From light-trapping it is known that male mirids are more flight-active during night than females (SOUTHWOOD 1960). In present study, in some species (e.g. *Deraeocoris lutescens*, *Cremnocephalus alpestris*) the observed differences in abundance between sexes might be also an effect of higher flight-activity of males rather than of higher densities. Proportion of males to females depends on the sampling method, as shown by STEWART & GAYLOR (1991) for tarnished plant bug (Miridae) colonising mustard and as documented by SOUTHWOOD (1960) for several heteropteran species in Great Britain. Moreover, in species overwintering in imaginal stage, sex ratios in spring can be affected by different winter mortality rates (WHEELER 2001).

It can be expected that activity of canopy plant bugs is restricted to the phenological periods of the host trees, e.g. vegetative growth, flowering, and fruiting. Therefore, activity is concentrated during a particular time interval. Despite some seasonal overlap a typical temporal separation exists (see WHEELER 2001). For example, WACHMANN et al. (2004) described the occurrence of some imaginal *Psallus* species on single oaks in short time-intervals with some time-overlapping. Due to adaptations to host phenology, most tree- and shrub-feeding mirids in temperate regions are univoltine (WHEELER 2001).

For some predacious species prey availability might be the crucial factor influencing seasonal and spatial patterns of activity. As GOßNER et al. (2005) pointed out activity of aphidophagous species on exotic *P. menziesii* might depend on availability of native aphids on native tree species.

Acknowledgements

I thank all forestry departments being involved in one of the projects for generous support of my research on their property and trust that they were not inconvenienced. Many thanks to Dr. H. Schubert, T. Maier, Dr. J. Müller, and Dr. U. Simon for placing their data at my disposal. I am grateful to M.Sc. J.D. May for linguistic help, to Dr. D. Wyniger for comments on the manuscript and to Prof. E. Wachmann and I. Altmann for the beautiful photographs of Heteroptera. Finally, many thanks to all those who helped us install the traps and to all students who sorted the samples. The studies were financed by grants of the Federal Ministry of Education, Science, Research and Technology, Germany ('Zukunftsorientierte Waldwirtschaft', project-no. 0339735/8) and the 'Kuratorium Wald' of Bavarian State Forestry Administration (project-no. L49, L51, L 52, ST 151, V56, V62).

Zusammenfassung

Phänologische Aktivitätsmuster imaginaler Heteroptera in der Krone verschiedener Baumarten in Bayern, Deutschland: Die Heteroptera wurden mit Hilfe von Lufteklektoren und Astfallen zwischen 1996 und 2004 im Rahmen von Baumkronenprojekten in Bayern, Deutschland erfasst. Der Fokus der Analyse von Aktivitätsmustern lag auf Saisonalität, Jahresschwankungen und Unterschieden zwischen Baumarten, Standorten und Geschlecht. Phänologische Daten werden zu den 21 häufigsten Arten präsentiert. Die Wanzenarten zeigten auffällige Unterschiede in den Aktivitätsmustern, die durch unterschiedliche ökologische Eigenschaften zu erklären sind. Als generelles Ergebnis kann festgehalten werden, dass 1) die Saisonalität phytosuger Arten im Wesentlichen durch die Phänologie der Wirtspflanze bestimmt ist; 2) das räumliche Aktivitätsmuster zoophager Arten durch die Beuteverfügbarkeit beeinflusst wird; 3) Jahresschwankungen durch klimatische Bedingungen sowie Unterschiede in der Beutedichte erklärt werden können. Darüber hinaus traten die Männchen der meisten Arten früher auf als die Weibchen und hatten eine kürzere Lebenszeit. Das Geschlechterverhältnis variierte deutlich zwischen den Arten.

References

AMMER U., ENGEL K., FÖRSTER B., GOßNER M., KÖLBEL M., LEITL R., SIMON U., SIMON U.E. & H. UTSCHICK (2002): Vergleichende waldökologische Untersuchungen in Naturwaldreservaten (ungenutzten Wäldern) und Wirtschaftswäldern unterschiedlicher Naturnähe (unter Einbeziehung der Douglasie) in Mittelschwaben. — Forschungsbericht des BMBF und des Bay. STMLF: 1-1001.

AUKEMA B. (1981): A survey of the Dutch species of the subgenus *Hylopsallus* of *Psallus* (Hemiptera-Heteroptera, Miridae). — Tijdschr. Entomol. **124** (1): 1-25.

AUKEMA B. (1989): *Psallus confusus* and *Psallus mollis* in The Netherlands (Heteroptera, Miridae). — Entomol. Ber. (Amst.) **49** (1): 15-17.

BARKER M.G. & M.A. PINARD (2001): Forest canopy research: sampling problems, and some solutions. — Plant Ecology **153**: 23-38.

BASSET Y. (2001): Invertebrates in the canopy of tropical rain forests. How much do we really know? — Plant Ecology **153**: 87-107.

BASSET Y., HORLYCK V. & S.J. WRIGHT (2003a) (Eds): Studying forest canopy from above: The International Canopy Crane Network. — Smithsonian Tropical Research Institute, Panama: 1-196.

BASSET Y., NOVOTNY V., MILLER S.E. & R.L. KITCHING (2003b) (Eds): Methodological advances and limitations in canopy entomology. — In: Arthropods of tropical forests: spatio temporal dynamics and resource use in the canopy. Cambridge University Press, Cambridge: 7-16.

BASSET Y., SPRINGATE N.D., ABERLENC H.-P. & G. DELVARE (1997): A review of methods for sampling arthropods in tree canopies. — In: STORK N.E., ADIS J. & R.K. DIDHAM (Eds), Canopy arthropods. Chapman & Hall, London: 27-52.

BAUGNEE J.Y. (1999): Notes on the presence in Belgium of the Microphysid *Loricula bipunctata*, and new data on three other species (Heteroptera, Microphysidae). — Bull. Ann. Soc. R. Belge Entomol. **135** (7/12): 196-200.

BOSMANS R. & F. CHEROT (1995): Contribution to the knowledge of Belgian Heteroptera: Miridae: I. Bryocorinae, Deraeocorinae, Diciphinae. — Bull. Ann. Soc. R. Belge Entomol. **131** (2): 175-186.

BÜTTNER K. & C. WETZEL (1964): Die Heteropterenfauna Westsachsens. — Faun. Abh. Mus. Tierkde. Dresden **2**: 69-100.

CARAYON J. (1989): Systematics and biology of the *Kleidocerys* spp. of Europe (Hemiptera, Lygaeidae). — Bull. Soc. Entomol. Fr. **94** (5-6): 149-164.

CASSON D.S. & I.D. HODKINSON (1991): The Hemiptera (Insecta) communities of tropical rain forest in Sulawesi, Indonesia. — Zool. J. Linn. Soc. **102** (3): 253-276.

CHÉROT F. (1990): Apport é la connaissance des Hétéroptëres Miridae de Belgique (Hemiptera Heteroptera) I. Deraeocorinae, Dicyphinae, Mirinae. — Bull. Ann. Soc. R. Belge Entomol. **126**: 199-205.

CHIRECEANU C. (2000): Structure of the predatory Heteroptera in populations of *Cacopsylla pyri* L. (Hom. Psyllidae) in pear orchards in southern of Romania. — Proc. Romanian Acad. Sci. Series B, Chemistry, Life Science and Geoscience **2** (1): 67-70.

CHUMAK V. (2004): Blattläuse der Ukrainischen Karpaten. — Karpaten-Biosphärenreservat, Ushhorod: 1-159.

CMOLUCHOWA A. & L. LECHOWSKI (1990): Bugs (Heteroptera) of a linden-oak-hornbeam association (Tilio-Carpinetum) in the Bachus Reserve (The Lubelska Upland). — Fragm. Faun. **33** (21): 361-372.

CMOLUCHOWA A. & L. LECHOWSKI (1993): Heteroptera communities of pine forests in Poland. — Fragm. Faun. **36** (8): 127-146.

DIOLI P. (1975): Emitteri Eterotteri nuovi o poco noti della Valtellina. — Mem. Soc. Entomol. Ital. **53**:30-38.

DOROW W.H.O. (1999): Heteroptera (Wanzen). — In: FLECHTNER G., DOROW W.H.O. & J.-P. KOPELKE, Naturwaldreservate in Hessen: Niddahänge östlich Rudingshain. Zoologische Untersuchungen 1990-1992. No **5/2.1.** Forschungsinstitut Senckenberg & Hessisches Ministerium für Umwelt, Landwirtschaft und Forsten, Frankfurt am Main: 241-398.

DOROW W.H.O. (2001): Heteroptera (Wanzen). — In: DOROW W.H.O., FLECHTNER G. & J.-P. KOPELKE, Naturwaldreservate in Hessen: Schönbuche. No **6/2.1**. Forschungsinstitut Senckenberg & Hessisches Ministerium für Umwelt, Landwirtschaft und Forsten, Frankfurt am Main: 157-254.

EHANNO B. (1965): Notes ecologiques sur les Miridae (Insecta-Heteroptera) observes en Bretagne sur le chene. — Vie et Milieu **16**: 517-533.

EHANNO B. (1977): Faunistical review of French Deraeocorinae and ecological notes on Armorican species (Hemiptera, Heteroptera, Miridae). — Ann. Soc. Entomol. Fr. **13** (1): 117-120.

ERWIN T.L. (1983): Tropical forest canopies: The last biotic frontier. — Bull. Ent. Soc. Am. **29**: 74-75.

ERWIN T.L. & J.C. SCOTT (1980): Seasonal size patterns, trophic structure, and richness of Coleoptera in the tropical arboreal ecosystem: The fauna of the tree *Luehea seemannii* Triana and Planch in the Canal Zone of Panama. — Coleopt. Bull. **34**: 305-322.

EVANS H.F. (1976): The effect of prey density and host plant characteristics on oviposition and fertility in *Anthocoris confusus*. — Ecol. Entomol. **1** (3): 157-162.

FAUVEL G. & P. ATGER (1981): Evolution of predaceous insects and their relationship with *Psylla pyri* and *Panonychus ulmi* in 2 pear orchards of Southern France in 1979. — Agronomie **1** (9): 813-820.

FLOREN A. & A. GOGALA (2002): Heteroptera from beech (*Fagus sylvatica*) and silver fir (*Abies alba*) trees of the Primary Forest Reserve Rajhenavski Rog, Slovenia. — Acta Entomol. Sloven. **10** (1): 25-32.

FRIESS T. (2000): Beitrag zur Kenntnis der an Grau-, Grün- und Schwarzerlen (*Alnus* spp.) vorkommenden Heteropteren in Südösterreich (Steiermark, Kärnten). — Beiträge zur Entomofaunistik **1**: 57-71.

GAGNÉ W.C. & F.G. HOWARTH (1981): Arthropods associated with foliar crowns of structural dominants. — In: MUELLER-DOMBOIS D., BRIDGES K.W. & H.L. CARSON (Eds), Island Ecosystems: Biological Organization of Selected Hawaiian Communities. US/IBP Synthesis Series **15**. Hutchinson Ross Publishing Co.,Woodshole, Massachusetts: 275-290.

GAUDERER M., GRUPPE A., GOẞNER M., MÜLLER J. & R. GERSTMEIER (2005): Vergleich der Kronenfauna von Tanne (*Abies alba*) und Fichte (*Picea *abies*). — Mitt. Dtsch. Ges. Allg. Angew. Ent.: in press.

Göllner-Scheiding U. (1970): Beiträge zur Heteropteren-Fauna Brandenburgs. 1. Die Heteropteren-Fauna des Gross-Machnower Weinbergs und seiner naheren Umgebung. — Arch. Naturschutz und Landschaftsforschung **10**: 41-70.

Göllner-Scheiding U. (1972): Beiträge zur Heteropteren-Fauna Brandenburgs. 2. Übersicht über die Heteropteren von Brandenburg. — Veröffentl. Bezirksheimat Mus. Potsdam **25/26**: 5-39.

Göllner-Scheiding U. (1974): Beiträge zur Heteropterenfauna Brandenburgs. 3. Die Heteropterenfauna der Oderwiesen und -hänge bei Lebus/Oder (Hemiptera, Heteroptera). — Faun. Abh. **5**: 181-198.

Göllner-Scheiding U. (1981): Die Insektenfauna des Hochmoores Balmoos bei Hasle, Kanton Luzern X. Heteroptera (Wanzen). — Ent. Ber. Luzern **5**: 83-85.

Göllner-Scheiding U. (1989): Ergebnisse von Lichtfängen in Berlin aus den Jahren 1981-1986 1. Heteroptera Teil I. Landwanzen (Cimicomorpha et Pentatomomorpha) (Insecta). — Faun. Abh. Mus. Tierkde. Dresden **16** (6-16): 111-124.

Göllner-Scheiding U. (1992): Einheimische Bäume als Lebensraum von Heteropteren (Insecta). — Faun. Abh. Mus. Tierkde. Dresden **18** (9): 103-129.

Göllner-Scheiding U. & L. Rezbanyai-Reser (1992). Zur Wanzenfauna des Monte Generoso, Kanton Tessin, Südschweiz (Heteroptera). — Ent. Ber. Luzern **28**: 15-36.

Göllner-Scheiding U. & L. Rezbanyai-Reser (2000): Weitere Angaben zur Wanzenfauna des Monte Generoso, Kanton Tessin, Südschweiz (Heteroptera). — Ent. Ber. Luzern **44**: 123-150.

Gorczyca J. (1990): *Asthenarius-Quercus* Kirschbaum and four other species of *Psallus* Fieber Subgen. *Hylopsallus* Wagner Heteroptera Miridae in Poland. — Pol. Pismo Entomol. **60** (3-4): 195-204.

Gorczyca J. (1991): Phylinae (Heteroptera, Miridae) of Poland. — Ann. Upper Silesian Mus., Entomol. **2**: 17-81.

Goßner M. (2004): Diversität und Struktur arborikoler Arthropodenzönosen fremdländischer und einheimischer Baumarten. Ein Beitrag zur Bewertung des Anbaus von Douglasie (*Pseudotsuga menziesii* (Mirb.) Franco) und Roteiche (*Quercus rubra* L.). — Neobiota **5**: 1-324.

Goßner M. (2005): The importance of Silver fir (*Abies alba* Mill.) in comparison to spruce (*Picea abies* (L.) Karst.) and oak (*Quercus petraea* (Matt.) Liebl.) for arboreal Heteroptera communities in Bavarian forests. — waldoekologie online **2**: 90-105.

Goßner M. (2006a): Heteroptera (Insecta: Hemiptera) communities in tree crowns of beech, oak and spruce in managed forests: diversity, seasonality, guild structure, and tree specificity. — In: Floren A. & J. Schmidl (Eds), Canopy arthropod research in Central Europe. Basic and applied studies from the higher frontier. Bioform, Heroldsberg: in press.

Goßner M. (2006b): Introduced tree species as an anthropogenic disturbance of arthropod communities in tree crowns of managed forests: a case study of native communities of Heteroptera (Insecta: Hemiptera) on red oak (*Quercus rubra* L.) (Angiospermae: Fagaceae). — In: Floren A. & J. Schmidl (Eds), Canopy arthropod research in Central Europe. Basic and applied studies from the higher frontier. Bioform, Heroldsberg: in press.

Goßner M. & M. Bräu (2004): Die Heteroptera der Neophyten Douglasie (*Pseudotsuga menziesii*) und Amerikanischer Roteiche (*Quercus rubra*) im Vergleich zur Fichte und Tanne bzw. Stieleiche und Buche in südbayerischen Wäldern – Schwerpunkt arborikole Zönosen. — Beitr. bayer. Entomofaunistik **6**: 217-235.

Goßner M., Engel K. & U. Ammer (2006): Effects of selection felling and gap felling on forest arthropod communities – a case study in a spruce-beech stand of Southern Bavaria. — Eur. J. Forest Res. 125: 345-360.

Goßner M., Gruppe A. & U. Simon (2005): Aphidophagous insect communities in tree crowns of Norway spruce (*Picea abies* L.) and Douglas-fir (*Pseudotsuga menziesi*i (Mirb.) Franco). — J. Appl. Entomol. **129** (2): 81-88.

Goula M. (1988): Miridae from the mountain of montserrat Spain: Additions to a previous list. — Misc. Zool. **12**: 364-368.

Grooves E. W. (1968): Hemiptera-Heteroptera of the London area. Part V. — Lond. Nat. **48**: 86-120.

Gulde J. (1921): Die Wanzen (Hemiptera-Heteroptera) der Umgebung von Frankfurt a. M. und des Mainzer Beckens. — Karl und Lukas v. Heyden-Stiftung der Senkenbergischen Naturforschenden Gesellschaft, Frankfurt am Main: 1-503.

Günther H. (1988): Auswertungen von Wanzenfängen von zwei Standorten im Raum Leverkusen (Hemiptera: Heteroptera). — Verh. Westd. Entom. Tag. **1988**, Düsseldorf: 233-242.

Günther H. & G. Schuster (2000): Verzeichnis der Wanzen Mitteleuropas (Insecta: Heteroptera). — Mitt. internat. entomol. Ver. Suppl. **VII**: 1-71.

Hallé F. & P. Blanc (1990): Biologie d'une canopée de forêt équatoriale. — Rapport de mission Radeau des cimes, Paris: 1-231.

Hannemann H.-J., Klausnitzer B. & K. Senglaub (2000) (Eds): Streseman: Exkursionsfauna von Deutschland, Wirbellose: Insekten. — Spektrum, Akad. Verlag, Heidelberg, Berlin: 1-959.

HEISS E. (2002): Zur Heteropterenfauna von vier ausgewählten Waldflächen in den Provinzen Bozen und Trient (Italien) (2. Beitrag) (Insecta, Heteroptera). — Ber. Naturwiss.-Med. Ver. Innsbruck **89**: 223-236.

HEISS E., GUENTHER H., RIEGER C. & H. MALICKY (1991): Artenspektrum und Phänologie von Heteropteren aus Lichtfallenausbeuten von Kreta (Heteropteren aus Kreta IX). — Ber. Naturwiss.-Med. Ver. Innsbruck **78**: 119-144.

HOBERLANDT L. (1961): Heteroptera collected in Ankara (Turkey) by light trap. — Acta Ent. Mus. Nat. Pragae **34** (590): 399-416.

HRADIL K. (2001): Important Heteroptera on oaks. — J. For. Sci. **47** (2): 101-105.

JAHN E. (1944): Über das Auftreten von *Tortrix viridiana* L. im Gebiet der Pollauer Berge und die Parasiten und Räuber des Schädlings. — Z. Angew. Entomol. **30**: 252-256.

JONNSON N. (1983): The bug fauna (Hem., Heteroptera) on apple trees in south-eastern Norway. — Fauna Norv., Ser. B **30**: 9-13.

JOSIFOV M.V. (1986): Verzeichnis der von der Balkanhalbinsel bekannten Heteropterenarten (Insecta, Heteroptera). — Faun. Abh. Mus. Tierkde. Dresden **14** (6): 61-93.

KERZHNER, I. M. & M. JOSIFOV (1999): Miridae. — In: AUKEMA B. & C. RIEGER (Eds.), Catalogue of the Heteroptera of the Palaearctic Region Vol. **3** (Cimicomorpha II: Miridae). Netherlands Entomol. Soc., Amsterdam: 1-576.

KOPONEN S., RINNE V. & T. CLAYHILLS (1997): Arthropods on oak branches in SW Finland, collected by a new trap type. — Entomol. Fenn. **8** (3): 177-183.

KULA E. (1999): Bugs in the tree-crown fauna of forest tree species in the air-pollution area of Sneznik forest administration. — J. For. Sci. **45** (6): 259-269.

KULLENBERG B. (1944): Studien über die Biologie der Capsiden. — Zool. Bidr. Upps. **23**: 1-522.

LAMINE K., LAMBIN M. & C. ALAUZET (2005): Effect of starvation on the searching path of the predatory bug *Deraeocoris lutescens*. — BioControl **50** (5): 717-727.

LANGE M. (1987): Vorläufiger Bestimmungsschlüssel für die Wanzen der Familienreihe Pentatomoidae in der Bundesrepublik Deutschland. — Deutscher Jugendbund für Naturbeobachtung, Hamburg: 1-56.

LAPKOVÁ Z. (1989): Die Migrations- und Nahrungsstrategie der Wanzen (Heteroptera) in Eichenwäldern. — Práce Slov. Ent. Spol. SAV, Bratislava **37**: 37-40.

LAPKOVÁ Z. (1989): Associations of Arthropoda on oaks with regard to Heteroptera. — Práce Slov. Ent. Spol. SAV, Bratislava **7**: 101-104.

LESTON D. (1961): The Miridae (Hemiptera) of Bedfordshire. — Proc. S. London Entomol. Nat. Hist. Soc. **1960**: 110-123.

LINDSKOG P. & B. VIKLUND (2000): On *Deraeocoris lutescens* (SCHILLING) and *Pinalitus atomarius* (MEYER-DÜR) in Sweden (Heteroptera: Miridae). — Entomol. Fenn. **11**: 231-238.

LOWMAN M.D. & P.K. WITTMAN (1996): Forest Canopies: Methods, Hypothesis, and Future Directions. — Annu. Rev. Ecol. Syst. **27**: 55-81.

MAIER T. (1997): Vergleich der Wanzenfauna (Heteroptera) von Natur- und Wirtschaftswäldern. Untersuchungen in der Stamm- und Kronenregion in fünf ausgewählten Beständen des Hienheimer Forstes in Niederbayern. — Diplomarbeit, Forstwissenschaftliche Fakultät, Ludwigs-Maximilians Universität München: 1-129.

MASSEE A.M. (1954): The Hemiptera-Heteroptera of Kent. — Trans. Soc. Br. Ent. **11** (12): 245-280.

MCCLURE M.S. (1979): Spatial and seasonal distribution of disseminating stages of *Fiorinia externa* (Homoptera: Diaspididae) and natural enemies in a hemlock forest *Tsuga Canadensis*. — Environ. Entomol. **8** (5): 869-873.

MCCLURE M.S. (1981): Effects of voltinism, interspecific competition and parasitism on the population dynamics of the helmlock scales *Fiorinia externa and Tsugaspidiotus tsugae* (Homoptera: Diaspididae). — Ecol. Entomol. **6**: 47-54.

MEURER J.J. (1956): Waarnemingen van Wantsen (Hem. Het.) met Deholp van een vang lamp. — Ent. Ber. **16**: 54-63.

MEURER J.J. (1957): Overzicht Wantsenfangsten met de vanglamp te Heemstede (N.H.) over 1955. — Ent. Ber. **17**: 80-96.

MITCHELL A.W., SECOY K. & T. JACKSON (2002) (Eds): Global Canopy Handbook: Techniques of access and study in the forest roof. — Global Canopy Programme, Oxford: 1-248.

MOFFETT M.W. (2001): The nature and limits of canopy biology. — Selbyana **22**: 155-179.

MÜLLER J. (2005): Waldstrukturen als Steuergröße für Artengemeinschaften in kollinen bis submontanen Buchenwäldern. — Dissertation, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt. Technische Universität. München: 1-197.

MÜLLER J., GRUPPE A., GOßNER M., BUßLER H., SIMON U., GAUDERER M., ZÖBL M. & R. GERSTMEIER (2005): Die Weißtanne *Abies alba*, eine ökologische Alternative zur Fichte *Picea abies*? Vergleichende Untersuchungen der Baumkronenzönosen. — Forst Holz **60** (12): 492-497.

MÜLLER J., SIMON U., BUßLER H., JOKIC Z., STRÄTZ C., MÄRKL G., MÜLLER-KROEHLING S., HACKER H. & H. SCHLUMPRECHT (2004): Waldökologischer Vergleich von Mittelwäldern und Eichenmischwäldern. — Forschungsbericht des Bay. STMLF: 1-514.

MUUL I. & B.L. LIM (1970): Vertical zonation in a tropical rain forest in Malaysia: methods of study. — Science **169**: 788-789.

MUUL I. (1999): Development of canopy walkways by Illar Muul and Associates: A brief history. — Selbyana **20** (1): 186-190.

NICOLAI V. (1986): The bark of trees: thermal properties, microclimate and fauna. — Oecologia **89**: 148-160.

NICOLAI V. (1987): Anpassung rindenbesiedelnder Arthropoden an Borkenstruktur und Feinddruck. — Spixiana **10** (2): 139-145.

NIELSEN B.O. (1974): A record of insect activity on beech stems *Fagus sylvaticus* by means of arboreal photo eclectors. — Entomol. Medd. **42** (1): 1-18.

ÖNDER F. & N. ADIGÜZEL (1979): Some Heteroptera collected by light trap in Diyarbakir (Turkey). — Türk. Bit. Kor. Derg. **3** (1): 24-34.

ÖNDER F., ÜNAL A. & E. ÜNAL (1981): Heteroptera fauna collected by light traps in some districts of north-western part of Anatolia. — Türk. Bit. Kor. Derg. **5** (3): 151-169.

ÖNDER F., ÜNAL E. & A. ÜNAL (1984): Heteropterous insects collected by light traps in Edirne (Turkey). — Türk. Bit. Kor. Derg. **8**: 215-224.

PARKER G.G. (1995): Structure and microclimate of forest canopies. — In: LOWMAN M.D. & N.M. NADKARNI (Eds), Forest canopies. Academic Press, San Diego: 73-106.

PARKER G.G., SMITH A.P. & K.P. HOGAN (1992): Access to the upper forest canopy with a large tower crane. — Bioscience **42**: 664-670.

PAULA A. S. & P.S.F. FERREIRA (2000): Fauna de Heteroptera de la "Mata do Corrego do Paraiso", Vicosa, Minas Gerais, Brasil. II. Patrones temporales. Distribucion anual y estacionalidad. — An. Inst. Biol. Univ. Nac. Auton. Mex. (Zool.) **71** (1): 7-19.

PÉRICART J. (1972): Hémiptères Anthocoridae, Cimicidae et Microphysidae de l'Ouest Paléarctique. — Faune de Europe et du Bassin Méditerranéen. Vol. **7**. Masson et Cie Éditeurs, Paris: 1-402.

PERRY D.R. (1978): A method of access into the crowns of emergent and canopy trees. — Biotropica **10** (2): 155-157.

PRINZING A. (2003): Are generalists pressed for time? An interspecific test of the Time-Limited Disperser Model. — Ecology **84** (7): 1744-1755.

PUTSHKOV V.G. (1961): Carnivorous Hemiptera of the USSR beneficial to agriculture and forestry. — Pr. Acad. Nauk. URSR Inst. Zool. **17**: 7-18.

RABITSCH W. (1999): Die Wanzensammlung (Insecta: Heteroptera) von Johann Moosbrugger (1878-1953) am Naturhistorischen Museum Wien. — Ann. Naturhist. Mus. Wien **101B**: 163-199.

REICHLING L. (1984): Les Hétéroptères du Grand-Duché de Luxembourg. 1. *Psallus* (*Hylopsallus*) *pseudoplatani* n. sp. (Miridae, Phylinae) et especes apparentees. — Trav. Sci. Mus. Hist. Nat. Luxembourg. **4** (1):1-17.

RENAULT D., SALIN C., VANNIER G. & P. VERNON (2002): Survival at low temperatures in insects: What is the ecological significance of the supercooling point? — CryoLetters **23** (4): 217-228.

REUTER O.M. (1908): Charakteristik und Entwicklungsgeschichte der Hemipteren-Fauna (Heteroptera, Auchenorrhynchia und Psyllidae) der Palearktischen Coniferen. — Druckerei der finnischen Literaturgesellschaft, Helsingfors: 1-129.

RIBES J. (1982): Hemipters del nord de Catalunya nous o interessants per a la fauna Iberica. — Misc. Zool. **6**: 45-57.

RIEGER C. & G. STRAUSS (1992): Neunachweise seltener und bisher nicht bekannter Wanzen in Baden-Württemberg (Insecta, Heteroptera). — Jh. Ges. Naturkde. Württemberg **147**: 247-263.

ROBERTS H.R. (1973): Arboreal Orthoptera in the rain forest of Costa Rica collected with insecticide: a report on the grasshoppers (Acrididae), including new species. — Proc. Acad. Nat. Sci. Phila. **125**: 46-66.

SCHAEFER M. (1991): Fauna of the European temperate deciduous forest. — In: RÖHRIG E. & B. ULRICH (Eds), Temperate deciduous forest (Ecosystems of the world). Elvesier, Amsterdam: 503-525.

SCHNEID T. (1954): Die Wanzen (Hemiptera-Heteroptera) der Umgebung von Bamberg. — Ber. Naturf. Ges. Bamberg **34**: 47-107.

SCHNEIDER I. (1962): Die Nadelholzspinnmilbe, *Paratetranychus unungius* [sic] Jac. (Acari, Trombidiformes), auf den Aufforstungsflächen Schleswig-Holsteins. — Allg. Forst. Jagdztg. **133**: 144-148.

SCHOPF A. & F. MITTERBÖCK (1991): Kronenverlichtung und Schädlingsspektrum an Eichen in Wien, Niederösterreich und Burgenland. — Österr. Ges. f. Waldökosystemforsch. u. exper. Baumforsch, Wien: 1-198.

SCHOPF A., ARNDORFER F. & E. ZELLINGER (1991): The influence of insect infestation on twig abscision of oaks (*Quercus petraea*). — Anz. Schaedlingskd. **64** (8): 145-148.

SCHUBERT H. (1998): Untersuchungen zur Arthropodenfauna in Baumkronen: Ein Vergleich von Natur- und Wirtschaftswäldern (Araneae, Coleoptera, Heteroptera, Neuropteroidea; Hienheimer Forst, Niederbayern). — Dissertation, Wissenschaft & Technik Verlag, Berlin: 1-154.

SCHUSTER G. (1981): Wanzenfunde aus Bayern, Baden-Württeberg und Nordtirol (Insecta, Heteroptera). — Ber. Naturf. Ges. Augsburg **36**: 5-50.

SCHUSTER G. (1990): Beitrag zur Wanzenfauna Schwabens (Insecta, Heteroptera). — Ber. Naturf. Ges. Augsburg **50**: 5-35.

SCHUSTER G. (1995): Die Wanzenfauna des Naturschutzgebiets "Hundsmoor" bei Westerheim im Allgäu (Insecta, Heteroptera). — Ber. Naturf. Ges. Augsburg **55**: 3-25.

SCHUSTER G. (2005): Wanzen aus Bayern IV (Insecta, Heteroptera). — Ber. Naturf. Ges. Augsburg **62**: 63-124.

SHAW D.C., MEINZER F.C., BIBLE K.J. & G.G. PARKER (2003): Wind River Canopy Crane Research Facilities, USA. — In: BASSET Y., HORLYCK V. & J. WRIGHT (Eds), Studying Forest Canopies from Above: The International Canopy Crane Network. Smithonian Tropical Research Institute, Balboa, Ancon, Panama: 98-107.

SIMON H. (1992): Vergleichende Untersuchungen zur Wanzenfauna (Heteroptera) von Streuobstwiesen im Nordpfälzer Bergland. — Beitr. Landespflege Rhld.-Pfalz **15**: 189-276.

SMYTHE N. (1982): The seasonal abundance of night-flying insects in a neotropical forest. — In: LEIGH E.C. Jr., RAND A.S. & D.M. WINDSOR (Eds), The ecology of a tropical forest seasonal rhythms and long-term changes. Smithsonian Institution Press, Washington D.C.: 309-318.

SONG B. (1998): Three dimensional forest canopies and their spatial relationship to understory vegetation. — PhD. Dissertation, Michigan Technological University, Houghton: 1-160.

SOUTHWOOD T.R.E. (1960): The flight-activity of Heteroptera. — Trans. R. Ent. Soc. Lond. **112** (8): 173-220.

SOUTHWOOD T.R.E. & D. LESTON (1959): Land and water bugs of the British Isles. — Warne & Co., Ltd., London: 1-436.

SOUTHWOOD T.R.E., WINT G.R.W., KENNEDY C.E.J. & S.R. GREENWOOD (2004): Seasonality, abundance, species richness and specificity of the phytophagous guild of insects on oak (*Quercus*) canopies. — Eur. J. Entomol. **101** (1): 43-50.

STARÝ B., BEZDĚČKA P., ČAPEK M., STARÝ P., ZELENÝ J. & J. ŠEDIVÝ (1988): Atlas of insects beneficial to forest trees. Vol. **2**. — Elsevier, Amsterdam: 1-100.

STEFFAN A.W. (1972): Unterord.: Aphidina, Blattläuse. — In: SCHWENKE W. (Ed), Die Forstschädlinge Europas. Bd. **1**. Verlag Paul Parey, Hamburg, Berlin: 264-268.

STEHLÍK J.L. (1998): The heteropteran fauna of introduced Cupressaceae in the southern part of Moravia (Czech Republic). — Acta Mus. Moraviae, Sci. biol. **82** (1997): 127-155.

ŠTEPANOVIČOVÁ O. & Z. BIANCI (1999): Ordnung Heteroptera. — In: PATOCKA J., KRISTÍN A., KULFAN J. & P. ZACH (Eds), Die Eichenschädlinge und ihre Feinde. Institut für Waldökologie der-Akademie der Wissenschaften, Zvolen: 40-44.

ŠTEPANOVIČOVÁ O. & Z. LAPKOVÁ (1986): Topic and trophic relationships of the bug Heteroptera community in beech forests in the small Carpathians Czechoslovakia. — Acta Fac. Rerum Nat. Univ. Comenianae Zool. **31**: 3-20.

ŠTEPANOVIČOVÁ O. (1972): Zur Kenntnis der Gesellschaft der Heteropteren in den Baumkronen der Gehölze eines Eichen-Weißbuchenwalds. — Biológia, Bratislava **27** (5): 353-357.

STEWART S.D. & M.J. GAYLOR (1991): Age, sex, and reproductive status of the tarnished plant bug (Heteroptera: Miridae) colonizing mustard. — Environ. Entomol. **20**: 1387-1392.

STICHEL W. (1958): Illustrierte Bestimmungstabellen der Wanzen. II. Europa (Hemiptera-Heteroptera Europaea), Vol. **3.** — Berlin-Hermsdorf: 1-428.

STONEDAHL G.M. (1990): Revision and cladistic analysis of the Holarctic genus *Atractotomus* FIEBER (Heteroptera: Miridae: Phylinae). — Bull. Am. Mus. Nat. Hist. **198**: 1-88.

STORK N.E., ADIS J.A. & R.K. DIDHAM (1997) (Eds): Canopy arthropods. — Chapman & Hall, London: 1-567.

STRAWIŃSKI K. (1936): Untersuchungen der Wanzenfauna der Bäume und Sträucher Polens. — Drukarnia Techniczna Spólka Akcyjna, Warszawa: 1-216.

STRAWIŃSKI K. (1964): Zoophagism of terrestrial Hemiptera-Heteroptera occurring in Poland. — Ekologia Polska **12**: 429-452.

SUGDEN A.M. (1985): Aerial walkways in rain forest canopies, construction and use in Panama, Papua New Guinea, and Sulawesi. — In: D'ARCY W.G. & M.D.A. CORREA (Eds), The Botany and Natural History of Panama. Missouri Botanical Garden, Saint Louis, Missouri: 207-219.

SUTTON S.L. (1979): A portable light trap for studying insects in the upper canopy. — Brunei Museum Journal **4**: 156-160.

SUTTON S.L. & P.J. HUDSON (1980): The vertical distribution of small flying insects in the lowland rainforest of Zaire. — Zool. J. Linn. Soc. **68**: 111-123.

TAKSDAL G. (1965): Hemiptera (Heteroptera) collected on ornamental trees and shrubs at the Agricultural Colledge of Norway, Ås. — Nor. Entomol. Tidsskr. **13**: 5-10.

TAMANINI L. (1981): Gli eterotteri della Basilicata e della Calabria (Italia meridionale) (Hemiptera, Heteroptera). — Mem. Mus. Civ. Stor. Nat. Verona, ser. 2, A, **3**: 1-164.

TAMANINI L. (1982): Gli eterotteri dell'Alto Adige (Insecta: Heteroptera). — Studi Trentini Sci. Nat., Acta Biol. **59**: 65-194.

THALENHORST W. (1962): Auftreten, Massenwechsel und Bekämpfung der Fichtenspinnmilbe *Paratetranychus* (*Oligonychus*) *ununguis* (JACOBI). — Forst-Holzw. **15**: 295-300.

URBAN J. (2003a): Bionomics and harmfulness of *Tetraneura ulmi* (L.) (Aphidinea, Pemphigidae) in elms. — J. For. Sci. **49** (4): 159-181.

URBAN J. (2003b): Biology and harmfulness of *Eriosoma* (=*Schizoneura*) *ulmi* (L.) (Aphidinea, Pemphigidae) in elm. — J. For. Sci. **49** (8): 359-379.

VAN PELT R. & J.F. FRANKLIN (2000): Influence of canopy structure on the understory environment in tall, old-growth, conifer forests. — Can. J. For. Res. **30**: 1231-1245.

VIDLIČKA L. (1993): Works on the Institute of exp. Phytopath. — And Ent., Ed. Vesna, Bratislava: 171-175.

VLACH M.R. (1994): Heteroptera of Valpolicella (Italy, Venetia, Veronese region). — Mem. Soc. Entomol. Ital. **73**: 59-152.

WACHMANN E. (1989): Wanzen beobachten, kennenlernen. — J. Neumann, Neudamm, Melsungen: 1-274.

WACHMANN E., MELBER A. & J. DECKERT (2004): Wanzen Band 2. — Die Tierwelt Deutschlands **75**. Goecke & Evers, Keltern: 1-288.

WAGNER E. (1952): Blindwanzen oder Miriden. — In: DAHL F. (Ed), Die Tierwelt Deutschlands und der angrenzenden Meeresteile **41**. Gustav Fischer Verlag, Jena: 1-218.

WAGNER E. (1962): Über *Psallus varians* Herrich-Schaeffer 1842 (Hem. Het. Miridae). — Nachrbl. Bayer. Entomol. **11**: 26-31.

WAGNER E. (1966): Wanzen oder Heteroptera I: Pentatomorpha. — In: DAHL F. (Ed), Die Tierwelt Deutschlands und der angrenzenden Meeresteile **54**. Gustav Fischer Verlag, Jena: 1-235.

WAGNER E. (1971): Die Miridae Hahn, 1831, des Mittelmeerraums und der Makaronesischen Inseln (Hemiptera, Heteroptera). Teil 1. — Entomol. Abh. Mus. Tierkde. Dresden **37**, Suppl.: 1-484.

WAGNER E. (1973): Die Miridae Hahn, 1831, des Mittelmeerraumes und der Makaronesischen Inseln (Hemiptera, Heteroptera). Teil 2. — Entomol. Abh. Mus. Tierkde. Dresden **39** Suppl. 2: 1-421.

WAGNER E. (1975): Die Miridae Hahn, 1831, des Mittelmeerraums und der Makaronesischen Inseln (Hemiptera, Heteroptera). Teil 3. — Entomol. Abh. Mus. Tierkde. Dresden **40**, Suppl.: 1-483.

WAGNER E. & H.H. WEBER (1964): Héteroptères Miridae. — Faune de France **67**: 1-592.

WAGNER T. (2001): Seasonal changes in the canopy arthropod fauna in Rinorea beniensis in Budongo Forest, Uganda. — Plant Ecology **153** (1-2): 169-178.

WHEELER A.G. (2001): Biology of the Plant Bugs (Hemiptera: Miridae) - Pests, Predators, Opportunists. — Cornell Univ. Press, Ithaka, NY: 1-506.

WHEELER A.G. Jr. (1976): Life history of *Kleidocerys resedae* (insect pests) on European white biorch (*Betula pendula*) and ericaceous shrubs (*Pieris japonica*). — Ann. Entomol. Soc. Am. **69** (3): 459-463.

WHEELER A.G. Jr. (1991): Plant Bugs of *Quercus ilicifolia*. Myriads of Mirids (Heteroptera) in pitch pine-scrub oak barrens. — J. N. Y. Entomol. Soc. **99** (3): 405-440.

WHEELER A.G. Jr. (1999): *Phoenicocoris claricornis* and *Pinophylus carneolus* (Hemiptera: Miridae): Distribution and seasonality of two specialists on microsporangiate strobili of pines. — J. N. Y. Entomol. Soc. **107** (2-3): 238-246.

WHEELER A.G. Jr. & T.J. HENRY (1977): Miridae associated with Pennsylvania conifers 1. Species on arborvitae, false cypress, and juniper. — Trans. Am. Entomol. Soc. **103**: 623-656.

WHEELER A.G. Jr. & T.J. HENRY (1992): A Synthesis of the Holarctic Miridae (Heteroptera): Distribution, Biology, and Origin, with Emphasis on North America. — The Thomas Say Foundation, Entomological Society of America, Lanham, Maryland: 1-282.

WINCHESTER N.N. & R.A. RING (1999): The biodiversity of arthropods from northern temperate ancient coastal rainforests: conservation lessons from the high canopy. — Selbyana **20**: 268-275.

WINTER K., BOGESCHÜTZ H., DORDA D, DOROW W.H.O., FLECHTNER G., GRAEFE U., KÖHLER F., MENKE N., SCHAUERMANN J., SCHUBERT H., SCHULZ U. & J. TAUCHERT (1999): Programm zur Untersuchung der Fauna in Naturwäldern. — IHW-Verlag, Freising; 1-61.

WOLDA H. (1979): Abundance and diversity of Homoptera in the canopy of a tropical forest. — Ecol. Entomol. **4**: 181-190

WOODROFFE G.E. (1967): Further notes on some Hemiptera-Heteroptera from the Aviemore district, Inverness-shire. — Entomol. Mon. Mag. **103**: 220.

ZÖBL M., GOßNER M., GERSTMEIER R., MÜLLER J. & A. GRUPPE (2005): Diversität von aphidophagen Insekten im Nationalpark Bayerischer Wald - welchen Beitrag leistet die Tanne im Vergleich zur Fichte? — Mitt. Dtsch. Ges. Allg. Angew. Ent.: [in press].

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Zeitschrift/Journal: Denisia

Jahr/Year: 2006

Band/Volume: 0019

Autor(en)/Author(s): Goßner [Gossner] Martin

Artikel/Article: Phenological activity patterns of imaginal Heteroptera in the canopy of different tree species in Bavaria, Germany 1055-1094