BIOLOGY, DEVELOPMENT AND LARVAL CHARACTERS OF *OXYPORUS MAJOR* (COLEOPTERA: STAPHYLINIDAE)[1]

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ABSTRACT: Known aspects of the life history and habits of *Oxyporus major* are described, based on material collected in the field and reared in the laboratory. Adults inhabit mature basidiocarps of a variety of fungi, including *Stropharia hardii, Lepiota acutaesquamosa*, and *Armillaria* spp. Two cases of oviposition and larval development in *S. hardii* are described. Development of *O. major* is very rapid, with progression from eggs or early larval instars to adults in 13-15 days at 21-23° C. Female protection of oviposition sites is suggested by field observations. The mature larva of *O. major* is described and illustrated.

Species of *Oxyporus* are known to be obligate inhabitants of higher fleshy mushrooms (Ashe 1984, Leschen and Allen 1988, Hanley and Goodrich 1994a, 1994b). The immatures of only six of the 14 species of *Oxyporus* known to occur in North America have been described (Paulian 1941; McCabe and Teale 1981; Leschen and Allen 1988; Hanley and Goodrich 1994a). The purpose of this paper is to describe the larva of a seventh, *Oxyporus major* Gravenhorst, and to describe known aspects of its life history and habits.

Adult *O. major* are large and black, with one or two distinct, ivory-colored longitudinal vittae on each elytron (see Campbell [1969] and Hanley and Goodrich [1994b] for complete diagnostic descriptions). Adults have been collected from Vermont and New Hampshire south to South Carolina and Georgia, and west to Missouri and Arkansas (Hanley and Goodrich 1994b). The larvae of *O. major* are undescribed and adults have not been reared from a host fungus until now.

METHODS

On 31 July 1994, one of us (MAG) collected one male and two female *O. major* on three widely separated basidiocarps of *Stropharia hardii* Atkinson in Baber Woods Nature Preserve, 4 miles SSE of Kansas, Edgar County, Illinois. Each adult was found in a tunnel (Fig. 14) in the host basidiocarp. The basidiocarps were visually inspected in the field at the time of collection, and a few hours later under a dissecting microscope in the laboratory, but no eggs or lar-

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vae were observed. However, this inspection was carefully performed to avoid damage to the tunnels produced by the beetles and to provide the best chance of development of any offspring that might be present, thus eggs and/or first larval instars could easily have been overlooked.

As the presence of eggs and/or first larval instars was suspected, two of the host basidiocarps (those found with adult females inside) were placed in a rearing chamber made from a 1.1 kg coffee can with a substrate of loose potting soil with a depth of 7.5 cm. A perforated plastic lid served as a cover to retain moisture, while permitting exchange of gases with the atmosphere. The third basidiocarp was preserved until the identity of the host fungus was confirmed.

Twenty-eight to 30 hours after collection, the basidiocarps in the rearing chamber were reexamined. Two large, mature larvae of *Oxyporus* were found. One of these was removed and preserved by killing in boiling water and preservation in 80% ethanol; the other was returned to the rearing chamber with the two basidiocarps. No other larvae were observed at this time, although it should be noted that a non-destructive examination of the basidiocarps was again performed, thus early larval instars could have been missed. The basidiocarps were returned to the rearing chamber and maintained in the laboratory at 21-23°C, with the chamber examined daily for emergence of adult beetles.

After five-six days, the basidiocarps were reduced to a remnant of their original structure. Any larvae present earlier would have had to complete development and crawl into the soil to pupate by this time. On 12 August, 13 days after collection of the specimen, one fully pigmented and sclerotized adult *O. major* was found in the rearing chamber. On 13 August, 13 additional fully pigmented and sclerotized adults of *O. major* were collected in the rearing chamber. The chamber was checked daily for two weeks with no additional emergence of specimens. At this point the soil in the chamber was removed and carefully examined. No additional larvae, pupae, or adult specimens were found.

The chaetotaxy used in the description of the mature larva of *O. major* is based on the system used by Hanley and Goodrich (1994a) in the description of the larvae of *O. stygicus* Say.

RESULTS AND DISCUSSION

Description of mature larva of *Oxyporus major* Gravenhorst.

Length 3.5 mm. Body elongate, gently curved, parallel-sided, slightly flattened dorsoventrally. Color white with thoracic and abdominal terga brown; head dark yellow to brown. Vestiture length variable, setae simple.

Head. Cylindrical to oval; ecdysial lines distinct, lateral arms fork-shaped, complete from back of head to bases of antennae; six pigmented stemmata in two vertical rows on each side (Fig. 1); setal arrangement as in Figs. 1 and 2. Antenna 3-segmented and inserted anterodorsally near stemmata in membranous socket; segment I elongate, asetose, length 4 times width; segment II trisetose, 0.6 times length of segment I, bearing tubercle-like sensory appendage with distinct basal collar, a single, narrow, conical sensory appendage also present; antennomere III 0.5 times length of segment II, bearing inner circle of 3 small, subequal setae at apex, surrounded by outer circle of 3 longer setae (Fig. 3). Labrum fused to frons with anterior margin serrate; chaetotaxy with labral marginal and labral lateral rows of 2 setae each, labral dorsal row of 1 seta (Fig. 4). Adoral surface of labrum (epipharynx) with numerous branched microtrichia and a large median furrow. Mandibles broad, flat, bifid apically, stout basally; margins finely serrate with many fine teeth, lateral margin with 2 small setae, prostheca absent (Fig. 5). Maxilla with cardo triangular, fused to stipes and mala, with 1 small seta; mala short, stout, trilobed, inner lobe with 2 non-articulated spines, middle lobe with 1 non-articulated spine, outer lobe with 1 non-articulated and 2 articulated spines dorsally (Fig. 6). Maxillary palpus 3-segmented; segment I asetose, about as long as wide; segment II bisetose, length 1.2 times length of segment III; segment III conical, asetose, minute sensory structure at apex (Fig. 6). Labium with diamond-shaped submentum and trapezoidal mentum, ligula absent; labial palpus 2-segmented, directed ventrally; segment I 0.6 times length of segment II; segment II elongate and conical with 3 very minute setae at apex; palpigers fused to form ventral premental sclerite bearing 3 pairs of setae, no campaniform sensillae present (Fig. 7).

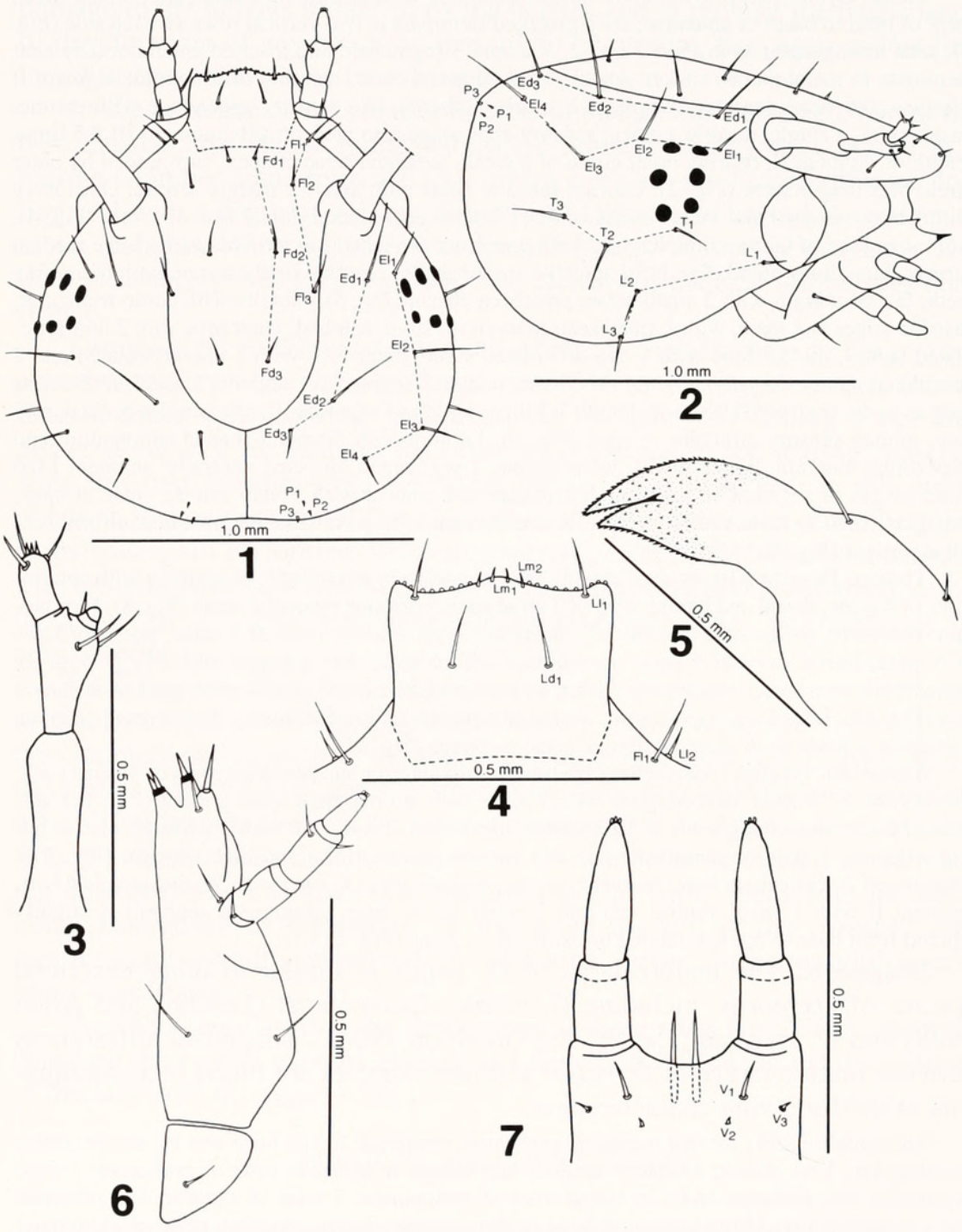
Thorax. Pronotum transverse, broadly oval, moderately sclerotized; chaetotaxy with anterior rows of 4 setae, discal and lateral rows of 3 setae each, posterior rows of 8 setae (Fig. 8). Mesonotum transverse, moderately sclerotized; chaetotaxy with anterior rows of 7 setae, posterior rows of 6 setae, lateral rows of 5 setae, membranes with 4 setae (M_2 grouped with M_{3-4}) (Fig. 9). Metanotum transverse; chaetotaxy similar to mesonotum, except only 4 setae present in lateral row (Fig. 10). Legs long, each similar in size and configuration; chaetotaxy with 9 setae on coxa, 6 setae on trochanter, 5 setae on tibia, 2 setae on tarsus (Fig. 11).

Abdomen. Tergum I transverse, chaetotaxy with anterior and posterior rows of 4 setae each, lateral rows of 3 setae, laterotergites with 3 setae each, no marginal setae present (Fig. 12); tergites and sternites of segments II-VIII similar in setation. Tergite IX with 3 pairs of setae at lateral margins, 1 pair of marginal setae and minute campaniform sensillae on disc (Fig. 13). Urogomphi 2-segmented; basal segments arising from tergum IX, each with 5 setae on apical half; segment II with 1 small ventral seta and 2 small apical setae. Abdominal segment X slightly tapered from base to apex, setation consisting of 12 setae (Fig. 13).

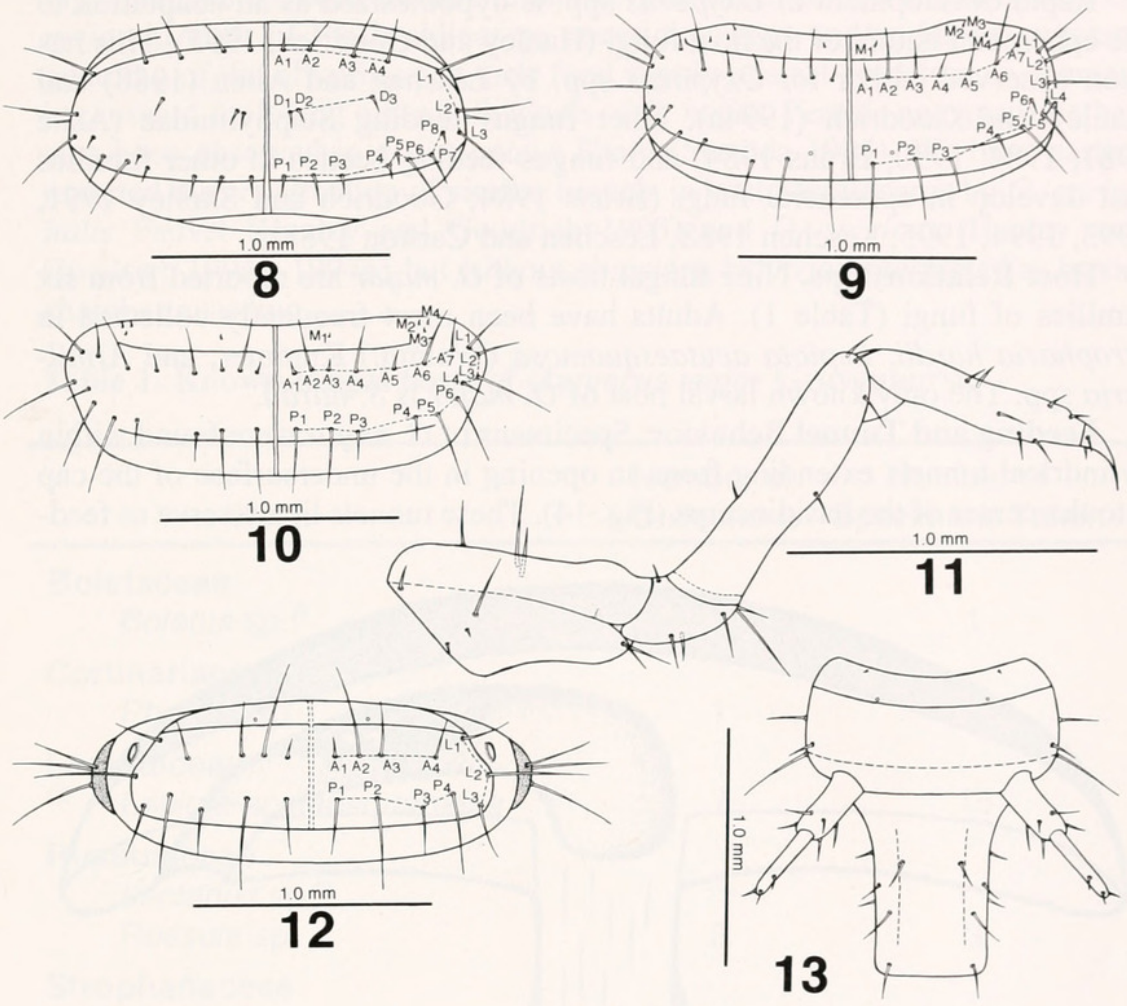
Diagnosis. The mature larva of *O. major* is similar to other described species of *Oxyporus,* including *O. vittatus* Gravenhorst (Leschen and Allen 1988) and *O. stygicus* (Hanley and Goodrich 1994a). Diagnostic differences between mature larvae of *O. major* and these species are found in a combination of the following characteristics:

Epicranial seta El_1 located medial to uppermost stemmata; lateral head seta L_4 absent; labral marginal seta Lm_3 absent; 4 setae in anterior and 8 setae in posterior rows of pronotum; 7 setae in anterior, 6 in posterior and 5 in lateral rows of mesonotum; 7 setae in anterior, 6 in posterior and 4 in lateral rows of metanotum; 4 setae in anterior rows and no marginal setae on abdominal tergum I.

Development. We have reported the rapid development of larvae in *O. stygicus* (Hanley and Goodrich 1994a). In *O. stygicus* the developmental time



Figs. 1-7. *Oxyporus major* Gravenhorst, mature larva. 1. head, dorsal view. 2. head, lateral view. 3. antenna, ventral view. 4. labrum, dorsal view. 5. mandible, dorsal view. 6. maxilla, dorsal view. 7. labium, ventral view. Abbreviations: Ed, epicranial dorsal row setae; El, epicranial lateral row setae; Fd, frontal dorsal row setae; Fl, frontal lateral row setae; L, lateral row setae; Ll, labral lateral setae; Lm, labral marginal setae; P. posterior epicranial setae; T. temporal row setae; V, ventral setae.



Figs. 8-13. *Oxyporus major* Gravenhorst, mature larva. 8. dorsal aspect of thorax, pronotum. 9. mesonotum. 10. metanotum. 11. prothoracic leg, anterior view. 12. abdominal tergum I. 13. abdominal terga IX-X. Abbreviations: A, anterior row setae; D, discal row setae; L, lateral row setae; M, membrane setae; P. posterior row setae.

from egg to adult was 16-18 days, with 7-10 days spent as pupae. In *O. major*, development is even more rapid, with fully pigmented and sclerotized adults emerging 12-13 days after collection of the basidiocarps of the host fungus. At most, the original samples contained eggs or early larval instars. The adult that emerged on 12 August must have been the single larva large enough to be visible on 1 August; the other 13 adults emerging on 13 August were still too small to be detected on 1 August, but clearly were still able to complete larval development and enter the soil to pupate by 5 August. Based on these observations, and our study of *O. stygicus*, we estimate total development time from egg to adult of *O. major* to be 13-15 days.

Rapid development of *Oxyporus* spp. is hypothesized as an adaptation to the ephemeral nature of the host fungi (Hanley and Goodrich, 1995). This has been observed earlier for *Oxyporus* spp. by Leschen and Allen (1988) and Hanley and Goodrich (1994a), other fungus feeding Staphylinidae (Ashe 1981, 1984, 1990; Bruns 1984) and fungus-feeding beetles in other families that develop in ephemeral fungi (Bruns 1984; Goodrich and Skelley 1991, 1993, 1994, 1995; Leschen 1988; Leschen and Carlton 1988).

Host Relationships. Nine fungal hosts of *O. major* are reported from six families of fungi (Table 1). Adults have been most frequently collected in *Stropharia hardii, Lepiota acutaesquamosa* (Weinm.) Kummer, and *Armillaria* spp. The only known larval host of *O. major* is *S. hardii.*

Feeding and Tunnel Behavior. Specimens of *O. major* were found within cylindrical tunnels extending from an opening in the undersurface of the cap into the center of the basidiocarps (Fig. 14). These tunnels likely serve as feed-

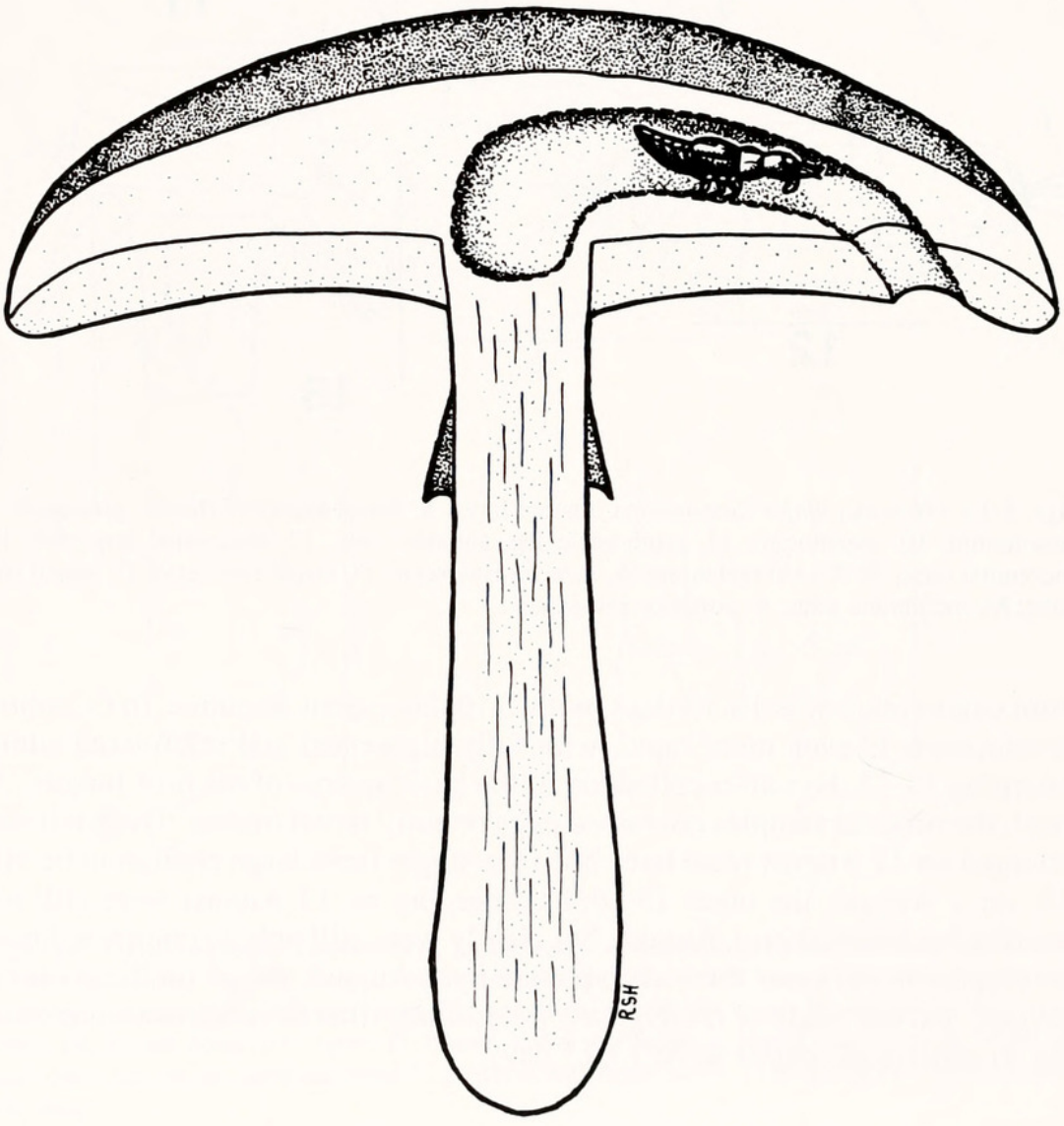


Fig. 14. Tunnel constructed by adult *Oxyporus major* Gravenhorst within host fungus, *Stropharia hardii* Atkinson.

ing chambers for both adults and larvae. The presence of a single female *O. major* in each of the basidiocarps containing eggs and/or larvae suggests guarding of the offspring and their food supply against predators or competing insects, including other individuals of *O. major*. Female egg guarding has also been observed in *O. japonicus* Sharp (Setsuda 1994). We have earlier reported the construction of similar tunnels in host basidiocarps by *O. occipitalis* Fauvel (Hanley and Goodrich 1993) and *O. stygicus* (Hanley and Goodrich 1994a; 1994b), but without observing behavior interpreted as brood chamber guarding.

Table 1. Known fungal hosts of *Oxyporus major* Gravenhorst.

Host	Number of Collections	Number of Specimens Taken
Boletaceae		
Boletus sp.[a]	1	1
Cortinariaceae		
Pholiota sp.	1	1
Lepiotaceae		
Lepiota acutaesquamosa	7	15
Russulaceae		
Lactarius sp.[b]	---	---
Russula sp.	3	3
Strophariaceae		
Stropharia hardii	13	33*
Tricholomataceae		
Armillaria gallica (Marxüller and Romagnesi)	2	2
Armillaria mellea (Vahl: Fr.) Kummer	1	1
Armillaria tabescens (Scop.: Fr.) Emel.	1	1

[a] Reported by Newton (1984).

[b] Reported by Campbell (1969) (no collection records given).

* Includes both adults and larvae.

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