The estimation of size of a sample population of the owl-fly *Libelloides macaronius*

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Abstract. The abundance and density of a sample of the population of the owlfly, *Libelloides (=Ascalaphus) macaronius*, on two Karst meadows was estimated, using the Jolly-Seber method. In planning the research and field work, it was necessary to study the ecological and behavioural charachteristics of the insect. This research work serves primarily as a starting point for further investigation; in solving the basic problems concerning the method and their solutions, new difficulties and possibilies for further work arose, in the fileds of *Libelloides* ecology and ethology.

Introduction. The owlfly, *Libelloides (=Ascalaphus) macaronius* is a common neuropteran on warm, uncultivated Karst meadows in spring and early summer months. It is a great predator, that catches insects, especially coleopterans in flight (Gogala, 1992). It is on the endangered species list in Slovenia (Uredba o zavarovanju ogroženih živalskih vrst, ULRS, 57/93).

The owlfly is on acount of its appearance often mistaken for a butterfly. It is of medium size (2.5 –3 cm), with a hairy head and and large eyes, divided medially by a furrow. The antennas are long, terminally clubbed. The wings are black, with yellow spots (Wachmann and Saure, 1997).

The bipartite eyes are sensitive to ultraviolet light, and it is because of this charachteristic, that the owlfly has been the subject of numerous biochemical and electrophysiological investigations.

They are active exclusively during the day, the degree of their activity corresponding to the intensity

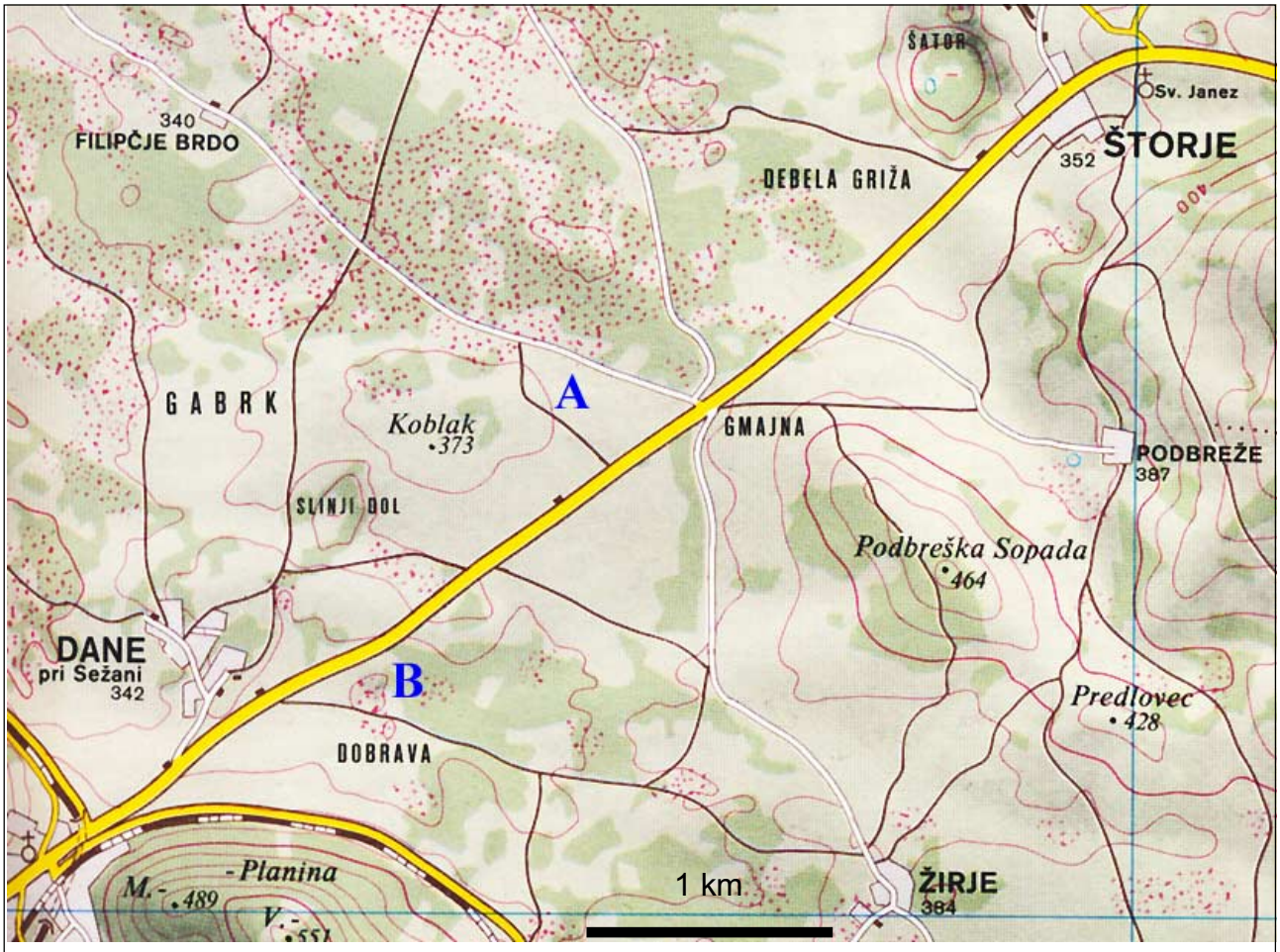


Figure 1:
Location of the two meadows near Štorje

of sunlight. They fly in sunny weather, when there is enough UV light, as soon as it becomes cloudy they sit on grass blades, with their wings spread, so they can quickly warm up for further flight (Gogala, 1988). They also spread their wings at sunrise, when they move higher up the blade on which they have spent the night. They fold their wings at night or when they feel threatened. In the latter case, they align their body with the grass blade and are scarcly visible in the grass. They turn along the axis of the blade, so that their ventral part always faces the potential predator. In our filed work, we had to take into acount all of the caharacteristics described above.

Because no research on the abundance of samples of owlfly populations has been done, we decided to test the Jolly-Seber method for open populations. The purpose of this research is to estimate the abundance of samples of the owlfly population on two Karst meadows and determine wether the two samples overlap. Also, to determine the ratio of males vs. females on each meadow and compare the results.

Materials and Methods

Location: two meadows SW of Štorje.

Relief: karst, 340-350 m a.s.l.

Area: each meadow 750 m2

Vegetation: characteristic karst vegetation, *Festuca ovina*, *Bromus erectus*. Shallow and dry soil on meadow A, deeper and moist soil on meadow B.

Field Work. The samplings were performed for five consequtive days, from 2.7. to 6.7. 2001, each morning from 6:30 to 7:45, by two people per meadow. The weather conditions were stable throughout the five days, the mornings were slightly cloudy, temperature between 17 and 19 °C.

The insects were handpicked from the grass blades, marked and returned to the same blade. The markings were waterproof and done with different coloured markers on each field.

Individulas on meadow A were marked with a dot on the left wing on the first day, on the second day they were marked with two dots on the left wing, on the third day they were marked with to dots on the left wing and one on the right, and on day four they were marked with two dots on both wings. The markings on meadow B were the same, only beginning with the right wing.

Statistical method. The Jolly-Seber metod is designed to estimate the abundance of open populations, which are constantly changing in size due to births, deaths, immigrations and emigrations (Krebs, 1989) (Appendix B). The mark and recapture samples are taken on consecutive sampling periods, with individuals being marked specifically according to the time (sampling period) of their capture. By definition, all individuals caught on the first day are unmarked. Individuals caught on subsequent days are either marked or unmarked. For marked individuals it is important to know when they were last caught. The data is then collected in a table and other varibales are thus defined.

Assumptions of the Jolly-Seber method. The method is used to study open populations, so no assumptions on the absence of recruitment or mortality need be made, as for closed populations. In the case of Jolly-Seber, the critical assumption is that the sampling be random.

1. Every individual has the same probability of being caught in the t^{th} sample, wether it is marked or unmarked.
2. Every marked individual has the same probability of surviving from the t^{th} to the $t+1^{st}$ sample.
3. Individuals do not loose their marks, and marks are not overlooked at capture.
4. Sampling time is negligible in relation to intervals between samples.

The data is then inserted into the mark and recapture table, from which we also obtain other variables (proportion marked, size of marked population, population estimate, probability of survival, number joining).

We can also calculate the transformed estimate, the variance and the confidence intervals.

Sex ratio. The sex of each caught individual was determined in order to calculate the ratio between males and females in the sample, for each day and for each meadow. The eventual statistically significant deviation of the ratio for each day was tested with the chi-squared test.

Table1: Mark and Recapture, meadow A

Area = 750m^2	Time of capture				
Parameter	**2.7.**	**3.7.**	**4.7.**	**5.7.**	**6.7.**
1		4	3	1	2
2			2	1	0
3				3	0
4					3
Total marked (mt)	0	4	5	5	5
Total unmarked (ut)	14	9	7	9	6
Total caught (nt)	14	13	12	14	11
Total released (st)	14	9	11	14	10

Table3: Mark and Recapture, meadow B

Area = 750m^2	Time of capture				
Parameter	**2.7.**	**3.7.**	**4.7.**	**5.7.**	**6.7.**
1		7	2	1	0
2			7	8	3
3				10	7
4					14
Total marked (mt)	0	7	9	19	24
Total unmarked (ut)	15	29	28	21	16
Total caught (nt)	15	36	37	40	40
Total released (st)	15	33	32	36	39

Table 2: Other variables calculated from Table 1

Sample	Alphat	Mt	Nt	phit	Bt
1	0.067	0.0	0.0	1.357	53.2
2	0.357	19.0	53.2	0.708	2.0
3	0.462	17.0	36.8	0.543	11.8
4	0.400	12.5	31.3	-	-
5	0.500	-	-	-	-

Table 4: Other variables calculated from Table 3

Sample	Alphat	Mt	Nt	Phit	Bt
1	0.063	0.0	0.0	0.825	57.2
2	0.216	12.4	57.2	0.808	74.0
3	0.263	31.0	117.8	0.809	-1.7
4	0.488	43.7	89.5	-	-
5	-	-	-	-	-

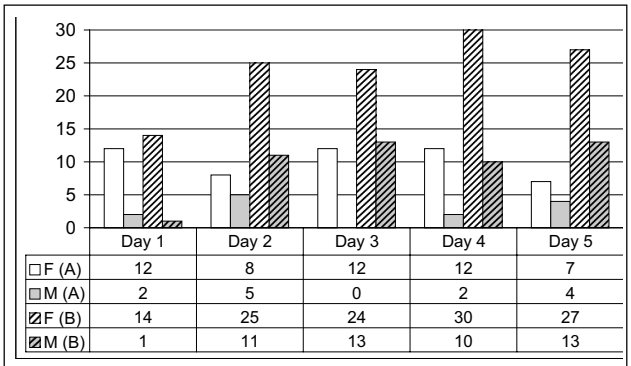
Table 5: Estimation of the abundance of population samples and sample density, meadow A

Sample	N_{sp}A	NA	N_{zg}A	G_{sp}A	GA	G_{zg}A
1	-	-	-	-	-	-
2	25	53	100	3.3	7.1	13.3
3	16	37	90	2.1	4.9	12
4	16	32	88	2.1	4.2	11.7
5	-	-	-	-	-	-

Table 6: Estimation of the abundance of population samples and sample density, meadow B

Sample	N_{sp}B	NB	N_{zg}B	G_{sp}B	GB	G_{zg}B
1	-	-	-	-	-	-
2	39	53	94	5.2	7.1	12.5
3	63	118	186	8.4	15.7	24.8
4	56	90	123	7.5	11.9	16.4
5	-	-	-	-	-	-

Legend:
alphat (α_t)- proportion marked
Mt – size of marked population
Nt – population estimate
phit (ϕ_t) – probability of survival
Bt – number joining
N – estimate of population size
N_{sp}, N_{zg} – upper and lower estimate boundary at 95%
G – directly calculated population density (number of individuals per 100m^2)
G_{sp}, G_{zg} – upper and lower population density boundadry at 95% confidence



	Day 1	Day 2	Day 3	Day 4	Day 5
□F (A)	12	8	12	12	7
▒M (A)	2	5	0	2	4
▨F (B)	14	25	24	30	27
▨M (B)	1	11	13	10	13

Figure 2:
Number of individuals caught each day on meadows A and B

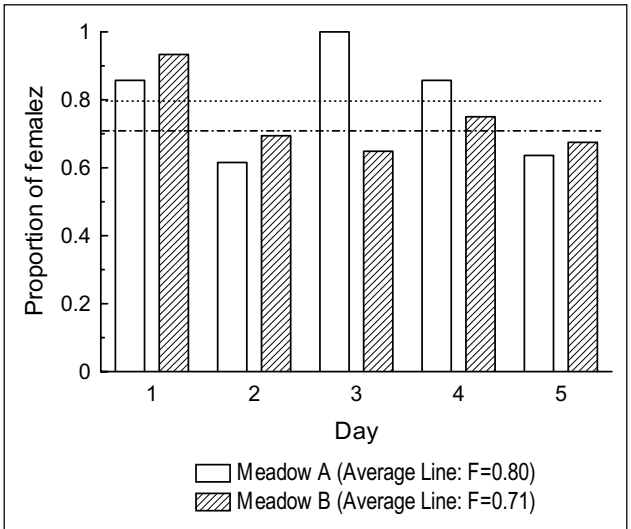


Figure 3:
Sexual structure of samples

Discussion. In planning this research, the scarcity of refrences was evident, from the viewpoint of the behaviour of the owlfly and from the viewpoint of the method to be used in estimating the abundance of insect populations. As mentioned earlier, the majority of research performed was biochemical or electrophysiological, very little is known about the life-cycle (Wachmann and Saure, 1997), and even less about the behaviour and ecology of the species. In carrying out the chosen method, we had to adapt to the owlfly's daily cycle and to given environmental conditions. Thus we feel it is important, that along with the obtained numerical results, we mention the working method and solutions that would improve the method in the future.

With the Jolly-Seber method we obtain several values for the abundance of the population sample – one for each sampling period. The best estimates are given by samplings done in the middle of the investigation. Because there were only five sampling days, all three sampling periods are exactly in the middle of the investigation. However, it is evident from the obtained results, that samplings 3 and 4 are in accord, and the second sampling deviates in both cases. In comparing the abundance and the density of the population sample, the values for the second sampling are almost identical, whereas for the other two samplings, the values are three times greater in meadow B. There was no contact between

the two population samples of both meadows.
The sex ratio results show that the females are more numerous, representing around three quarters of the population. Testing with the chi-square test showed that the ratio between caught males and females did not significantly deviate from the total sex ratio on each meadow separately.
The problems that arose during the research, and their solutions, are concerned with the markings of the individuals, the sampling method, the time, season and the sampling location.
Alternative forms of markings could be tagging of individuals, tags however may both fall off and impede flight and movement and thus violate assumptions 1, 2 and 3 of the Jolly-Seber method. In the future, markings of individuals could be done at least in some research meadows, in order to study the movement of individual animals, along with the estimation of population size. The morning was chosen as the sampling time, because the animals were not warmed up yet and could not fly away. Their being unable to fly also enabled us to perform a systematic search through the field. The animals were hand-picked of off stalks and marked. The use of the catcher was avoided, because it may have damaged the animal and thus lowered its chances of survival. Two people were performing the systematic sampling, however one person alone could have done the work. This way, the trampling of the meadow could have been avoided or at least decreased. The trampling of the meadow could have caused unnatural deaths, or more likely increased the rate of immigrations from the research location. This, however reamins to be proven, by comparing the sample population abundance in a meadow with only one person performing the work and a meadow with two or more researchers. The owlfly appears on karst meadows in late spring, this research, however was carried out at the beginning of july. Therefore, the sampling season also represents a problem. In the future, comparisons between seasons could be done. The sex ratio is highly in favour of the females, which carry or lay eggs in the summer months. The caught males were all in a more or less bad condition (torn wings, fading colour), signaling their decline. Thus this method could be carried out throughout the owlfly season, noting the fluctuations of populations as a whole and also of both sexes. A botanical overview of the main plant species present was made. The only obvious difference between the two meadows was that meadow A was becoming more forrested, with a fairly high number of small bushes.

Conclusions. The owlfly inhabits warm, uncultivated Karst meadows in spring and early summer months. It is active in sunlight, with specific behavioural and predatory patterns due largely to its UV sensitive eyes. They are inactive in early morning, in cloudy weather and at night, not only because of the lack of light, but also because of lowered temperatures. When inactive, they sit on grass blades.
The behaviour of the insect is important in choosing the method to estimate the abundance of the population and planning the research. The abundance and density of an open population can be estimated with the Jolly-Seber method. In the future, the insects could be marked individually, which would enable us to monitor their movement within the field and migartion to other locations.
The results obtained give a rough estimate of the abundance of populations in two meadows, that differ. The significance of this difference can not be established based on a single investigation. In order to obtain more reliable results with a more general estimate, more research should be carried out at different locations, throughout the owlfly season. Studies of adjacent meadows, divided by bush/tree lines should be performed, in order to investigate the rate of migrations of the owlfly to and from certain locations. Also more meadows, in different Karst regions, could be included in the research in order to recognize the distribution and spread of owlfly populations. This method could be carried out throughout the owlfly season, noting the fluctuations of populations as a whole and also of both sexes.
This research work serves primarily as a preface to studying the behaviour and ecology of the owlfly. It is a trial of the Jolly-Seber method for the chosen species, which was in itself successful and at the same time opened new problems and guidelines for future research. For a more detailed understanding of the ecological role of the owlfly, other experts taking part in the study should be entomologists, zoologists and ecologists, specialized in grassland and field ecosystems. Also, more precise botanical and phytocenological studies of the fields inhabited by the owlfly, should be made.

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