Structure and size of a threatened population of the False Ringlet *Coenonympha oedippus* (Fabricius, 1787) (Lepidoptera: Nymphalidae) in Hungary

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Abstract

Butterflies react sensitively to changes in habitat quality. Their diversity has been decreasing in Europe due to habitat degradation, fragmentation, management changes and climate change. The False Ringlet (*Coenonympha oedippus*) is one of the 59 butterfly species protected in Hungary. The species occupies marshy meadows dominated by *Molinietum* vegetation. Besides drainage, inappropriate management can also deteriorate these habitats. Nowadays the butterfly remains present in a habitat complex in Hungary, at the north-western part of the Hungarian Great Plain and a newly (2009) rediscovered population in north-western Hungary. Mark–release–recapture method was used to estimate the population size and describe population structure in a 0.65 ha habitat patch from 2005 to 2007. The population size did not fluctuate during the 3 years; the total estimated number of individuals ranged between 130 and 270. The survival probability was 0.81–0.84/day in the case of males, in females 0.70–0.89/day. The catchability was between 0.27–0.53 in males and 0.22–0.38 in females. The structure of the population indicates that the False Ringlet is a sedentary butterfly species, with low dispersal ability. In the study area, drainage seems to be the main threatening factor for its habitat. The studied population has recently moved to neighbouring lower parts of the habitat patch, because the formerly occupied part of the habitat patch had been desiccated and the vegetation had been changed. For the long-term survival of the species at this habitat patch the drainage should be inhibited, while in other habitat patches around, the control of invasive plant species is inevitable beside habitat restoration.

Keywords: False Ringlet, *Coenonympha oedippus*, Hungary, MRR, population size

Introduction

The diversity of butterfly species has decreased in large volume in Europe, some surveys show even larger decrease, than in the groups of bird or plant species (e.g. Thomas et al. 2004). Similarly, the threat status of the species decayed more strongly among butterflies (Van Strien et al. 2009). The main reasons of butterfly diversity decline in Europe are habitat fragmentation (Ehrlich 1988, Maes & Van Dyck 2001), habitat loss (Pullin 2002) and changes of land management (Skórka et al 2007). Due to their sensitivity to temperature, climate change has also enhanced effect on the diversity of butterflies (Lewis & Bryant 2002; Settele et al. 2008).

Agricultural landscapes are affected by either intensification (Thomas 1995) or abandonement, both of which can diminish formerly suitable butterfly habitats (Strijker 2005). The succession after abandonment and the colonization of invasive alien species can decrease the diversity and abundance of native species (Skórka et al. 2007). Species inhabiting wet meadows are among the most endangered ones, because the area of those habitats is declining rapidly as they can be easily converted to agricultural landscapes (Maes & van Dyck 2001, Maes et al. 2004). Drainage is widely recognized as the most important threatening factor for wet meadows, which can affect large areas throughout water table equalization (IUCN 1993).

The False Ringlet (*Coenonympha oedippus*) inhabits wet meadows dominated by *Molinia* species. It is one of the most endangered butterflies in Europe; it is considered as nearly threatened by IUCN (2008) and listed in Annex II and IV of Habitats Directive and Annex II of the Bern Convention. The geographical distribution of the species is highly fragmented and colonies are isolated (Van Helsdingen et al. 1996, Kudrna 2002). The size and distribution of the European populations are declining at several localities and seem to be stable at others, while limited information is available about the populations in Asia.

One of the first publications about the species describes its weak, jumping flight, which is related to the supposed weak dispersal ability (Seitz 1906). The first description of the ecological requirements of the species is from France. Lhonore & Lagarde (1999) mention the problems of fragmentation, isolation and other threatening factors, which endanger the long-time survival of the butterfly. The size and structure of a Slovenian population was studied with mark–release–recapture method by Čelik (2004) from 1995 to 1996. The maximum density of the butterflies was 145 individuals/ha in a 1.27 ha habitat patch, which in contrast to other European habitats consists of areas of *Brachypodium* grasslands and shrubs. Survival probability was 0.77/day for males and 0.80/day for females in the second year (Čelik 2004).

In Hungary, there were several suitable habitat areas for the species earlier, e.g. remarkable populations were described from the Hanság, Kiskunság, Óbuda regions and from Szár according to specimens in the collection of the Hungarian Natural History Museum (Bálint et al. 2006). Due to large-scale drainage in the Kiskunság and Hanság, several wet meadows disappeared, hence their vegetations have been changed (Molnár et al. 2008). The Óbuda area (today the northern part of Budapest) was lost due to urban development.

There is a habitat complex left in the Kiskunság region, in the north-western part of the Hungarian Great Plain, near to Ócsa. However, extinction directly threatens the species in this habitat complex as well due to habitat deterioration and isolation. Habitat degradation is the result of drainage accompanied with aggressive dispersion of invasive plant species. The transformation of vegetation associations caused by desiccation can lead to the spread of invasive alien plant species (e.g. *Solidago* spp.), which are present around the area. In Eastern European wet meadows, *Solidago* spreads forcefully and affects negatively the butterfly communities (Moroń et al. 2009). Since the 1980's the butterfly has left some parts of the habitat, which have become unsuitable and it has moved to lower habitat patches. There was a large population at the Csiffári meadows 2.8 km from the study site (Seregélyes et al. 1986), but that area has become very dry recently and now it is covered by mesophilous vegetation instead of *Molinietum*.

The nearly threatened status of the species motivates the monitoring of the population size. However, to facilitate long-term survival of the species, more accurate population size estimation and the exploration of population structure are necessary. The aim of this study was to estimate some essential parameters of population dynamics (e.g. population size, sex ratio, survival rate, average lifespan) in a single population of the False Ringlet in a three-year period using mark–release–recapture method.

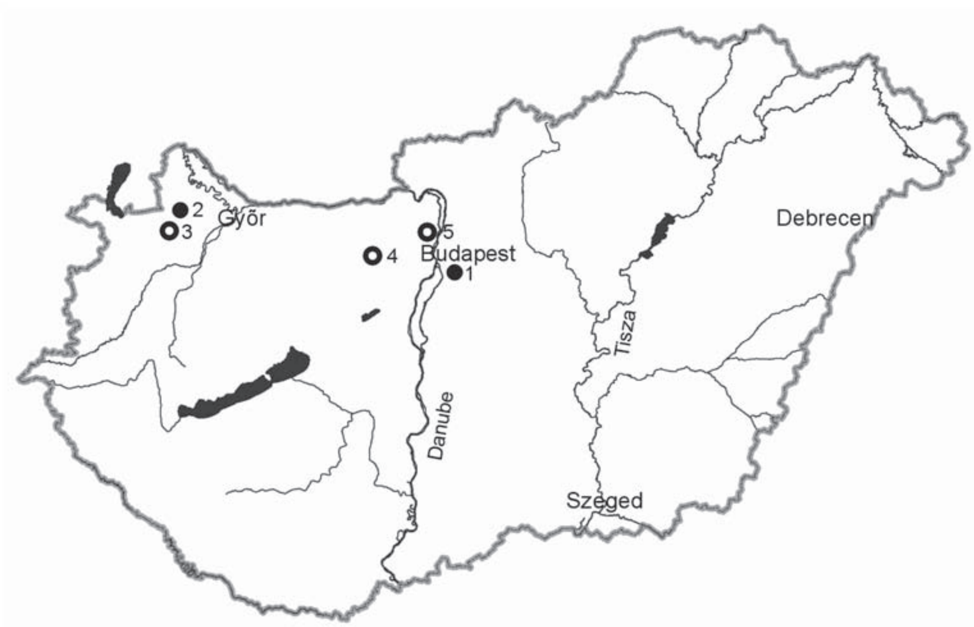

Fig. 1. Present (•) and former (○) populations of the False Ringlet in Hungary. 1 study site at Ócsa (Kiskunság region), 2 new population found in 2009 (Hanság), 3 Hanság, 4 Szár, 5 Óbuda.

Material and methods

Distribution

The distribution of the species is just partly documented; populations were probably widely distributed in the steppe zone of the temperate region, in *Molinietum* habitats. Outside Europe the species is present in temperate Asia as well: Ural, S and W Siberia, N Kazakhstan, Mongolia, China and Japan (Tolman & Lewington 2008). Based on the database of the IUCN the nearly threatened species is native in Austria, Belgium, France, Germany, Hungary, Italy, Japan, Kazakhstan, Liechtenstein, Mongolia, Poland, Russian Federation, Slovakia, Spain, Switzerland and Ukraine (IUCN 2008). The map of the "Encyclopedia of life" shows 18 localities in France, 8 in Italy, 8 in Austria, 5 in Liechtenstein, 4 in Poland, 2 in Switzerland, 2 in Spain and 1 in Hungary, based mainly on data from museum collections. In Asia 2 localities in Japan and 1 in South Korea are known (EOL 2009). None of the databases contains information about the existing Croatian and Slovenian populations (Sasic, this volume, Čelik et al. this volume), for other countries the information is extremely incomplete, e.g. Italy had more than 100 populations (Bonelli et al. this volume).

In Hungary, former populations of the species existed in the Hanság, Óbuda and Kiskunság region (Fig. 1). The only present population was considered to be in the Kiskunság region, but in 2009 a new, unknown location was found in the north-western part of Hungary.

Study site

Our study site was 0.65 ha in size, covered with *Molinietum* vegetation and surrounded with bushes and trees (*Salix* spp.) The area tends to be overgrown by common reed (*Phragmites australis*), reed mace (*Typha* spp.) and willow (*Salix* spp.) shrubs. The traditional management was extensive mowing or light grazing. Presently the meadow is mown once in a couple of years. The water table level is lower than ideal due to two reasons. The drainage started in the 1920's (Seregélyes et al. 1986), while later on the advance of gravel mining accelerated the desiccation of the area. The butterfly population has recently moved to lower areas compared to the habitat maps from the 1980's (L. Peregovits personal observation).

Table 1. Results of MRR: capture statistics for *Coenonympha oedippus* in 2005–2007 at Ócsa.

Year	No. of marked individuals		No. of recaptures		No. of captures	
	male	female	male	female	male	female
2005	70	66	139	95	209	161
2006	106	140	234	326	340	466
2007	58	42	26	12	84	54

Species

The species is strictly protected by law in Hungary, considered as nearly threatened by IUCN (2008). Part of its Hungarian habitats are strictly protected in the Ócsa Landscape Protected Area and designated as Sites of Community Interests. The False Ringlet has one generation in Hungary; the flight period is in June–July. Females lay eggs from late June. The polyphagous larvae hatch after 2–3 weeks and start feeding on *Molinia* and *Carex* species.

Sampling method

For population size estimation mark–release–recapture method was used in one habitat patch. Samplings occurred between 16th. June – 1st. July 2005, 17th. June – 7th. July 2006 and 6th. June – 20th. June 2007. The sampling effort was different in the three years: sampling was conducted daily in 2005 and 2006, while every second day in 2007. The butterflies were marked individually with permanent ink pen. A grid of 5×5 m quadrates was laid down in the habitat and capture locations were recorded.

The apparent survival probability and capture probability were estimated for both sexes with the Cormack–Jolly–Seber method using Mark 5.1 (White & Burnham 1999). The best models were selected based on Akaike's information criterion (AIC). Mean lifespan was calculated from survival probability (Cook et al. 1967). The daily population size was estimated with program POPAN 5 (Arnason & Schwarz 1999). The total size of butterflies in a year was calculated with the modified method of Cook et al. (1967). The dominant grasses and sedges were identified in 2005 in the presently and formerly occupied habitat patches of the species.

Table 2. Results of MRR: population structure and parameter estimations.

Year	Daily survival probability ±SE		Mean lifespan		Capture probability ±SE		Estimated total population size	
	male	female	male	female	male	female	male	female
2005	0.84±0.02	0.89±0.02	5.74	8.58	0.4±0.04	0.22±0.03	67.85	69.71
2006	0.82±0.02	0.87±0.01	5.04	7.18	0.53±0.03	0.38±0.02	116.30	157.46
2007	0.78± 0.04		3.95		0.27±0.06		212.80	

Results

The number of marked, captured and recaptured males was higher than those of females in two years, females outnumbered males in capture statistics in 2006 (Table 1).

The model selection resulted gender dependent survival and capture probability in the first two years and gender independent survival and capture probability in the third year. Female survival probability was slightly higher than that of the males in 2005 and 2006. The survival probability in the third year was gender independent and decreased to 0.78. The mean lifespan of females was 8.58 and 7.18 days in the first years, while mean lifespan of males was 5.74 in 2005 and 5.04 in 2006. The mean lifespan had decreased to 3.95 for both sexes in 2007 (Table 2). Capture probability was 0.40 and 0.53 in males and 0.22 and 0.38 in the case of females in the first years and 0.27 in 2007 (Table 2). The estimated total population size was 137 in 2005, 273 in 2006 and 212 in 2007, for the intensive study years 2005 and 2006 this is close to the number of actually marked individuals (Tables 1 and 2).

The highest estimated daily population size changed between 45–81 for males and 29–96 for females (Fig. 2). Males reached their maximum estimated daily population size earlier than females in each year. The butterfly showed the characteristics of protandry, males outnumbered females in the first days of the observation period (Figs. 2 and 3).

Observations of individual movements during the sampling suggested that the butterflies preferred the wettest areas, while avoided open spaces probably due to the more balanced microclimate in the vicinity of bushes; the individuals were sedentary, their flight was short and jumping. They performed short movements. The average distance between

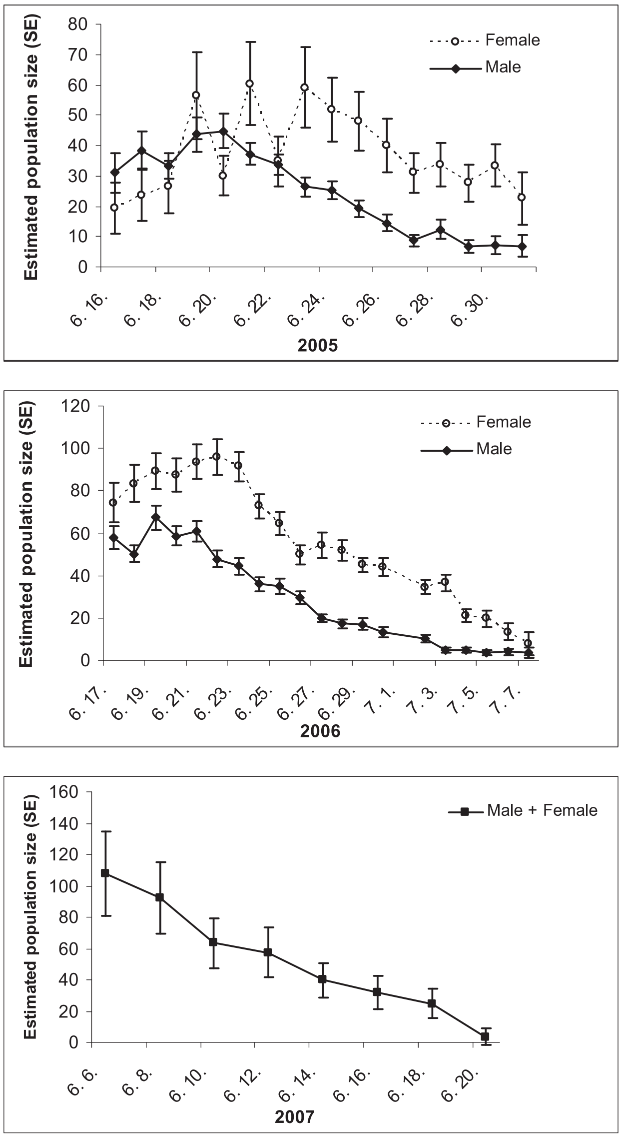

Fig. 2. Estimated daily population size in a habitat patch of *Coenonympha oedippus* from 2005 to 2007, based on MRR studies.

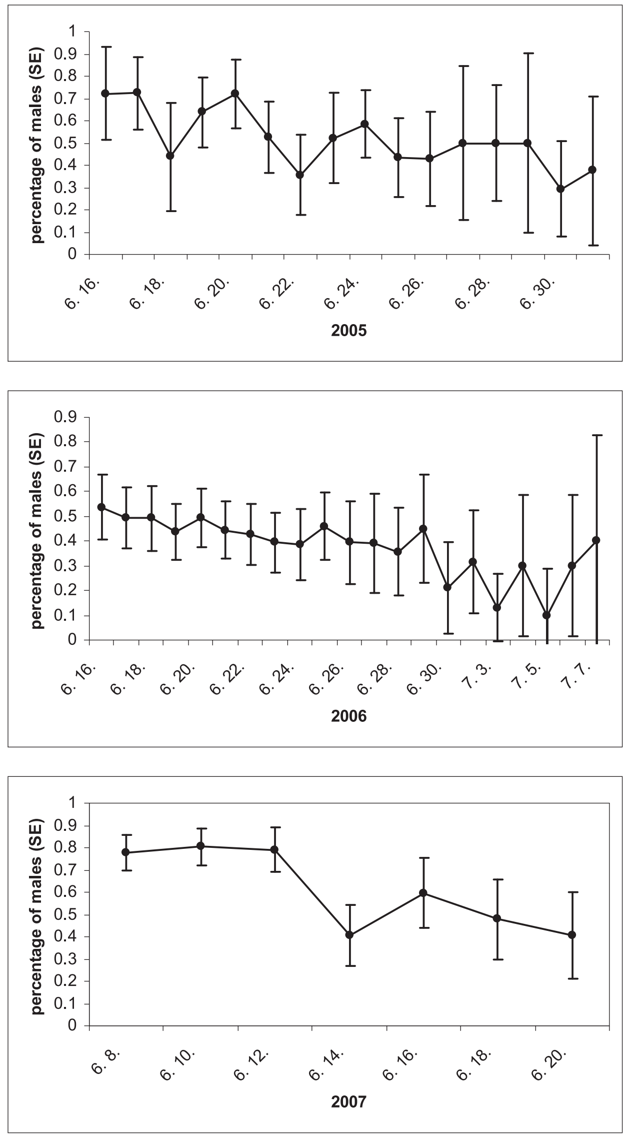

Fig. 3. Percentage of males based on daily capture exceeds female ratio during the first days of sampling in all the examined years.

Table 3. Plant species list in the recent and in the earlier habitat patch, the species composition is changing due to drainage.

	Recent habitat	**Earlier habitat**
Vegetation	species rich *Molinietum*	searing *Molinietum*, with mesophyl patches
Dominant grass species	*Deschampsia caespitosa, Molinia* sp., *Phragmites australis*	*Molinia* sp., *Festuca pratensis, Calamagrostis epigeios*
Dominant sedge species	*Carex acutiformis, Cladium mariscus, Schoenus nigricans*	
Characteristic attendant species	*Equisetum arvense, Inula britannica, Lythrum salicaria, Carex flacca, Cirsium palustre*	*Rhinanthus* sp., *Galium verum, Deschampsia caespitosa, Dactylis glomerata, Briza media*

consecutive recaptures was 38.3 m (52 animals, 1–11 movements/animal). According to the tracking data of individuals, males moved more frequently and flew longer distances (approx. 10–15 m/occasion) than females (0.2–4m), although sample size was not sufficient for statistical analysis.

In the presently occupied habitat patch a species rich *Molinietum* complex exists, while the neighbouring, formerly occupied part of the habitat shows characteristics of a mesophilous meadow with plenty of herbaceous plant species (Table 3).

Discussion

During the three years of the survey, there was no major fluctuation in population size, a promising sign regarding its survival, even though long–term trend cannot be estimated in this time scale. Along with Čelik's survey in Slovenia, protrandric population structure was observed (Čelik 2004), which is a widely recognized phenomenon among butterflies. Early eclosion of males minimizes the energy consumption of females and predation threats before reproduction, while males have enough time to seek for females (Ehrlich 1989). Both males' and females' movement was restricted to short-distance within the habitat patch, similar to Čelik's results (2004). Short flights imply sedentary living habits and closed population.

The apparent survival rate (0.78–0.89) of the species is in the higher region among butterflies. According to Brakefield (1982), survival probability around 0.8 is typical to butterfly species with colonial population structure in temperate climate zones. Although survival rate can be as high as 0.94 in other butterflies species, like *Euphydryas aurinia* (Schtickzelle et al. 2005); or 0.88 for males and 0.84 for females as in the case of *Lopinga achine* (Bergman & Landin 2002). Both butterflies' dispersal ability is similar to sedentary and vulnerable species (Bergman & Landin 2002, Schtickzelle et al. 2005). Our observations on within site movement do not contradict with these results, as the movement lengths of *Coenonympha oedippus* between two consecutive captures are generally short. We can confirm that survival rate around 0.8 might be a sign that the population is closed and dispersal of individuals is low. During 2005 and 2006, the survival rate of the females was higher than that of the males, which is in agreement with the results of Čelik (2004).

Decline of the survival rate in 2007 is a reason to worry, as the shorter lifespan of females can have a direct effect on the quantity of eggs laid. It's proven in the case of *M. rebeli* that the total quantity of eggs possibly laid can be many times higher than the realized number of eggs laid, in other words the females are time-constrained regarding their egg-laying (Kőrösi et al. 2008). Therefore, along with the decrease of the lifetime, the number of laid eggs probably decreases, making the basis of the next generation and the long-term survival of the population uncertain. However, the decline of the apparent survival rate can be a sign of growing dispersion too, because of the declining quality of the habitat patch or any other general problem, i.e. the paramount hot weather in June and July in 2007. The mean lifespan of males was 5 to 6, females 7 to 9 days in the first years, which is slightly higher than estimated in the Slovenian population (Čelik 2004). But in 2007 the mean lifespan was similar to the Slovenian results (Čelik 2004).

It has particular importance that at the beginning of our sampling in 2005 the population was found in a different location, in a deeper site, than during the last surveys in the 80's. In this respect this fact warns of the danger of continuous desiccation. Vegetation contains *Molinia* tussocks only in the current habitat, while the previous habitat patch is now rather a meadow rich in mesophilous species. This is characteristic recently to the whole area – the formerly base-habitat of Csiffári rét (2.8 km form our study site; Seregélyes et al. 1986) has now a strongly desiccating *Astragalo–Festucetum*, where the butterfly is now absent. Assuming that this meadow had been a firmly wet *Molinietum*, the average groundwater level dropped with 20–40 cm since the 80's (Seregélyes et al. 1986).

Although the habitat complex of Ócsa lies within the borders of Duna–Ipoly National Park, the area is not exempt from human impact: there are some gravel pits in the vicinity of the strictly protected area. Gravel mining creates large-surfaced deep lakes, which load themselves with groundwater. As a result of evaporation, these lakes take groundwater from the surrounding areas, which dries them up and change the vegetation (Tari et al. 2008). The region is also well-drained, which causes a lower water retention ability and desiccation as well (Hubayné Horváth 2005).

Another threatening factor of the *Coenonympha oedippus* habitats is the advance of weeds and invasive plant species. Primarily, *Solidago* species occupy a growing percentage of the habitat complex, which could be controlled by regular mowing during flowering time (Weber 2000, Moroń et al. 2009). However, the complete elimination of *Solidago* seems to be unlikely. Wet meadows between groves of trees are used by hunting organizations as well, providing corn and other grains (containing weeds) for the game. This activity creates weed-communities, altering and deteriorating further the vegetation required by the butterfly.

In the absence of management, succession in this area will result in bushy groves, which is not appropriate for the butterflies. According to our observations butterflies also avoid large open areas. To apply appropriate conservation management it is inevitable to learn more about the butterfly's habitat use, considering the different aspects of requirements of all life stages (Dennis et al. 2006, Vanreusel & Van Dyck 2007).

In Hungary *Coenonympha oedippus* is present in this habitat complex and a newly discovered population in north-western Hungary only. Part of the formerly known habitats are vanished, such as those around Óbuda and Szár, other parts are now being reconstructed, such as those in Hanság (Margóczi et al. 2002). There are some areas in the Kiskunság National Park that seem to be appropriate for the butterfly. The isolation of the remained populations (among them this surveyed one) with small size indicates the possibility of inbreeding, which should be excluded or confirmed by genetic surveys. Accordingly, we conclude that the development of conservation actions for *Coenonympha oedippus* is essential and inevitable. Habitat degradation should immediately be stopped, especially the desiccation, and the spread of invasive plants should be controlled, to maintain proper habitats for long-term survival of the species in Hungary.

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