Schwerdtfeger, F., 1981: Die Waldkrankheiten. 4. Aufl. Hamburg, Berlin: Paul Parey.
Skuhravý, V.; Hochmut, R., 1980: Monitoring of the nun moth, *Lymantria monacha*, in Czechoslovakia using pheromone traps (Lepidoptera, Lymantriidae). Acta Ent. Bohemosl., *77*, 426–429.
Szöcs, G.; Tóth, M.; Novák, L., 1981: Sex attractants for eight lepidopterous species. Z. ang. Ent. *91*, 272–280.

Anschrift der Verfasser: Dr. Reinhard Albert, Dr. Hermann Bogenschütz und Dr. Erwin König, Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Abt. Waldschutz, 7801 Stegen-Wittental

Distribution, host plants, and reproductive biology of the *Sitona humeralis* Stephens group of species (Coleoptera, Curculionidae)

By J.-P. Aeschlimann

Abstract

Four taxa have hitherto been confused under the specific name of *Sitona humeralis*. Their present distribution and host plant relationship are described, based on the analysis of over 60000 specimens, field collected from 16 countries of the Western Palaearctic. Results show that the true *S. humeralis* achieved high levels of both abundance and dominance on cultivated lucerne, whereas *S. hicolor hicolor* was most successful on annual *Medicago* species. *S. bicolor concavirostris* and *S. discoideus* were able to reach similar degrees of dominance on both categories of host plants, the distribution of the latter species in southwest Europe, however, being correlated with that of annual medics.

There is a wide overlap in the distribution of *S. humeralis* and that of the other species of the group, and rearing in the laboratory demonstrated that interbreeding was likely to occur in some field situations. Combination of *S. discoideus* with *S. humeralis* resulted in a reduced percentage of mated females and depressed fecundity and fertility as compared with conspecific matings. The average fecundity of *S. humeralis* (1098 eggs per mated female) did not differ significantly from that of *S. discoideus* (1009 eggs), but oviposition lasted distinctly longer and showed different peak periods. In temperate areas adult *S. humeralis* emerge in late summer and undergo hibernation, but adults of the same species emerge in spring and undergo aestivation in the Mediterranean region.

As with their annual *Medicago* spp. hosts, species of the *S. humeralis* group seem to form a succession along the northern coast of the ancient Mediterranean Sea, indicating that they most probably evolved together over the whole region.

1 Introduction

Several species of the genus *Sitona* Germar (Col., Curculionidae) have an almost cosmopolitan distribution and have been reported to specifically attack both wild and cultivated *Medicago* spp. (Leguminosae). In widely different areas, Allen (1971), Lodos et al. (1978), Aeschlimann (1978, 1983b), Rotrekl (1981), Kain and Trought (1982), and Goldarena et al. (1984) in

particular have recorded economic damage to cultivated lucerne (*M. sativa* L.) as caused by various biotypes of the species *S. humeralis* Stephens. Following the accidental introduction of one of these biotypes into Australia, the CSIRO Division of Entomology, from their laboratory at Montpellier (France), initiated surveys to search for potential biological control agents in the Mediterranean basin that could be released in the infested areas of southeastern Australia.

HOFFMANN (1950) considered these various biotypes to represent merely "formes" or "variétés" of *S. humeralis*. However recent work (ROUDIER, pers. comm.; THEROND 1976; TEMPERE 1977; THOMPSON, pers. comm.; LODOS et al. 1978; DIECKMANN 1980) suggests that a number of species were in fact confused under that name. These authors based the distinction between these closely related species on taxonomic characters first defined by A. ROUDIER (pers. comm.) prior to 1975, the formal publication of which only occurred recently (ROUDIER 1980). The following three distinct species are now recognised to belong to the *S. humeralis* group, and occur on *Medicago* spp. in the Western Palaearctic region:

1. *S. humeralis* Stephens, which is present throughout the Western Palaearctic and reaches southwards to the northern coast of the Mediterranean Sea. ROUDIER (1980) commented on the morphological variation between specimens from different parts of the Mediterranean basin, but considered further separation unjustified.
2. *S. discoideus* Gyllenhal, which occurs together with *S. humeralis* in southwestern Europe. *S. discoideus* is the only member of this group present in North Africa, and is the correct name for the species accidently introduced into Australia and New Zealand.
3. *S. bicolor* Fahraeus, of which two subspecies are found together with *S. humeralis* i.e.: one *S. bicolor bicolor*, in the Balkans, and one, *S. b. concavirostris* Hochhuth (cf. ROUDIER 1980, pro errore!), from Turkey eastwards.

As suggested by ROUDIER (1980), the additional *S. inops* Gyllenhal will not be regarded here as a proper member of this group of species.

This paper discusses the present distribution of the species of the *S. humeralis* group, and their possible evolution, based on recent investigations on their host plant relationships and reproductive behaviour.

2 Materials and methods

2.1 Host plant relationship and distribution

During surveys carried out by CSIRO from 1973 onwards, using sampling techniques that have already been described in detail (AESCHLIMANN 1978, 1979), more than 60 000 individuals of the *S. humeralis* group of species have been collected from 603 different sites around the Mediterranean Sea. In analyzing the data obtained from the investigations in the western Mediterranean, AESCHLIMANN (1980) had to pool the results for the various species of the *S. humeralis* group into a single systematic category, because of the doubtful taxonomic status of *Sitona* species at that time. This material has now been entirely re-examined, and, together with the specimens sampled from 1981 to 1984 in the eastern Mediterranean, classified into the four valid taxonomic units now recognised to occur in southern Europe, North Africa and the Middle East. These weevils were associated with the following categories of host plants:

1. Cultivated perennial lucerne (*Medicago sativa* L.).
2. Annual, usually volunteer, medic species (in particular *M. arabica* L., *M. intertexta* L., *M. laciniata* L., *M. [illegible]alis* Rohde, *M. minima* L., *M. orbicularis* L., *M. polymorpha* L., *M. scutellata* L., *M. [illegible]ata* L. and *M. truncatula* Gaertner).

2.2 Mating and fecundity

Information on the mating behaviour and reproductive biology of *S. discoideus* and *S. humeralis* was obtained by rearing weevils of two different origins simultaneously under laboratory conditions.

In 1977, reproductive adult *Sitona* were collected towards the end of summer in lucerne fields of central and Mediterranean France by means of a sweep-net (AESCHLIMANN 1978). Fifteen pairs from each of the following localities were reared in an open insectary at Montpellier where photoperiod, temperature and humidity fluctuated with natural conditions:

A. Central France *S. humeralis* sampled from the Lusignan area (Vienne département).

B. Mediterranean *S. discoideus originating from Saint-Martin-de-Crau (French Bouches-du-*Rhône département), a site previously used for life-table studies (AESCHLIMANN 1979).

In 1978, reproductive adults were maintained under constant conditions (20°; 60 % R.H.; 12 h *photophase) in a laboratory. Weevils of the following origin, as well as their crosses, were* compared:

C. Newly emerged *S. humeralis* adults sampled from lucerne fields in the Giessen area (Land Hessen, German Federal Republic), and forwarded to Montpellier towards the end of September.

D. Late-instar larval *S. discoideus* extracted from the root system of annual medics in pastures near Montpellier at the beginning of spring. These were subsequently reared to adults using techniques described by AESCHLIMANN (1979) and AESCHLIMANN et al. (1984). Emerging weevils were identified, sexed, and placed individually with some fresh lucerne leaves in glass Petri dishes (10 cm diam.) for aestivation from April to September. These artificial conditions unfortunately seemed to result in a distinct reduction in vigour, particularly in male weevils, which also affected the number of observations that could be made on this species.

Weevils still available in September 1978 were divided into 4 sets of 15 pairs each (table 2), i.e. *S. discoideus* pairs, *S. humeralis* pairs, and the reciprocal combinations. Each pair was held in a glass Petri dish (10 cm diam.) together with some fresh lucerne leaves. The weevils' behaviour was observed daily. The foliage was changed once a week and the eggs produced by each female were collected at the same time. The eggs were counted, cleaned, and placed in polystyrene vials (30 mm diam.) for incubation in a large container at 20° and over 90 % R. H. At the end of the eclosion period, i.e. after more than two weeks incubation, eggs were examined with a binocular microscope. Any uneclosed, still intact eggs were dissected. Infertile eggs remained whitish translucent, and were rapidly covered by a dense fungal growth. Fertile black eggs were assigned to the following three categories: 1. normally eclosed, 2. with dead first instar larva inside the chorion, and 3. dark whole eggs showing no signs of development for reasons unknown (cf. AESCHLIMANN 1979).

3 Results

3.1 Host plant relationship and distribution

The occurrence on each host plant category of the various species of the *S. humeralis* group will be described in terms of "abundance" and "dominance" as previously discussed (AESCHLIMANN 1980; cf. also STEIN 1967). For a given weevil species, the criterion of "abundance" reflects the proportion, expressed in %, of adult specimens caught on host plants of each category (table 1).

The criterion of "dominance" is measured by the ratio between the number of individuals of each species and the total weevil numbers of all species of the genus found at one study site; 25 different *Sitona* species have been identified to date on various *Medicago* spp. during this study. This ratio is expressed as an index representing five class intervals (apart from 0 = complete absence), and ranging from 1 (for a species which comprises < 20 % of the total) to 5 (for a species which comprises > 80 % of the *Sitona* weevils sampled). The mean index is obtained for each taxon by averaging the indices over all study sites (table 1).

To illustrate more clearly the changing relationship between the various species of the *humeralis* group itself, the total individuals collected of each

Table 1. Abundance and dominance of the *S. humeralis* group of species

Weevil species	Area of investigation	Relative abundance (%) on lucerne	Relative abundance (%) on medics	Average index of dominance on lucerne	Average index of dominance on medics
S. b. bicolor Fahraeus	Greece	0.7	99.3	1.0	5.0
S. b. concavirostris Gyllenhal	Turkey, Cyprus, Syria and Iraq	96.4	3.6	1.4	2.0
S. discoideus Gyllenhal	SW Europe from Portugal to Italy, and North Africa	90.5	9.5	4.1	4.2
S. humeralis Stephens	S Europe and Middle East from Spain to Iraq	99.9	0.1	4.5	0.1

species over the whole of a climatically homogeneous area (from 1 to 25 sites per area), expressed as a percentage of all individuals of all species of the group present in the area, was calculated for each host plant category. These proportions are presented geographically in figs 1 and 2.

Table 1 demonstrates that high levels both of abundance, and of dominance were recorded for *S. humeralis* on cultivated lucerne, and for *S. b. bicolor* on annual medics in the Balkans. Relatively high indices of dominance were recorded for *S. discoideus* on both categories of host plants. On cultivated lucerne, however, high indices of dominance for this species were essentially confined to the drier zones in the southwestern part of the Mediterranean region (fig. 1), where *S. humeralis* was either totally absent (North Africa, Portugal) or remained rare (coastal Hérault and Gard départements in southern France). *S. humeralis* was virtually absent from annual medics in southwestern Europe (12 individuals only out of more than 20 000), whereas *S. b. bicolor* was found to be similarly rare on cultivated lucerne in the Balkans It was also evident (fig. 1) that the relative abundance of *S. humeralis* rapidly increased with the distance of the sites from Mediterranean climatic areas.

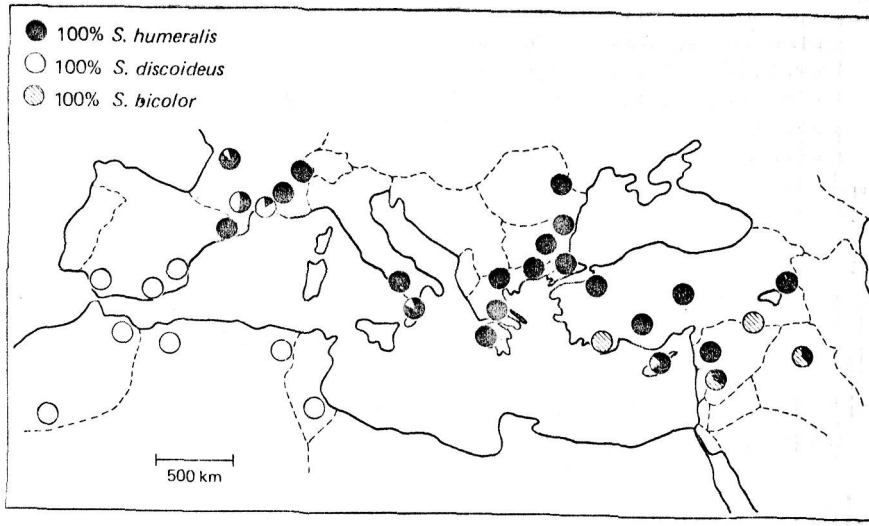

Fig. 1. Proportions of species of the *S. humeralis* group on *M. sativa* in the Mediterranean region. Each circle represents the average of all collections from an area