

2. Beschädigungen der Oocytenkerne und Vakuolisierung des Oocytenplasmas.
3. Unregelmäßige Verteilung der Dotterschollen bei der Eireifung.
4. Störung des Eiablagemechanismus und lytische Zersetzung der reifen Oocyten innerhalb des behandelten Tieres. In exponierten Entwicklungsstadien wird die Weiterentwicklung zur Imago und die Weiterentwicklung des Genitalapparates zum funktionstüchtigen reproduktiven System wohl verzögert, aber nicht verhindert. Die Schäden, die sich nach der Imaginalhäutung im Genitalapparat zeigen, sind dieselben wie die in exponierten Adulten.

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Megastigmus suspectus Borries, 1895 (Hymenoptera, Torymidae), its morphology, biology and economic significance

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With 17 figures

Abstract

The stages of development, biology and economic significance of *Megastigmus suspectus* Borr., a pest insect of seeds of fir-trees (*Abies alba* Mill.) are presented in this paper. The insects in question were bred in the years 1976–1977 from seeds and disintegrated cones of *Abies alba*, originating from forest inspectorates: Krynica and Piwniczna in Poland.

1 Introduction

Megastigmus suspectus Borr. (Hymenoptera, Torymidae) (fig. 1a, b) is a pest insect in the seeds of *Abies alba* Mill. (= *A. pectinata* Dc.), *A. nordmanniana* Spach (SORAUER 1953; BOUČEK 1970) and others *Abies* spp. (LESSMANN 1962) also of *Cedrus atlantica* Manetti (BOUČEK 1970). According to BOUČEK (1970) revision of this species its synonyms are *Megastigmus piceae* Seitner, 1916 and *M. bornmülleriana* Hussey, 1957. Despite the fact of its being known for a long time and mostly considered as the one infesting the seeds of fir-trees, there are gaps in its morphology and biology. Relatively many data refer to the imago stage (BORRIES 1895; SEITNER 1916; HOFFMEYER 1929, 1931; ESCHERICH 1939, 1942; NIKOLSKAJA 1952; KAPUŚCIŃSKI 1966; BOUČEK 1970). Information concerning the biology and harmful activities of this species is reported, among others, by KOZIKOWSKI, KUNTZE 1936; ESCHERICH 1942; SORAUER 1953; GÄBLER 1954; GYÖRFI 1956; NIKOLSKAJA 1956; KAPUŚCIŃSKI 1966.

The aim of this work was to present information concerning the stages of development, the biology and economic significance of *Megastigmus suspectus* Borr.

2 Methods of investigation

Laboratory and field studies were conducted in the years 1976–1977. The material under study comprised the samples from *Abies alba* cones and seeds originating from 9 localities of southern Poland, Forest Inspectorates Krynica (Forest: Kopciowa, Mochnaczka) and Piwniczna (Forest: Wierchomla, Lomnica, Roztoka Mała). In the autumn and winter periods the studied material was exposed to external weather conditions to be transported to the laboratory in the spring. Individual (1 seed in the test tube) and mass cultures were grown in bottling jars and Petri dishes. Similar cultures were made from disintegrating cones. Analysis of seed infestation by the pest insect was made using the technique of cutting 300 seeds from each locality (TYSZKIEWICZ 1952). From the imagines thus obtained preparations were made which after being labelled, served as a collection.

With a view to observe developmental stages of *M. suspectus* every few days some seeds were opened and the larvae were taken to the test tubes where the emergence of semipupa, pupa or pupa coloration could be observed.

In order to observe the morphology of *M. suspectus* preparations from different parts of imagines were made in alcohol and Canada balsam. Figures were made with the use of an eyepiece PZO, microscope PZO ML5 and microscope MBS1 made in the USSR.

3 Developmental stages of *Megastigmus suspectus*

3.1 The egg

A ripe egg extracted from the ovary and prepared is of a white colour. It is composed of a short appendix (83 μ), of a central elliptical part (215.8 μ long and 91.3 μ in the widest place) and of an elongated posterior part (1743 μ) (fig. 2). The outline of this egg resembles the outline of an eggs of *Megastigmus laricis* Marcov. (MARCOVITCH 1914), *M. spermotrophus* Wachtl (HUSSEY 1955) and *M. pictus* (Först.) (SKRZYPczyńska 1973).

3.2 The larva

Fully grown larva of *M. suspectus* has an arch-shaped body, white in colour with the distinguishing themselves bowels darker in colour. It is composed of the head and 13 segments (fig. 3). The body bears delicate bristles arranged in several rows, facilitating the locomotion of the larva, within the seed. Head (caput), placed orthognathically is the widest in the facial part, then gradually narrows. On the forehead there are four bristles and two segmented antennae. In the anterior part of the head capsule can be seen mouth parts. They are of orthopteroidal type and are composed of labrum, labium, maxillae and mandibulae. In the latter can be distinguished the fundamental bone rectangular and oval in shape and a triangular tooth-bearing one (fig. 4). In the apical part tooth and four lateral teeth can be seen. The colour of the mandibles in the fundamental part is yellowish-brown while the rest, which is strongly sclerotised, is dark brown. The other elements of the mouth part are comparatively weakly sclerotised what renders them less conspicuous. Laterally the larva body bears 10 pairs of stigmata, localized on the segments 2 to 11, forming a peripneustic system.

A fully grown larva prior to pupation is 4.75 mm long, 1.55 mm wide, its cephalic part being 0.55 mm wide (mean values).

3.3 The semipupa and the pupa

In the semipupa stage (fig. 5) of the species under study the first four segments are rather visibly augmented and between the fourth and fifth segments a narrowing is formed, more pronounced on the dorsal side. The semipupa is 4.5 mm long and 1.3 mm wide (mean values). It is of a milk-white colour.

Pupa (fig. 15a) is of a free type (pupa libera). In the pupa the rudimentary wings reach as far as the third abdominal segment partly covering the median and hind pairs of extremities. In female pupa an ovipositor is visible which is dorsally bent and slightly longer than the body length. The body of the pupa is 4.1 mm long and 1.0 mm wide (mean values). The colour of the unpigmented pupa is milk-white.

3.4 The imago

Megastigmus suspectus was generally described by BORRIES in 1895. According to him female body length is 3.5–6 mm and the ovipositor is 4–6 mm. The body length of the female imagines obtained in our culture was from 3.75 mm to 5.1 mm (average 4.5 mm) and the ovipositor is 4.25 mm to 5.6 mm (average 5.09 mm). The body of imago is black with a yellowish pattern. The top of the female head is black, the rest of it being yellowish-brown. Its thorax is black, abdomen yellowish brown and apically black, antennae brown, limbs brownish-yellow; anterior and median coxa at their basis black, the posterior ones brownish.

As has been pointed out, earlier literature almost completely lacks morphological descriptions of *M. suspectus* except those referring to the diagnostic traits of this insect. That is why you will find below the descriptions and figures of its body parts.

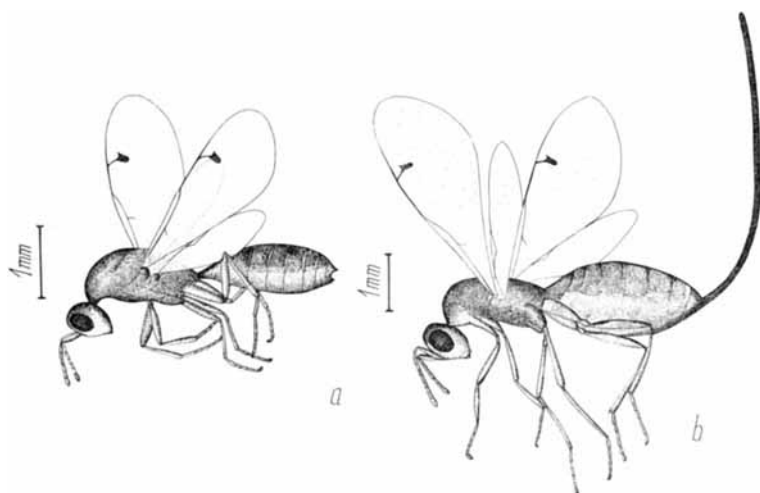


Fig. 1. *Megastigmus suspectus* Borr. a – male, b – female (orig.)

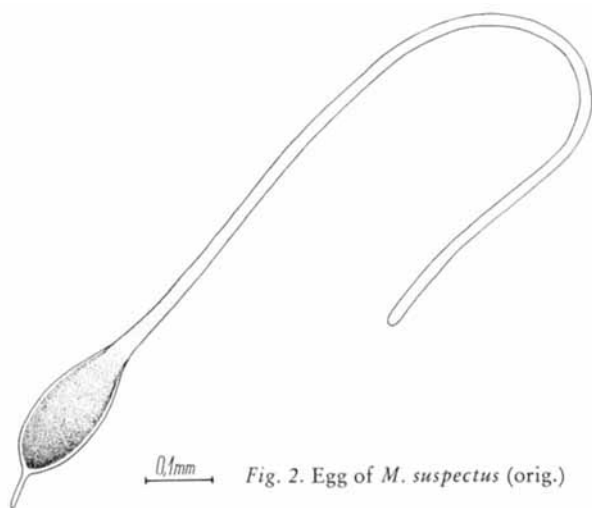


Fig. 2. Egg of *M. suspectus* (orig.)

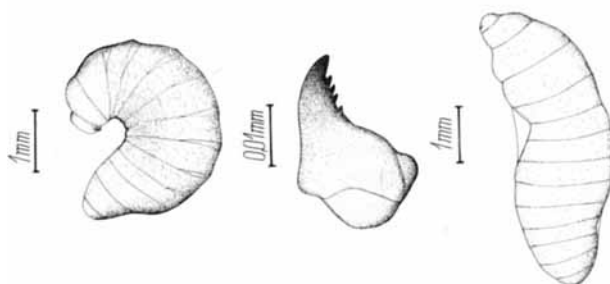


Fig. 3 (left). Fully grown larva with distinguishing themselves bowels (orig.). – Fig. 4 (center). Left mandibula of fully grown larva seen from above (orig.). – Fig. 5 (right). Semipupa (orig.)

Head (caput) (fig. 6) is perpendicular to the body axis, rounded, anteriorly convex and slightly sunken posteriorly. It bears black hairs, apically are situated 3 ocelli forming an isosceles triangle. In the section between the median ocellum and basis of antennae are visible two antennal furrows (scrobs antennalis). Laterally are situated relatively large oval eyes highly vaulted. Eleven-segmented antennae (fig. 7a, b) are attached almost in the middle of head length between the eyes. The antenna in the female bears a radícula slightly wider than its length, the scapus in its basal part being about twice as wide as in the apical one. Pedicellus, by means of its widened end is connected with anelli which is almost as wide as its length. The segments of flagellum are almost cylindrical but extensible. The final portion of the flagellum bears an egg-shaped clava composed of 3 parts, the last one being the smallest.

In the front part of the head are located mouth parts of orthopteroid type. Close to the peristom one can see the clypeus with an arch-curved anterior margin. Below the clypeus is situated the labrum (fig. 8) with its anterior part being developed into two triangular teeth. On either side of the clypeus and labrum are to be found the mandibles (fig. 9) whose outline is in the shape of a wide wedge. In the arch-shaped incisor are set two teeth. Apically from either tooth ramify the stripes which gradually enlarge toward the basal part of the mandible. The mandible is set in the capsule by means of two articulated heads situated in its basal part. The coloring of mandibles is dark brown due to a strong sclerotisation.

Beneath the mandibles are situated paired maxillae (fig. 10) which consist of a comparatively small anchor (cardo), elongate stipes, four-segmented palpus maxillaris, lobus externus and lobus internus. The lower lip (labium) (fig. 11) is located on the bottom part of the head between the mandibles. It consists of the submentum, the elongate, oval mentum terminated with a clypeiform ligula and paired three-segmented palpus labialis. The mouth parts are covered with bristles and hairs constituting the endings of the sense of taste.

Thorax is arch-shaped with a highly developed mesonotum. The abdominal structure of *M. suspectus* is like that of other *Megastigmus* species (KAPUŚCINKI 1946).

The thorax in its dorsal part bears the wings (alae) (fig. 12) which are transparent and covered with numerous hairs. The ratio of the anterior wing length to its width is 11:4. The proportions of vein lengths between the veins: subcosta, marginalis, postmarginalis and radius are 49:20:24:5 respectively. From the marginal vein goes off the radius at an angle of 70° , ended up with the pterostigma. The pterostigma, a very important taxonomic feature of the species, is of different outline in females and males of *M. suspectus* (fig. 13a, b). In the female pterostigma the length/width ratio is 4:1. In the apical part of the pterostigma are situated four sensilla placodea. The coloring of the pterostigma is brown with some darkened membranous area round it. The hind wing venation consists of one vein reaching almost as far as the $3/5$ of its length. Both the front and hind wings bear a very specific device being responsible for coupling them on each side and making them function as one.

The thorax on its ventral side bears 3 pairs of legs (pedes) (fig. 14) consisting of a basal coxa, trochanter, femur, tibia and tarsus ended up with unguiculi. The limbs of each pair vary in shape, size, colour and distribution

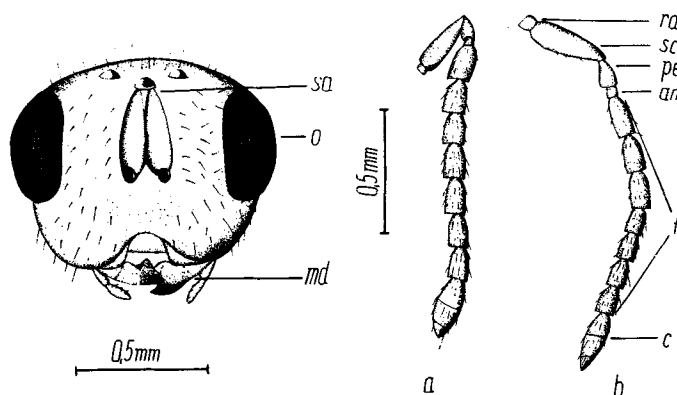


Fig. 6 (left). Caput of the female seen from front. md – mandibulae, o – oculi, sa – crobs antennalis (orig.). – Fig. 7 (right). Antenna. a – male, b – female, an – anelli, c – clava, f – flagellum, pe – pedicellus, ra – radícula, sc – scapus (orig.)



Fig. 8 (left). Labrum of the female seen from front (orig.). – Fig. 9 (right). Left mandibula. of the female, seen from above (orig.)

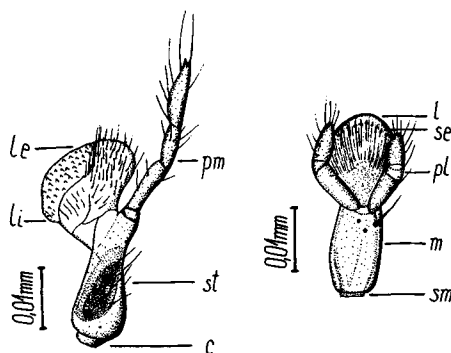


Fig. 10 (left). Maxilla of the female seen from below. c – cardo, le – lobus externus, li – lobus internus, pm – palpus maxillaris, st – stipes (orig.). – Fig. 11 (right). Labium of the female seen from below. l – ligula, m – mentum, pl – palpus labialis, se – sensilla trichodea, sm – submentum (orig.)

of sense organs. The structure of *M. suspectus* limbs is like that of other *Megastigmus* spp. (KAPUŠKIŃSKI 1946).

The abdominal structure differs between the sexes. In the female it is egg-shaped, eight-segmented, glossy and covered with hairs. Its final part

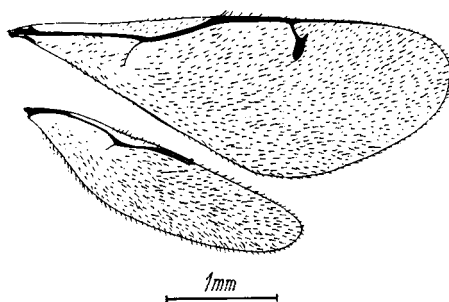


Fig. 12. Female ala antica and postica seen from above (orig.)

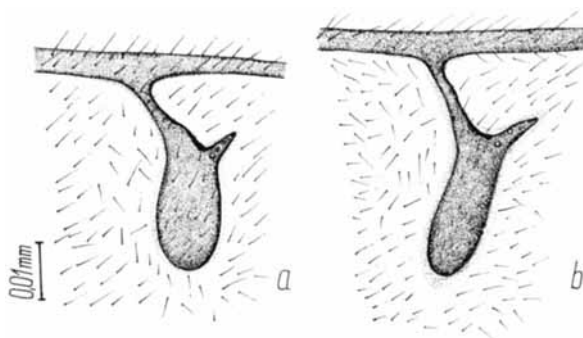


Fig. 13. Pterostigma seen from above, a – male, b – female (orig.)

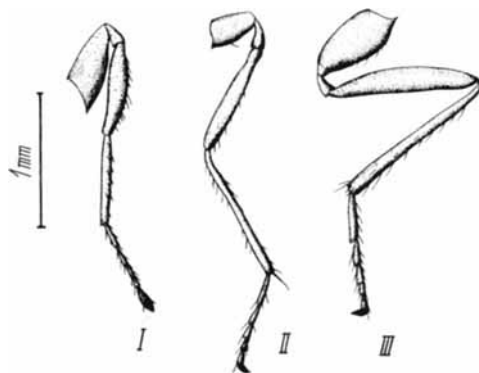


Fig. 14. Left legs of the female. I – pes anterior, II – pes medius, III – pes posterior (orig.)

bears the ovipositor sheaths (valvulae aculei) pointed obliquely. The ovipositor consists of valvulae aculei and two piercing parts (spiculae) situated in the position safeguarding mutual mobility.

The structural features of male *Megastigmus suspectus* are similar to those of the female. The body length is 3.5 mm to 3.65 mm. The male head in its occipital part is black, the rest of it being yellowish-brown. Thorax

almost completely black, abdomen dorsally black, the rest being yellowish-brown. The coloring of male limbs and antennae like in females. For the antenna see fig. 7a. On the forewing similarly to the female is to be found the pterostigma, the wing length/width ratio 16:7 (fig. 13a).

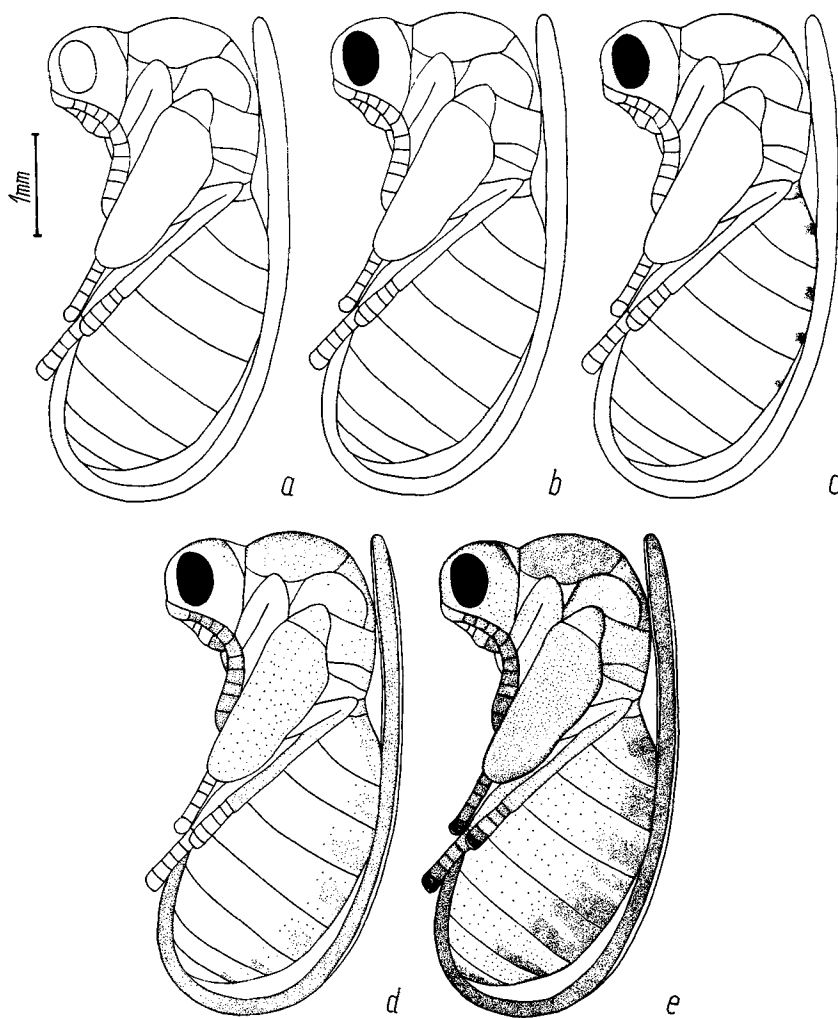


Fig. 15. The stages of coloration of the female pupa. — a depigmented pupa, b first stage, c second stage, d third stage, e fourth stage (orig.)

Abdomen elongate, fusiform, connected with the thorax by means of the petiolus which is longer than in the females. The male abdomen is seven-segmented, the last two of them being narrower than the rest. The final segment has an indentation whose posterior margin bears the styloid processes (cerci).

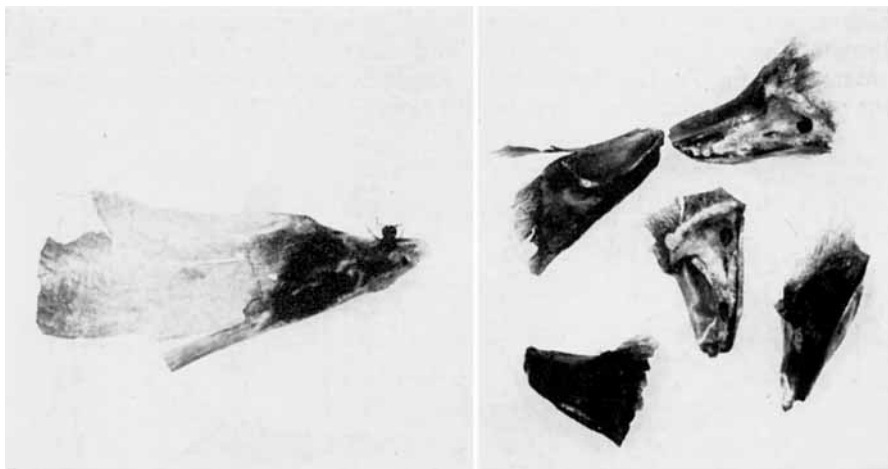


Fig. 16 (left). Imago of *Megastigmus suspectus* Borr. emerging from the seed of *Abies alba* Mill. (Photo: W. Zabecki). – Fig. 17 (right). Seeds of *Abies alba* Mill. with exit hole of female *Megastigmus suspectus* Borr. Magnified about $1.5\times$. (Photo: W. Zabecki)

4 Biology of *Megastigmus suspectus*

4.1 Imago stage

In laboratory conditions, imagines began to appear in spring, usually on the 14th day, counting from the date when the raising was started. Imagines emerged from the culture of disintegrated cones or from the seeds recently harvested. Cone and seed samples before being used for laboratory studies had been exposed to external weather conditions. The hatching period lasted for almost a month. In the species under study males are rare. A total of individuals obtained from the culture was 192 ♀♀ and 3 ♂♂. It should be pointed out that exclusively female, 441 individuals were obtained by LESSMANN (1974).

Imago before flying out of the seed, bores and eats away a spherical exit hole with ragged edges (fig. 17). Its diameter amounts to about 1 mm.

The insect finds its way out of the seed through a prepared opening pushing forward its head, than a part of its thorax with the first pair of limbs (fig. 16) what is followed by an attempt to free the rest of its body out of the seed, all the time being attached to the seed surface with its forelimbs. After leaving the seed the insect cleans with its legs at first the wings and next antennae and other body parts. Imagines lived for 3–9 days in the laboratory, whether they received food (sugar syrup, apple) or not.

Mention should be made that a decrease in air humidity has an adverse effect on the number of imagines causing their mortality inside the seeds or in the moment of getting free off them.

Studies conducted on 10 ovaries of female *Megastigmus suspectus* have shown that the female is able to lay 32–60 eggs (average 42 eggs). Similar results were obtained by HUSSEY (1955) for *M. spermotrophus* Wachtl and SKRZYPCZYŃSKA (1973) for *M. pictus* (Först.).

4.2 Larval stage

The seeds infested by the larvae, at first appearance do not differ from the sound ones, only their shell, knocks under to pressure. The larva consumes gradually the embryo and endosperm of a seed so that before the next spring comes all the content of the seed is eaten out, what results in a large larval cell. Its bottom part contains a dry bowl-like mass of larva excrement of brown coloring. The seed coat, which is intact by the insect serves as a natural areola for the future development stages of the insect.

4.3 Semipupal and pupal stages

Megastigmus suspectus semipupae were taken out of the cut seeds of *Abies alba* coming from the cones which had been collected in the Forest Inspectorate Krynica. The caput of the semipupa is directed towards the top of the seed. The pupa in the cell adopts the same position. From the cut seeds only the female pupae were obtained. The female pupae were depigmented (fig. 15a) or were found to be in various stages of coloration.

In the coloration process of the pupa four stages can be distinguished (fig. 15b-e). Stage I.: 6 days after the pupation it is to be noticed in the eyes. Stage II.: 10 days following the pupation the coloring extends to the thorax and abdomen. Stage III: 12 days after the pupation the pigmentation appears in the limbs, wings, antennae and that of thorax and abdomen becomes more intensive. Stage IV.: 15 days following the pupation, the head, thorax and partly the abdomen are black, the antennae and wings grey the limbs yellowish-grey and the ovipositor is of pitch-dark coloring. On this very day the imago appears.

As proved by numerous laboratory cultures, the complete developmental cycle of *Megastigmus suspectus* amounts to 1 year, but it must be noted that larvae can remain in seeds for a period of 2 years at least.

5 Economic significance

The analysis of *Abies alba* seeds by cutting 300 seeds from every locality (together 2700 seeds), showed 2–20% (average 5.83%) of seeds infested by the larvae of *Megastigmus suspectus*. LAIDLAW (1931) reports on the damage caused by *M. suspectus* to the Scottish fir-trees amounting to 17% and according to SCHIMITSCHEK (1935) 63% of fir seeds was infested by *M. suspectus*. Damage caused by this insect is more serious due to the fact that seed abundance in *Abies alba* occurs every 3–5 years and their germinating capacity is on an average 40% (TYSZKIEWICZ 1952). Based on our studies, in the seed samples coming from the last crop and analysed in the next march there were 36–77% (average 47%) of barren seeds.

Megastigmus suspectus occurs in Poland in many localities with fir-trees (KOZIKOWSKI, KUNTZE 1936; KAPUŚCIŃSKI 1966).

As concerns pest control methods *Megastigmus suspectus* can be destroyed in a similar way to that used against various insects of *Megastigmus* spp. (SORAUER 1953; KEEN 1958; SCHNAIDER 1970).

6 Results and conclusions

1. 3 ♂♂ and 192 ♀♀ of *Megastigmus suspectus* obtained from the cultures confirm the view that males of this species are scarce.
2. More consideration should be given to *M. suspectus* because of considerable damage done by this insect to *Abies alba* in particular that the seed abundance in species fall every 3–5 years and occasionally occurs a considerable percentage of barren seeds.
3. The fact that not a single parasite was obtained from the cultures could indicate a slight environmental resistance to pest insect.
4. Further studies on *M. suspectus* parasites are indicated.
5. The most effective method of *M. suspectus* pest control seems to be with the use of higher temperature on its larvae during their diapause in the seeds.

Zusammenfassung

Megastigmus suspectus Borries, 1895 (Hymenoptera, Torymidae), seine Entwicklungsstadien, Biologie und wirtschaftliche Bedeutung

Vorliegende Arbeit enthält die Ergebnisse der Untersuchungen über *Megastigmus suspectus* Borr. (Hymenoptera, Torymidae), einem schädlichen Insekt der Samen der Tanne (*Abies alba* Mill.).

Die Entwicklungsstadien von *M. suspectus* werden beschrieben und die Lücken in seiner Morphologie und Biologie ergänzt. *M. suspectus* hat eine Generation im Jahr.

Der Verlust an Samen betrug 2 bis 20 % (durchschnittlich 5,8 %). Die Zucht aus Samen ergab 3 ♂♂ und 192 ♀♀. Dies bestätigt die bisherige Erfahrung, daß Männchen von *M. suspectus* selten sind. Die Imagines wurden zwischen 1976 und 1977 aus den Samen und den zerfallenden Zapfen von Tannen (*Abies alba* Mill.) aus den Oberförstereien Krynica und Piwniczna (9 Bestände) in Polen gezogen.

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The fecundity and the fertility of *Spodoptera litura* (Fabr.) in relation to photoperiod

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Abstract

The fecundity and fertility of *S. litura* in relation to photoperiod of 100 foot candle light for 8, 12 and 24 hours duration per 24 hours was studied by exposing the newly emerged pairs during its normal adult life of about a week. For control newly emerged pairs were kept in complete darkness throughout the life. Maximum fecundity was observed under 12 hours per 24 hours in the light intensity of 100 foot candle. However, 24 hours exposure to light markedly reduced both fecundity and fertility. In the dark condition hatching percentage of the eggs was the highest.

1 Introduction

Among insects, photoperiods affect the fecundity and the fertility in *Bruchus obtectus* (MENUSAN 1934), *Dacus tryoni* (BROWNE 1956), *Acrosternum hi-*