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A COMPARISON OF METHODS FOR ESTIMATING DENSITY OF GRASSHOPPERS (*INSECTA:ORTHOPTERA*) ON ALPINE PASTURELANDS

COMPARAISON DE METHODES D'ECHANTILLONNAGE DES PEUPLEMENTS D'ORTHOPTERES (*INSECTA:ORTHOPTERA*) EN PATURAGES ALPINS

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SUMMARY - The aim of this paper is unifying methods for evaluating environmental resources. Two widely used techniques, lineal transects -relative method- and biocenometers -absolute method-, were tested as means of sampling grasshoppers (Insecta: Orthoptera) in an outbreak area on alpine pastureland in southeastern France (Parc National de la Vanoise). The biocenometer gives directly the density of population, but it is difficult and slow to apply, and gives a poor exploration of rare species. The lineal indexs of abundance (ILA), obtained from transects, are easier to apply but subjectif. Both methods could be indistinctly used to determinate the predominant species of the community, the percentage of adults and the sex ratio. The correlation that exists between lineal indexs of abundance and data from biocenometers allows us to use them as complementary methods in one sampling, bringing together the accuracy and precision of the absolute method, and the speed and versality of the relative method.

KEY WORDS - Orthoptera, relative and absolute sampling methods, lineal indexs of abundance, biocenometer, pastureland, Alps.

RÉSUMÉ - On compare deux méthodes d'échantillonnage des peuplements d'Orthoptères en milieu ouvert, l'une quantitative (biocenomètres) et l'autre relative (indices linéaires d'abondance), dans une zone de pullulation en pâturages alpins (Parc National de la Vanoise, France). Avec le biocénomètre on obtient directement les densités, mais c'est une méthode lourde, nécessitant beaucoup de personnel et de temps, et elle est peu précise pour les espèces rares. Avec la méthode relative on obtient des mesures approximatives, plus faciles et plus rapides à effectuer, mais on ne connait pas le niveau de précision avec lequel on travaille. Les deux méthodes sont aussi bonnes pour connaître les espèces dominantes, le pourcentage d'adultes et le "sex-ratio". Les corrélations qu'on trouve entre les indices linéaires d'abondance et les mesures au biocénomètre permettent de les utiliser comme des méthodes complementaires dans un échantillonnage, et de transformer les données relatives en quantitatives.

MOTS-CLÉS - Orthopteres, méthodes d'échantillonnage, index d'abondance, biocénomètre, pâturages, Alpes, Vanoise

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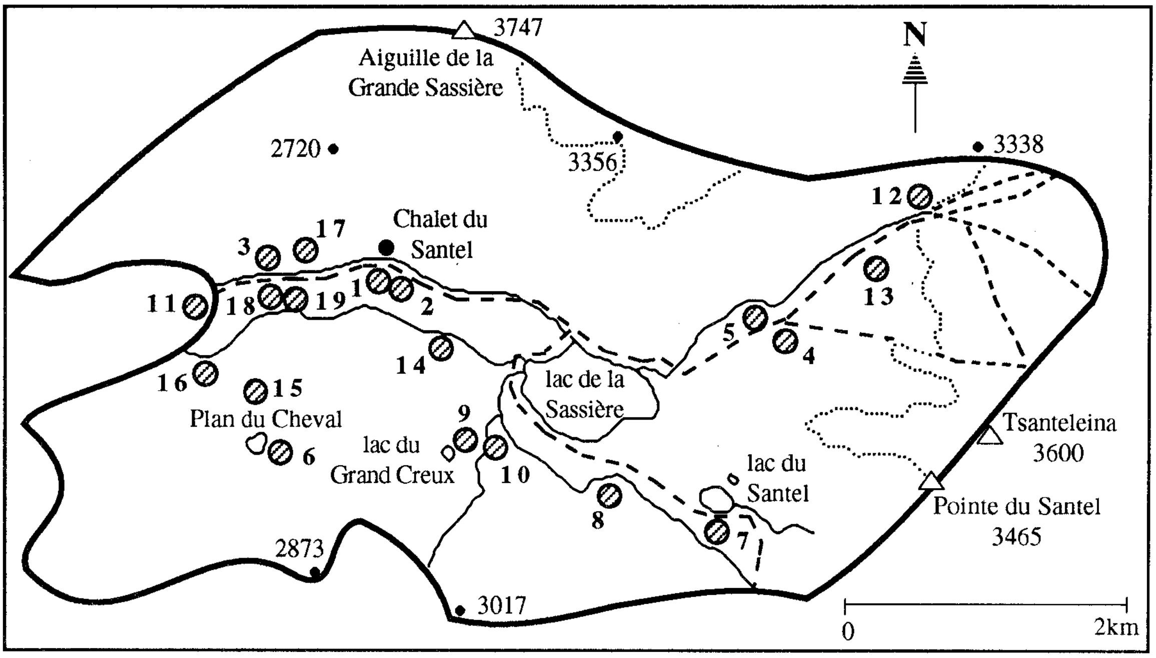

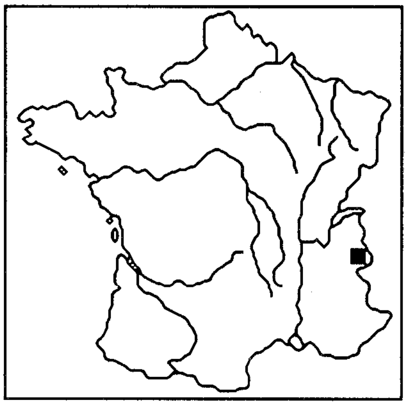

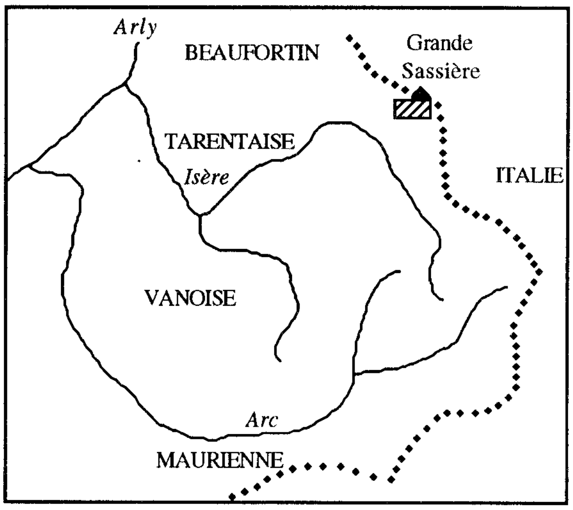

Fig. 1. Location of the sampling sites employed in the field study sited in the Vanoise National Park (Alps, Savoie, France). See also Table 1.

INTRODUCTION

As qualitative study of terrestrial ecosystems advances, it becomes necessary to quantify the density of their taxocenosis to complete the knowledge of their dynamics.s

Most of the census methods carried out, being easy to apply, do not produce data on density related to surface unit but rather on other parameters, such as length, observation time, etc. which, at least, allows inter-comparison of the different environments. The separation between relative methods (number of individuals per parameter unrelated to surface) and absolute methods (number of individuals per surface unit) is thus born (Lamotte & Bourlière, 1969).

One way of solving the problem is to calibrate the methods, by means of the applying, in a particular place, during a short experimental period, and absolute method, costly though guaranteed, and another relative method, simpler to apply but usually more difficult to control statistically. In this way, finding the necessary correction factors for the latter, it can be applied successively, giving trustworthy results with less effort (Blondel, 1969; Southwood, 1978).

Grasshoppers *(Insecta: Orthoptera)* have seen to be quantitatively important in many open environments, especially in outbreak areas, and different methods have been used for estimating population numbers. Richards (1953) related lineal transects on foot with capture-recapture methods in the study of the red locust. Later, Scheepers & Gunn (1958) used lineal transects by car to estimate thesepopulations. Onsager (1977) compared different absolute and relative methods in rangelands. Evans *et al.* (1983) compared night trapping and sweeping in tallgrass prairies.

In the Alps grasshoppers seem to be quantitatively important, even in recent years, since an outbreak of *Aeropus sibiricus* L. took place in the "Parc National de la Vanoise". Some studies have been carried out in the area (Voisin, 1986a & 1986c) by means of lineal transects producing lineal indexs of abundance (ILA), a relative method widely used in studying grasshopper communities in open environments (Dreux, 1962; Marty, 1969; Voisin, 1979; Defaut, 1978 & 1987).

However, no quantitative comparison of the relative accuracy and precision associated with use of this method on alpine grasshoppers has been established.

In this paper the lineal indexs of abundance are compared with an absolute method for epigeal arthropod fauna, the biocenometer (Gillon & Gillon, 1967). Different models of biocenometer have been employed for grasshopper sampling (Makulek, 1971; Gueguen & Delaunay, 1980; Kaushal & Vats, 1984; Barker, 1985; Isern-Vallverdú, 1990, among others).

The aim was to calibrate the relative method, to evaluate the advantages and disadvantages of each method and to show how complementary the information obtained by both methods was.

STUDY AREA

The study was carried out in the Alps, during August 1989, in the highest part of the Grande-Sassière valley (Tarentaise, Savoie, France), on pastureland belonging tohigher subalpine and alpine floors, from 2300 m to 2900 m altitude (Fig. 1). This area was almost completly taken up by a Nature Reserve managed by the Vanoise National Park.The valley bottom was used for livestock, whereas the higher areas are mainly grazed by ***Rupicapra rupicapra*** L. ("chamois") and *Capra ibex* L. ("bouquetin"). In recent years the main primary consumers were grasshoppers, ever since a plague of *Aeropus sibiricus* L. took place at the valley bottom (Voisin, 1986a).

We chose nineteen plots of 15 x 8 m^2 spread out throughout the valley, taking care that the principal communities with herbaceous vegetation were included, avoiding shrubed and stony areas. In each plot the greatest possible homogeneity were represented both in their releif as well as in their floristic composition and recovering (Fig.1, Table 1).

TABLE 1. Characteristics of the study area: Number of each plot (PLOT), elevation in metres a.s.l. (ELEV), exposure (EXPO), and presence (x) of the main plant species : *Trifolium alpinum* L. (TRal), *Nardus stricta* L. (NAst), *Festuca gr. rubra* L. (FEru), *Geum montanum* L. (GEmo), *Achillea millefolium* L. (ACmi), *Alchemilla sp.* (ALsp), *Plantago alpina* L. (PLal) and *Carex sp.* (CAsp). See also Fig. 1.

PLOT	ELEV	EXPO	TRal	NAst	FEru	GEmo	ACmi	ALsp	PLal	CAsp
1	2325	W		x						
2	2325	W		x						
3	2300	SW						x		
4	2500	SE	x	x			x			
5	2550	SE		x		x				
6	2515	NW			x	x			x	
7	2870	NW			x					
8	2600	N				x			x	x
9	2630	NE				x			x	x
10	2560	NE		x		x		x	x	
11	2300	SW								
12	2750	SE								
13	2570	SW			x	x		x		
14	2410	NE								x
15	2420	N		x	x			x		
16	2430	E	x	x		x			x	x
17	2355	S						x		x
18	2330	S		x			x	x		
19	2320	S		x				x		

METHODS

The plots were explored using two types of sampling methods simultaneously:

1. Relative Method

Lineal indexs of abundance (ILA) were used together with extensive explorations of the plot. ILA were obtained from lineal transects. The basis of assessments is the count of adult grasshoppers flushed per unit length of a traverse. The main factor affecting the accuracy of any traverse assessment is, obviously, the readiness of grasshoppers to respond to the disturbance by jump or flight (Uvarov, 1977), and early investigations (Richards, 1953) have shown that a high variable proportion of the population may remains undiscovered, because flight may be inhibited by low temperature, strong winds, grasshopper immaturity and the density and height of vegetation. So we made all the assessments in similar conditions, avoiding unfavourable weather and selecting plots in short herbaceous vegetation (see also "Study area"). The ILA were obtained by an experienced researcher, who made a lineal displacement on foot, of ten metres length, helped by a string fixed at one extreme, and counted the number of adult grasshoppers he comes across, on a band of about 0.5 m width. This was repeated five or six times for each sampling. The mean values, the standard deviation (*S.D.*), and the standard error (D= $1/\bar{x}\ \sqrt{(S.D.)^2/n}\ t$; $t_{0.05}$= 1.96) were calculated for the total number of grasshoppers.

As well as these transects, an extensive exploration of each plot was carried out for about half an hour in order to identify adults and their sex, and to determine the species. In case the species cannot be recognized on sight, the individuals should be caught as they are found. In this paper this method was not necessarily. Each species' frequency obtained in the extensive exploration was used in calculating partial ILA for each species. In the same way the percentage of adults and the sex ratio was obtained.

This method was described in detail by Voisin (1980 & 1986b).

2. Absolute Method

Biocenometers were used. These consist of bottomless cages, covered with nylon gauze on a framework of metal, with which an area of pasture can be isolated and in whose interior fauna can be captured by two researchers. These apparatus, with a base of one squaremetre, allow us to estimate population and community densities and, therefore, their biomass and other quantitative parameters. Biocenometers theoretically should provide an accurate estimate of grasshopper density in grassland habitats, provided a reasonable number of subsamples is examined. We made all the assessments in similar conditions, avoiding strong winds and rainy days, in the same plots and simultaneously to transects. The traps were hand carried and placed on the ground at random locations and thrown from a distance of about 2 m while moving against sun to avoid casting shadow, in order to prevent flushing of insects.The process was repeated five times per plot per sample. Mean values, standard deviation, and standard error were calculated for each species and for the total number of grasshoppers.

The method was described in detail by Gillon & Gillon (1967). This model, employed in Pyrenean pasturelands (Isern- Vallverdú & Pedrocchi-Renault, 1988), was described by Isern- Vallverdú (1988).

3. Comparison

To enable the transformation of relative values obtained by ILA into absolute values we calculated the correlation coefficient (r) and the regression lines for the obtained data on each plot with both methods. Previously we carried out a variance comparison test (test F) and a mean values comparison test (Student's t).

To see if there was a significant difference between both methods with regard to adult percentage and to the sex ratio sendos tests of chi- squared were carried out on the most abundant species.

RESULTS

1. Relative Method

Table 2 shows the list of found species and the values obtained for each using the relative method: the global ILA obtained directly from the transects, and the calculated ILA for adults and for each species, both extrapolated from the frequencies obtained in the extensive exploration and starting with the global ILA.

Ten species were found all of which had already been mentioned in previous studies in the area (Dreux, 1962; Voisin, 1986c). *Aeropus sibiricus* was the most abundant species (81 %) and most frequent (100 %).

The sampling precision for the community was considered acceptable (D<0.50) on 16 of the 19 plots.

TABLE 2.1 Results obtained in the nineteen plots (PLOT) by means of the relative method (ILA or lineal transects) for the total of individuals: Mean values of the total number of grasshoppers per transect (ILAt), number of transects (nT), standard deviation (*S.D.*), and standard error (D, in italics when D>0.50). Estimate results (from ILA and extensive explorations) for the total of adults (ILAa) and number of species (nS).

PLOT	ILAt	NT	S.D.	D	ILA a	nS
1	17.8	6	4.8	0.22	17.8	2
2	8.6	5	2.9	0.29	8.6	1
3	7.6	5	1.8	0.21	7.6	4
4	56.5	6	7.2	0.10	56.5	1
5	25.5	6	4.6	0.14	24.4	3
6	17.2	6	3.6	0.17	16.3	5
7	3.0	5	1.9	0.55	2.9	5
8	15.2	5	3.3	0.19	14.4	4
9	30.6	5	10.1	0.29	29.8	2
10	39.6	5	6.8	0.15	38.0	4
11	4.4	5	1.3	0.27	4.4	5
12	3.6	5	2.6	0.63	3.1	3
13	39.6	5	5.8	0.13	37.3	4
14	21.8	5	2.7	0.11	21.6	4
15	11.6	5	3.3	0.25	11.2	5
16	23.0	5	1.9	0.07	22.4	4
17	2.2	5	2.2	0.86	2.2	5
18	2.8	5	1.1	0.34	2.7	8
19	5.2	5	1.3	0.22	5.2	4

TABLE 2.2 Estimate data (number of individuals per transect or presence (x)) obtained by means of the relative method (from ILA and extensive explorations) in each plot (PLOT), for each grasshopper species : *Anonconotus alpinus* (Yers.) (ANal), *Metrioptera saussuriana* (Frey-Gess.) (MEsa), *Decticus verrucivorus* (L.) (DEve), *Melanoplus frigidus* (Bohem.) (MEfr), *Podisma pedestris* (L.) (POpe), *Mecostethus grossus* (L.) (MEgr), *Stenobothrus lineatus* (Panzer) (STli), *Omocestus viridulus* (L.) (OMvi), *Chorthippus parallelus* (Zetterstedt) (CHpa), and *Aeropus sibiricus* (L.) (AEsi).

PLOT	ANal	MEsa	DEve	MEfr	POpe	MEgr	STli	OMvi	CHpa	AEsi
1	0.1									17.7
2										8.6
3	0.1	3.6	0.2							3.6
4										56.5
5	0.7				0.6					23.0
6	0.2			2.2	5.4			0.6		7.8
7	x			x	0.1			x		2.4
8	x			3.5				x		10.7
9				3.0						26.7
10	0.3			2.8	3.2					31.7
11	0.1	1.6				1.9			0.6	0.2
12				0.6				x		2.6
13	0.3			0.6				10.3		34.1
14	0.7			0.3		1.4				17.7
15	1.8	0.2			1.3			0.4		7.5
16	0.6				1.9			0.7		19.3
17	x	0.1						x	x	2.0
18	0.1	0.1	0.1		x		x	x	x	2.3
19	x	0.2			x					4.9

2. Absolute Method

Table 3 shows the values obtained from biocenometers: each species' density and total values.

Eight species were collected. Two species found in very low densities with the relative method (*Decticus verrucivorus* (L.) and *Stenobothrus lineatus* (Paenz)) were not collected in the sampling. For the most abundant species, *A. sibiricus*, identical values of abundance and frequency to those using the relative method were obtained.

The sampling precision for the community was acceptable on 12 of the 19 plots.

TABLE 3.1 Results obtained in the nineteen plots (PLOT) by means of the absolute method (biocenometer) for the total of individuals: Mean values of density, in number of grasshoppers per square metre (DENS), number of subsamples (sS), standard deviation (*S.D.*), and standard error (D, in italics when D>0.50). Number of species (nS).

PLOT	DENS	sS	S.D.	D	nS
1	9.0	5	7.1	*0.69*	1
2	6.2	5	1.5	0.21	2
3	4.6	5	2.1	0.39	3
4	24.8	5	15.1	*0.53*	1
5	7.4	5	3.0	0.36	2
6	5.2	5	1.5	0.25	3
7	0.4	5	0.5	*0.87*	2
8	6.6	5	3.4	0.45	3
9	8.2	5	2.7	0.29	2
10	13.2	5	4.1	0.27	3
11	4.4	5	2.9	*0.57*	5
12	0.4	5	0.9	*1.96*	1
13	24.2	5	11.6	0.42	4
14	8.2	5	2.2	0.23	4
15	3.2	5	1.1	0.30	3
16	5.0	5	2.7	0.48	5
17	2.2	5	2.2	*0.86*	2
18	1.8	5	1.3	*0.63*	2
19	4.2	5	1.8	0.37	2

TABLE 3.2 Density data (number of individuals per square metre) obtained by means of the absolute method (biocenometer) in each plot (PLOT), for each grasshopper species : *Anonconotus alpinus* (Yers.) (ANal), *Metrioptera saussuriana* (Frey-Gess.) (MEsa), *Melanoplus frigidus* (Bohem.) (MEfr), *Podisma pedestris* (L.) (POpe), *Mecostethus grossus* (L.) (MEgr), *Omocestus viridulus* (L.) (OMvi), *Chorthippus parallelus* (Zetterstedt) (CHpa), and *Aeropus sibiricus* (L.) (AEsi) : Mean values of density, in number of grasshoppers per square metre (DENS), and standard deviation (*S.D.*).

PLOT		ANal	MEsa	MEfr	POpe	MEgr	OMvi	CHpa	AEsi
1	DENS								9.0
	S.D.								7.1
2	DENS	0.4							5.8
	S.D.	0.9							1.5
3	DENS	0.2	3.6						0.8
	S.D.	0.4	1.3						1.1
4	DENS								24.8
	S.D.								15.0
5	DENS				0.4				7.0
	S.D.				0.9				2.6
6	DENS			1.6	1.2				2.4
	S.D.			1.5	0.4				0.9
7	DENS			0.2					0.2
	S.D.			0.4					0.4
8	DENS			2.2			0.2		4.2
	S.D.			2.0			0.4		1.8
9	DENS			0.4					7.8
	S.D.			0.5					2.8
10	DENS			1.8	0.6				10.8
	S.D.			1.5	0.9				2.9
11	DENS	0.2	2.2			1.2		0.2	0.6
	S.D.	0.4	1.3			1.1		0.4	0.5
12	DENS								0.4
	S.D.								0.9
13	DENS	0.4		0.2			1.6		22.0
	S.D.	0.5		0.4			1.1		10.7
14	DENS	0.2		0.2		2.4			5.2
	S.D.	0.4		0.4		0.9			1.9
15	DENS	0.5					1.3		1.8
	S.D.	0.2					1.9		0.4
16	DENS	0.2		0.6	0.2		0.2		3.8
	S.D.	0.4		0.5	0.4		0.4		2.5
17	DENS		0.6						1.6
	S.D.		0.5						2.3
18	DENS		0.8						1.0
	S.D.		1.1						1.2
19	DENS		0.8						3.4
	S.D.		0.4						1.5

3. Comparison

Figure 2 and Table 4 show the comparison of the results from the two methods.

There was no significant difference between the variances in all the plots (with a significance level higher than 0.01). In the comparison of mean values was not accepted the equalitybetween the ILA values and those with biocenometers in five cases, and could be accepted with a significance level higher than 0.01 in ten cases. With these results it appears to be clearly impossible to use directly the relative method values as densities per surface unit.

To transform the data obtained with ILA into density values per surface unit, the correlation coefficient values and the regression lines between the two methods were calculated (Table 5). Calculations were made for the six most abundant species and for the grasshopper total.

In each case, the correlation coefficient values were accepted at 99 %.

Table 6 shows the percentage data for adults and the percentage data for males among the different populations of *A. sibiricus* according to the extensive exploration data and to the biocenometer data.

The comparison of the two methods -when data were available- shows that there was no significant difference in the adult percentages nor in the sex ratio.

TABLE 4. Variance comparison (test *F*) and mean values comparation (Student's *t*) of grasshopper data obtained by means of relative and absolute sampling methods in nineteen plots (PLOT). Number of degrees of freedom (*n*); signification level (level); not accepted values (N.S.); significance level higher than 0.01 in italics.

PLOT	*F*	n1	n2	level	t	n	level
1	*2.14*	4	5	0.20	*2.21*	9	0.050
2	*3.79*	5	4	0.05	*0.89*	9	0.400
3	*1.29*	4	4	0.20	*2.18*	8	0.050
4	*4.31*	4	5	0.05	4.14	9	0.001
5	*2.26*	5	4	0.20	6.82	9	N.S.
6	*5.92*	5	4	0.05	6.30	9	N.S.
7	*11.56*	4	4	0.01	2.67	8	0.025
8	*1.06*	4	4	0.20	3.66	8	0.005
9	*14.31*	4	4	0.01	4.27	8	0.001
10	*2.72*	4	4	0.05	6.60	8	N.S.
11	*4.62*	4	4	0.05	*0.00*	8	-
12	*8.60*	4	4	0.01	*2.32*	8	0.025
13	*4.06*	4	4	0.05	*2.37*	8	0.025
14	*1.52*	4	4	0.20	7.89	8	N.S.
15	*9.11*	4	4	0.01	4.84	8	0.001
16	*2.15*	4	4	0.20	10.85	8	N.S.
17	*1.00*	4	4	0.20	*0.00*	8	-
18	*1.42*	4	4	0.20	*1.18*	8	0.200
19	*1.90*	4	4	0.20	0.90	8	0.400

TABLE 5. Correlation coefficients (*r*) and regression lines (y=ax+b; where y : relative data (from ILA and extensive explorations); x: absolute data (from biocenometer). For the most abundant grasshopper species : *Anonconotus alpinus* (Yers.) (ANal), *Metrioptera saussuriana* (Frey-Gess.) (MEsa), *Melanoplus frigidus* (Bohem.) (MEfr), *Podisma pedestris* (L.) (POpe), *Omocestus viridulus* (L.) (OMvi), and *Aeropus sibiricus* (L.) (AEsi); for the total of adults (TOTa) and the total data (TOTAL).

	n	r	level	y=ax+b
ANal	19	0.6704	99%	y=0.25x+0.04
MEsa	19	0.9639	99%	y=1.03x+0.10
MEfr	19	0.8539	99%	y=0.49x+0.03
POpe	19	0.8741	99%	y=0.17x-0.01
OMvi	19	0.9769	99%	y=0.12x+0.02
AEsi	19	0.9279	99%	y=0.40x-0.42
TOTa	19	0.9033	99%	y=0.37x+0.32
TOTAL	19	0.9016	99%	y=0.40x+0.20

TABLE 6. Total of individuals (N), percentages of adults (% A) and percentage of males (% M) for each of the nineteen plots (PLOT) for *Aeropus sibiricus* L. by mean of both methods: extensive exploration (RELATIVE METHOD) and biocenometer (ABSOLUTE METHOD). Chi-squared test (METHOD COMPARISON) for adults percentage (2A) and males percentage (2M), with the signification levels (lev.). * Non-data; ** Number of individuals < 5.

PLOT	RELATIVE METHOD			ABSOLUTE METHOD			METHOD COMPARISON			
	N	%A	%M	N	%A	%M	2A	lev.	2M	lev.
1	168	97.6	32.3	45	95.6	23.3	0.55	.025	1.32	.250
2	123	100	22.8	29	96.6	17.9	4.29		0.32	-
3	65	100	32.3	4	100	25.0	**		**	
4	*			124	91.1	28.3	*	.100	*	
5	130	95.4	37.9	35	100	14.3	1.67		6.92	.050
6	39	92.3	44.4	12	83.3	40.0	0.83		0.06	-
7	94	95.7	75.5	1	100	0.0	**	.100	**	
8	91	94.5	51.2	21	85.7	38.9	1.99	.250	0.90	-
9	108	97.2	51.4	39	100	43.6	1.11	.010	0.70	-
10	104	96.1	52.0	54	85.2	50.0	6.10		0.05	-
11	5	100	40.0	3	33.3	100	**		**	
12	121	85.9	69.2	2	100	0.0	**	-	**	
13	126	93.6	53.4	110	90.9	42.0	0.62	-	2.02	.100
14	122	100	32.8	26	100	30.8	0.00	.010	0.04	-
15	89	96.6	46.5	9	77.8	57.1	5.98	.100	0.29	-
16	106	97.2	37.9	19	89.5	35.3	2.48	-	0.04	-
17	96	100	24.0	8	100	25.0	0.00	-	.005	-
18	103	98.1	12.9	5	100	20.0	0.10	.050	0.21	-
19	136	99.3	26.7	17	94.1	25.0	3.40		0.02	-

CONCLUSIONS

1. Relative Method : Linear indexs of abundance (ILA) and extensive explorations.

The advantages of this method were: speedy application by only one researcher; high precision for global community sampling; facility of application on rough or steep terrain.

The main drawbacks were: need for previous knowledge of the fauna and for the determining on sight of the species thus being only possible for experts (otherwise a widespread capture must be used); subjectivity, preventing comparison with data obtainedby other authors; ignorance of the error with which one was working at species, state, and sex level; the necessity of moderate grasshopper densities.

2. Absolute Method : Biocenometers.

The advantages of this method were: direct obtaining of density values per surface unit, and indirect obtaining of biomass and other ecological parameters; the sample could be examined in the laboratory without previous knowledge of the fauna among the collectors; results of other authors could be compared.

The main drawbacks were: slow sample taking and need of two researchers; poor exploration of less abundant species; poor precision of sampling when the densities were low; need of employing under similar weather conditions.

Most authors found biocenometers as good estimators of grasshopper numbers (Onsager, 1977; Evans *et al.*, 1983; Barker, 1985). Unfortunately, accuracy and precision of the sampling methods seem to be inversely related to convenience (Onsager, 1977).

3. Method Comparison

There was no significant difference between the results obtained by means of extensive explorations (relative method) and by those of biocenometers (absolute method) as far as adult ratios and sex ratios were concerned. So, any method could be used in the community to find out these features. There was no difference in frequency and abundance of the main species in the area, *Aeropus sibiricus*. So, both methods could be indistinctly used to determinate the predominant species of the community.

The correlation between the two methods were highly significant for both the total numbers and the six most abundant species. This permited the transformation of the relative data of ILA into density values per surface unit by applying the calculated regression lines. Other authors found moderate correlations in comparing transects and quantitative methods (Barker, 1985).

The complementary use of absolute and relative methods allowed us to resolve the disadvantatges of both; for example, the slowness and poor exploration of rare species in biocenometers and the subjectivity and necessity of previous knowledge of the fauna in the ILA.

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