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A POPULATION OF THE HUNGARIAN ZEPHYR BLUE, *PLEBEJUS SEPHIRUS KOVACSI* (LEPIDOPTERA: LYCAENIDAE)

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ABSTRACT.– This study of one of the largest populations in Hungary of the protected Hungarian Zephyr Blue (*Plebejus sephirus kovacsi* Szabó, 1954), listed in the "Red Book" includes estimations of foodplant, larval numbers and life-history, chrysalis, individual numbers and activity of imagos, and nectar sources.

KEY WORDS: Apocynaceae, behavior, biology, bionomics, Caryophyllaceae, Cistaceae, Compositae, conservation biology, Cruciferae, Cyperaceae, endangered species, Ephedraceae, Euphorbiaceae, Europe, Gramineae, hostplants, Hungary, immatures, Iridaceae, Labiatae, larvae, Leguminosae, Liliaceae, nectaring, Orchidaceae, Palearctic, *Plebejus*, population dynamics, pupa, Rosaceae, Scrophulariaceae.

According to the Hungarian Red Data Book, the Hungarian Zephyr Blue (*Plebejus sephirus kovacsi* Szabó) is actually endangered. The known home occurrences lie in sandy regions which are, as is well-known, extremely vulnerable. The oldest known population thrives on Mt. Somlyó at the village of Fót. For this population no estimates of population dynamics and individual numbers have so far been made, and only observations on the actual size and state of the population are available. It appears, however, that one of the largest populations of individual numbers occurs not in this "classical" locality near Budapest, but on the Szentendre Isle, in the Danube, north of Budapest, the subject of the present study.

STUDY AREA AND MATERIAL

The series of national parks in Hungary will soon include additonal ones in the near future. One of them shall be the Duna-Ipoly National Park, comprising Mt. Pilis, Mt. Visegrád, Mt. Börzsöny, certain reaches of the river Ipoly, and Szentendre Island; the area of the latter is still in a natural—or nearly natural—state. Szentendre Is. has a characteristic landscape, with its sparse woods, but its invaluable feature is the sandhill area featuring the vegetation of the Kiskunság National Park of the plains of Hungary, or puszta. From the foot of the lowest hills, silver poplar-juniper associations expand uphill, surrounding the open sand puszta grasslands and meadows of special springtime beauty. Early in the spring, there are flowers of *Potentilla arenaria* (Rosaceae) and *Gagea lutea* (Liliaceae), with intermittent stands of *Carex humilis* (Cyperaceae). Beginning with the end of April, the brilliant blue and violet of *Muscari racemosum* (Liliaceae) and *Orchis morio* (Orchidaceae) appear, simultaneously with the yellowing sides of the hills due to *Iris humilis* (= *arenaria*) (Iridaceae), locally blossoming together with *Vinca herbacea* (Apocynaceae) of the puszta. Associated with them are *Alyssum montanum* (Cruciferae), *Astragalus exscapus* (Leguminosae) and *Ephedra distachya* (Ephedraceae). Slightly later appear groups of the equisite Hungarian pink *Dianthus pontederae* (Caryophyllaceae), accompanied by *Fumana vulgaris* (Cistaceae) and *Helianthemum ovatum* (Compositae). The sandhill region is the most picturesque in June, with a grassy sea of *Stipa pennata* (Gramineae) billowing in the gentle breezes. Subsequently, *Anthericum liliago* (Liliaceae) and *Verbascum phoeniceum* (Scrophulariaceae) adorn the hills, and by early autumn the violet masses of *Colchicum arenarium* (Liliaceae) cover the lower sections of the sand.

This area of peculiar beauty, which harbours many a protected puszta plant, is also the home of a number of protected animal species listed in the Hungarian Red Data Book: principally birds, reptiles and insects. Among the latter, the most important is the population of the Hungarian Zephyr Blue; its theoretical value (the fine levied for the wilful destruction of a specimen) is 50,000 Forints (ca. US $500), therefore one of the more highly valued protected species. As to its taxonomy, distribution and biology, we refer to papers by Bálint (1992), Bálint and Kertész (1990), and Fiedler and Bálint (1993); studies concerning these aspects of the species will not be discussed here, only our new and unpublished data on the biology of the species.

Our studies have been carried out continuously since 1988. The largest uninterrupted data series originates from the years 1988-1990; the basis of the present work relates mainly to these data (Fig. 1-3).

METHODS AND RESULTS

FOODPLANT

The plant association type in the habitat of *P. sephirus* is the sand puszta meadow (*Astragalo-Festucetum rupicolae*) (Fig. 4-5). The foodplant of the larva in these situations is *Astragalus ex-*

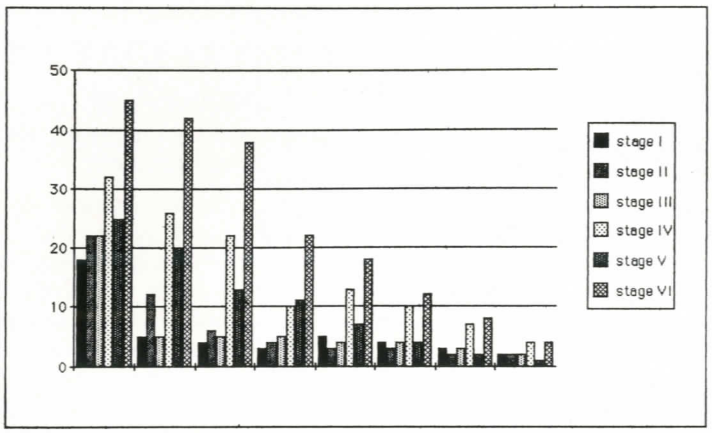

Fig. 1. Larva/100m² (7-14 May 1988)

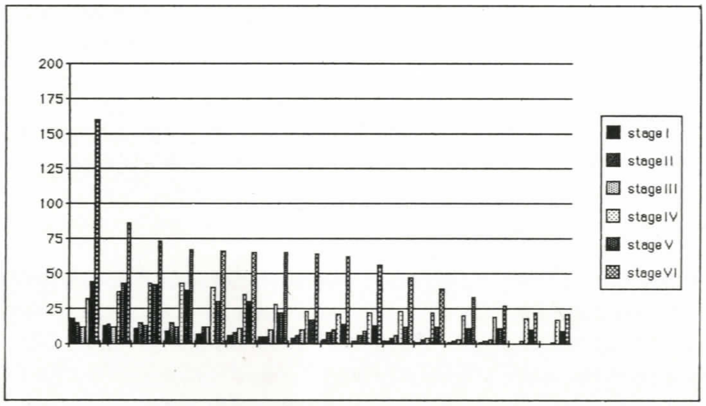

Fig. 2. Larva/100m² (19 Apr - 4 May 1989)

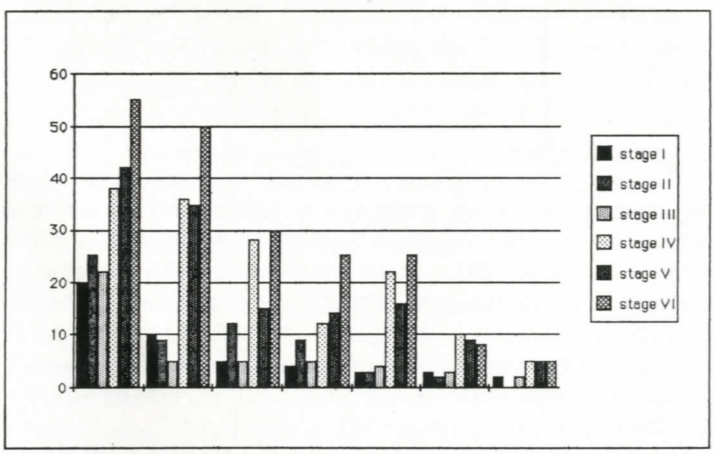

Fig. 3. Larva/100m² (8-14 Apr 1990)

scapus, which according to the Hungarian Red Data Book (Rakonczay, 1989) is also an endangered species. Our butterfly does not occur in any other sand association even if the foodplant is present there.

The female of the Hungarian Zephyr Blue oviposits by the end of May or in the first days of June, singly on the leaves of the *Astragalus exscapus*. The larvae hatch soon and feed on the surface and underside of the leaves. By the end of the vegetative period of the plant, they retreat into diapause and reappear mainly as second stage caterpillars next April, to feed concomitantly with the growth of the foodplant. They consume the fresh shoots, leaves, and later mainly the flowers. By the time of the fructification of the plants, the larvae are wholly developed. They retreat to pupate (Fig. 7) into the galleries of ants at the base of the host. The life-history of the species is thus manifestly associated with this one plant — only the nectar source flowers of the imagos being different — therefore the size and state of the stand is of prime importance to the population of this butterfly. Accordingly, our first examinations aimed at estimating the stand of the foodplant. And parallel with this, there was every opportunity to estimate also the individual numbers of the larval populations.

The stand of *Astragalus exscapus* in the study area

— The method of stand estimation:

We applied the so-called "quadrat" method as follows (Fig. 6): in 7 representative sites of the habitat we staked 10m x 10m sampling quadrats and marked individually the *A. exscapus* plants growing in the respective sample units. Every plant was given an identification number. The distribution of the foodplants was entered on the maps for the sampling areas and, thus, every foodplant could be identified even years later. The counting of the larvae was made parallel with that of the plants and their distribution noted.

— The size of the stand:

Sample quadrats	Foodplant
1	98
2	59
3	19
4	60
5	66
6	190
7	109

There occurred 601 *A. exscapus* plants in an area of 700m², most composed of several (5-30) rosettes of the basal leaves. Since the sampling sites represented about 0.1 per cent of the total area, there flourished, according to our estimate, at least 5500-6000 robust foodplants in it. A remarkable stand in every sense of the word! Its survival may be endangered by a contiguous growth of the woods (or even by afforestation), traffic (roads to riding paths), grazing (sheep, goats) and the sand quarries.

LARVAE

Life History

The circumstances mentioned above are further complicated by the fact that, similarly to other species of Blues, the larvae of this species are typically myrmecophilous, hence they are associated in every case with certain species of ants (Fig. 8). In exchange for consuming the larval exudates, the ants also function as a sort of "protectors" of the larvae and later of the pupae. At the time of the moulting and the pupation, the ants build for the larvae a minute pyramid made of sand and vegetation detritus at the base of the *A. exscapus* plants. Therefore there is practically no danger from predator incurred by the caterpillars of this lycaenid. An important, occasionally major, factor influencing individual numbers is weather conditions. During wet and cold periods, the great majority of the larvae perish in diverse fungal diseases. The effects of overgrazing, as well as treading (animal or human), may also be significant, because the leaves and even flowers of the foodplant are recumbent on the soil.

Individual numbers

An estimation of individual numbers of larvae was made

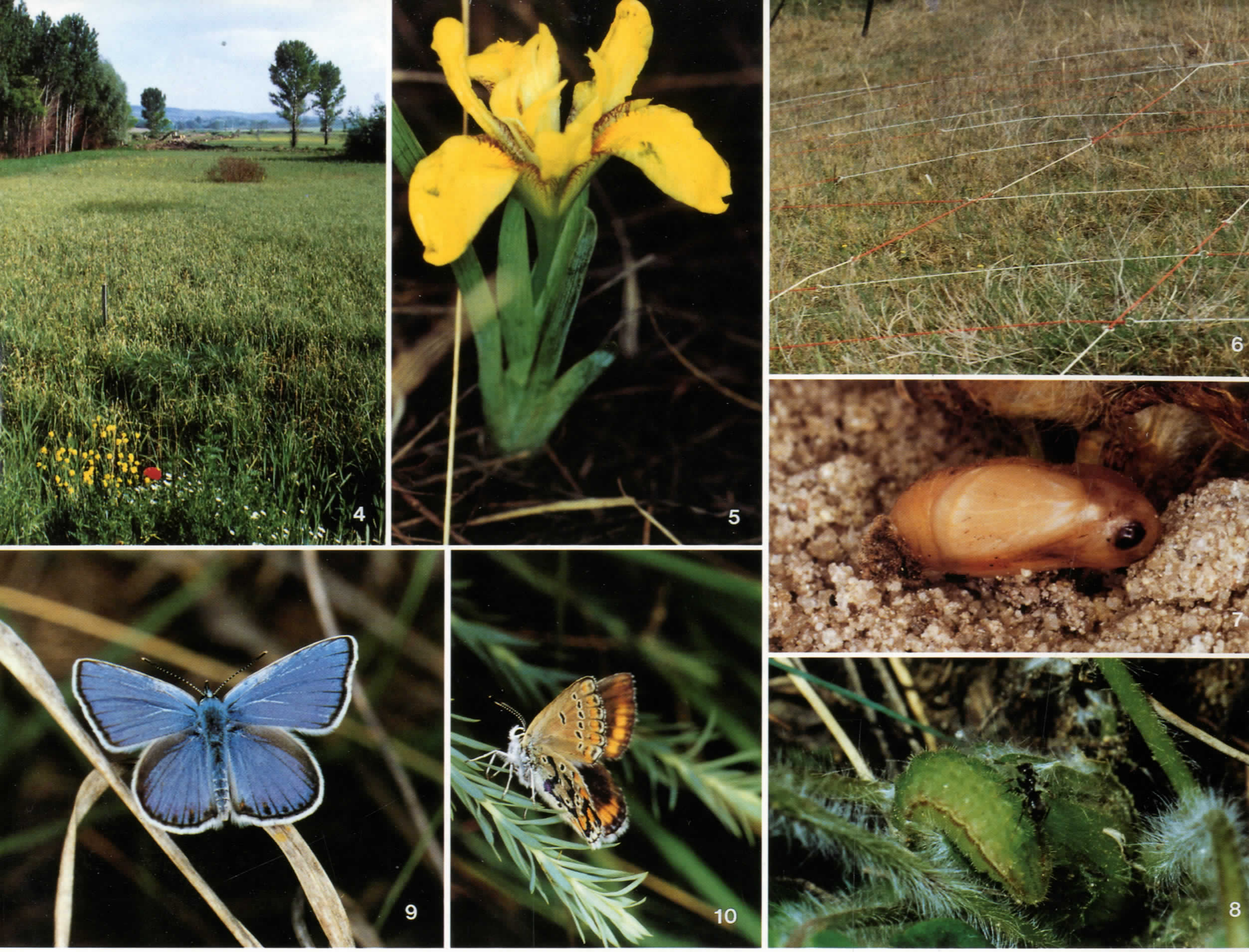

Fig. 4-10. *Plebejus sephirus kovacsi*: 4. Study area. 5. *Iris humilis* (Iridaceae). 6. The "quadrat" method. 7. Pupa. 8. Larva with ants. 9. Adult ♂. 10. Adult ♀ (marked).

simultaneously by the same method as used with the foodplants.

The estimated number of individuals in the spring:

Year	Larvae
1988	1560
1989	4210
1990	1450

The dynamics of the larval development can be traced in Fig. 1-3. As seen there, the larvae appeared and went to pupation gradually earlier during the years of observation, caused by the early advance of the spring weather. Unfortunately, larval instars 4 and 5 are more frequently exposed to the concomitant cold and wet weather conditions and the eclosion of the imagos begins in the even less favourable weather of the first half of May.

According to the breeding data and observations made in the field, the larvae molt every 5-7 days. Since most larvae hibernate in larval instar 2, those in stages 3, 4, 5 are present for 10-14 days on the foodplants. During this period the habitat needs increased protection owing to the inimical factors discussed above. [Note in proof: Fig. 1-3 should have only 5 larval instars noted; no known temporate polyommatines have 6 instars]

PUPAE

Pupation (Fig. 7) takes place as already described above, in the ant galleries opening at the base of the foodplants. This stage of development can, in view of the inherent difficulties, not be studied in the field. We succeeded merely in finding a few pupae on the site. Breeding data reveal that the pupation period takes 24-27 days. This was corroborated also by observations in the habitat.

VARIATIONS OF INDIVIDUAL NUMBERS

The number of individuals of the imagos was studied by the mark-recapture method through the application of individual marking. The data were elaborated by the Fischer-Ford statistical method.

The individual number of the imagos

It should be pointed out for the study years that the imagos appeared gradually earlier, similarly to the case of the larvae, and for the same reasons. The first specimens emerged about 20 May 1988, on 15 May 1989, and males were already on the wing before 10 May 1990. As to the number of individuals, the population was the most numerous in 1988: the estimated maximum individual number (N) of the males was 770 (mean survival rate being = 0.993), of the females 235 (= 0.890). In 1989, the data were 450 for the males (= 0.820), of the females 144 (= 0.870). In 1990, the data were 124 for the males (= 0.745) and 162 of the females (= 0.820). The maximum individual numbers represent — according to the statistical calculations and considering the average survival — the total size of the population, since at that time the earliest specimens are still living and the latest ones already on the wing.

As can be seen, the fact that the individual numbers of the *P. sephirus* population at that locality decreases is inferable also from the variations of the survival rate. Among others, the weather conditions in the years of study were responsible for this phenomenon. Another cause was the grazing by sheep and goats of the region, from the autumn of 1988 till May 1989 (= until flowering of *A. exscapus*). For this reason a great number of larvae may not have had sufficient amounts of food.

Population dynamics

In the spring of 1988, the estimated number of individuals of the larval population was 1560. According to our statistics, this gave rise to 770 male and 235 female butterflies (64% survival). The estimated number of eggs laid by these females (on the basis of a count of the eggs) was 11,650, representing about 50 eggs laid per female. Of this total the survival of 4,210 larvae can be rendered as probable on the basis of larval counts in the spring of 1989. They produced 450 male and 150 female imagos (14% survival), which is unequivocally ascribable to the effects of grazing. These females laid about 5,100 eggs, that is, 34 per female. In the spring of 1990, we estimated the presence of 1,450 larvae (28% survival), of which 20% (124 male and 163 female butterflies) emerged. All this indicates that by the effect of a single period (of a few months) of grazing (plus treading) the size of the population had continuosly diminished. In that year, 40 per percent fewer imagos emerged owing to the perishing of the larvae, followed by a further 30 per cent decreased oviposition by reason of the dearth of available nectar source plants. The outcome was that the size of the population decreased by 1990 to a third of its original size.

BEHAVIOUR OF THE IMAGOS

Parallel with the study of population dynamics, we have also examined the behaviour of the imagos (Fig. 9-10) as regards their activity and feeding habits.

Activity

The activity of specimens at capture:

Males/females: feeding, resting, flying, copulating, chasing

Females: ovipositing.

It can be stated in general that the males fly more than do the females. Their greater activity is corroborated by the fact that their average flight distance, calculated from the capture data, is 456m (= the total of distances of capture points), while that of the females is only 170.5m. The distance between the two furthermost points is 67.8m for the males, and 53.6m for the females. The daily average flight distance for males is 40.4m, and for females 35.1m.

Resting places of the imagos

The males choose principally grasses for their resting places (32%), while the females select the foodplant of the larvae (39%). The foodplant is the secondary resting place for the males (17%), and low grasses for the females (23%). For both sexes the third favourite resting place is *Dianthus pontederae* (males: 14.5; females 7.5%); the fourth in line is the *Stipa* spp. (males: 12.5; females: 7%); the fifth is *Alyssum montanum* (males: 4.5; females: 4%); and the sixth is *Thymus serpyllum* (2.5% for both sexes). Occasionally, they use other sites as resting places, including the ground, and some other plant species (about 14%). Except for *Astralagus* and the grass species, the plants listed above are also nectar sources for the imagos.

Nectar plants

The principal nectar plant is *Dianthus pontederae* (visited by 76% of the males and 69% of the females). *Alyssum montanum* stands in second place (8.5% for both sexes); in third rank is *Thymus serpyllum* (males: 6.5; females: 10.5%); the fourth is *Euphorbia seguiriana* (3% for both sexes). Occasionally, the flowers of some other plant species are also visited.

The flowering of *Dianthus pontederae* is of prime importance, because in its absence the females are compelled to search for other nectar plants and thus lay fewer eggs (cf. above).

SUMMARY

To sum up, a significant — and possibly the largest — population of *Plebejus sephirus kovacsi* Szabó, the Hungarian Zephyr Blue, inhabits the region of sand hills of the Szentendre Isle. The strict protection of this area is of special importance for the establishment of a future National Park. With regard to the study results, we can only recommend that in the management of this invaluable habitat, no anthropogenic activity of any kind be pursued, except possibly minor pasturing to keep it grassland.

We should like to especially emphasize that, during both the establishment of the protected areas and the subsequent elaboration of management procedures, the fundamental stipulation were a thorough knowledge of the populations of at least the species considered important from a conservation point of view. As regards the arthropod fauna this is by far not so as yet, although no rational and successful practical natural conservation can otherwise be conceived.

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