

COMPARISON OF THE VERTICAL DISTRIBUTION OF LEAFHOPPERS - TRAPPED
BETWEEN 5 AND 155 m ABOVE THE GROUND - WITH THE GROUND POPULATION

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ABSTRACT

294 Cicadina were caught on sticky mesh traps, fixed on a meteorological tower at eight levels between 5 and 155 m above the ground. 20 Auchenorrhyncha species were found of which 98% of the specimens were tree- and bush-feeders from the genera Allygus, Idiocerus and Oncopsis and some Cixius, Aphrophora, Alebra, Fagocyba and Speudotettix. Only 2% were grass- or Juncus-feeders: Laodelphax striatellus and Conosanus obsoletus. 31 Cicadina species were caught on nearby trees and bushes with sweep nets, and 38 additional species on the surrounding low vegetation. The vertical distribution, the possible migration and the reasons for the selection in the sticky traps are discussed.

KEY WORDS

Auchenorrhyncha, sticky-traps, flight, migration, dispersion.

INTRODUCTION

Werner NAEF obtained his B.Sc. in natural history in the Zoological Institute of the University of Basle (under the supervision of Dr. P. DUELLI, Swiss Federal Institute of Forest Research, Birmensdorf ZH) on the vertical distribution of some insect groups in the Rhine-valley just above Basle (in Schwörstadt FRG, across from Möhlin AG, Switzerland). He collected about 6800 insects and spiders using sticky mesh traps at 8 heights between 5 and 155 m above ground, fixed on a meteo-tower. Some of the Diptera and Hymenoptera and all Thysanoptera and Aphidoidea were not counted. I received 294 Homoptera-Auchenorrhyncha, which I determined down to the species level. The number of the Cicadina caught is rather small, but it was a unique opportunity to study leafhoppers which had been caught up to 155 m above ground.

METHODS

The sticky mesh traps, situated at 5-10-20-30-40-70-100 and 155 m above ground, were exactly 1 m², mesh distance 5 mm, wire diameter 0.5 mm. At the beginning of the investigation and after each control (11th, 22nd May, 1st, 12th, 18th, 25th June, 2nd, 8th, 16th July, 5th, 13th, 18th, 28th August and 3rd September 1984), the mesh was coated with an adhesive (Tanglefoot Co, Michigan USA). The adhered insects had been detached with petrol and conserved in 70% alcohol, which made the determination much more difficult. In spite of the mesh distance of 5 mm, small insects only 2 mm long had also been caught.

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Table 1 - Auchenorrhyncha species in sticky traps on a meteo tower

Auchenorrhyncha species	number		*	hostplants	over- winter ** as
	♂	♀			
<i>Cixius nervosus</i> (L.)	2	2	p	L: roots, A: trees, bushes	L
<i>Laodelphax striatellus</i> (FALL.)		4	p	grasses	L
<i>Aphrophora salicina</i> (GOEZE)	1	2	o	L: herbs, A: Salix	E
<i>Oncopsis alni</i> (SCHRANK)		1	o	Alnus	E
" <i>flavicollis</i> (L.)		1	o	Betula	E
" <i>subangulata</i> (SAHLB.)	2		o	Betula	E
<i>Idiocerus cupreus</i> KBM.	4	1	o	Populus	E
" <i>fuchsii</i> KBM.	2	5	?		?
" <i>poecilus</i> (H.-S.)	3	2	o	Populus	A
" <i>rutilans</i> KBM.	1		o	Salix	E
" <i>similis</i> KBM.	1		o	Salix	E
" <i>stigmatalis</i> LEWIS	1		o	Salix	E
" ♀		1	-		-
<i>Alebra wahlbergi</i> (BOH.)	1		p	deciduous trees	E
<i>Fagocyba douglasi</i> (EDW.)	1		p	" "	E
<i>Allygus communis</i> (FERR.)	26	145	p	L: herbs, A: herbs/dec. trees	?
" <i>mixtus</i> (FABR.)		19	p	L: " A: " / "	?
" <i>modestus</i> SCOTT	10	46	p	L: " A: " / "	?
<i>Speudotettix subfuscus</i> (FALL.)		1	p	L: grasses, A: bushes	L
<i>Conosanus obsoletus</i> (KBM.)		1	o	Juncus	E
damaged specimens	(8)		-		-
total specimens	55	231	*	p = polyphag, o = oligophag	
" species	20		**	E = eggs, L = larvae, A = adults	

In the surrounding area, I caught the Cicadina with sweep nets, in the cereal field just around the meteo tower, and in fields, on grasses and low vegetation in the neighbourhood, on solitary trees and at the edge of the wood. In the north, the wood was situated about 700 m from the meteo tower, in the southwest about 120 m and up to 1000 m on the other side of the River Rhine (in Möhlin AG). The collecting dates were the 6th August and 22nd September 1986 and 5th April, 2nd June and 15th July 1987.

RESULTS

Auchenorrhyncha species on the sticky traps

20 species had been caught (Table 1). 86% of the specimens were *Allygus* spp, 7.3% *Idiocerus* spp, 1.4% *Oncopsis* spp, 2.4% *Cixius nervosus* and *Aphrophora salicina* and one specimen each of *Alebra wahlbergi*, *Fagocyba douglasi* and *Speudotettix subfuscus*. The adults of all these species live on trees or bushes and they represent 98.3% of all the specimens. Only 1.7% of the specimens caught and only 2 species live on grasses or *Juncus*: *Laodelphax striatellus* and *Conosanus obsoletus*.

Table 2 - Vertical distribution of the Auchenorrhyncha species in sticky traps

species	size of adults mm	number of specimens in the sticky traps, at a height of .. m								total
		5	10	20	30	40	70	100	155	
<i>Cixius nervosus</i>	6-8	1		1			1	1		4
<i>Laodelphax striatellus</i>	2-3	1			1			1	1	4
<i>Aphrophora salicina</i>	9-11		1		1		1			3
<i>Oncopsis alni</i>	5-6	1								1
" <i>flavicollis</i>	5		1							1
" <i>subangulata</i>	5-6	2								2
<i>Idiocerus cupreus</i>	5	5								5
" <i>fuchsii</i>	5	3	3	1						7
" <i>poecilus</i>	5-6	2	1	1				1		5
" <i>rutilans</i>	5	1								1
" <i>similis</i>	5-6		1							1
" <i>stigmatalis</i>	6-7						1			1
" <i>♀</i>	6							1		1
<i>Alebra wahlbergi</i>	4	1								1
<i>Fagocyba douglasi</i>	3-4	1								1
<i>Allygus communis</i>	6-7	49	50	26	22	22	2			171
" <i>mixtus</i>	5-7	5	10		1	1	2			19
" <i>modestus</i>	6-7	38	5	9	1	3				56
<i>Spseudotettix subfusc.</i>	5-6	1								1
<i>Conosanus obsoletus</i>	4-6					1				1
damaged specimens	-	3	2	1	1			1		8
total specimens		114	74	39	27	27	7	5	1	294

Vertical distribution and monthly appearance

Table 2 shows the vertical distribution. The *Allygus* spp were caught from August to September at 5 to 70 m, the *Idiocerus* spp mainly in May-June, some in August, at 5 to 100 m, the *Oncopsis* spp in June-July at 5 to 10 m only, the *Alebra* and *Fagocyba* spp in July at 5 m. *Laodelphax striatellus* was in the sticky traps in May, June and July at 5, 30, 100 and 155 m, and *Conosanus obsoletus* in August at 40 m.

DISCUSSION

The vertical distribution

The frequency of Cicadina, caught in sticky traps, decreases very markedly with increasing height (Fig. 1).

The distribution of insect density in relation to height is exponential which gives a linear relationship in the double logarithmic transformation. The problem is that the density at ground level can not approach infinity, as in an exponential relationship. In the literature, we found two models to overcome this problem.

JOHNSON (1957) adds a constant value z_e to all the observed heights. He determines the value of z_e by trial and error to give the best fit.

In his examples, with measurements up to 1500 m, z_e varies from 0.3 to 30 m, in some cases up to 1000 m. According to JOHNSON, the value of z_e depends on the rate of exchange of insects between ground and air.

TAYLOR (1974) divides the relationship into two parts: near the ground is the "boundary layer" (where the flight-speed of the insects is greater than the wind-speed), and the "free air" zone (where the flight-speed of insects is lower than the wind-speed and the insects are distributed as expected for inert particles from normal diffusion theory). The discontinuity in the profile is also found by trial and error to give the best fit to the two linear parts. In his examples the boundary layer for Homoptera (Aphids) over a meadow was at 1 m, for other insect groups between 0.3 and some metres above ground.

The density-height profile should be considered for each species separately, but it is often difficult to collect a sufficient number of a single species at considerable heights.

In our example, z_e according to JOHNSON would be 20 or 30 m and the discontinuity according to TAYLOR is about 30 m (Fig. 2). In the following discussion, the expressions "boundary layer" and "free air" in the sense of L.R. TAYLOR are used.

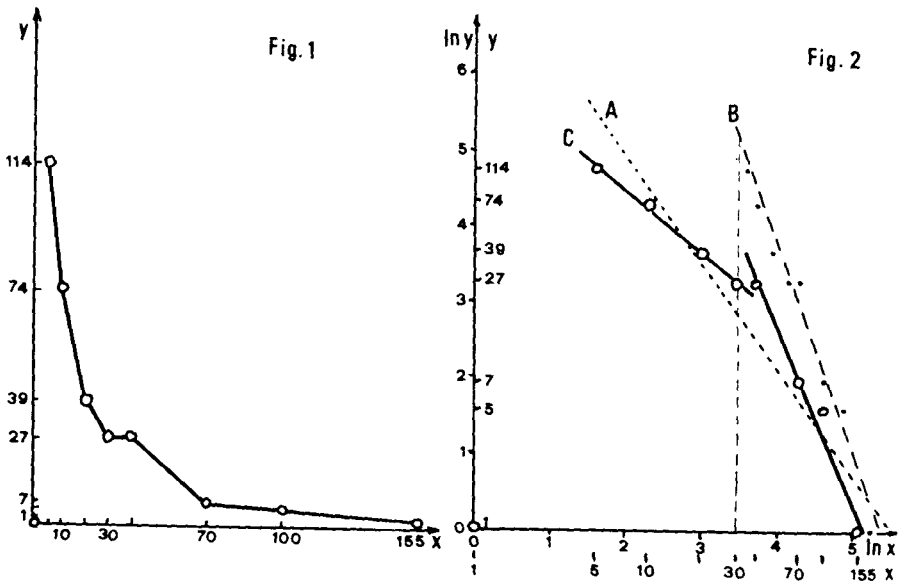


Fig. 1 - Vertical distribution in the sticky traps:
y=number of Cicadina at height x in metres

Fig. 2 - A: ln-ln transformation : $\ln y = 5.499 - 0.704 \ln x$, $r^2 = 0.91$

B according to JOHNSON: $\ln y = 5.324 - 0.368 \ln (x+30)$, $r^2 = 0.98$

C₁ according to TAYLOR: $\ln y(5/30) = 7.457 - 1.220 \ln x$, $r^2 = 0.99$

C₂ " " " : $\ln y(40/155) = 5.107 - 0.415 \ln x$, $r^2 = 0.96$

Active migration or passive dispersal by wind

We can recognise three groups of Auchenorrhyncha species in the sticky traps. In the first group are rather large leaf- and froghoppers (5 to 10 mm long), the Tarvae of which live on roots or on low vegetation and the adults on trees and bushes. The Allygus spp are the most dominant, Cixius, Aphrophora and Speudotettix species also belong to this group, but probably also Idiocerus. They represent 96% of the Cicadina specimens in the sticky traps and fix the boundary layer at about 30 m above ground, the height of the trees and woods 120 to 700 m distant. They are all good fliers and they actively migrate from the low vegetation to the trees and bushes, such as Allygus, Cixius, Aphrophora and Speudotettix, or for a hibernation site (such as Idiocerus poecilus) or to new plants for food or oviposition. HEGAB et al. (1980) studied the biology of Allygus spp. They caught many larvae on herbs at grass level. After the appearance of the adults, they had been caught for 7 to 10 days only on the low vegetation, and later on more frequently at the canopy level of fruit trees, but some adults were still caught at the grass level. At the end of the flight period in October, they were sometimes caught even more frequently in the low vegetation (perhaps for oviposition). HEGAB also caught many adult Allygus in light traps, which shows that they are good fliers.

Most of the adults of these large species were caught in the sticky traps in the boundary layer up to 30 m. However some were also caught at 40 - 70 m and even at 100 m, which proves that some are transferred by wind in the free air zone and may be passively transported for greater distances.

The second group consists of smaller tree- and bush dwellers (3 - 6 mm long), such as Uncopsis, Alebra and Fagocyba. They represent only 2% of all leafhoppers caught on sticky traps. They are also good fliers; most of them were caught at a height of 5 m and only one at 10 m. It seems that the boundary layer for this group is about 10 m and that they are less active migrators than the species of the first group.

In the third group are the dwellers of the low vegetation, such as Laodelphax striatellus and Conosanus obsoletus. They represent only 2% of the Cicadina in the sticky traps and were caught at heights of 5, 30, 40, 100 and up to 155 m above ground. Using two identical traps, operated one above the other at 1.2 and 9.1 m above ground, WALOFF (1984) caught more dwellers of low vegetation at 1.2 m and more arboreal species at 9.1 m. The small species of the low vegetation probably have a boundary layer lower than our lowest sticky trap at 5 m (perhaps about 1 m) and therefore the active fliers had not been trapped, only those in the free air zone. But their presence at 30, 40, 100 and 155 m proves that wind transport of "fliers, flitters and jumpers" (WALOFF 1984) is possible.

With a sticky screen trap fixed on an airplane, GLICK collected many insect species and reported in 1957 the presence of 22 Auchenorrhyncha species between 30 and 1520 m above ground. In 1960, the same author strengthened other data which suggested that wind transport of Empoasca fabae (HARRIS) is possible from the Mississippi Delta 800 km northwards to the North-Central States of the USA. Wind transport for hundreds of km has also been demonstrated for "Macrosteles fascifrons (STÅL)" (= M. quadrilineatus FORBES) and Circulifer tenellus BAKER in the USA, or for Nilaparvata lugens (STÅL) and Sogatella furcifera (HORVATH) in Asia (JOHNSON 1969).

Table 3 - Auchenorrhyncha species on trees and bushes
in the area surrounding the meteo tower

Auchenorrhyncha species +	number		* hostplants
	♂	♀	**
+ <i>Aphrophora alni</i> (FALL.)	3	1	p L:herbs, A:deciduous trees
+ <i>Oncopsis carpini</i> (SAHLB.)	7	5	m <i>Carpinus betulus</i>
<i>Pediopsis tiliae</i> (GERM.)	2		o <i>Tilia</i>
<i>Macropsis graminea populi</i> (EDW.)		2	o <i>Populus</i>
+ <i>Idiocerus stigmatalis</i> LEWIS		2	o <i>Salix</i>
" <i>vitreus</i> (FABR.)	3	8	o <i>Populus</i>
" <i>nitidissimus</i> (H.-S.)	1	1	o <i>Populus</i>
<i>Alebra albostrigata</i> (FALL.)	13	11	o <i>Quercus</i>
" <i>neglecta</i> WAGNER	1		p <i>Carpinus, Corylus, Prunus pa.</i>
+ " <i>wahlbergi</i> (BOH.)	22	28	p <i>Tilia, Acer camp., Carpinus</i>
<i>Empoasca vitis</i> (GOETHE)		5	p deciduous trees
<i>Dryocyba carri</i> (EDW.)	5	10	p <i>Tilia, Quercus</i>
+ <i>Fagocyba cruenta</i> (H.-S.)	1	1	m <i>Fagus silvatica</i>
" <i>douglasi</i> EDW.	21	40	p <i>Carpinus, Fagus ...</i>
<i>Edwardsiana barbata</i> (RIB.)	1		o <i>Salix</i>
" <i>frustrator</i> (EDW.)	1		p deciduous trees
" <i>hippocastani</i> (EDW.)	1	1	p <i>Tilia, Ulmus, Corylus</i>
<i>Zonocyba bifasciata</i> (BOH.)	5	4	o <i>Quercus, Carpinus</i>
<i>Typhlocyba quercus</i> (FABR.)	8	10	p <i>Quercus, Prunus, Crataegus</i>
<i>Eurhadina</i> ♀ (? <i>concinna</i> GERM.)		4	p <i>Quercus, Fagus, Carpinus</i>
<i>Alnetoidia alneti</i> (DAHLB.)	4	10	p <i>Alnus, Tilia, Carpinus</i>
<i>Flammigeroidia flammigera</i> (FOURC.)		1	p dec. trees, esp. <i>Prunoideae</i>
<i>Arboridia erecta</i> (RIB.)	7	5	p <i>Carpinus, Malus ...</i>
" <i>velata</i> (RIB.)	2	1	o <i>Quercus</i>
<i>Frutoidia bisignata</i> (M.R.)		1	p deciduous trees
+ <i>Allygus communis</i> (FERR.)		1	p L:herbs, A:herbs/dec.trees
+ " <i>mixtus</i> (FABR.)	1	5	p L: " A: " / " "
+ " <i>modestus</i> SCOTT	2		p L: " A: " / " "
♀♀ <i>Kybos/Edwardsiana/Erythroneurini</i>		8	- <i>Salix / Quercus / Carpinus</i>

+ = the same genus or species also in sticky traps
* p = polyphag, o = oligophag, m = monophag
** L = larvae and nymphs, A = adults

Comparison of the Auchenorrhyncha species in the sticky traps with the ground population

The area around Basle is warmer and less windy than the rest of North-Switzerland. I found there for instance *Stictocephala bisonia* (KOFF & YONKE) (GÜNTART 1987 a) and in the surroundings of the meteo tower also *Frutoidia bisignata*, which otherwise were only found in the Southern Swiss areas. In the surroundings of the meteo tower, I collected 69 Cicadina species, compared with 20 on the meteo tower. When we compare the Auchenorrhyncha species in the sticky traps with those caught with sweeping nets in the surroundings, we observe that the first group i.e. the larger dwellers of trees and bushes, the larvae of which live on the low vegetation, such as *Allygus*, *Aphrophora* and *Speudotettix*, including the *Idiocerus* spp, represent only 2% of the specimens in the surroundings

Table 4 - Auchenorrhyncha species on low vegetation
in the area surrounding the meteor tower

Auchenorrhyncha species	number	
	♂	♀
Megadelphax sordidulus (STÅL)	2	3
+ Laodelphax striatellus (FALL.)	16	10
Acantodelphax spinosus (FIEB.)	1	
Dicranotropis hamata (BOH.)	30	48
Xanthodelphax stramineus (STÅL)	1	2
Criomorpus albomarginatus CURT.	2	1
Javesella dubia HBM.	8	8
" pellucida (FABR.)	3	3
Ribautodelphax albostriatus (FIEB.)	2	2
Cercopis vulnerata GERM.	1	8
Cicadella viridis (L.)	2	1
Emelyanoviana mollicula (BOH.)	1	1
Forcipata ♀ (? citrinella ZETT.)		1
Chlorita ♀ (? viridula FALL.)		1
Eupteryx atropunctata (GOEZE)	1	
" aurata (L.)	32	1
" ♀ (? calcarata OSSI.)		3
" ♀ (? collina FLOR)		1
" notata CURTIS		1
" urticae (FABR.)	1	
Zyginella scutellaris (H.-S.)	31	40
Balclutha punctata (FABR.)	3	1
" ♀ (? saltuella (KBM.)		1
Macrosteles cristatus (RIB.)	3	
" laevis (RIB.)	10	4
" sexnotatus (FALL.)	1	2
Deltocephalus pulicaris (FALL.)	1	1
Doratura stylata (BOH.)		1
** Allygus communis (FERR.)		1
Paluda ♀ (? adumbrata/preyssleri)		1
+ Speudotettix subfuscus (FALL.)	1	
Euscelis incisus (KBM.)	8	2
Artianus interstitialis (GERM.)	1	
Psamotettix alienus (DAHLB.)	8	21
" cephalotes (H.-S.)	2	
" confinis (DAHLB.)	1	
Errastunus ocellaris (FALL.)	1	3
Jassargus sursumflexus (THEN)		1
** ♀♀		21

+ the same genus or species also in the sticky traps
* counted as dweller of trees and bushes
** ♀♀ Delphacidae, Agallia, Empoasca, Macrosteles, Euscelis, Psamotettix

areas (in the sticky traps, 96%). It seems that especially the Allygus spp have a pronounced dispersion activity. In the second group are the smaller tree- and bush dwellers, such as Oncopsis, Atebra and Fagocyba. Most of the species in Table 3, such as Pediopsis, Macropsis, Kybos, Empoasca, Dryocyba, Fagocyba, Edwardsiana, Zonocyba, Typhlocyba, Eurhadina, Alnetiodia, Arboridia, Frutoidia and Flammigeroidia also belong to this group. Together they represent 41% of all Cicadina specimens (but only 2% in the sticky traps). It is striking that this group is so poorly represented in the sticky traps. It seems to me that these species are more confined to the hostplants and do not migrate as actively as the Allygus species. I am disappointed that not a single Flammigera specimen was caught on the sticky traps (on the search for a plant to hibernata, GÜNTHART 1987 b). The third group, the dwellers of the low vegetation, represent 57% of all specimens in the surroundings of the meteo-tower (Table 4), but only 2% in the sticky traps. As their boundary layer is probably lower than our lowest sticky trap at 5 m, only some specimens in the free air zone had been trapped. It is a pity that there were no sticky traps between a height of 0 and 5 m, where many dwellers of the low vegetation would probably have been trapped.

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