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OCCURRENCE, BIONOMICS AND HARMFULNESS OF *CREPIDODERA AUREA* (GEOFFR.) (COLEOPTERA, ALTICIDAE)

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Abstract

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The paper deals with the occurrence, bionomics and harmfulness of a flea-beetle *Crepidodera aurea* (Geoffr.) (Alticidae). The pest was studied at the Bílovice nad Svitavou Forest District (Training Forest Enterprise Masaryk Forest in Křtiny) in the period 2007 to 2010 and in a laboratory. The main host species *Populus tremula* was about five times more damaged there than *Salix caprea*. Last year's beetles occurred on the trees from the beginning of May to the beginning of November (most abundantly at the beginning of June). This year's (young) beetles occurred from the end of July to the 10th of November (most abundantly in September). Before hibernation, about 1/6 beetles abandoned their earth pupal chambers. The beetles damaged 6.7 cm^2 leaves of *P. tremula* before hibernation (and 14.3 cm^2 after hibernation). Females lay on average 194 eggs, namely on the average in 11 clutches at 18 eggs. In the period of the most intensive reproduction (in the second half of May and at the beginning of June), females laid one clutch on average for two days. With the increasing size of females the average number of eggs in ovaries increased as well as their average size. The development was obligatorily univoltine. With respect to the relatively low consumption of food it is not necessary to control the pest. In case of mass outbreak it is possible to control the beetles from the 5th to the 10th of May.

Alticidae, *Crepidodera aurea*, hibernation, occurrence, host species, fertility, food consumption, harmfulness

The flea-beetle *Crepidodera* (= *Chalcoides*) *aurea* (Geoffr.) is one of the most abundant and forestry most important representative of the species-rich and biologically interesting family of Alticidae in the CR. From a closely related family Chrysomelidae Alticinae differ particularly by the occurrence of a special sclerotized organ ("spring organ") in the distal part of thickened femurs of rear legs. However, many authors rank Alticidae traditionally among the family Chrysomelidae, viz. the subfamily flea beetles (Alticinae = Halticinae). The beetles are mostly oligophagous. They live on herbs, rarely on woody species and skeletonize or perforate their leaves. Larvae browse fine roots of plants or mine in stems and leaves; they seldom skeletonize or perforate leaves. Numerous species are important agricultural pests of crops from the family Brassicaceae etc. Only a few of species rank among pests of woody species.

For example, species of the genus *Crepidodera* Chevr. develop on woody species. Beetles of this genus are phylophagous, larvae being rhizophagous. Thickened femurs of rear legs make possible long jumps. Their shiny body shows that it refers to considerably thermophilic and light-demanding insect. On the other hand, larvae live hidden on roots of plants and therefore, their development

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is virtually nearly unknown. Out of six Central-European species of the genus *Crepidodera*, *C. aurea* is considered to be the second most important species after *C. aurata* (Marsh.) as for the abundance of occurrence and harmfulness. Undoubtedly, far smaller importance show *C. nitidula* (L.), *C. fulvicornis* (F.) and *C. plutus* (Latr.). *C. lamina* (Bed.) is a rare and thus economically unimportant species.

In 2007 to 2010, very abundant to mass occurrence of *C. aurea* on *Populus* spp. and *C. aurata* on *Salix* spp. was noted at many localities in Moravia. The activation of both pests occurred even in the vicinity of Brno, namely e.g. at the Bílovice nad Svitavou Forest District (Training Forest Enterprise Masaryk Forest in Křtiny). These facts were used for the systematic field and laboratory studies of their occurrence, bionomics and harmfulness. The paper presented deals with findings obtained about *C. aurea* on *Populus tremula* L. and *Salix caprea* L.

Distribution

A flea beetle *Crepidodera aurea* is a eurytopic species with wide ecological amplitude. It occurs on an extensive area including the major part of Europe and considerable part of Asia. Heikertinger (1948) mentions the species nearly from the whole Europe, namely from a wide zone extending from west (England, France) to east (central Russia) and from south (Italy, north of the Balkan peninsula, the Caucasus) to north (the Netherlands, Denmark, northern Germany). According to the author, the species occurs also in Asia Minor and Siberia. For example, Reitter (1912), mentions its occurrence nearly throughout Europe and Siberia (particularly on alluvia, in moist stands and on clear-felled areas). It is abundant in England and in Wales, sporadic in Ireland (Hubble, 2010). Hellén *et al.* (1939) mention that in northern Europe, *C. aurea* occurs only in Denmark whereas e.g., *C. aurata* also in Sweden and Finland. Its absence in Scandinavia mentions indirectly Mohr (1966). According to him, the European range of *C. aurea* reaches up to northern Germany. The northern limit of its range in Denmark is also proved by Maisner (1974), who also mentions its utmost southern occurrence in the Pyrenean peninsula and in northern Italy. According to Bukejs (2009), it concerns an insufficiently known species occurring in Central and southern Europe, Latvia, Denmark, Caucasus, Asia Minor, Kazakhstan and Siberia. It is of interest that in northerly localized Latvia, the genus *Crepidodera* is represented by the same species (Telnov, 2004) as in the CR, Slovakia, Poland, Germany and in the European part of the former Soviet Union.

Petitpierre (1999) considers *C. aurea* to be a Euro-Siberian and Euro-Asian element with a southern limit of occurrence reaching Spain. For example, Aslan *et al.* (1999), Tozlu (2001) and Tozlu *et al.* (2010) consider the species to be quite common in the European and Asian part of Turkey. It was also noted on the major part of the former USSR with the exception of Azerbaijan, Turkmenistan, Uzbekistan, Kyrgyzstan and Tajikistan (Nadein, 2010). According to Gruev (2006), it is widespread in Europe, in the Caucasus, Asia Minor, Cyprus, in Iran, Kazakhstan, Central Asia and Siberia. In the Balkan Peninsula, it was not demonstrated in Montenegro, Macedonia, Albania, and Romania (Gruev, 2005). The opinion of Gruev (2005) is somewhat revised by Maican (2005) and Maican & Serafim (2001, 2004). These authors rank *C. aurea* among the permanent part of fauna of Romania and, as well as Rozner (2003), consider the species to be a Palaearctic species. In Bulgaria (Tomov & Gruev, 1969), it ranks among ordinary and sometimes graduating species. In Bulgaria, it rises up to an altitude of 1 500 m (Warchalowski, 1974) and in Turkey, up to 2 100 m (Aslan *et al.*, 1999). Also in Hungary, it occurs even in hilly upland and mountain regions (Vig, 1997).

In the CR and in Slovakia, *C. aurea* ranks among abundant and widespread species (Fleischer, 1927–1930; Roubal, 1937–1941). According to Januš (2004), it is very abundant throughout the CR and its abundance is of increasing trend in last decades. It colonizes fast various natural and anthropogenic sites (e.g. early succession stages of forest trees on clear-felled areas, riverine and ruderal ecosystems, plants in forest nurseries, parks etc.). In Slovakia and Austria, it is very abundant in the inundation zone of the Danube at an altitude of about 130 m (Muránsky, 1999; Bail, 2007). The species is common in Central Moravia (e.g. the Poodří region) at an altitude of about 200 m (Novotný *et al.*, 2006) and elsewhere from lowlands to mountains. In the Tatra Mountains, it rises roughly up to an altitude of 900 m (Roubal, 1937–1941).

Host species

Flea beetles (Alticidae) are generally characterized by marked tendencies to oligophagy or monophagy. Thus, they rather differ from leaf beetles (Chrysomelidae) including many polyphages. D'alessandro & Biondi (2008) consider *C. aurea* as an arboricolous and oligophagous species. According to the majority of literary data, species of the genus *Populus* spp. and *Salix* spp. (Kuhnt, 1913; Heikertinger, 1954; Pfeffer *et al.*, 1954; Mohr, 1966; Rozner, 2003; Januš, 2004; Bukejs, 2009 etc.) are host species of *C. aurea*. On British Isles, the beetle prefers *Populus* spp. to *Salix* spp. Occasionally it occurs also on other plants (Hubble, 2010). For example, Maisner (1974) mentions on the predominant occurrence of the flea beetle on *Populus* spp. and less abundant occurrence on *Salix* spp.

Only species of the genus *Populus* spp. (mainly *P. tremula*) (Fleischer, 1927–1930; Javorek, 1947; Medvedev & Šapiro, 1965; Tomov & Gruev, 1969; Petitpierre, 1999; Georgiev, 2000; Tozlu, 2001; Tozlu *et al.*, 2010 etc.) are very often considered as hosts of *C. aurea*. According to Reitter (1912) and Roubal (1937–1941) the flea-beetle colonizes abundantly shrubby *P. tremula* L., *P. nigra* L., according to Schaufuss (1916) *P. tremula* and *S. caprea* L. Somewhat the more concrete spectrum of host

species mentions Heikertinger (1948), namely *P. tremula*, *P. nigra* and *Salix* spp., particularly *S. caprea*. The trophic affinity of *C. aurea* is similarly evaluated by Maican & Serafim (2004). According to the authors, the species develops on *P. tremula*, *P. nigra* and *S. caprea*. On an inundation area along the Danube, *C. aurea* commonly occurs on *P. nigra* and *P. alba* L. (Muránsky, 1999).

In Central and southern Europe, species of the genus *Salix* are not evidently main hosts of *C. aurea*. Unlike *C. aurata,* the species is not mentioned among pests of plantation grown willows (Wagner & Ortmann, 1959; Kadłubowski & Czalej, 1962; Schnaider, 1972; Kinelski & Szujecki, 1972; Czerniakowski, 2002; Sadej *et al.*, 2006; Walerys & Sadej, 2008; Urban, 1981, 1982, 1983 etc.).

Feeding behaviour of insect herbivores is selective because it is always markedly affected by physical or chemical factors. Toughness or trichomes of plant organs, concentration of nutrients, tannins and last but not least the chemical composition and the content of phenolic glycosides and other secondary metabolites in tissues decide, for example, on the consumption of food. As a rather specialized (oligophagous) herbivore, *C. aurea* shows higher tropic affinity only to several species from the extensive family of Salicaceae.

Development and harmfulness

In spite of the extensive distribution in the best part of the Palaearctic region and tendencies to gradations the biology of *C. aurea* has not been virtually known yet. The cause of this paradoxical situation consists mainly in the hidden development of preimago stages in the earth. It is surprising that till the 70s of the last century, an opinion persisted that larvae of the genus *Crepidodera* lived freely on leaves skeletonizing them. There are even notes on successful chemical measures against the beetles and reputedly also larvae *C. aurea* feeding on leaves. Ecological requirements of *C. aurea* can be only partly derived from numerous faunistic and entomological papers. There are nearly no more detailed data on the development, bionomics, population dynamics and harmfulness of the species in available literature. Noticeable studies of Brackenburg & Wang (1995) and Schmitt (2004) on spring organs and kinematics of skipping of some species of the family Alticidae including *C. aurea* are a certain exception.

Steinhausen (2005) attempted to the phenological evaluation of Central-European species of the family Alticidae. The author described in total five types of development within the family. Species of the genus *Crepidodera* were classed into type 1, which included 68% of all species of the family Alticidae. At this developmental stage, imagoes overwinter an lay eggs early in spring. Larvae develop in summer and after the subsequent pupation, beetles of a new generation hatch still in the same growing season. A two-peak curve of the occurrence abundance is a result. According to the author mentioned above, the first maximum of *C. aurea*, *C. fulvicornis* and *C. plutus* occurs at the beginning of June and the second maximum in mid-September. Imagoes of *C. aurata* are most abundant at the end of June and at the beginning of September. According to two numerical maxima in a year, species of the genus *Crepidodera* are mistakenly considered to be bivoltine.

Crepidodera aurea is a highly mobile expansive species able to colonize fast young shrubby poplars and willows on various sites. It outbreaks mainly on *P. tremula*, namely on a mass scale. Imagoes perforate reticularly or skeletonize young leaves of host species and at intense feeding or heavy defoliation they largely damage the species. Nevertheless, it is considered to be an economically important pest only rarely (e.g. Maisner, 1974; Georgiev, 2000; Tozlu *et al.*, 2010).

MATERIAL AND METHODS

The majority of field studies was carried out in Forest Range Resslovka, Forest District Bílovice nad Svitavou (Training Forest Enterprise Masaryk Forest in Křtiny) in 2010.

Four of the studied localities (stands 374 E, 380 A, 380 B and 381 B) occurred at the Hádecká planinka locality at an altitude of about 400 m. One locality (stand 373 D) was localized on a near southern slope at an altitude of about 340 m. Mean annual temperature amounts to 7.7 °C (in April to September 14.1 °C), mean annual precipitation 620 mm (in April to September 388 mm) and mean growing season amounts to 160 days. An advantage of the studied localities consisted in easy availability by means of the Brno urban mass transportation.

The selected stands ranked among the 1st and the 2nd age class. They were created by the rich mixture of naturally originated (self-seeding) broadleaved species, partly by planted species (oak, maple, spruce etc.). *P. tremula* and *S. caprea* were the most abundant self-seeding species in stands 381 B, 380 A, 380 B and 373 D and *S. caprea* in 374 E. At all five localities, both dominant species of flea beetles, i.e. *C. aurea* and *C. aurata*, were studied simultaneously. This paper deals, however, in more details only with the first species.

Field checks were carried out in week intervals, namely from the end of April to the half of November 2010. The numerical occurrence of flea beetles was determined using the method of sweep nets. In crowns of *P. tremula* and *S. caprea*, always 100 bilateral sweepings were carried out. Checks were carried out at any weather from 11 to 13 hours. In total, 28 checks were carried out in each of the stands. Furthermore, the flea beetles were also caught by individual sweeping or simple collection for laboratory studies. Special attention was paid to the ethology of beetles and damage to trees.

In addition to systematic checks carried out at the five localities at the time of midday, in the northern

and central part of the stand 380 B, the numerical occurrence of imagoes was determined depending on the daytime. Flea beetles were caught there by the method of sweeping (always 100 bilateral sweepings on *P. tremula*). The sweeping was carried out mostly in week intervals from the beginning of June to the end of October, namely three times a day (at 6 hours, at 12 hours and at 18 hours). During 21 check days, in total 63 samplings were carried out. The studied stand was homogenous from the aspect of species, age and space. It was divided to three parts, which were divided by about 10 m belts where the beetles were not caught at all. Each of the three sample plots was checked once a week and the order of checks (6, 12 an 18 hours) was regularly changed on them. The aim of planned and implemented samplings was to obtain preferably the most objective data to assess the diurnal (or circadian) activity of imagoes.

Simultaneously with field investigations, flea beetles were also studied in detail in the laboratory. Caught imagoes were evaluated separately within particular stands and host species (*P. tremula* and *S. caprea*). In particular check terms, the length of a body was measured and the imago sex was determined. Through the microscopic dissection of female ovaries the number of females with eggs was determined as well as the number of eggs. Dimensions (length and width) of unlaid eggs were measured by means of micrometry. Using the same method all imagoes caught by the method of sweeping were studied.

In the laboratory environment, part of imagoes of *C. aurea* was monitored in individual and common (collective) rearing on *P. tremula*, *S. caprea* and on some other species of the family Salicaceae. In collective rearing of last year's imagoes of *C. aurea* (caught on 1 May 2007), mean damaged area of leaves of *P. tremula* was determined in the laboratory as well as the average number of laid eggs. At naturally died females, the number of unlaid eggs was determined by the dissection of ovaries. Defecation, particularly the number, dimensions and volume of frass pellets were studied in detail. Numerous (although less successive) rearings of last year's and this year's beetles was carried out in 2010. Individual rearings of this year's males and females was carried out until the beginning of January 2011.

For the rearing, glass vessels of a diameter of 10 (or 20) cm and height 5 (or 10) cm were used. In smaller vessels, freshly taken leaves of host species were dished up to the beetles. Leaf-stalks were inserted into test tubes with water or wrapped by tailings of slightly moistened cotton wool. About 15 cm long foliaged sections of shoots were placed into larger vessels. Basal ends of sections were inserted into small vessels with water and throats of the vessels were sealed by cotton wool. In regular week intervals, damaged or slightly wilted leaves were replaced by new fresh leaves. As necessary, balls of moist cotton wool were placed ob the bottom of vessels or small amounts of moist sterilized garden earth. The number of laid eggs, their localization and the period of embryogenesis were noted.

Eggs and larvae of the first instar were placed into non-transparent (dark) plates with slightly moistened cotton wool or garden earth, viz. on freshly taken roots of host species. For the purpose of rearing, also host species were used grown from cuttings in flower pots with garden substrate. Flower pots with woody plants (or herbs or bunches of grass) were individually inserted into lockable bags of light monofilament fabrics. Part of the beetles was inserted into large glass cylinders (diameter 40 cm and height 50 cm), which were covered by light permeable fabrics. In this close space, the beetles consumed leaves of woody species, copulated and females laid abundantly eggs into the garden earth. Nevertheless, findings on the development of larvae on roots adequate to spent effort have not been obtained.

RESULTS AND DISCUSSION

Host species

The flea-beetle *Crepidodera aurea* (Fig. 1) is an eurytopic oligaphage, which develops optimally only on several close-relative species of the family Salicaceae. No doubt, P. *tremula* ranks among its most favourable host species. This species was the main host species of C. *aurea* at all studied localities. The beetle was most abundant in stand 380 B where it caused even 80% defoliation of P. *tremula*. At this heavy damage, our most widespread and most abundant arboricolous flea-beetle *C. aurata* participated only minimally (less than 5%). Nevertheless, the absolute and relative numerical proportion of last year's beetles of *C. aurata* on *P. tremula* was far lower than the proportion of this year's beetles. The cause of this phenomenon is also related to seasonal changes in the quality and quantity of food substrate. However, *C. aurata* occurred very abundantly on individually or group-interspersed shrubs or stands of *S. caprea*. On the other hand, *C. aurea* occurred on the willow rarely or sporadically. Representative results of systematic investigations carried out from the beginning of May to mid-November 2010 in stand 374 E have been demonstrated unambiguously. In sweepings carried out in this stand on *S. caprea* in week intervals, *C. aurea* was represented only in 0 to 7.2% (on average 1.5%) from the number of C. *aurata*.

The selective trophic behaviour of *C. aurea* in relation to several species of the family Salicaceae (mainly *P. tremula*, *P. nigra*, *S. caprea* and *S. alba*) was preliminarily determined under laboratory conditions. Last year's beetles damaged *P. tremula* on average 5.5 times (this year's 4 times) more than *S. caprea*. With respect to the low-abundant (virtually accidental) occurrence of *C. aurea* on *S. caprea* damage to *S. caprea* determined in the laboratory is rather high. According to field observations of Reitter (1912), Roubal (1937–1941, Heikertinger

1: *Flea beetle Crepidodera aurea – female*

(1948), Maican & Serafím (2004) etc., food tests have demonstrated that imagoes in captivity consume rather willingly leaves of *P. nigra*. On the other hand, *S. alba* probably does not rank among main host species of *C. aurea*. Beetles in rearings damaged *S. alba* only very little, namely only at that time if other more suitable hosts were not available. According to Muránsky (1999), Topp *et al.* (2002) and several other authors *C. aurea* occurs in the open air also abundantly on *S. alba*.

Generally, it is possible to state that the spectrum of hosts of *C. aurea* is narrower as compared with *C. aurata*. *C. aurata* occurs (often rather harmful) in the high number of broadleaved and narrow leaved *Salix* spp. (Javorek, 1947; Wagner & Ortmann, 1959; Medvedev & Šapiro, 1965; Urban, 1981; Petitpierre, 1999; Sadej *et al.*, 2006; Walerys & Sadej, 2008; Hubble, 2010 etc.). Particularly in recent decades, *C. aurata* is often mentioned also as a pest on *Populus* spp. (Tomov & Gruev, 1969; Maisner, 1974; Georgiev, 2000; Tozlu *et al.*, 2010 etc.). In Germany, *C. aurata* was rarely found on *Alnus glutinosa* Gaertn. and *A. incana* Moench. (Gharadjedaghi,1977). Heikertinger (1954) mentions opinions of Southeye that in England, the species can occur even on *Humulus lupulus* L.

Occurrence and daily activities of last year's beetles on *P. tremula*

Crepidodera aurea (as well as all other representatives of the genus *Crepidodera*) overwinters as a beetle, namely above all in the earth. There are no data on concrete places of hibernation in available literature. Roubal (1937–1941) gives more detailed information on wintering grounds of a relative species *C. aurata*. According to this author, beetles survive winter in fallen leaves close to willows and under bark in fissures of stems and branches. For the purpose of wintering, they use also holes in the soil and sand and allegedly penetrate abundantly into nests of common mole (*Talpa europaea* L.). According to our studies carried out at the Bílovice n. Svitavou Forest District, about 85% beetles of *C. aurea* winter in the place of their development in the earth. About 15% beetles winter at other hidden places, namely particularly again in the earth. The successful wintering of imagoes in the earth can markedly reduce spring floods. Due to long-term floods, species composition is generally simplified and the abundance of communities of phytophages (including species of the genus *Crepidodera*) (Lopatin, 1960) is also decreased. The entrance and course of leaving winter hiding-places by beetles of *C. aurea* are markedly affected by weather (mainly temperature and precipitation). Also the further fate of last year's beetles (i.e. their occurrence on trees and reproduction) are closely related to weather. In available literature, no more detailed information on the occurrence and development of *C. aurea* is known. According to Heikertinger (1948) and Mohr (1966), beetles appear in the open air from May to October, according to Maisner (1974) from May to the beginning of October. Steinhausen (1998) mentions the species occurrence from mid-April to the end of August. In his later publication, Steinhausen (2005) mentions two maxima (at the beginning of June and in mid-September). The second numerical maximum of beetles is mistakenly ascribed by the author to the second generation. According to Januš (2004), beetles *C. aurea* occur in the open air from the foliation of nutritive plants until the end of the growing season.

Based on the text mentioned above, it is evident that present knowledge on the occurrence of beetles of *C. aurea* on forest trees is rather poor. Systematic, studies evaluating the occurrence of last year's (old, parent) beetles and this year's (young) beetles do not exist at all. The study of population dynamics is often complicated by the difficult differentiation between last year's and this year's beetles. The determination of age of some individuals can be somewhat facilitated by the microscopic dissection of inner body organs. Uncertain findings on the seasonal

I: *The number of last year's males/females of C. aurea caught in four stands on P. tremula. Bílovice n. Svitavou, 2010.*

Date	Number of last year's males/females					Total ♂♂+♀♀
	Stand 381 B	Stand 380 A	Stand 380 B	Stand 373 D	Total	
6. 5.	38/36	15/6	71/80	12/16	136/138	274
13. 5.	67/48	35/28	120/92	34/30	256/198	454
20. 5.	89/66	53/38	107/80	41/31	290/215	505
27. 5.	82/43	50/27	130/65	77/39	339/174	513
3. 6.	115/55	98/46	218/106	118/55	549/262	811
10. 6.	38/29	40/31	82/39	40/34	200/133	333
16. 6.	18/12	12/8	52/35	33/20	115/75	190
24. 6.	52/39	26/15	151/89	47/27	276/170	446
1. 7.	59/57	55/53	65/64	32/31	211/205	416
8. 7.	40/48	22/29	43/57	21/28	126/162	288
14. 7.	23/46	11/23	37/77	5/10	76/156	232
21. 7.	8/22	8/40	20/42	4/16	40/120	160
28. 7.	5/20	4/8	34/66	11/17	54/111	165
4. 8.	5/8	2/10	9/45	3/13	19/76	95
11. 8.	1/10	3/7	10/14	5/3	19/34	53
18. 8.	4/4	2/4	10/22	-/2	16/32	48
25. 8.	3/5	-/4	24/18	-/2	27/29	56
1. 9.	3/4	2/2	9/9	2/-	16/15	31
8. 9.	4/5	3/1	38/25	1/1	46/32	78
15. 9.	4/1	-	25/23	2/-	31/24	55
22. 9.	5/-	-	14/8	-/2	19/10	29
29. 9.	4/3	-	8/5	-	12/8	20
6. 10.	-	-/2	4/1	-	4/3	7
13. 10.	2/3	1/5	2/4	-	5/12	17
20. 10.	3/-	-	4/-	-	7/-	7
27. 10.	-	-	-	-	-	-
3. 11.	1/-	-	-	-	1/-	1
10. 11.	-	-	-	-	-	-
Total	673/564	442/387	1 287/1 066	488/377	2 890/2 394	5 284
(%)	12.7/10.7	8.4/7.3	24.4/20.2	9.2/7.1	54.7/45.3	100.0
(%)	23.4	15.7	44.6	16.3	100.0	-

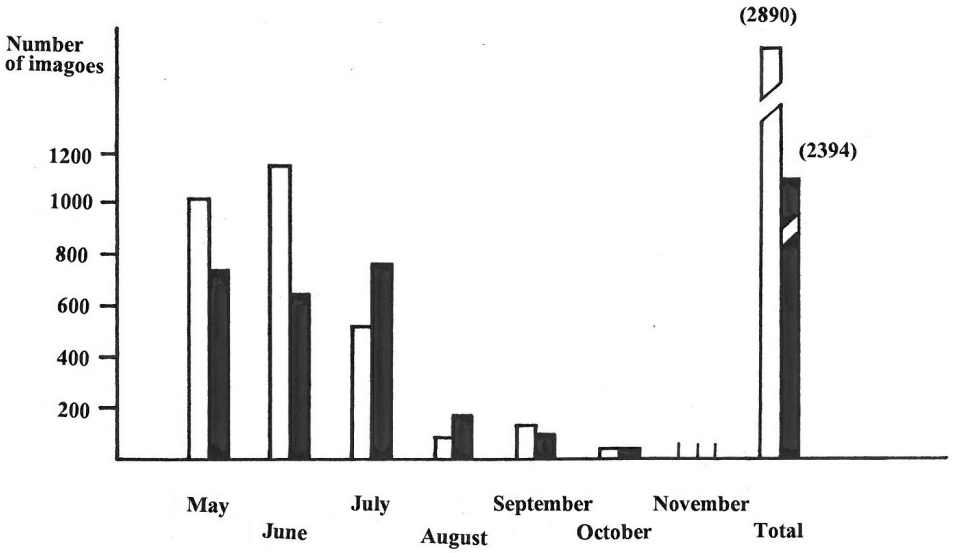
dynamics of *C. aurea* reflect in the simplified or false assessing the generation conditions. Extensive studies carried out at the Bílovice n. Svitavou Forest District were used to elucidate this problem.

The occurrence of last year's males and females of *C. aurea* in sweepings on *P. tremula* in 2010 shows Tab. I. Beetles became to occur on trees only at the beginning of May. At that time, the majority of shrubby *P. tremula* was for the most part flushed. After reaching host species, beetles started to feed immediately on freshly flushed growing and grown-up leaves. The number of last year's beetles on trees gradually increased from the beginning of May until the beginning of June when it reached maximum. Since the time, the number of beetles irregularly decreased until October. Last last year's beetles were noted in the second half of October (even at the beginning of November). Tab. I shows that the total period of the occurrence of last year's beetles on trees is surprisingly long. In the first third of the period (i.e. in May and June), males were more abundant at all studied localities than females (sex ratio 1.4/1 to 1.8/1). The numerical predominance of males over females is obviously partly related to the early departure of females into the earth to lay eggs there. In the second third of the period of occurrence (i.e. in July and August), males were, on the contrary, less abundant than females (sex ratio 0.5 to 0.7/1). At the end of the period of occurrence (September to November), males numerically predominated over females again (sex ratio 1.1 to 1.4/1). Generally, last year's males slightly predominated over females (sex ratio 1.2/1) (Tab. II, Figs. 2 and 3).

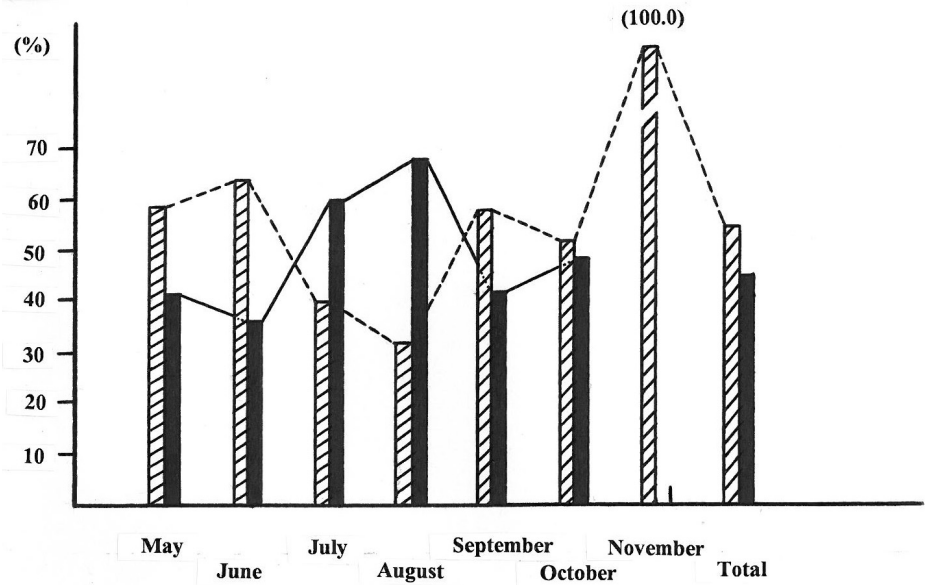
There is an opinion on beetles of the genus *Crepidodera* that it refers to insect of light and warm. Therefore, it could be possible to expect that about midday (i.e. at the time with high daily temperatures) imagoes will be most abundant on

II: *Sex ratio of last year's imagoes of C. aurea caught in four stands on P. tremula. Bílovice n. Svitavou, 2010.*

Month	Sex ratio of last year's imagoes				Total ♂♂:♀♀
	Stand 381 B	Stand 380 A	Stand 380 B	Stand 373 D	
May	1.4:1	1.5:1	1.4:1	1.4:1	1.4:1
June	1.7:1	1.8:1	1.9:1	1.7:1	1.8:1
July	0.7:1	0.6:1	0.7:1	0.7:1	0.7:1
August	0.5:1	0.3:1	0.5:1	0.4:1	0.5:1
September	1.5:1	1.7:1	1.3:1	1.7:1	1.4:1
October	1.7:1	0.1:1	2:1	-	1.1:1
November	1:0	-	-	-	1:0
Total	1.2:1	1.1:1	1.2:1	1.3:1	1.2:1



2: *The number of last year's males (light) and females of C. aurea (dark) caught on P. tremula in stands 381 B, 380 A, 380 B and 373 D. Bílovice n. Svitavou, 2010.*



3: *The percentage proportion of last year's males (light) and females of C. aurea (dark) caught on P. tremula in stands 381 B, 380 A, 380 B and 373 D. In total, 5 284 imagoes were caught, namely 2 890 (54.7%) males and 2 394 (45.3%) females. Bílovice n. Svitavou, 2010.*

woody species. However, results of studies of the daily activity of last year's beetles did not prove this hypothesis. Out of the total number of last year's beetles, the least number of beetles (23.8%) was always caught at 12:00. At 06:00 a.m. 35.2% beetles were caught. The highest number of beetles (41.0%) was caught at 06:00 p.m. (Tab. III). The least number of imagoes was caught in all warmest months (i.e. in June, July and August) in the year at 12 hours. Even in September, when the average temperature decreased, the smallest number of imagoes was obtained just at 12 hours. Only at the further fall of temperature in October, the activity of surviving last year's imagoes shifts to warmer midday hours (Tab. IV, Fig. 4). According to results given in Tab. II in June, males predominated markedly over females (sex ratio 1.3:1). In July and August, males were less abundant than females (sex ratio 0.5:1). The total sex ratio was balances (Tab. V, Fig. 5).

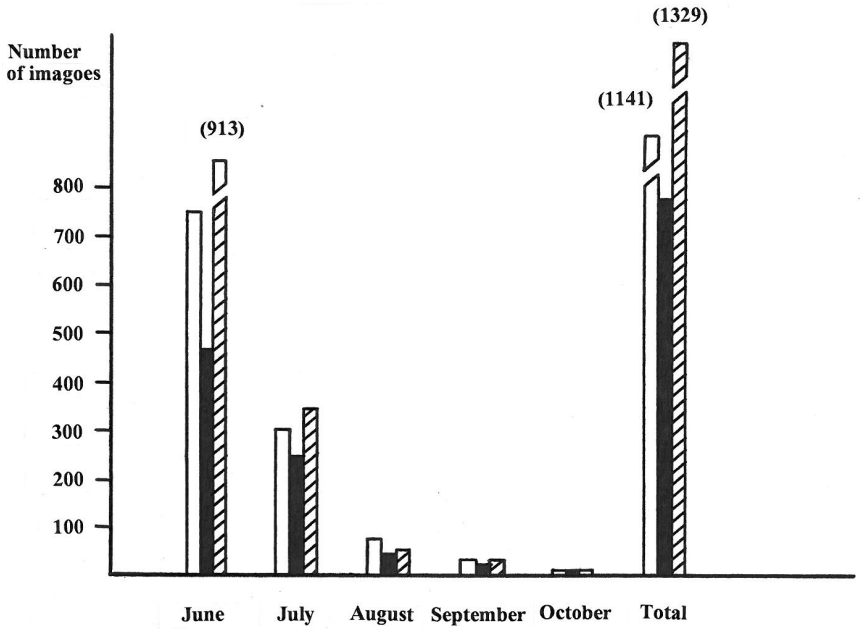
Results obtained show that last year's beetles *C. aurea* occur on trees both during the light and dark part of the day. However, their abundance regularly fluctuates during the 24-hour life cycle. The beetles are most active at night. However, they are also active during the day. With the increasing temperature, however, part of last year's beetles

III: *The number of last year's males/females of C. aurea caught in various times of the day on P. tremula. Bílovice n. Svitavou, 2010.*

Date	Number of last year's males/females caught in stand 380 B				Total ♂♂+♀♀
	at 06:00	at 12:00	at 18:00	Total	
8. 6.	110/54	38/29	80/43	228/126	354
13. 6.	62/31	69/31	190/102	321/164	485
18. 6.	100/92	43/41	78/65	221/198	419
20. 6.	91/85	32/60	45/49	168/194	362
29. 6.	64/57	46/68	148/113	258/238	496
6. 7.	43/60	34/65	58/83	135/208	343
13. 7.	33/79	13/54	29/35	75/168	243
23. 7.	15/40	12/40	33/65	60/145	205
30. 7.	5/20	10/19	12/24	27/63	90
10. 8.	5/17	6/15	10/10	21/42	63
17. 8.	6/14	1/6	2/6	9/26	35
24. 8.	5/16	4/2	10/6	19/24	43
31. 8.	2/2	1/2	1/1	4/5	9
7. 9.	4/3	4/3	5/4	13/10	23
14. 9.	3/3	2/5	7/4	12/12	24
21. 9.	5/8	2/5	2/3	9/16	25
28. 9.	3/-	1/-	1/-	5/-	5
5. 10.	1/-	0/1	-	1/1	2
12. 10.	3/-	3/-	3/1	9/1	10
19. 10.	-	2/2	1/-	3/2	5
26. 10.	-	-	-	-	-
Total	560/581	323/448	715/614	1 598/1 643	3 241
(%)	17.3/17.9	10.0/13.8	22.1/18.9	49.3/50.7	100.0
(%)	35.2	23.8	41.0	100.0	-

IV: *The number of last year's imagoes of C. aurea caught in various times of the day on P. tremula. Bílovice n. Svitavou, 2010.*

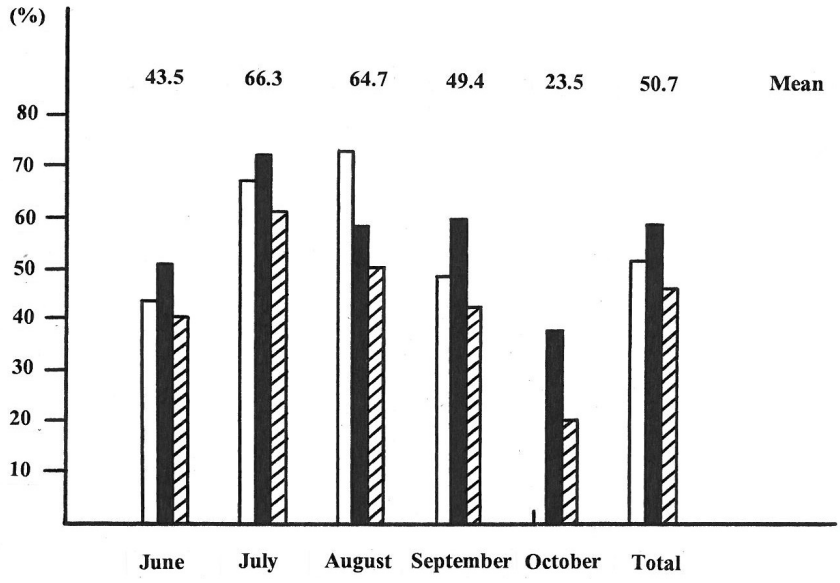
Month	Number of last year's imagoes/mean temperature			
	06:00	12:00	18:00	Total
June	746/16.5	457/21.5	913/20.7	2 116/18.7
July	295/19.5	247/23.8	339/22.8	881/21.4
August	67/13.4	37/18.6	46/19.7	150/17.4
September	29/8.5	22/15.3	26/14.9	77/12.9
October	4/4.9	8/10.6	5/9.3	17/7.3
Total	1 141/12.6	771/18.0	1 329/17.5	3 241/15.5
(%)	35.2/-	23.8/-	41.0/-	100.0/-



4: *Number of last year's imagoes of C. aurea caught on P. tremula at 06:00 (light), at 12:00 (dark) and at 18:00 (dashed line) in stand 380 B. Bílovice n. Svitavou, 2010.*

V: *Sex ratio of last year's imagoes of C. aurea caught in various times of the day on P. tremula. Bílovice n. Svitavou, 2010.*

Date	Sex ratio of last year's imagoes caught in stand 380 B			Total ♂♂:♀♀
	at 06:00	at 12:00	at 18:00	
June	1.3:1	1:1	1.4:1	1.3:1
July	0.5:1	0.4:1	0.6:1	0.5:1
August	0.4:1	0.5:1	1:1	0.5:1
September	1.1:1	0.7:1	1.4:1	1:1
October	4:0	1.7:1	4:1	3.2:1
Total	1:1	0.7:1	1.2:1	1:1



5: *The percentage proportion of last year's females of C. aurea caught on P. tremula at 06:00 (light), at 12:00 (dark) and at 18:00 (dashed line) in stand 380 B. Total number of caught imagoes amounted to 3 241, out of the number 1 598 (49.3%) were males and 1 643 (50.7%) females. Bílovice n. Svitavou, 2010.*

protects from direct insolation by translocation to the abaxial face of leaves, to the herb undergrowth, plant litter etc. Part of females uses preferentially the period of most intense insolation for laying eggs. Such behaviour is significantly demonstrated by the lower number of beetles caught at checks always at 12:00. The rhythmical fluctuation of abundance during the day can be disturbed by the sadden fall of temperature, rain or strong wind.

Occurrence and daily activities of this year's (young) beetles on *P. tremula*

This year's beetles begin to appear on woody species only in the period of peak summer. While last year's (old) beetles gradually died since July, this year's beetles together with living last year's beetles occur on trees for the whole rest of the growing season. Beetles of a new generation began to occur on studied localities at the end of July and at the beginning of August (i.e. about three months from the beginning of the beetle spring invasion to trees). The abundance of this year's beetles increased during August reaching in September maximum values. In October, it irregularly decreased. Last this year's beetles were found at the end of the first decade of November (Tab. VI). Beetles were concentrated on terminal and central parts of young shoots and intensively perforated or skeletonized growing up and freshly grown leaves. Unlike last year's beetles, the sex ratio of this year's beetles was rather balanced (about 0.8:1) during the whole period of occurrence and did not change substantially (Tab. VII, Figs. 6 and 7).

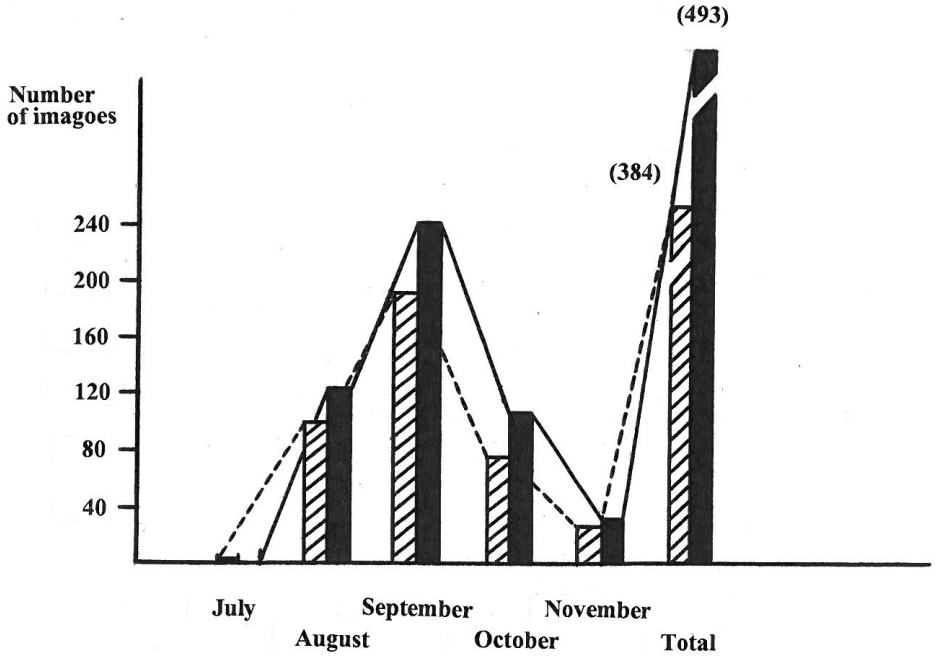
The flea-beetle *C. aurea* occurs in the area of Training Forest Enterprise Masaryk Forest Křtiny mainly on young fast-growing *P. tremula*. On grown up trees, older leaves from the beginning of September began to die and fell gradually. In mid-October, about 75% leaves fell (at the beginning of November 100% leaves). On shoots and young advance growth, the leaf fall began later (in the second half of October). Young leaves suitable for

VI: *The number of this year's males/females of C. aurea caught in four stands on P. tremula. Bílovice n. Svitavou, 2010.*

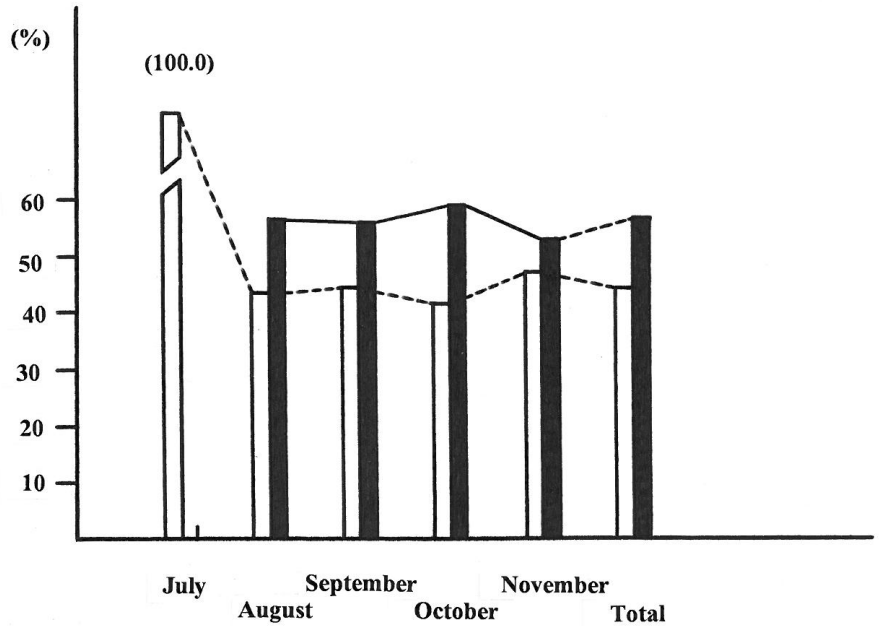
Date	Number of this year's males/females					Total ♂♂+♀♀
	Stand 381 B	Stand 380 A	Stand 380 B	Stand 373 D	Total	
28. 7.	1/-	-	-	-	1/-	1
4. 8.	1/3	1/3	8/11	-	10/17	27
11. 8.	5/4	4/4	19/12	1/-	29/20	49
18. 8.	7/5	5/4	20/12	3/3	35/24	59
25. 8.	4/9	-/2	15/46	4/7	23/64	87
1. 9.	6/7	4/2	13/9	2/4	25/22	47
8. 9.	3/8	2/2	30/38	-/1	35/49	84
15. 9.	6/4	-	39/63	-/2	45/69	114
22. 9.	7/5	2/-	36/48	2/2	47/55	102
29. 9.	7/9	4/2	23/26	2/5	36/42	78
6. 10.	2/7	-/4	8/6	2/-	12/17	29
13. 10.	9/10	-/2	24/24	-/2	33/38	71
20. 10.	9/8	-/3	14/27	-/2	23/40	63
27. 10.	3/2	1/2	2/4	-/1	6/9	15
3. 11.	12/6	1/4	9/12	1/2	23/24	47
10. 11.	1/3	-	-	-	1/3	4
Total	83/90	24/34	260/338	17/31	384/493	877
(%)	9.5/10.3	2.7/3.9	29.7/38.5	1.9/3.5	43.8/56.2	100.0
(%)	19.8	6.6	68.2	5.4	100.0	-

VII: *Sex ratio of this year's imagoes of C. aurea caught in four stands on P. tremula. Bílovice n. Svitavou, 2010.*

Month	Sex ratio of this year's imagoes				Total ♂♂:♀♀
	Stand 381 B	Stand 380 A	Stand 380 B	Stand 373 D	
July	1:0	-	-	-	1:0
August	0.8:1	0.8:1	0.8:1	0.8:1	0.8:1
September	0.9:1	2.0:1	0.8:1	0.4:1	0.8:1
October	0.9:1	0.1:1	0.8:1	0.4:1	0.7:1
November	1.4:1	0.3:1	0.8:1	0.5:1	0.9:1
Total	0.9:1	0.7:1	0.8:1	0.5:1	0.8:1



6: *The number of this year's males (light) and females of C. aurea (dark) caught on P. tremula in stands 381 B, 380 A, 380 B and 373 D. Bílovice n. Svitavou, 2010.*



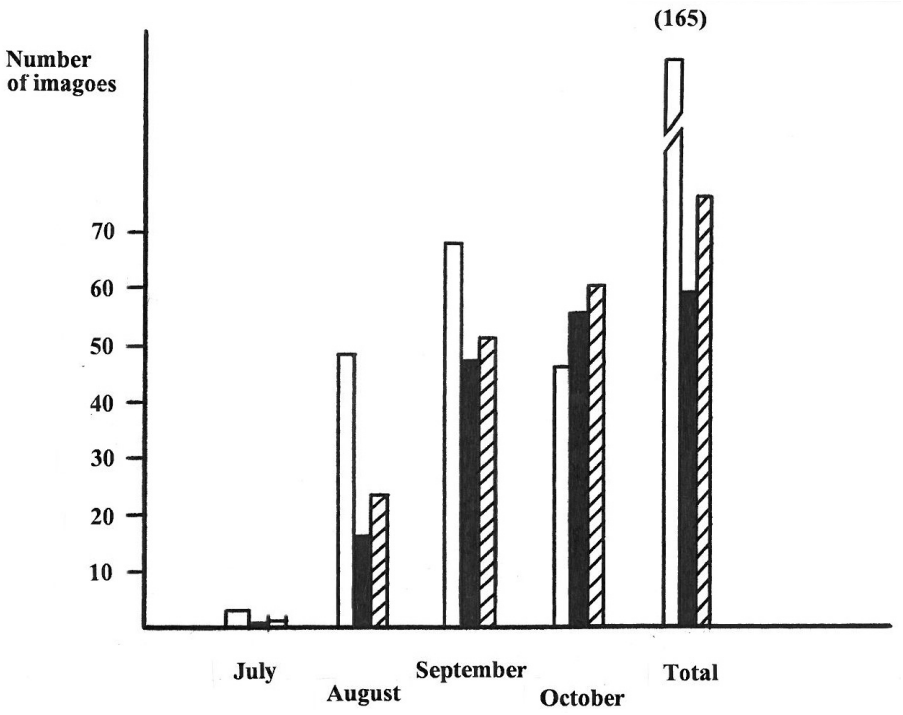
7: *The percentage proportion of this year's males (light) and females of C. aurea (dark) caught on P. tremula in stands 381 B, 380 A, 380 B and 373 D. In total, 877 imagoes were caught, out of the number 384 (43.8%) males and 493 (56.2%) females. Bílovice n. Svitavou, 2010.*

feeding occurred on these species only after the arrival of autumn frosts. This year's beetles invaded preferably the species and damaged them heavily.

Out of the total number of this year's beetles, the smallest number of beetles (28.4%) was caught in stand 380 B about at noon. A little higher number of this year's beetles (32.2%) was caught at 06:00 p.m. and the highest number (39.4%) at 06:00 a.m. (Tab. VIII). The numerical fall of this year's beetles was noted at noon in August and September. In a relatively cold October, the numerical minimum was shifted to 06:00 a.m. (Fig. 8). The sex ratio of this year's beetles caught in particular months did not change substantially. As well as in checks carried out at other localities (see Tab. VII), also here females slightly predominated over males (sex ratio 0.9:1) (Tab. IX, Fig. 9). It was proved again that this year's beetles hatched at sex ratio roughly 1:1.

VIII: *The number of this year's males/females of C. aurea caught in various times of the day on P. tremula. Bílovice n. Svitavou, 2010.*

Date	Number of this year's males/females caught in stand 380 B				Total ♂♂+♀♀
	at 06:00	at 12:00	at 18:00	Total	
30. 7.	1/2	-/1	-/1	1/4	5
10. 8.	1/9	1/-	2/2	4/11	15
17. 8.	4/9	4/-	4/2	12/11	23
24. 8.	13/6	3/4	4/5	20/15	35
31. 8.	3/3	2/2	2/2	7/7	14
7. 9.	5/9	8/5	5/3	18/17	35
14. 9.	4/5	6/6	9/11	19/22	41
21. 9.	16/19	13/6	5/7	34/32	66
28. 9.	4/6	1/2	3/8	8/16	24
5. 10.	2/1	-/4	3/5	5/10	15
12. 10.	7/18	12/11	17/18	36/47	83
19. 10.	5/4	6/15	5/9	16/28	44
26. 10.	7/2	4/3	2/1	13/6	19
Total	72/93	60/59	61/74	193/226	419
(%)	17.2/22.2	14.3/14.1	14.6/17.6	46.1/53.9	100.0
(%)	39.4	28.4	32.2	100.0	-



8: *The number of this year's imagoes of C. aurea caught on P. tremula at 06:00 (light), at 12:00 (dark) and at 18:00 (dashed line) in stand 380 B. Bílovice n. Svitavou, 2010.*

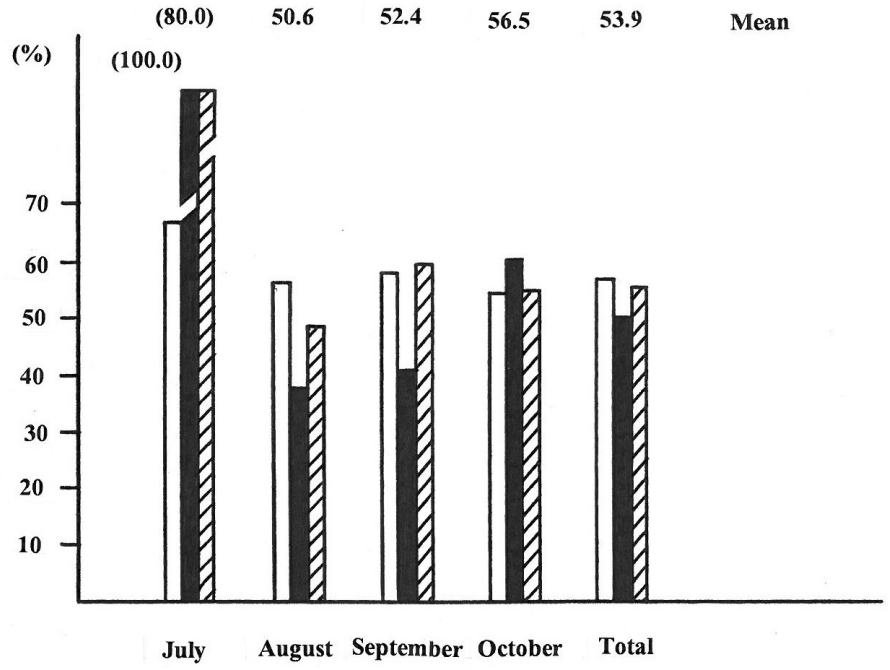
Comparison of the numerical occurrence of beetles C. *aurea* and C. *aurata* on *P. tremula* and *S. caprea*

In a chapter "Host species", it was stated that main host species of *C. aurea* was *P. tremula* at all examined localities. In 28 checks carried out in week intervals during the growing season 2010, some 6 161 imagoes (95.9%) of *C. aurea* were found on *P. tremula* and 261 (4.1%) imagoes of *C. aurata*. In simultaneously carried out sweepings on *S. caprea*, only 36 (1.8%) imagoes *C. aurea* and 1 950 (98.2%) imagoes *C. aurata* were noted. Thus, it is evident that *C. aurea* was found on *S. caprea* only rarely whereas *C. aurata* on *P. tremula* somewhat more often (Tab. X).

Both species of flea beetles occurred on the woody species at the same time. Last year's beetles were found from the beginning of May until 20

IX: *The sex ratio of this year's imagoes of C. aurea caught in various times of the day on P. tremula. Bílovice n. Svitavou, 2010.*

Date	Sex ratio of this year's imagoes caught in stand 380 B			Total ♂♂:♀♀
	at 06:00	at 12:00	at 18:00	
July	0.5:1	0:1	0:1	0.3:1
August	0.8:1	1.7:1	1.1:1	1:1
September	0.7:1	1.5:1	0.8:1	0.9:1
October	0.8:1	0.7:1	0.8:1	0.8:1
Total	0.8:1	1:1	0.8:1	0.9:1



9: *The percentage proportion of this year's females of C. aurea caught on P. tremula at 06:00 (light), at 12:00 (dark) and at 18:00 (dashed line) in stand 380 B. In total, 419 imagoes were caught, out of the number 193 (46.1%) males and 226 (53.9%) females. Bílovice n. Svitavou, 2010.*

October and rarely till 3 November (mostly at the end of May and at the beginning of June). This year's beetles were found from the end of July until 10 November (mostly in September) (Tab. X, Figs. 10 and 11). Out of the total number of beetles *C. aurea* caught on *P. tremula* (6 161 pcs) only a small number of beetles (877 pcs, i.e.14.2%) belonged to this year's beetles. Therefore, the second maximum of the numerical occurrence of beetles (in September) was not marked. Out of the total number of beetles *C. aurata* caught on *S. caprea* (1 950 pcs) some 561 pcs (i.e. 28.8%) were this year's beetles. The second numerical maximum (in September) was much more distinct at *C. aurata* compared to *C. aurea*.

At both compared flea beetles, outbreak is of chronic character. Therefore, it is possible to suppose that in the examined area, about 1/6 beetles *C. aurea* and 1/3 beetles *C. aurata* leave their pupal chambers in the same year. These young beetles occur on host species in the second half of summer and at the beginning of autumn and damage their leaves for the period of two to three weeks. With the occurrence of the first early frosts and leaf fall the beetles finish their maturation feeding and look for suitable wintering grounds. According to Steinhausen (2005), all beetles of a new generation occur in the open air and thus, the curve of their numerical occurrence is typically two-peak. According to our studies, only last year's beetles occurred on woody species in May, June and the best part of July. From the end of July till the end of October or the beginning of November, their percentage proportion decreased and the proportion of this year's beetles gradually increased (Tab. XI).

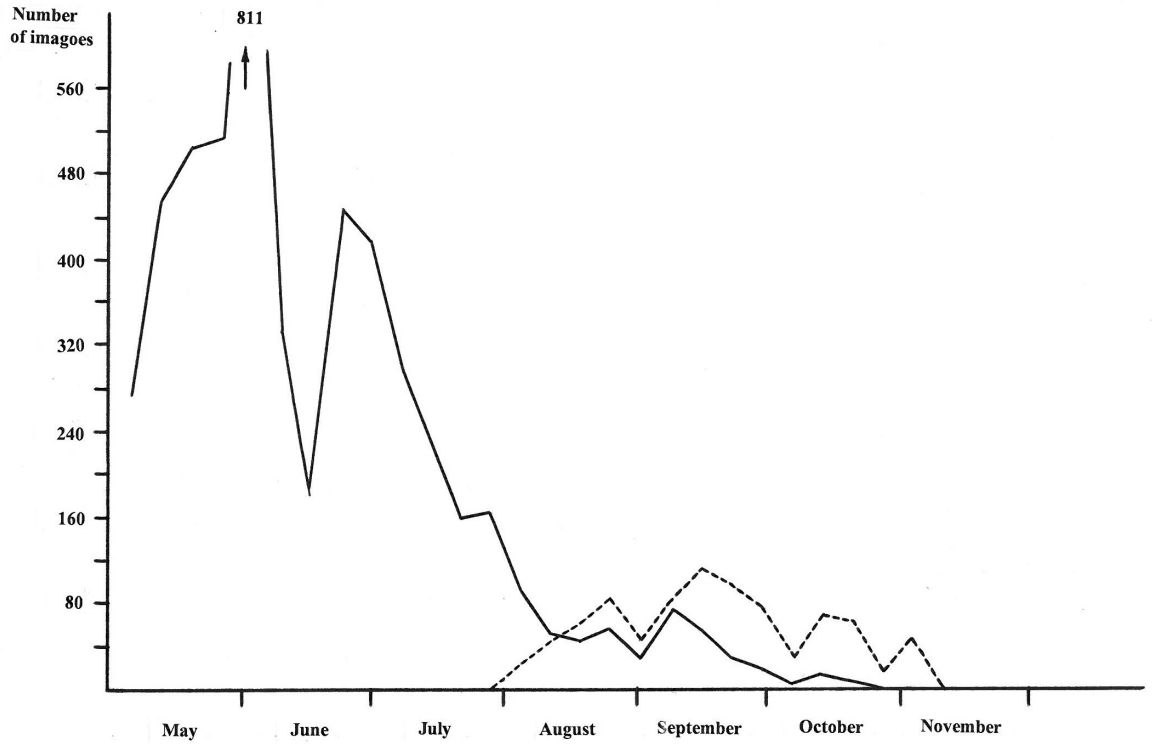
Imagoes of flea beetles of the genus *Crepidodera* are very movable. Under warm weather, they move lively or fly, namely even to longer distances. They have got well-developed membraneous wings, which are twice longer than wing-cases. They can fast spread to near or distant surroundings particularly passively by means of air streams (Januš, 2004). Their seasonal dynamics is dependent mainly on weather and host species. The occurrence and development of flea beetles can be also affected by seasonal changes in the quantity and quality of food. The trophic

X: *The occurrence of last year's/this year's imagoes of C. aurea and C. aurata in sweepings on P. tremula and S. caprea. Bílovice n. Svitavou, 2010.*

Date	P. tremula		S. caprea	
	C. aurea	C. aurata	C. aurea	C. aurata
6. 5.	274/-	-	-	40/-
13. 5.	454/-	2/-	-	?
20. 5.	505/-	3/-	1/-	91/-
27. 5.	513/-	1/-	2/-	114/-
3. 6.	811/-	5/-	2/-	126/-
10. 6.	333/-	1/-	5/-	125/-
16. 6.	190/-	4/-	-	44/-
24. 6.	446/-	6/-	6/-	137/-
1. 7.	416/-	1/-	2/-	74/-
8. 7.	288/-	9/-	3/-	134/-
14. 7.	232/-	3/-	1/-	28/-
21. 7.	160/-	3/-	-	59/3
28. 7.	165/1	5/3	-	42/17
4. 8.	95/27	1/-	1/-	25/15
11. 8.	53/49	5/2	-	27/18
18. 8.	48/59	9/7	1/1	34/29
25. 8.	56/87	5/5	-	64/35
1. 9.	31/47	9/6	-	31/29
8. 9.	78/84	13/14	2/1	39/47
15. 9.	55/114	15/16	-/1	51/64
22. 9.	29/102	12/22	1/-	50/82
29. 9.	20/78	10/19	2/2	16/40
6. 10.	7/29	2/4	-/2	13/27
13. 10.	17/71	3/13	-	21/72
20. 10.	7/63	2/17	-	4/44
27. 10.	-/15	2/2	-	-/18
3. 11.	1/47	-	-	-/19
10. 11.	-/4	-	-	-/2
Total	5 284/877	131/130	29/7	1 389/561
(%)	82.3/13.6	2.1/2.0	1.4/0.4	69.9/28.3
Total	6 161	261	36	1 950
(%)	95.9	4.1	1.8	98.2
(%)	100.0		100.0	

value of leaves (as the food substrate of beetles) decreases with their age. Therefore, beetles can search for new food sources at the end of summer and at the beginning of autumn, for example on young fast-growing shoots or advance growth. The movement of flea beetles searching for food was demonstrated at this year's and surprisingly also last year's beetles of *C. aurata*. In August and particularly in September and October, beetles flew over from *S. caprea* to young *P. tremula*. While in May and June, beetles *C. aurata* occurred on *P. tremula* only rarely, in September and October these beetles created nearly 18 % of all caught individuals of the genus *Crepidodera* (Tab. XII). The gradual increase of the population density of *C. aurata* on *P. tremula* can be explained mainly by their immigration from *S. caprea*. At the end of the growing season, leaves of *S. caprea* are rather leathery (tough) being less suitable as food for small beetles of *C. aurata*. At searching for suitable food some beetles can seat also on a secondary (additional) host species *P. tremula*. Young and large sappy leaves of sprouts and naturally regenerating *P. tremula* can provide food of higher quality to beetles of *C. aurata* then older leaves of *S. caprea*, which otherwise rank among the most favourite host species of *C. aurata*.

Results of an extensive examination carried out on *P. tremula* in the central and northern part of stand 380 B support a theory on the migration of beetles of *C. aurata* from *S. caprea* to *P. tremula*. The gradual



10: *The number of last year's imagoes (full) and this year's imagoes of C. aurea (dashed line) caught on P. tremula. Bílovice n. Svitavou, 2010.*

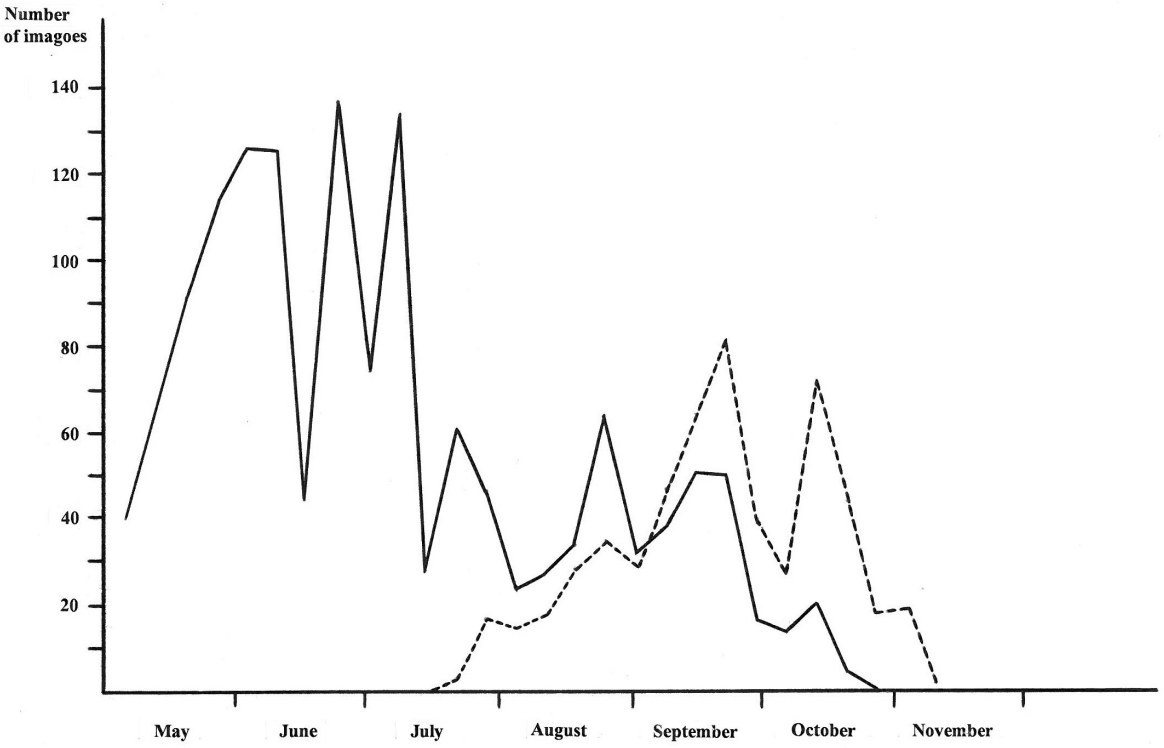
XI: *The percentage proportion of this last year's/year's imagoes of C. aurea and C. aurata in sweepings on P. tremula and S. caprea. Bílovice n. Svitavou, 2010.*

Month	P. tremula		S. caprea	
	C. aurea	C. aurata	C. aurea	C. aurata
May	100.0/-	100.0/-	100.0/-	100.0/-
June	100.0/-	100.0/-	100.0/-	100.0/-
July	99.0/0.1	87.5/12.5	100.0/-	94.4/5.6
August	53.2/46.8	58.8/41.2	66.7/33.3	60.7/39.3
September	33.4/66.6	43.4/56.6	55.6/44.4	41.6/58.4
October	14.8/85.2	20.0/80.0	0/100.0	19.1/80.9
November	1.9/98.1	-	-	-/100.0
Total	85.8/14.2	50.2/49.8	80.6/19.4	71.2/28.8

decline of the number of beetles of *C. aurea* and an increase of the number of beetles of *C. aurata* during June to October 2010 was noted in checks carried out at 06:00 a.m., 12:00 and 06:00 p.m. During these five months, the mean numerical proportion of *C. aurata* increased from 0.6 to 41.3%. In populations of *C. aurata* increased both the proportion of last year's beetles and particularly the proportion of this year's beetles (Tabs. XIII, XIV and XV).

Feeding last year's beetles

After the termination of hibernation (usually at the beginning of May), last year's beetles leave their wintering grounds and occur on host species. On these species, they search for new growing up and mature leaves and begin immediately ingest. The beetles bit out minute irregular holes (windows) or area sockets into a leaf blade reaching up to an opposite leaf epidermis (Figs. 12, 13 and 14). Dimensions of feeding marks vary depending on the host species, age and size of leaves. At the beginning of the period of feeding on young leaves of *P. tremula*, feeding marks are 0.4 to 4.0 (on average 1.7) mm long and 0.3 to 1.5 (on average 0.8) mm wide. With the growth of young leaves and their ageing, dimensions of feeding marks somewhat increase. Fine new (fresh) leaves of *P. tremula* are usually perforated by the beetles at the beginning of the growing season. Somewhat older leaves with completed growth are usually skeletonized and partly also perforated. During feeding on leaves of *P. tremula*, beetles occur more often (in 75%) on the abaxial face of leaves. Leaves of *S. caprea* are heavily hairy on the abaxial



11: *The number of last year's imagoes (full) and this year's imagoes of C. aurata (dashed line) caught on S. caprea. Bílovice n. Svitavou, 2010.*

XII: *The numerical and percentage proportion of imagoes of C. aurea and C. aurata in sweepings on P. tremula and S. caprea. Bílovice n. Svitavou, 2010.*

Month	P. tremula		S. caprea	
	C. aurea	C. aurata	C. aurea	C. aurata
May	1 746/99.7	6/0.3	3/1.2	245/98.8
June	1 780/99.1	16/0.9	13/2.9	432/97.1
July	1 262/98.1	24/1.9	6/1.7	357/98.3
August	474/93.3	34/6.7	3/1.2	247/98.8
September	638/82.4	136/17.6	9/2.0	449/98.0
October	209/82.3	45/17.7	2/1.0	199/99.0
November	52/100.0	-	-	21/100.0
Total	6 161/95.9	261/4.1	36/1.8	1 950/98.2
Total	6 422/100.0		1 986/100.0	

face. Beetles of *C. aurea* largely perforate them, namely always from the adaxial face.

Feeding marks of *C. aurea* consist of small sockets or holes of 0.2 × 0.2 to 1.0 × 1.0 (on average 0.5 × 0.5) mm. These particular damage are ordered as a rule closely subsequently, thereby the feeding marks obtain lengthwise shape. Minute feeding marks are usually separated from each other by negligible rests of leaf parenchyma, vein anastomoses and sporadically also veins. The beetles partly damage fine veins while larger veins remain undamaged.

During the species outbreak, leaf damage shows rather fast course. For example, in stand 380 B, about 30% leaf area of *P. tremula* was damaged already in mid-May. On leaves of an average area of 15 cm^2, there were on average 2 630 area sockets (reaching up to the opposite epidermis), more rarely holes. These minute feeding marks of a diameter of about 0.5 mm were grouped into on average 450 merged elongated feeding marks. In the consolidated feeding marks of an average size 1.8 × 0.9 mm, there were on average 5.8 minute feeding marks. On the most damaged leaves, the line arrangement of feeding marks changed to reticular-area arrangement.

In the laboratory, last year's beetles of *C. aurea* 85% skeletonized and 15% perforated leaves of *P. tremula*. Leaves were damaged from 60% on the abaxial face and from 40% on the adaxial face. The beetles bit out in leaves particular feeding marks of an area of 0.2 × 0.17 to 0.4 × 0.3 mm. Combined feeding marks of males were on average evidently smaller (2.3 × 0.55 mm) than feeding marks of females

XIII: *The occurrence of last year's/this year's imagoes of C. aurea and C. aurata in sweepings on P. tremula in stand 380 B (at particular checks according to various times of the day). Bílovice n. Svitavou, 2010.*

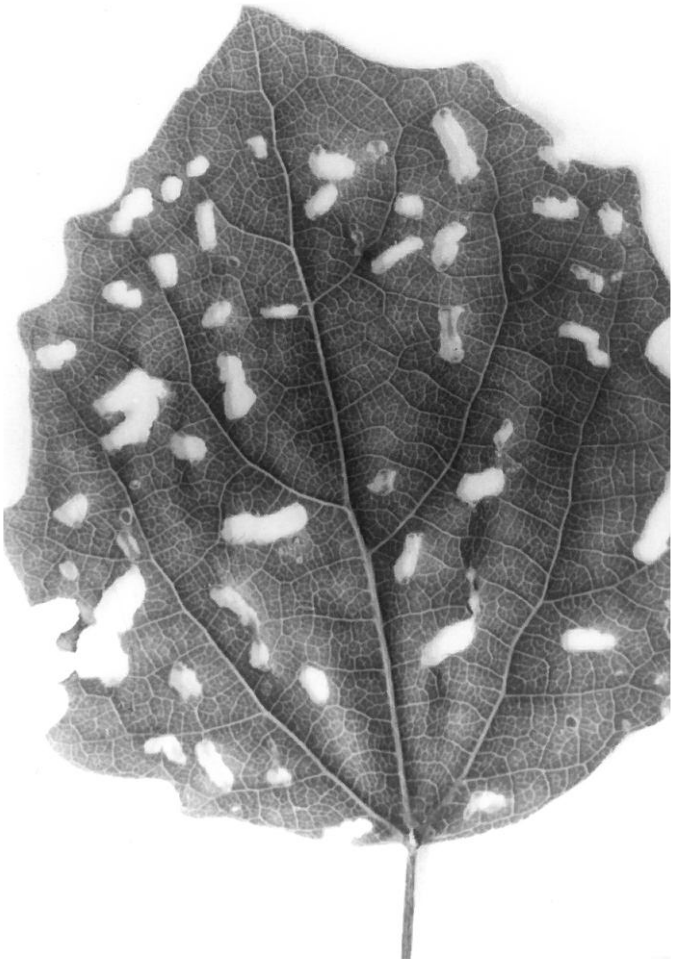
Date	at 06:00		at 12:00		at 18:00		Total	
	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata
8. 6.	164/-	1/-	67/-	-	123/-	-	354/-	1/-
13. 6.	93/-	-	100/-	1/-	292/-	1/-	485/-	2/-
18. 6.	192/-	1/-	84/-	1/-	143/-	3/-	419/-	5/-
20. 6.	176/-	2/-	92/-	2/-	94/-	1/-	362/-	5/-
29. 6.	121/-	-	114/-	-	261/-	-	496/-	-
6. 7.	103/-	2/-	99/-	1/-	141/-	5/-	343/-	8/-
13. 7.	112/-	-	67/-	1/-	64/-	1/-	243/-	2/-
23. 7.	55/-	1/-	52/-	1/-	98/-	1/-	205/-	3/-
30. 7.	25/3	-	29/1	-	36/1	2/-	90/5	2/-
10. 8.	22/10	1/-	21/1	-/1	20/4	-	63/15	1/1
17. 8.	20/13	2/1	7/4	1/-	8/6	1/1	35/23	4/2
24. 8.	21/19	-	6/7	1/-	16/9	2/1	43/35	3/1
31. 8.	4/6	-	3/4	-	2/4	-	9/14	-
7. 9.	7/14	2/2	7/13	3/4	9/8	2/3	23/35	7/9
14. 9.	6/9	3/6	7/12	3/5	11/20	4/6	24/41	10/17
21. 9.	13/35	5/8	7/19	4/6	5/12	12/2	25/66	21/38
28. 9.	3/10	-/2	1/3	3/4	1/11	1/2	5/24	4/8
5. 10.	1/3	1/3	1/4	3/7	-/8	2/4	2/15	6/14
12. 10.	3/25	2/9	3/23	7/26	4/35	2/11	10/83	11/46
19. 10.	-/9	2/13	4/21	-/6	1/14	-/1	5/44	2/20
26. 10.	-/9	-/5	-/7	-/5	-/3	-/4	-/19	-/14
Total	1 141/165	25/49	771/119	32/76	1 329/135	40/57	3 241/419	97/182
Total	1 380		998		1 561		3 939	
(%)	82.7/12.0	1.8/3.5	77.3/11.9	3.2/7.6	85.1/8.6	2.6/3.7	82.3/10.6	2.5/4.6
(%)	100.0		100.0		100.0		100.0	

XIV: *The numerical and percentage occurrence of imagoes of C. aurea and C. aurata in sweepings on P. tremula in stand 380 B (in particular months according to various times of the day). Bílovice n. Svitavou, 2010.*

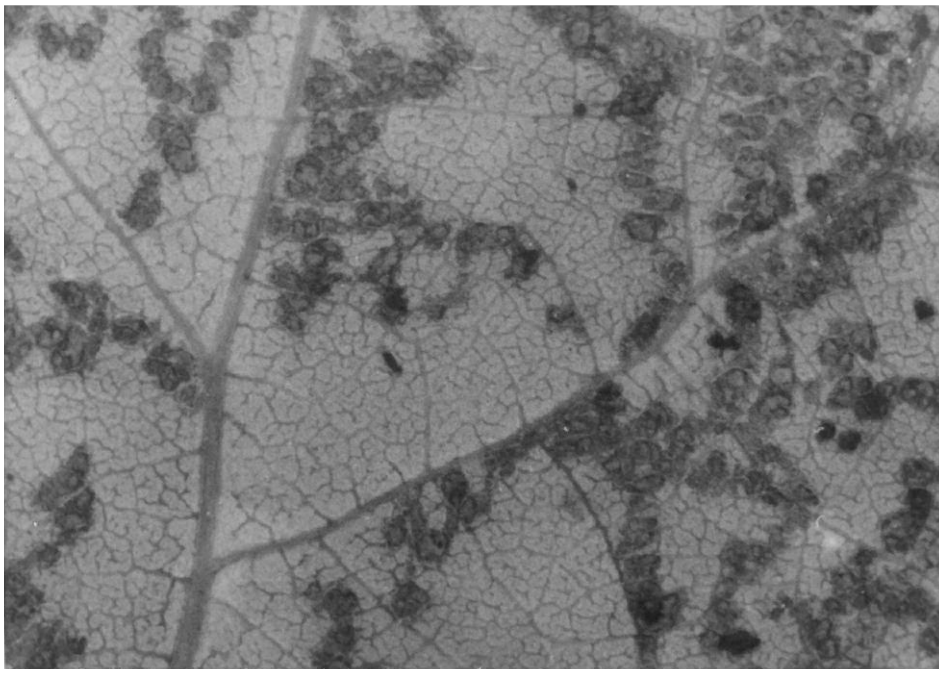
Month	at 06:00		at 12:00		at 18:00		Total	
	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata
June	746/99.5	4/0.5	457/99.1	4/0.9	913/99.5	5/0.5	2 116/99.4	13/0.6
July	298/99.0	3/1.0	248/98.8	3/1.2	340/97.4	9/2.6	886/98.3	15/1.7
August	115/96.6	4/3.4	53/94.6	3/5.4	69/93.2	5/6.8	237/95.2	12/4.8
September	97/77.6	28/22.4	69/68.3	32/31.7	77/58.8	54/41.2	243/68.1	114/31.9
October	50/58.8	35/41.2	63/48.8	66/51.2	65/73.0	24/27.0	178/58.7	125/41.3
Total	1 306/94.6	74/5.4	890/89.2	108/10.8	1 464/93.8	97/6.2	3 660/92.1	279/7.1
Total	1 380/100.0		998/100.0		1 561/100.0		3 939/100.0	

XV: *The percentage proportion of last year's/this year's imagoes of C. aurea and C. aurata in sweepings on P. tremula in stand 380 B (in particular months according to various times of the day). Bílovice n. Svitavou, 2010.*

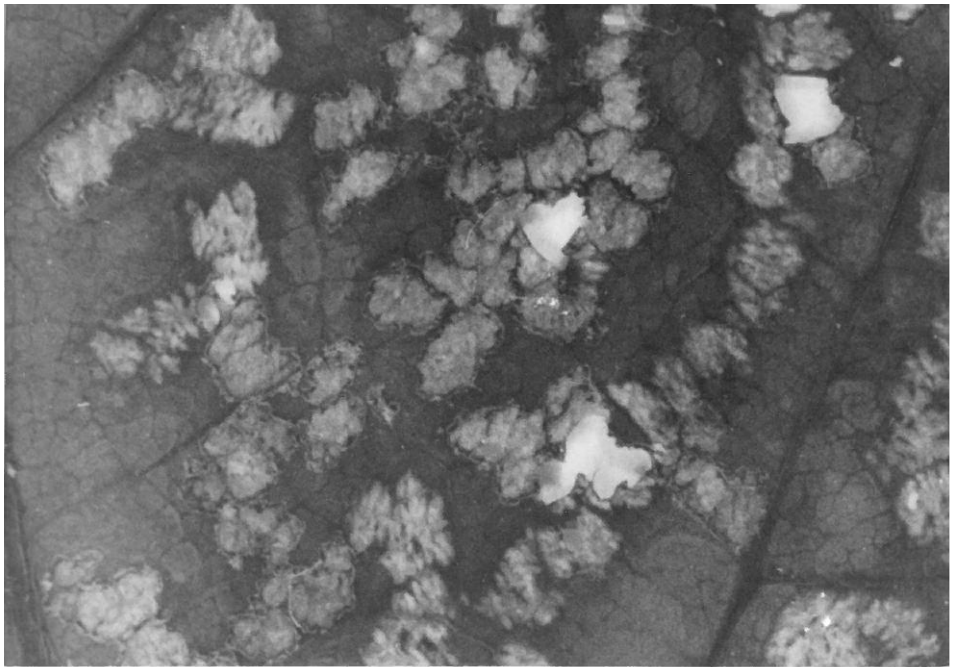
Month	at 06:00		at 12:00		at 18:00		Total	
	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata	C. aurea	C. aurata
June	100.0/-	100.0/-	100.0/-	100.0/-	100.0/-	100.0/-	100.0/-	100.0/-
July	99.0/1.0	100.0/-	99.6/0.4	100.0/-	99.7/0.3	100.0/-	99.4/0.6	100.0/-
August	58.3/41.7	75.0/25.0	69.8/30.2	66.7/33.3	66.7/33.3	60.0/40.0	63.3/36.7	66.7/33.3
September	29.9/70.1	35.7/64.3	31.9/68.1	40.6/59.4	33.8/66.2	35.2/64.8	31.7/68.3	36.8/63.2
October	8.0/92.0	14.3/85.7	12.7/87.3	15.2/84.8	7.7/92.3	16.7/83.3	9.6/90.4	15.2/84.8
Total	87.4/12.6	33.8/66.2	86.6/13.4	29.6/70.4	90.8/9.2	41.2/58.8	88.6/11.4	34.8/65.2



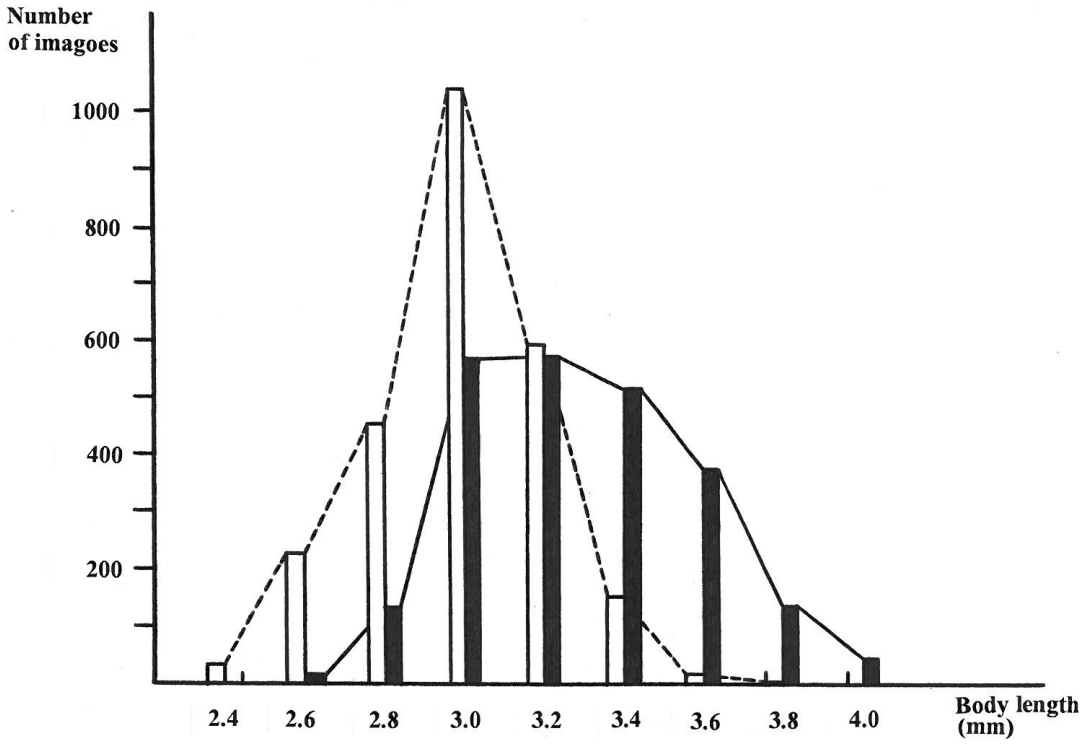
12: *A leaf of P. tremula damaged by imagoes of C. aurea (top view)*



13: *A detail of a leaf of P. tremula damaged by imagoes of C. aurea (bottom view)*



14: *A detail of a leaf of P. tremula damaged by imagoes of C. aurea (top view)*



15: *The body length of last year's males (light) and females of C. aurea (dark) caught on P. tremula. Bílovice n. Svitavou, May to October 2010.*

(4.9 × 0.67 mm). The larger average size of female feeding marks is mainly given by their larger size (Fig. 15). Last year's males (2 494 beetles measured) were 2.4 to 3.8 (on average 3.0) mm long. Last year's females (2 350 beetles measured) were 2.4 to 4.0 (on average 3.3) mm long. The same body size was also found at 428 this year's males and 510 this year's females.

The beetles live several months after overwintering. They are most active in May and in the first half of June. At this time, they damage leaves intensively, copulate repeatedly and lay eggs. In July, the majority of last year's beetles die. Only small part

XVI: *Damaged leaf area, number of laid eggs and defecation of imagoes of C. aurea on P. tremula. Imagoes were caught in the open on 1 May 2007. Laboratory examination, 2007.*

Period (from–to)	Number of living ♂♂/♀♀	Mean						
		Damaged area (cm²)	Number of laid eggs	Number of frass pellets	Length/ width of frass pellets (mm)	Volume of one frass pellet (mm³)	Volume of all frass pellets (mm³)	Number/ volume of frass pellets in mm³ (from 1 cm² leaf area)
1.–8. 5.	2/6	1.2	15.8	72.9	0.48/0.15	0.0085	0.6200	60.8/0.52
9.–15. 5.	2/6	2.6	24.8	140.0	0.50/0.16	0.0100	1.4000	53.8/0.53
16.–22. 5.	2/6	3.3	65.2	170.3	0.54/0.19	0.0153	2.6056	51.6/0.79
23.–29. 5.	2/6	5.1	54.5	330.6	0.42/0.18	0.0107	3.5374	64.8/0.69
30.–5. 6.	2/6	1.6	28.0	133.0	0.42/0.16	0.0084	1.1172	83.1/0.70
6.–10. 6.	-	0.5	5.5	29.1	0.41/0.15	0.0072	0.2095	58.2/0.42
Total	(2/6)	14.3	193.8 (+ 9.7)	875.9	0.4608/ 0.1722	0.0108	9.4897	61.3/0.66

XVII: *Damaged leaf area, number of laid eggs and defecation of imagoes of C. aurea on P. tremula. Imagoes were caught in the open on 6 May 2010. Laboratory examination, 2010.*

Period (from–to)	Number of living ♂♂/♀♀	Total damaged area (cm²)	Total number of laid eggs	Total number of frass pellets	Mean length/ width of frass pellets (mm)	Mean volume of a frass pellet (mm³)	Volume of frass pellets (mm³)
7.–14. 5.	6/6	15	155	912	0.40/0.19	0.0113	10.3056
15.–21. 5.	6/6	31	101	2 644	0.39/0.19	0.0110	29.0840
22.–28. 5.	5/6	43	78	2 859	0.40/0.17	0.0091	26.0169
29.–4. 6.	1/3	10	24	759	0.40/0.17	0.0091	6.9069
5.–11. 6.	1/2	3.5	8	473	0.40/0.16	0.0080	3.7840
12.–18. 6.	1/-	2.5	-	346	0.41/0.16	0.0082	2.8372
19.–25. 6.	1/-	0.3	-	52	0.43/0.15	0.0076	0.3952
26.–2. 7.	1/-	1.8	-	200	0.40/0.15	0.0071	1.4200
3.–9. 7.	-	0.3	-	67	0.40/0.15	0.0071	0.4757
Total	(6/6)	107.4	366	8 312	-	-	81.2255
Mean	-	9.0	61	692.7	0.40/0.177	0.0098	6.7688
Mean/cm²	-	-	-	77.4	-	-	0.76

XVIII: *Damaged leaf area, number of laid eggs and defecation of imagoes of C. aurea on P. tremula. Imagoes were caught in the open on 6 May 2010. Laboratory examination, 2010.*

Period (from–to)	Number of living ♂♂/♀♀	Total damaged area (cm²)	Total number of eggs	Total number of frass pellets	Mean length/width of frass pellets (mm)	Mean volume of a frass pellet (mm³)	Volume of frass pellets (mm³)
7.–14. 5.	4/8	13	158	1 626	0.46/0.18	0.0117	19.0125
15.–21. 5.	4/8	25	88	2 797	0.40/0.19	0.0113	31.6061
22.–28. 5.	3/8	44	93	2 570	0.43/0.16	0.0086	22.1020
29.–4. 6.	1/1	4	2	454	0.42/0.17	0.0095	4.3130
5.–11. 6.	1/1	4.5	-	392	0.50/0.19	0.0142	5.5664
12.–18. 6.	-	0.3	-	57	0.46/0.17	0.0104	0.5928
Total	(4/8)	90.8	341	7 895	-	-	83.1928
Mean	-	7.6	42.6	657.9	0.43/0.177	0.0106	6.9327
Mean/cm²	-	-	-	86.9	-	-	0.92

of the beetles survives on trees until the end of the growing season. In rearings, beetles lived mostly only 1.5 months, most 2.5 months. In a successful mass rearing carried out in 2007 on *P. tremula*, beetles damaged on average 14.3 cm^2 leaf blade, which corresponded to the average area of one leaf (Tab. XVI). In similarly arranged mass rearing in 2010, beetles damaged on average only 7.6 to 9.0 cm^2 leaf blade (Tabs. XVII, XVIII and XIX). Numerous individual rearings of males and females on leaves of *P. tremula* were little successful. Beetles damaged only 0.1 to 5.1 cm^2 and died during a month.

Defecation

Imagoes defecate considerable number of frass pellets during feeding. In mass rearings, frass pellets were (immediately after defecation) on average 0.43 mm long and 0.18 mm wide. In individual rearing (which never proceeded optimally), beetles produced on average smaller frass pellets than in mass rearings. Mean dimensions of male frass pellets were markedly smaller (0.37 × 0.15 mm) than mean dimensions of female frass pellets (0.40 × 0.18 mm). They are of fusiform to cylindrical shape being rough on their surface. They are created of thin funicular frass of a diameter about 0.06 mm, which is closely spirally winded. In too moist environment, the frass pellets increase their volume and the spirals disintegrate to thin strands of various length. After defection, frass pellets are dark green, later brown to black. In the open, they do not stick on leaves and usually immediately or early after defection they fall to the earth. In rearings, 75.7% frass pellets were localized on leaves, 23.8% on the bottom and walls of vessels and 0.5% in moistened cotton wool.

In laboratory studies carried out in 2007, last year's beetles produced on *P. tremula* on average 876 frass pellets of an average size 0.46 × 0.17 mm and mean volume 0.0108 mm^3. They defecated on average 9.49 mm^3 frass pellets. At the average damage 14.3 cm^2, they produced on average 61.3 frass pellets of a volume of 0.66 mm^3 from 1 cm^2 damaged leaf (Tab. XVI). In 2010, beetles defecated from 1 cm^2 on average 77.4 to 86.9 frass pellets of a volume of 0.76 to 0.92 mm^3 (Tabs. XVII, XVIII and XIX). In a successful breeding in 2007, beetles produced smaller volume of frass pellets from 1 cm^2 damaged leaf area than in less successful breeding in 2010. Generally, with the increased average area of damage (from 7.6 to 14.3 cm^2) the volume of frass pellets gradually decreased from 1 cm^2 (namely, from 0.92 to 0.66 mm^3). Well thriving beetles consumed totally the larger volume of food, however, produced from 1 cm^2 damaged leaf area the smaller volume of frass pellets than worse thriving beetles. Relationships between the intensity of feeding of last year's beetles *C. aurea* on *P. tremula* and the volume of frass pellets produced from 1 cm^2 damaged leaf is demonstrated on Fig. 16.

Reproduction

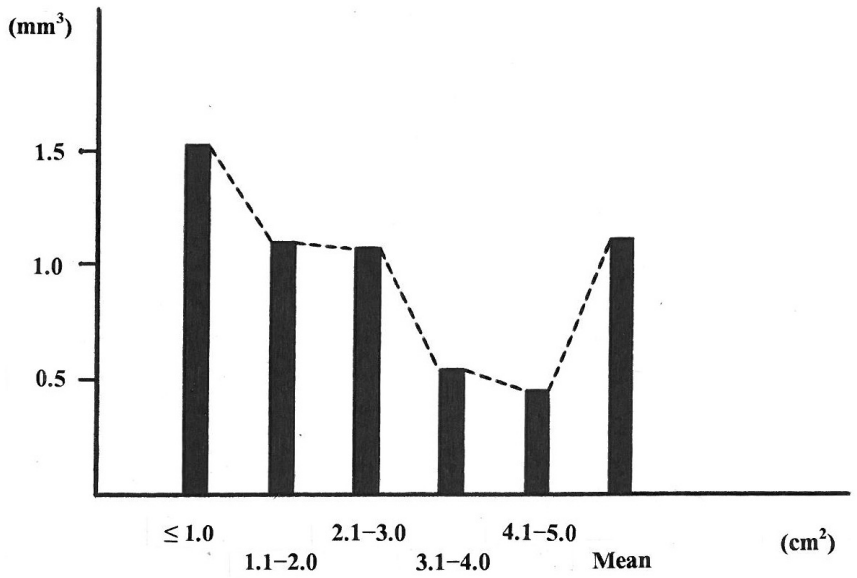
Last year's beetles *C. aurea* mate for the first time already after several few days of feeding. The first copulating pairs were noted in 2010 already on 5 May. The time of copulation is considerable. For example, on 11 May, beetles were observed at midday hours copulating for a period of 35 and 45 minutes. In captivity, copulation was observed only rarely. The sexual activity (particularly copulation frequency) of *C. aurea* is much lower as compared with many species of the family Chrysomelidae (e.g. *Lochmaea caprea* /L./, *Galerucella lineola* /F./, *Chrysomela populi* L. and *Plagiodera versicolora* /Laich./). Otherwise, the beetles are very watchful. In case of danger, females usually skip even during copulation and together with males fall to the earth mostly without interrupting their copulation. In undergrowth, beetles hide and thus avoid danger.

Eggs develop in ovaries of females of *C. aurea* gradually. They are laid, however, in groups at 10 to 30 (on average 18) pieces. In rearings, females laid eggs exclusively into the surface layer of garden earth. If earth was not inserted into breeding vessels then eggs were mostly (in 52.4%) laid on the vessel walls. Eggs were laid on leaves in 27.8% and into moderately moist cotton wool in 19.8%. For ovipositing, females use a false ovipositor, which can be pushed out more than 2 mm.

The fertility of females is rather high. In 2007, females laid out on average 193.8 eggs from 1 May until 7 June, i.e. on average 10.8 clutches at

XIX: *Damaged leaf area, number of laid eggs and defecation of imagoes of C. aurea on P. tremula. Imagoes were caught in the open on 6 May 2010. Laboratory examination, 2010.*

Period (from–to)	Number of living ♂♂/♀♀	Total damaged area (cm^2)	Total number of laid eggs	Total number of frass pellets	Mean length/width of frass pellets (mm)	Mean volume of a frass pellet (mm^3)	Volume of frass pellets (mm^3)
7.–14. 5.	5/5	17	154	1 946	0.39/0.20	0.0122	23.7412
15.–21. 5.	5/5	25	68	2 246	0.47/0.19	0.0133	29.8718
22.–28. 5.	4/5	39	44	2 102	0.38/0.17	0.0086	18.0772
29.–4. 6.	-	0.3	-	42	0.38/0.17	0.0086	0.3612
Total	(5/5)	81.3	266	6 336	-	-	72.0514
Mean	-	8.1	53.2	633.6	0.415/0.186	0.0114	7.2051
Mean/cm^2	-	-	-	77.9	-	-	0.89



16: *Relationships between the average week area of leaves of P. tremula damaged by last year's imagoes of C. aurea (cm²) and the volume of frass pellets defecated from 1 cm² damaged leaf area (mm³). Laboratory examination, 2010.*

18 eggs. In the course of two to seven days after the termination of egg laying, the females died. In ovaries of dead females, there were 0 to 18 (on average 9.7) unlaid eggs. In the period of the most intensive feeding and reproduction (i.e. in the second half of May), females laid on average 65.2 eggs during a week (i.e. 3.6 clutches at 18 eggs). At that time, average intervals between particular clutches were two days (during the whole period of oviposition four days) (Tab. XVI). In less successful rearings in 2010, females laid on average 42.6 to 61.0 eggs. Generally, with increasing the average damaged leaf area the average number of eggs increased (Tabs. XVII, XVIII and XIX). At some beetles, tendencies to cannibalism became evident because up to 20% eggs were damaged by them.

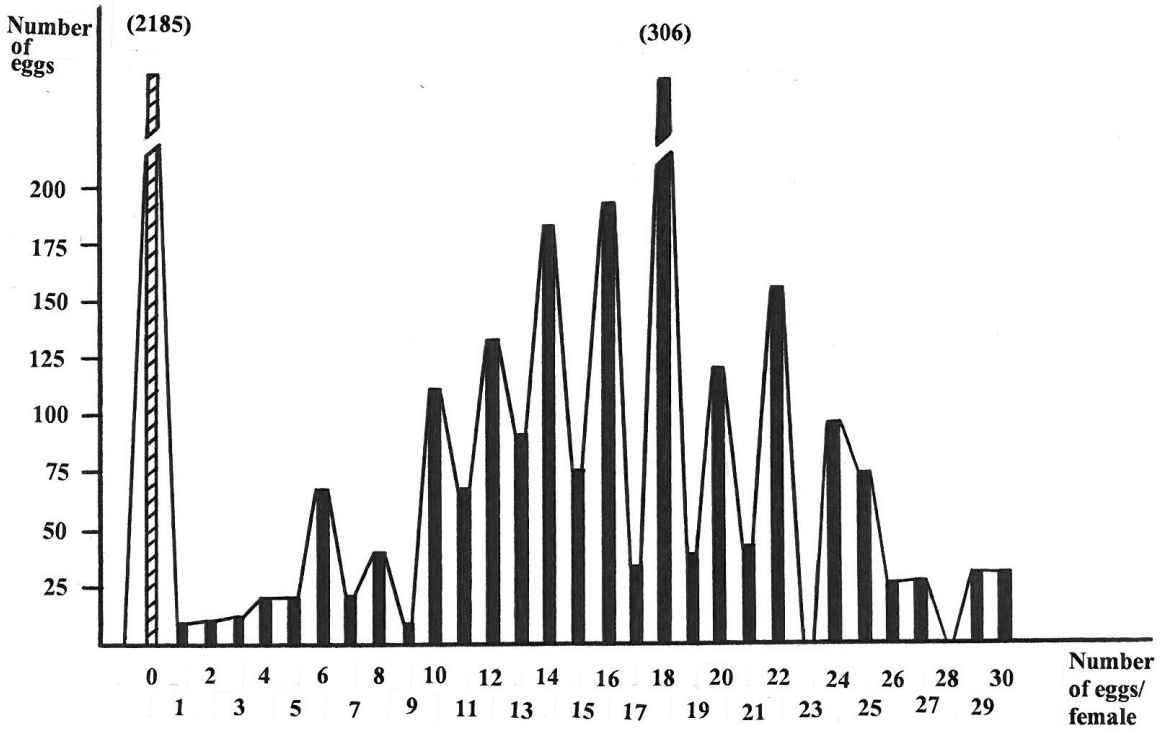
Eggs of *C. aurea* are lengthwise oval, yellow-white. Their chorion is smooth, soft and elastic. Under dry conditions, eggs shrink fast and embryos die. On the other hand, in the moist environment, eggs absorb water from the outdoor environment and swell. After egg laying, they are 0.60 to 0.79 (on average 0.70) mm long and 0.25 to 0.32 (on average 0.29) mm wide. The embryonal development takes 11 to 13 days at 9 to 22 °C. In the half of the embryonal development time, eggs are on average 0.73 mm long and 0.31 mm wide. Closely before eclosion, average dimensions of eggs increase up to 0.75 × 0.32 mm. Closely before hatching, egg envelopes on the head end crack longitudinally (at the most up to 1/3 egg length). Egg larvae climb out through fissures in egg envelopes. The cranium of larvae of the first instar is 0.18 to 0.22 (on average 0.20) mm wide and after hatching, their body is 0.93 to 1.18 (on average 1.04) mm long. No relevant findings were obtained on the postembryonal development of larvae on roots of plants. Also laboratory rearings of larvae on roots of woody species (mainly *P. tremula*, *S. caprea* and *S. alba*), various herbs and grasses were quite unsuccessful.

Analyse of ovaries of last year's females

Eggs originate in pair ovaries. These consist of meroistic ovarioles of a telotrophic type. In a germarium, primary cells originate and these cells gradually change to oocytes through oogonia. Eggs originate from oocytes. The eggs shift towards pedicle of ovarioles being fertilized in oviducts. After creation the certain number of eggs (which corresponds to a great extent to the number of functional ovarioles), females hide in upper layers of soil to lay eggs. Through microscopic dissections of ovaries of 2 342 females, in total 2029 eggs were

XX: *The occurrence of eggs in ovaries of last year's females of C. aurea caught on P. tremula. Bílovice n. Svitavou, May to September 2010.*

Last year's females	Number of females	(%)	Total number of eggs	(%)	Mean number of eggs
Without eggs	2 185	93.3	-	-	-
With the even number of eggs	108	4.6	1 482	73.0	13.7
With the odd number of eggs	49	2.1	547	27.0	11.2
Total	2 342	100.0	2 029	100.0	0.9 (12.9)



17: *Frequency of the occurrence of eggs in ovaries of last year's females of C. aurea. Some 2 342 females with 2 029 eggs were examined. Bílovice n. Svitavou, May to September 2010.*

found at 157 (i.e. at 6.7%) females. The number of eggs in ovaries considerably fluctuated from 0 to 30 pcs. The number of eggs of an even number amounted to 73.0% and those with odd number amounted to 27.0% (i.e. 2.7 times less) (Tab. XX, Fig. 17). This finding clearly demonstrates the pair structure of ovaries and rather uniform function of particular ovarioles.

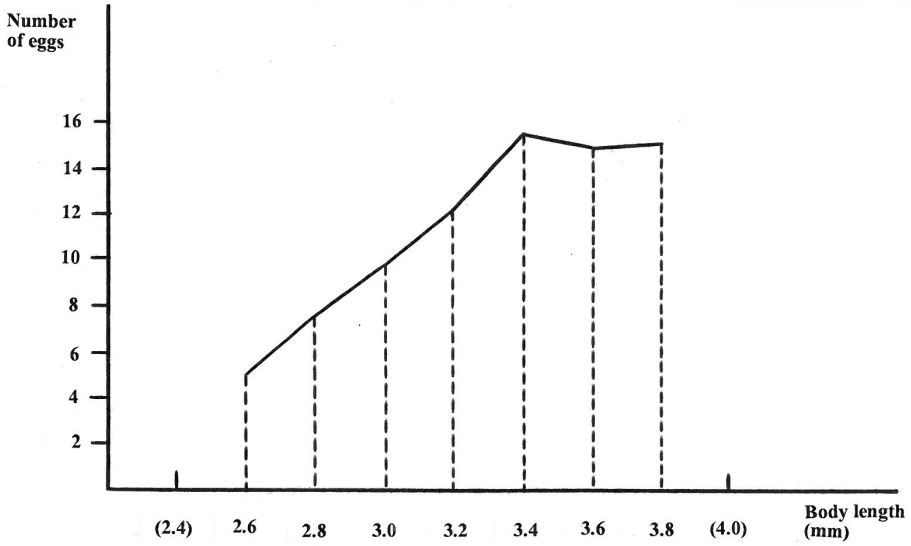
The average number of eggs in ovaries and their mean size increased with the increasing length of the female body (however, from 3.4 mm stagnated) (Tab. XXI, Fig. 18). The larger average number of eggs in ovaries of larger females reflects in the more abundant clutches and undoubtedly also into their higher total fertility. During the growing season, the average number of eggs in ovaries of females (including their average size) gradually decreased (Tab. XXII, Figs. 19 and 20). Based on the table, it is evident that ovaries contained far the highest number of eggs in May.

Feeding this year's beetles

In the studied area, only a small number of young (this year's) beetles occurs in the second part of the

XXI: *The number and size of eggs in ovaries of last year's females of C. aurea caught on P. tremula (depending on the female body length). Bílovice n. Svitavou, May to September 2010.*

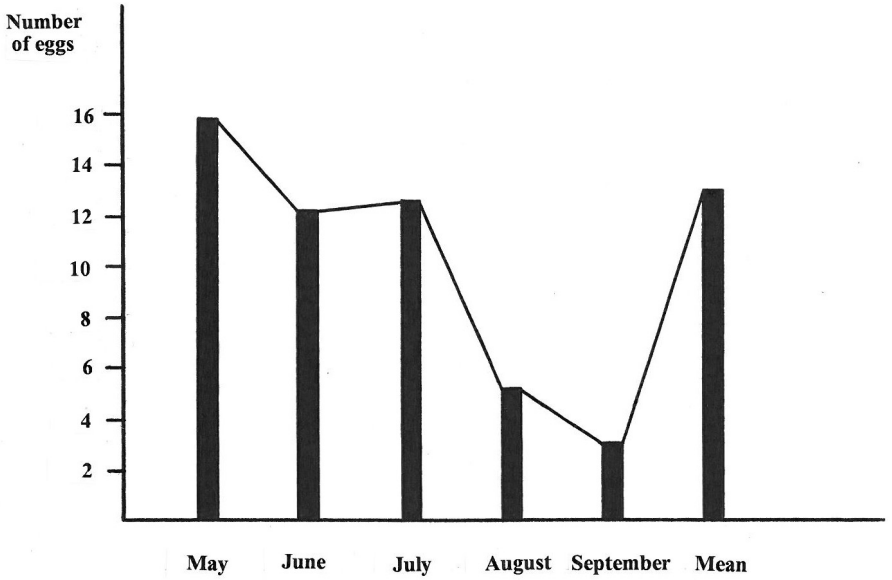
Body length (mm)	Number ♂♂/♀♀	Total number of imagoes	Number/% of females with eggs	Number of eggs/ mean number of eggs	Total mean number of eggs	Mean length / width of eggs (mm)
2.4	35/1	36	-	-	-	-
2.6	224/16	240	1/6.3	5/5.0	0.3	0.61/0.25
2.8	452/138	590	5/3.6	38/7.6	0.3	0.65/0.25
3.0	1 040/546	1 586	31/5.7	303/9.8	0.6	0.69/0.28
3.2	588/567	1 155	45/7.9	549/12.2	1.0	0.70/0.29
3.4	146/526	672	41/7.8	631/15.4	1.2	0.72/0.28
3.6	8/368	376	25/6.8	369/14.8	1.0	0.73/0.30
3.8	1/138	139	9/6.5	134/14.9	1.0	0.70/0.28
4.0	0/42	42	-	-	-	-
Total	2 494/2 342	4 836	157/6.7	2 029/12.9	0.9	0.71/0.28
Mean (mm)	3.0/3.3	-	-	-	-	-



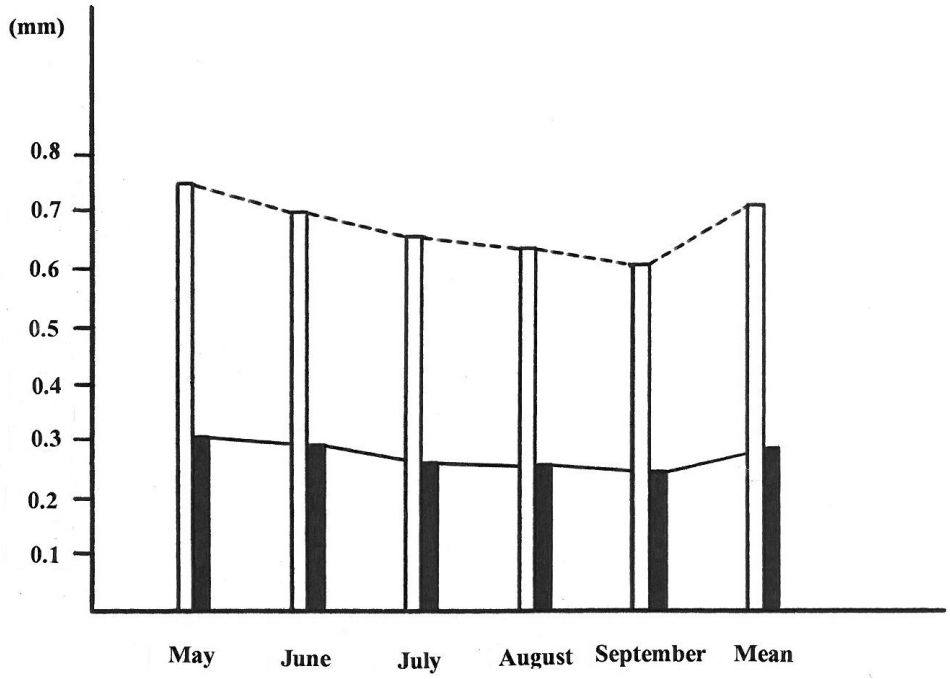
18: *The average number of eggs in ovaries of last year's females of C. aurea (depending on the body length). Some 2 342 females were examined. Out of the number, only 157 (6.7%) showed 1 to 30 (on average 12.9) eggs in ovaries. Bílovice n. Svitavou, May to September 2010.*

XXII: *The number and size of eggs in ovaries of last year's females of C. aurea caught on P. tremula. Bílovice n. Svitavou, 2010.*

Month	Number ♂♂/♀♀	Total number of imagoes	Number/% of females with eggs	Number of eggs / mean number of eggs	Total mean number of eggs	Mean length/ width of eggs (mm)
May	388/289	677	49/17.0	768/15.7	2.7	0.75/0.30
June	1 493/1 076	2 569	48/4.5	587/12.2	0.6	0.70/0.29
July	395/734	1 129	50/6.8	625/12.5	0.8	0.66/0.26
August	86/149	235	9/6.0	46/5.1	0.3	0.64/0.26
September	108/83	191	1/1.2	3/3.0	0.04	0.61/0.25
October	24/11	35	-	-	-	-
Total	2 494/2 342	4 836	157/6.7	2 029/12.9	0.9	0.71/0.28



19: *The average number of eggs in ovaries of last year's females of C. aurea (depending on the month of catching). Out of 2 342 females only 157 (6.8%) showed eggs in ovaries (in total 2 029). Bílovice n. Svitavou, 2010.*



20: *The mean length (light) and width of eggs in ovaries of last year's females of C. aurea (dark). Bílovice n. Svitavou, May to September 2010.*

growing season on host trees. These beetles ingest for the period of two to three weeks and with the occurrence of cold days they search for wintering grounds. Males in individual laboratory rearings damaged 3.2 to 10.4 (on average 6.2) cm² leaves. Females damaged 5.3 to 10.8 (on average 7.2) cm² leaves of *P. tremula*. Generally, this year's beetles destroyed (as compared to last year's beetles) 2.0 to 2.3 times smaller leaf area. During feeding, males defecated on average 616 frass pellets of an average size of 0.36 × 0.16 mm. Females defecated on average 483 frass pellets of an average size of 0.40 × 0.18 mm. Generally, males produced on average 4.47 (females 4.91) mm³ frass pellets. Out of 1 cm² damaged leaf area, males defecated on average 0.72 (females 0.68) mm³ frass pellets. Compared to last year's beetles, which defecated on average 0.66 mm³ frass pellets from 1 cm² damaged leaf area, the effectiveness of using food by this year's beetles was somewhat lower. This fact is undoubtedly related to the lower trophic value of leaves consumed by this year's beetles in the second half of the growing season.

This year's beetles reared in the laboratory skeletonized as a rule leaves of *P. tremula*, most often from the adaxial face of leaves. Beetles 90% perforated leaves of *S. caprea*, namely always from the adaxial face. They nearly did not damage leaf veins including anastomosis at all. After about two weeks of feeding the beetles withdrawed into hiding places among leaves, into moist cotton wool etc. They remained in the hiding places even after the beginning of a heating season (27 September 2010). They left temporarily their hiding places mostly only at the end of November. Until mid-December (or at the end of December), they slightly damaged available leaves of *S. caprea*. Until the end of the year, when the rearing was terminated for the absence of suitable food, young males damaged on average 1.9 (females 1.8) cm² leaves.

Harmfulness

After *C. aurata* the flea beetle *C. aurea* is the second most abundant and widespread representative of the genus. It occurs on some species of the family Salicaceae, mainly on *P. tremula*. However, it is considered to be a forestry important insect pest only rarely (Maisner, 1974; Georgiev, 2000; Tozlu, 2001; Tozlu *et al.*, 2010 etc.). According to our studies, beetles damaged leaves of *P. tremula* of an average area of 6.7 cm² before hibernation. Of course, it is necessary to emphasize that in 2010 in the examined area of the Křtiny Training Forest Enterprise, only about 17% young beetles of a new generation left their pupal chambers before hibernation. After overwintering, beetles damaged on average 14.3 cm² leaves in the course of maturation and regeneration feeding. Generally, beetles damaged about 21 cm² leaves. Other damage (so far unknown) was caused by larvae on roots of host species. As compared to this damage, average damage caused by beetles of the majority of forestry important species of the family Chrysomelidae is much higher. For example, beetles *Chrysomela populi* L. (without larvae) destroy about 186 cm² leaves on their main host species, *Agelastica alni* (L.) about 78 cm², *Linaeidea aenea* (L.) 63 cm², *Chrysomela vigintipunctata* (Scop.) 47 cm², *Lochmaea caprea* (L.) (= *L. capreae* /L./) 47 cm², *Galerucella lineola* (F.) 35.5 cm², *Phratora vitellinae* (L.)

33 cm² and *Plagiodera versicolora* (Laich.) 30.5 cm² leaves. A smaller leaf average area than *C. aurea* (only 12.3 cm²) is damaged e.g., by beetles of *Gonioctena quinquepunctata* (F.) (Urban, 2008).

Young growth-active undergrowth, young growth and shoots of host species are optimal for feeding and reproduction of imagoes of *C. aurea* in May and June. Through the intensive feeding of imagoes at the beginning of the growing season considerable loss of the leaf assimilatory area takes place and thus decrease or even stopping the growth of trees. Trees can respond to defoliation by the creation of additional shoot. Shoots (mainly young species grown up in the second half of the growing season) slowly mature in autumn being subsequently damaged by early frost.

Generally, it is not necessary to control the flea beetle *C. aurea*. In case of its mass outbreak, it would be possible to control effectively last year's beetles, namely in spring at the latest 10 days from the beginning of maturation feeding. In the area of Brno region, the most suitable time for control measures would be until 5 to 10 May.

SUMMARY

In 2007 to 2010, the very abundant to mass occurrence of flea beetle *Crepidodera aurea* (Geoffr.) (Alticidae) was noted at many localities in Moravia. The pest was also activated at the Bílovice n. Svitavou Forest District (Training Forest Enterprise Masaryk Forest, Křtiny). The paper is the result of a systematic field and laboratory studies of its occurrence, bionomics and harmfulness. Following results were obtained:

1. The main host species of *C. aurea* in the examined area is *Populus tremula*. The species occurred rarely (on average in 1.5% from the number of imagoes of *C. aurata* /Marsh./) also on *Salix caprea*. Last year's beetles in the laboratory damaged *P. tremula* 5.5 times (this year's 4 times) more than *S. caprea*.
2. About 85% this year's imagoes of *C. aurea* overwintered in the place of their development in the earth. Only 15% this year's imagoes left pupal chambers and after passing through their regeneration feeding wintered mainly in the earth. Last year's imagoes occurred on woody species from the beginning of May to the beginning of November (most abundant at the beginning of June). In the first third of the period of occurrence (in May and June), males numerically predominated (1.6:1). In the second third (in July and August), females numerically predominated (0.6:1) and at the end of the growing season (in September to November), males predominated again (1.2:1).
3. The abundance of beetles on woody species regularly fluctuates during the 24-hour life cycle. Beetles are most active at night. Out of the total number of last year's imagoes least beetles (23.8%) were caught at 12:00. At 06:00 a.m., on average 35.2% beetles were caught and at 06:00 p.m. 41.0% beetles. The rhythmical variation of the abundance can be disturbed by cold, rainy or windy weather.
4. This year's beetles occurred on woody species from the end of July to the end of the first decade of November (most abundant in September). The sex ratio was 0.8:1. As well as at last year's beetles, the smallest number of this year's beetles (28.4%) was caught at 12:00. At 06:00 p.m., 32.2% beetles were caught and at 06:00 a.m. 39.4% beetles.
5. Out of the total number of beetles *C. aurea* caught during the whole growing season 2010 on *P. tremula*, only 14.2% were this year's beetles. The second numerical maximum (in September) was, therefore, indistinctive. Out of the total number of beetles *C. aurata* caught on *S. caprea*, 28.8% were this year's beetles. The second numerical maximum (in September) was much more marked as against *C. aurea*. Thus, it is possible to state that only 1/6 young beetles of *C. aurea* and 1/3 beetles of *C. aurata* left their pupal chambers before hibernation.
6. At the beginning of the growing season, beetles of *C. aurea* usually perforated leaves of *P. tremula*, later skeletonized them, namely mainly (75%) from the abaxial face. Beetles mainly perforated leaves of *S. caprea*, namely always from the adaxial face. In 2007 after overwintering, beetles damaged on average 14.3 cm² leaves of *P. tremula*. They defecated on average 876 frass pellets of an average size 0.46 × 0.17 mm and total volume 9.49 mm³. With an increase of the average area of damage (from 7.6 to 14.3 cm²) the volume of frass pellets from 1 cm² damaged leaf area gradually decreased (from 0.92 to 0.66 mm³). Well thriving beetles damaged larger leaf area; however, they produced smaller volume of frass pellets from 1 cm² damaged leaf area (i.e. they used food more effectively).
7. Females of *C. aurea* laid on average 194 eggs in 11 clutches at 18 eggs. At the time of the most intensive reproduction (in the second half of May and at the beginning of June) they laid one clutch on average in two days. After oviposition, eggs are 0.70 mm long and 0.29 mm wide. The embryonal development took about 12 days at 20 to 22 °C. Unlaid eggs in ovaries occurred only

at 6.7% last year's females, namely as many as 30 eggs. The number of eggs of an even number was 73%, those of odd number 27%. With the length of the female body increased both the average numbers of eggs in ovaries and their average size.

8. This year's males damaged on average 6.2 (females 7.2) cm^2 leaves of *P. tremula* before hibernation. Males produced 4.47 (females 4.91) mm^3 frass pellets (i.e. on average 0.70 mm^3/cm^2). With respect to the (on average) lower trophic value of older leaves the effectiveness of utilization by this year's beetles was (as against last year's beetles) lower. The development of C. *aurea* is obligatorily univoltine.
9. If young betles *C. aurea* occur on trees still before hibernation then until their departure to wintering grounds they destroy on average 6.7 cm^2 leaves *P. tremula*. After wintering, they destroy on average 14.3 cm^2 leaves. Generally, beetles damage about 21 cm^2 leaves. The leaf area damaged by beetles (without larvae) is 8.9 times lower compared to *Chrysomela populi* L. In comparison with *Agelastica alni* (L.), it is 3.7 times lower, compared to *C. vigintipunctata* (Scop.) and *Lochmaea caprea* L. (= *capreae* L.) it is 2.2 times lower, compared to *Galerucella lineola* (F.) 1.7 times, compared to *Phratora vitellinae* (L.) 1.6 times and as against *Plagiodera versicolora* (Laich.) 1.5 times.
10. Beetles of *C. aurea* damage most growth-active advance regeneration, young growth and shoots of *P. tremula*. With respect to the relatively low consumption of food, it is not necessary, as a rule, to control the pest. In case of its mass gradation it is possible to control the beetle in the period from 5 to 10 May.

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