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# Occurrence, biology and harmfulness of *Galerucella lineola* (F.) (Coleoptera, Chrysomelidae) – Part 1. Last year's (parent) beetles

**J. Urban**

*Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry Brno, Brno, Czech Republic*

**ABSTRACT**: In Moravia in 1995 to 2006, the abundant occurrence of *Galerucella lineola* (F.) was used to study its occurrence, biology and harmfulness. An "alder" biological form was studied in *Alnus glutinosa* and *A. incana* mainly in Polnička Forest District (Žďár region) and a "willow" form in *Salix viminalis*, *S. triandra* and *S. caprea* in riparian and accompanying stands of the Svitava river near Bílovice nad Svitavou (Brno region). Imagoes leave their sites usually in the 1st half of May. In the course of 2.5 to 3 months, they damage on average 22.6 $cm^2$ leaves of *A. glutinosa* and *S. caprea* (of this value, males 3.2 times less than females). Males eat on average 15 times during 24 hours for a period of 3.5 minutes, i.e. in total 52 minutes (3.6% day). Females eat on average 36 times for a period of 7 min, i.e. 252 min (17.5% day). Imagoes copulate on average 10.2 times per day for a period of 67 min. For the whole period of reproduction (about 42 days), they copulate on average 428 times, i.e. for 20 days. Eggs are laid into groups of 3 to 20 (on average 14) pieces. Females lay 457 to 791 (on average 612) eggs, i.e. about 15 eggs per day. *Medina collaris* (Fall.) (Tachinidae) and *Townesilitus fulviceps* (Ruthe) (Braconidae) belong, among others, to the enemies of imagoes.

**Keywords**: Chrysomelidae; *Galerucella lineola*; host species; hibernation; feeding; last year's imagoes; reproduction; natural enemies

In connection with climatic/meteorological anomalies (particularly mild and dry winter and spring periods) at the end of the last and at the beginning of this century, a series of dendrophilous insect species markedly actuated. Extreme weather and primary physiological weakening of tree species resulted in a decrease in the effective fecundity and in an increase in the mortality of insects. In the CR, a striking increase in population density was noted e.g. in numerous species of Chrysomelidae. Gradations associated with heavy feeding to defoliation occurred in some traditional domestic pests (e.g. *Agelastica alni* [L.], *Linaeidea aenea* [L.], *Chrysomela populi* [L.], *Plagiodera versicolora* [Laich.], *Phratora vitellinae* [L.] and *Lochmaea capreae* [L.]), and also in species little known in this country (e.g. *Chrysomela vigintipunctata* [Scop.] and *Gonioctena quinquepunctata* [F.]). Gradations of these species of Chrysomelidae in Moravia were used to study their occurrence, biology and economic importance. New findings were also obtained on *Galerucella* (= *Pyrrhalta*) *lineola* (F.) dealt with in this paper consisting of two parts. In Part 1, mainly host species are described including the feeding and reproduction of imagoes after hibernation. Part 2 deals particularly with the development of larvae, pupae and this year's imagoes, generation conditions of the chrysomelid and harmfulness.

*G. lineola* is the most important species of the genus that is represented by 7 species in the CR fauna. It is a widely distributed Palaearctic species with the centre of occurrence in the temperate boreal zone of Eurasia (Kožančikov 1958). The southern boundary of the species natural range is in Algeria, Turkey and Asia Minor, the northern boundary reaches the polar circle (Arnoldi et al. 1955; Turanli et al.

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2003). The area colonized by the species includes a wide zone from Portugal, Spain, Great Britain and Northern Ireland through western, central and eastern Europe including the European part of the former Soviet Union. In Scandinavia, it occurs in the best part of the area with the exception of the northernmost part of the country (Hellén et al. 1939). A number of authors who studied the chrysomelids most frequently mentioned this species (e.g. Klapálek 1903; Schaufuss 1916; Escherich 1923; Roubal 1937–1941). It occurs also in the Crimea, Caucasus, northern Kazakhstan, Kyrgyzstan, Siberia, the Primorsk Territory in Far East (Arnoldi et al. 1955), and in China (Wen, Huang 1995). Warchalowski (1973) concisely summarized the chrysomelid distribution. According to the author, *G. lineola* is a Palaearctic species inhabiting almost the whole Europe, northern Africa, Siberia, China, Mongolia and Japan.

As for the altitude, *G. lineola* is distributed from lowlands up to foothills. It is a considerably hygrophilous species requiring high air humidity and soil moisture. Therefore, we can find it along the banks of watercourses, ponds, reservoirs and lakes. For example, in the Ukraine, it is most abundant on a periodically flooded area along the Dnieper River or at artificially irrigated places (Lopatin 1960). In northern parts of its range, it colonizes trees in open and well-insolated (often heavily waterlogged) localities (Kožančikov 1958).

Until the beginning of the last century, willows (*Salix* spp.) were considered to be nearly exclusively host plants of *G. lineola* (Calwer 1876; Henschel 1876; Eckstein 1897; Reitter 1912, etc.). Only later, it was also reported on alder (*Alnus* spp.) or other species. The chrysomelid was named according to the abundant occurrence on *Salix* spp., e.g. in German (Behaarter Weidenblattkäfer, Gelber Weidenblattkäfer), English (brown willow beetle), Russian (zholtyj ivovyj listoed), French (galéruque de l'oisier), Spanish (galeruca de la mimbrera) and Polish (szarynka wiklinówka). Kuhnt (1913) reported the species occurrence on willow, alder and hazel. The same host species (particularly *S. viminalis* L.) was mentioned by Schaufuss (1916). For example, Hansen and Henriksen (1927) and Medvedev and Šapiro (1965) reported the general occurrence of the species on willows and alders. Nüsslin and Rhumbler (1922) specified the spectrum of the host plants of *G. lineola*. According to these authors, the pest attacks mainly *S. triandra* L., *S. viminalis* L. and *S. caprea* L. In addition to these species it damages *S. purpurea* L., poplar, alder and hazel to a smaller extent (Escherich 1923). According to Živojinovič (1948) it attacks willows (mainly *S. viminalis* and *S. caprea*), alders and hazels. Pernersdorfer (1941) found the species on *S. alba* L. and *S. triandra* in Austria. In the territory of the former Czechoslovakia, the species attacked mainly *S. caprea* (Fleischer 1927–1930). Roubal (1937–1941) reported it both on willow and alder, and near Bratislava even on *Robinia pseudoacacia* L. According to Ogloblin (1936) it lived most often on *S. alba* L. f. *vitellina* and *S. viminalis*. The author also mentioned the existence of dubious data on the potential of the species to consume leaves of *Lysimachia vulgaris* L. and *Rumex* sp. Information on the occasional damage to fruit trees (Sorauer et al. 1932), leaves of *Fragaria* spp. and flowers of *Rosa* spp. (Matesova et al. 1962) is, however, quite credible. The spectrum of host plants was summarized by Mohr (1966) and according to him *Salix* spp., *Corylus avellana* L., *Alnus glutinosa* (L.) Gaertn., *A. incana* (L.) Moench and *Populus nigra* L. belong to host plants. As for willows the chrysomelid attacks *S. lapponum* L., *S. aurita* L., *S. viminalis*, *S. fragilis* L., *S. daphnoides* Vill., *S. pentandra* L. and *S. caprea* (Brovdij 1973). In addition to the leaves of willows, alders and hazels, beetles and larvae of the pest can reputedly consume also the leaves of *Padus avium* Mill. and *Rubus* sp.

The adaptation of *G. lineola* to living conditions and particularly its food specialization to quite a narrow spectrum of main host tree species resulted in the gradual differentiation of the species into two biological forms (Kožančikov 1958; Brovdij 1968, 1973). According to Kožančikov (1958) the willow biological form lives in Karelia mainly on 1 to 2 m shrubs of *S. nigricans* Sm. (= *S. myrsinifolia* Sal.) and sporadically on *S. lapponum* and *S. aurita*. It occurs most abundantly at the edge of large lakes and along streams and rivers, viz usually on waterlogged and periodically flooded lands. It was not found on other arborescent willows (*S. fragilis*, *S. daphnoides*, *S. pentandra*, *S. triandra* and *S. caprea*). In artificial rearing, however, the chrysomelid willingly consumed the leaves of *S. caprea*. The willow biological form lives exclusively on willows under conditions of the Karelian Isthmus.

On the coast of the Finnish Gulf and banks of adjacent lakes, the alder biological form of *G. lineola* occurs on shrubby and arborescent *Alnus glutinosa* (height even over 10 m). On *A. incana* (as well as on poplars), however, the chrysomelid was not found. Late leaf unfolding can mainly cause its absence on poplars. For example, *P. tremula* L. flushes there 3 to 4 weeks later than willows, i.e. at the time when beetles already reproduce. After wintering (usu-

ally in the 2nd decade of May), imagoes of the alder biological form together with imagoes of the willow form occur on flushed willows where they carry out intensive feeding. After completing the first stage of maturation feeding on willows, however, imagoes of the alder form fly over to alders at the end of May and at the beginning of June. Thus, further development of the chrysomelid occurs there. Alders (*Alnus* spp.) are phenologically similar to poplars. They unfold leaves rather late, but accrue until the late summer creating leaves suitable for consumption even at the close of the growing season.

Kožančikov (1958) assumed that the original biological form of *G. lineola* was the alder form which occurred in the western part of the species natural range. The continental willow form, which is broadly distributed in Eurasia, is a derived form (according to Ikonen et al. 2003 an original form). The adults and larvae of both forms do not differ morphologically from each other. They differentiate mainly by feeding relations to host species and considerable ecological (and evidently also reproduction) isolation. Under certain circumstances, however, adults of both races can mate with each other and produce fertile progeny. According to Ikonen et al. (2003), it is probable that there is no marked host relationship of the chrysomelid only to alders or willows.

Occurrence and dynamics of the abundance of *G. lineola* and other phytophagous insect species on *A. glutinosa* and *A. incana* were studied by Gharadjedaghi (1997) in the vicinity of Bayreuth (northern Bavaria). At one of the three localities under investigation, the chrysomelid caused defoliation on *A. glutinosa.* According to the author it was quite a sporadic case of such a heavy outbreak of the chrysomelid on alder trees inland. Heavy gradations of the chrysomelid are known on alder *A. subcordata* Mey. in Iran (Sadeghi et al. 2004).

References in literature to the harmful occurrence of *G. lineola* in osier plantations are numerous. In the last decades, the chrysomelid was also studied many times in bioenergy plantations of willows which were established mainly in western and northern Europe. At this specific method of willow growing large amounts of young plant material accumulate in stands, the material being attractive for numerous insects and other pests. In osier plantations and energy plantations of willows, numerous species of Chrysomelidae find a suitable environment for their development. According to Escherich (1923) *G. lineola* causes the greatest damage to osier plantations, often even greater than "blue" chrysomelids *Plagiodera versicolora* (Laich.) and *Phratora* spp. (= *Phyllodecta* spp.). Wagner and Ortmann (1959) ranked the chrysomelid among the main pests of *S. caprea*, *S. triandra*, *S. viminalis* and sometimes also *S. purpurea* plantations in Germany. In the Netherlands (Tuinzing 1946), former Yugoslavia (Kovačevič 1957), Great Britain (Hunter 1992; Sage, Tucker 1997; Sage et al. 1999), Sweden (Höglund et al. 1999), Czech Republic (Urban 1981) and elsewhere the species ranks among common pests. In *Salix* cv. *Americana* plantations in Poland, *G. lineola* was found quite rarely (Kadłubowski, Czalej 1962; Czerniakowski 2002). However, e.g. in Spain, *S.* cv. *Americana* and *Populus* spp. are considered to be its main host species (Vicente et al. 1998). The chrysomelid was named according to the willow also in Spanish. Similar differences in opinions on the trophic affinity of the chrysomelid to various host species occur in literature quite frequently.

In Sweden, Wirén and Larsson (1984) studied the preference of the species for various willow clones during egg laying. The authors suppose that females select leaves which are suitable for the development of larvae because the larvae show limited possibilities to change host plants. Larsson et al. (1986) studied the effects of light and nutrition on the concentration of phenolic substances in leaves of *S.* × *dasyclados* Wimm. (= *S. cinerea* × S. *viminalis*) and suitability of leaves for the nutrition of *G. lineola* imagoes. In their rearing, imagoes consumed five times more leaves of plants grown under low illumination, which were optimally supplied with plant nutrients. In these leaves, the concentration of phenolic substances was significantly 2/3 lower compared to the leaves of plants intensively illuminated and optimally or suboptimally supplied with nutrients. According to Raupp and Sadof (1991) phenolic glucosides significantly affect the quality of food (similarly like tannins, water and nitrogen content and the stiffness of leaves).

An antiherbivorous function is usually attributed to phenolglucosides. Their composition and concentration in leaves of various willow species differ very often. According to Tahvanainen et al. (1985) phenolglucosides show both stimulation and inhibition effects which are dependent on the degree of adaptation of the particular species of chrysomelids. The authors found that *S. nigricans* contains an extremely high concentration of phenolic glucosides (mainly salicortin and salicin) in leaves (whereas *S.* cv. *Aquatica* and *S.* × *dasyclados* has a medium concentration). The total low concentration of a large number of glucosides was found in leaves of *S. bicolor* Willd. (= *S. phylicifolia* L.), *S. caprea* and *S. viminalis.* Leaves of *S. pentandra* and *S. triandra* contain the minimal concentration of common glucosides, but

rather high concentrations of little known glucosides (e.g. salidrosid in *S. triandra*). *G. lineola* is evidently considerably adapted to the use of salidrosid. Similarly like *Lochmaea capreae* (L.), however, it consumes most willingly leaves of willows with the total low content of phenolic glucosides. The high concentration of phenolglucosides in leaves of *S. nigricans* and *S. pentandra* (and low in *S. bicolor*) was found in Switzerland by Rank et al. (1998).

Denno et al. (1990) studied egg laying including the development of larvae on two species of willows rich in salicyl alcohol (*S. fragilis* and *S.* × *dasyclados*) and one willow species poor in salicyl alcohol (*S. viminalis*). In their experiments, females preferred oviposition on *S. viminalis* and *S. fragilis* and they did not lay any eggs on *S.* × *dasyclados* et al. The larvae also developed much better on *S. viminalis* and *S. fragilis* than on *S.* × *dasyclados* (see Part 2). Behaviour and development of the chrysomelid were undoubtedly affected by the total concentration of simple phenolic compounds, which was lowest in leaves of *S. fragilis*, higher in leaves of *S. viminalis* and highest in leaves of *S.* × *dasyclados*.

Seldal et al. (1994) studied the effects of an experimental leaf injury of *A. incana* on egg laying and on the development of larvae of *G. lineola.* The authors demonstrated that through the injury proteinase inhibitors were induced showing important impacts on the chrysomelid. Peacock et al. (2001) studied volatile substances from leaves of 10 willow species and their effect on *G. lineola*, *Phratora vulgatissima* (L.) and *P. vitellinae* (L.). The number and concentration of volatile substances after damage to leaves increased in all species of willows. The authors demonstrated a negative correlation between the amount of cis-3-hexenylacetate and resistance of willows to *G. lineola* and *P. vulgatissima*.

Kolehmainen et al. (1995) tested the effects of phenolic glucosides on the selection of host plants of *G. lineola*. According to Tahvanainen et al. (1985) the chrysomelid is particularly attracted by the main glycoside, i.e. salidrosid. The pest develops slowly on food-suboptimum hosts (e.g. *S.* × *dasyclados*), which increases its mortality (Häggström, Larsson 1995). Hallgren (2002) investigated the inheritance of secondary metabolites in hybrids between *S. repens* L. and *S. caprea* and the impacts of hybridization on herbivores including *G. lineola*. Kendall et al. (1996) studied the degree of damage to 24 clones of willows (12 domestic, 6 from Canada and 6 from Sweden) by *G. lineola* and *Phratora vulgatissima* in England. Beetles damaged mostly *S. viminalis*, *S. aurita*, *S. caprea* and *S. cinerea*. They preferred *S. eriocephala* Michx. to the lowest extent, followed by *S. purpurea*, *S. burjatica* Nas. and *S.* × *dasyclados*. Surprisingly, *S. triandra* was also attacked very little. The results of the authors indicate that both species of chrysomelids are repelled from feeding by high concentrations of phenolglucosides in leaves.

The effects of the shading of *S. bicolor* on damage caused by *G. lineola* were studied by Sipura and Tahvanainen (2000). According to their observations adults preferred to damage willows in the open area. However, they did not found any differences in the development of larvae in the open area and at shady places.

In Finland, the chrysomelid heavily attacks *S. bicolor* at moist sites. It does not look for these sites due to the higher quality of food or the lower pressure of predators, but because beetles as well as larvae (particularly larvae of the 1st instar) are considerably hygrophilous there (Sipura et al. 2002).

## MATERIAL AND METHODS

The paper refers to the study of the occurrence, bionomics and harmfulness of Chrysomelidae (including *G. lineola*) which was carried out in six osier plantations in northern, central and southern Moravia in 1969 to 1976 (Urban 1981). In the period 1995 to 1998, the alder biological form of *G. lineola* was studied, viz in 3 to 20-years-old *A. glutinosa* and *A. incana* in Polnička Forest District (Forest Enterprise of Dr. R. Kinský, Žďár nad Sázavou). The locality occurs at an altitude of about 650 m above sea level. Mean annual temperature is 5.8°C, mean annual precipitation 740 mm and the growing season about 135 days. Field inspections were carried out in the course of the growing season usually in 1 to 2-week intervals. The relative numerical proportion of the pest was determined by the method of sweeping (always 100 one-sided sweepings).

Simultaneously with field studies, the alder biological form of *G. lineola* was studied in individual and mass rearing on leaves of alder or other species. Leaves of a certain age (or foliaged terminal sections of shoots) were taken from the same tree and from the same part of the crown. Petioles or lower ends of shoots were wrapped by slightly moistened cotton wool or inserted into small vessels with water. The throat of the vessels was then sealed by cotton wool. For rearing, glass plates 10 (or 20) cm in diameter and height 5 (or 10) cm were used. In regular 2 to 3-day intervals, fresh food was served to the chrysomelids. In 2 to 3-day intervals, damaged leaf area was measured using a planimeter. The number and localization of laid eggs were registered. Dimensions

of eggs were measured occasionally during the embryonal development of the pest. In dead imagoes, the body length was measured and the number of unlaid eggs was determined by microscopic dissection. In selected rearings of males and females, the number of frass pellets was recorded and their dimensions were measured micrometrically.

Using the same methods, the willow biological form of *G. lineola* was studied in 1999 to 2006. This form occurred abundantly on *S. triandra* and *S. viminalis* in riparian and accompanying stands of the Svitava River in the stretch between Bílovice nad Svitavou and Adamov (former Brno-venkov District). The locality is situated at an altitude of about 235 m. Mean annual temperature is 8.4°C, mean annual precipitation 547 mm and the growing season about 168 days. For laboratory rearings of the chrysomelid, leaves of *S. caprea* and *S. fragilis* were used most often.

Parasitism was determined in beetles caught in nature. Hatched parasitoids of the family of Tachinidae were determined by Prof. J. Vaňhara (Brno) and of the family of Braconidae by Assoc. Prof. M. Čapek (Brno). Herewith, I highly appreciate the help of both specialists. Attention was also paid to the development and harmfulness of larvae of particular instars as well as to the development and harmfulness of young (this year's) beetles (see Part 2).

## RESULTS AND DISCUSSION

### Host species

In the area of the Žďárské vrchy Hills, beetles of the alder biological form were found mainly on *A. glutinosa*, sparsely on *A. incana*. Sporadically, they were found in sweepings on *Picea abies* (L.) Karst. and *Betula* sp. They were often noted (and caught by simple collection or by means of sweep nets) on *A. glutinosa* in the Brno region or elsewhere. In the laboratory, beetles consumed willingly leaves of *A. glutinosa*. Larvae developed optimally also on the alder (see Part 2). The chrysomelid is less trophically adapted to *A. incana*. In laboratory rearings, it is able to consume leaves of some species of willows (e.g. *S. fragilis*). In the case of famine, the beetles consumed reluctantly leaves of *S. alba* and *Betula* sp.

*G. lineola* is one of the most abundant species of chrysomelids in osier plantations in Moravia. It damages *S. viminalis* to the largest extent. The chrysomelid often attacks plantations of *S.* × *smithiana* Willd. (= *S. caprea* × *S. viminalis*), *S.* × *mollissima* Ehrh. (syn. *S.* × *hippophaeifolia* Thuill.) (= *S. triandra* × *S. viminalis*), *S.* × *rubra* Huds. (= *S. purpurea* × *S. viminalis*) and *S. caprea* admixed in plantations (Urban 1981). S. × *basfordiana* Schl. (= *S. alba* L. f. *vitellina* × *S. fragilis*), *S. purpurea* and surprisingly also *S. triandra* and interspersed *S. fragilis* belong to little sought-after or even neglected species.

In the open nature, it occurs commonly on shrubs of *S. triandra* and *S. viminalis* growing along watercourses on soils rich in minerals affected by the fluctuating groundwater table. In a flooded riparian zone along the Svitava River in the region of Brno, the chrysomelid was about 4 times more abundant on *S. triandra* than on *S. viminalis*. It was often found on young *S. fragilis* and *S.* × *rubens* Schr. (= *S. alba* × *S. fragilis*) and sporadically on *S. alba* growing along the Svitava River in a stretch between the Brno district Obřany and Bílovice nad Svitavou.

In extensive laboratory tests, the imagoes of the willow biological form of *G. lineola* usually damaged most *S. viminalis*, somewhat less *S. caprea* and *S. triandra* and least *S. fragilis* (damaged leaf area ratio 3:2.5:2.5:1).

Provided that the imagoes had a possibility of selecting one of the host plants mentioned above, they consumed substantially less or quite refused *S. alba*, *S. alba* f. *vitellina pendula* Rehd. and *S.* × *erythroflexuosa* Rag. Starving imagoes of the willow form did not damage the leaves of *A. glutinosa*, *A. incana* and *Populus nigra* and they died within several days. Larvae developed normally in the laboratory not only on *S. viminalis*, *S. caprea* and *S. triandra*, but also on *S. fragilis* (see Part 2).

The results of field observations and laboratory investigations corroborate the idea of Denno et al. (1990) that the willow form of *G. lineola* can successfully develop on quite a wide spectrum of willows. With respect to the existence of the willow and alder biological form it is necessary to consider the chrysomelid to be a polyphagous species.

### Hibernation and leaving winter habitats

According to Nüsslin and Rhumbler (1922), Escherich (1923), Arnoldi et al. (1955), Gäbler (1955), Koehler and Schnaider (1972), Brovdij (1973), Gharadjedaghi (1997) and Vicente et al. (1998) the imagoes of *G. lineola* winter in leaf litter. Kožančikov (1958) localized hibernation shelters. According to him imagoes winter not only in litter but also in fissures of bark and rotten trees, sometimes even en masse in several layers. Häggström and Larsson (1995) and Kendall et al. (1996) reported wintering in fissures of bark and litter (or in other hidden places). Sage et al. (1999) found imagoes in aggregations (as many as 20 individuals)

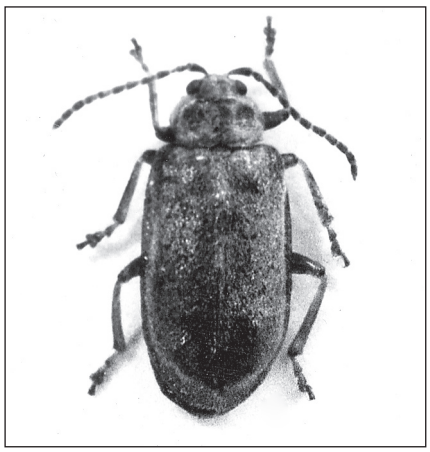

Fig. 1. A female of the alder biological form of *Galerucella lineola*

under released bark of older trees of *S. fragilis*, *S. alba* and *Sambucus nigra* L., rarely under bark of dead branches and stems. Imagoes very often wintered in dead hollow stalks of plants of the family Umbelliferae and *Epilobium* sp. Hibernation shelters occur mostly in the vicinity of host trees (Gharadjedaghi 1997) and in the surroundings at a distance up to 20 m (Sage et al. 1999). In osier plantations in Moravia, imagoes mostly winter in litter, less frequently in fissures of pollard willows and elsewhere. For example, in an osier plantation with *S. viminalis* in Skalička near Hranice in Moravia (former Přerov District), on average 0.5 imagoes per 1 $m^2$ occurred in spring 1974. After defoliation on *S. viminalis* in Prosenice (former Přerov District), up to 35 imagoes per 1 $m^2$ occurred in autumn 1975 (Urban 1981).

According to literature, imagoes leave their hibernation shelters already in April (Schaufuss 1916; Escherich 1923; Živojinovič 1948; Gäbler 1955; Mohr 1966; Vicente et al. 1998) or at the end of April and at the beginning of May (Häggström, Larsson 1995; Larsson et al. 1997). In Great Britain, imagoes colonize host plants for a period of about 2 weeks, viz from the end of March to mid-April (Sage et al. 1999) or in April and May (Kendall et al. 1996). Gharadjedaghi (1997) found the first imagoes on about 12 May in Bavaria. In boreal Karelia, imagoes occur on trees as late as in mid-May when mean daily temperatures exceed 10°C (Kožančikov 1958). In Iran, on the other hand, imagoes activate already at the end of March (Sadeghi et al. 2004). In the warmest areas of Moravia, beetles leave their winter habitats usually at the end of April, in the area of central and northern Moravia usually at the beginning of May or during the first half of May. The beginning and course of leaving the winter habitats are affected by climate and weather. Under favourable conditions most beetles leave winter habitats during a week. In the population of the last year's beetles, males and females occur at the ratio of 1:1 to 1:1.2. According to Kožančikov (1958) beetles hibernate for a period of 6 to 7 months. According to our observations, beetles of the alder biological form hibernate in the region of Žďár on average 7 months (from mid-October to mid-May). Beetles of the willow form hibernate in the Brno region on average 8.5 months (from mid-August to the beginning of May).

Beetles of the alder biological form (Fig. 1) are on average larger than beetles of the willow form. Nevertheless, males of both forms are on average smaller than females (Figs. 2 and 3). Beetles of the alder biological form are 4.6 to 6.8 (on average 5.7) mm long. Males are on average 5.4 and females 5.9 mm long. Beetles of the willow biological form are 4.4 to 5.6 (on average 5.0) mm long. Males are on average 4.8 and females 5.1 mm long. Medvedev and Šapiro (1965), Mohr (1966) and Maisner (1974) reported

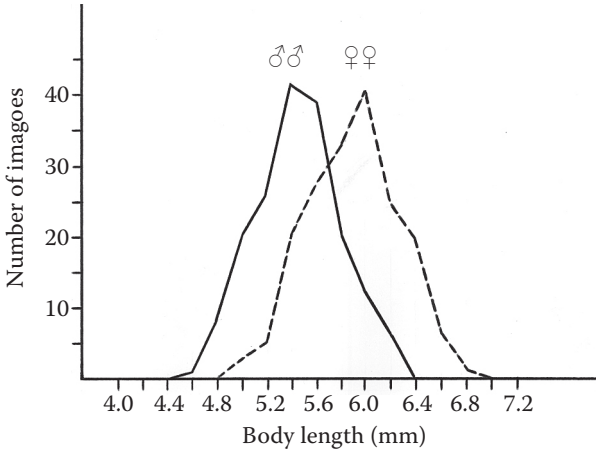


Fig. 2. The body length of males and females of the alder biological form of *G. lineola*

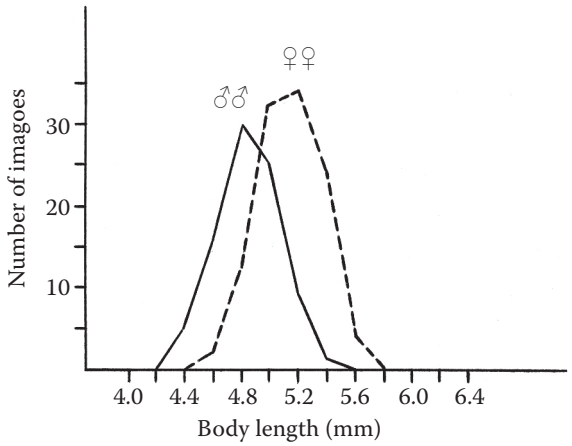


Fig. 3. The body length of males and females of the willow biological form of *G. lineola*

Fig. 4. An imago of *G. lineola* at perforating leaves of *A. glutinosa*. Polnička, 15 May 1998

Fig. 5. Damage to a young leaf of *A. glutinosa* by imagoes of *G. lineola*. Polnička, 15 May 1998

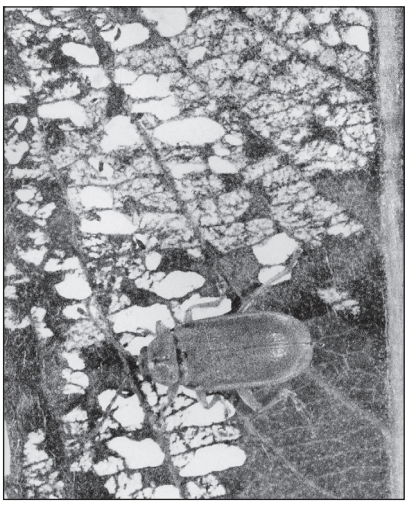

Fig. 6. An imago of the willow biological form of *G. lineola* at skeletonizing the older leaf of *S. fragilis*. Laboratory rearing, 18 June 1998

a similar length of the body of beetles (4.5 to 6 mm). Reitter (1912) and Escherich (1923) mentioned a considerably different (5 to 6 mm) length of the body. Calwer (1876) and Henschel (1895) reported a wrong length of the beetles.

### Feeding of imagoes

In spring, starved and weakened imagoes fly onto young (scarcely also older) budding and newly budded host trees growing in moist, open and insolated sites and start early to ingest. From the adaxial face of the leaf, they begin to bite out irregular holes in leaf blades. The holes sometimes reach the leaf margins and partly damage lateral veins (Figs. 4 and 5).

Beetles usually skeletonize somewhat older leaves without damaging the venation and opposite epidermis (Fig. 6). Feeding marks on alders are on average significantly larger (about 2.7 mm) than on willows. Feeding marks on young leaves of willows are on average larger (about 1.8 mm) than feeding marks on older leaves of willows (about 1.1 mm). In laboratory rearings, imagoes damaged leaves of smoothed-leaved willows *S. triandra* and *S. fragilis* mainly from the adaxial face. On the other hand, the leaves of *S. caprea*, which are densely pubescent on the abaxial face, were damaged by imagoes exclusively from the adaxial face. In the lack of suitable food (e.g. at the non-coincidence of the time of budding and the time of beetle invasion or due to heavy

Table 1. Abundance of *G. lineola* imagoes at sweeping on *A. glutinosa* and *A. incana* (Polnička, 1996). The mean leaf area of *A. glutinosa* damaged by imagoes and the mean number of laid eggs in the laboratory. An asterisk* indicates 28.6% parasitization of imagoes by tachinas *Medina collaris* (Fall.). In rearings free of tachinas, the total mean life span is given of male and female imagoes in captivity. Field and laboratory examinations, 1996

| Date of trapping | Number of imagoes | Number of ♂♂/♀♀ | Average damaged area ($cm^2$) | Average number of laid eggs | Generation of imagoes | Average life of ♂♂/♀♀ (days) |
|---|---|---|---|---|---|---|
| 12 May | 11 | 6/5 | 19.8 | 112.6 | last year's | 26/25 |
| 25 May | 14 | 5/9 | 17.9 | 115.0 | last year's | 27/24 |
| 8 June | 6 | –/6 | 27.3 | 160.0 | last year's | –/35 |
| 25 June | 11 | 4/7 | 17.0 | 170.9 | last year's | 83/26 |
| 14 July | 25 | 15/10 | 11.1 | 62.5 | last year's | 52/32 |
| Total | 67 | 30/37 | – | – | – | (47/28) |
| 2 August | 14 | 5/9 | 0.9 | 0 | this year's* | 17/12 |
| 23 August | 3 | 1/2 | 4.6 | 0 | this year's | 155/144 |
| 13 September | 8 | 5/3 | 5.3 | 0 | this year's | 177/142 |
| 10 October | 4 | 1/3 | 5.8 | 0 | this year's | 139/125 |
| Total | 29 | 12/17 | – | – | – | (168/136) |

Table 2. Abundance of *G. lineola* imagoes at sweeping on *A. glutinosa* and *A. incana* (Polnička, 1997). The mean leaf area of *A. glutinosa* damaged by imagoes including the mean number of laid eggs in the laboratory. An asterisk* indicates the occurrence of *Beauveria bassiana*. In rearings free of infection, the total mean life span is given of male and female imagoes in captivity. Field and laboratory examinations, 1997

| Date of trapping | Number of imagoes | Number of ♂♂/♀♀ | Mean damaged area (cm²) | Mean number of laid eggs | Generation of imagoes | Mean life of ♂♂/♀♀ (days) |
|---|---|---|---|---|---|---|
| 17 May | 2 | 1/1 | 17.0 | 155.0 | last year's | 30/26 |
| 1 June | 3 | 3/– | 3.8 | – | last year's* | 17/– |
| 13 June | 9 | 1/8 | 11.2 | 98.9 | last year's* | 36/19 |
| 27 June | 11 | 5/6 | 16.5 | 165.7 | last year's | 58/47 |
| 13 July | 6 | 3/3 | 6.2 | 40.2 | last year's | 50/40 |
| 25 July | 0 | 0 | – | – | – | – |
| Total | 31 | 13/18 | – | – | – | (52/43) |
| 7 August | 1 | 1/– | 0 | 0 | this year's* | 29/– |
| 21 August | 3 | 3/– | 2.0 | – | this year's* | 42/– |
| 27 August | 6 | 3/3 | 4.8 | 0 | this year's* | 42/41 |
| 8 October | 2 | –/2 | 1.0 | 0 | this year's | –/136 |
| 22 October | 0 | 0 | – | – | – | – |
| Total | 12 | 7/5 | – | – | – | (?/136) |

defoliation) beetles are able to browse buds or fine bark of shoots.

In the climatically colder area of Žďár, the last year's imagoes usually occurred on alders from 10 May to 5 August, i.e. for the period of nearly 3 months (Tables 1 and 2, Fig. 7). In the warmer area of Brno, the last year's imagoes usually occurred on willows from 5 May to 20 July (i.e. 2.5 months) (Table 3, Fig. 7). In the laboratory, imagoes of both forms usually lived only 1 to 2 months. Last year's imagoes of the alder biological form lived in total about 292 days, imagoes of the willow form about 310 days.

Beetles of the alder biological form damaged trees usually from 20 May to the beginning of July and beetles of the willow form mainly in the 2nd half of May and in the 1st half of June. Laboratory-reared beetles of the alder form which hibernated in a refrigerator at 5°C damaged on average 18.7 cm² leaves of *A. glutinosa* in spring and after wintering they lived only 15 to 25 days (Table 4). Males of the wil-

Table 3. Abundance of *G. lineola* imagoes at sweeping on *S. triandra* and *S. viminalis* (Bílovice nad Svitavou, 2006). The mean leaf area of *S. caprea* or *S. fragilis* (from 1 January 2007 *S. alba* f. *vitellina pendula* Rehd. and *S.* × *erythroflexuosa* Rag.) damaged by imagoes and the mean number of laid eggs. An asterisk* indicates about 50% parasitization of imagoes by *Medina collaris* (Fall.). In imagoes with intact development, the mean life span in captivity is given. Laboratory examination 2006 (2007)

| Date | Number of imagoes | Number of ♂♂/♀♀ | Laboratory rearings of ♂♂/♀♀ | Host plants | Mean damaged area (cm²) | Mean number of laid eggs | Generation of imagoes | Mean life span of ♂♂/♀♀ (days) |
|---|---|---|---|---|---|---|---|---|
| 12 May | 20 | 10/10 | 10/10 | *S. caprea* | 22.7 | 600 | last year's | 47/44 |
| 30 May | 24 | 11/13 | 11/13 | *S. caprea* | 16.0 | 443 | last year's | 30/28 |
| 24 June | 7 | 3/4 | 3/4 | *S. caprea* | 11.4 | 199 | last year's | 19/22 |
| Total | 51 | 24/27 | 24/27 | – | – | – | – | (36/33) |
| 13 July | 10 | 7/3 | 2/2 | *S. fragilis* | 39.1 | 270 | this year's* | 171/101 |
| 20 July | 20 | 13/7 | 1/1 | *S. caprea* | 25.0 | 670 | this year's* | 29/93 |
| 29 July | 21 | 10/11 | 3/2 | *S. caprea* | 26.0 | 173 | this year's* | 130/145 |
| | | | 2/2 | *S. fragilis* | 19.1 | 26 | this year's* | 97/146 |
| 5 August | 12 | 6/6 | 3/3 | *S. caprea* | 17.0 | 92 | this year's* | 125/150 |
| 16 August | 2 | 0/2 | 0/1 | *S. caprea* | 10.3 | 32 | this year's* | 0/168 |
| Total | 65 | 36/29 | 11/11 | – | – | – | – | (121/136) |

Table 4. The weekly area of *A. glutinosa* leaves damaged by the last year's imagoes of the alder biological form of *G. lineola* and the weekly number of laid eggs. Imagoes completed their maturation feeding on 22 November 1995 and wintered in a refrigerator (5°C). Laboratory rearing, 1996

| Week | Period (from–to) | Damaged area | | Laid eggs | |
|---|---|---|---|---|---|
| | | ($cm^2$) | (%) | number | (%) |
| 1st | 6–12 May | 30 | 22.9 | 84 | 15.1 |
| 2nd | 13–19 May | 67 | 51.2 | 264 | 47.5 |
| 3rd | 20–26 May | 24 | 18.3 | 108 | 19.4 |
| 4th | 27–2 June | 5 | 3.8 | 59 | 10.6 |
| 5th | 3–9 June | 3 | 2.3 | 28 | 5.1 |
| 6th | 10–16 June | 2 | 1.5 | 13 | 2.3 |
| 7th | 17–19 June | 0 | 0 | 0 | 0 |
| Total | | 131 | 100.0 | 556 | 100.0 |
| Number of ♂♂/♀♀ | | 2/5 | | | |
| Mean area ($cm^2$) | | 18.7 | | 111.2 | |
| Mean life span of ♂♂/♀♀ (days) | | 15/25 | | | |

low form which were caught in nature in spring 2006 at the beginning of colonization damaged on average 11.1 $cm^2$ leaves of *S. caprea*, females on average 36.0 $cm^2$ and pairs of males and females on average 20.9 $cm^2$ (Table 5). Males lived on average 48 days and females 44 days.

For the whole period of spring feeding, males produced on average 3,865 and females on average

Table 5. The mean weekly leaf area of *S. caprea* damaged by imagoes of *G. lineola* after wintering. The mean weekly number of defecated frass pellets and laid eggs. Dimensions of frass pellets and their volume. Male and female imagoes were reared individually and in pairs. Laboratory examination, 2006

| Week | Period (from–to) | Males (8 individuals) | | Females (8 individuals) | | | Males + females (4 pairs 1:1) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | mean damaged area ($cm^2$) | mean number of frass pellets | mean damaged area ($cm^2$) | mean number of frass pellets | mean number of eggs | mean damaged area ($cm^2$) | mean number of frass pellets | mean number of eggs |
| 1st | 12–18 May | 3.3 | 1,044 | 8.4 | 1,328 | 122 | 5.1 | 869 | 150 |
| 2nd | 19-25 May | 2.3 | 767 | 9.8 | 1,473 | 125 | 5.0 | 813 | 177 |
| 3rd | 26–1 June | 1.6 | 547 | 6.5 | 1,046 | 120 | 3.7 | 650 | 119 |
| 4th | 2–8 June | 1.3 | 479 | 4.8 | 814 | 91 | 3.4 | 570 | 111 |
| 5th | 9–15 June | 1.0 | 470 | 3.5 | 625 | 80 | 1.8 | 382 | 56 |
| 6th | 16–22 June | 0.7 | 238 | 1.8 | 358 | 25 | 0.9 | 315 | 23 |
| 7th | 23–29 June | 0.5 | 215 | 1.0 | 299 | 13 | 0.9 | 252 | 12 |
| 8th | 30–6 July | 0.3 | 95 | 0.2 | 39 | – | 0.1 | 26 | – |
| 9th | 7–10 July | 0.1 | 10 | – | – | – | – | – | – |
| Mean | | 11.1 | 3,865 | 36.0 | 5,982 | 576 | 20.9 | 3,877 | 648 |
| from–to | | 6.2–13.3 | 2,025–4,674 | 26.3–45.2 | 4,092–8,055 | 457–661 | 18.7–23.0 | 3,173–4,462 | 532–791 |
| Mean length/width of a frass pellet (mm) | | 0.725/0.096 | | 0.9496/0.1214 | | | ? | | |
| Mean volume of a frass pellet ($mm^3$) | | 0.0052 | | 0.011 | | | ? | | |
| Volume of frass pellets ($mm^3$) | | 20.1 | | 65.7 | | | ? | | |
| Volume of frass pellets/$cm^2$ ($mm^3$) | | 1.8 | | 1.8 | | | ? | | |
| Mean life span (days) | | 48 | | 44 | | | 46/44 | | |

Table 6. The weekly leaf area of *A. glutinosa* (cm$^2$) damaged by imagoes of the alder biological form of *G. lineola* from Polnička (in numerator). An asterisk* indicates the weekly area of *S. fragilis* leaves damaged by imagoes of the willow biological form of *G. lineola* from Bílovice nad Svitavou. Weekly number of laid eggs (in denominator). Laboratory examination, 1998

| Week | Date of trapping/generation of imagoes | | | | |
|---|---|---|---|---|---|
| | 10 May/ last year's | 11 May*/ last year's* | 24 May/ last year's | 20 June/ last year's | 11 September/ this year's |
| 1st | 25/131 | 4/48 | 16/157 | 11/118 | 2/0 |
| 2nd | 30/132 | 11/42 | 28/178 | 22/170 | 2/0 |
| 3rd | 26/107 | 8/38 | 21/204 | 15/87 | 0 |
| 4th | 20/79 | 7/5 | 15/149 | 16/74 | 0 |
| 5th | 13/49 | 3/0 | 12/107 | 3/14 | 1/0 |
| 6th | 0 | 1/0 | 5/24 | 0 | 1/0 |
| 7th | – | 0 | 1/49 | – | 0 |
| 8th | – | – | 0 | – | 0 |
| 9th < | – | – | – | – | 0 |
| Total | 114/498 | 37/133 | 98/868 | 67/463 | 6/0 |
| Number of ♂♂/♀♀ | 4/2 | 2/1 | –/3 | –/2 | –/1 |
| Mean | 19/249 | 12/133 | 33/289 | 34/232 | 6/0 |
| Mean life span of ♂♂/♀♀ (days) | 30/38 | 44/25 | –/43 | –/36 | –/213 |

Table 7. The weekly area of *A. glutinosa* leaves (cm$^2$) damaged by imagoes of the alder biological form of *G. lineola* from Polnička (in numerator). Weekly number of laid eggs (in denominator). Laboratory examination, 1996

| Week | Date of trapping/generation of imagoes | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 May/ last year's | 25 May/ last year's | 8 June/ last year's | 25 June/ last year's | 14 July/ last year's | 23 August/ this year's | 13 Sept./ this year's |
| 1st | 76/142 | 92/447 | 71/414 | 54/439 | 74/78 | 3/0 | 41/0 |
| 2nd | 68/287 | 96/322 | 45/254 | 37/443 | 61/248 | 3/0 | 1/0 |
| 3rd | 38/110 | 40/192 | 25/176 | 41/266 | 48/160 | 2/0 | 0 |
| 4th | 16/0 | 12/69 | 15/68 | 19/48 | 37/61 | 2/0 | 0 |
| 5th | 11/0 | 5/5 | 7/48 | 7/0 | 25/52 | 1/0 | 0 |
| 6th | 3/24 | 5/0 | 1/0 | 1/0 | 16/26 | 2/0 | 0 |
| 7th | 2/0 | 1/0 | – | 0 | 9/0 | 1/0 | 0 |
| 8th | 2/0 | 0 | – | 2/0 | 0 | 0 | 1/0 |
| 9th | 1/0 | – | – | 2/0 | 1/0 | 0 | 0 |
| 10th | 1/0 | – | – | 1/0 | 1/0 | 0 | 0 |
| 11th | – | – | – | 2/0 | 2/0 | 0 | 0 |
| 12th | – | – | – | – | 3/0 | 0 | 0 |
| 13th < | – | – | – | – | 0 | 0 | 0 |
| Total | 218/563 | 251/1,035 | 164/960 | 187/1,196 | 277/625 | 14/0 | 43/0 |
| Number of ♂♂/♀♀ | 6/5 | 5/9 | –/6 | 4/7 | 15/10 | 1/2 | 5/3 |
| Mean damaged area (cm$^2$) | 19.8 | 17.9 | 27.3 | 17.0 | 11.1 | 4.6 | 5.4 |
| Mean number of eggs | 112.6 | 115.0 | 160.0 | 170.9 | 62.5 | 0 | 0 |
| Mean life of ♂♂/♀♀ (days) | 26/25 | 27/24 | –/35 | 83/26 | 52/32 | 155/144 | 177/142 |

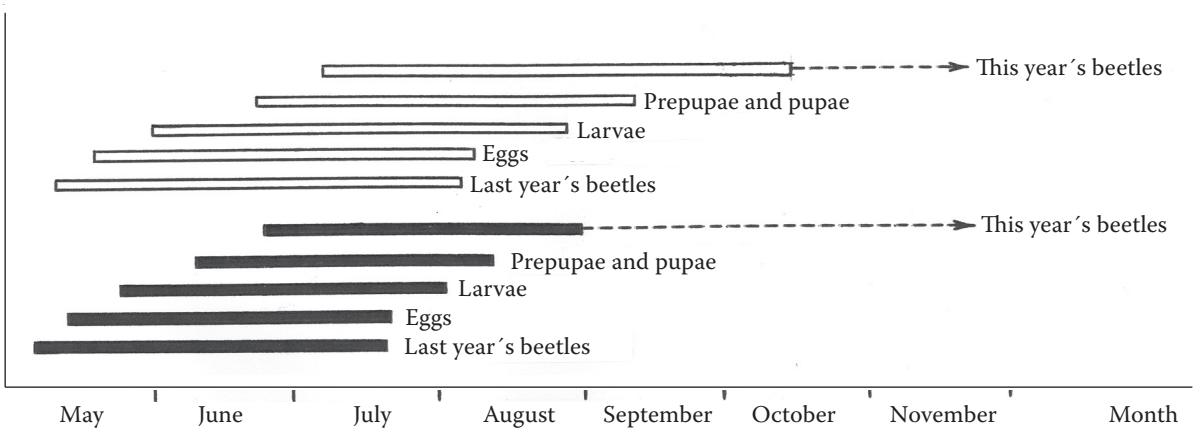


Fig. 7. The diagram of occurrence and development of the alder biological form of *G. lineola* on leaves of *A. glutinosa* and *A. incana*. Polnička, 1995 (light). The diagram of occurrence and development of the willow biological form of *G. lineola* on leaves of *S. viminalis*, *S. triandra* and *S. caprea*. Bílovice nad Svitavou, 2006 (dark)

5,982 frass pellets. Frass pellets of imagoes were elongated, slightly irregularly strangulated, immediately after defecation dark green, later black. Male frass pellets were on average 0.725 mm long and 0.096 mm wide, female frass pellets were 0.950 mm long and 0.121 mm wide. Frass pellets of the willow form were on average 0.84 mm long and 0.11 mm wide (Table 5). According to the table, males produced on average 20.1 $mm^3$ frass pellets for the whole period of feeding (i.e. on average 1.8 $mm^3/cm^2$ damaged leaf). On the other hand, females produced on average 65.7 $mm^3$ frass pellets (i.e. 1.8 $mm^3/cm^2$ damaged leaf). Thus, it is possible to derive that individuals of both sexes used the ingested food equally effectively.

Mean leaf area damaged by the last year's imagoes of the alder biological form of *G. lineola* reared on *A. glutinosa* in the laboratory is given in Tables 6 and 7. Imagoes damaged leaves mainly during the first 3 to 4 weeks and usually died within a month. Average damaged area and average time of the life of imagoes were not (surprisingly) often in expected correlation with the date of trapping in nature. Imagoes of the alder biological form damaged on average 22.6 $cm^2$ leaves of *A. glutinosa*. Imagoes of the willow biological form damaged on average 16.5 $cm^2$ leaves of *S. fragilis* in 1999 and on average 22.7 $cm^2$ leaves of *S. caprea* in 2006. The results of laboratory rearings illustrate that in spite of the larger mean size of bodies imagoes of the alder race damage after hibernation on average the same area of leaves of *A. glutinosa* as imagoes of the willow race on *S. caprea*.

Through the all-day monitoring of the feeding of male and female imagoes reared in the laboratory on leaves of *S. caprea* it was found that the imagoes ingested in the daytime and at night, however, only for rather a short time. Within 24 hours (i.e. 1,440 min), males were eating mere 52 min (3.6%) and females 252 min (17.5%). The total daily time of male feeding was divided on average into 15 partial stages by 3.5-minute intervals. Females ate on average 36 times by 7 min during the day. Breaks in feeding took in males on average 94 min and in females 34 min (Table 8). During breaks, imagoes digest and gradually defecate as much as 8 frass pellets. Eating imagoes usually do not defecate and if they do, then only 1 (scarcely 2) frass pellets.

### Copulation

After about one-week (in the laboratory already four-week) intensive feeding on leaves of unfolding shoots, imagoes mate for the first time. It means that

Table 8. All-day time picture of the consumption of food and movement of imagoes of the willow biological form of *G. lineola*. Imagoes (3 males and 3 females) were reared individually on leaves of *S. caprea*. Laboratory examination, 30 May 2006

| Mean values (during 24 hours, i.e. during 1,440 minutes) | | Males | Females |
|---|---|---|---|
| Period of feeding/period of breaks in feeding | (min) | 52/1,388 | 252/1,188 |
| | (%) | 3.6/96.4 | 17.5/82.5 |
| Number of feeding stages (= number of stages of break in feeding) | | 15 | 36 |
| Period of one stage of feeding (min) | | 3.5 | 7 |
| Period of one stage of break in feeding (min) | | 94 | 34 |
| Number of migrations from leaves to glass | | 69 | 16 |
| Ditto (during one stage of a break in feeding) | | 4.6 | 0.4 |

Table 9. Frequency of copulation and period of copulation of the last year's and this year's imagoes of the 1st generation of *G. lineola*. Laboratory examination, 2006

| Mean value | | Imagoes | |
|---|---|---|---|
| | | last year's (12–14 May) | this year's (2–4 August) |
| Number of copulations | light stage of the day (6 to 18 hours) | 6.5 | 9 |
| | dark stage of the day (18 to 6 hours) | 3.7 | 7 |
| | all day (24 hours) | 10.2 | 16 |
| Duration of one copulation (min) | light stage of the day | 63 | 32 |
| | dark stage of the day | 72 | 32 |
| | all day | 67.5 | 32 |
| Period of copulation (min/%) | light stage of the day | 410/57 | 288/40 |
| | dark stage of the day | 266/37 | 224/31 |
| | all day | 676/47 | 512/36 |
| Number of copulations for the whole period of (i.e. for 42 days and 47 days) | | 42 × 10.2 = 428 | 47 × 16 = 752 |
| Period of copulation for the whole life | | 428 × 67.5 = 28,890 min (= 20 days) | 752 × 32 = 24,064 min (= 16.7 days) |

before leaving for winter habitats (i.e. during the last year's maturation feeding) the imagoes do not mate under natural conditions of Moravia (with the exception of the warmest south) and usually unfertilized females hibernate. After hibernation, however, females copulate repeatedly, namely with more males. Copulating imagoes can be observed in nature nearly for the whole period of their occurrence on trees. The number and the period of copulations during the light and dark stage of the day are given in Table 9. Imagoes of the willow biological form copulated in the experiment on average 10.2 times per day, the mean period of one copulation being 67 min. During the whole day, imagoes copulated on average 676 min (47% of the day), of this 410 min (57%) in the light part and 266 min (37%) in the dark part of the day. For the whole period (on average 42 days), imagoes copulated 428 times spending on average 20 days at copulation. For the purpose of comparison, the table gives the frequency of copulation and the period of copulation of imagoes of this year's generation.

### Egg laying

Fertilized females of *G. lineola* lay eggs on the abaxial face of leaves, namely in groups of up to 20 pieces (Schaufuss 1916). For example, Escherich (1923) and Živojinovič (1948) reported clutches of roughly 20 eggs and Maisner (1974) of roughly 25 eggs. According to Kožančikov (1958) females bite out small spots into the surface part of leaves (mainly into cuticula) and then lay eggs on them. Brovdij (1973) also described the biting out of small holes. According to the author, the groups consist of 2 to 14 (scarcely even 18) eggs. Specified numbers of eggs in clutches (10 to 20) were mentioned by Kožančikov (1958), Häggström (1997) and Höglund et al. (1999). Kendall and Wiltshire (1998) identified clutches of 13 to 20 eggs. According to our studies, females lay eggs into groups of 3 to 20 (on average 14). The mean group of eggs is laid during about 26 min, i.e. one egg on average during 1 min and 51 sec.

The first eggs occur in nature after 7 to 10-day (in the laboratory 5-day) feeding. The period of the

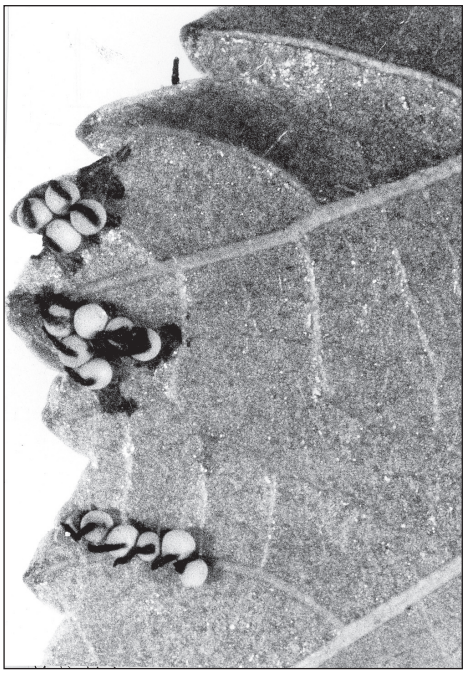

Fig. 8. Eggs of *G. lineola* on the abaxial face of leaves of *A. glutinosa*. Polnička, 4 June 1998

Table 10. Localization of eggs of the alder biological form of *G. lineola* in rearings on *A. glutinosa* and willow biological form in rearings on *S. fragilis*. Laboratory examination, 1995 to 1998

| Localization of eggs | Last year's females | | This year's females | | Females in total | |
|---|---|---|---|---|---|---|
| | alder biological form | willow biological form | alder biological form | willow biological form | alder biological form | willow biological form |
| Abaxial face | 5,426/71.6 | 262/73.0 | 1,276/74.7 | 2,258/78.1 | 6,702/72.2 | 2,520/77.5 |
| Adaxial face | 2,064/27.2 | 95/26.5 | 397/23.2 | 581/20.1 | 2,461/26.5 | 676/20.8 |
| Glass | 81/1.1 | 2/0.5 | 10/0.6 | 53/1.8 | 91/1.0 | 55/1.7 |
| Petiole | 6/0.1 | – | 25/1.5 | – | 31/0.3 | – |
| Total | 7,577/100.0 | 359/100.0 | 1,708/100.0 | 2,892/100.0 | 9,285/100.0 | 3,251/100.0 |

occurrence of eggs of the alder biological form in Polnička in 1996 and of the willow form in Bílovice nad Svitavou in 2006 is illustrated in Fig. 7. In Polnička, eggs occurred from 19 May to 8 August (i.e. about 3 months). In Bílovice nad Svitavou, eggs occurred from 12 May to 21 July (i.e. about 2.5 months). Females of the alder form laid eggs in the laboratory on average less than 4 (max. 6) weeks (Table 4). Females of the willow form laid eggs in the laboratory on average 5 (max. 7) weeks (Table 5). Females of the alder form lived on average 9 days after egg-laying and females of the willow form 6 days. Usually no unlaid eggs occurred in the ovaries of naturally died females. According to Brovdij (1973) females lay eggs for the period of mere 20 to 30 days.

Eggs of *G. lineola* (Fig. 8) are markedly orange-yellow, lengthwise oval and rounded. Their length is on average 0.62 mm and width 0.47 mm (according to Brovdij [1973] 0.76 and 0.58 mm, respectively). During their embryonal development, the mean length of eggs increases up to 0.74 mm and width to 0.61 mm. On the surface of the rather tough leathery chorion, there are tiny light brown dimples of pentagonal shape. Dimples 0.005 to 0.011 mm in size cover the whole surface of eggs. At the place of a micropyle, dimples are very fine. Eggs are masked by small frass pellets 0.5 mm in diameter and 0.1 mm in width. These frass pellets are roughly twice smaller than frass pellets defecated during numerous breaks in feeding. They separately cover most of the eggs often passing to neighbouring eggs, seldom a leaf. Thus, they help to fix eggs in groups or to a leaf. Eggs are stuck to leaves by means of sticky secretion, namely usually perpendicularly to the leaf surface. Before egg laying, females often nibble the leaf epidermis at the place of oviposition, thereby removing eventual hairs. Thus, the close contact of eggs with a leaf which significantly stimulates their embryonal development is enabled. In nature, females lay eggs almost exclusively on the abaxial face of leaves. Sporadically, eggs occur on the bark of young shoots (e.g. in osier plantations on the bark of *S. viminalis*). Groups of eggs laid on bark consist only of 2 to 9 eggs. Females place eggs usually on the subapical part of the leaf blade or along the periphery of the leaf blade apical half. For example, on leaf blades of *S. viminalis* 7.5 cm long, the majority of the eggs was localized at a distance of about 10 mm from the leaf tip. Leaves in the upper half of shoots are laid by eggs most. The mean number of eggs in groups laid by females of the willow form from the beginning of the period of egg-laying to mid-June slightly increases and later sharply decreases. For example, about 20 May, females caught in 1975 in a *S. viminalis* plantation in Prosenice (former Přerov District) laid on average 11 eggs into groups. In mid-June, there were on average 17 eggs in groups and about 10 July ca. 6 eggs. According to Brovdij (1973) the number of eggs in groups gradually increases from the beginning of oviposition.

In laboratory rearings, females of both biological forms laid on average 72.3% eggs on the abaxial face of leaves, 26.8% eggs on the adaxial face of leaves, 0.8% eggs on glass walls of rearing trays and 0.1% eggs on petioles (Table 10). For the purpose of comparison, the table also gives the localization of eggs laid by this year's females. In contrast to natural conditions, females in captivity laid eggs both individually and in open groups (with interspaces) as well as in compact groups. In groups, on average 7.9 eggs were laid, of this on average 4.8 eggs to compact groups and 16.7 eggs to open groups (Table 11).

The fecundity of *G. lineola* females is high (112 to 675 – on average 550 – eggs). For example, females of the willow biological form caught in natural conditions on 12 May 2006 and fed on leaves of *S. caprea* laid 457 to 791 (on average 612) eggs during 40 days, namely on average up to 45 partial clutches by 14 eggs (Table 5). Every day, females laid on average 15 eggs to 1.1 clutches. In the period of the most intensive feeding (in about mid-June), they laid up to 30 eggs to 2.1 clutches per day. The females of the alder biological form also show high fecundity (as many as

Table 11. Number of eggs of the alder biological form of *G. lineola* laid on leaves of *A. glutinosa* to compact and open groups of eggs. Laboratory rearings, 1995 to 1999

| Number of eggs per group | Compact groups of eggs | | Open groups of eggs | | Groups total | |
|---|---|---|---|---|---|---|
| | number of groups/number of eggs | (%) | number of groups/number of eggs | (%) | number of groups/number of eggs | (%) |
| 1 | 169/169 | 19.3/4.0 | – | – | 169/169 | 14.3/1.8 |
| 2 | 145/290 | 16.5/6.8 | – | – | 145/290 | 12.3/3.1 |
| 3 | 161/483 | 18.4/11.4 | – | – | 161/483 | 13.6/5.2 |
| 4 | 108/432 | 12.3/10.2 | – | – | 108/432 | 9.1/4.6 |
| 5 | 59/295 | 6.7/7.0 | – | – | 59/295 | 5.0/3.2 |
| 6 | 48/288 | 5.5/6.8 | – | – | 48/288 | 4.1/3.1 |
| 7 | 36/252 | 4.1/5.9 | – | – | 36/252 | 3.1/2.7 |
| 8 | 26/208 | 3.0/4.9 | 3/24 | 1.0/0.5 | 29/232 | 2.4/2.5 |
| 9 | 24/216 | 2.8/5.1 | 4/36 | 1.3/0.7 | 28/252 | 2.4/2.7 |
| 10 | 8/80 | 0.9/1.9 | 11/110 | 3.7/2.2 | 19/190 | 1.6/2.1 |
| 11 | 9/99 | 1.0/2.3 | 6/66 | 2.0/1.3 | 15/165 | 1.3/1.8 |
| 12 | 13/156 | 1.5/3.7 | 12/144 | 4.0/2.8 | 25/300 | 2.1/3.2 |
| 13 | 9/117 | 1.0/2.7 | 11/143 | 3.6/2.8 | 20/260 | 1.7/2.8 |
| 14 | 12/168 | 1.4/4.0 | 22/308 | 7.3/6.2 | 34/476 | 2.9/5.1 |
| 15 | 2/30 | 0.2/0.7 | 22/330 | 7.3/6.5 | 24/360 | 2.0/3.9 |
| 16 | 7/112 | 0.8/2.6 | 40/640 | 13.2/12.7 | 47/752 | 4.0/8.1 |
| 17 | 9/153 | 1.0/3.6 | 33/561 | 10.9/11.1 | 42/714 | 3.6/7.7 |
| 18 | 10/180 | 1.1/4.2 | 48/864 | 15.9/17.2 | 58/1,044 | 4.9/11.2 |
| 19 | 2/38 | 0.2/0.9 | 35/665 | 11.6/13.2 | 37/703 | 3.1/7.6 |
| 20 | 8/160 | 0.9/3.8 | 40/800 | 13.2/15.9 | 48/960 | 4.1/10.4 |
| 21 | 3/63 | 0.4/1.5 | 5/105 | 1.6/2.1 | 8/168 | 0.7/1.8 |
| 22 | 1/22 | 0.1/0.5 | 3/66 | 1.0/1.3 | 4/88 | 0.3/1.0 |
| 23 | – | – | 2/46 | 0.7/0.9 | 2/46 | 0.2/0.5 |
| 24 | 3/72 | 0.3/1.7 | 2/48 | 0.7/1.0 | 5/120 | 0.4/1.3 |
| 25 | 3/75 | 0.3/1.8 | 2/50 | 0.7/1.0 | 5/125 | 0.4/1.4 |
| 26 | 1/26 | 0.1/0.6 | – | – | 1/26 | 0.1/0.3 |
| 27 | – | – | – | – | – | – |
| 28 | 1/28 | 0.1/0.7 | – | – | 1/28 | 0.1/0.3 |
| 29 | – | – | 1/29 | 0.3/0.6 | 1/29 | 0.1/0.3 |
| 30 | 1/30 | 0.1/0.7 | – | – | 1/30 | 0.1/0.3 |
| Total | 878/4,242 | 100.0/100.0 | 302/5,035 | 100.0/100.0 | 1,180/9,277 | 100.0/100.0 |
| Even number of eggs in groups | | | 181/3,004 | 59.9/59.7 | 573/5,256 | 48.6/56.7 |
| Odd number of eggs in groups | | | 121/2,031 | 40.1/40.3 | 607/4,021 | 51.4/43.3 |
| Mean number of eggs | 4.8 | | 16.7 | | 7.9 | |

687 eggs). The fecundity of the last year's females which were reared from eggs and hibernated in a refrigerator or under outdoor conditions was much lower (112 to 257 – on average 170 – eggs). According to Brovdij (1973) females lay eggs with breaks lasting 1 to 2 days and, in total, they lay about 200 eggs (according to Kožančikov [1958] about 185 eggs).

The females have by 10 meristic ovarioles in the ovaries. Thus, eggs develop maximally in 20 ovarioles at the same time. At the synchronized development of eggs in all ovarioles, females could theoretically lay always 20 eggs into a group. Owing to deviations in the function of ovarioles the number of eggs in particular clutches is, however, usually lower. Moreover, females very often lay the supply of mature eggs into 2 (or even more) partial groups.

In laboratory rearings, females laid 1 to 30 eggs to one place and sporadically located eggs even to

previously laid clutches (Table 11). According to the table it is evident that the pair structure of ovaries markedly reflects in the number of eggs in groups (in spite of irregularities in their function). In groups with the even number of eggs there occurred 56.7 to 59.7% of eggs whereas in groups with the odd number of eggs there was only 40.3 to 43.3% of eggs.

### Natural enemies of imagoes

Extreme weather conditions during hibernation and during the beginning of the growing season are the main regulator of the abundance of *G. lineola*. Under mild and moist winters, a considerable part of exhausted imagoes is subject to the attack of entomopathogenic fungi, particularly *Beauveria bassiana* (Bals.) Vuill. Long-term floods can also affect wintering beetles unfavourably. Under conditions of precocious warming, beetles activate even before budbreak and subsequently die of hunger. Beetles are often killed by various predators, e.g. birds (Aves) (Lundvall et al. 1998), predatory insects (Insecta) and spiders (Aranea). In China, imagoes are infected by *Nosema aenescens* sp. nov. (Microspora, Nosematidae) (Wen, Huang 1995).

*Townesilitus fulviceps* (Ruthe) (Braconidae) was reared from about 5% of the last year's and this year's imagoes of the alder biological form in Polnička. It is the first finding of the species in the area of the CR. The braconid is known from England, France, Sweden, Austria, Russia and Kazakhstan (Haeselbarth 1988).

In 1996, about 50% of the last year's imagoes of the alder form were parasitized by *Medina collaris* (Fall.) (Tachinidae) in Polnička. To a smaller extent, the last year's (and particularly this year's) imagoes of the willow form were parasitized by a tachina in Bílovice nad Svitavou. In a *S. viminalis* plantation in Prosenice (former Přerov District) in 1975, a negligible part of imagoes (about 1%) was parasitized by nematodes of the family Mermithidae (det. prof. I. Rubcov, Saint Petersburg) (Urban 1981). Other information on natural enemies of *G. lineola* is given in Part 2 of the paper.

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## Výskyt, biologie a škodlivost *Galerucella lineola* (F.) (Coleoptera, Chrysomelidae) – Část 1. Loňští (mateřští) brouci

**ABSTRAKT**: Hojného výskytu *Galerucella lineola* (F.) na Moravě bylo v letech 1995 až 2006 využito k vyšetření jejího výskytu, biologie a škodlivosti. Olšová biologická forma byla studována na *Alnus glutinosa* a *A. incana* hlavně na polesí v Polničce (Žďársko) a vrbová forma na *Salix viminalis*, *S. triandra* a *S. caprea* v břehových a doprovodných porostech řeky Svitavy poblíž Bílovic nad Svitavou (Brněnsko). Imaga opouštějí zimoviště obvykle v první polovině května. Během 2,5 až tří měsíců poškodí průměrně 22,6 cm$^2$ listů *A. glutinosa* a *S. caprea* (z toho samečci 3,2krát méně než samičky). Samečci žerou během 24 hodin průměrně 15krát po dobu 3,5 minut, tj. 52 minut (3,6 % dne). Samičky žerou denně průměrně 36krát po dobu 7 minut, tj. 252 minut (17,5 % dne). Imaga kopulují průměrně 10,2krát denně po dobu 67 minut. Za celou dobu rozmnožování (kolem 42 dnů) kopulují průměrně 428krát, tj. plných 20 dnů. Vajíčka kladou do 3 až 20členných (průměrně 14členných) skupin. Samičky vykladou 457 až 791 (průměrně 612) vajíček, tj. kolem 15 vajíček denně. K nepřátelům imag patří mj. *Medina collaris* (Fall.) (Tachinidae) a *Townesilitus fulviceps* (Ruthe) (Braconidae).

**Klíčová slova**: Chrysomelidae; *Galerucella lineola*; hostitelské dřeviny; hibernace; žír; loňská imaga; rozmnožování; přirození nepřátelé

*Corresponding author:*

Prof. RNDr. Ing. Jaroslav Urban, CSc., Mendelova zemědělská a lesnická univerzita v Brně, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 121, fax: + 420 545 211 422, e-mail: urbanj@mendelu.cz