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Variation in species richness of plants and diverse groups of invertebrates in three calcareous grasslands of the Swiss Jura mountains

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Variation in species richness of plants and diverse groups of invertebrates in three calcareous grasslands of the Swiss Jura mountains. - Species richness and abundance of vascular plants and several groups of invertebrates (spiders, oribatid mites, diplopods, grasshoppers and bush crickets, ground beetles, butterflies and terrestrial gastropods) were recorded in three calcareous grasslands (Nenzlingen, Movelier and Vicques) in the northwestern Swiss Jura mountains. Species richness varied both between taxonomical groups and between sites (species richness ranges: 96-116 vascular plants, 60-66 spiders, 18 oribatid mites at each site, 1-7 diplopods, 10-16 grasshoppers and bush crickets, 19-21 ground beetles, 32-46 butterflies and 15-21 terrestrial gastropods). Species overlap (number of species that occurred at all sites) was relatively large in terrestrial gastropods (59.1%), butterflies (56.5%), vascular plants (53.8%) and grasshoppers (47.1%), but relatively low in oribatid mites (32.3%), spiders

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(25.0%), ground beetles (18.4%) and diplopods (12.5%). Diversity expressed by the Shannon-Wiener index (H') was compared for five groups of invertebrates. Diversity was largest in spiders and ground beetles and lowest in terrestrial gastropods. Different taxonomical groups had their maximum diversity at different sites: each grassland had the highest diversity in at least one group. The three sites also varied in the abundance of different invertebrate groups. Most groups had the highest densities in Nenzlingen and the lowest densities in Vicques. All three sites contained a high proportion of species listed in the Red Data Book of Switzerland with values averaging 49.5% in grasshoppers and bush crickets, 28.9% in butterflies, 18.9% in vascular plants, 11.2% in terrestrial gastropods, and 6.7% in ground beetles. One spider species (*Oxyptila pullata*) and two mite species (*Epilohmannia cylindrica minima* and *Pergalumna myrmophila*) were recorded for the first time in Switzerland.

Key-words: Acari - Araneae - Biodiversity - Calcareous grassland - Coleoptera - Diplopoda - Gastropoda - Lepidoptera - Orthoptera - Vascular plants.

INTRODUCTION

Many human activities, such as intensive agriculture, urbanisation, deforestation, and the building of roads and railways reduce natural habitats to remnants of different sizes. In addition to the overall decrease in the area available for the organisms, the fragmentation of habitats leads to a division of existing populations into isolated subpopulations of small size and to changes in habitat characteristics in the fragments (SOULÉ 1986, SAUNDERS *et al.* 1991). It is generally assumed that habitat fragmentation contributes significantly to the local extinction of animal and plant species (SAUNDERS *et al.* 1991).

In the northwestern Jura mountains, unfertilized calcareous grasslands were large and continuous at the beginning of this century, but since the 1950's changes in agricultural practices such as the use of modern machinery, chemical fertilizers, herbicides and pesticides, and new breeds of plants have reduced the size of these areas and split them into small and isolated fragments. For example, between 1950 and 1985 the total area of unfertilized calcareous grassland was reduced by 78% in the Passwang region in northwestern Switzerland (ZOLLER *et al.* 1986). This overall reduction of the unfertilized grassland area and the isolation of the remnants may have led to a dramatic loss of species within a short period.

In 1993, a multidisciplinary coordinated project was started to experimentally analyse fundamental aspects of biodiversity using dry grasslands on calcareous soils in the northwestern Swiss Jura mountains as an exemplary model (LESER 1994, BAUR & ERHARDT 1995). Most of the field work is done at three sites (Nenzlingen, Movelier and Vicques). The present paper examines species richness and abundance of vascular plants and various groups of invertebrates (spiders, oribatid mites, diplopods, grasshoppers and bush crickets, ground beetles, butterflies and terrestrial gastropods) in

these grasslands. In particular, we address the following questions: (1) Do the three grasslands differ in plant and invertebrate species richness? (2) Are there any associations between the species richnesses of different taxonomical groups? (3) Do different taxonomical groups differ in species overlap at the three sites? (4) Do the three sites differ in the overall density of particular taxonomical groups? and (5) Do the three sites differ in number and proportion of rare and/or threatened species?

STUDY SITES AND GENERAL METHODS

The three field sites are nutrient-poor, dry calcareous grasslands (belonging to the Teucrio-Mesobrometum type; ELLENBERG 1988) situated near Nenzlingen (10 km S of Basel), Movelier (5 km N of Delémont) and Vicques (5 km E of Delémont). The three sites are situated within 20 km of each other.

There are local differences between the three sites. The study site in Nenzlingen (1.5 ha in size) is situated on a SW-facing slope with an inclination of 19-22° at an altitude of 500 m a.s.l. A deciduous forest borders the investigation area to the NE. Annual precipitation averages 991 mm in Grellingen (3 km E of the study site). Soil properties and soil profiles of the investigation area are presented in OGERMANN *et al.* (1994). Until 1993, the site was grazed by cattle from May to September with a high stocking rate. The lower part of the slope was moderately fertilized by cattle dung.

The investigation area in Movelier (1.3 ha) is situated on a SSE-facing slope (inclination 20-22°) at an altitude of 780 m. Half of the site is surrounded by deciduous forest. The humus layer is relatively thick, contains some clay and is moister than in Nenzlingen and Vicques. Until 1993, the site was grazed by cattle and a moderate amount of artificial fertilizer was used.

The investigation area in Vicques (2.0 ha) is situated on a SE-facing slope (inclination 15-27°) at an altitude of 570 m. The humus layer is thin and there are several patches of exposed bedrock (this type of habitat is lacking at the other sites). There is mixed forest at the SW-border of the area. Until 1993, the site was exposed to a low grazing pressure by cattle.

In spring 1993, we initiated a field experiment to investigate possible effects of habitat fragmentation on animal and plant populations at these sites. We experimentally fragmented selected areas of grassland into plots of different sizes to examine whether species diversities of plants and various groups of invertebrates change after fragmentation. The fragmentation was created by mowing the vegetation around the experimental plots (see BAUR & ERHARDT (1995) for a figure of the experimental set-up). An experimental unit (= block) contains one large (4.5 x 4.5 m), one medium (1.5 x 1.5 m) and two small fragments (0.5 x 0.5 m), all of them separated by a 5-m wide strip of mown vegetation, as well as the corresponding control plots. The experiment consists of 12 blocks distributed over the three sites (five blocks in Nenzlingen, three blocks in Movelier and four blocks in Vicques). The fragmentation is maintained by regularly mowing the isolation area. This type of fragmentation is

reversible, but reduces dispersal of pollen and seeds in many plant species as well as dispersal of several invertebrate species.

In this paper, we present data on species richness and abundance of vascular plants and various groups of invertebrates at the beginning of the long-term experiment. We have tried to minimize any additional disturbances of the fragmented ecosystem by using non-destructive methods whenever possible. Data were collected either within the experimental blocks (plants, grasshoppers and terrestrial gastropods), at the border of each experimental block (oribatid mites), and/or in the areas adjacent to or surrounding the experimental blocks (spiders, diplopods, grasshoppers, ground beetles, butterflies and terrestrial gastropods). Species determination of grasshoppers, butterflies and gastropods occurred *in situ*. Pitfall trapping was used for other taxonomical groups in which species identification is difficult in the field (spiders, diplopods, ground beetles). Details on the collecting methods are given in the corresponding sections dealing with the different groups of organisms.

DATA ANALYSIS

Diversity has two components, the species richness measured by the total number of species in an area, and the equitability of species abundances. The number of species was used as a measure of the relative richness of the grasslands, but it cannot be thought of as the absolute richness of a site, since numerous rare species may not have been recorded in this study. The diversities of different taxonomic groups were compared using the Shannon-Wiener index (H', base *e*) and the equitability or eveness (E) of distribution of individuals among the species (Lloyd & Ghelardi 1964, Krebs 1988).

Species-abundance distributions were plotted to compare the proportion of rare species (species with one individual) among the different taxonomical groups. The similarity of the different species assemblages were compared using the coefficient of Sørensen (based on presence/absence data) and the Renkonen index (based on abundance data; Krebs 1988, Mühlenberg 1989).

VASCULAR PLANTS

Jasmin Joshi and Bernhard Schmid

Methods

Plant species richness was recorded in all fragments and control plots during the growing seasons of 1993 and 1994. Data on the presence/absence of plant species were obtained in Nenzlingen in May, June and August 1993 and in May and August 1994, in Movelier in June and August 1993 and at the beginning of June and in August 1994, and in Vicques at the beginning of July and in August 1993 and in May and August 1994. In August 1994, the recording in Nenzlingen took place after mowing of the experimental plots. Therefore, the presence of some grass species may have been overlooked.

Nomenclature of the vascular plants follows BINZ & HEITZ (1990). Endangered and threatened species are listed in LANDOLT (1991).

RESULTS AND DISCUSSION

A total of 143 plant species were found in the three investigated calcareous grasslands (Appendix 1). The highest plant species richness was found in Movelier (116 species), where only 24 plots were investigated. In Nenzlingen we recorded 111 plant species (in 40 plots) and in Vicques 96 species (in 32 plots). Seventy-seven of the 143 species (53.8%) were recorded at all three sites (Table 1). Movelier also had the highest proportion of plant species of the total species pool found exclusively at one site (15.4%) compared with Nenzlingen (7.7%) and Vicques (4.9%) (Table 2).

TABLE 1

Species richness and species overlap of diverse taxonomical groups at the three investigation sites Nenzlingen, Movelier and Vicques.

Taxonomical group	Number of species recorded in Nenzlingen	Movelier	Vicques	Total number of species recorded (species pool)	Number (%) of species that occurred at all sites
Vascular plants	111	116	96	143	77 (53.8)
Spiders	60	63	66	108	27 (25.0)
Oribatid mites	18	18	18	31	10 (32.3)
Millipedes	1	4	7	8	1 (12.5)
Grasshoppers	13	16	10	17	8 (47.1)
Ground beetles	19	19	21	38	7 (18.4)
Butterflies	32	46	40	46	26 (56.5)
Terrestrial gastropods	21	16	15	22	13 (59.1)

TABLE 2

Number of species and percentage of the total species pool (in parentheses) that occurred exclusively at one site.

Taxonomical group	Nenzlingen	Movelier	Vicques
Plants	11 (7.7)	22 (15.4)	7 (4.9)
Spiders	14 (13.0)	19 (17.6)	21 (19.4)
Oribatid mites	4 (12.9)	7 (22.6)	5 (16.1)
Millipedes	0	1 (12.5)	4 (50.0)
Grasshoppers	0	3 (17.6)	0
Ground beetles	10 (26.3)	6 (15.8)	9 (23.7)
Butterflies	0	7 (15.2)	0
Terrestrial gastropods	4 (18.2)	1 (4.5)	0

All three sites were dominated by *Bromus erectus*, a typical grass species of extensively managed calcareous grasslands. *Sanguisorba minor*, *Ranunculus bulbosus* and *Hieracium pilosella* also occurred frequently at each site. Two of the species

which were found at all three sites (*Trifolium ochroleucon* and *Veronica prostrata*) are listed as vulnerable in the Red Data Book of Switzerland (Landolt 1991). Furthermore, *Gentiana cruciata*, found exclusively in Vicques, is also considered as vulnerable in Switzerland. Altogether, seven of the 143 species (4.9%) recorded belong to the endangered species, 19 (13.3%) to the vulnerable species and one (0.7%) to the rare plant species in the northern Jura mountains (Landolt 1991).

SPIDERS (Arachnida, Araneae)

Ambros Hänggi

Methods

Pitfall traps were used to collect ground-living arthropods (Araneae, Diplopoda and Coleoptera). The traps were white plastic jars, 7 cm deep x 7 cm in diameter, containing about 50 ml formalin (4%) with detergent. The traps were protected against rain by grey plastic roofs (measuring 18 x 18 cm) that were fixed horizontally about 10 cm above ground. Specimens were removed and formalin replaced at intervals of two weeks from 5 May to 12 November 1994. At each site, nine traps were placed in groups of three (within-group distance 1 m) in three different grassland subtypes.

At each site, the grassland subtypes considered were 50 - 100 m apart; they may reflect the heterogeneity of the three grasslands. In Nenzlingen the grassland subtypes were (1) a moderately fertilized patch of the pasture, (2) an unfertilized area (typical Mesobrometum), and (3) a patch dominated by bracken (*Pteridium aquilinum*); in Movelier (1) a moderately fertilized patch of the pasture, (2) an unfertilized area (typical Mesobrometum), and (3) a part of the slope structured by cow paths; in Vicques (1) an unfertilized area of the pasture with exposed bedrock (karst rocks), (2) an unfertilized area (typical Mesobrometum), and (3) a patch of the pasture (5 x 10 m) partly covered with bramble (*Rubus* spp.).

Spiders were determined by Theo Blick, Hummeltal (Germany). Nomenclature follows Maurer & Hänggi (1990). All spiders collected are deposited in the Naturhistorisches Museum Basel.

Results and Discussion

A total of 2701 adult spiders belonging to 108 species were collected at the three study sites (Appendix 2). The sites were similar in species richness (60 species in Nenzlingen, 63 in Movelier and 66 in Vicques), but differed in species composition (Table 1, Appendix 2). Only 27 of the 108 species (25.0%) were found at all three sites (Table 1). Twenty-one (19.4%) of the total 108 species were exclusively found in Vicques, indicating an extraordinary spider community in this grassland (Table 2). The highest similarity was found between the spider communities in Nenzlingen and Movelier, whereas the spider community in Vicques was quite different from those of the other sites (Table 3). Diversity expressed by the Shannon-Wiener index (H') was

TABLE 3

Comparison of similarity in different groups of organisms at the three field sites. Ne = Nenzlingen, Mo = Movelier, and Vi = Vicques.

		Sørensen similarity index			Renkonen similarity index		
		Ne-Mo	Ne-Vi	Mo-Vi	Ne-Mo	Ne-Vi	Mo-Vi
Vascular plants	1993	0.79	0.82	0.74	–	–	–
	1994	0.79	0.82	0.76	–	–	–
Spiders		0.59	0.59	0.54	0.57	0.35	0.41
Oribatid mites		0.56	0.67	0.50	0.61	0.40	0.64
Millipedes		0.40	0.25	0.55	0.91	0.73	0.76
Grasshoppers	1993	0.82	0.78	0.80	0.61	0.63	0.73
	1994	0.91	0.74	0.76	0.60	0.53	0.60
Ground beetles		0.47	0.40	0.55	0.31	0.21	0.24
Butterflies	1993	0.78	0.90	0.88	–	–	–
	1994	0.79	0.87	0.92	–	–	–
Gastropods		0.81	0.83	0.84	0.84	0.83	0.80

highest in Vicques, whereas Movelier and Nenzlingen showed slightly lower H'-values (Table 4).

Relating the number of individuals caught (Appendix 2) to the number of trapping days (1719 trapping days per site), the activity density of spiders was lower at the three sites (Table 5) than has been reported from similar habitats (Inntal: THALER 1985; Tessin: HÄNGGI 1992). The reason for this discrepancy might be that the collection period lasted only six months in the present study (animals were caught during the period of vegetation growth).

Several spider species collected are interesting from a faunistic point of view. *Oxyptila pullata* was found for the first time in Switzerland (two males were collected in Vicques; one between 5 and 18 May 1994, the other between 14 September and 1 October 1994). This species is known to occur in extremely dry grasslands and

TABLE 4

Shannon-Wiener diversity index (H') and eveness (E; in parentheses) in various invertebrate groups at the three investigation sites. Where the sampling effort was unequal (oribatid mites, grasshoppers and gastropods), the values have been calculated for equal subsamples of three blocks (see Methods).

Taxonomical group	Nenzlingen	Movelier	Vicques
Spiders	2.96 (0.72)	3.02 (0.73)	3.18 (0.76)
Oribatid mites	2.06 (0.72)	1.58 (0.55)	1.81 (0.64)
Grasshoppers (1993)	1.72 (0.81)	1.80 (0.75)	1.73 (0.86)
(1994)	1.41 (0.70)	1.77 (0.78)	1.76 (0.85)
Ground beetles	2.50 (0.85)	2.43 (0.83)	2.55 (0.84)
Terrestrial gastropods	1.25 (0.51)	1.26 (0.62)	1.46 (0.70)

TABLE 5

Relative densities of various invertebrate groups at the three investigation sites.

Taxonomical group		Nenzlingen	Movelier	Vicques
Spiders (individuals/trapping day)		0.61	0.49	0.48
Oribatid mites (individuals/m^2)		18'700	19'200	5'600
Grasshoppers (individuals/block)	(1993)	43.8	66.2	45.2
	(1994)	47.9	59.1	42.8
Ground beetles (individuals/trapping day)		0.09	0.04	0.08
Terrestrial gastropods (individuals/trap)		0.83	0.18	0.13

habitats with rocks, stones or sand in southern and eastern Europe (BAUCHHENSS 1990). *Talavera* (=*Euophrys*) *inopinata* was collected for the second time in Switzerland (two males in Vicques between 15 and 29 June 1994 and one female in Movelier between 17 and 24 July 1994). This species was described by Wunderlich (1993) based on specimens collected in similar habitats in the region of the present study (Jura mountains between Delémont and Porrentruy; see HÄNGGI 1993).

A further taxon, *Pardosa* sp. (not listed in MAURER & HÄNGGI 1990), has not yet been described, but may belong to the species group of *Pardosa lugubris* s.l. (TÖPFER-HOFMANN & VON HELVERSEN (1990) named this taxon *Pardosa saltans* (nomen nudum!)). Most probably this undescribed taxon occurs more frequently in Switzerland than *P. lugubris* s.str., as indicated by museum specimens (most of them wrongly determined as *P. lugubris*). *Pardosa* sp. was found in small numbers at all three sites.

Six further species can be regarded as rare (recorded fewer than five times in Switzerland; cf. MAURER & HÄNGGI 1990): *Bathyphantes parvulus*, *Centromerita concinna*, *Tegenaria picta*, *Eperigone trilobata*, *Mioxena blanda* and *Dipoena prona*. A single specimen of each of the first three species was collected in this study. Information on the ecology of these species is summarized in HÄNGGI *et al.* (1995). *Eperigone trilobata* is widespread in northern America and was most probably introduced to Europe some 20 years ago (DUMPERT & PLATEN 1985). *Eperigone trilobata* can now frequently be found in dry, unfertilized grasslands in central Europe (HÄNGGI 1990, RENNER 1992). *Dipoena prona* (three males collected in Vicques between 24 July and 5 August 1994) is a widespread species, but is rarely found in Europe (MILLER 1967). *Mioxena blanda* (one male caught in Nenzlingen between 13 and 27 October 1994) is widely distributed but rare in northern and western Europe (ROBERTS 1985).

No Red Data List has been compiled for spiders in Switzerland. However, 27 of the 108 (25.0%) species found in the present study have narrow niches (stenoecious; MAURER & HÄNGGI 1990). Most of these spiders seem to be thermophilous,

preferring dry, open habitats. These types of habitat have dramatically declined in Switzerland. Consequently, these 27 species can be regarded as potentially endangered mainly due to habitat destruction. Vicques harbours a particularly threatened spider fauna since 11 of the 21 species recorded exclusively at this site belong to the group of potentially endangered species.

ORIBATID MITES (Acari, Oribatei)

Daniel BORCARD & Josef STARÝ

METHODS

Cylindrical soil samples, 5 cm in diameter and 8 cm in depth, were taken at the margins of the control areas of each experimental block, using the soil augers described by BIERI *et al.* (1978). The samples were divided into two parts (0-4 cm and 4-8 cm). The soil fauna was extracted by means of a MacFadyen-derived extractor (BORCARD 1986). Each site was sampled three times, on 10 March, 19 July and 14 November 1994. Four samples were taken in each block on each occasion. In all, 144 samples were taken.

RESULTS AND DISCUSSION

A total of 4079 adult oribatid mites belonging to 31 different species were captured at the three sites (Appendix 3). At each site, 18 mite species were found. However, species number is often influenced by sampling effort. To account for the lower number of blocks sampled in Movelier (n = 3), we computed the expected number of species at the two other sites, assuming that only three blocks had been sampled. The average of the total number of species of each possible combination of three blocks was 17.5 in Nenzlingen and 17.0 in Vicques.

Eight of the 31 mite species (25.8%) were found at all three sites (Table 1, Appendix 3). In contrast, four species (12.9%) were exclusively found in Nenzlingen, seven species (22.6%) exclusively in Movelier and five species (16.1%) exclusively in Vicques (Table 2).

The differences in species composition between seasons were small, accounting for 2.7% of the total variation as indicated by a canonical correspondence analysis (CCA; TER BRAAK 1986). Consequently, data from the three sampling occasions were pooled for each site for further analysis. Moreover, unless noted otherwise, all mites collected (depth 0-8 cm) were considered, although the majority of the mites were found in the upper soil layer (between 0 and 4 cm depth; Nenzlingen 84.2%, Movelier 71.8% and Vicques 65.6%).

The among-site differences in species composition were significant as indicated by a CCA including all 144 samples (Monte Carlo test, 999 permutations, $p = 0.001$). These differences accounted for 11.4% of the total variation. In this analysis, Vicques represented the most heterogeneous sampling site. Overall the species richness was low when compared with other biotopes (such as forests), but normal for

open grassland (BACHELIER 1978). In comparison with the two other sites, Vicques again represented an extraordinary site: the local richness (as measured by the average number of species per sample) was very low (about half that of Nenzlingen), but this was compensated by the overall heterogeneity of the site.

With estimated values of slightly below 20'000 individuals/m^2, the overall densities of the mite communities in Nenzlingen (18'700 individuals/m^2) and Movelier (19'200 individuals/m^2) corresponded well to those described in the literature for similar habitats (for a review see Bachelier 1978). In contrast, Vicques had an extremely low mite density (5'600 individuals/m^2). This can be partly explained by the dryness as well as by the scarce vegetation and extremely shallow soil at this site.

Two species, *Epilohmannia cylindrica minima* (in Movelier) and *Pergalumna myrmophila* (in Vicques), were recorded for the first time in Switzerland. So far, these species have been considered as specialists that occur in the Mediterranean subregion and Pannonian district. With the exception of *Minunthozetes semirufus*, all species captured at only one of the three sites had low densities. The most important components of the investigated oribatid mite communities include semicosmopolitan species (nine species, i.e. 29% of the total species number) and holarctic species (10 species; 32%). Most of these species are eurytopic with a large ecological amplitude (e.g. *Oppiella nova*, *Scheloribates laevigatus*, *Xylobates capucinus* and *Tectocepheus sarekensis*), and are usually dominant in early stages of secondary succession or indicate non-stabilized biotopes affected by human activity. Ten species (32%) are found only in Europe.

MILLIPEDES (Diplopoda, Myriapoda)

Ariane PEDROLI-CHRISTEN

METHODS

Pitfall traps were used to collect millipedes as described in the spider section (see above). Nomenclature follows PEDROLI-CHRISTEN (1993).

RESULTS AND DISCUSSION

A total of 154 adult diplopods belonging to eight species were collected (Appendix 4). Seven species were found in Vicques, four in Movelier and one in Nenzlingen. *Cylindroiulus caeruleocinctus* dominated the diplopod communities at all three sites (100% in Nenzlingen, 91% in Movelier and 73% in Vicques). This species is characteristic for open and exposed habitats such as calcareous grasslands. It can occasionally occur along forest edges, but never in the forest. The remaining species (*Glomeris* spp. and *Tachypodoiulus niger*) are associated with woody habitats, but can also occur in stands of bramble (in Vicques). None of the diplopod species recorded in the present study is rare.

GRASSHOPPERS, BUSH CRICKETS AND TRUE CRICKETS
(Orthoptera: Saltatoria)

G. Heinrich THOMMEN

METHODS

The relative abundances of the different Saltatorian species were recorded in the experimental blocks (isolated fragments and the corresponding control plots) using a direct census method. The entire vegetation of the experimental plots was carefully searched for Saltatoria. Plants were slightly moved with a bamboo rod for an easier detection of the insects. In addition, in each block an area of 4.5 x 4.5 m of mown vegetation (isolation area of the experiment) was searched for Saltatoria. The number of individuals observed was recorded for each species (no animals were caught). Monitoring was repeated three times at all sites between July and early September both in 1993 and 1994.

A transect count technique was used to record the composition and relative abundance of Saltatorian species in the grassland surrounding the experimental blocks. These areas (1-2 ha in size) were slowly walked through in a zigzag line. All adult individuals seen within a strip of 1-1.2 m width were counted. The adjacent areas were surveyed once at each of the three sites during summer 1994.

Only Saltatoria species that typically inhabit unwooded open land were censused. True arboreal species and inhabitants of the forest edge were not included in this study. Nomenclature follows BELLMANN (1993).

RESULTS AND DISCUSSION

Thirteen species of Saltatoria were recorded in Nenzlingen (11 of them in the experimental blocks), 16 species in Movelier (14 in the experimental blocks), and 10 species in Vicques (9 in the experimental blocks; Appendix 5). A total of 17 species were recorded from all three sites combined, which represents approximately half of the Saltatorian species known in dry grasslands of the Swiss Jura mountains. Eight of the 17 (47.1%) species occurred at all three sites (Table 1).

The higher species richness in the areas adjacent to the experimental blocks could be explained by the larger size and higher degree of heterogeneity of these areas. The surrounding areas are more variable in cover and height of vegetation, in soil moisture content, inclination of slope and in the structure of the surface (e.g. single rocks or exposed limestone bedrock) than the experimental blocks. Patches with relatively high soil moisture may explain the presence of *Metrioptera roeselii* in Nenzlingen as well as *Metrioptera brachyptera* and *Chrysochraon dispar* in Movelier; all three species are mesohygrophilic, preferring moist or tall grass habitats. These three species are lacking in Vicques, the driest of the three sites.

Chorthippus parallelus, usually associated with fertilized meadows, was one of the most frequent species (19-32% of all adult individuals) at all three investigation sites. *Stenobothrus lineatus*, a mesoxerophilic grasshopper species, was frequent (23-31%) in the experimental blocks at all three sites, but less frequent (10-17%) in the

surrounding areas. *Chorthippus biguttulus*, another mesoxerophilic species, was frequent in Nenzlingen (24%) and in Vicques (21%), whereas *Gomphocerus rufus*, which prefers the higher herbaceous stratum (e.g. *Rubus* spp.) in close vicinity to scrub and woodland, was common in Movelier (22%).

Only juvenile stages of *Gryllus campestris* were observed in the period from July to early September. In the present survey, the low representation of this ground-dwelling cricket may be due to the difficulty of observing it under a dense vegetation layer. Similarly, the abundance of *Tetrix tenuicornis* might have been underestimated due to its inconspicuous colour and small size.

Eight of the 17 species (47.1%) recorded in this study are listed in the Red Data Book of Northern Switzerland (Appendix 5; NADIG & THORENS 1994). Movelier harboured the largest number of Red Data Book species (8 species), followed by Vicques (6 species) and Nenzlingen (5 species; Table 6).

TABLE 6

Number and percentage (in parentheses) of species that are listed in the Red Data Book of Switzerland (cf. LANDOLT 1991, DUELLI *et al.* 1994).

Taxonomical group	Nenzlingen	Movelier	Vicques
Plants	11 (9.9)	23 (19.8)	14 (14.9)
Grasshoppers	5 (38.5)	8 (50.0)	6 (60.0)
Ground beetles	1 (5.3)	1 (5.3)	2 (9.5)
Butterflies	7 (21.9)	16 (34.8)	12 (30.0)
Terrestrial gastropods	3 (14.3)	2 (12.5)	1 (6.7)

GROUND BEETLES (Coleoptera, Carabidae)

Ambros HÄNGGI & Henryk LUKA

METHODS

Pitfall traps were used to collect ground beetles as described for spiders (see above). Ground beetles were determined by Henryk Luka. Nomenclature follows FREUDE *et al.* (1976) and LOHSE & LUCHT (1989). A reference collection is deposited at the Naturhistorisches Museum Basel.

RESULTS AND DISCUSSION

A total of 366 ground beetles belonging to 38 species were collected (Appendix 6). Compared with studies on intensively managed grasslands (e.g. TIETZE 1985), the number of individuals caught was low, whereas the number of species was high. This confirms the findings of STRÜVE-KUSENBERG (1980), TIETZE (1985) and ZELTNER (1989) that in ground beetle communities the ratio of species number to the number of individuals is high in extensively used grasslands and low in intensively used grasslands.

The three sites had similar numbers of species (19 species in Nenzlingen, 19 in Movelier and 21 in Vicques). However, the three sites differed considerably in species composition. Seven of the 38 carabid species (18.4%) were found at all three sites (Table 1). On the other hand, a high proportion of species occurred exclusively at one site: 47.4% in Nenzlingen, 31.6% in Movelier, and 42.9% in Vicques (Table 2). This resulted in a low similarity of the species assemblages between the sites (Table 3). Diversity expressed by the Shannon-Wiener index H' was higest in Vicques, followed by Nenzlingen and Movelier (Table 4).

Four of the 38 (10.5%) carabid species found are listed in the Red Data Book of Switzerland (MARGGI 1994). *Anisodactylus nemorivagus* was exclusively found in Nenzlingen. Little is known concerning the life history of this species (LINDROTH 1945, MARGGI 1992). We collected individuals of *A. nemorivagus* in the moderately fertilized patch and the typical Mesobrometum part of the grassland in Nenzlingen. Only one individual of *Carabus convexus* was found in the typical Mesobrometum part of Movelier. This species does not tolerate intensively cultivated grasslands and is considered as threatened (MARGGI 1992). In general, *C. convexus* is not rare in the Swiss Jura mountains (MARGGI 1992). Two further species listed in the Red Data Book were found exclusively in Vicques. All 10 individuals of *Carabus auratus* were caught in the patch partly covered with bramble. *Carabus auratus* is also restricted to extensively cultivated open areas. The four individuals of *Panagaeus bipustulatus* were caught in the patch partly covered with bramble and in the area with exposed bedrock in Vicques. This species seems to be strongly xerophilous (MARGGI 1992).

A high number of polyphagous-phytophagous species (belonging to the genera *Amara*, *Anisodactylus*, *Harpalus* and *Parophonus*), which also climb onto the vegetation, was collected in Nenzlingen (cf. WACHMANN *et al.* 1995). In Movelier, there was a surprisingly high proportion of large species of *Carabus* (32% of all species, 37% of all individuals). Among them was *Carabus monilis*, which does not tolerate intensive management of grasslands (MARGGI 1992, PFIFFNER & LUKA 1994). Indeed, we collected no specimens of this species in the fertilized patch of the grassland. The carabid community of Vicques was characterized by thermophilous species such as *Panagaeus bipustulatus* and *Callistus lunatus*. The latter is known to prefer temperatures reaching 40-50 °C (BECKER 1975, THIELE 1977).

BUTTERFLIES (Lepidoptera)

Hans-Peter RUSTERHOLZ & Andreas ERHARDT

METHODS

Estimates of species richness were obtained from observations on the activity of foraging butterflies. Three 10 x 10 m plots were established in undisturbed grassland vegetation adjacent to the blocks of the fragmentation experiment at each site. Butterfly activity was recorded for periods of 45 min. between 10.00 a.m. and 4.30 p.m. during sunny weather conditions. The number of individuals of each species was

counted in the plots. Observations were made on eight days between the end of May and the end of August in 1993, and on 9 days between the beginning of June and the end of August in 1994. Each plot was observed for a total of 6.5 hours in 1993 and 7.25 hours in 1994. True arboreal butterfly species were excluded from this study. Nomenclature follows the "LEPIDOPTEROLOGEN-ARBEITSGRUPPE" (1987) and KOCH (1991).

RESULTS AND DISCUSSION

A total of 46 butterfly species were recorded at the three study sites which represent 65% of the butterfly species occurring in the Swiss Jura mountains (Appendix 7; GONSETH 1987, "LEPIDOPTEROLOGEN-ARBEITSGRUPPE" 1987, GONSETH & GEIGER 1984, 1985). Twenty-eight and 30 butterfly species were observed in Nenzlingen in 1993 and 1994, respectively. The corresponding figures for Movelier were 45 and 46 species and those for Vicques 35 and 39 species.

A comparison of the three sites shows that 30 species (65.2%) occurred at all sites (Table 1), whereas seven species were exclusively found in Movelier (Table 2). All species observed in Nenzlingen were also found at the other sites. Nine of the 46 butterfly species (19.6%) are endangered or vulnerable (Appendix 7) and are therefore of special interest for conservation issues (GONSETH 1994).

Species richness was lowest in Nenzlingen and highest in Movelier. The pronounced differences in species richness at the three sites could be due to differences in spatial heterogeneity, in plant composition and vegetation structure, and/or intensity of grassland management (ERHARDT 1985). The latter suggestion is supported when only butterfly species closely associated with typical calcareous grassland are considered (Appendix 7). The high intensity of grassland management in Nenzlingen might be responsible for the reduction of approximately 50% of the Lycaenidae species compared to the other sites, and for the similar reduction in the number of threatened species (Appendix 7). These butterfly species are particularly sensitive to alterations of habitat quality such as a reduced variability of habitat structure and intensification of grassland management (ERHARDT 1985). It follows that these butterfly species can be considered as excellent indicators of habitat type and quality.

TERRESTRIAL GASTROPODS (Mollusca, Gastropoda)

Peter OGGIER, Stephan LEDERGERBER & Bruno BAUR

METHODS

BOAG (1982) demonstrated that wet sheets of cardboard or masonite placed in grassland vegetation create a moister microclimate, and thus attract gastropods onto the underside of the sheets. We used this type of non-destructive traps to record the relative abundance of gastropod species in the experimental blocks. Using a 1 m^2-grid, we placed one sheet of cardboard (10 x 10 cm) per m^2 over the entire area of

each block (32 x 32 m; see BAUR & ERHARDT 1995). In the isolated fragments and the corresponding control plots we increased the trap density to four sheets of cardboard per m^2. Thus, the sampling effort was 1208 cardboard traps per block.

The efficiency of this trapping method is largely influenced by weather conditions. We placed the cardboards into the vegetation in the evening (between 6 and 8 p.m.) of a rainy day and inspected them for adhering gastropods on the following morning (between 7 and 10 a.m.). We identified the gastropods in the field, recorded the number of individuals per species and released the animals at the same spot where they were trapped. In this way, each of the 12 blocks was examined once for gastropods between 14 September and 26 October 1994.

True forest species and inhabitants of forest edge that may occasionally enter grassland (e.g., *Cochlodina laminata* and *Perforatella incarnata* in Nenzlingen, *Helicodonta obvoluta*, *Aegopinella pura* and *Nesovitrea hammonis* in Movelier, and *Cochlostoma septemspirale* in Vicques) were not included in this study. Juvenile slugs of the family Limacidae were counted but could not be determined to the species level in the field. In the species lists we also included records of gastropods that were observed in the course of other studies (e.g. species associated with rocks that were not caught by the traps used). Nomenclature follows KERNEY *et al.* (1983).

RESULTS AND DISCUSSION

Considering all three sites, a total of 22 gastropod species were recorded (Table 1). The three grasslands differed in gastropod species richness: 21 species were found in Nenzlingen, 16 in Movelier and 15 in Vicques (Appendix 8). Thirteen of the 22 (59.1%) gastropod species were recorded at all three sites (Table 1).

The investigation area in Nenzlingen had the highest species richness. This finding can be partly explained by the larger sampling effort made at this site (five blocks compared with three blocks in Movelier and four blocks in Vicques). Considering only gastropods recorded with the trapping method, we calculated the expected number of species assuming that only three blocks were sampled at each site. The average of the total species number of each possible combination of three blocks was 13.4 (15 in five blocks) in Nenzlingen, and 10.5 (11 in four blocks) in Vicques compared with 12 species in Movelier. Thus, the species richness was highest in Nenzlingen even when differences in sampling effort were accounted for. The larger heterogeneity of the investigation area in Nenzlingen (see description of study sites) might contribute to the relatively high species richness observed.

The slug *Deroceras reticulatum* was the most frequent species at all three sites, followed in decreasing abundance by *Trichia plebeia*, *Helicella itala*, *Pupilla muscorum*, *Vertigo pygmaea* and *Cochlicopa lubrica*. The three sites differed significantly in gastropod density. A sheet of cardboard attracted on average 0.83 individuals in Nenzlingen, 0.18 individuals in Movelier and 0.13 individuals in Vicques (Table 5). Different factors may influence snail abundance in grasslands. Differences in plant cover, structure, moisture and depth of soil and in the amount of precipitation

might be the most prominent ones. However, further experimental studies are needed to increase our unterstanding of causes that affect local land snail density.

Three species (*Helicella itala* at all sites, *Helix pomatia* in Nenzlingen and Movelier and *Vitrea contracta* in Nenzlingen) are listed in the Red Data Book as potentially endangered in Northern Switzerland (TURNER *et al.* 1994).

One of the advantages of the sampling technique used is the possibility to compare different areas at a given time without removing the animals and destroying the vegetation. However, this trapping technique may attract different species to a different extent. Based on the experience of mark-release-recapture experiments, we assume that *Vertigo pygmaea* is underrepresented in the present data set. However, the extent to which the cardboard technique accurately reflects the abundances of the species present at each site is difficult to test because other sampling techniques may be subject to other biases (BOAG 1982).

GENERAL RESULTS AND DISCUSSION

COMPARISON OF SPECIES RICHNESS BETWEEN SITES

Table 1 gives an overview of the number of species recorded in the various taxonomical groups for each site. Combining data from the eight taxonomical groups, Movelier showed the highest species richness (298 species), followed by Nenzlingen (275 species) and Vicques (273 species). Vicques, which harboured the smallest number of plant species, had a relatively large number of invertebrate species, but a relatively low number of herbivores.

In general, there were no clear associations between plant species richness and species richness of any invertebrate group. One may expect a close association between the species richness of plants and butterflies (ERHARDT 1985). However, this association might exist beyond the spatial scale of the present study (investigation areas of 1-2 ha) in these highly mobile animals. The fact that different taxonomical groups showed low associations in species richness is important for conservation issues. So far, plant species richness has preferentially been used to assess the conservation value of an unfertilized grassland or any other potential nature reserve in Switzerland. However, a site with a relatively low plant species richness (e.g. Vicques) may contain a variety of highly endangered invertebrates. A proper judgement of the conservation value of a potential area should therefore consider species diversity of more than one group of organisms (for other criteria see below).

Diversity expressed by the Shannon-Wiener index (H') was compared among five groups of invertebrates. Diversity was higest in spiders and ground beetles (Table 4) and lowest in terrestrial gastropods. The latter may be due to the dominance of a single gastropod species (*D. reticulatum*). There was a considerable between-site variation in diversity among the different taxonomical groups (Table 4). Each site had the highest diversity in at least one taxonomical group. However, it is dangerous to base a conservation evaluation on diversity indices alone. Sites with a high con-

servation value often have a low diversity (SOULÉ 1986). Other criteria, such as the rarity of the habitat type or the number of endangered and threatened species that the habitat contains might be more helpful for conservation evaluation. For example, the highest number of unique species (species that were exclusively found at one site) was recorded in Movelier (60 species). Vicques harboured 46 unique species and Nenzlingen 43 (Table 2). Furthermore, the number of species listed in the Red Data Book was highest in Movelier (49 species; Vicques: 34 species; Nenzlingen: 27 species; Table 6). For a proper judgement of the conservation value of a grassland, we suggest to survey at least three different taxonomical groups whose species have low associations with each other and occur at different levels of the trophic chain.

Species overlap (number of species that occurred at all sites) varied among taxonomical groups (Table 1). Species overlap was relatively large in terrestrial gastropods (59.1%), butterflies (56.5%), vascular plants (53.8%) and grasshoppers (47.1%), but relatively low in oribatid mites (32.3%), spiders (25.0%), ground beetles (18.4%) and diplopods (12.5%). Species overlap was much higher in herbivores (gastropods, butterflies and grasshoppers; mean: 54.9%) than in ground- and soil-dwelling invertebrates (spiders, oribatid mites and ground beetles; mean 25.2%). The species overlap of herbivores was very close to that of vascular plants (53.5%), which could reflect an association of herbivores with food plants. Soil predators, on the other hand, are not directly associated with plant species, but are restricted in their occurrence by soil conditions (THIELE 1977). Small-scaled variations in soil properties between the sites are most likely to be responsible for the recorded differences in the species composition of soil-dwelling arthropods.

A high proportion of spiders, oribatid mites and ground beetles were found exclusively at one site (Table 2). Most of the species are rare, as indicated by the shape of the species abundance distributions (Fig. 1). In the grasslands examined, a few species were dominant in their communities (e.g., the grass *Bromus erectus* among the plants, *Xylobates capucinus* among the oribatid mites, *Cylindroiulus caeruleocinctus* among the diplopods and the slug *Deroceras reticulatum* among the gastropods).

At the species level, there was a positive correlation between the total number of individuals recorded (or caught) and the number of sites occupied (Spearman rank correlation; spiders: $r_s = 0.67$, $n = 106$, $p < 0.001$; oribatid mites: $r_s = 0.78$, $n = 31$, $p < 0.001$; grasshoppers: $r_s = 0.74$, $n = 13$, $p < 0.01$; ground beetles: $r_s = 0.58$, $n = 39$, $p < 0.001$; terrestrial gastropods: $r_s = 0.89$, $n = 17$, $p < 0.001$). As an example, the correlation between the number of collected oribatid mites and the number of investigation sites occupied by the 31 different mite species is presented in Fig. 2. Thus, in all invertebrate groups, species that were numerically dominant occurred on average at more than one site. Similar findings have been reported for ground beetles at different sites in Finnish mature taiga (NIEMELÄ *et al.* 1994).

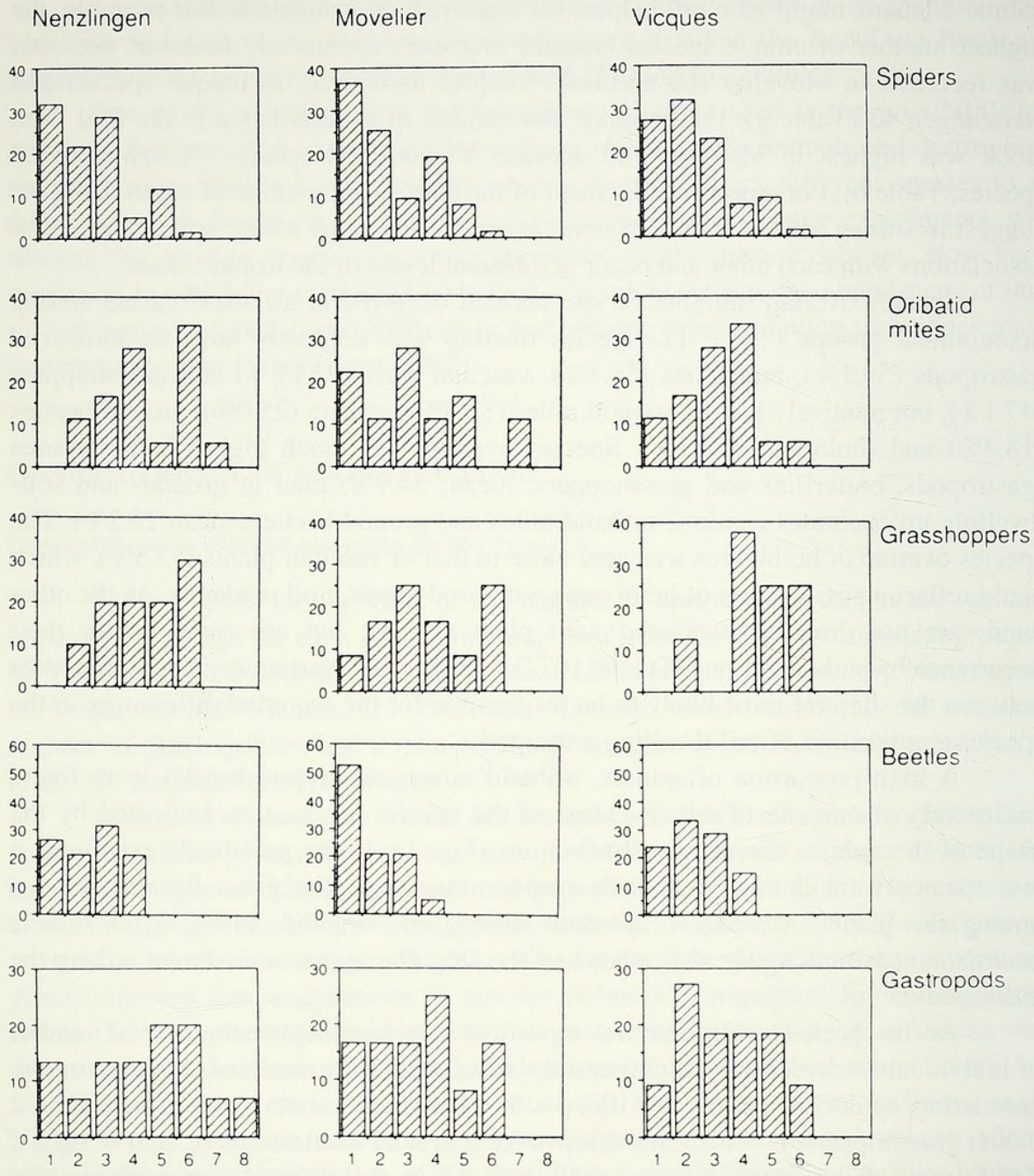

FIG. 1

Percentage of species in various invertebrate groups at the three sites plotted against number of individuals arranged in abundance classes with log3 base. The y-axis indicates the relative abundance (%) of species and the x-axis refers to individuals in abundance classes.

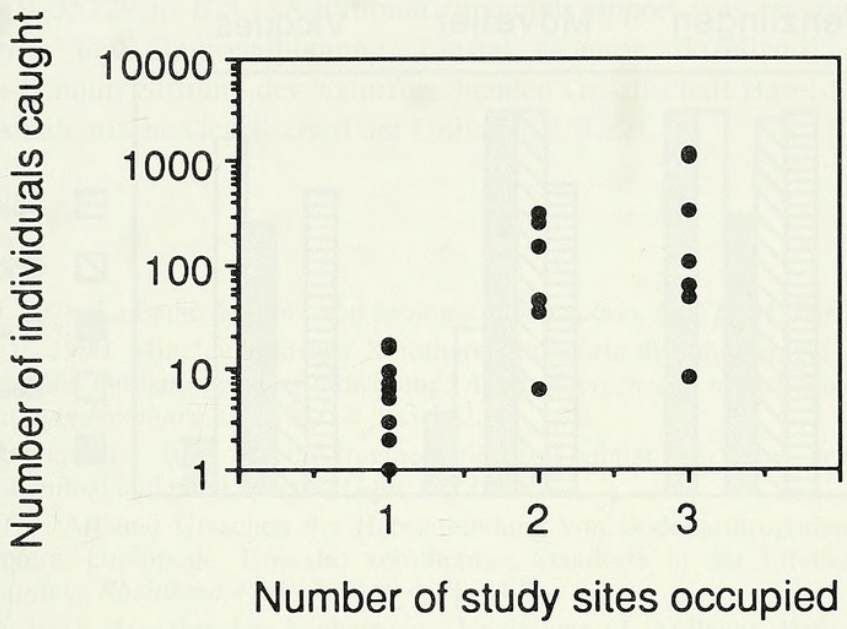

FIG. 2

Correlation between the number of individuals collected per species and the number of study sites occupied by the 31 oribatid mite species (Spearman rank correlation: $r_s = 0.78$, $n = 31$, $p < 0.001$).

SIMILARITY OF SPECIES ASSEMBLAGES

Sørensen's similarity coefficient of species composition and Renkonen's similarity index varied between groups of organisms (Table 3). In general, herbivores (grasshoppers, butterflies and gastropods) had more similar species assemblages between the investigated sites than ground-dwelling arthropods (spiders, oribatid mites and ground beetles). Considering all taxonomical groups, there was no distinct similarity pattern of species composition between the sites examined. Each site combination had the highest similarity of species composition in at least one group of organisms.

BETWEEN-SITE DIFFERENCES IN LOCAL POPULATION DENSITY

The three sites also varied in the abundance of different groups of organisms (Table 5). For example, with the same sampling effort, on average six times more gastropods were caught in Nenzlingen than in Vicques. Similarly, high densities of oribatid mites were found in Nenzlingen and Movelier, but a low density in Vicques. Figure 3 shows the relative densities of various invertebrate groups. Most invertebrate groups had the highest densities in Nenzlingen, suggesting that this site might be the most productive one. Overall, the relative densities of invertebrates in Movelier and Vicques were only 75% and 60%, respectively, of that in Nenzlingen.

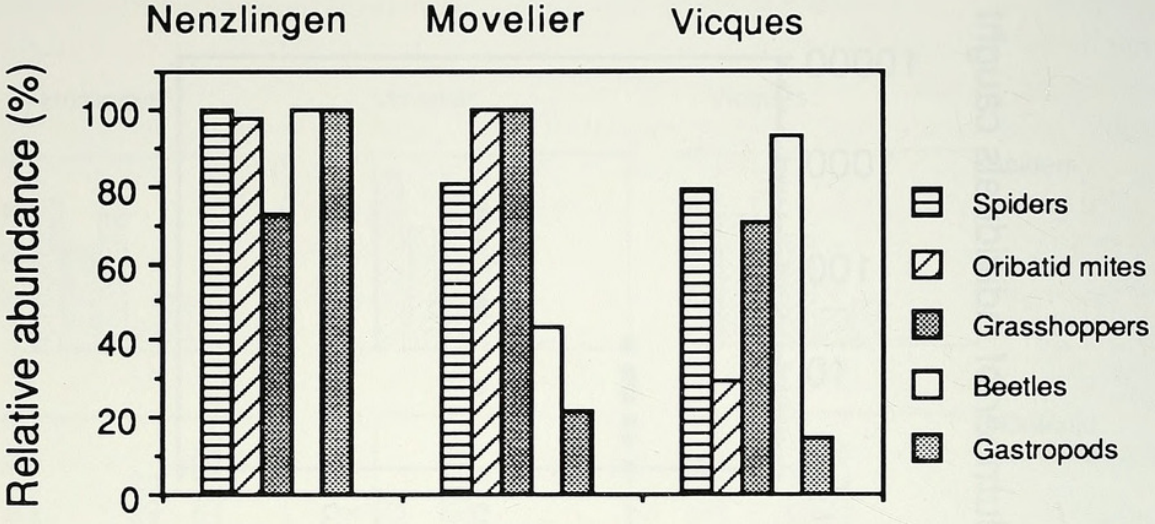

FIG. 3

Relative densities of diverse invertebrate groups at the three investigation sites. The density of each invertebrate group was set equal to 100% at the site where its density was highest.

BETWEEN-SITE DIFFERENCES IN NUMBER OF RARE, ENDANGERED AND THREATENED SPECIES

The relative merits of any sampling technique depend upon its practicality under the given circumstances, particularly in relation to the questions being asked (BOAG 1982). In this study, we determined the species composition and abundances of plant and animal communities without removing any individuals from the experimental areas (except the animals caught with pitfall traps around the experimental blocks and the animals collected in small soil samples). Surely, with more destructive methods we would be able to record a larger number of rare species. Nonetheless, a relatively high proportion of species listed in the Red Data Book of Switzerland were recorded at all three sites. The mean values ranged from 6.7% in ground beetles, 11.2% in terrestrial gastropods, 18.9% in vascular plants, and 28.9% in butterflies to 49.5% in grasshoppers and bush crickets. These figures demonstrate the high conservation value of unfertilized calcareous grasslands in the Jura mountains and demand an appropriate management to maintain (or in some cases even to enhance) species richness.

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APPENDIX 1

Percentage of plots in which plant species were present in 1993 and 1994. A total of 40 plots were examined in Nenzlingen, 24 plots in Movelier and 32 plots in Vicques . - indicates the absence of a particular species and asterisks refer to species listed in the Red Data Book of Switzerland (Landolt 1991); 1: Endangered species in northern Jura; 2: Vulnerable species in northern Jura; 3: Rare species in northern Jura .

	Nenzlingen		Movelier		Vicques	
Species	1993	1994	1993	1994	1993	1994
Acer campestre L.	3	-	-	21	38	16
Achillea millefolium L. s.l.	40	30	33	33	41	25
Agrimonia eupatoria L.	45	38	50	42	50	53
Agrostis tenuis SIBTH.	55	50	54	63	72	78

Anthoxanthum odoratum L. s.l.	83	90	13	21	-	3
Bellis perennis L.	53	50	8	8	13	22
Betonica officinalis L.	50	48	67	71	81	78
Brachypodium pinnatum (L.) B.P.	35	18	42	79	53	75
Briza media L.	73	33	58	79	75	81
Bromus erectus HUDSON s.str.	100	100	100	100	97	100
Campanula rotundifolia L.	8	5	21	13	9	13
Carex caryophyllea LA TOURRETTE	60	58	58	88	69	78
Carex flacca SCHREBER	33	55	46	88	69	75
Centaurea jacea L. s.l.	45	40	83	63	81	78
Centaurium erythraea RAFN * 2	3	3	8	-	25	31
Cerastium fontanum BAUMG. s.l.	58	58	29	29	3	9
Chamaespartium sagittale (L.) P. GIBBS	13	13	21	17	81	94
Cirsium acaule SCOP.	55	50	71	71	47	41
Crataegus monogyna JACQ..	20	18	29	33	16	16
Cynosurus cristatus L.	83	25	42	42	44	44
Dactylis glomerata L.	83	48	50	58	38	47
Danthonia decumbens (L.) DC.	45	3	46	29	56	44
Daucus carota L.	13	18	75	83	75	72
Euphorbia cyparissias L.	78	63	8	-	66	59
Fagus sylvatica L.	5	-	8	4	-	6
Festuca ovina L. s.l.	58	58	75	63	59	50
Festuca pratensis HUDSON s.l.	78	8	50	38	3	-
Festuca rubra L. s.l.	38	8	4	-	-	6
Galium album MILLER	8	13	8	13	16	6
Galium verum L.	13	8	21	25	41	47
Helianthemum nummularium (L.) MILLER s.l.	20	23	25	29	25	22
Hieracium pilosella L.	78	75	96	92	94	100
Hippocrepis comosa L.	13	5	13	17	31	13
Hypericum perforatum L.	25	35	38	38	41	47
Hypochoeris radicata L.	50	38	58	63	44	38
Knautia arvensis (L.) COULTER emend. DUBY	48	45	8	8	56	53
Koeleria pyramidata (LAM.) P.B. s.l * 2	25	13	67	79	63	78
Lathyrus pratensis L.	60	50	33	38	9	6
Leontodon hispidus L. s.l.	40	25	75	75	6	3
Leucanthemum vulgare LAM. s.l.	53	43	88	79	19	13
Linum catharticum L. * 2	33	20	75	79	75	72
Lolium perenne L.	45	8	25	17	16	3
Lotus corniculatus L. s.l.	83	73	71	83	94	91
Luzula campestris (L.) DC.	75	65	17	17	3	9
Medicago lupulina L.	55	30	58	21	28	9
Ononis repens L.	13	8	63	67	72	72
Phleum pratense L. s.l.	10	5	33	42	9	3
Plantago lanceolata L.	78	58	67	75	59	63
Plantago media L.	78	80	79	75	69	63
Poa compressa L.	3	-	13	13	41	6
Poa pratensis L. s.l.	75	55	25	38	25	25
Polygala amarella CRANTZ	3	5	13	13	9	-
Polygala comosa SCHKUHR * 2	20	10	13	25	38	25
Potentilla erecta (L.) RÄUSCHEL	35	23	67	63	16	13
Potentilla neumanniana RCHB.	5	8	63	63	63	63
Potentilla sterilis (L.) GARCKE	60	68	13	17	22	6
Primula veris L. emend. HUDSON s.l.	40	28	42	50	6	9
Prunella grandiflora (L.) SCHOLLER	13	10	42	54	69	78
Prunella vulgaris L.	73	65	54	50	28	16

Prunus spinosa L.	13	8	29	25	22	25
Ranunculus bulbosus L.	95	90	92	96	78	84
Rosa spec.	25	25	13	8	25	28
Sanguisorba minor SCOP.	100	95	92	92	97	97
Scabiosa columbaria L. * 2	23	23	54	42	9	3
Senecio erucifolius L.	50	43	38	29	50	53
Taraxacum officinale WEBER s.l.	50	20	50	21	13	-
Teucrium chamaedrys L.	3	3	50	50	56	50
Thymus serpyllum L. s.l.	30	25	83	92	97	78
Trifolium medium L.	38	35	38	42	66	63
Trifolium montanum L. * 2	35	40	63	54	63	56
Trifolium ochroleucon HUDSON * 2	43	23	63	42	88	66
Trifolium pratense L. s.l.	93	83	67	50	50	16
Trifolium repens L.	70	15	42	8	44	6
Veronica chamaedrys L.	63	63	17	8	16	6
Veronica officinalis L.	30	40	21	13	59	66
Veronica prostrata L. s.l. * 2	3	5	-	4	-	9
Viola hirta L.	30	35	71	83	66	44
Abies alba MILLER	3	-	8	-	-	-
Campanula glomerata L. s.l.* 2	3	3	75	79	-	-
Colchicum autumnale L.	5	10	4	-	-	-
Crepis taraxacifolia THUILL.	10	-	8	4	-	-
Holcus lanatus L.	50	48	-	4	-	-
Orchis morio L. * 1	-	5	4	4	-	-
Orchis ustulata L.	3	3	21	21	-	-
Pinus sylvestris L.	3	3	17	4	-	-
Plantago major L. s.l.	8	3	4	-	-	-
Poa trivialis L. s.l.	33	3	13	29	-	-
Potentilla reptans L.	3	-	4	-	-	-
Quercus robur L.	3	5	8	4	-	-
Rubus spp.	8	8	8	8	-	-
Veronica serpyllifolia L. s.l.	50	45	-	8	-	-
Anthyllis vulneraria L. s.l.	13	13	-	-	25	13
Carpinus betulus L.	20	13	-	-	25	22
Origanum vulgare L.	15	8	-	-	13	9
Pimpinella saxifraga L. s.l.	28	10	-	-	53	19
Salvia pratensis L. * 2	38	28	-	-	53	34
Sedum sexangulare L. emend. GRIMM	8	5	-	-	53	53
Trifolium campestre SCHREBER	35	3	-	-	59	31
Veronica arvensis L.	33	25	-	-	-	3
Vicia sativa L. s.l.	53	60	-	-	9	3
Allium oleraceum L.	-	-	4	-	3	-
Asperula cynanchica L. * 2	-	-	54	54	41	34
Platanthera chlorantha (CUSTER) RCHB. * 2	-	-	13	17	-	3
Ajuga reptans L.	8	5	-	-	-	-
Anemone nemorosa L.	5	5	-	-	-	-
Avenula pubescens (HUDSON) DUMORTIER	33	15	-	-	-	-
Cardamine spec.	-	3	-	-	-	-
Crepis biennis L.	28	-	-	-	-	-
Geranium dissectum L.	20	-	-	-	-	-
Hedera helix L.	-	3	-	-	-	-
Ligustrum vulgare L.	3	3	-	-	-	-
Pteridium aquilinum (L.) KUHN	15	10	-	-	-	-
Ranunculus acris L. s.l.	3	3	-	-	-	-
Rumex acetosa L.	28	23	-	-	-	-

Agrostis stolonifera L.	-	-	21	-	-	-
Alchemilla hybrida agg. * 1	-	-	8	-	-	-
Anacamptis pyramidalis (L.) RICH. * 1	-	-	25	17	-	-
Anthericum ramosum L.	-	-	4	-	-	-
Aster amellus L.	-	-	8	4	-	-
Carex pilulifera L. * 3	-	-	8	29	-	-
Carlina acaulis L. s.l.	-	-	17	-	-	-
Euphorbia verrucosa L. emend. L. * 2	-	-	4	4	-	-
Galium pumilum MURRAY	-	-	8	4	-	-
Gentianella ciliata (L.) BORKH. * 2	-	-	13	-	-	-
Gentiana verna L. * 2	-	-	4	-	-	-
Gentianella germanica (WILLD.)BÖRNER s.l.*2	-	-	21	-	-	-
Gymnadenia conopsea (L.) R.BR.	-	-	25	29	-	-
Orchis militaris L. * 1	-	-	4	4	-	-
Silaum silaus (L.) SCH. et TH. * 2	-	-	17	17	-	-
Sorbus aria (L.) CRANTZ	-	-	-	4	-	-
Spiranthes spiralis (L.) CHEVALLIER * 1	-	-	4	-	-	-
Succisa pratensis MOENCH	-	-	63	58	-	-
Tetragonolobus maritimus (L.) ROTH * 2	-	-	75	88	-	-
Teucrium montanum L.	-	-	8	8	-	-
Thlaspi perfoliatum L.	-	-	25	13	-	-
Vicia cracca L. s.l.	-	-	17	17	-	-
Acinos arvensis (LAM.) DANDY	-	-	-	-	16	6
Convolvulus arvensis L.	-	-	-	-	9	6
Genista tinctoria L. * 2	-	-	-	-	9	6
Gentiana cruciata L. * 1	-	-	-	-	3	3
Juniperus communis L. s.l.	-	-	-	-	3	-
Veronica teucrium L. * 1	-	-	-	-	3	6
Vicia hirsuta (L.) S.F. GRAY	-	-	-	-	19	16
Number of species	108	103	111	100	90	91

APPENDIX 2

Abundance and percentage (in parentheses) of spiders (Aranea) collected at each investigation site in 1994.

Species	Number (%) of individuals collected		
	Nenzlingen	Movelier	Vicques
Alopecosa cuneata (Clerck, 1757)	105 (10.1)	23 (2.7)	69 (8.5)
Alopecosa pulverulenta (Clerck, 1757)	12 (1.2)	7 (0.8)	3 (0.4)
Aulonia albimana (Walckenaer, 1805)	69 (6.6)	97 (11.5)	101 (12.4)
Bianor aurocinctus (Ohlert, 1865)	2 (0.2)	2 (0.2)	1 (0.1)
Cnephalocotes obscurus (Blackwall, 1834)	1 (0.1)	4 (0.5)	3 (0.4)
Drassodes pubescens (Thorell, 1856)	4 (0.4)	3 (0.4)	4 (0.5)
Enoplognatha thoracica (Hahn, 1833)	1 (0.1)	1 (0.1)	1 (0.1)
Eperigone trilobata (Emerton, 1882)	40 (3.8)	51 (6.0)	12 (1.5)
Haplodrassus signifer (C. L. Koch, 1838)	8 (0.8)	7 (0.8)	8 (1.0)
Lepthyphantes tenuis (Blackwall, 1852)	13 (1.3)	16 (1.9)	7 (0.9)
Meioneta beata (O. P. - Cambridge, 1906)	51 (4.9)	27 (3.2)	8 (1.0)
Meioneta rurestris (C. L. Koch, 1836)	10 (1.0)	2 (0.2)	66 (8.1)
Micaria formicaria (Sundevall, 1831)	1 (0.1)	10 (1.2)	6 (0.7)
Micrargus subaequalis (Westring, 1851)	121 (11.6)	66 (7.8)	49 (6.0)

Myrmarachne formicaria (Degeer, 1778)	2	(0.2)	17	(2.0)	12	(1.5)
Pachygnatha degeeri (Sundevall, 1830	66	(6.3)	65	(7.7)	3	(0.4)
Pardosa hortensis (Thorell, 1872)	113	(10.9)	3	(0.4)	49	(6.0)
Pardosa pullata (Clerck, 1757)	159	(15.3)	160	(19.0)	5	(0.6)
Pardosa sp.	4	(0.4)	2	(0.2)	1	(0.1)
Phrurolithus festivus (C. L. Koch, 1835)	5	(0.5)	10	(1.2)	2	(0.3)
Pirata latitans (Blackwall, 1841)	1	(0.1)	14	(1.7)	1	(0.1)
Trochosa terricola Thorell, 1856	4	(0.4)	17	(2.0)	8	(1.0)
Walckenaeria antica (Wider, 1834)	6	(0.6)	22	(2.6)	2	(0.3)
Zelotes petrensis (C. L. Koch, 1839)	1	(0.1)	11	(1.3)	13	(1.6)
Zelotes praeficus (L. Koch, 1866)	72	(6.9)	17	(2.0)	19	(2.3)
Zelotes pusillus (C. L. Koch, 1833)	8	(0.8)	1	(0.1)	1	(0.1)
Zora spinimana (Sundevall, 1833)	1	(0.1)	1	(0.1)	1	(0.1)
Bathyphantes gracilis (Blackwall, 1841)	1	(0.1)	2	(0.2)	-	
Erigone dentipalpis (Wider, 1834)	7	(0.7)	2	(0.2)	-	
Euophrys frontalis (Walckenaer, 1802)	5	(0.5)	3	(0.4)	-	
Meioneta mollis (O. P. - Cambridge, 1871)	18	(1.7)	18	(2.1)	-	
Microneta viaria (Blackwall, 1841)	2	(0.2)	1	(0.1)	-	
Pardosa palustris (Linné, 1758)	4	(0.4)	1	(0.1)	-	
Pocadicnemis juncea Locket & Millidge, 1953	7	(0.7)	3	(0.4)	-	
Tiso vagans (Blackwall, 1834)	3	(0.3)	66	(7.8)	-	
Zelotes latreillei (Simon, 1878)	13	(1.3)	2	(0.2)	-	
Agelena labyrinthica (Clerck, 1757)	-		1	(0.1)	1	(0.1)
Clubiona neglecta O. P. - Cambridge, 1862	-		4	(0.5)	1	(0.1)
Diplostyla concolor (Wider, 1834)	-		1	(0.1)	1	(0.1)
Euophrys aequipes (O. P. - Cambridge, 1871)	-		1	(0.1)	20	(2.5)
Evarcha arcuata (Clerck, 1757)	-		1	(0.1)	1	(0.1)
Harpactea lepida (C. L. Koch, 1838)	-		1	(0.1)	3	(0.4)
Steatoda phalerata (Panzer, 1801)	-		1	(0.1)	2	(0.3)
Talavera inopinata (Wunderlich, 1993)	-		1	(0.1)	2	(0.3)
Argenna subnigra (O. P. - Cambridge, 1861)	10	(1.0)	-		4	(0.5)
Atypus piceus (Sulzer, 1776)	1	(0.1)	-		3	(0.4)
Episinus truncatus Latreille, 1809	1	(0.1)	-		1	(0.1)
Histopona torpida (C. L. Koch, 1834)	1	(0.1)	-		9	(1.1)
Lepthyphantes pallidus (O. P. - Cambridge, 1871)	1	(0.1)	-		3	(0.4)
Pardosa bifasciata (C. L. Koch, 1834)	13	(1.3)	-		125	(15.3)
Pardosa monticola (Clerck, 1757)	7	(0.7)	-		42	(5.2)
Pisaura mirabilis (Clerck, 1757)	2	(0.2)	-		1	(0.1)
Trochosa robusta (Simon, 1876)	2	(0.2)	-		15	(1.8)
Zelotes pumilus (C. L. Koch, 1839)	4	(0.4)	-		16	(2.0)
Centromerita bicolor (Blackwall, 1833)	1	(0.1)	-		-	
Hahnia nava (Blackwall, 1841)	13	(1.3)	-		-	
Micaria fulgens (Walckenaer, 1802)	1	(0.1)	-		-	
Micaria pulicaria (Sundevall, 1831)	2	(0.2)	-		-	
Mioxena blanda (Simon, 1884)	1	(0.1)	-		-	
Oedothorax apicatus (Blackwall, 1850)	1	(0.1)	-		-	
Oxyptila nigrita (Thorell, 1875)	1	(0.1)	-		-	
Oxyptila simplex (O. P. - Cambridge, 1862)	5	(0.5)	-		-	
Phrurolithus festivus (C. L. Koch, 1835)	3	(0.3)	-		-	
Trochosa ruricola (Degeer, 1778)	12	(1.2)	-		-	
Xysticus kochi Thorell, 1872	1	(0.1)	-		-	
Xysticus robustus (Hahn, 1832)	1	(0.1)	-		-	
Zelotes pedestris (C. L. Koch, 1837)	1	(0.1)	-		-	
Zora silvestris Kulczynski, 1897	16	(1.5)	-		-	
Alopecosa trabalis (Clerck, 1757)	-		8	(1.0)	-	

Bathyphantes parvulus (Westring, 1851)	-	1 (0.1)	-
Centromerita concinna (Thorell, 1875)	-	1 (0.1)	-
Clubiona diversa O. P. - Cambridge, 1862	-	1 (0.1)	-
Drassodes cupreus (Blackwall, 1834)	-	3 (0.4)	-
Drassodes lapidosus (Walckenaer, 1802)	-	1 (0.1)	-
Erigone atra (Blackwall, 1841)	-	2 (0.2)	-
Hahnia pusilla C. L. Koch, 1841	-	14 (1.7)	-
Haplodrassus silvestris (Blackwall, 1833)	-	1 (0.1)	-
Lepthyphantes keyserlingi (Ausserer, 1867)	-	3 (0.4)	-
Pardosa prativaga (L. Koch, 1870)	-	1 (0.1)	-
Phrurolithus minimus (C. L. Koch, 1839)	-	15 (1.8)	-
Pocadicnemis pumila (Blackwall, 1841)	-	2 (0.2)	-
Robertus lividus (Blackwall, 1836)	-	1 (0.1)	-
Tapinocyboides pygmaeus (Menge, 1869)	-	1 (0.1)	-
Tegenaria picta Simon, 1870	-	1 (0.1)	-
Tricca lutetiana (Simon, 1876)	-	1 (0.1)	-
Walckenaeria atrotibialis (O. P. - Cambridge, 1878)	-	21 (2.5)	-
Zelotes apricorum (L. Koch, 1876)	-	1 (0.1)	-
Alopecosa accentuata (Latreille, 1817)	-	-	8 (1.0)
Araeoncus humilis (Blackwall, 1841)	-	-	13 (1.6)
Cicurina cicur (Fabricius, 1793)	-	-	1 (0.1)
Cnephalocotes sanguinolentus (Walckenaer, 1837)	-	-	2 (0.3)
Coelotes terrestris (Wider, 1834)	-	-	3 (0.4)
Dipoena coracina (C. L. Koch, 1841)	-	-	4 (0.5)
Dipoena prona (Menge, 1868)	-	-	3 (0.4)
Dysdera erythrina (Walckenaer, 1802)	-	-	4 (0.5)
Gnaphosa lucifuga (Walckenaer, 1802)	-	-	2 (0.3)
Haplodrassus kulczynskii Lohmander, 1942	-	-	6 (0.7)
Harpactea hombergi (Scopoli, 1763)	-	-	1 (0.1)
Neottiura suaveolens (Simon, 1879)	-	-	1 (0.1)
Pelecopsis radicicola (L. Koch, 1875)	-	-	5 (0.6)
Phrurolithus nigrinus (Simon, 1878)	-	-	12 (1.5)
Oxyptila atomaria (Panzer, 1810)	-	-	1 (0.1)
Oxyptila pullata (Thorell, 1875)	-	-	2 (0.3)
Oxyptila scabricula (Westring, 1851)	-	-	3 (0.4)
Scotina celans (Blackwall, 1841)	-	-	2 (0.3)
Xerolycosa nemoralis (Westring, 1861)	-	-	1 (0.1)
Xysticus erraticus (Blackwall, 1834)	-	-	1 (0.1)
Zelotes exiguus (Mueller & Schenkel, 1895)	-	-	36 (4.4)
Total number of individuals	1041	844	816
Number of species	60	63	66

Appendix 3

Abundance and percentage (in parentheses) of oribatid mites (Acari, Oribatei) sampled at the margins of the experimental blocks at each investigation site in 1994.

Species	Number (%) of individuals collected Nenzlingen	Movelier	Vicques
Cultroribula bicultrata (Berlese, 1905)	39 (1.8)	17 (1.3)	5 (1.0)
Microppia minus (Paoli, 1908)	3 (0.1)	28 (2.1)	17 (3.3)
Oppiella nova (Oudemans, 1902)	158 (7.2)	106 (7.8)	69 (13.2)

Peloptulus phaeonotus (C. L. Koch, 1844)	11	(0.5)	67	(4.9)	32	(6.1)
Rhysotritia ardua (C. L. Koch, 1841)	4	(0.2)	12	(0.9)	2	(0.4)
Scheloribates laevigatus (C. L. Koch, 1835)	692	(31.4)	438	(32.3)	27	(5.2)
Tectocepheus sarekensis Trägårdh, 1910	45	(2.0)	11	(0.8)	7	(1.3)
Xylobates capucinus (Berlese, 1908)	306	(13.9)	570	(42.1)	261	(49.9)
Eupelops curtipilus (Berlese, 1917)	236	(10.7)	76	(5.6)	-	
Minunthozetes semirufus (C. L. Koch, 1840)	253	(11.5)	1	(0.1)	-	
Ceratozetes minutissimus Willmann, 1951	129	(5.9)	-		22	(4.2)
Ctenobelba pectinigera (Berlese, 1910)	229	(10.4)	-		26	(5.0)
Fosseremus laciniatus (Berlese, 1905)	13	(0.6)	-		33	(6.3)
Hypochthonius luteus Oudemans, 1917	30	(1.4)	-		5	(1.0)
Suctobelbella palustris (Forsslund, 1953)	-		1	(0.1)	5	(1.0)
Ceratozetes gracilis (Michael, 1884)	15	(0.7)	-		-	
Platynothrus peltifer (C. L. Koch, 1840)	15	(0.7)	-		-	
Scutovertex minutus (C. L. Koch, 1836)	16	(0.7)	-		-	
Suctobelbella sarekensis (Forsslund, 1941)	7	(0.3)	-		-	
Brachychthonius berlesei Willmann, 1928	-		1	(0.1)	-	
Ceratoppia quadridentata (Haller, 1882)	-		3	(0.2)	-	
Epilohmannia cylindrica minima Schuster, 1960	-		9	(0.7)	-	
Galumna alata (Hermann, 1804)	-		7	(0.5)	-	
Nanhermannia nana (Nicolet, 1855)	-		1	(0.1)	-	
Oppiella subpectinata (Oudemans, 1900)	-		2	(0.1)	-	
Scutovertex sculptus Michael, 1879	-		5	(0.4)	-	
Carabodes labyrinthicus (Michael, 1879)	-		-		1	(0.2)
Cymberemaeus cymba (Nicolet, 1855)	-		-		1	(0.2)
Pergalumna myrmophila (Berlese, 1915)	-		-		2	(0.4)
Suctobelbella subcornigera (Forsslund, 1941)	-		-		6	(1.1)
Suctobelbella tuberculata (Strenzke, 1950)	-		-		2	(0.4)
Total number of individuals	2201		1355		523	
Number of species	18		18		18	

Appendix 4

Abundance and percentage of millipedes (Diplopoda, Myriapoda) collected at each investigation site in 1994.

Species	Number (%) of individuals collected Nenzlingen		Movelier		Vicques	
Cylindroiulus caeruleocinctus (Wood, 1864)	38	(100.0)	42	(91.3)	51	(72.9)
Allajulus nitidus (Verhoeff, 1891)	-		1	(2.2)	1	(1.4)
Glomeris hexasticha intermedia Latzel, 1884	-		1	(2.2)	4	(5.7)
Polydesmus denticulatus C. L. Koch, 1847	-		2	(4.3)	-	
Glomeris conspersa C. L. Koch, 1847	-		-		2	(2.9)
Glomeris marginata (Villers, 1789)	-		-		3	(4.3)
Glomeris undulata C. L. Koch, 1844	-		-		1	(1.4)
Tachypodoiulus niger (Leach, 1815)	-		-		8	(11.4)
Total number of individuals	38		46		70	
Number of species	1		4		7	

Appendix 5

Abundance and percentage (in parentheses) of grasshoppers, bush crickets and true crickets (Orthoptera: Saltatoria) recorded in the experimental blocks at each investigation site in 1993 and 1994. Figures in italics indicate Saltatoria recorded in the areas surrounding the experimental blocks. Asterisks refer to species listed in the Red Data Book of Switzerland (Nadig & Thorens 1994). (h) indicates that individuals of this species were only heard.

Species	Number (%) of individuals recorded											
	Nenzlingen			Movelier			Vicques		
	1993	1994	*1994*	1993	1994	*1994*	1993	1994	*1994*
Chorthippus biguttulus (Linné, 1758)	86 (13.1)	68 (9.5)	*76 (24.1)*	123 (20.6)	36 (6.8)	*15 (10.8)*	91 (16.8)	94 (18.3)	*50 (21.3)*
Chorthippus parallelus (Zetterstedt, 1821)	141 (21.5)	294 (40.9)	*101 (32.0)*	9 (1.5)	34 (6.4)	*27 (19.4)*	21 (3.9)	24 (4.7)	*44 (18.7)*
Gryllus campestris Linné, 1758 *	14 (2.1)	9 (1.3)	*3 (0.9)*	9 (1.5)	4 (0.8)	*(h)*	2 (0.4)	3 (0.6)	*(h)*
Metrioptera bicolor (Philippi, 1830) *	123 (18.7)	56 (7.8)	*8 (2.5)*	13 (2.2)	59 (11.1)	*6 (4.3)*	29 (5.4)	118 (23.0)	*20 (8.5)*
Omocestus rufipes (Zetterstedt, 1821) *	18 (2.7)	29 (4.0)	*26 (8.2)*	18 (3.0)	12 (2.3)	*7 (5.0)*	89 (16.4)	79 (15.4)	*26 (11.1)*
Platycleis albopunctata (Goeze, 1778) *	97 (14.8)	24 (3.3)	*23 (7.3)*	127 (21.3)	59 (11.1)	*4 (2.9)*	122 (22.5)	65 (12.6)	*41 (17.4)*
Stenobothrus lineatus (Panzer, 1796)	153 (23.3)	225 (31.3)	*43 (13.6)*	162 (27.2)	163 (30.6)	*14 (10.1)*	153 (28.2)	120 (23.3)	*39 (16.6)*
Chrysochraon brachyptera (Ocskay, 1826)	-	3 (0.4)	*6 (1.9)*	99 (16.6)	149 (28.0)	*21 (15.1)*	-	-	-
Gomphocerus rufus (Linné, 1758)	11 (1.7)	8 (1.1)	*27 (8.5)*	29 (4.9)	8 (1.5)	*30 (21.6)*	-	-	*12 (5.1)*
Tetrix tenuicornis Sahlberg, 1893	11 (1.7)	3 (0.4)	*1 (0.3)*	2 (0.3)	1 (0.2)	-	-	-	-
Decticus verrucivorus (Linné, 1758) *	-	-	-	1 (0.2)	-	-	35 (6.5)	10 (1.9)	*2 (0.9)*
Tettigonia viridissima Linné, 1758	-	-	-	-	5 (0.9)	*2 (1.4)*	-	1 (0.2)	*1 (0.4)*
Metrioptera roeselii (Hagenbach, 1822)	3 (0.5)	-	-	-	-	*(h)*	-	-	-
Phaneroptera falcata (Poda, 1761) *	-	-	*2 (0.6)*	-	-	-	-	-	-
Chrysochraon dispar (Germar, 1831-35) *	-	-	-	-	2 (0.4)	*5 (3.6)*	-	-	-
Metrioptera brachyptera (Linné, 1761) *	-	-	-	4 (0.7)	-	-	-	-	-
Chorthippus dorsatus (Zetterstedt, 1821)	-	-	-	-	-	*8 (5.8)*	-	-	-
Total number of individuals	657	719	*316*	596	532	*139*	542	514	*235*
Number of species	10	10	*11*	12	12	*13*	8	9	*10*

Appendix 6

Abundance and percentage (in parentheses) of ground beetles (Coleoptera, Carabidae) collected at each investigation site in 1994. Asterisks indicate species listed in the Red Data Book of Switzerland (Marggi 1994).

Species	Number (%) of individuals collected					
	Nenzlingen		Movelier		Vicques	
Abax parallelepipedus (Piller & Mitt., 1783)	3	(1.9)	1	(1.5)	15	(10.4)
Anisodactylus binotatus (Fabr., 1787)	11	(7.1)	1	(1.5)	3	(2.1)
Calathus fuscipes (Goeze, 1777)	3	(1.9)	15	(22.4)	4	(2.8)
Carabus coriaceus L., 1758	1	(0.6)	1	(1.5)	8	(5.6)
Carabus purpurascens Fabr., 1787	8	(5.2)	11	(16.4)	4	(2.8)
Poecilus cupreus (L., 1758)	3	(1.9)	4	(6.0)	37	(25.7)
Pterostichus ovoideus (Sturm, 1824)	1	(0.6)	2	(3.0)	1	(0.7)
Amara convexior Steph., 1828	8	(5.2)	1	(1.5)	-	
Amara lunicollis Schiödte, 1837	25	(16.1)	11	(16.4)	-	
Carabus cancellatus Illig., 1798	-		2	(3.0)	1	(0.7)
Carabus monilis Fabr. 1792	-		5	(7.5)	3	(2.1)
Carabus problematicus Herbst, 1786	-		5	(7.5)	5	(3.5)
Pterostichus madidus (Fabr., 1775)	-		1	(1.5)	10	(6.9)
Harpalus dimidiatus (Rossi, 1790)	20	(12.9)	-		12	(8.3)
Amara aenea (De Geer, 1774)	20	(12.9)	-		-	
Amara communis (Panz., 1797)	5	(3.2)	-		-	
Anisodactylus nemorivagus (Duft., 1812) *	23	(14.8)	-		-	
Brachinus explodens Duft., 1812	3	(1.9)	-		-	
Nebria brevicollis (Fabr., 1792)	1	(0.6)	-		-	
Parophonus maculicornis (Duft., 1812)	12	(7.7)	-		-	
Platynus dorsalis (Pont., 1763)	6	(3.9)	-		-	
Pterostichus melanarius (Illig., 1798)	1	(0.6)	-		-	
Trechus quadristriatus (Schrank, 1781)	1	(0.6)	-		-	
Badister bullatus (Schrank, 1798)	-		1	(1.5)	-	
Carabus convexus Fabr., 1775 *	-		1	(1.5)	-	
Harpalus atratus Latr., 1804	-		1	(1.5)	-	
Harpalus latus (L., 1758)	-		2	(3.0)	-	
Poecilus versicolor (Sturm, 1824)	-		1	(1.5)	-	
Stomis pumicatus (Panz., 1796)	-		1	(1.5)	-	
Abax parallelus (Duft., 1812)	-		-		1	(0.7)
Badister meridionalis Puel, 1925	-		-		2	(1.4)
Bembidion quadrimaculatum (L., 1761)	-		-		1	(0.7)
Callistus lunatus (Fabr., 1775)	-		-		6	(4.2)
Carabus auratus L., 1761 *	-		-		10	(6.9)
Harpalus rubripes (Duft., 1812)	-		-		14	(9.7)
Ophonus puncticeps (Steph., 1828)	-		-		2	(1.4)
Panagaeus bipustulatus (Fabr., 1775) *	-		-		4	(2.8)
Pterostichus selmanni (Duft., 1812)	-		-		1	(0.7)
Total number of individuals	155		67		144	
Number of species	19		19		21	

APPENDIX 7

Butterfly and Zygaenidae species recorded at each investigation site in 1993 and 1994. Asterisks indicate species listed in the Red Data Book (GONSETH 1994) and G refers to species which are closely associated with unfertilized calcareous grasslands.

Species		Nenzlingen		Movelier		Vicques	
		1993	1994	1993	1994	1993	1994
Aglais urticae (Linné, 1758)		+	+	+	+	+	+
Anthocharis cardamines (Linné, 1758)		+	+	+	+	+	+
Argynnis paphia (Linné, 1758)		+	+	+	+	+	+
Brintesia circe (Fabricius, 1775)*	G	+	+	+	+	+	+
Clossiana dia (Linné, 1767)*	G	+	+	+	+	+	+
Coenonympha pamphilus (Linné, 1758)		+	+	+	+	+	+
Colias hyale (Linné, 1758)		+	+	+	+	+	+
Cupido minimus (Fuesslin, 1775)*	G	+	+	+	+	+	+
Cyaniris semiargus (Rottemburg, 1775)	G	+	+	+	+	+	+
Erynnis tages (Linné, 1758)	G	+	+	+	+	+	+
Gonepteryx rhamni (Linné, 1758)		+	+	+	+	+	+
Hipparchia semele (Linné, 1758)*	G	+	+	+	+	+	+
Inachis io (Linné, 1758)		+	+	+	+	+	+
Lasiommata megera (Linné, 1767)	G	+	+	+	+	+	+
Lysandra bellargus (Rottemburg, 1775)	G	+	+	+	+	+	+
Maniola jurtina (Linné, 1758)	G	+	+	+	+	+	+
Melanargia galathea (Linné, 1758)	G	+	+	+	+	+	+
Mellicta parthenoides (Keferstein, 1851)*	G	+	+	+	+	+	+
Papilio machaon (Linné, 1758)	G	+	+	+	+	+	+
Pieris rapae (Linné, 1758)		+	+	+	+	+	+
Pieris brassicae (Linné, 1758)		+	+	+	+	+	+
Polyommatus icarus (Rottemburg, 1775)	G	+	+	+	+	+	+
Pyrgus malvae (Linné, 1758)*	G	+	+	+	+	+	+
Spialia sertorius (Hofmannsegg, 1804)	G	+	+	+	+	+	+
Thymelicus sylvestris (Poda, 1761)	G	+	+	+	+	+	+
Zygaena filipendulae (Linné, 1758)	G	+	+	+	+	+	+
Agriodiaetus damon (Denis & Schiffermüller,1775)*	G	-	-	+	+	+	+
Aphanthopus hyperanthus (Linné, 1758)		-	-	+	+	-	-
Araschnia levana (Linné, 1758)		-	-	+	+	-	-
Aricia agestis (Denis & Schiffermüller, 1775)*	G	-	-	+	+	+	+
Chazara briseis (Linné, 1764)*	G	-	-	+	+	-	-
Coenonympha glycerion (Borkhausen, 1788)*	G	-	-	+	-	-	-
Colias alfacariensis (Ribbe, 1905)	G	-	+	+	+	-	+
Colias crocea (Geoffroy in Fourcroy, 1785)	G	-	+	-	+	-	+
Cynthia cardui (Linné, 1758)		+	-	+	+	+	+
Erebia aethiops (Esper, 1777)*		-	-	+	+	-	-
Hesperia comma (Linné, 1758)	G	-	-	+	+	+	+
Iphiclides podalirius (Linné, 1758)*	G	-	-	+	+	+	-
Leptidea sinapis (Linné, 1758)		-	-	+	+	-	+
Lycaena tityrus (Poda, 1761)	G	-	-	+	+	-	+
Lysandra coridon (Poda, 1761)*	G	-	+	+	+	+	+
Maculinea arion (Linné, 1758)*	G	-	-	+	+	-	+
Melitaea cinxia (Linné, 1758)*	G	-	-	-	+	-	-
Ochlodes venatus (Bremer & Grey 1853)	G	-	+	+	+	+	+
Pieris napi (Linné, 1758)		+	-	+	+	+	+
Plebicula dorylas (Denis & Schiffermüller, 1775)*	G	-	-	+	+	+	+
Thecla betulae (Linné, 1758)		-	-	+	+	-	-
Total number of species		27	30	45	46	35	39

APPENDIX 8

Abundance and percentage (in parentheses) of terrestrial gastropods (Mollusca) recorded in the experimental blocks at each investigation site. + indicates species that were observed on other occasions. Asterisks indicate species listed in the Red Data Book of Switzerland (TURNER *et al.* 1994).

Species	Number (%) of individuals recorded					
	Nenzlingen		Movelier		Vicques	
Arion distinctus Mabille, 1868	6	(0.1)	+		+	
Arion lusitanicus Mabille, 1868	56	(1.1)	11	(1.7)	3	(0.5)
Cochlicopa lubrica (O. F. Müller,1774)	112	(2.2)	14	(2.1)	34	(5.6)
Deroceras reticulatum (O. F. Müller,1774)	3073	(61.4)	336	(50.8)	292	(48.2)
Helicella itala (Linné, 1758) *	190	(3.8)	98	(14.8)	13	(2.1)
Limax spp. (juveniles)	41	(0.8)	1	(0.2)	+	
Punctum pygmaeum (Draparnaud, 1801)	20	(0.4)	4	(0.6)	4	(0.7)
Pupilla muscorum (Linné, 1758)	332	(6.6)	23	(3.5)	96	(15.8)
Trichia plebeia (Draparnaud, 1805)	952	(19.0)	141	(21.3)	116	(19.1)
Vallonia pulchella (O. F. Müller, 1774)	8	(0.2)	+		1	(0.2)
Vertigo pygmaea (Draparnaud, 1801)	184	(3.7)	19	(2.9)	39	(6.4)
Vitrina pellucida (O. F. Müller, 1774)	27	(0.5)	11	(1.7)	6	(1.0)
Candidula unifasciata (Poiret, 1801)	+		-		2	(0.3)
Cepaea hortensis (O. F. Müller, 1774)	+		1	(0.2)	-	
Helix pomatia Linné, 1758 *	4	(0.1)	2	(0.3)	-	
Aegopinella pura (Alder, 1830)	1	(<0.1)	-		-	
Vallonia costata (O. F. Müller, 1774)	1	(<0.1)	-		-	
Arion ater (Linné, 1758)	+		+		+	
Abida secale (Draparnaud, 1801)	+		-		+	
Truncatellina cylindrica (Férussac, 1807)	+		-		-	
Vitrea contracta (Westerlund,1871) *	+		-		-	
Succinea oblonga Draparnaud, 1801	-		+		-	
Total number of individuals	5007	(100)	661	(100)	606	(100)
Number of species	21		16		15	