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ANNUAL DYNAMICS OF THE GROUND BEETLE COMMUNITY IN TWO BEECH STANDS IN MAVROVO NATIONAL PARK

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ABSTRACT

The results of the investigation on annual dynamics of ground beetle community (Coleoptera, Carabidae) in two localities (Bunec and Shunteski Rid) in beech association Calamintho grandifloraе-Fagetum in Mavrovo National Park (western Macedonia) are presented in this paper. Bunec stand was under stronger anthropogenic pressure while the Shunteski Rid was better preserved (although managed) beech stand. The investigation was conducted in the period of April to November 2002.

The material was collected by pitfall traps and qualitative and quantitative composition of the ground beetle community was determined (number, seasonal dynamics, biomass and sexual structure).

The influence of the forest degradation level on the ground beetle community was discussed, based on the qualitative and quantitative criteria.

Key words: ground beetles (Carabidae) community, dynamics, number, biomass, sex structure, beech forest, forest degradation

ИЗВОД

Прикажани се резултатите од истражувањето на годишната динамика на заедницата на тркачите (Coleoptera, Carabidae) на два локалитети во Националниот парк „Маврово“ (Бунец) и Шунтески Рид). На двата локалитети се развива буковата шума т.е. заедницата Calamintho grandifloraе-Fagetum. Локалитетот Бунец е под посилно антропогено влијание во однос на локалитетот Шунтески Рид каде се развива подобро зачувана (но сепак искористувана) букова шума. Истражувањето беше вршено во периодот април-ноември 2002 година.

Материјалот беше собиран со замки со цел да се определи квалитативниот и квантитативниот состав на заедницата на тркачите (бројност, сезонска динамика, биомаса и полова структура).

Направен е обид да се определи влијанието на деградацијата на состоината врз заедницата на тркачите врз база на квалитативни и квантитативни параметри.

Клучни зборови: заедница на тркачите (Carabidae), динамика, бројност, биомаса, полова структура, букова шума, деградација на шума

INTRODUCTION

The annual activity patterns are an important part of insect life cycles, and they differ among species. Carabids are excellent subject for studies of the effects of fragmentation on species with different dispersal abilities and habitat requirements (den Boer 1990 in Niemelä et al. 1993). A number of studies on the annual cycles of Carabid assemblages and species have been conducted in Northern and Central Europe (Niemelä et al. 1989). However, there are only few ecological studies of ground beetles in forest ecosystems of the Balkans (Tabaković-Tošić, 1988; Stoyanov &

Penev 2003). Breeding time is an important factor affecting the survival of a carabid population, especially in temperate zones. Species that breed during the time of intensive management practices (spring) are affected more than species that breed during times of less disturbance (autumn) (Rushton et al. 1990 in Magura et al. 1999).

Temperate forest is a patchy environment and ground beetles occur there in aggregations. Forest specialists, in particular, are associated with certain microhabitat types (Niemelä et al. 1990). For instance, abundance of deciduous litter is a sign of a high quality 'resource spot' for many carabids, and these spots may serve as source patches from which individuals move into lower-quality patches nearby (Haila et al. 1994). These spots of deciduous litter are especially important in forests with poor soils and humus layer (Koivula et al. 1999). After forest clearance, specialized forest species, which are often large-sized and door dispersers, decrease in number (Halme and Niemelä 1993; Niemelä et al.1993). Because these species have poor dispersal ability they might not be able to move to suitable habitats over clear-cuts (Halme and Niemelä 1993). Additional decrease in number and size of remaining mature forest patches may cause local extinctions in these species (Koivula et al. 2002). Furthermore, there may be indirect effects on the specialized species, e.g. through decreased abundance of prey species (Haila et al. 1994). Although forest management affects specialized forest species, the dominance structure does not necessarily change. Overall, it appears that 'adversity selection' is functioning in the boreal forest as regards carabids. This implies that only a few species are able to maintain high population sizes, while most species are scarce, probably due to the harsh conditions of the temporal forest environment.

The main goal of this study was to investigate the annual dynamics of ground beetle community (Coleoptera, Carabidae) in two localities (Bunec and Shunteski Rid) in beech association Calamintho grandiflorae-Fagetum in Mavrovo National Park. The influence of the forest degradation level on the ground beetle community was analyzed, based on the qualitative and quantitative criteria.

STUDY AREA

The investigation was performed in the beech forest ecosystem (ass. Calamintho grandiflorae-Fagetum Em 1968) in Mavrovo National Park, western Macedonia. Carabid communities were investigated in two beech stands: Shunteski Rid and Bunec.

Climate in Mavrovo region is mountain-continental with Mediterranean influence (Filipovski et al. 1996). Meteorological data according to Lazarevski (1993), based on the measurements of meteorological station Mavrovo (1240 m), show that the average annual temperature is 7.1 ^{o}C, the minimal average monthly temperature is below 0 ^{o}C (during the winter), the mean monthly maximal temperature is 16,3 ^{o}C (in July). The mean annual fluctuation of temperature is 18.7 ^{o}C. The mean annual precipitation is 1103 mm. In colder period of the year it consists mainly of snow. From October to March there is over 100 mm precipitation per month, April and May are characterized by 80-100 mm and July and August have less than 50 mm monthly precipitation.

Shunteski Rid locality (SR)

Stationary for complex ecologic investigation (Grupče & Melovski 1998) is situated in well-developed middle aged beech forest in village Leunovo district, near Mavrovo Lake at an elevation of 1300 m. The community is developing on dystric cambisole soil type. Beech (*Fagus sylvatica*) absolutely dominates in the investigation locality with a density of 1200 trees·ha^{-1}. Mean DBH (diameter at breast height) of trees was 16.5 cm in 2005. Shrub layer is represented mainly by beech and fir (*Abies borisii-regis*) shrubs (Melovski et al. 2003). Aboveground annual litter fall biomass of the tree layer was 4.97 t·ha^{-1} (Šušlevska et al. 2001). The forest floor biomass was 20.6 t·ha^{-1} (Melovski et al. 2004).

Bunec locality (B)

The beech stand at Bunec locality is at the same altitude as Shunteski Rid locality - about

1270 m. The soil type is dystric cambisole as well.

According to the condition of the tree layer, the beech stand in this locality is under stronger anthropogenic pressure. The stand is younger with sprouting beech trees as a result of cut.

Unfortunately, systematic research of the stand characteristics was not conducted. However, measurements of DBH (October 2006) and forest floor biomass (June 2005) were performed. The mean DBH of the trees was 13.6 cm which is less than the DBH in SR. The biomass of the forest floor was smaller, as well (17.3 $t \cdot ha^{-1}$).

MATERIAL AND METHODS

For the collection of Carabidae in each locality, pitfall traps were used (with diameter of 8.5 cm, volume of 500 ml), placed flush with the ground. Traps contained formalin-vinegar as a killing-preserving solution. The distance between the traps in each locality was three meters. Overall, there were 18 traps: 9 in each locality during the sampling procedure. Trapped individuals were collected once or twice a month from April to October, which is the main activity period of the species. Captured mesofauna was placed in closed containers with 70 % alcohol for preservation until the identification.

Preserved specimens were partly dried out by filter paper and weighed. Measurements of biomass were performed for separate species per catch.

RESULTS AND DISCUSSION

In total 15 species of ground beetles were recorded in the investigated localities: 12 at SR and 13 in B. Data on additional species recorded at these two sites (collected by other methods) were already published: *Leistus spinibarbis*, *Notiophilus biguttatus*, *Calosoma sycophanta*, *Pterostichus strenuus* and *Dromius fenestratus* (Hristovski et al. 2003). Nevertheless, the total number of species is relatively low and that corresponds to the results of other studies on different forest types conducted in Europe (Heijerman & Turin 1989; Niemelä et al. 1989; Loreau 1992).

Tab. 1. Number of captured specimens and species dominance in two beech stands
Таб. 1. Број на уловени примероци и доминантност на видовите во двете состоини

		Shunteski Rid				Bunec			
	Species	♂	♀	**N**	**D%**	♂	♀	**N**	**D%**
1.	*Molops rufipes steindachneri*	151	166	317	44.15	180	128	308	60.04
2.	*Tapinopterus dochii*	119	120	239	33.29	100	54	154	30.02
3.	*Cychrus semigranosus montenegrinus*	36	27	59	8.22	7	8	15	2.92
4.	*Pterostichus brucki*	10	17	27	3.76	5	2	7	1.36
5.	*Carabus intricatus*	11	10	21	2.92	7	3	10	1.95
6.	*Myas chalybaeus*	10	12	15	2.09	0	1	8	1.56
7.	*Carabus croaticus ljubetensis*	6	9	22	3.06	2	6	1	0.19
8.	*Leistus spinibarbis rufipes*	8	3	11	1.53	1	1	2	0.39
9.	*Trichotichnus laevicollis*	1	0	1	0.14	0	4	4	0.78
10.	*Aptinus merditanus*	2	1	3	0.42	0	1	1	0.19
11.	*Stomis pumicatus*	1	1	2	0.28	0	0	0	0
12.	*Carabus convexus dilatatus*	0	0	0	0	0	1	1	0.19
13.	*Laemostenus terricola punctatus*	0	0	0	0	0	1	1	0.19
14.	*Omphreus gracilis*	0	0	0	0	0	1	1	0.19
15.	*Calathus melanocephalus*	0	1	1	0.14	0	0	0	0
	Total	**355**	**367**	**718**	**100**	**302**	**211**	**513**	**100**

N - total number of captured specimens
D - dominance ($D=n_i/N*100$) where: n - number of individuals of species "i" in sample; N - number of all specimens in the sample

Most dominant species (Tab. 1) were subendemics *Molops rufipes steindachneri* and *Tapinopterus dochii* comprising 77 and 90 % in SR and B, respectively.

Interspecific competition may contribute to the negative relationship between two dominant species *Molops rufipes steindachneri* and *Tapinopterus dochii*, which show similar habitat preference, similar patterns of seasonal activity and food preference. SR is locality under lower anthropogenic pressure, with undisturbed forest floor, which acts as a buffer against environmental variations in more mature forests and allows presence of a diversified fauna. *Tapinopterus dochii* showed higher abundance in B (Fig. 3) which leads to assumption that this species is less sensitive to anthropogenic pressure.

It is important to notice that other subendemics were present in higher numbers in both localities such as *Cychrus semigranosus montenegrinus*, *Pterostichus brucki*, *Myas chalybaeus* and *Carabus croaticus ljubetensis* and *Carabus intricatus* in Shunteski Rid locality.

Also, few species with one specimen (*Carabus convexus dilatatus*, *Laemostenus terricola punctatus* and *Omphreus gracilis*) were registered only in B, while *Stomis pumictus* (with two specimens) and *Calathus melanocephalus* (one specimen) were noted in SR.

It is obvious that the higher number of specimens were captured in SR than in B (Tab. 1) resulting from higher number of captured specimens of *Tapinopterus dochii* as well as *Cychrus*, *Carabus*, *Myas* and *Pterostichus* species.

Carabids depend on several abiotic and biotic factors. These include (1) temperature or humidity, (2) food conditions, (3) presence and distribution of competitors, and (4) life history and season, including migration between hibernation and reproduction habitat (Lövei and Sunderland 1996). These are one of the first macroinvertebrates to suffer from forestry or habitat fragmentation. Also, their numbers have already started to decline, which might be directly caused by change in abiotic and/or biotic factors (Blake et al.1996).

Most of the highly abundant generalist species, such as *Cychrus semigranosus montenegrinus*, *Pterostichus brucki*, *Myas chalybaeus* and *Carabus croaticus ljubetensis* and *Carabus intricatus* (which is readily able to utilize even highly disturbed habitat), were less abundant in B which was under stronger anthropogenic pressure.

The annual dynamics of ground beetles in the both localities is shown on Fig. 1. The summer peak was observed both in SR and B. The amplitude in SR locality is higher than in B locality. However, it should be stressed that there are year-to-year variations in carabid population sizes (Niemelä et al. 1993; Abildsnes & Tømmeros 2000). The summer peaks suggest that most of the species are "spring breeders" while the "autumn breeders" are not present (Niemelä et al. 1989).

Also, it is interesting to notice that in B only one specimen was captured after September. Although in low numbers, specimens in SR were captured until the first snow cover in late October (Fig. 1). Since measurements of the micro-climate were not conducted it can be only postulated that better preserved beech forest in SR provides better conditions for survival of ground beetles, meaning that microclimatic regimes (temperature, moisture etc.) are without strong fluctuations in this locality.

In this respect we can consider beech forest in B locality as more severe with higher annual temperature amplitudes and lower temperatures in autumn period. Such differences in temperature regime in forests are well known (Aussenac 2000). Unfortunately, such temperature difference was not evidenced since measurements of climatic factors were not undertaken. We can hypothesize that there is a positive relationship between the ground temperature and the carabid's abundance, because higher ground temperature may provide favorable sites for egg and larval development.

According to Niemelä et al. (1993) there are three general responses of ground beetles to logging: 1. at least initially, species typical of open, grassy habitats increase; 2. forest generalists decrease but seem to recover with forest regeneration and 3. some mature forest specialists fail to recolonize regenerating for-

est and are at risk of extinction in logged patches. In B or SR there were no species of open, grassy habitats. Some differences in dominance were observed in *Molops rufipes steindachneri* in direction of the increase from the SR to B. Other species, *Cychrus semigranosus montenegrinus* and *Pterostichus brucki*, were less dominant in B compared to SR. This might be due to the requirements of the latter two species for weather conditions.

SR had higher values of relative biomass compared to B (Fig. 2). As in the case of number of captured specimens (Fig. 1) there was summer peak in the SR relative biomass dynamics (Fig. 2). This was not observed in B due to lower catch of specimens of *Tapinopterus dochii* and species with bigger weight such as *Carabus* and *Cychrus*.

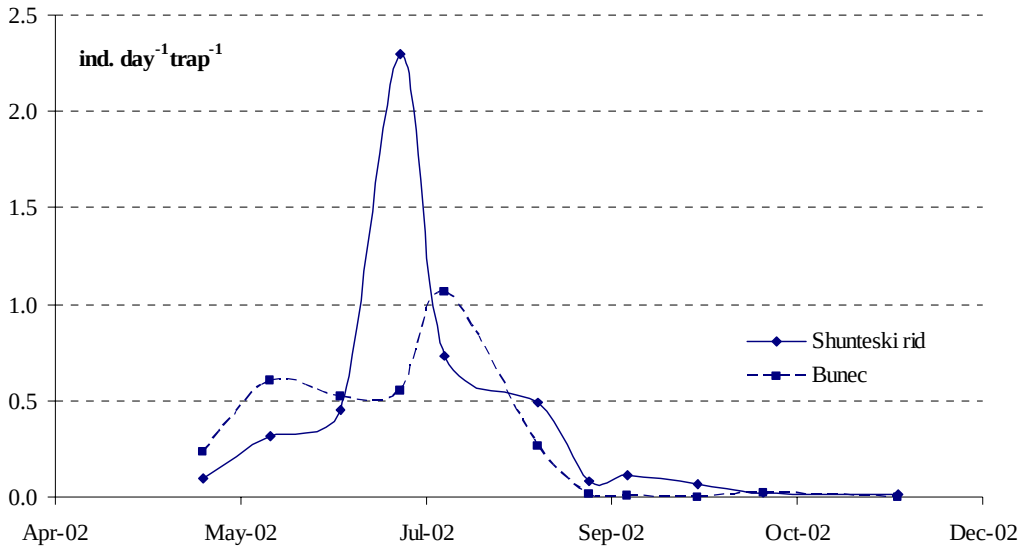

Fig. 1. Dynamics of the ground beetle community in two beech forests
Сл. 1. Динамика на заедницата на тркачите во две букови состоини

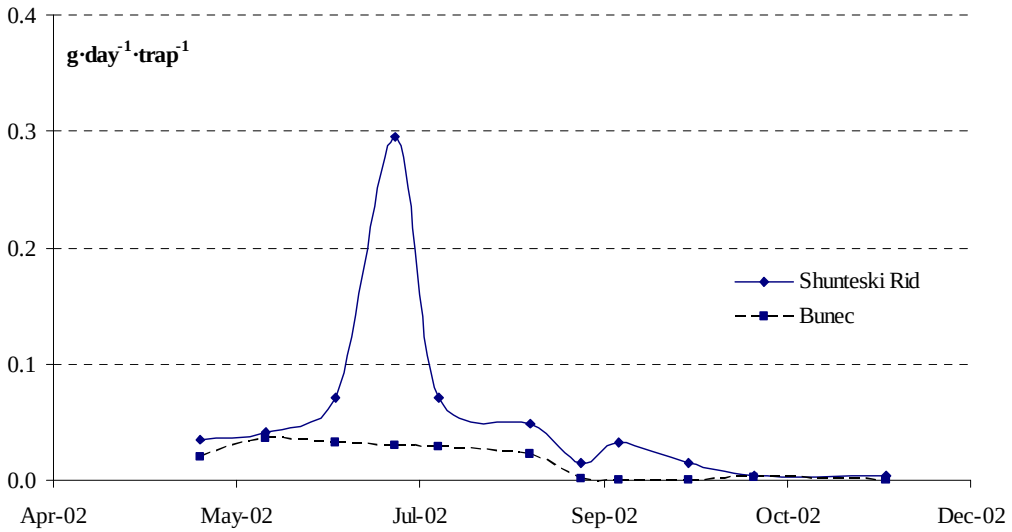

Fig. 2. Dynamics of the relative biomass of the ground beetle community in two beech forests
Сл. 2. Динамика на релативната биомаса на тркачите во две букови состоини

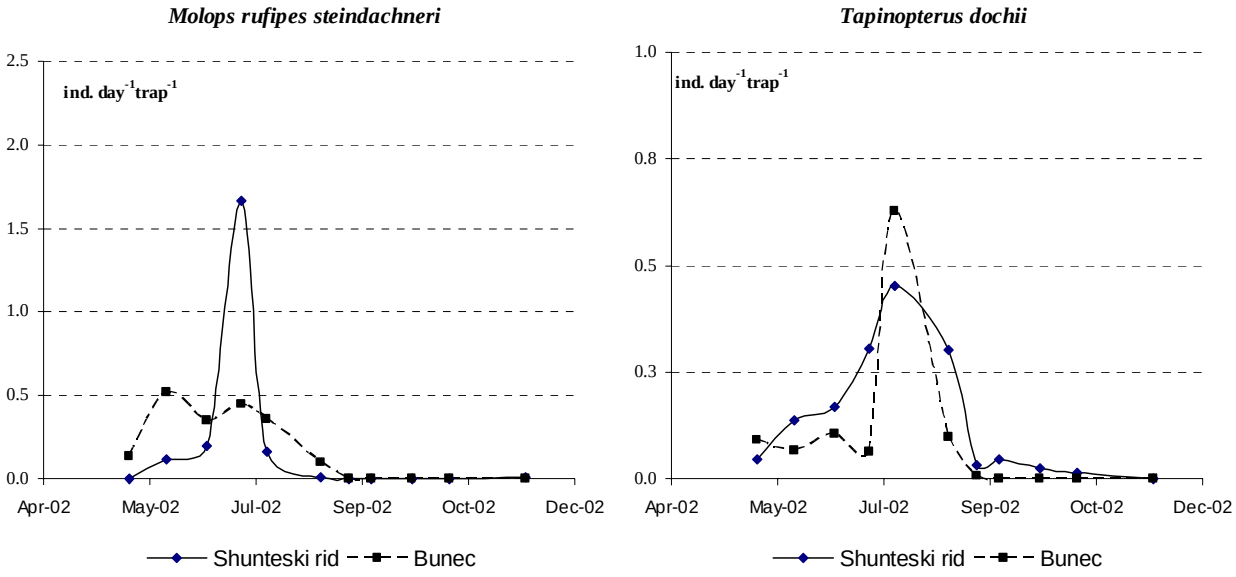

Fig. 3. Annual cycles of the dominant species in the investigated beech stands: *Molops rufipes steindachneri* and *Tapinopterus dochii*

Сл. 3. Годишна динамика на доминантните видови во истражуваните букови состоини: *Molops rufipes steindachneri* и *Tapinopterus dochii*

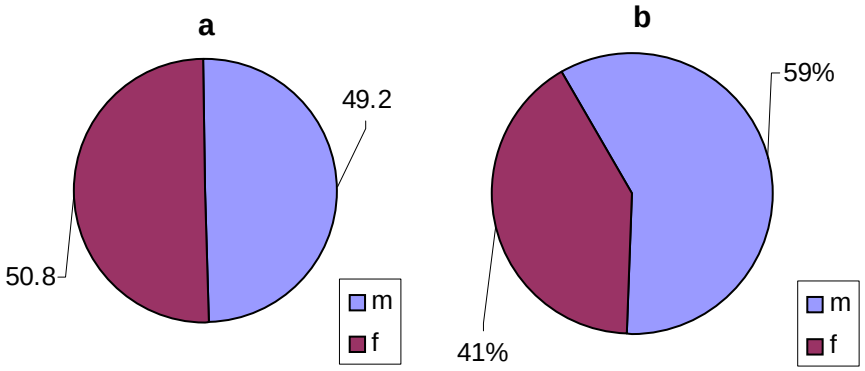

Fig. 4. Sex structure of the ground beetle community in the locality Shunteski Rid (a) and Bunec (b)

Сл. 4. Полова структура на заедницата на тркачите во локалитетот Шунтески Рид (a) и Бунец (b)

While the sex ratio is balanced in SR (Fig. 4a), it shifts in favor of males in B (Fig. 4b). This difference is a result of higher number of males of *Tapinopterus dochii* and *Molops rufipes steindachneri* in B (Tab. 1). The difference in the number of males and females in B of these two species as well as the difference in the whole carabid community was statistically significant ($p<0.05$; χ^2 test statistics).

Hypothesized explanation for this feature is that during summer months, after the breeding period (which is correlated with the collecting months), females enter deeper into the soil to lay eggs, avoiding severe climatic conditions in this locality. The increased proportion of females over males with soil depth is well known phenomenon for some species (*Abax ater* and *Pterostichus oblongopuncta-*

tus) in other beech forest (Loreau 1987). Moreover, it can be noticed that the life cycle in B ends in the beginning of September while in SR it ends much later, in late October (Fig. 1).

CONCLUSIONS

The investigation of the dynamics of the ground-beetle community in the beech forests was conducted in two beech stands in Mavrovo region (Bistra Mt.) in 2002. In total, 15 species were registered: 13 species in the Shunteski Rid locality and 12 species in Bunec locality. Highest abundance was recorded in the late spring-early summer period, suggesting that most of the species are "spring breeders".

Dominant species in both localities were *Molops rufipes steindachneri* (with total number of 317 specimens in Shunteski Rid and 308 specimens in Bunec) and *Tapinopterus dochii* (with total number of 239 specimens in Shunteski Rid and 154 specimens in Bunec). The same species gave the greatest percent of the total biomass and determined sex structure where females were presented by 50,8 % in Shunteski Rid locality and 41.1 % in Bunec locality.

Our results revealed that anthropogenic pressure might have negative effects on the composition and abundance of ground beetles. This hypothesis should be confirmed by additional investigation on ecological factors in the investigated beech stands and analysis of the ecology of separate species.

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ГОДИШНА ДИНАМИКА НА ЗАЕДНИЦАТА НА ТРКАЧИТЕ (Coleoptera, Carabidae) ВО ДВЕ БУКОВИ СОСТОИНИ ВО НАЦИОНАЛНИОТ ПАРК „МАВРОВО“

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РЕЗИМЕ

Заедницата на тркачите (Coleoptera, Carabidae) беше истражувана на два локалитети (Бунец и Шунтески Рид) со букова шума (Calamintho grandiflorae-Fagetum) во Националниот прак „Маврово“.

Локалитетот Бунец беше под силно антропогено влијание според набљудувањата и карактеристиките на биоценозата. Локалитетот Шунтески Рид се одликуваше со подобро зачувана (иако искористувана) букова шума. Истражувањата на заедницата на тркачите беа спроведени во тек на периодот април-ноември 2002 година.

Материјалот беше собиран со замки поставени на оддалеченост од 3 m во мрежа од 3 x 3 замки. Беше определен квалитативниот и квантитативниот состав, како и бројноста, сезонската динамика, биомасата и половата структура.

Во двете букови состоини беа регистрирани вкупно 15 видови (13 – Бунец и 12 – Шунтески Рид). Доминантни видови беа *Molops rufipes steindachneri* (317 примероци беа уловени во локалитетот Шунтески Рид и 308 примероци во локалитетот Бунец) и *Tapinopterus dochii* (239 примероци од Шунтески Рид и 154 од Бунец). Овие два вида ја дадоа и најголемата биомаса.

Од анализата на половата структура се покажа дека женските индивидуи беа застапени со 50.8 % во локалитетот Шунтески Рид и 41.5 % во Бунец.

Највисока бројност на тркачите беше регистрирана кон крајот на јуни во локалитетот Шунтески Рид и во јули во Бунец. Ваквата динамика покажува дека најголем дел од видовите тркачи се размножуваат во „пролетниот период“.

Вкупната бројност и вкупната биомаса беа повисоки во локалитетот Шунтески Рид во однос на Бунец што укажува на влијанието на подобрата зачуваност на локалитетот Шунтески Рид.