Occurrence, development and harmfulness of the bark anobiid *Ernobius mollis* (L.) (Coleoptera: Anobiidae)

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ABSTRACT: The paper summarizes results of the study of the occurrence, development and harmfulness of *Ernobius mollis* (Linnaeus, 1758), which occurred plentifully on *Pinus nigra* Arn. impaired by drought in the CR in 2000. It is based on laboratory rearings in photoeclectors and numerous analyses of branches (stems) of pines from 5 localities in Brno. Partial studies were carried out in 5 other localities in Moravia and Eastern Bohemia. Under laboratory conditions, imagoes occurred mainly in June–August, viz at a 1 ♂: 3 ♀♀ ratio. Males and females were on average 4.4 and 4.9 mm long, respectively. In living trees, imagoes of substandard dimensions developed. In dead trees, the average length of males and females gradually decreased with increasing damage in the particular years. Immediately after hatching, gonads of imagoes were mostly only partly developed. Females matured sexually during the first hours (maximally during 2 days) of their life in the open. In their ovaries, some 14 to 136 (on average 42.2) eggs occurred. With the increasing size of females their fecundity increased significantly. The development of larvae progressed through 4 instars. One grown up larva destroyed about 1.8 cm^2 cambium. Wood was damaged to a depth of 2 mm and sporadically to a depth of 15 mm. Imagoes left wood through exit holes of a diameter of 1.1 to 2.1 (on average 1.6) mm in bark. Their development was univoltine. The pest damaged the same wood repeatedly for a period of 5 years.

Keywords: Anobiidae; *Ernobius mollis*; *Pinus nigra*; occurrence; development; harmfulness

The bark anobiid *Ernobius mollis* (L.) is one of the most abundant native species of Anobiidae. In the fauna of the CR, the family is represented by 63 species, 8 of them belong to the genus *Ernobius* Thoms. (Zahradník 1993). Beetles of this taxonomically rather difficult and relatively little known genus are small, elongated and usually rubiginous or brown. They have filamentous 11-segment antennae with 3 enhanced last segments. The scutellum is not tubercled from above but furnished longwise with a sharp lateral edge. Wing cases show smooth and finely scattered spots. Its body is finely monochromatically pubescent, pedal segments are long and slim. Representatives of the genus are characterized by sexual dimorphism, considerable size variability, formation of varieties and frequent inversion of genitals.

E. mollis (Fig. 1) is the most ordinary representative of the genus. Linné described the species as *Dermestes mollis* in 1758. Natural variability of imagoes caused difficulties with the name and systematic classification of the species. From the end of the 18th century to the beginning of the 19th century, the species was usually classified in the genus *Anobium* F. and described under various (at least 27) scientific names (Cymorek 1974; Burakowski et al. 1986, etc.). Imagoes were described by Ratzeburg (1839), Perris (1854), Klapálek (1903), Kuhnt (1913), Kemner (1915), Koch (1928), Tooke (1946), Gardiner (1953), Johnson (1975), Espanol and Blas (1991), etc. Some authors (e.g. Gardiner 1953) also studied the anatomy of imagoes, namely their digestive and reproductive system.

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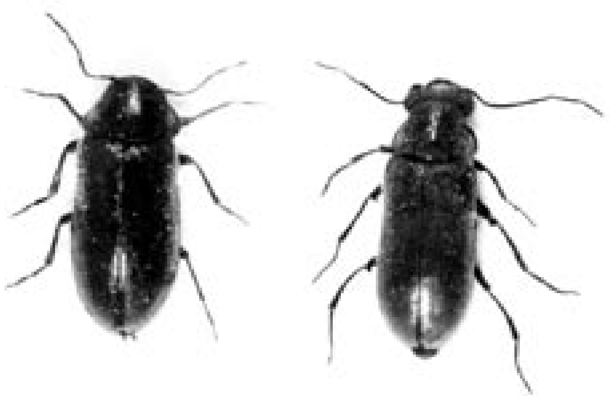

Fig. 1. *Ernobius mollis* (L.) (female left, male right)

E. mollis differs from the other members of the genus particularly by the cut-out of the 4th pedal segment of rear legs reaching about its half. The length of the 9th antenna segment is smaller than the length of previous 4 segments together. Nevertheless, each of the last 3 segments of antennae (i.e. 9th to 11th segment) is much longer than any other segment of antennae. The scutum is slightly arched, somewhat uneven, sometimes with a shallow central line before the base. According to our extensive measurements, the scutum is on average 0.1 mm narrower than wing cases in shoulders and at the sides, the scutum is round. It connects with wing cases along its whole width and rear and front edges are markedly round. The top side of beetles is (except for the yellowish apical drawing on wing cases) monochromatically rusty or dark brown and slightly bright. The body surface is densely and very finely grainy and densely and tightly pilous. Hairs are rather long being of yellow or grey colour. Only scutellum is frequently more densely pilous and, therefore, of lighter colour.

Sexual dimorphism in adults of *E. mollis* is manifested particularly in the body size, length and form of antennae and in the shape of the tergite of the last visible segment of the beetle abdomen. Males are on average smaller than females having longer and slender antennae than females. According to Gardiner (1953), the length of the last 3 apical segments of male antennae exceeds the total length of proximal segments. During rest, antennae of males are pulled to the ventral side of the body reaching nearly to the half of the abdomen whereas in females, they do not exceed the thorax. Segments of the antennal club are parallel at the sides in males whereas in females the segments are distally enlarged and somewhat curved at the sides. The tergum of the last visible segment of the abdomen is laterally convex in males and from the front to the back somewhat concave and so its rear part heads slightly up. In females, the tergum is convex both laterally and from the front to the back and so its rear part heads slightly down.

The larva of *E. mollis* was briefly described by Perris (1854), Kemner (1915), Munro (1915), Tooke (1946), Kelsey (1946), Weidner (1953), Dominik and Starzyk (1989), etc. Several authors (e.g. Perris 1854 and Tooke 1946) also presented a brief description of the pupa. Similarly, a description of the growing larva including diagnostic features distinguishing it from other species was given by Parkin (1933). The morphology of eggs, larvae of younger instars and pupae including the anatomy of the digestive system of full-grown larvae was studied in detail by Gardiner (1953). The digestive system of full-grown larvae (and particularly histology and symbiotic organisms of the mid-gut) was studied by Heitz (1927), Breitsprecher (1928), Müller (1934), etc.

The larva is of a white grub type, up to 8(9) mm long (Fig. 2). It is equipped with well-developed 5-segment thoracic legs and 10-segment abdomen. According to our observations, its body has long and sparse tiny hairs. The fine hairs are grey or red-black being longest at the rear of the abdomen. Along the sides of the last and last but one segments of the abdomen there are numerous tiny dark spines. Erect and by their point slightly backwards headed spines occur also on prenotal folds on the metathorax and on the first 7(8) segments of the abdomen. The more intensely sclerotized dark-coloured frontal part of the cranium is roughly semicircular its width being nearly a double of its length.

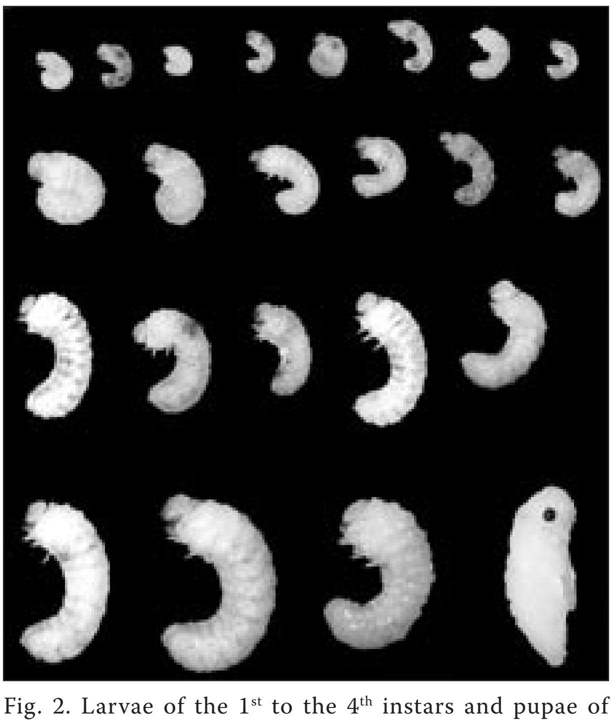

Fig. 2. Larvae of the 1st to the 4th instars and pupae of *E. mollis*

E. mollis is a Palearctic species with its centre of occurrence in Europe and Siberia. In Fennoscandinavia (particularly in Norway), it reaches far northwards (Hellén et al. 1939). *E. mollis* was introduced to North America (Craighead 1950; Simeone 1962; White 1982; Seybold, Tupy 1993; Seybold 2001, etc.), to N Africa, Near East (e.g. Halperin, Espanol 1978), Japan and Southern Hemisphere. It occurs in Australia, New Zealand, New Caledonia and S Africa (Clarke 1932; Kelsey 1946; Tooke 1946; Casimir 1958; Milligan 1967; Neumann 1979; Hockey 1987, etc.).

E. mollis develops in phloem (including the inner layer of bark), in cambium and in surface parts of the wood of dead conifers (more rarely dying conifers) and sporadically also in their cones. Hosts are as follows: various species of pine (e.g. *Pinus sylvestris* L., *P. nigra* Arn., *P. radiata* D. Don., *P. pinaster* Ait., *P. halepensis* Mill., *P. taeda* L., *P. canariensis* C. Smith), Norway spruce (*Picea abies* [L.] Karst.), European larch (*Larix decidua* Mill.), Douglas fir (*Pseudotsuga taxifolia* [Poir.] Brit.) and giant sequoia (*Sequoiadendron giganteum* [Lindl.] J. Buchh.). On 4–22 October, 2004, its larvae were abundantly found in Brno-Pisárky on dying branches of overmature trees of blue spruce (*Picea pungens* Engelm.) which are grown for decorative purposes there. The species has not probably been found in silver fir yet. It is evident that *E. mollis* is a wide polyphage in conifers (mainly in pine and spruce). According to Cymorek (1964), its larvae can also successfully develop under bark and in surface parts of the sapwood of beech (*Fagus sylvatica* L.). This unique find does not come from the wild but from a floor made from imperfectly barked lateral parts of beech boards.

Biology of *E. mollis* is known only insufficiently. Literature data on its way of life are usually of the character of mere notes concerning mainly the period of the beetle occurrence, place and number of laid eggs, the way of feeding of larvae, generation conditions and harmfulness. Relatively small interest in the more detailed study of the beetle biology can undoubtedly be explained by its markedly secondary character and only surface damage to wood conditioned by the presence of bark. Detailed data were given mainly by Kemner (1915), Gardiner (1953), Adlung (1957), Dominik (1958) and Toskina (1966). Thanks to the authors *E. mollis* is the best-known representative of the genus. Some specifically oriented papers such as cytological studies of spermatogenesis (Virkki 1960) or studies on the effect of sulphanilamide on symbionts of *E. mollis* (Jurzitza 1963) etc. contribute to the knowledge of its biology.

According to literature it is evident that *E. mollis* is the species of dead unbarked coniferous wood. In forests, it colonizes particularly recently fallen dead trees (Tooke 1946; Bletchley 1967), fuelwood (Clarke 1932) or dead standing trees of the stem diameter below 20 cm (Kelsey 1946). However, it can also attack physiologically impaired and dying trees (Roubal 1936; Diminic et al. 1995) and cones (Roques 1983; Karanikola, Markalas 2001). It is abundant not only in the wild but also in timber-yards and in various wooden constructions, furniture, tools, museum exhibits, etc. A number of entomological and entomological-forest protection papers reported its harmfulness (e.g. Nüsslin, Rhumbler 1922; Escherich 1923; Trägårdh 1934, 1940, 1947; Madel 1941; Butovitsch 1951; Harris 1953; Schmidt 1954; Nuorteva, Nuorteva 1954; Gäbler 1955; Dominik 1958, 1967; Kudela 1970; Becker 1984; Vasiljev et al. 1975; Hockey 1987, etc.). Protection measures were dealt with for example by Trägårdh (1949), Harris (1953), Dominik (1958), Baker (1964) and Milligan (1967, 1977).

MATERIAL AND METHODS

In 2000, sudden decline and dieback of *Pinus nigra* occurred in the region of Brno and at many other places in the CR. Mainly young trees (10 to 20 years old) were affected in urban plantings and rarely also older trees in forest stands. The damage was noticed both in solitary pines and in pines growing in pure and mixed groups. The main cause of damage was the acute deficit of precipitation together with above-average temperatures and drying up winds in spring. The decline of impaired trees was accelerated by fungi (*Lophodermium pinastri* [Schrad.] Chev., *Mycosphaerella pini* E. Rostr., *Armillaria ostoye* [Romagn.] Herink) and cambioxylophagous insect pests (mainly *Pityophthorus glabratus* Eichh., *Pityogenes bidentatus* Hbst., *P. trepanatus* Nördl., *P. bistridentatus* Eichh., *Magdalis rufa* Germ. and *Pissodes castaneus* Deg.) (Urban 2000). In dying and dead branches and stems, *E. mollis* also occurred frequently. The species was determined by Doc. P. Zahradník (Forestry and Game Management Research Institute, Jíloviště-Strnady) and thereby I highly appreciate his assistance.

The first detailed analyses of the attack of *P. nigra* by the bark anobiid *E. mollis* were carried out in June 2000, viz in branches and stems of young pines coming from Brno-Lesná and older pines (about 60 years old) from Brno-Kociánka. On 9 June 2000 in Brno urban parts Lesná, Veveří, Černá Pole and

Table 1. Frequency of the occurrence of males and females of *Ernobius mollis* according to the length of the body without (and including) the rear part of the abdomen overlapping wing-cases (mm)

Body length (mm)	Number of ♂♂ of the body length		Number of ♀♀ of the body length	
	without overlapping abdomen	including the overlapping abdomen	without overlapping abdomen	including the overlapping abdomen
3.0–3.2	20	6	6	–
3.3–3.5	99	18	64	5
3.6–3.8	146	54	104	23
3.9–4.1	273	169	240	98
4.2–4.4	187	233	221	158
4.5–4.7	115	199	195	212
4.8–5.0	75	166	241	291
5.1–5.3	10	54	76	187
5.4–5.6	3	19	33	122
5.7–5.9	–	6	6	38
6.0–6.2	–	5	4	48
6.3–6.5	–	–	–	7
6.6–6.8	–	–	–	1
In total	929	929	1,190	1,190
Mean length of the body	4.1	4.4	4.4	4.9

Žabovřesky, samples were taken from young pine trees and in Brno-Kociánka from older pine trees. In each of the localities, 15 to 52 sections 40 cm in length and 5 to 40 mm in diameter were obtained. The samples were put into photoeclectors placed in a laboratory (temperature 20 to 25°C, relative air humidity 35 to 55%). The photoeclectors were inspected once a week in the period from 9 June 2000 to 30 November 2004. The caught beetles were placed into 70% ethyl alcohol for later examinations.

On 11 June 2001, other samples were taken from *P. nigra* coming from Brno-Lesná and Brno-Veveří. A part of the samples was analyzed and a part of them was placed into photoeclectors in the laboratory. Partial analyses of the topical attack were carried out in *P. nigra* coming from the Křtiny Training Forest Enterprise (former district Brno-venkov), from Polnička (former district Žďár nad Sázavou), Lednice na Moravě (former district Břeclav), Deštné in the Orlické hory Mts. (former district Rychnov nad Kněžnou) and Bystřička (former district Vsetín). In 2004, the health condition was monitored of *Picea pungens* in an ornamental garden in Brno-Pisárky.

In beetles obtained by means of photoeclectors, the date of catching, sex and body length (without the rear part of the abdomen overlapping wing-cases and including the overlapping rear of the abdomen) were recorded. In females, the number of eggs in ovaries was determined. The size of larvae was assessed according to the width of cranium and body length. After nearly 5 years of study, samples of *P. nigra* from photoeclectors were analyzed. The main objective of the study was to determine the average area of bark and cambium destroyed by 1 larva of *E. mollis* with finished development.

RESULTS AND DISCUSSION

Occurrence of beetles

Literature data on the occurrence of beetles are very different. For example Ratzeburg (1839) found beetles abundantly in spruce during spring and at the same time they also hatched from branches of pine. Kemner (1915) noted that in Sweden beetles swarmed throughout summer. In Australia (Hockey 1987) beetles occurred in spring and early summer. Munro (in Vité 1952) reported the swarming of beetles in April and May, Langendorf (1961) and Kudela (1970) in May and June and Schaufuss (1916) in May to July. Toskina (1966) noted the occurrence of beetles in the former USSR from May to mid-July. According to the 3-year monitoring of Dominik (1958), the beetles flew in Poland from mid-May to the end of July (most abundantly in June) and occurred particularly on windows and in their proximity. Quite a different period of the occurrence of beetles was mentioned by Tooke (1946). According to the author, in South Africa beetles did not occur in the wild before August and September but in warmed up buildings they occurred all the year round. Gardiner (1953) found beetles under room

Table 2. The number of measured males and females of *E. mollis* and the size of the overlapping of their abdomen over wing-cases in relation to the body length (without the overlapping abdomen) (mm)

Body length (mm)	Number		Overlapping of the abdomen (mm)	
	♂♂	♀♀	♂♂	♀♀
≤ 3.5	120	70	0.40	0.50
3.6–4.0	397	323	0.37	0.48
4.1–4.5	290	367	0.36	0.47
≥ 4.6	124	432	0.31	0.47
In total	931	1,192	0.36	0.45

conditions from 26 May to the beginning of October. According to him, isolated beetles hatched in October to survive winter in quiescence and it is possible that they also reproduced in the next spring.

Tables 1–4 and Fig. 3 show the results of our observations of the occurrence of imagoes in particular months of 2001 to 2004. According to Table 1 it is evident that under standard laboratory conditions the large majority (about 90%) of beetles occurs in the open in June to August and nearly 50% of the number occur in July. In other months (i.e. in September to May of the next year inclusive), only about 10% beetles hatched. The average date of occurrence in photoeclectors (17 July) fluctuated in rearings established on 9 June 2000 both in particular years and within particular localities, viz in the range of 3 to 4 weeks. Imagoes always occur only during high summer and negligible differences in the average date of occurrence are obviously caused mainly by trophic conditions (Tables 2 and 3).

It has been proved that individuals of both sexes hatch in the same time, viz roughly at a 1:1.3 ratio. In 2001, males slightly predominated (sex ratio 1.2:1); in 2002 to 2004, however, females predominated (sex ratio 1:1.2 to 2.4) (Table 4, Fig. 4). The causes of a significant gradual increase in the proportion of females in trapping during particular years are not known.

Table 3. The average length of the body (including the abdomen rear overlapping wing-cases) in mm/number of measured males and females of *E. mollis* in particular years and in total. Laboratory rearing in photoeclectors was established on 9 June 2000. In the table, beetles are not included obtained by means of photoeclectors from Bystřička (former Vsetín district), Polnička (former Žďár nad Sázavou district), Lednice (former Břeclav district) and Training Forest Enterprise Masaryk Forest in Křtiny (former Brno-country district)

Locality	Sex	Year				In total
		2001	2002	2003	2004	
Lesná 1	♂♂	4.8/46	4.4/163	4.3/31	–	4.5/240
	♀♀	5.0/34	4.9/194	4.8/35	4.6/1	4.9/264
	in total	4.9/80	4.7/357	4.6/66	4.6/1	4.7/504
Kociánka	♂♂	4.6/23	4.5/66	4.2/44	–	4.5/133
	♀♀	5.0/21	5.0/79	4.6/57	–	4.8/157
	in total	4.8/44	4.8/145	4.4/101	–	4.7/290
Veveří 1 (Úvoz)	♂♂	4.6/85	4.4/163	4.1/44	3.8/1	4.4/293
	♀♀	5.1/94	4.8/220	4.7/49	–	4.8/363
	in total	4.8/179	4.6/383	4.4/93	3.8/1	4.6/656
Černá Pole	♂♂	4.5/17	4.7/7	4.5/38	4.2/9	4.5/71
	♀♀	4.8/7	5.1/7	4.9/33	4.4/18	4.8/65
	in total	4.6/24	4.9/14	4.7/71	4.3/27	4.6/136
Žabovřesky	♂♂	4.8/5	4.5/3	–	–	4.7/8
	♀♀	4.8/1	5.3/2	–	–	5.1/3
	in total	4.8/6	4.8/5	–	–	4.8/11
In total	♂♂	4.6/176	4.4/402	4.3/157	4.2/10	4.4/745
	♀♀	5.0/157	4.9/502	4.7/174	4.4/19	4.8/852
	in total	4.8/333	4.7/904	4.5/331	4.3/29	4.6/1,597

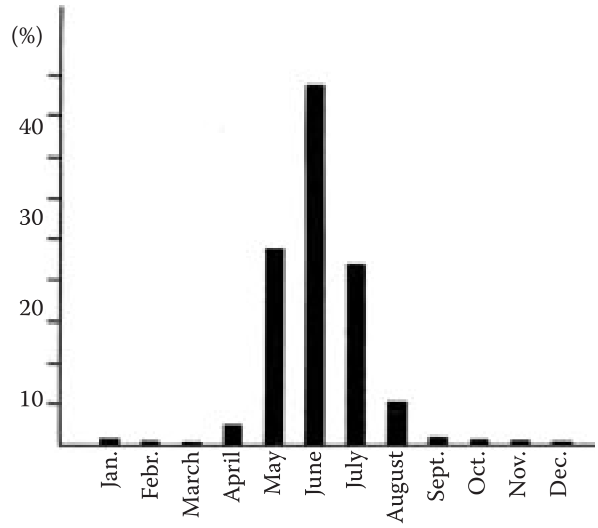

Fig. 3. Frequency of the occurrence of *E. mollis* in particular months (in % of the total number of 1,597 caught imagoes). Laboratory rearing, 2001 to 2004

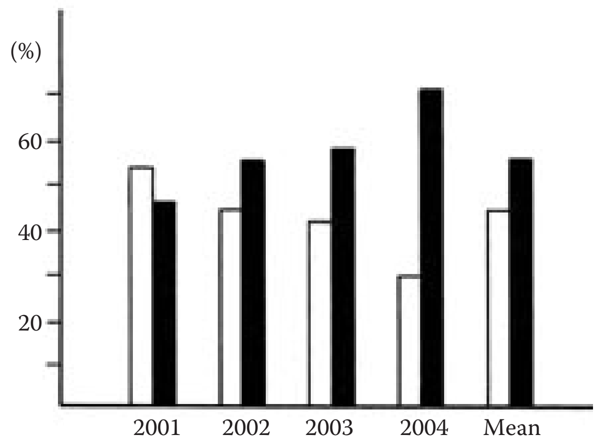

Fig. 4. The percentage proportion of male (light) and female (dark) imagoes of *E. mollis*. Laboratory rearing, 2001 to 2004

The beetles are most active at night or at dusk. During the day, they usually hide from light. At the time of hatching, they do not produce any ticking sounds that are characteristic of some other species of woodworms. In danger, they usually draw up legs and antennae to their body and in the condition of stiffness they wait until the danger disappears.

Copulation and oviposition

Immediately after leaving pupal chambers, the genitalia of beetles are partly or nearly completely developed. Gonads fully mature usually only after the first hours (at the latest within two days) of their life in the open. In more than a half of the newly hatched females, it is possible (through dissection) to find a well-developed corpus adiposum and eggs in various stages of development. On the other hand, Gardiner (1953) reported that genital glands of males and females were always quite developed in the period of emergence. According to the author, the period 6 to 12 days is quite sufficient for the maturation of eggs and sperms of beetles. During the period, newly hatched imagoes occur in pupal chambers.

Soon after leaving pupal chambers, beetles mate in the open. Both beetles with completely developed gonads and sexually maturing beetles participate in the copulation. Gardiner (1953) noticed the copulation usually at night (in the case of warm weather sometimes even during a day) a few of hours (exceptionally within 12 days) after emergence. It occurs usually on host material or also on walls of rooms and rearing vessels, on windows, etc. According to Gardiner (1953), the mating takes about 24 hours, according to Dominik (1958) only several (maximally 20) hours. During the copulation, beetles sometimes hide in fissures of bark, in old emergence holes of *Molorchus minor* (L.), etc. The coupling often remains even in pairs that died in a preserving

Table 4. The average length of the body (including the abdomen rear overlapping wing-cases) in mm/number of measured males and females of *E. mollis* in particular years and in total. Laboratory rearing in photoeclectors was established on 11 June 2001

Locality	Sex	Year				In total
		2001	2002	2003	2004	
Lesná 2	♂♂	(4.0/12)	4.8/12	4.4/107	4.0/47	(4.3/178)
	♀♀	(5.4/1)	5.0/17	4.9/192	4.6/118	(4.8/328)
	in total	(4.1/13)	4.9/29	4.7/299	4.4/165	(4.6/506)
Veveří 2	♂♂	(4.0/7)	–	–	–	(4.0/7)
	♀♀	(4.3/6)	5.2/2	–	–	(4.5/8)
	in total	(4.1/13)	5.2/2	–	–	(4.3/15)
In total	♂♂	(4.0/19)	4.8/12	4.4/107	4.0/47	(4.3/185)
	♀♀	(4.5/7)	5.0/19	4.9/192	4.6/118	(4.8/336)
	in total	(4.1/26)	4.9/31	4.7/299	4.4/165	(4.6/521)

agent in the photoeclector. The same beetles can mate repeatedly and lay eggs in periods between particular copulations.

Females begin to search for suitable places for oviposition immediately after insemination. At the same time, they run on the bark examining its surface by means of their antennae. Optical, mechanical and chemical incentives decide on the choice of actual places for oviposition. Sugars exhibit an important attractive function while esters of fatty acids and volatile oils show a repellent function (Adlung 1957). Females always stop at selected places (mostly around the bases of branches with scaly and rough bark). By means of a far protruded (nearly 2 mm) ovipositor females lay one or two or a few (according to Adlung [1957] maximally 6) eggs under protruding scales or into fissures in bark. The number of eggs in a group increases with the size of fissures and bark thickness (Dominik 1958). Generally, the small number of eggs in groups was also noticed by Gardiner (1953) and Dominik (1958). Toskina (1966) even mentioned that under laboratory conditions, females laid eggs always only individually. With respect to the marked nocturnal activity of beetles oviposition occurs mainly during darkness. It mostly begins already during the first or the second day after leaving pupal chambers and takes about 2 weeks (according to Gardiner [1953] in captivity maximally 9 days). Beetles live in the wild about one month, in laboratory maximally 1 to 2 weeks. Males live usually for a shorter time than females. During their life, they do not take solid food drinking only water. After completing reproduction they die during several days.

Eggs of *E. mollis* are whitish, oval, rounded on one end being somewhat elongated on the other end with a micropyle. Their length ranges from 0.45 to 0.65 mm and width from 0.25 to 0.35 mm. During oviposition, they are often pressed into fissures and their shape is considerably deformed. The chorion of the eggs is slightly sculptured in the form of pentagons or hexagons or flat cells, many of them showing partitions inside (Toskina 1966). This sculpture resembling a honeycomb occurs nearly on the whole surface of eggs. It is most marked on poles with the micropyle, being absent only at the places of contact with bark. The sculpture is so characteristic that according to the texture it is possible to roughly determine *E. mollis.*

The fecundity of females

There are very few reliable data on the fecundity of *E. mollis* females in literature. According to Kemner (1915), a female lays only 10 to 15 eggs and according to Dominik (1958) more than 30 eggs. In laboratory rearings of Gardiner (1953), females laid on average 15 and 26 eggs in 1947 and 1948, respectively. During a single night, the females laid 1 to 25 eggs and many individuals laid eggs only one night. The maximum number of eggs laid by one female was 66. The author assumed that this number could be overcome. Every ovary contains 12 meroistic ovarioles (by 6 in two rows) each of them being able to produce at least 5 eggs. Thus, females can potentially produce at least 120 eggs. Similarly like in a majority of the species of the family Anobiidae, the actual fecundity of females is, however, rather small (Toskina 1966).

Imagoes of *E. mollis* are very variable as for their size (similarly like the majority of cambioxylophagous species of insects). This striking fact was already noticed by Perris (1854) and later e.g. by Tooke (1946), etc. According to the majority of authors, the length of imagoes ranges from 3.5 to 6.5 mm. One of the main objectives of our study was to evaluate in detail both relationships between the size of imagoes and intensity of damage or the age of host samples (from the date of their sampling) and relationships between the size of imagoes and the number of eggs in ovaries. Table 5 and Fig. 5 show

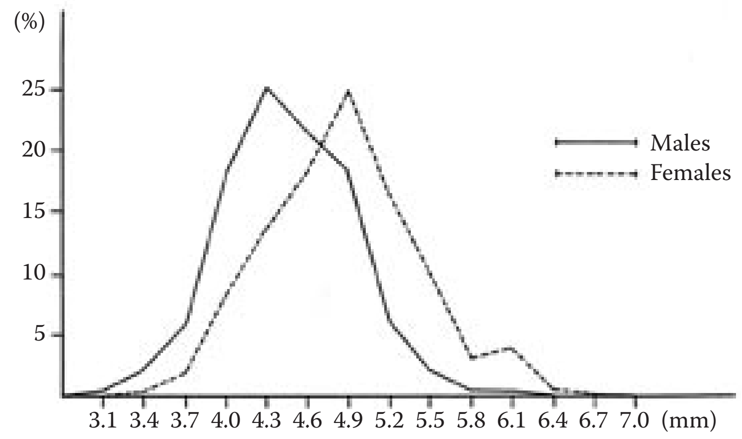

Fig. 5. The percentage proportion of male and female imagoes of *E. mollis* in relation to the total length of the body (mm). Laboratory rearing, 2001 to 2004

Table 5. The number of males/females of *E. mollis* obtained in photoeclectors from European black pine (*P. nigra*) in the course of particular months including the sex ratio. Laboratory rearing was established on 9 June 2000 (from Lesná 2 locality 11 June 2001)

Locality	Month	Year				In total	Mean ♂♂:♀♀
		2001	2002	2003	2004		
Lesná 1	Jan.–May	4/6	13/11	3/3	–	20/20	1:1
	June	5/8	55/76	2/9	–	62/93	1:1.5
	July	24/8	62/79	12/12	–	98/99	1:1
	Aug.	9/10	23/23	8/7	0/1	40/41	1:1
	Sep.–Dec.	4/2	10/5	6/4	–	20/11	1.8:1
	in total	46/34	163/194	31/35	0/1	240/264	1:1.1
Kociánka	Jan.–May	–	2/2	4/4	–	6/6	1:1
	June	1/1	5/14	6/12	–	12/27	1:2.2
	July	8/5	41/38	20/18	–	69/61	1.1:1
	Aug.	8/9	12/20	8/15	–	28/44	1:1.6
	Sep.–Dec.	6/6	6/5	6/8	–	18/19	1:1
	in total	23/21	66/79	44/57	–	133/157	1:1.2
Veveří 1	Jan.–May	1/0	0/1	2/1	–	3/2	1.5:1
	June	2/3	43/76	10/15	–	55/94	1:1.7
	July	27/36	85/100	24/25	–	136/161	1:1.2
	Aug.	37/46	31/36	4/5	1/0	73/87	1:1.2
	Sep.–Dec.	18/9	8/3	4/3	–	30/15	2:1
	in total	85/94	167/216	44/49	1/0	297/357	1:1.2
Černá Pole	Jan.–May	–	–	–	–	–	–
	June	5/2	3/2	9/9	–	17/13	1.3:1
	July	6/3	2/4	21/15	5/11	34/33	1:1
	Aug.	5/2	2/1	6/6	4/5	17/14	1.2:1
	Sep.–Dec.	1/0	–	2/3	0/2	3/5	1:1.7
	in total	17/7	7/7	38/33	9/18	71/65	1.1:1
Lesná 2	Jan.–May	?	–	0/1	0/1	(0/2)	(0:2)
	June	(2/0)	3/5	9/22	2/9	(16/36)	(1:2.3)
	July	1/1	4/8	73/122	26/69	104/200	1:1.9
	Aug.	7/0	2/1	15/32	15/30	39/63	1:1.6
	Sep.–Dec.	2/0	3/3	10/15	4/9	19/27	1:1.4
	in total	(12/1)	12/17	107/192	47/118	(178/328)	(1:1.8)
In total	Jan.–May	(5/6)	15/14	9/7	0/1	(29/30)	(1:1)
	June	(15/14)	109/173	36/67	2/9	(162/263)	(1:1.6)
	July	66/53	194/229	150/192	31/80	441/554	1:1.3
	Aug.	66/67	70/81	41/65	20/36	197/249	1:1.3
	Sep.–Dec.	31/17	27/16	28/33	4/11	90/77	1.2:1
	in total	(183/157)	415/513	264/366	57/137	(919/1,173)	(1:1.3)
Ratio ♂♂:♀♀		(1.2:1)	1:1.2	1:1.4	1:2.4	(1:1.3)	–

that the length of males (including their rear part of the abdomen overlapping wing-cases) amounts to 3.0–6.1 (on average 4.4) mm and the length of females is 3.4–6.7 (on average 4.9) mm. The mean length of females is thus markedly (on average by 0.5 mm, i.e. by 11.4%) larger. In males, the part of the abdomen visible from above overlaps wing-cases on average by 0.36 mm, in females on average by 0.45 mm. At the same time, with the increasing body length the overlapping of the abdomen over wing-cases gradually decreases in individuals of both sexes (Table 6).

Table 6. The occurrence of imagoes of *E. mollis* in photoeclectors during the particular months of 2001 to 2004. Laboratory rearing of the pest on *Pinus nigra* imported on 9 June 2000 from the Brno urban parts Lesná, Kociánka, Veveří, Černá Pole and Žabovřesky and on 11 June 2001 from urban parts Lesná and Veveří

Month	Rearing from 9 June 2000 to 31 December 2004		Rearing from 11 June 2001 to 31 December 2004		In total	
	number of imagoes	(%)	number of imagoes	(%)	number of imagoes	(%)
January	11	0.7	1	0.2	12	0.6
February	7	0.5	–	–	7	0.3
March	2	0.1	–	–	2	0.1
April	3	0.2	1	0.2	4	0.2
May	34	2.1	–	–	34	1.6
June	374	23.4	55	10.5	429	20.2
July	696	43.5	314	60.3	1,010	47.7
August	347	21.8	102	19.7	449	21.2
September	83	5.2	39	7.4	122	5.8
October	18	1.1	8	1.5	26	1.2
November	13	0.8	–	–	13	0.6
December	9	0.6	1	0.2	10	0.5
In total	1,597	100.0	521	100.0	2,118	100.0

Table 7. Average date of the occurrence/number of imagoes of *E. mollis* in photoeclectors in 2001 to 2004. The rearing was established on 9 July 2000

Locality	2001	2002	2003	2004	Mean/in total
Lesná 1	12.7./80	6.7./357	12.7./66	7.8./1	8.7./504
Kociánka	18.8./44	21.7./145	15.7./101	–	23.7./290
Veveří 1	9.8./179	14.7./383	12.7./93	7.8./1	21.7./656
Černá Pole	18.7./24	12.7./14	16.7./71	30.7./27	19.7./136
Žabovřesky	30.7./6	6.8./5	–	–	2.8./11
Mean/in total	2.8./333	12.7./904	14.7./331	31.7./29	17.7./1,597

It is of interest that the average size of imagoes of both sexes significantly decreases (Table 7, Fig. 6) with the increasing intensity of damage and age of the host substrate (from the rearing establishment). The decrease in the size of imagoes is directly proportional to the percentage of damage of cambium in samples from various localities. At the end of 2004, 90% of samples from Brno-Lesná 1 taken on 9 June 2000 were damaged, 70% of samples from Brno-Kociánka, 95% from Brno-Veveří, 69% from Brno-Černá Pole and 5% of samples from Brno-Žabovřesky were damaged. The development of the anobiid in these samples was fully completed at the end of 2004. The total average length of the body (i.e. the body length including the abdomen rear part visible from above) of males amounted to 4.6, 4.4, 4.3 and 4.2 mm in 2001, 2002, 2003 and 2004, respectively. The total average length of the body of females amounted to 5.0, 4.9, 4.7 and 4.4 mm in 2001, 2002, 2003 and 2004, respectively.

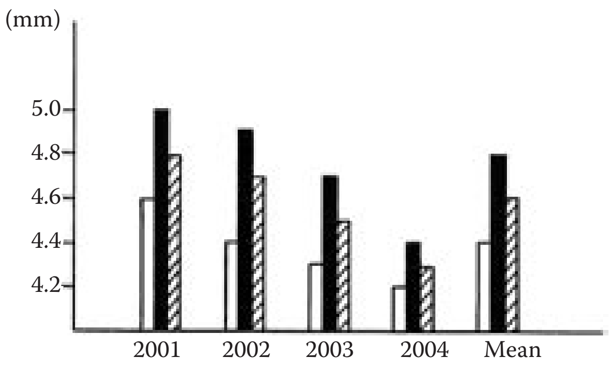

Fig. 6. The average length of the body of male imagoes (light), female imagoes (dark) and individuals of both sexes (dashed) of *E. mollis* (mm). Laboratory rearing, 2001 to 2004

The results of measurements of the body length of males and females obtained by means of photoeclectors in a rearing established on 11 June 2001 are given in Table 8. 50% of samples from Brno-Lesná 2 were attacked at the end of 2004. Larvae of various age and sporadically also pupae occurred in them quite frequently. At the end of 2004, only 1% of

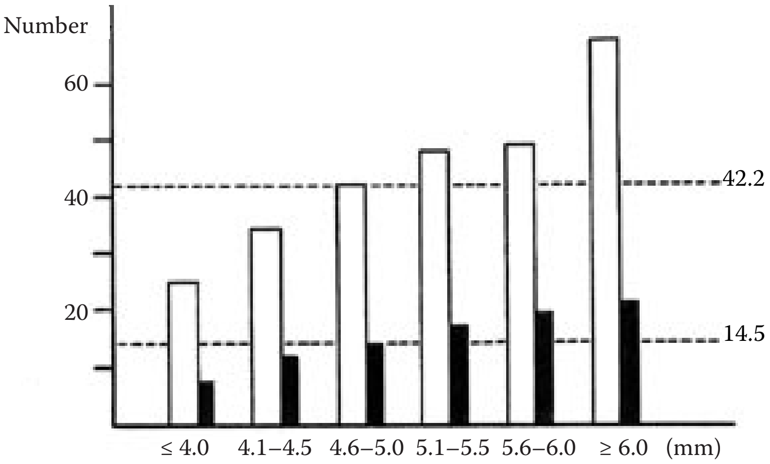

Fig. 7. The number of eggs in ovaries of sexually mature (light) and maturing (dark) females of *E. mollis*. Average numbers of eggs in ovaries are represented by a dashed line. Laboratory rearing, 2001 to 2004

samples from Brno-Veveří 2 was damaged and they did not include any living larvae or pupae of the anobiid. Table 8 shows that beetles hatched in 2001 were smaller than beetles hatched in the following years. This fact can obviously be explained by sampling the beetles from still living parts of pines. In this substrate, larvae of *E. mollis* developed optimally as late as the following year (2002) when they also reached the largest average dimensions.

Through the microscopic dissection of ovaries of 1,186 females of *E. mollis* it was found that in the period of catching well-developed ovaries occurred in less than 36% females (average length 4.9 mm). The majority (58%) of females (of an average length of 4.8 mm) showed little developed ovaries. Only 6% females (of an average length of 4.8 mm) partly or completely laid eggs (Table 9). Thus, the statement of Gardiner (1953) on the complete sexual maturity of females immediately after their flying out from bark does not correspond to reality (see also the chapter Copulation and oviposition). The mean potential fecundity of females with the fully developed genitalia amounted to 42.2 eggs and with the increasing size of females it gradually significantly increased. The smallest females (length 4.0 mm and less) produced on average only 25.0 eggs while the biggest females (length 6.1 mm and more) produced about 68.0 eggs, i.e. 2.7 times more (Table 9, Fig. 7).

The results of dissection of ovaries corroborate that the mean physiological fecundity of females of

Table 8. Average date of the occurrence/number of imagoes of *E. mollis* in photoeclectors in 2001 to 2004. The rearing was established on 11 June 2000

Locality	2001	2002	2003	2004	Mean/in total
Lesná 2	(5.8./13)	28.7./29	21.7./299	21.7./165	(22.7./506)
Veveří 2	(9.7./13)	30.9./2	–	–	(20.7./15)
Mean/in total	(22.7./26)	1.8./31	21.7./299	21.7./299	(22.7./521)

Table 9. Results of the analysis of ovaries of *E. mollis* females in relation to different length of the body (mm). Laboratory observation, 2001 to 2004

Total length ♀♀ (mm)	♀♀ with well-developed ovaries		♀♀ with little developed ovaries		♀♀ partly and completely laid		♀♀ in total	
	number ♀♀	mean number of eggs	number ♀♀	mean number of eggs	number ♀♀	mean number of eggs	number ♀♀	mean number of eggs
≤ 4.0	23	25.0	66	7.8	9	1.3	98	11.2
4.1–4.5	104	33.8	171	12.2	16	5.9	291	19.6
4.6–5.0	137	42.6	242	14.9	19	5.7	398	24.0
5.1–5.5	112	48.6	151	17.3	16	3.5	279	29.1
5.6–6.0	43	48.9	52	19.7	10	1.9	105	30.0
≥ 6.1	7	68.0	6	22.3	2	–	15	40.6
In total	426	42.2	688	14.5	72	4.0	1,186	23.8
%	35.9	–	58.0	–	6.1	–	100.0	–

E. mollis is markedly higher as compared with existing literature data. Only 12.2% females (out of the total number of 426 females with well-developed ovaries) had less than 20 eggs in ovaries before oviposition. In total 40.6, 33.1, 10.3 and 0.7% females had 21 to 40, 41 to 60, 61 to 80 and more than 101 eggs in ovaries, respectively. The highest number of eggs (136) was found in the ovaries of an above-average (6.5 mm long) female caught on 15 June 2003 from a sample coming from Brno-Veveří 1.

In the ovaries of 688 sexually immature females, 0 to 68 (on average 14.5) fully developed eggs occurred. With the increasing size of females the mean number of well-developed eggs in ovaries increased from 7.8 to 22.3 (Table 9, Fig. 7). In the ovaries of 72 laying or already laid females, 0 to 26 (on average 4.0) eggs occurred. It is of interest that 50% of the females laid all their eggs. Thus we can suppose that the actual proportion of totally laid females both in captivity and in the wild is even much higher. Therefore, under laboratory conditions (and undoubtedly in the wild), the average physiological fecundity of *E. mollis* females considerably approaches real fecundity.

Embryonic development

In a laboratory, according to Gardiner (1953) larvae of *E. mollis* hatch from eggs after 10 to 21 (on average after 13.5) days, according to Dominik (1958) after 12 to 14 days. Embryogenesis is affected by temperature and other external factors to a certain extent. However, usual fluctuations of temperature during the growing season do not virtually affect the average time of embryonic development and larvae hatch from the large majority (minimally from 84%) of eggs (Gardiner 1953). On the other hand, embryogenesis under laboratory conditions is differently long at various temperatures. According to Adlung (1957), it takes 11 days at 23°C, 6 days at 31°C and 4 days at 40°C. At 40°C, however, a considerable part of embryos dies.

Inside the egg covering, larvae can move in a limited way. Immediately before the hatching of larvae eggs become more dull. Through egg coverings, larvae bite their way out either on one or on the other egg pole and by means of holes with uneven margins originated in this way the egg larvae can get out.

Post-embryonic development

Through its development, the anobiid *E. mollis* is strictly related to the presence of bark. Therefore, it is rather easy to find and observe the anobiid larvae under bark and in surface layers of wood. In spite of this, the study of their development is difficult mainly due to the unusual size variability of larvae. Metric characteristics of larvae of particular instars (e.g. the width and length of the head) overlap considerably. Thus, it is not possible to use them (without combination with other characteristics) for the reliable determination of the larva instar or for the determination of the total number of instars. The situation is also complicated by the fact that after ecdysis, egg larvae first eat either a part of or the whole exuvia. In worm-holes, the remnants of exuviae occur only sporadically in the form of more sclerotized parts of moulted crania of higher larva instars. Of course, it is not possible to determine dimensions of the head of particular instars or their number according to the remnants of exuviae. Due to these serious reasons the development of larvae is known rather little yet.

An attempt to determine the number of instars on the basis of the length of about 150 crania of *E. mollis* larvae was not successful (Gardiner 1953). The

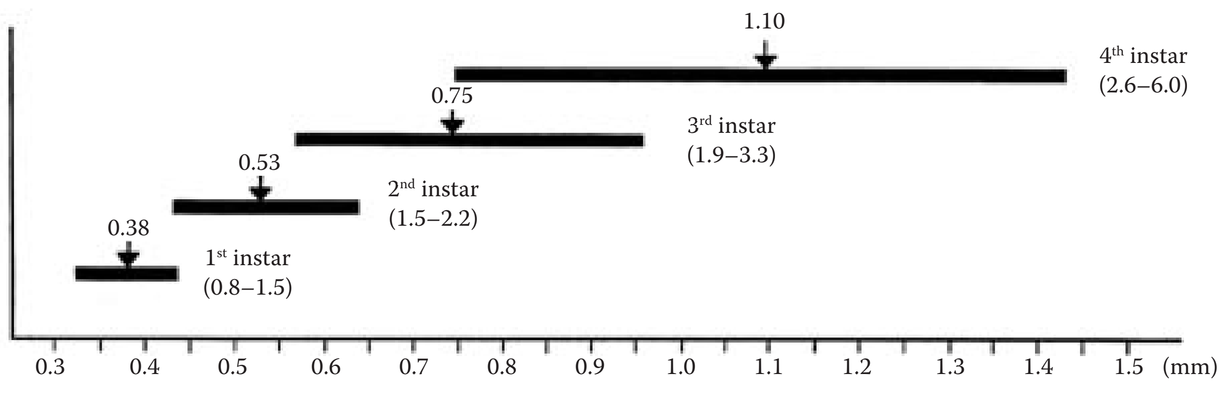

Fig. 8. The width of the cranium of larvae of particular instars of *E. mollis*. Arrows and numbers indicate the average width of the cranium. Numbers in parentheses indicate the minimum and maximum length of the body of larvae in a natural (crescent-shaped) form (all in mm)

Fig. 9. Part of a twig of *Pinus nigra* of the diameter 1 cm damaged by *E. mollis*

Fig. 10. Damage to a branch of *P. nigra* of the diameter about 1.5 cm by larvae of *E. mollis* (after the removal of bark)

author mentioned larvae of the 1st to the 3rd instar, however, the total number of instars was not given. In order to verify a possibility questioned by Gardiner to use the size of the head for dimensional and developmental categorization of larvae the width of the head of 728 larvae of various sizes was measured using micrometry. With the exception of larvae of the 1st and the 2nd instar it was possible to determine the range of head widths of other instars only approximately. At the same time, it was necessary to take into account also widths of several preserved exuviae of heads of larvae of the 3rd instar and heads of larvae of the 4th instar belonging to them. Only then, it was possible to roughly differentiate particular instars of larvae according to the criteria (Fig. 8).

The width of the cranium of newly hatched egg larvae is about 0.37 mm and the length 0.7 to 0.8 mm. Their body is straight with the little enlarged thorax and the larvae are able to move quickly on a pad. Their movement is facilitated by two small slightly protruded conical projections along the sides of the anus. The larvae first consume (partly or completely) egg envelopes which are their first food. Then, they begin to search for suitable places to penetrate into bark. For the purpose, they often use fissures in rough bark (e.g. in the vicinity of knots) and roughness in cross cut bark at ends of wood. Soon after hatching they can begin to make entrance holes. However, the first attempts to penetrate into bark are frequently unsuccessful. Larvae then migrate on the bark for a certain time. According to Gardiner (1953) larvae can migrate on the bark surface to 2 days and at the same time to cover a distance of several centimetres. The larger migration of larvae of the 1st instar as compared to larvae of *Anobium punctatum* (Deg.) was found by Cymorek (1964). According to Milligan (1967), under laboratory conditions larvae can directly penetrate into soft wood of *Knightia excelsa* and successfully develop in it.

Egg larvae penetrate through short more or less radial entrance holes through bark into phloem and cambium. Places of their entrance reveal small hillocks formed by petty brown or black frass of a loaf or disk form and amorphous bore dust. At the border between bark and wood, they begin to eat out predominantly longitudinal holes 0.3–0.5 mm wide. The cross section of the holes is oval. They are filled up with slightly compacted dark bore dust of oval or lenticular shape of the size 0.07 × 0.05 mm. The frass of young larvae eating phloem and cambium is not usually mixed with amorphous bore dust. Very numerous small erect spines heading slightly back-

Fig. 11. Damage to twigs of *P. nigra* of the diameter about 7 mm by larvae of *E. mollis*

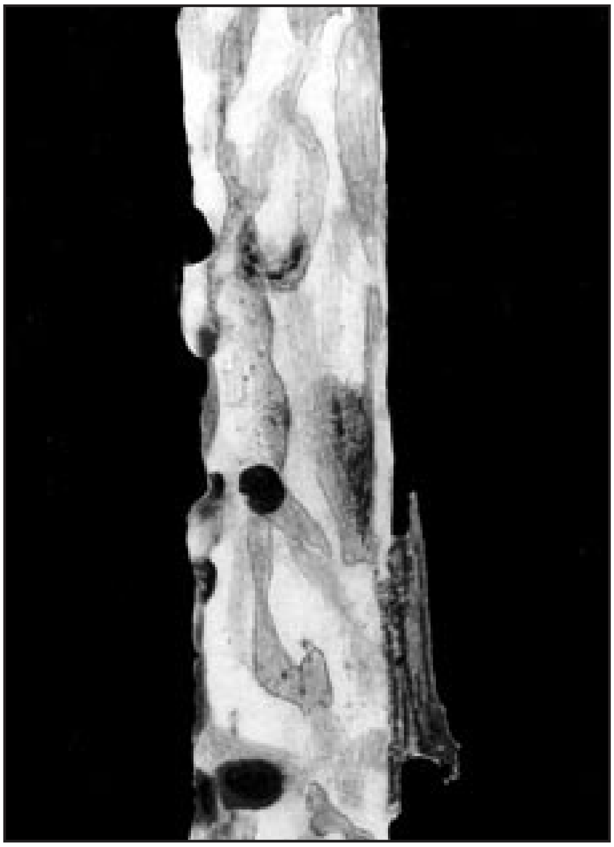

Fig. 12. Damage to a twig of *P. nigra* of the diameter 8 mm by larvae of *E. mollis* (after the removal of bark). Dark oval places depict entrance holes to the wood pith

wards obviously contribute significantly to stabilize larvae during feeding and ensure their limited movement. The spines are localized in narrow transverse stripes on prenotal folds of body segments (before small tubercles protruding above the exoskeleton). These roughening formations on the surface of the larva integument are best created in larvae of higher instars.

The larvae live endophytically for their whole further development. They gradually obtain a characteristic bent (horseshoe-shaped) form and lose the capability of free movement on a pad. After about a weekly feeding in cambium and the adjacent layer of phloem they moult for the first time. Larvae of the 2nd instar feed on the same tissues. The cranium of these larvae is about 0.53 mm wide and their body in natural (horseshoe-shaped) form is 1.5 to 2.2 mm long. They deepen holes 0.4 to 0.9 mm wide. They fill up the holes with frass of lenticular shape of the diameter about 0.25 mm and height 0.14 mm. Usually still during the growing season, larvae of the 2nd instar moult.

Besides phloem and cambium larvae of the 3rd instar (in contrast to larvae of the first two instars) can also consume the inner parts of bark and surface parts of wood. The cranium of these larvae is about 0.75 mm wide and their body is 1.9 to 3.3 mm long. They deepen holes 0.7 to 1.4 mm wide and fill them with a mixture of markedly shaped lenticular frass (diameter about 0.4 mm and height 0.2 mm) and amorphous woody bore dust. The colour of the bore dust is various. While the frass produced by larvae eating in phloem and cambium is dark brown or black, woody frass (similarly like woody bore dust) is whitish or yellow. After the third ecdysis (which occurs in the same year or only after wintering), larvae of the 4th (last) instar occur.

Larvae of the 4th instar deepen holes affecting phloem including the inner layer of bark, cambium and the surface of wood maximally to a depth of 2 mm (Figs. 9 and 10). The holes are very irregular, mostly longitudinal, in some sections even oblique or transverse. Under conditions of intense colonization they create a confused labyrinth of galleries on the surface of wood. In thin branches of the diameter maximally 1 cm, full-grown larvae often penetrate up to the branch pith (Figs. 11 and 12). In branches or stems of a larger diameter, growing up larvae bore sporadically into wood to a depth of 15 mm. These galleries are always of oval cross-section (diameter about 2 mm) being filled up mainly with woody bore

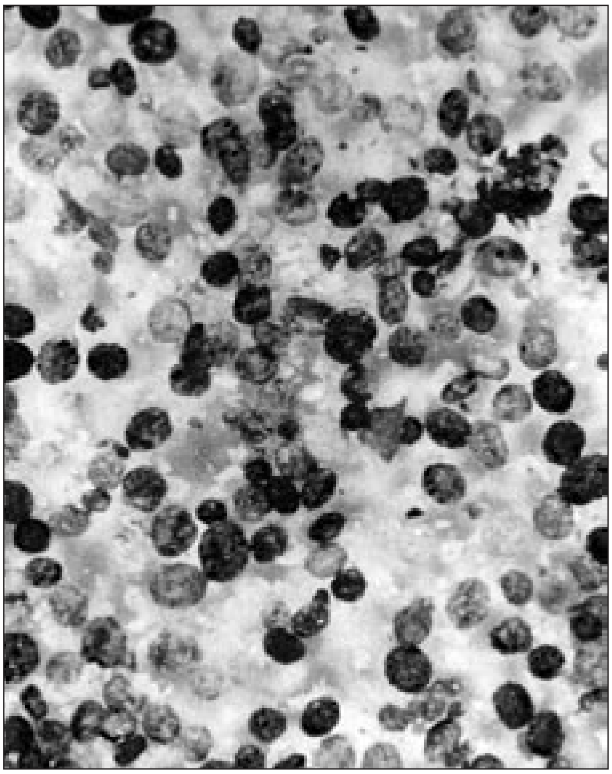

Fig. 13. Dark and light disk-shaped frass and much smaller light amorphous bore dust of full-grown larvae of *E. mollis*

dust and with frass to a lesser extent. They intersect annual rings and usually return to the bark surface. On the other hand, under-bark galleries (i.e. galleries running virtually in parallel with the bark surface on the interface between bark and wood) are always far more abundant. They are filled up with uniform lenticular frass (diameter about 0.57 mm and height 0.3 mm) and small amorphous bore dust (Fig. 13). The average width of the cranium of larvae of this instar is 1.1 mm and the body length (crescent-shaped) 2.6 to 6(7) mm.

In spring of the next year larvae of *E. mollis* grow up. The grown-up larvae produce oval pupal chambers at the end of galleries which are trough-shaped recessed into wood. The pupal chambers are 6 to 8 mm long and 2.5 to 3 mm wide. They are surrounded by a mixture of firmly glued frass and bore dust. In large-diameter wood, pupal chambers are mostly parallel with the wood surface. In thin branches, they are oriented in various directions and in branches up to 1 cm in diameter they are often placed even in pith.

About 1 to 2 days after the creation of pupal chambers, larvae become to pupate. Literature data on the period of pupation are rather scarce and moreover different. According to Gardiner (1953) larvae pupate from May to September. Dominik (1958) found that larvae pupated both in heated and unheated rooms about mid-April. Later pupation (from mid-April) was reported by Dominik and Starzyk (1989). According to our observations (nearly for a period of 5 years), both under natural and laboratory conditions larvae of *E. mollis* pupate from the beginning of May to mid-August. Out of the period (i.e. during winter) pupae occur rather rarely. The very long period (3.5 months) of pupation reflects significantly in the whole future development of the anobiid.

Table 10. Results of the analysis of damage to European black pine (*P. nigra*) by *E. mollis* in 2000 to 2004. The analysis was carried out in November 2004, i.e. after completing the development of the anobiid in photoeclectors. An asterisk indicates the mean area of damaged bark and cambium corresponding to one hatched beetle. The numerator gives values without taking into account (the denominator with taking into account) the mortality of larvae

Characteristics under evaluation		Locality					Mean
		Lesná 1	Kociánka	Veveří 1	Černá Pole	Žabovřesky	
Branches (stems)	number	30	21	52	15	18	27.2
	diameter (mm)	12.0	13.6	8.7	8.1	9.3	10.3
	length (mm)	40	40	40	40	40	40
Total area (cm^2)	bark	4,522	3,580	5,702	1,520	2,108	3,486
	cambium	3,580	2,860	4,270	1,096	1,570	2,675
Damaged area (cm^2)	bark	4,070	2,506	5,417	1,046	110	2,630
	cambium	3,222	2,008	4,057	754	78	2,024
% damage to bark (cambium)		90	70	95	69	5	66
Total number	imagoes	594	295	797	158	15	372
	exit holes	492	242	748	149	15	329
Mean number of imagoes/1 hole		1.2	1.2	1.1	1.1	1.0	1.1
Mean area (cm^2)*	bark	6.9/3.4	8.5/4.2	6.8/3.4	6.7/3.3	7.3/3.6	7.2/3.6
	cambium	5.4/2.7	6.8/3.4	5.1/2.5	4.8/2.4	5.2/2.6	5.5/2.7

The period of pre-pupa and actual pupa takes about 2 weeks, according to Gardiner (1953) 11 to 12 days and according to Dominik (1958) 14 to 16 days. Newly hatched beetles remain 1 to 2 weeks in pupal chambers. During the period, they gradually get proper coat and their exoskeleton becomes hard. At the same time, the beetles partly or nearly completely physiologically mature. Only then, they begin to bite oval or orbiculate emergence holes in paper-thin bark to get out. The diameter of emergence (flight) holes ranges from 1.1 to 2.1 (on average 1.6) mm (Table 10). The size of holes virtually corresponds to the average width of wing-cases at shoulders. The thorax of larvae is on average 1.5 mm wide (i.e. 7% smaller than wing-cases at shoulders). Their cranium is on average only 1.1 mm wide (i.e. 45% smaller than wing-cases at shoulders). Similar sizes of exit holes (from 1.3 to 1.9 [on average 1.7] mm) were given by Cymorek (1964). According to Dominik (1958), the diameter of exit holes is 1.5 to 2.0 mm, according to Gardiner (1953) and Langendorf (1961) about 2 mm, according to Weidner (1953) 2 to 3 mm and according to Koch (1928) allegedly about 3 mm.

Generation conditions

Beetles of *E. mollis* occur in the open from June to September, i.e. for the period of about 4 months. In consequence of the long period of oviposition, larvae of various instars occur, therefore, from autumn to spring often in the immediate proximity beside one another. For example, in an extensive study carried out in November 2004, in addition to one pupa some 728 larvae were found. Larvae of the 1st instar accounted for about 4% of this number, larvae of the 2nd instar for 12%, larvae of the 3rd instar for 29% and larvae of the 4th instar for 55%.

According to the present knowledge, *E. mollis* hibernates nearly exclusively in the stage of larva. A negligible part of the population can survive the winter period also in the stage of pupa or imago (and as a rarity perhaps also eggs). Thus, it refers to a species with the genetically fixed latent potential to diapause in various developmental stages. The potential to enter into an inactive condition in any developmental stage was undoubtedly induced during evolution by periodically repeating changes in living conditions within seasons and particularly by low temperatures during winter. The genetic constitution of insect reflects in its responses to the ambient environment. It affects developmental conditions of insect even when no radical change in the environment occurred (particularly a decrease in air temperature below the limit necessary for ordinary physiological processes). Only on the basis of genetics it is possible to explain the fact that larvae (particularly young) are nearly always in inactive conditions during winter, viz both in the wild and in heated rooms.

Opinions on the generation cycle of *E. mollis* gradually changed with the increasing degree of knowledge. For example, Ratzeburg (1839) mentioned that the development took two years. One-year or two-year development was mentioned e.g. by Langendorf (1961) and predominantly one-year development was reported e.g. by Vité (1952) or Gardiner (1953). The majority of authors (e.g. Escherich 1923; Gäbler 1955; Dominik 1958; Burakowski et al. 1986; Hockey 1987, etc.), however, considers *E. mollis* to be a species with a uniform one-year developmental cycle.

The univoltine development of *E. mollis* has also been corroborated by our 5-year studies. According to our findings, considerable differences in the size of larvae (noticed already by Gardiner [1953] in samples from late summer to spring) are caused particularly by the lengthy period of hatching and swarming of beetles and oviposition. Larvae hatched from eggs laid in various stages of the growing season hibernate in various instars and grow up and pupate after wintering. Young imagoes sexually mature and soon after leaving pupal chambers they reproduce even in the same year. On the other hand, Gardiner (1953) assumed that differences in the size of larvae were caused by irregularities in their growth and thus some of them reputedly required for their development more than one year.

Harmfulness

In the wild, *E. mollis* develops mainly in dead (more rarely dying) conifers of various dimensions. It is very abundant in branches and unbarked drying and air-dried assortments, poorly barked sawntimber, various wooden structures and products. It is a typical cambioxylophagous pest. Its galleries run predominantly in parallel with the bark surface reaching even a diameter of 3 mm. During this feeding the pest damages wood to a depth of maximally 2 mm. Sometimes, full-grown larvae recess transverse bow-shaped galleries of a diameter about 2 mm reaching even 15 mm into wood. In thin shoots (maximally 1 cm in diameter), they often penetrate to pith. Thus, the damage partly resembles feeding marks of *E. nigrinus* Strm. or *E. pini* Strm., the larvae of which develop in the pith of one-year-old wilting shoots of pines.

According to Escherich (1923) etc., galleries of *E. mollis* are strikingly short. According to Dominik

Table 11. Results of the analysis of damage to European black pine (*P. nigra*) by *E. mollis* in 2000 to 2004. The analysis was carried out in November 2004, i.e. in the period when the development of the anobiid from Lesná 2 was not quite completed in photoeclectors. An asterisk indicates the mean area of damaged bark and cambium corresponding to a potentially hatched beetle (in parentheses) or an actually hatched beetle (without parentheses). The numerator gives vales without taking into account (the denominator with taking into account) the mortality of larvae

Characteristics under evaluation		Locality		Mean
		Lesná 2	Veveří 2	
Branches (stems)	number	105	96	100.5
	diameter (mm)	8.3	9.9	9.1
	length (cm)	40	40	40
Total area (cm^2)	bark	10,889	11,945	11,417
	cambium	8,160	9,308	8,734
Damaged area (cm^2)	bark	5,565	119	2,842
	cambium	4,098	87	2,092
% damage to bark (cambium)		50	1	25
Total number	imagoes/larvae	586/122	18/0	302/61
	exit holes	(586)	18	(302)
Mean number of imagoes/1 hole		(1.0)	1.0	(1.0)
Mean area (cm^2)*	bark	(7.9/3.9)	6.6/3.3	(7.3/3.6)
	cambium	(5.8/2.9)	4.9/2.5	(5.4/2.7)

(1958) and Dominik and Starzyk (1989), their total length does not exceed 6 to 7 cm. In contrast to Scolytidae, Buprestidae, Pissodinae and the majority of Cerambycidae, the anobiid can attack the same wood repeatedly for several generations. According to Dominik (1958), it colonizes pine wood for a period of 2 or 3 generations, according to Seybold (2001) even for 6 generations. According to our findings obtained in the laboratory environment, the pest can repeatedly attack the same substrate (*P. nigra*) for a period of even 5 years.

Table 12. The diameter of exit holes of the anobiid *E. mollis*. Laboratory rearing, 2000 to 2004

Diameter of exit holes (mm)	Number of exit holes	(%)
1.1	6	1.0
1.2	20	3.4
1.3	65	10.9
1.4	90	15.1
1.5	95	16.0
1.6	104	17.5
1.7	91	15.3
1.8	64	10.7
1.9	33	5.5
2.0	17	2.9
2.1	10	1.7
In total	595	100.0

Results of the analysis of 5-year repeated damage of sections of branches and stems of *P. nigra* of the diameter 4 to 40 (on average 10.3) mm are given in Tables 11 and 12. One hatched beetle destroyed on average 7.2 cm^2 of bark and 5.5 cm^2 of cambium. Both these values are surprisingly high mainly due to the mortality of larvae of all instars. The mortality of larvae was considerable reaching maximum values in the last year of our study. Under conditions of food shortage, larvae of older instars frequently extended and deepened holes made by larvae of younger instars. The actual average area of bark and cambium damaged by one larva is only a fraction (roughly 1/3) of the values mentioned above. Taking into account the mortality of larvae, the average area of bark damaged by one larva was estimated to be 2.4 cm^2 and the average area of cambium was only 1.8 cm^2.

These values already roughly correspond to rather small average dimensions of holes. It is of great interest that under conditions of more serious damage to bark (cambium) (more than 50%) the number of exit holes was 10 to 20% lower compared to the number of flown out beetles. It means that a smaller part of beetles used exit holes which were previously made by other beetles.

During abundant and repeated colonization, larvae can damage all phloem including inner parts of bark, cambium and surface layers of wood. Galleries are loosely filled with frass and bore dust which easily drop out from exit holes in bark. The proportion of frass and bore dust in the total weight of branches and stems (with quite destroyed subsurface peripheral tissues) decreases with the increasing thickness of damaged substrate. For example, the weight of frass including bore dust amounted to 41.7% of the total weight of damaged samples of *P. nigra* of the diameter about 8.7 cm from the Brno-Veveří 1 locality. More than a half of the loose material dropped out through exit holes and the rest could easily be removed with several light percussions. Bore dust and frass from gallery systems drop out spontaneously by their own weight and due to atmospheric agents, larvae and young beetles.

Larvae of *E. mollis* require a high degree of wilting of host tissues. They can find suitable conditions in twigs, branches and stems of dead standing trees, stem breaks and windfalls in various logging debris, in wood stocked for a longer time, roundwood, fuelwood, etc. The pest often colonizes wood attacked by some bark beetles, etc. (Pfeffer et al. 1954).

In timber yards, the beetle often attacks wood together with long-horned beetles *Molorchus minor* (L.) and *Callidium* spp. (Vité 1952). The abundant common occurrence of larvae of the anobiid with larvae of *M. minor* was found in Brno-Pisárky in 2004. The larvae were detected in dying and dead branches of *Picea pungens* Engelm. and *P. abies* (L.) Karst.

E. mollis very often develops in poorly barked drying and mainly dried up sawn timber, in roof truss structures, beams, boards, planks, furniture, joiner's products, tools, etc. In using panels from attacked poorly barked wood larvae can get into structures. Through exit holes, hatched beetles damage floors, lining of internal walls and ceilings, veneers and other materials on the surface of doors, furniture and other wood products (Trägårdh 1934; Madel 1941; Milligan 1977, etc.). The beetle causes serious damage in museums, depositories and laboratories where it destroys collections of woody species and feeding marks and products from unbarked wood (Nüsslin, Rhumbler 1922; Escherich 1923; Schmidt 1954; Gäbler 1955; Dominik, Starzyk 1989, etc.).

In evaluating the harmfulness of *E. mollis* it is necessary to differentiate. Considering the surface damage to wood many authors (Schwerdtfeger 1944; Langendorf 1961; Becker 1984, etc.) usually do not consider the anobiid to be an economically important species. According to Cymorek (1974) damaged lying wood is, however, ranked among lower quality classes. Its occurrence in fuelwood is frequent (although economically negligible) (Clarke 1932; Seybold 2001). Damage caused in processed wood and mainly in coniferous building timber and wood products is undoubtedly economically important (Schaufuss 1916; Trägårdh 1940, 1947, 1949; Tooke 1946; Butovitsch 1951; Harris 1953; Weidner 1953, 1979; Baker 1964; Bletchley 1967; Dominik 1967; Milligan 1967, 1977; Espanol 1969; Schmidt 1971; Becker 1984; Hockey 1987; Veronese 1995, etc.).

The anobiid *E. mollis* occurs occasionally also in still living woody species. Its development in the pith of wilting twigs of conifers (mainly Scots pine) in the former CSR was reported e.g. by Roubal (1936). Our findings also corroborate possibilities of its development in physiologically weakened spruce trees. On the coast of the Adriatic Sea, the pest significantly participated in the decline of 1 to 2 year-old shoots of *Pinus nigra* (L.) (Diminic et al. 1995). In northern Greece, it was frequently found in 2-year-old cones of *P. brutia* Ten. (Karanikola, Markalas 2001). In France, Roques (1983) noted damage to cones and seeds of *Pseudotsuga taxifolia* (Poir.) Brit and *Sequoiadendron giganteum* (Lind.) J. Buchh. It is also suspected to spread some harmful fungi (e.g. *Fusarium circinatum* Nir. et O'Donn. on *Pinus radiata* D. Don. in California – Nirenberg and O'Donnell in Seybold 2001). These and some other less usual or even rarity finds of *E. mollis* (e.g. in flitches of *Fagus sylvatica* L. – Cymorek 1964) demonstrate its wide ecological potential.

Protection and control

Preventive measures consist in observing hygienic principles in forests and timber yards. The simplest and most effective method of the protection and control of wood is thus its careful barking before further processing and use. It is necessary to bear in mind that even small remainders of bark can be the cause of the pest importation to buildings and various wood products.

If the removal of bark is hardly practicable or undesirable (e.g. in style wainscot), then the wood has to be treated with a suitable preparation with long-term repellent and insecticide effects. The preparations can be applied to wood through paints, spraying and dipping or dry impregnation and pasting. A very good effectiveness in the control of larvae and other developmental stages was observed, according to Dominik (1958), after dipping pine wood into 4% water solution of sodium fluoride (NaF) for 24 hours. Treatment of Douglas fir beams with 0.1% concentration of dieldrin provided sufficient protection (Milligan 1967). At present, there are many preventive and sanitation preparations on the market both for the surface and deep impregnation of wood in interiors and exteriors.

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Výskyt, vývoj a škodlivost červotoče hnědého (*Ernobius mollis* [L.]) (Coleoptera: Anobiidae)

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ABSTRAKT: Práce shrnuje výsledky studia výskytu, vývoje a škodlivosti *Ernobius mollis* (Linnaeus, 1758), který se v ČR hojně objevil v roce 2000 na *Pinus nigra* Arn. oslabené suchem. Vychází z laboratorních chovů ve fotoeklektorech a z četných analýz větví (kmínků) borovic z pěti lokalit v Brně. Dílčí šetření byla vykonána na pěti dalších lokalitách na Moravě a ve východních Čechách. Dospělci se v laboratorních podmínkách objevovali hlavně v červnu až srpnu, a to v poměru 1 ♂: 3♀♀. Samečci byli dlouzí průměrně 4,4 mm, samičky 4,9 mm. Na dosud živých dřevinách se vyvíjeli dospělci podprůměrných velikostí. Na mrtvých dřevinách průměrná délka samečků a samiček s nárůstem poškození během jednotlivých let postupně klesala. Bezprostředně po vylíhnutí byly gonády dospělců většinou jen částečně vyvinuté. Samičky pohlavně dozrávaly během prvních hodin (maximálně během dvou dnů) života na volnosti a v ovariích měly 14 až 136 (průměrně 42,2) vajíček. Se stoupající velikostí samiček plodnost průkazně stoupala. Vývoj larev probíhal přes čtyři instary. Jedna dorostlá larva zničila přibližně 1,8 cm^2 kambia. Dřevo bylo poškozováno do hloubky 2 mm, pomístně až do hloubky 15 mm. Dospělci dřevo opouštěli výletovými otvory v kůře o průměru 1,1 až 2,1 (průměrně 1,6) mm. Vývoj byl univoltinní. Škůdce poškozoval stejné dřevo opakovaně po dobu pěti let.

Klíčová slova: Anobiidae; *Ernobius mollis*; *Pinus nigra*; výskyt; vývoj; škodlivost

V roce 2000 bylo v mladých sídlištních výsadbách a jinde na Brněnsku a dalších místech v ČR zaznamenáno chřadnutí a odumírání borovice černé (*Pinus nigra* Arn.). Prvotní hlavní příčinou poškození bylo akutní sucho v kombinaci s nadprůměrnými teplotami a výsušnými větry na jaře 2000. Hynutí oslabených borovic urychlovaly různé druhy hub a hmyzích kambioxylofágních škůdců včetně červotoče hnědého (*Ernobius mollis* [L.]).

Práce je věnována pětiletému studiu výskytu, biologie a škodlivosti *E. mollis* v desetiletých až dvacetiletých výsadbách *P. nigra* v brněnských městských částech Lesná, Veveří, Černá Pole a Žabovřesky a v padesátiletém porostu v Brně-Kociánce. V červnu 2000 byly z těchto lokalit odebrány větve (případně kmínky) k analýzám aktuálního výskytu a vývojového stavu červotoče a k jeho laboratorním chovům ve fotoeklektorech. Ty byly kontrolovány jednou týdně od 9. června 2000 do 30. listopadu 2004. Obdobné šetření bylo vykonáno v červnu 2001 na vzorcích z Brna-Lesné a Brna-Veveří. Dílčí průzkum byl uskutečněn na dalších pěti lokalitách na Moravě a ve východních Čechách. U dospělců byl mj. zjišťován výskyt, pohlaví, velikost a počet vajíček v ovariích. U larev byla mj. měřena šířka crania (případně šířka zachovalých exuvií hlav), délka těla a plocha kůry a kambia zničená jednou larvou s ukončeným vývojem.

Hlavní dosažené výsledky:

1. Hostitelskými dřevinami *E. mollis* jsou různé druhy borovic a jiných jehličnanů (kromě jedle). Jeho larvy byly nalezeny v roce 2004 v Brně-Pisárkách také v odumírajících a odumřelých větvích smrku pichlavého (*Picea pungens* Engelm.).
2. V běžných laboratorních podmínkách se dospělci objevovali na volnosti hlavně v červnu (20 %), v červenci (48 %) a v srpnu (21 %). V září se vylíhlo 6 % (a v ostatních měsících roku celkem 5 %) dospělců. Samečci se líhli ve stejnou dobu jako samičky, a to v poměru 1 : 3. Podíl samiček ve fotoeklektorech postupně vzrůstal od 1,2 : 1 (2001) až k 1 : 2,4 (2004).
3. Samečci byli dlouzí 3,0 až 6,1 (průměrně 4,4) mm, samičky 3,4 až 6,7 (průměrně 4,9) mm. Se vzrůstajícím poškozením a dobou umístění dřeva ve fotoeklektorech klesala průměrná délka samečků od 4,6 mm (2001) do 4,2 mm (2004) a samiček od 5,0 mm (2001) do 4,4 mm (2004). Největších průměrných velikostí tedy dosahovaly larvy vyvíjející se v mrtvém dřevě, a to v prvním roce po úhynu dřevin. Tato závislost

nebyla prokázána u subpopulací červotoče vyvíjejících se v dosud živých dřevinách, v nichž dospělci dosahovali výrazně podprůměrných velikostí.

4. Bezprostředně po vylíhnutí byly gonády dospělců většinou jen částečně vyvinuté a plně dozrávaly až během prvních hodin (nejpozději během dvou dnů) života na volnosti. Brzy po výletu z kuklových kolébek se imaga pářila a oplodněné samičky ihned vyhledávaly vhodná místa ke kladení vajíček. Titíž jedinci se mohou pářit opakovaně. V přírodě žijí asi měsíc, v laboratoři nejdéle jeden až dva týdny. Vajíčka jsou bělavá, oválná, průměrně 0,55 mm dlouhá a 0,30 mm široká. Podle charakteristické skulptury chorionu, připomínající včelí plástev, lze druh orientačně determinovat.
5. Celkem 36 % odchycených samiček mělo ovaria dobře vyvinuta, 58 % málo vyvinuta a 6 % samiček bylo částečně nebo zcela vykladeno. Pohlavně zralé samičky měly v ovariích 14 až 136 (průměrně 42) vajíček. S velikostí samiček plodnost průkazně vzrůstala. Nejmenší samičky (pod 4 mm) vyprodukovaly průměrně 25 vajíček, největší samičky 68 vajíček (tj. 2,7krát více). Fyziologická plodnost se značně blížila plodnosti reálné.
6. Kombinací šířky crania 728 larev a 15 zachovaných exuvií hlav vyšších instarů bylo zjištěno, že *E. mollis* se vyvíjí přes čtyři instary. Přesnější rozpětí šířek hlavových schránek jednotlivých instarů larev je však možné v důsledku velkých překryvů stanovit jen přibližně. Navíc larvy po svlečení obvykle zkonzumují své exuvie, takže je nelze využít ke spolehlivému určení instaru.
7. Larvy 1. instaru mají cranium široké kolem 0,38 mm a tělo dlouhé kolem 0,75 mm. Vyžírají chodby v lýku a kambiu o šířce 0,3 až 0,5 mm a vyplňují je čočkovitými až bochánkovitými trusinkami o průměru kolem 0,07 a výšce 0,05 mm. Larvy 2. instaru mají cranium široké kolem 0,53 mm a tělo v přirozeném (podkovovitém) tvaru dlouhé kolem 1,8 mm. Hloubí chodby v lýku a kambiu o šířce 0,4 až 0,9 mm a vyplňují je pouze čočkovitými trusinkami o průměru kolem 0,25 mm a výšce 0,14 mm. Larvy 3. instaru mají cranium široké kolem 0,75 mm a tělo dlouhé kolem 2,6 mm. Hloubí chodby v lýku, kambiu a povrchové vrstvě dřeva o šířce 0,7 až 1,4 mm. Vyplňují je směsí čočkovitých trusinek (o průměru kolem 0,4 mm a výšce 0,2 mm) a amorfních drtinek. Larvy 4. instaru mají cranium široké kolem 1,1 mm a délku (v přirozeném tvaru) kolem 4,5 mm. Hloubí podkorní chodby o šířce až 3 mm, postihující lýko včetně vnitřní vrstvy kůry, kambium a dřevo do hloubky až 2 mm. Vzrostlé larvy často zhotovují chodby o průměru kolem 2 mm, které sahají až 15 mm do dřeva nebo na tenkých větvích (o průměru do 1 cm) až do dřeně.
8. Dorostlé larvy se kuklí od začátku května do poloviny srpna a asi za dva týdny se líhnou dospělci. Ti po jednom až dvou týdnech vyzrávání opouštějí dřevo výletovými otvory v kůře o průměru 1,1 až 2,1 (průměrně 1,6) mm.
9. *E. mollis* má jednotný univoltinní vývoj. V důsledku rozvláčného rojení a kladení vajíček zimují larvy v různých (převážně vyšších) instarech, výjimečně také kukly a raritně snad i dospělci.
10. Škůdce může opakovaně zamořovat tentýž substrát po dobu až pěti let. Larvy hlodají poměrně krátké (maximálně 7cm) chodby a zničí kolem 2,4 cm^2 kůry (tj. 1,8 cm^2 kambia). Škody působené na větvích a kmenech souší, na zlomech, vývratech, kulatině a palivu jsou málo významné. Mnohem více poškozuje prosychající a proschlé řezivo, krovy a nejrůznější výrobky ze špatně odkorněného dřeva. Citelné škody působí brouci, kteří při cestě na volnost svými výletovými otvory poškozují obložení stěn, odýhovaný nábytek, domácí nářadí, muzeální, výukové a laboratorní sbírky dřevin, požerků aj.
11. *E. mollis* je svým vývojem přísně vázán na kůru. Nejjednodušším a nejúčinnějším způsobem ochrany a obrany je proto důsledné odkornění dřeva před jeho dalším zpracováním.

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