Population size of the largest population of *Leucorrhinia albifrons* in the Czech Republic (Odonata: Libellulidae)

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Zusammenfassung

Untersuchungen zur Populationsgröße der größten Population von *Leucorrhinia albifrons* in Tschechien (Odonata: Libellulidae) – *Leucorrhinia albifrons* ist eine in West- und Mitteleuropa sehr verstreut vorkommende Art. Zumeist bildet sie nur kleine Populationen aus, die daher ein großes Aussterberisiko beinhalten. Daher ist der Schutz großer Populationen der Schlüssel zum Erhalt der Art. In dieser Studie untersuchten wir die Populationsgröße und andere Populationsmerkmale von *Leucorrhinia albifrons* am Komáří-Teich. Wir kombinierten die Mark-Release-Recapture-Methode (Markierung von 726 adulten Tieren) und Exusivensuche (1.564 Exemplare), um die genaue Populationsgröße abzuschätzen. Die Wiederfangrate war sehr gering. Es konnte eine Lebensdauer von bis zu 41 Tagen nachgewiesen werden. Nach unseren Ergebnissen umfasst die untersuchte Population 15.000–28.000 Tiere, was die größte nachgewiesene Population in der Tschechischen Republik ist. Dennoch handelt es sich um eine isolierte Population, die bei einer Änderung der Landnutzung bedroht sein könnte.

Souhrn

Studie početnosti největší populace *Leucorrhinia albifrons* v České republice (Odonata: Libellulidae) – Vážka běloústá (*Leucorrhinia albifrons*) je druhem západní a střední Evropy. Její výskyt je velmi roztroušený, většinou se jedná pouze o malé nestabilní populace. Ochrana velkých a stabilních populací je proto v těchto oblastech pro zachování druhu klíčová. Cílem našeho výzkumu bylo zjistit velikost populace vážek na lokalitě Komáří rybník v západních Čechách. K výpočtu populační hustoty jsme použili mark-release-recapture metodu a sběr exuvií. Celkem bylo označeno 726 jedinců a nalezeno 1564 exuvií. Byl za-

znamenán nízký počet zpětně odchycených jedinců (47 ex.). Největší zaznamenaná délka života byla 41 dnů. Z našich výsledků vyplývá, že velikost populace vážek *Leucorrhinia albifrons* na Komářím rybníce může dosahovat 15–28 tisíc jedinců, což z ní dělá nejpočetnější populaci v České republice. Každopádně se jedná o izolovanou populaci, která může být ohrožena změnou využití rybníka nebo výkyvem přírodních podmínek.

Abstract

Distribution of threatened dragonfly *Leucorrhinia albifrons* is very scattered throughout Western and Central Europe. Most of them are small populations that are at high risk of extinction, therefore protecting large populations is key to maintaining the entire species in these regions. In this study we investigated population size and other population characteristics of *Leucorrhinia albifrons* at locality Komáří pond. We combined mark-release-recapture method (marking 726 adults) and exuvia sampling (1,564 specimen) to estimate precise population size. Very low recapture rate was recorded and life span was up to 41 days. According to our results the investigated population comprises 15,000–28,000 specimens, which is the largest detected population in the Czech Republic. Nevertheless, it is an isolated population that may be threatened by a change of land use management or accidental disturbances.

Introduction

Leucorrhinia albifrons (Burmeister, 1839) is palaearctic species, with Eurosibiric faunistic distribution. The species is widespread in northeast Germany, northern Poland, the Baltic States, southern Finland, and part of Sweden. It is only scattered in Russia, although it seems to be well present in the southern Ural. Contrarily, it is very rare and has strongly declined in the west and the south of its area. The northern populations are frequently large, but to the west and south, populations get small and localized to small sized habitats. It has strongly declined in Germany, the Netherlands (one population left), Austria, Switzerland, France, Czech Republic, Slovakia, and Ukraine (two localities). It is rare in these countries and most of remaining populations are isolated (Clausnitzer 2020; Mauersberger pers. com.).

On account of *L. albifrons* being generally rare in its range and having experienced a severe decline in western Europe, the species is one of the protected dragonflies listed in the Habitats Directive (FFH). In the IUCN red list it is classed as being of Least Concern (Clausnitzer 2020), but in the European Union it is identified as Near Threatened (Kalkman et al. 2010). In the Czech Republic it belongs to Vulnerable Species and is protected by law (Dolný et al. 2017).

Leucorrhinia albifrons inhabits a wide range of lakes, ponds, pools, and peaty lakes, preferring shallow ones in forests with abundant floating and emergent vegetation (Dijkstra 2006). In the Czech Republic it inhabits mainly secondary habitats such as peaty ponds, sand pits or other oligotrophic ponds (Dolný et al. 2007). *Leucorrhinia albifrons* prefers habitats that are unshaded but protected by

surrounding forest. It is a relatively thermophilic species preferring shallow waters without fish. It is relatively common in acidic waters, which are naturally unsuitable for fish, or in habitats with abundant floating stands of peat with emergent vegetation, which gives shelter against fish predation (Dolný et al. 2007; Clausnitzer 2020).

The occurence of *L. albifrons* in the whole area of the Czech Republic is very scattered to isolated populations, while in some big areas is missing all together (South-west Bohemia, North Moravia). Only six populations are considered as long-term (daily estimates more than 20 individuals, NCA CR 2021).

Odonates are convenient model organisms for mark–recapture studies for many reasons (Cordero-Rivera & Stoks 2008). In this study we aim to estimate the population size and other population characteristics. Such knowledge can be important for the optimalization of management of the locality. Moreover, it can serve as model locality for the conservation of *L. albifrons* in different locations.

Study site

The study was undertaken at one peat bog pond in the chain of two ponds called Komáří rybníky, Krásno nad Teplou district, 9 km southeast of Sokolov, West Bohemia (WGS 84: N 50.1216, E 12.7466, approx. 670 m a.s.l., Fig. 1). The pond's area is

Figure 1. Study site, 30-vi-2019. – **Abbildung 1:** Untersuchungsgewässer, 30.06.2019, Photo: MV

1.87 ha and maximum depth about 2.5 m. It is supplied by a small un-named forest stream and water flows out to the stream Komáří potok. The origin of the pond is associated with metal mining in the Horní Slavkov region in 16th century. The pond serves for recreation, with no fish production for at least the last decade.

Most of the shore slopes gradually with scattered littoral vegetation, except at the dam, where the shore is steep. Vegetation at the rest of the shore is formed mainly by floating sweet-grass *Glyceria fluitans* and only sporadically by bottle sedge *Carex rostrata* and blister sedge *C. vesicaria*. Nearby the inflow, floating bog moss *Sphagnum* sp. cover most of the shores. Water floating plant communities are not present. The water is peaty, clear and with a visible sandy bed. The pond is surrounded by extensive spruce forest.

The study population of *L. albifrons* was discovered accidentally in 2009. An intensive monitoring was conducted in 2010. The population of *L. albifrons* appeared to be very numerous and a protected area – National monument (NM) was established there in 2017.

Method

In the Czech republic, first imagines of *L. albifrons* emerge from late May until the third week of June, while the period of imago activity lasts up to mid-August (Dolný et al. 2007). The research was conducted during the entire imagines emergence period, which was from 14 June till 21 August 2019. The captures were made once in 3–4 days. We chose days with optimal weather conditions where possible and monitored in the daytime between 10 a.m. to 5 p.m. The researcher walked slowly alongside the shoreline and waded in the water. *L. albifrons* individuals were captured using entomological nets while in flight, perched on vegetation or copulated in tandem. The captured individuals were marked using oil-based permanent markers, handled very carefully, and released immediately. Only males of *L. albifrons* were marked. Each individual obtained a unique code (a combination of marks) allowing visual recognition even when the animal was perching. Each of four marking researchers used a different color. We used marks on 12 positions on the wing (Dolný et al. 2016), three dots could be made per wing (at the end of the wing, in the middle and near the body). The combination of dots in each marked individual can be referred to the numerical code (for example 1-2-3 means 3 dots on first wing, etc.). The data about observed numbers of newly hatched imagines and tandems were also recorded.

We analysed mark-recapture data to evaluate the demographics of the *L. albifrons* population using the constrained linear model in the MARK program, version 6.1 (Cooch & White 2012). In MARK, we applied the Jolly-Seber method and POPAN parameterization for open population parameter estimates. This model estimates three primary parameters: Q_i (residence), which combines the probability of an animal surviving between occasions i and i+1, and thus essentially combines mortality and emigration rates; p_i (catchability); and $pent_i$, which is the

probability of entering the population (a combination of birth and immigration). The primary parameters can be independent of both sex and time, can be dependent on time in a factorial (t), linear (t_{lin}), or polynomial (t^2 lin+lin) manner. Sex-time interactions can be either multiplicative (g*t) or additive (g+t). Complex polynomial models were calculated and subsequently simplified. Model selection was based on an information-theory approach, using corrected Akaike information criterion (AICc). The model with the lowest AICc value was chosen as the final model. Models that had DAICc ≤ 2 in comparison to the best model were considered as equivalent.

Longevity was computed as the difference in day between first and last capture. No distinction was made between mortality and emigration.

Additionally, exuviae were collected along the whole shoreline from the 14 June till July, once a week. The researcher walked and waded along the shoreline vegetation and searched for exuviae. These exuviae were collected to prevent double counting.

Results

The 20 visits were made within 10 weeks. Five visits were excluded from the later analysis because of bad weather conditions or low numbers of imagines at the beginning and end of the season (tenerals were too fragile to mark). A total of 726 males were marked, while only 47 males (6,47%) were recaptured (Table 1). The population size was estimated to 8,610 (6,342–11,687, SE = 1,351) males per season.

When excluding individuals that were never seen again, the mean longevity of recaptured males was 13.7 days. The oldest one was recaptured after 41 days (marked on 19 June and recaptured on 30 July). Only three individuals were recaptured twice; none of them were recaptured more than this.

We collected 1,564 exuviae in total (Table 2). The first visit on 8 June did not reveal any activity of *L. albifrons*. Collecting of exuviae started on 14 June (when only tenerals were recorded) and ended on 21 July (when very few exuviae were found). Most of the population emerged during the first two weeks of the emergence period. The most productive shoreline was the small, sunny, shallow bay with vegetation (15% of the shoreline), where more than 52% of exuviae were collected. In this area of 100 m^2, the maximum of 326 exuviae and average of 127.4 exuviae per visit were found.

Other Odonata species with reproductive status recorded at the locality were in order of frequency of appearance: *Enallagma cyathigerum*, *Libellula quadrimaculata*, *Cordulia aenea*, *Pyrrhosoma nymphula*, *Anax imperator*, *Aeshna grandis*, *Coenagrion puella*, *Erythromma najas*, *Leucorrhinia dubia*, *Somatochlora metallica*, *Sympetrum danae*, *Coenagrion hastulatum*, *Aeshna cyanea*, *Cordulegaster boltonii*, *Lestes sponsa*, *Aeshna juncea*, *Orthetrum cancellatum*, *Calopteryx virgo*, *Sympetrum sanguineum*, *Calopteryx splendens*, *Sympetrum vulgatum*, *Orthetrum coerulescens*,

Table 1. Numbers of male imagines captured and juveniles and tandems observed in each visit. Shaded data were excluded from analysis. – **Tabelle 1:** Anzahl der gefangenen männlichen Imagines sowie der beobachteten Jungtiere und Tandems bei jedem Besuch. Schattierte Daten wurden von der Analyse ausgeschlossen.

Date	Captured	Recaptured	Juveniles	Tandems
14.6.2019	1	0	20	0
19.6.2019	49	0	80	0
23.6.2019	45	0	20	6
26.6.2019	37	1	10	12
30.6.2019	32	2	8	30
3.7.2019	64	1	-	22
7.7.2019	2	0	5	4
10.7.2019	55	4	-	19
14.7.2019	0	0	2	4
17.7.2019	48	2	-	12
22.7.2019	87	2	0	50
25.7.2019	86	7	0	50
30.7.2019	31	2	-	9
1.8.2019	81	4	0	40
4.8.2019	29	4	0	16
8.8.2019	44	6	0	15
13.8.2019	11	7	0	8
18.8.2019	2	0	0	2
21.8.2019	22	5	0	13

Table 2. Numbers of exuviae collected at study site 2019. – **Tabelle 2:** Anzahl der gesammelten Exuvien.

Date	14.6.	19.6.	23.6.	30.6.	7.7.	14.7.	22.7.	Total
Exuviae	53	257	453	632	95	12	12	1564

Libellula depressa, *Sympetrum flaveolum*, *Chalcolestes viridis* and *Ischnura elegans*. Incidentally *Gomphus vulgatissimus* and *Crocothemis erythraea* were also recorded.

Discussion

Estimates have been generated for male imagines only. According to the literature the sex ratio of *L. albifrons* was female dominated: 43.4% males in Sweden (N =

182, Johansson et al. 2005), 42.1% males in Austria (Staufer & Pöchhacker-Florian, 2018). Using a simple conversion to the whole population size generates a total number of imagines between 15,000 to 28,000 individuals. Similar results were obtained in a previous study in 2010 (unpublished data).

An interesting insight can bring a comparison between different methods of sampling. For example, on 23. June, only 65 imagines were noticed at the site (45 imagines captured and 20 tenerals observed), while 763 exuviae were collected up to that date (so evidently emergence took place at the site) and the number of 1,365 (in the range of 860–2,166) imagines was the result of the POPAN model. Similarly, on 21. July, 89 imagoes were observed ,1,564 exuvias collected since that time and 2,644 (in the range of 1,803–3,879) imagines counted.

Despite of the considerable sampling effort, the total number of exuviae obtained by sampling was relatively low. It is therefore evident that the estimates of the two methods are difficult to compare. This may be related mainly to the lower detectability of exuviae (Bried et al. 2011) or due to its low durability (Rychla 2021).

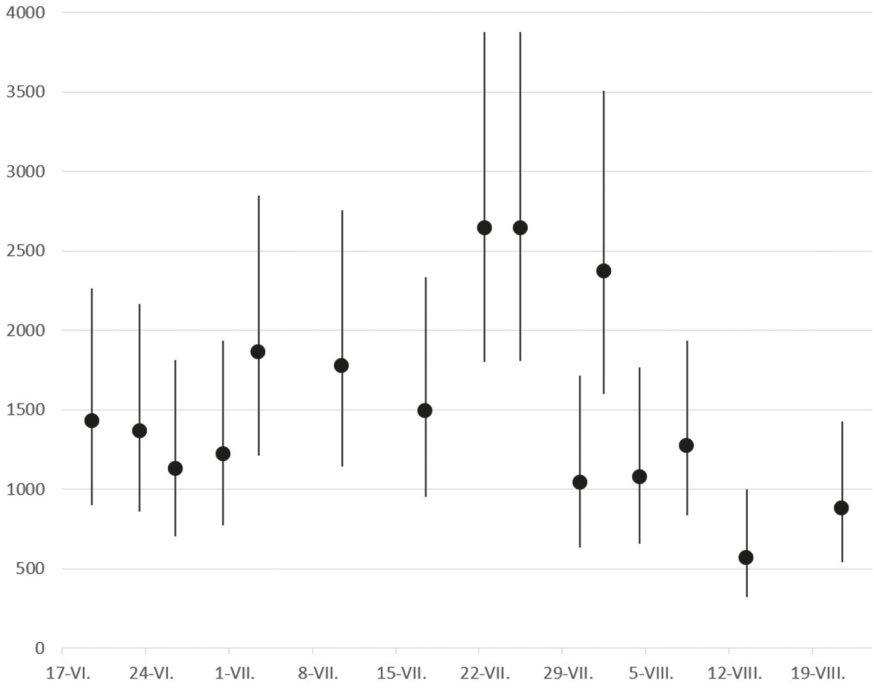

Figure 2. Daily estimates of *L. albifrons* male population size with Standard-error according to the POPAN model. – **Abbildung 2:** Schätzung der Populationsgröße der Männchen von *L. albifrons* pro Fangtag mit Standardfehler nach dem POPAN-Modell.

Remarkably there is a big difference between the number of observed male imagines at the locality and the results of the POPAN model. It is suggested that the daily density of male dragonflies by water is regulated by their reproductive behaviour (Moore 1953) and that the use of non-water habitats in dragonflies can be much extensive than was assumpted (Dolný et al. 2014).

Although our data of longevity of recaptured individuals can be biased by low recapture rate, the obtained data are in accordance with the literature for comparable species. The longevity of odonates has been reviewed by Corbet (1999). He found that the average longevity of Anisoptera is 11.5 days, with maximum longevities in the range of 17–64 days and 15–77 days respectively. Michiels & Dhondt 1989 found an average longevity of males *Sympetrum danae* of 12.85 days in natural and 27.9 in semi-natural conditions with a maximum of 41 and 54 days.

Despite the fact that it is a very large population, the nearest population of *L. albifrons* is 29 km away and it consists of few individuals. Other findings are proved as random and unique (NCA CR 2021). According to these indications, it is an isolated population (Simpkin et al. 2000), which in the future could serve as a source population for the settlement of suitable freshwater habitats in the area. Its threat is mainly related to the fact that it is an artificial pond, and any changes in management can have fatal consequences for the monitored population (Dolný et al. 2014). The main threat is potential fish farming, bad condition of the dam and changes to the pond due to the effects of long term drying and changes in local water condition.

Conclusion

Our findings suggest that this population of *L. albifrons* at Komáří rybník has a very large size and can be vital in the long term, if the current optimal conditions at the locality are maintained. Enhancing the protection of the locality is crucial for the protection of the species in the Czech republic. The great importance of preserving habitat conditions at Komáří rybník was demonstrated.

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