J. Fac. Agr. Hokkaido Univ., Vol. 65, Pt. 3 : 239~273 (1992)

SEM OBSERVATIONS ON GROWING CONDITIONS OF THE FUNGI IN THE GALLERIES OF SEVERAL AMBROSIA BEETLES (Coleoptera: Scolytidae and Platypodidae)

Toshio NAKASHIMA*, Tetuya OTOMO, Yasuko OWADA*** and Toshihiko IIZUKA**
Department of Agricultural Biology, Faculty of Agriculture,
Hokkaido University. Sapporo, 060 Japan.
(Received October 18, 1991)

INTRODUCTION

Ambrosia beetles cultivate symbiotic fungi in their galleries and feed on the fungi. Many authors have listed the fungi isolated from the galleries and adult beetles, and the conventional methods to identify the fungi have usually been used on the cultivated samples. Therefore, owing to the polymorphic phenomena of the fungi and the artificial culture media which might be more suitable for contaminant than for the symbiotic fungi, there may be a possibility of misjudging other fungi to be the true symbiotic ones.

In the present study, in order to eliminate these problems, the fungi growing in the galleries were directly observed with a scanning electron microscope as a preliminary step to relaible identification.

MATERIALS AND METHODS

Pinholed beech logs (*Fagus crenata*) were collected from beech forests at the Hiyama Forest Experiment Station of Hokkaido University. In order to observe the fungi growing in the galleries of ambrosia beetles, the galleries were aseptically cut from the logs and the exposed walls of the galleries were fixed by 2% CsO_4 vapor, then coated with carbon and gold. Observations were made with a scanning electron microscope. To confirm the species of the beetle which made the gallery under observation, only the galleries containing adult beetles were adopted.

---

* Emeritus Professor of Hokkaido University.
** Ministry of Agriculture and Fishery.
*** Nisho-iwai Co. Ltd.

RESULTS

Family Scolytidae

I. Genus *Xyleborus*

In the present stuly six species were observed. The galleries of these species are of the communal room (or tunnel) type (Table 1), the mother beetle, larvae and pupae living together in the same room or tunnel.

Table 1. Types of galleries.

Beetles observed		Parent's sex taking care of brood	Type of gallery		Place of gallery
SCOLYTIDAE	*Xyleborus seriatus*	♀	Communal	Room(s)	under bark
	X. attenuatus				in sapwood
	X. germanus				
	X. saxeseny				
	X. ishidai			Tunnels	
	X. validus				
	Trypodendron signatus	♀&♂	Individual larval cradles		
	Scolytoplatypus shogun				
	S. daimio				
	S. mikado				
	S. tycon				
PLATYPODIDAE	*Platypus severini*		Larval stage……Communal tunnels Pupal stage……Individual Pupal cradles		in sapwood and heartwood
	Crossotarsus niponicus				

1. *Xyleborus seriatus* Blandford

The boring behavior of this species is very similar to that of bark beetles, producing communal galleries under bark. Only *X. seriatus* out of the six species taken up in this paper bores its room in this manner.

In the present study, 5 samples were observed in late July. Only 2-4 new female adults were contained in the galleries which were about 1mm in width and 20mm in length.

Plate 1 shows the fungi growing on the wall of the gallery nearest to the entrance. Many oval or sausage-shaped fungi (1-2μm×2-4μm, Plate 1:1a)) were growing on the sticky material painted in the wall. Innermost of the room, wood tissue was exposed at some parts and the sticky material was found to be less than on the part nearest the entrance. The oval fungi were rare and several long club-shaped mycelia were forming bundles(Plate 1:1b) and 1c)).

2. *Xyleborus attenuatus* Blandford

The gallery belongs to the communal room type. In the present study, observations were made in late June, early and mid-July, and early December.

In late June, the gallery consisted of a mother tunnel (about 20-50mm in length, with a mother beetle and several larvae) and an egg cradle (about 4mm in depth, with about 10 eggs). At the part adjacent to the entrance of the mother tunnel, a mass of fungi, dark in color, were observed. At the innermost part of the tunnel, the wall was covered with sticky material less dark in color. The round ambrosial cells on the sticky material were big in size (3-7μm) at the part adjacent to the entrance (Plate 2:2a), 2b), medium-sized at the middle part (Plate 2:2c), 2d) and small (1-4μm) at the deep part (Plate 2:2e), 2f)). In the egg cradle, the wall was light in color. Sticky material and fungi were not so clear and broken wood tissue was exposed (Plate 3:3a)).

In mid-July, the gallery had been widened into a communal room. Several larvae, pupae and new adults co-existed in the communal room. Well-grown fungi were producing ambrosial cells (2-6μm in diameter) forming monilioid chains (Plate 3:3b), 3c)).

In December, nearest the entrance, there was only broken wood tissue (Plate 3:3d), 3e)). In the deepest part of the gallery, only mycelia and no ambrosial cells were found (Plate 3:3f)).

3. *Xyleborus germanus* Blandford

The gallery of this beetle is of the communal room type[12]. The mother beetle deposits about 30-40 eggs in a mother tunnel. Later, the tunnel is widened into a communal room. The size of this room is about 10mm in length, 5mm in height, and 2mm in width. Plate 4 shows the galleries with eggs, larvae, pupae or new adults.

In the present study, galleries were observed in mid-May, early July, and at the end of July.

In mid-May, about 10 hibernated female adults were found in the gallery. The wall was dark gray in coler and few mycelia and conidia were growing (Plate 5:5a), 5b), 5c)).

Early July was the best breeding season for the larvae and fungi. In the main part of the galleries, well-grown ambrosial cells forming monilioid chains were observed (Plate 5:5d), 5e), 5f)). The cells were about 3μm in diameter. On the other hand, in the galleries in which all larvae had already grown to pupae or new adults, the ambrosial cells were somewhat collapsed in shape and there were no monilioid chains (Plate 6:6a), 6b)). At the bottom of the galleries, several kind of fungi were observed (Plate 6:6c), 6d)).

At the end of July, only new female adults existed in the galleries. The walls were covered with dense mycelial mat, lustrous black in color (Plate 7:7a), 7b), 7c)).

4. *Xyleborus saxeseni* Ratzburg

The mother beetle bores a mother tunnel about 40-50mm in length and deposits eggs in clusters there. The tunnel is extended later into a communal room about 20-40mm in width. In the present study, a single gallery was observed at the end of April. Two female and one male adults were still hibernating there.

Several spherical fungi, about 4μm in diameter and irregularly compressed, were making colonies at several places in the gallery (Plate 8:8a), 8b)).

5. *Xyleborus ishidai* Niijima

This beetle makes a communal-tunnel type gallery consisting of one or two tunnels about 30-60mm in length and an egg cradle about 4mm in depth. In the present study, observations were made in late June and in early July.

In late June, 3-5 larvae were eating fungi in the tunnels. The tunnel wall was black in color. Somewhat spherical fungi were growing in all parts of the gallery (Plate 9:9a), 9b)). The fungi were in the condition of pure culture and their ambrosial cells, 6-7μm in diameter, were forming monilioid chains making a thick mat.

In early July, many new adults were inhabiting the tunnels. The ambrosial cells and monilioid chains were deformed (Plate 9:9c), 9d)), and some other fungi were growing at the innermost part of the gallery (Plate 9:9e), 9f)).

6. *Xyleborus validus* Eichhoff

The gallery is of the communal tunnel type and very similar to that of *X. ishidai*. Plate 10 shows the eggs and larvae of this beetle in the tunnels. Observations on fungi were made in early June and in early July.

In early June, there were several eggs and no larvae. Near the entrance, the wall was plastered with sticky material and several hemispherical granules, about 2μm in diameter, were growing on the material (Plate 11:11a), 11b)).

In early July, spoon-shaped (Plate 11:11c), 11d)), sweet-potato-shaped (Plate 11:11e), 11f)), and Chinese-yam-shaped (Plate 11:11g), 11h)) fungi were growing at the middle and deep parts of the gallery.

II. Genus *Trypodendron*

In the case of the genus *Trypodendron*, both parents take care of their galleries; the male works on boring main tunnels, throwing dust, changing air in the galleries, protecting the galleries from parasitic mites etc.; and the female works on control of the fungal development and breeding larvae.

In the present study, only one species, *T. signatus*, was observed.

7. *Trypodendron signatus* Fabricius

The gallery is of the compound type with individual larval cradles arranged in series both above and below the main tunnels (mother tunnels), which branch in a horizontal plane and cut across the grain of the wood (Table 1). Plate 12 (12a), 12b)) shows a pupa or a new adult in the pupal cradle. Observations were carried out in late June and in early July.

In late June, there was an adult pair, eggs, and young larvae in the galleries. Plate 12c) shows a mother tunnel and an egg cradle. Near the entrance of the mother tunnel, broken wood tissue and some fungi were observed (Plate 13: 13a), 13b), 13c)). These fungi were grown thickly at the middle part of the tunnel (Plate 13:13d)), and at the parts nearest the egg cradles (Plate 13:13e), 13f)). At the far end of the tunnels, there were many broken wood tissues and few mycelia (Plate 14:14a), 14b)). In the egg and larval cradles, there were crumpled tape-like mycelia thickly grown, but no ambrosial cells (Plate 14:14c), 14d), 14c), 14f)).

In early July, well-grown ambrosial cells, 4-5μm in diameter with many fine wrinkles on the surface, were forming monilioid chains in both the egg and pupal cradles (Plate 15:15a), 15b), 15c), 15d), 15e)). New adults were observed in some pupal cradles.

III. Genus *Scolytoplatypus*

The type of the galleries of the *Scolytoplatypus* species is the individual-larval-cradle type and very similar to those of the *Trypodendron* species (Table 1)[9]. Plate 16 (16a) and 16b)) shows a horizontal and a longitudinal section of a typical gallery of *S. shogun*. Plate 16 (16c) and 16d)) shows an egg in an egg cradle and a full-grown larva in a pupal cradle of *S. shogun* respectively.

Previously, Nakashima[9,10] reported about the fungi growing in the gallery of *S. shogun*. In the present study, observations were made on three other species which belong to the genus *Scolytoplatypus*.

8. *Scopytoplatypus daimio* Blandford

The gallery type of this species is an individual larval cradle type. In the breeding season, a pair of adults takes care of the gallery in cooperation. In the present study, observation was made in early July.

At the time, some new adults were still contained in the pupal cradles and some had already left the galleries. In the mother tunnels, well-grown ambrosial cells were forming monilioid chains (Plate 17:17a), 17b)). These ambrosial cells were very similar to those of *S. shogun* but a little smaller (7-10μm in diameter). These ambrosial cells were few at the part nearest the entrance of the gallery (Plate 17:17c)), and well grown at the part nearest the pupal cradles (Plate 17:17d), 17e)). In the pupal cradles, wood tissue was exposed and a few fungi, more or less spherical (1-1.5μm in diameter) (Plate 18:18a)) or bundled-rope in shape (Plate 18:18b), 18c)), were growing

9. *Scolytoplatypus mikado* Blandford

The behavior of this species and its gallery type are very similar to those of *S. shogun* and *S. daimio*. In the present study, the authors had a chance to observe them in early May. Hibernated adults were still inhabiting the pupal cradles. Mother galleries and pupal cradles had been filled with white fungi (Plate 19:19a), 19b)), and clustered round spores, about 2μm in diameter, were observed sporadically (Plate 19:19c)).

10. *Scolytoplatypus tycon* Blandford

The type of the gallery and behavior of this species are very similar to those of other *Scolytoplatypus* species. In the present study, observation was made in early November.

At the time, the condition of the mycelia was considerably dry. The maycelia were about 10μm in diameter and had many spheres which were about 20-25μm in diameter with many dots on the surface (Plate 20:20a), 20b)).

Family Platypodidae

IV. Genus *Platypus*

11. *Platypus severini* Blandford

This species differs from the scolytid mentioned above in the type of gallery. The male adult bores main tunnels (mother tunnels) (Plate 21:21a), 21b)), followed by the female depositing her eggs in the tunnels (Plate 21:21c)). The female adult lives in the inner part of the tunnels and takes care of larvae and symbiotic fungi, while the male adult lives near the entrance of the gallery and cast out larval fecula, exuvia and other waste materials from the gallery. The parents and larvae move freely within the tunnels and feed on the fungi growing in the galleries (Plate 21:21d)). Fully grown larvae bore their individual pupal cradles arranged in series both above and below the mother tunnels (Plate 21: 21e);Table 1). Observations on the fungi growing in the galleries were made in early May, July and November.

In early May, a pair of adults was in the gallery; however, there were no eggs yet. Mushroom-shaped fungi, 1-2μm in size, were growing near the entrance (Plate 22:22a), 22b), 22c)). At the deep part of the gallery, the wall was covered with intertwined mycelia moistened with mucous secretion (Plate 22: 22d), 22e), 22f)). At the part near the entrance, ambrosial cells, 3-4μm in diameter, were found growing (Plate 23:23a)).

In early July, the ambrosial cells had grown at the part near the entrance as in May (Plate 23:23a)). At the middle and deep sections of the gallery, other typed fungi, banana-shaped, 1μm in width, 3-4μm in length, and vertically

striped, were growing (Plate 23:23c),23d)). In the pupul cradles, both the round and banana-shaped fungi were mixed in mucous material (Plate 23:23e)).

In early November, some round flat fungi, 1-2μm in diameter (Plate 24 : 24 a)), and field-horsetail-shaped fungi, 6-10μm in height (Plate 24:24b)), were buried in mucous material. In some parts a few filamentous fungi were observed (Plate 24:24c), 24d)).

V. Genus *Crossotarsus*

12. *Crossotarsus niponicus* Blandford

The boring behavior of this species is similar to that of *Platypus severini* (Tab' 1)[7]. The gallery winds through the sapwood and often penetrates deeply into the heartwood (Plate 25:25a)). The female deposits her eggs in the tunnels (Plate 25:25b)), and the parents and larvae move freely in the tunnels and feed on the fungi growing on the walls (Plate 25:25c), 25d)). The type of pupal cradles is, however, different from that of *P. severini*. Full-grown larvae bore their pupal cradles parabolically on one side of the tunnels (Plate 25:25e)). The adults, eggs, larvae and pupae can be almost continuously observed from spring to late autumn. The gallery is surrounded by characteristic black dyed lines (Plate 25). Observations on the fungi growing in the galleries were done in late July and in early October and November.

In late July, small round cells, 2-3μm in diameter, were on the walls of all galleries (Plate 26:26a) 26b)). These round cells appeared to be making no monilioid chains.

In early October, rabbit-ear-like fungi were observed in some pupal cradles (Plate 26:26c), 26d)). There were dense mats of fungi at the deep part of the pupal cradles (Plate 26:26e)).

In November, felt-like fungus material was found in the pupal cradles (Plate 26:26f)

DISCUSSION

Table 1 shows the types of the galleries of thirteen species of the ambrosia beetles (12 species in the present study, 1 species from NAKASHIMA[8,9]). Only *X. seriatus* bores its tunnels under bark like bark beetles do. The associated fungi of *X. seriatus* were not similar to those of other *Xyleborus* spp. NOBUCHI[11] reported that *X. seriatus* is strikingly similar to bark beetles in the morphology of the proventriculus. It seems that *X. seriatus* lives symbiotically with some fungi which are closely related to those associated with bark beetles.

Ten species of the scolytid beetles (*X. attenuatus, X. germanus, X. saxeseny, X. ishidai, X. validus, X. signatus, S. shogun, S. daimio, S. mikado and T. tycon*) live symbiotically with species-specific fungi which produce their own character-

istic ambrosial cells with monilioid chains. Based on morphological characteristics, these fungi were recognized as *Ambrosiella* spp. Batra[1,2,3], Franke-Grosmann[5] and French and Roeper[6] reported that the primary ambrosia fungus of one beetle may sometimes be an auxiliary fungus for other species of ambrosia beetles. In the present study, however, this phenomenon was not confirmed.

In the galleries of *P. severini* and *C. niponicus*, both of which belong to the family Platypodidae, several species of fungi were observed and they were recognized to be symbiotic fungi of those beetles.

The symbiotic fungi of scolytid beetles belong to two or three species including the primary ambrosia fungi, while some species of fungi were recognized for platypodid beetles.

In identifying the symbiotic fungi, the present study is the first step. In the second step, the conditions under which specific ambrosial cells and monilioid chains are made in ordinary or artificial cultures in the laboratory should be examined. Batra[3,4] reported that the fungi in the galleries grow like a yeast under continual graze by larvae and adults, while the fungi in an artificial cultural condition are like a thread in shape. Nakashima et al.[10], however, have succeeded to observe the feature of ambrosial cells and monilioid chains of *Ambrosiella* sp. under laboratory conditions without continual graze by beetles.

The ambrosia beetles in the present study were collected from the same place (Hiyama, Hokkaido) and from the same beech log. In spite of this, these beetles lived symbiotically with species-specific fungi; therefore, the primary ambrosia fungi were different according to the species of beetles associated. This fact suggests that the symbiotic relationship between the ambrosia beetle and its primary ambrosia fungi is strong and strict. Our final target of research on this field is to know why and how different species of beetles living in the same log have their own specific ambrosia fungi. These sophisticated relationships between beetles and fungi will be cleared by the following steps.

SUMMARY

The galleries of 12 species of ambrosia beetles in the beech logs were observed in a scanning electron microscope to investigate the growing conditions of the symbiotic fungi of these beetles. Ten species of the scolytid beetles lived symbiotically with specific fungi, which were recognized as *Ambrosiella* spp. In the galleries of scolytid beetles, some two or three species of fungi including the primary ambrosia fungi were growing. In the galleries of platypodid beetles, however, several kinds of fungi were growing.

LITERATURE CITED

1. BATRA, L. R.: Ecology of ambrosia fungi and their dissemination by beetles. Trans.

Kansas Acad. Sci. **66** : 213-236. 1963
2. BATRA, L. R. : Ambrosia fungi : extent of specificity to ambrosia beetles. Science **153** : 193-195. 1966
3. BATRA, L. R.: Ambrosia fungi: a taxonomic revision, and nutritional studies of some species. Mycologia **59** : 976-1017. 1967
4. BATRA, S. W. T. and L. R. BATRA: The fungus gardens of insects. Sci.Amer. **271** : 112-120. 1967
5. FRANCKE-GROSMANN, H.: Some new aspects in forest entomology. Ann. Rev. Ent. **8** : 415-438. 1963
6. FRENCH, J. R. J. and R. A. ROEPER : Interactions of the ambrosia beetle, *Xyleborus dispar* (Coleoptera: Scolytidae), with its symbiotic fungus *Ambrosiella hartigi* (fungi imperfecti). Can. Ent. **104** : 1635-1641. 1972
7. NAKASHIMA, T.: Notes on the associated fungi and the mycetangia of the ambrosia beetle, *Crossotarsus niponicus* Blandford (Coleoptera: Platypodidae). Appl.Ent. Zool. **6** : 131-137. 1971
8. NAKASHIMA, T.: Function and location of mycetangia in ambrosia beetles. The Ultrastructure and functioning of insect cells. (ed. Akai et al.):87-90. 1982
9. NAKASHIMA, T.: Observation on the ambrosia fungus, *Ambrosiella* sp., growing in the gallery of *Scolytoplatypus shogun* Blandford (Coleoptera : Scolytidae) and on the concurrent damage of wood tissue. Jour. Fac. Agric. Hokkaido Univ. **64** : 99-105. 1989
10. NAKASHIMA, T., C. GOTO and T. IIZUKA : The primary and auxiliary ambrosia fungi isolated from the ambrosia beetles, *Scolytoplatypus shogun* Blandford (Coleoptera: Platypodidae) and *Crossotarsus niponicus* Blandford (Coleoptera : Platypodidae). Jour. Fac. Agric. Hokkaido Univ. **63** : 185-208.1987
11. NOBUCHI, A.: A comparative morphological study of the proventriculus in the adult of the superfamily Scolytoidea (Coleoptera). Bull. Government Forest Exp. Station **224** : 39-109, 17plates. 1969
12. WEBER, B. C. and J. E. McPHERSON : The ambrosia fungus of *Xylosandrus germanus* (Coleoptera: Scolytidae). Can. Ent. **116** : 281-283. 1984

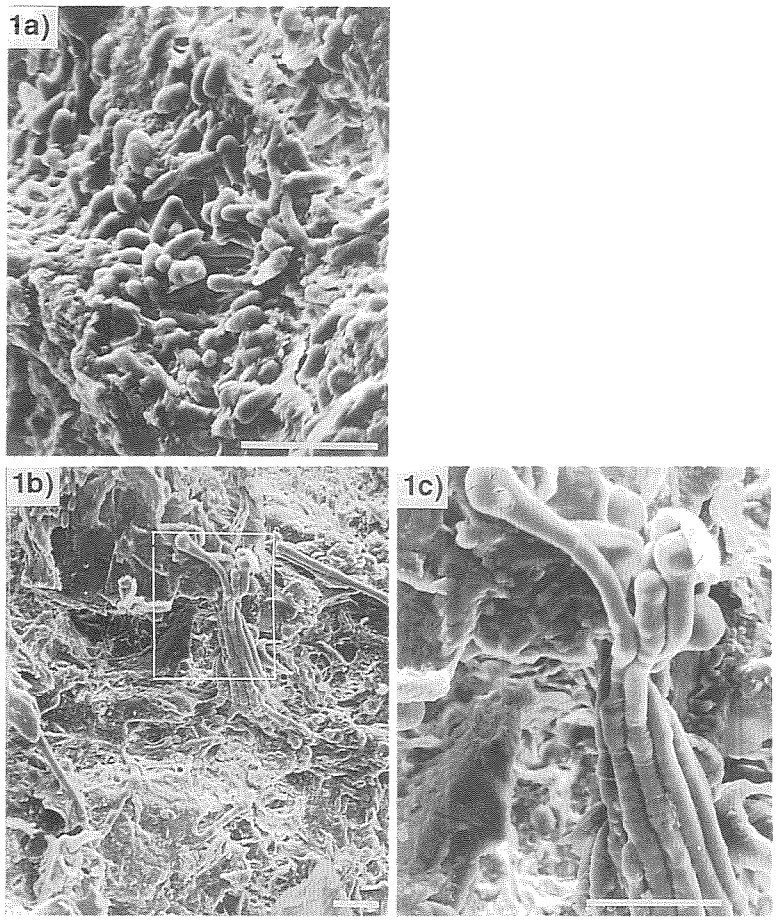

Plate 1. Fungi associated with *Xyleborus seriatus* : 1a), oval or sausage-shaped fungi growing in the gallery at the part nearest the entrance (late July) ; 1b), long-club -shaped mycelia in the gallery at the deep part (late July) ; 1c), high magnification of the area surrounded by white lines in 1b) Bars : 10μm

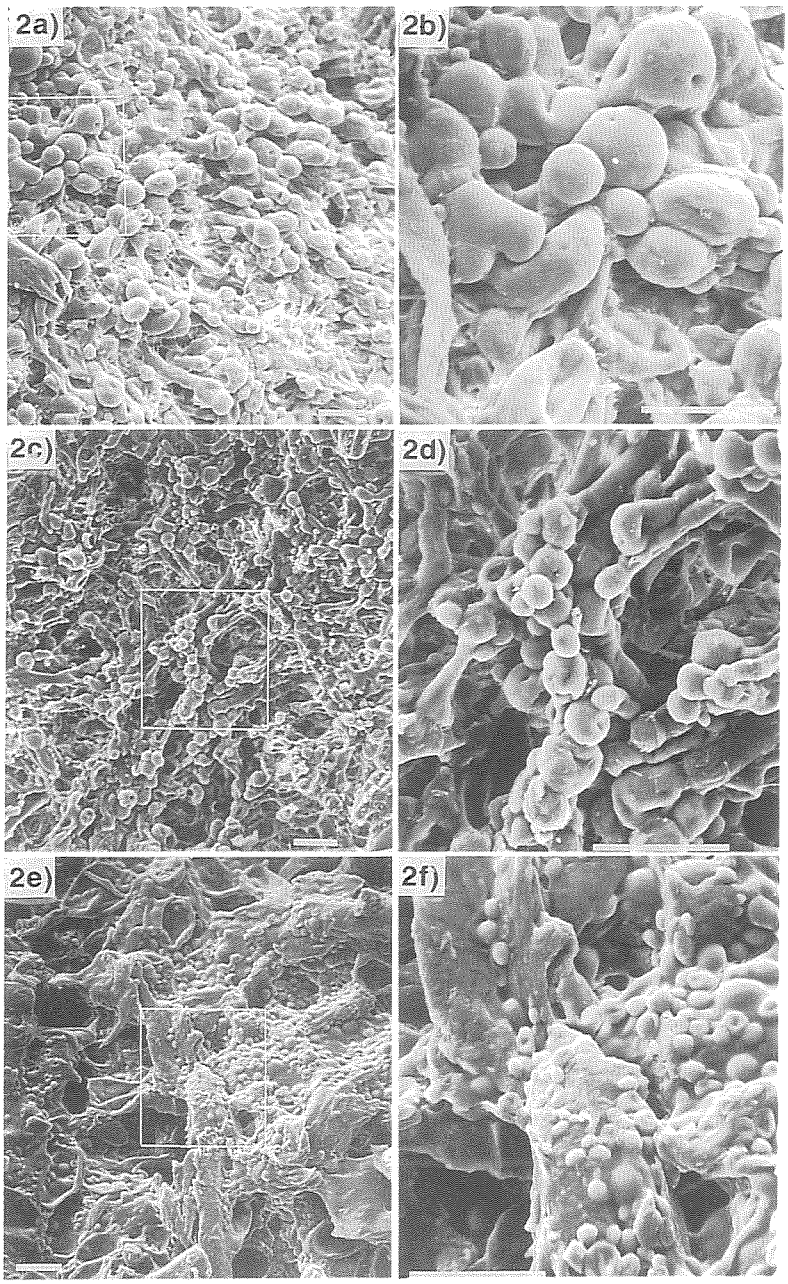

Plate 2. Fungi associated with *X. attenuatus* : 2a), round cells growing on sticky material (the part nearest the entrance, late June) ; 2b), high magnification of 2a ; 2c), round cells at the middle part of the gallery (late June) ; 2d), high magnification of 2c) ; 2e), round cells at the innermost part of the gallery (late June) ; 2f), high magnification of 2e). Bars : 10μm

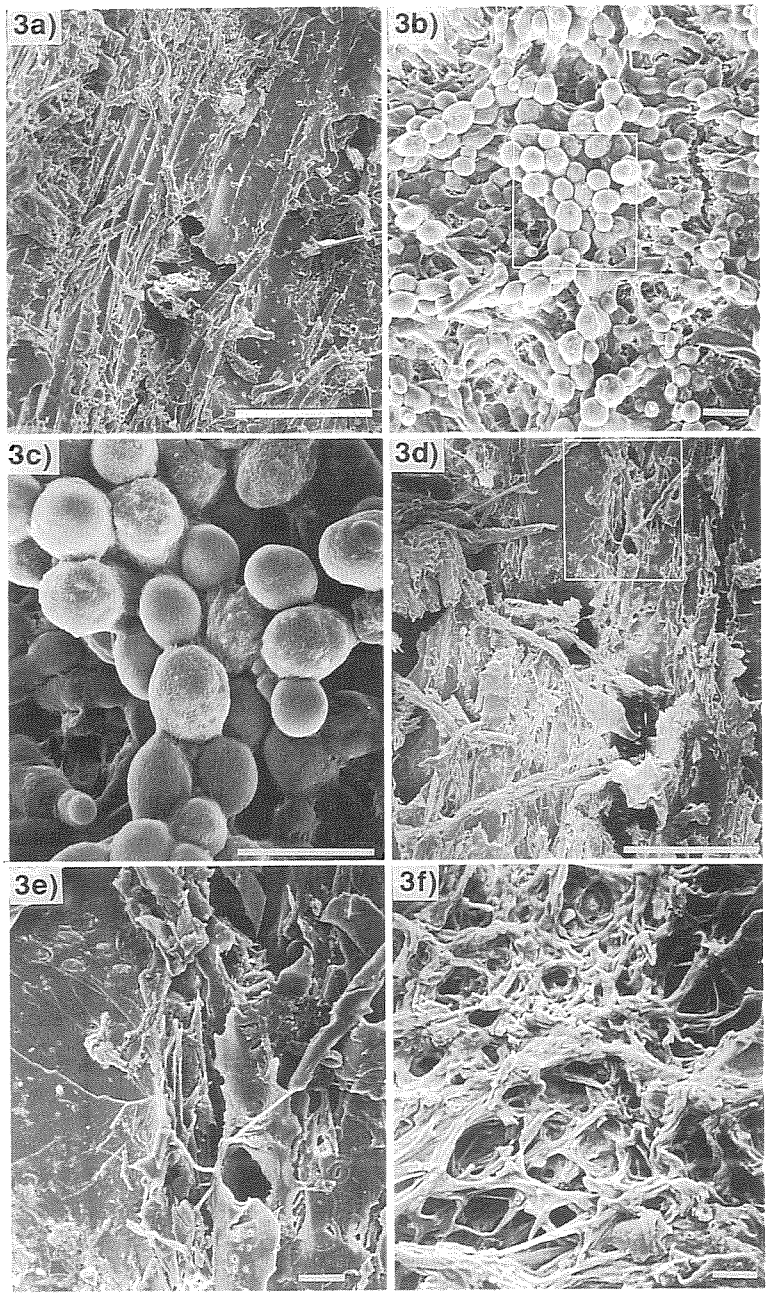

Plate 3. Fungi associated with *X. attenuatus* : 3a), the wall of an egg cradle (late June) ; 3b), ambrosial cells with monilioid chains (mid- July) ; 3c), high magification of 3b), broken wood tissue near the entrance (December) ; 3e), high magnification of 3d) ; 3f), maycelia at innermost part of the gallery (December). Bars : 10μm

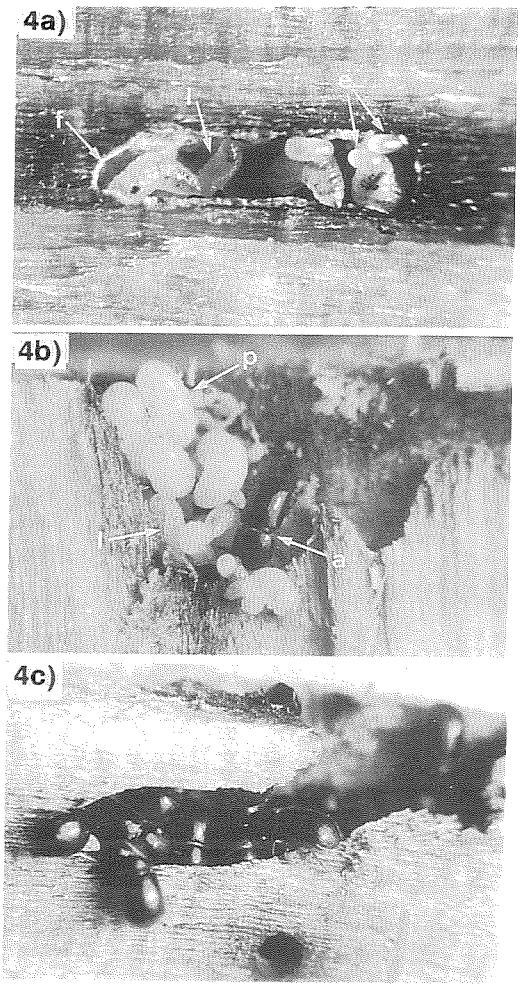

Plate 4. Eggs, broods, pupape and adults of *X. germanus* : 4a), eggs(e), larvae (l) ad mat of fungi(f) in a gallery ; 4b), an adult beetle(a), larvae (l)and pupae (p) in a gallery ; 4c), new adults in a gallery.

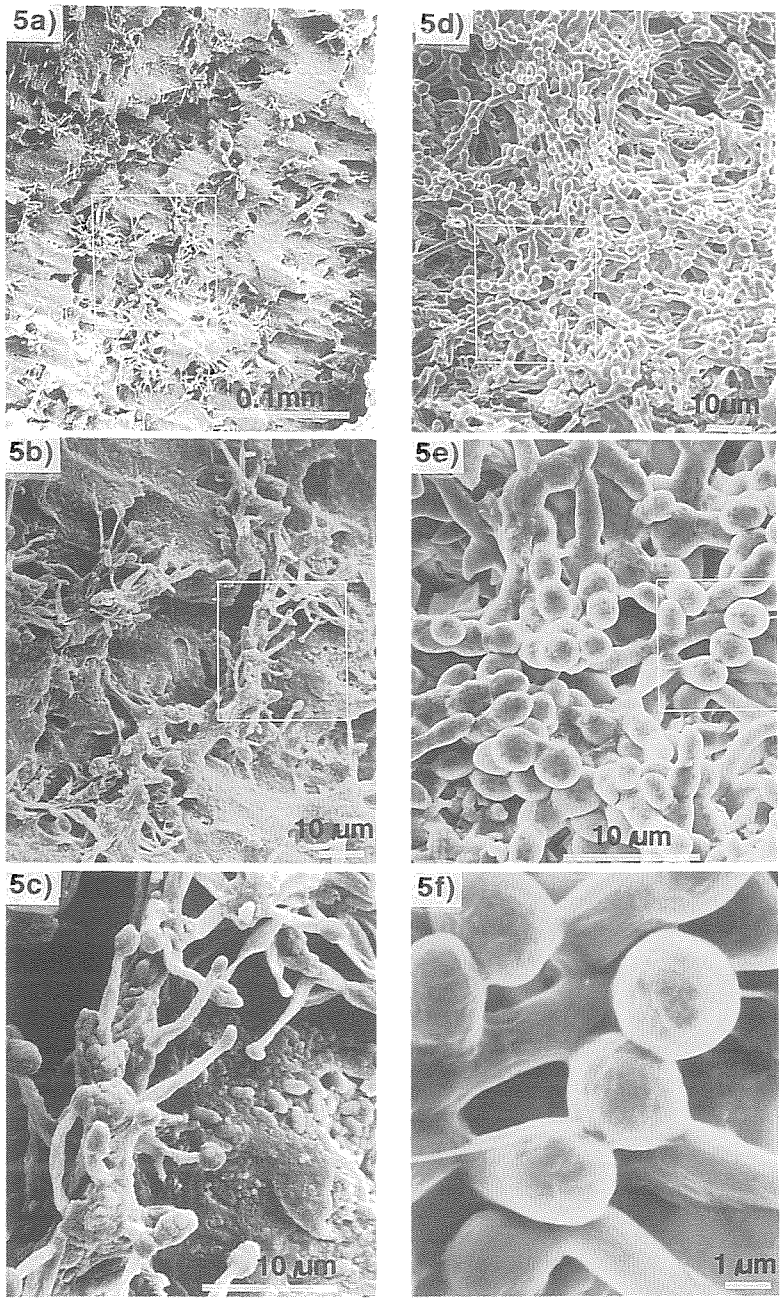

Plate 5. Fungi associated with *X. germanus* : 5a), fungi growing in a gallery inhabited by hibernating adults (mid- May) ; 5b), higher magnification of 5a); 5c), still higher magnifications of 5a); 5d), ambrocial cells with monilioid chains in main part of the gallery; 5e), higher magnification of 5d); 5f), still higher magnification of 5d).

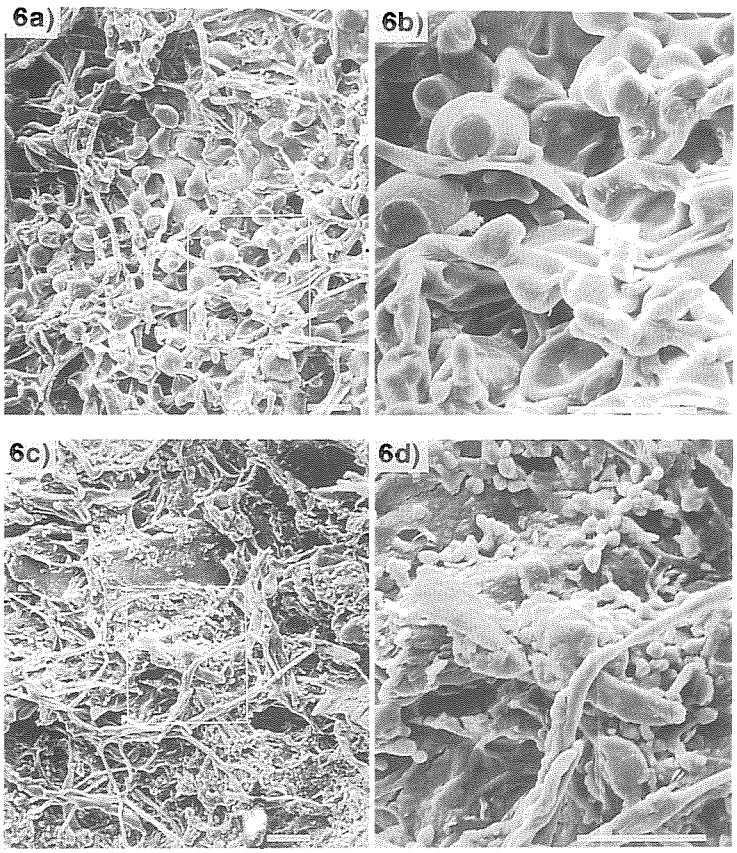

Plate 6. Fungi associated with *X. germanus* : 6a), fungi growing in the gallery in which all larvae had already grown up to pupae or new adults (early July) ; 6b), high magnification of 6a) ; 6c), fungi growing at the bottom of the galleries (early July) ; 6d), high magnification of 6c). Bars : 10μm

Plate 7. Fungi associated with X. *germanus*:7a), dense mycelial mat covered the wall (end of July) ; 7b), higher magnification of 7a) ; 7c), still higher magnification of 7a). Bars : 7a)-0. 1mm; 7b)-10μm ; 7c)-1μm

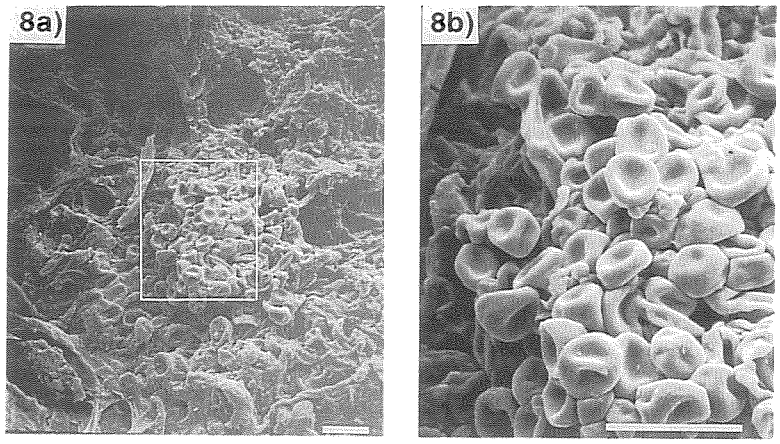

Plate 8. Fungi associated with *X. saxeseni* : 8a), spherical fungi with some dents (end of April) ; 8b), high magnification of 8a). Bars : 10μm

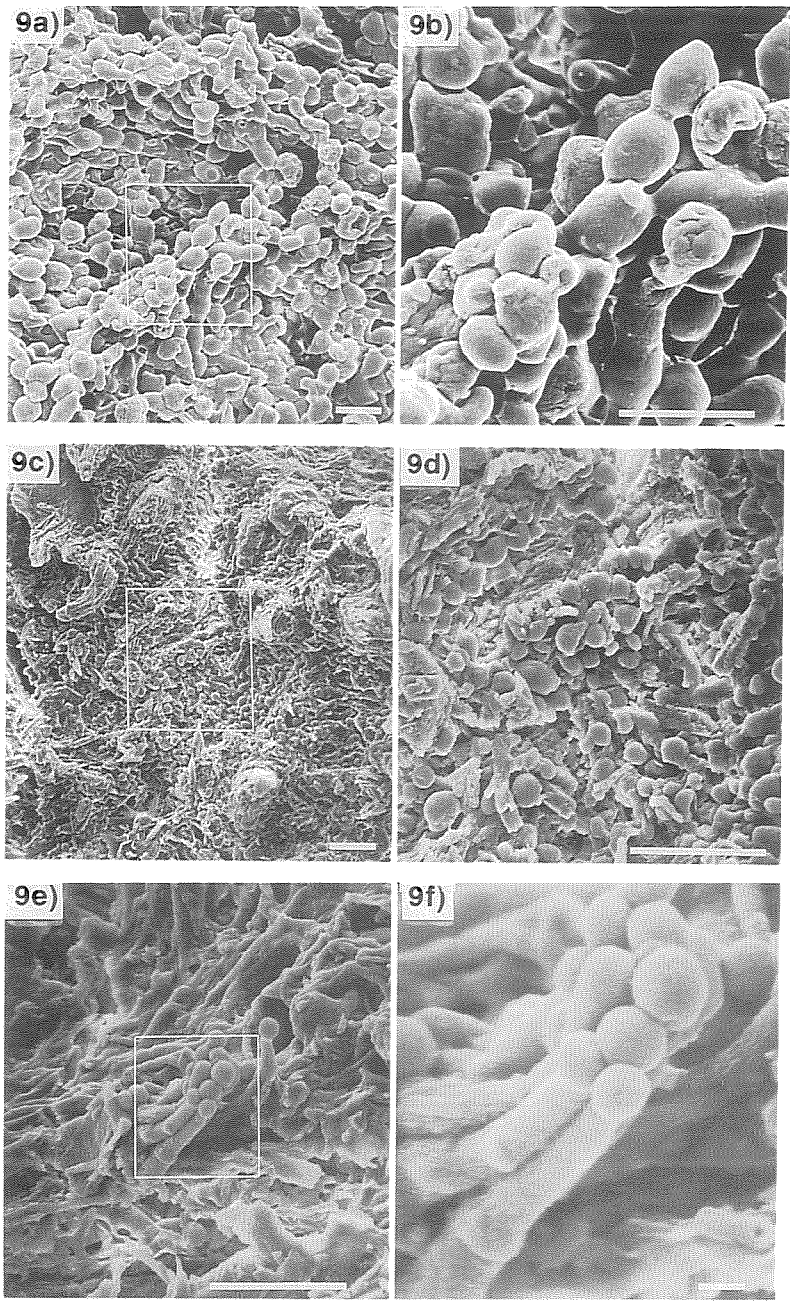

Plate 9. Fungi associated with *X. ishidai* : 9a), thick mat of monilioid chains made by ambrosial cells (late June) ; 9b), high magnification of 9a) ; 9c), deformed ambrosial cells with minilioid clains (early July) ; 9d), high magnification of 9c) ; 9e), fungi growing at the deep part of the gallery (early July) ; 9f), high magnification of 9e). Bars : 9a), 9b), 9c), 9d) and 9e)-10μm ; 9f)- 1μm

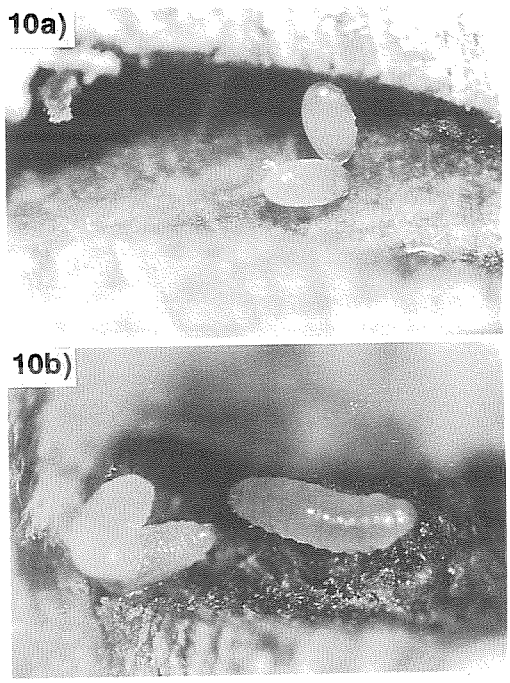

Plate 10. Eggs and larvae of *X. validus* : 10a), eggs in a tunnel ; 10b), larvae in a tunnel.

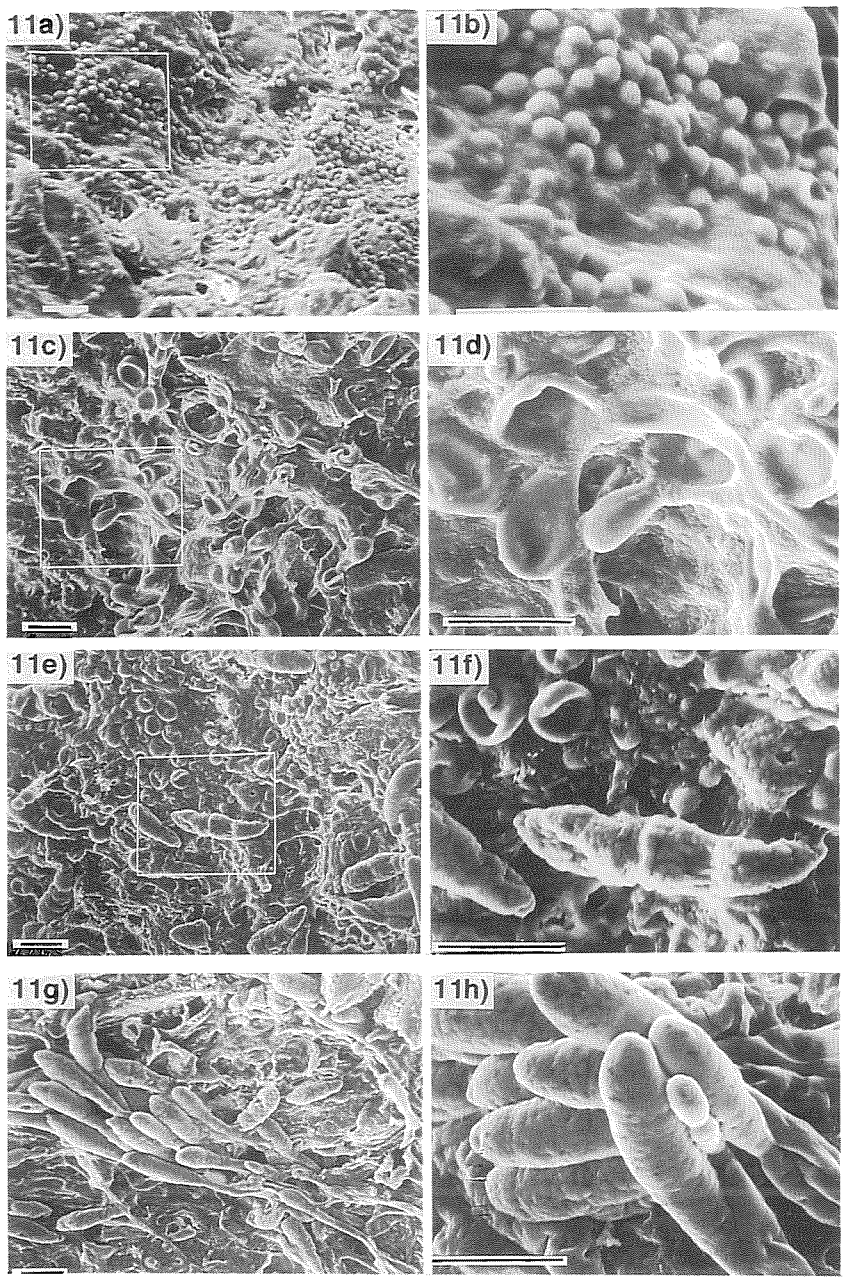

Plate 11. Fungi associated with *X . validus* : 11a), hemispherical granules on sticky material near the entrance (early June) ; 11b), high magnification of 11a) ; 11c), spoon-shaped fungi at the middle and deep parts (early June) ; 11d), high magnification of 11c) ; 11e), sweet potato-shaped fungi at the middle and deep parts (early July) ; 11f), high magnification of 11e) ; 11g), Chinese yam-shaped fungi at the middle and deep parts (early July) ; 11h), high magnification of 11g). Bars : 10μm

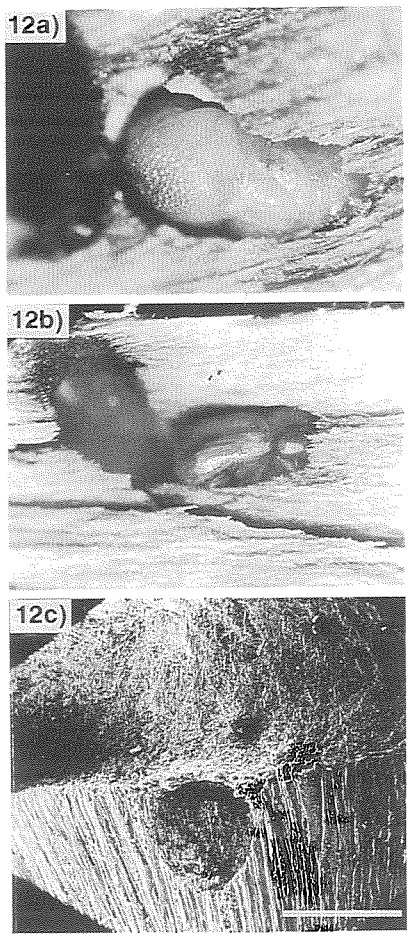

Plate 12. A pupa, new adult and gallery of *Trypodendron signatus* : 12a), a pupa contained by a pupal cradle ; 12b), an adult contained by a pupal cradle ; 12c), wall condition of the mother tunnel an egg cradle (late June). Bars : 1mm

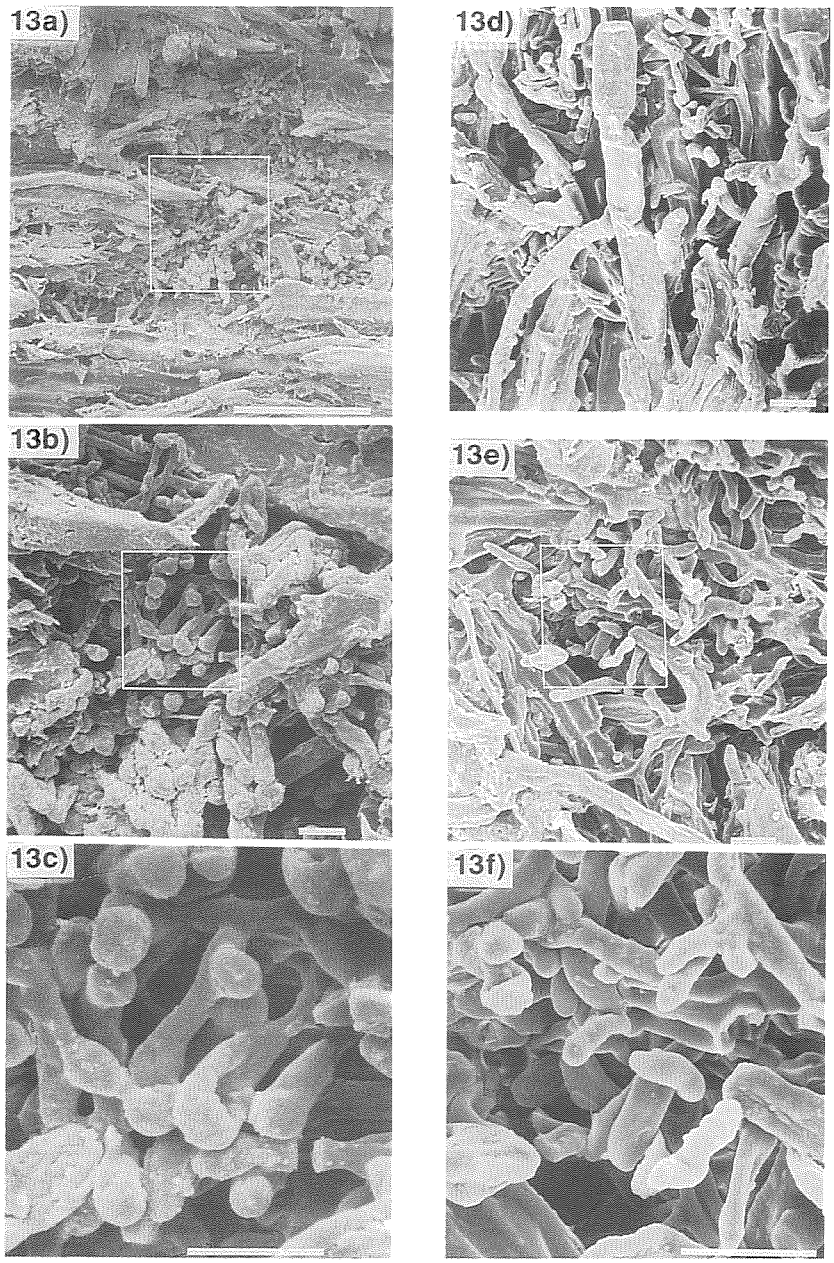

Plate 13. Fungi associated with *T. signatus* : 13a), the wall condition of a mother tunnel near the entrance (late June) ; 13b), higher magnification of 13a) ; 13c), still higher magnification of 13a) ; 13d), thick mat of fungi at the middle part of a mother tunnel ; 13e) thick mat of fungi near egg cradles in a mother tunnel ; 13f), high magnification of 13e). Bars : 13a)- 0.1mm ; 13b), 13c), 13d), 13e) and 13f)- 10μm

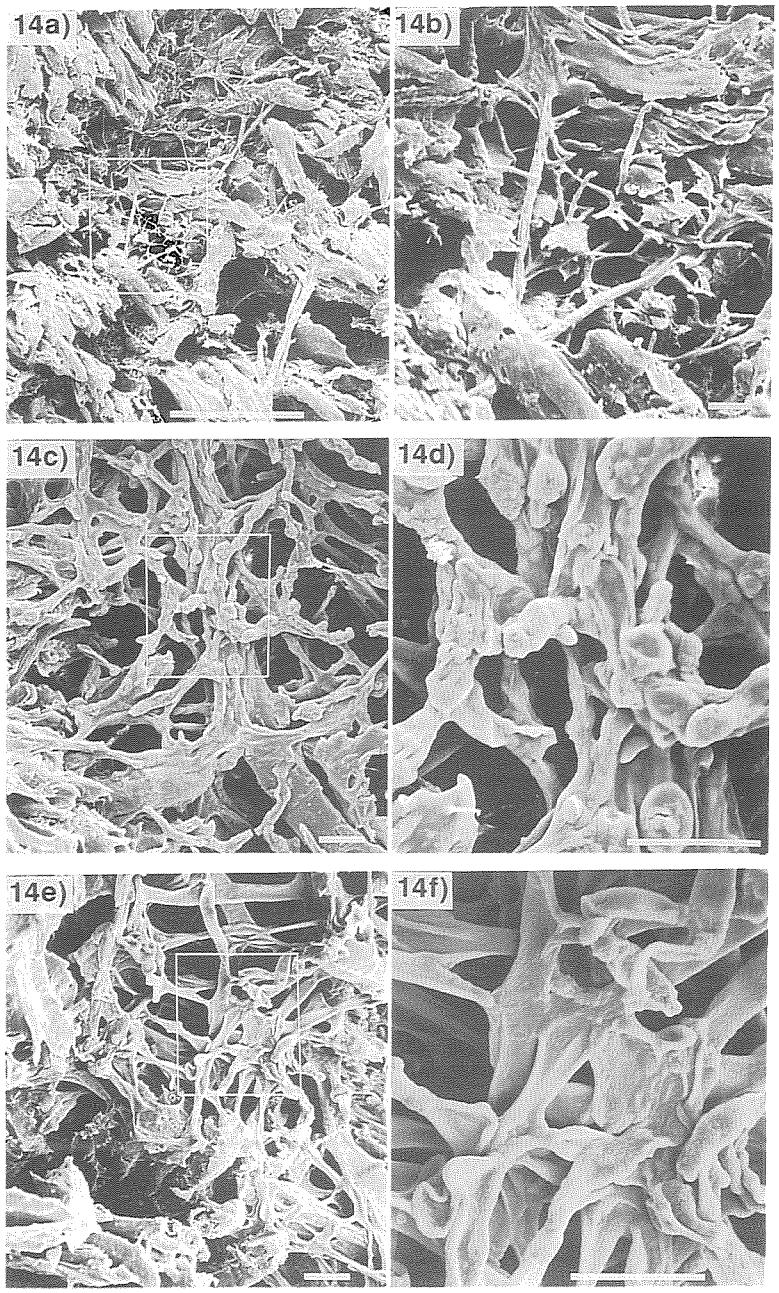

Plate 14. Fungi associated with *T. signatus* : 14a), broken wood tissues and a few fungi at the end of a mother tunnel (late June) ; 14b), high magnification of 14a) ; 14c), fungi in an egg cradle (late June) ; 14d), high magnification of 14c); 14e), fungi in a larval cradle (late June) ; 14f), high magnification of 14e). Bars : 14a) - 0.1mm ; 14b), 14c), 14d), 14e) and 14f) - 10μm

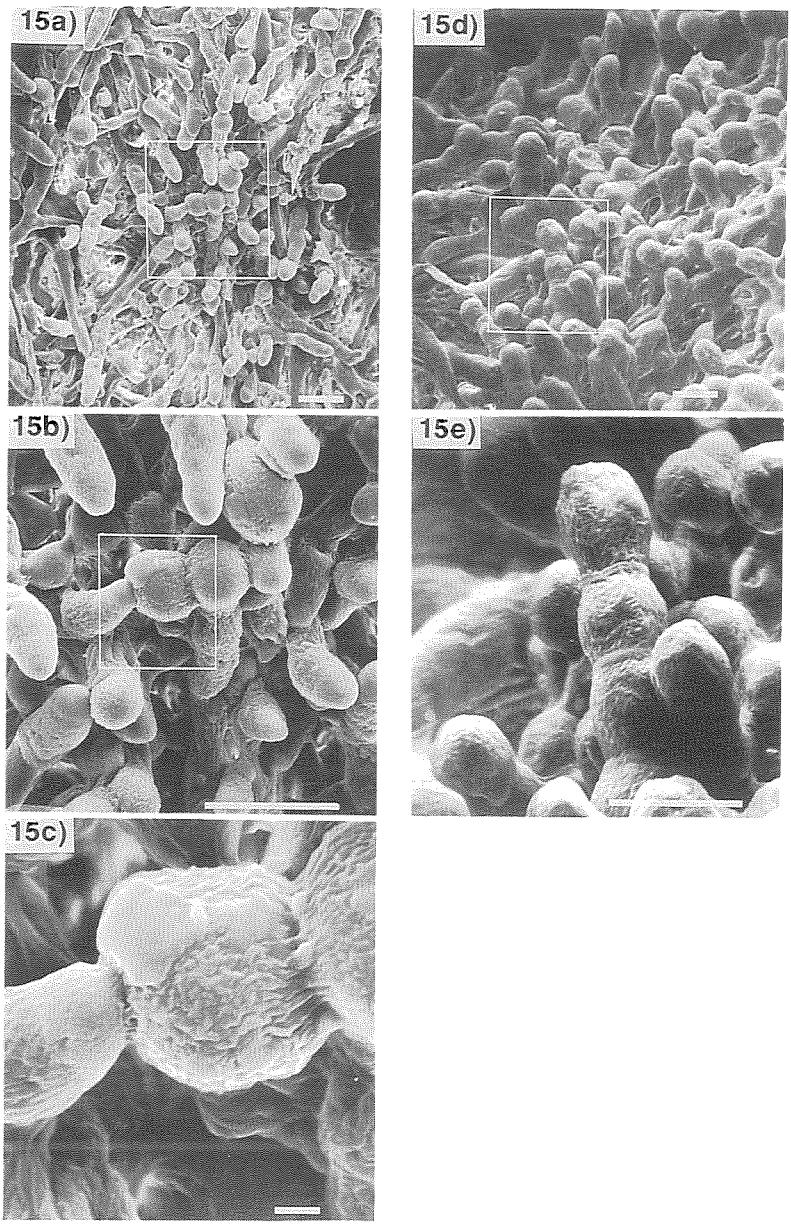

Plate 15. Fungi associated with *T. signatus* : 15a), ambrosial cells with monilioid chains in an egg cradle (late July) ; 15b), higher magnification of 15a) ; 15c), still higher magnification of 15a) ; 15d), ambrosial cells with monilioid chains in a pupae cradle ; 15e), high magnification of 15d). Bars : 15a), 15b), 15d), and 15e) - 10μm ; 15c) - 1mm

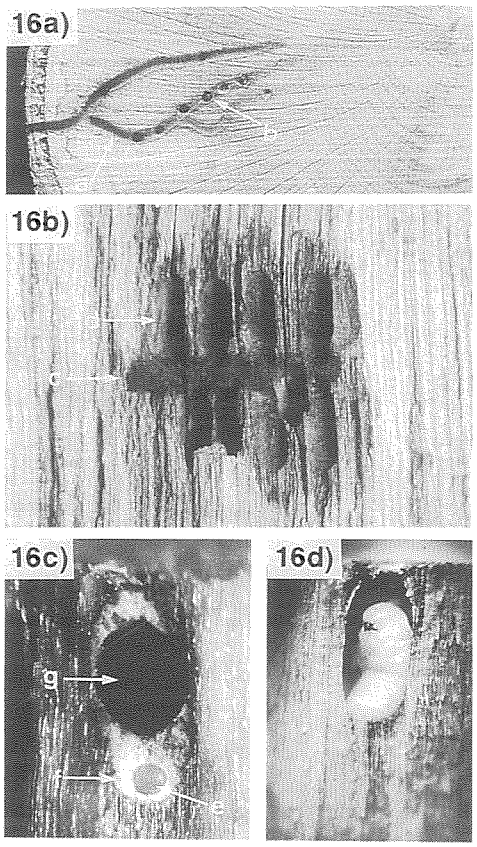

Plate 16. An egg and a larva of *Scolytoplatypus shogun* in the galleries : 16a) , a horizontal section of a gallery ; 16 b) , a vertical section of a gallery ; 16c) a cross section of a mother tunnel ; 16d) , a full-grown larva in a larval cradle, a: mother tunnel ; b: larval cradle ; c: mother tunnel ; d: larval cradle ; e: egg ; f: fungi ; g: mother tunnel.

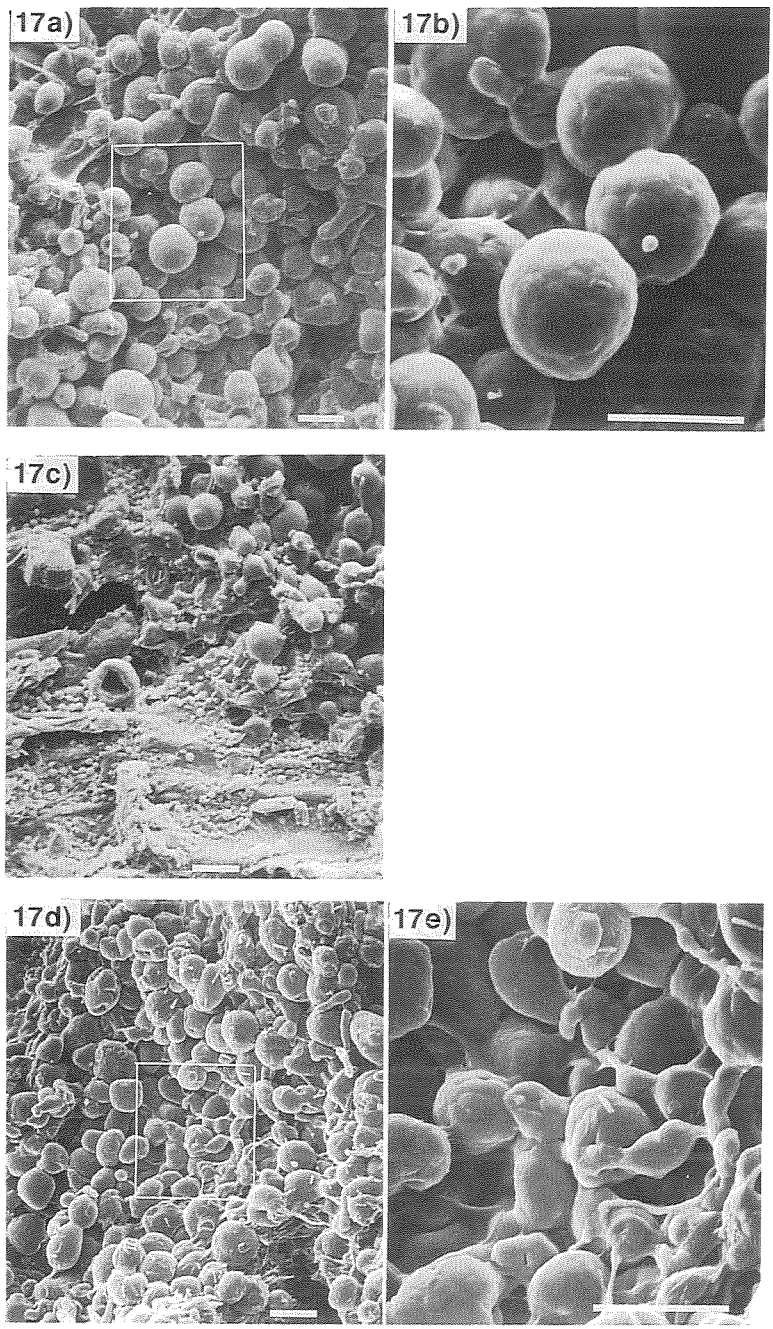

Plate 17. Fungi associated with *S. daimio* : 17a), ambrosial cells with monilioid chains in a mother tunnel (early July) ; 17b), high magnification of 17a) ; 17c), ambrosial cells near the entrance (early July) ; 17d), ambrosial cells with monilioid chains near pupal cradles (early July) ; 17e), high magnification of 17 d). Bars : 10μm

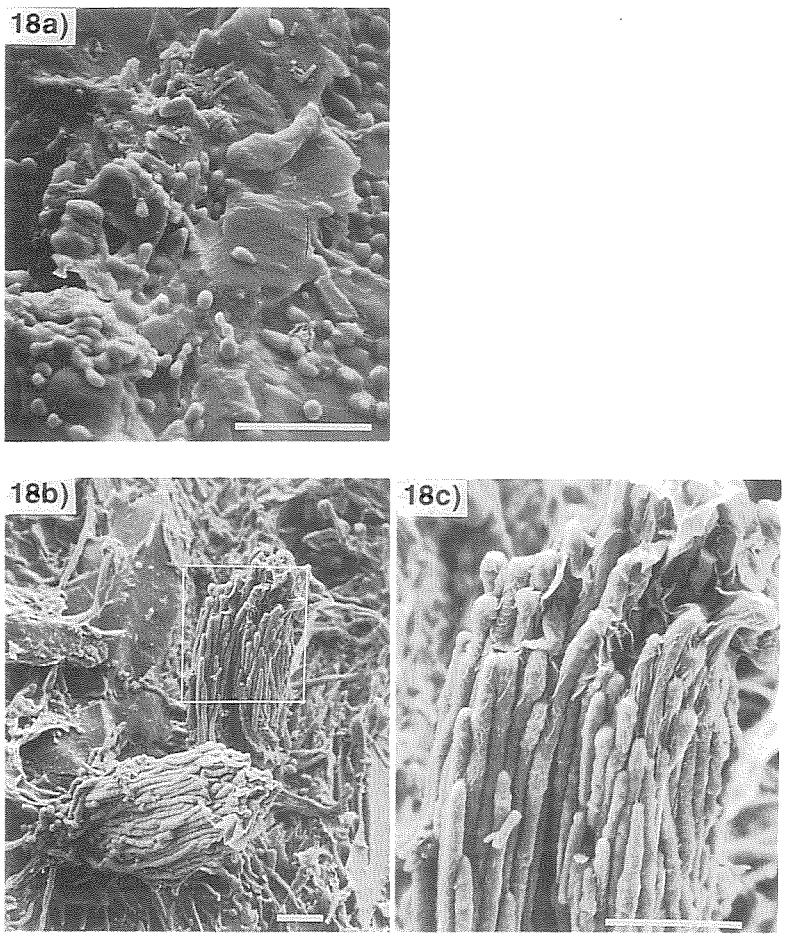

Plate 18. Fungi associated with S. *daimio* : 18a), spherical fungi in a pupal cradle (early July) ; 18b), bundled-rope-like fungi in a pupal cradle (early July) ; 18c), high magnification of 18b). Bars : 10μm

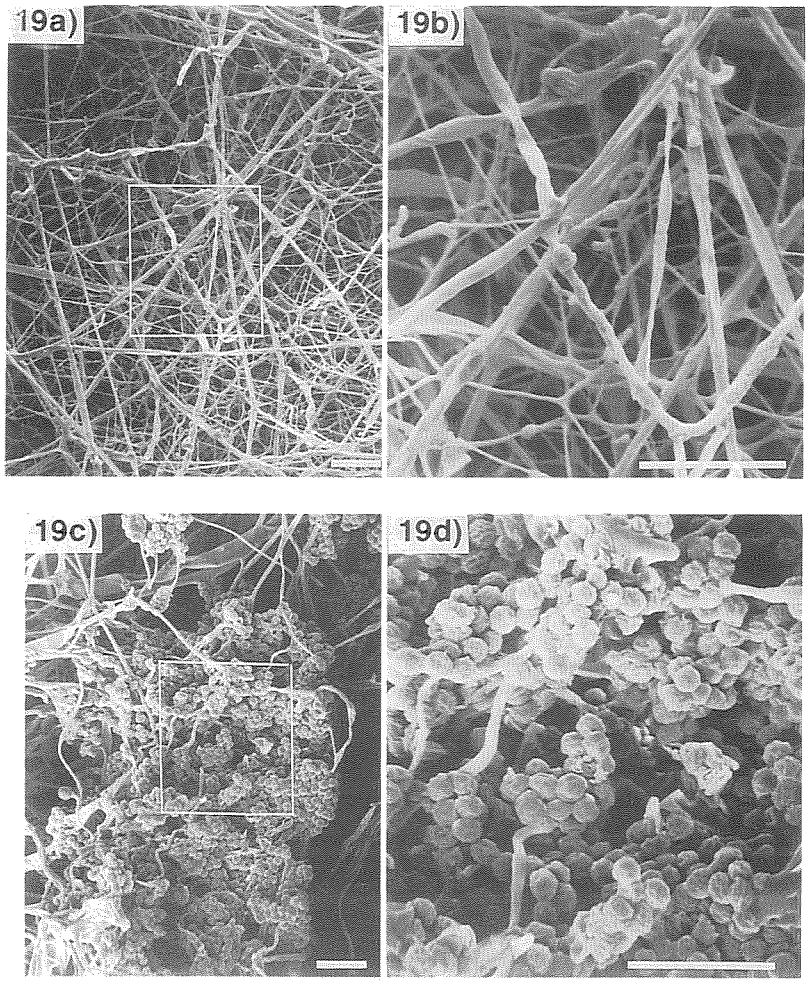

Plate 19. Fungi associated with *S. mikado* : 19a), fungi at mother tunnels (early May) ; 19b), high magnification of 19a) ; 19c), sporadically clusterd round spores (early May) ; 19d), high magnification of 19c). Bars : 10μm

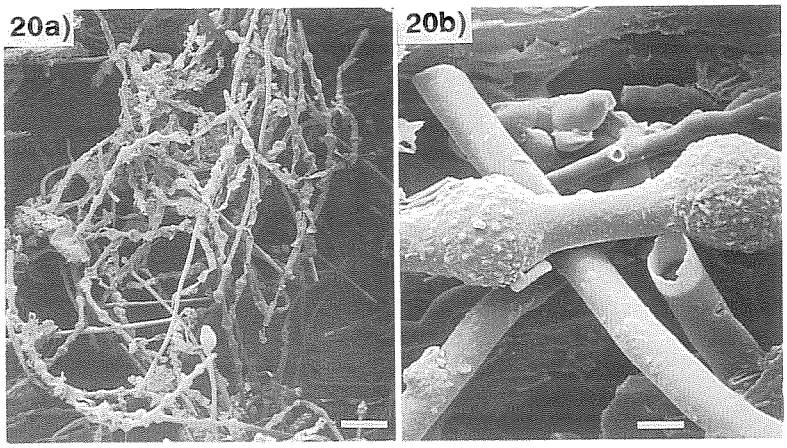

Plate 20. Fungi associated with *S. tycon* : 20a), mycelia with many spherical parts at middle and end parts of mother tunnels (early November) ; 20b), high magnification of 20a). Bars : 20a)- 0.1mm ; 20b)- 10μm

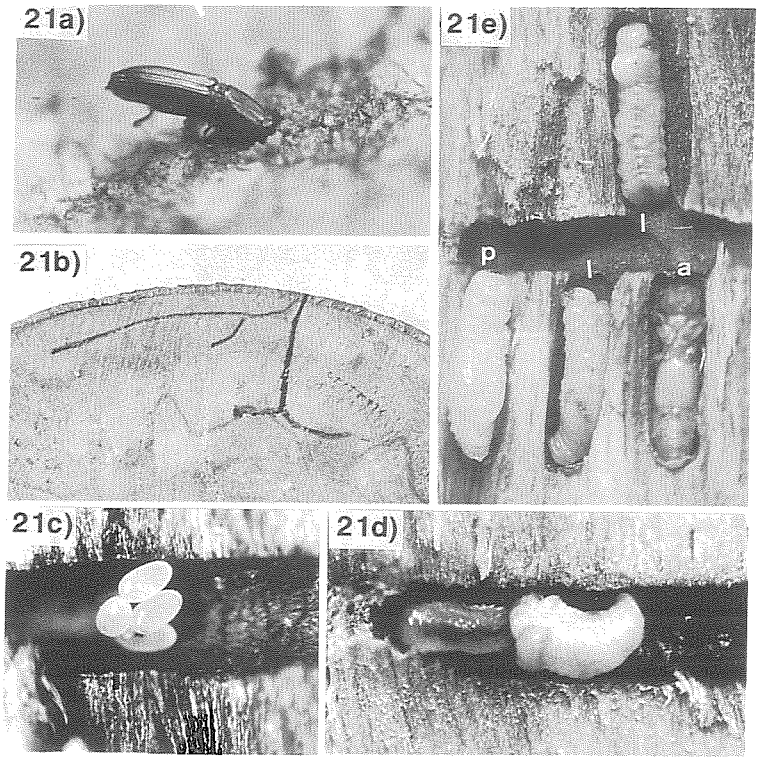

Plate 21. Tunnels, adult beetle, eggs, larvae and pupae of *Platypus severini* : 21a), an adult beetle (♂) boring a tunnel ; 21b), tunnels bored in a beech log ; 21c), eggs in a tunnel ; 21d), larvae in a tunnel ; 21e), full grown larvae (l), a pupae (p) and a new adult (a) in pupal cradles.

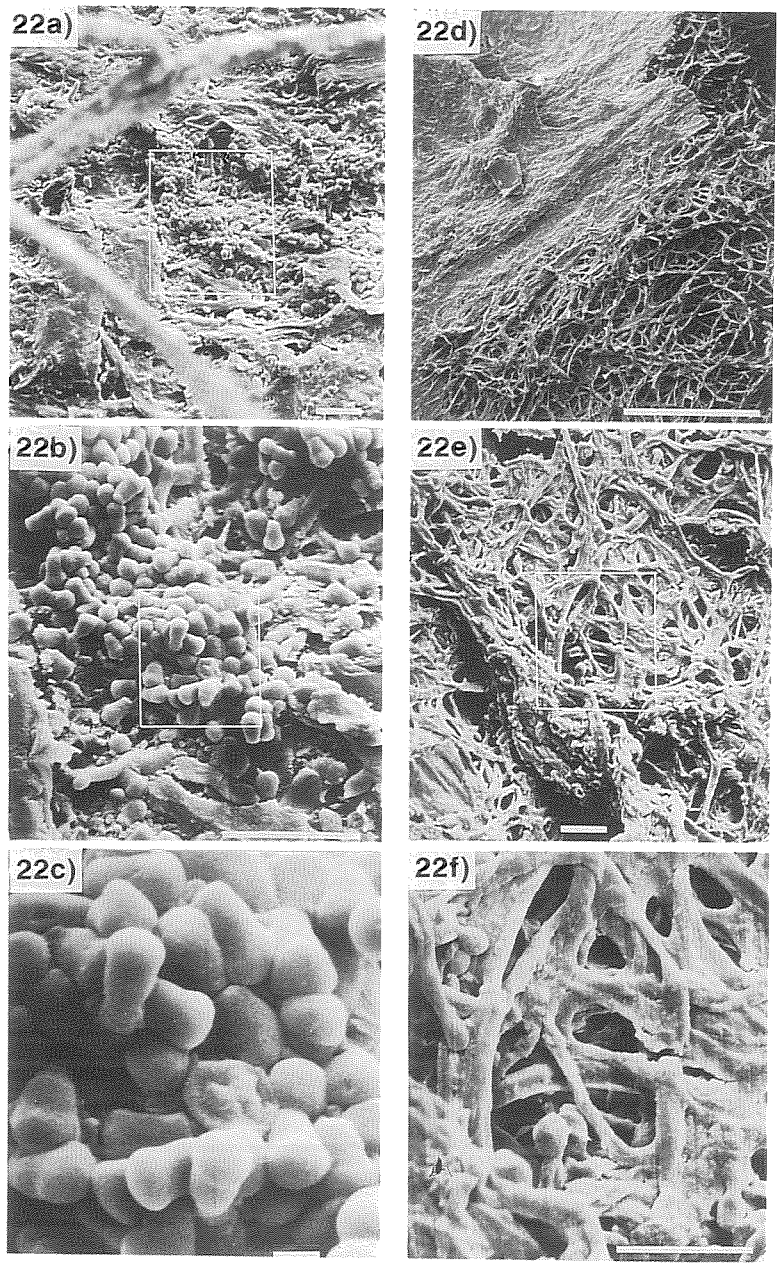

Plate 22. Fungi associated with *P. severini* : 22a), mushroom-shaped fungi near the entrance (early May) ; 22b), higher magnification of 22a) ; 22c), still higher magnification of 22a) ; 22d), intertwined mycelia moistened with mucous secretion at deep part (early May) ; 22e), higher magnification of 22d) ; 22f), still higher magnification of 22d). Bars : 22a), 22b), 22e) and 22f) - 10μm ; 22c) - 1μm ; 22d) - 0.1mm

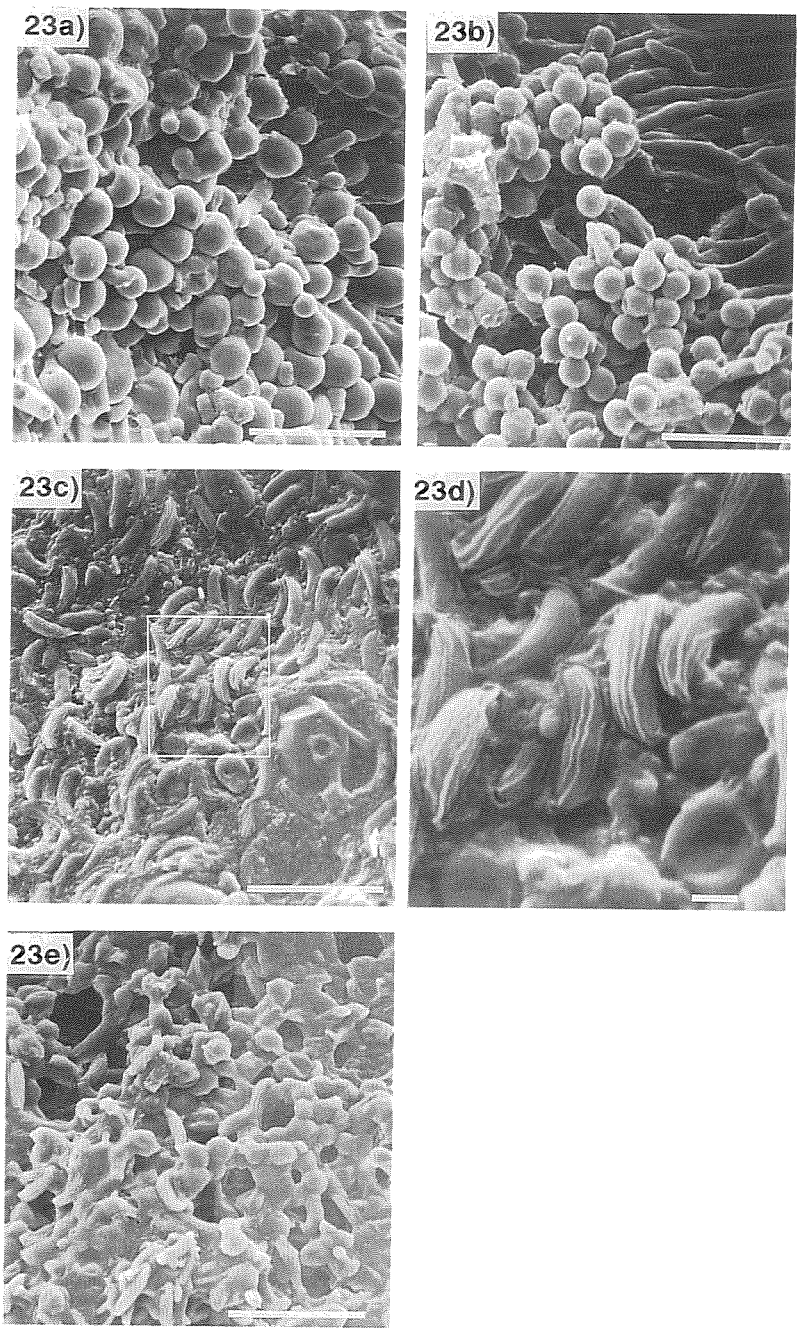

Plate 23. Fungi associated with *P. severini* : 23a), ambrosial cells near the entrance (early May) ; 23b), ambrosial cells near the entrance (early July) ; 23c), banana-shaped fungi with vertical stripes at middle and deep parts (early July) ; 23d), high magnification of 23c) ; 23e), fungi in pupal cradles. Bars : 23a), 23b), 23c) and 23 e)- 10μm ; 23d)- 1μm

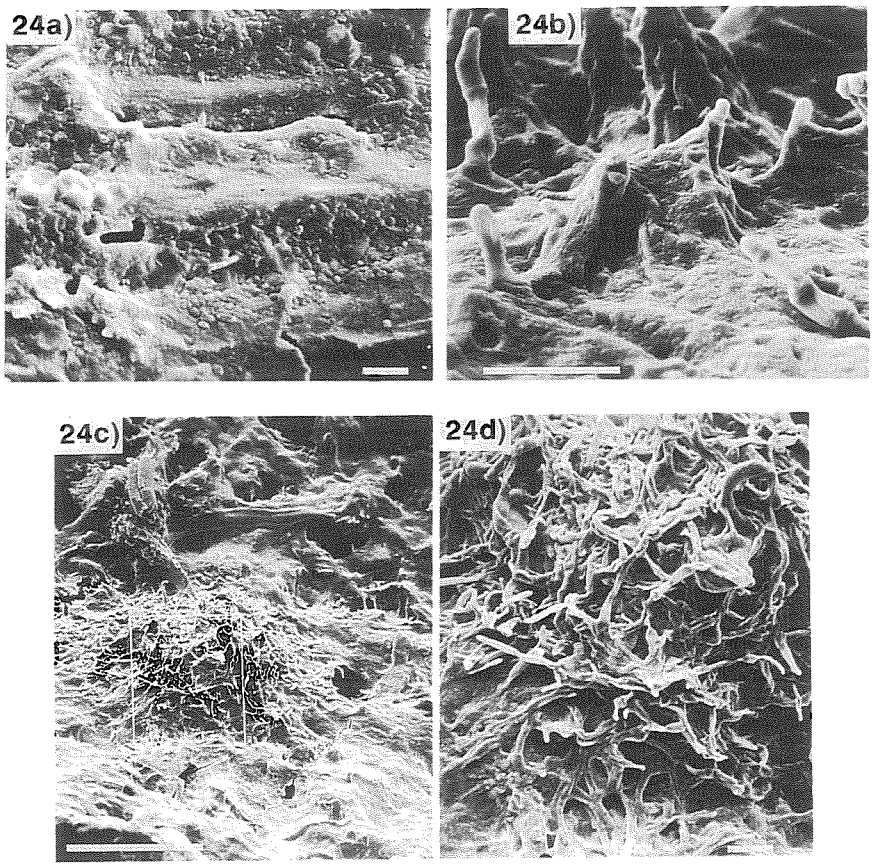

Plate 24. Fungi associated with *P. severni* : 24a), round and flat fungi buried in mucous material (early November) ; 24b), field-horsetail-shaped fungi buried in mucous materials (early November) ; 24c), filamentous fungi (early November) ; 24d), high magnification of 24c). Bars : 24a), 24b), and 24d)- 10μm ; 24c) -0.1 mm

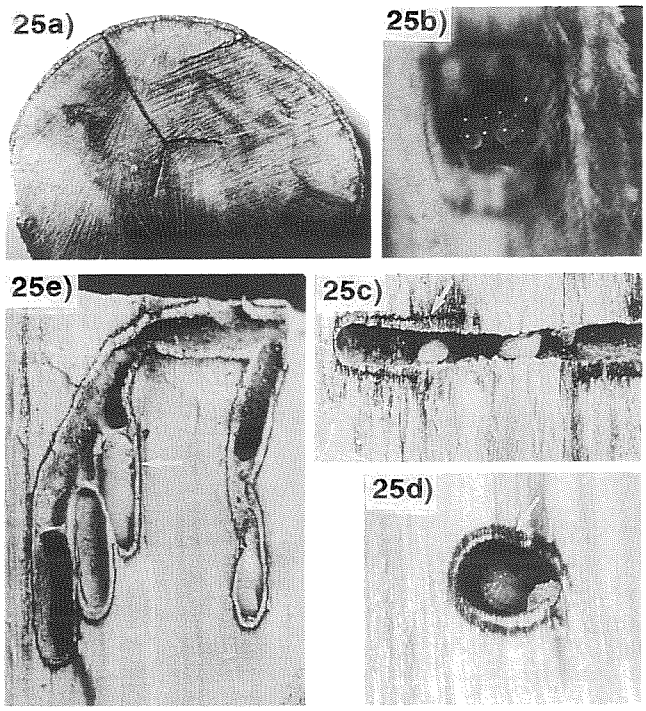

Plate 25. Galleries, eggs, larvae and pupae of *Crossotarsus niponicus* : 25a), tunnel bored in a beech log ; 25b), eggs in a tunnel ; 25c) and 25 d), larvae in a tunnel ; 25e), pupae in pupal cradles. Arrow shows the characteristic black line around the galleries of *C. niponicus*.

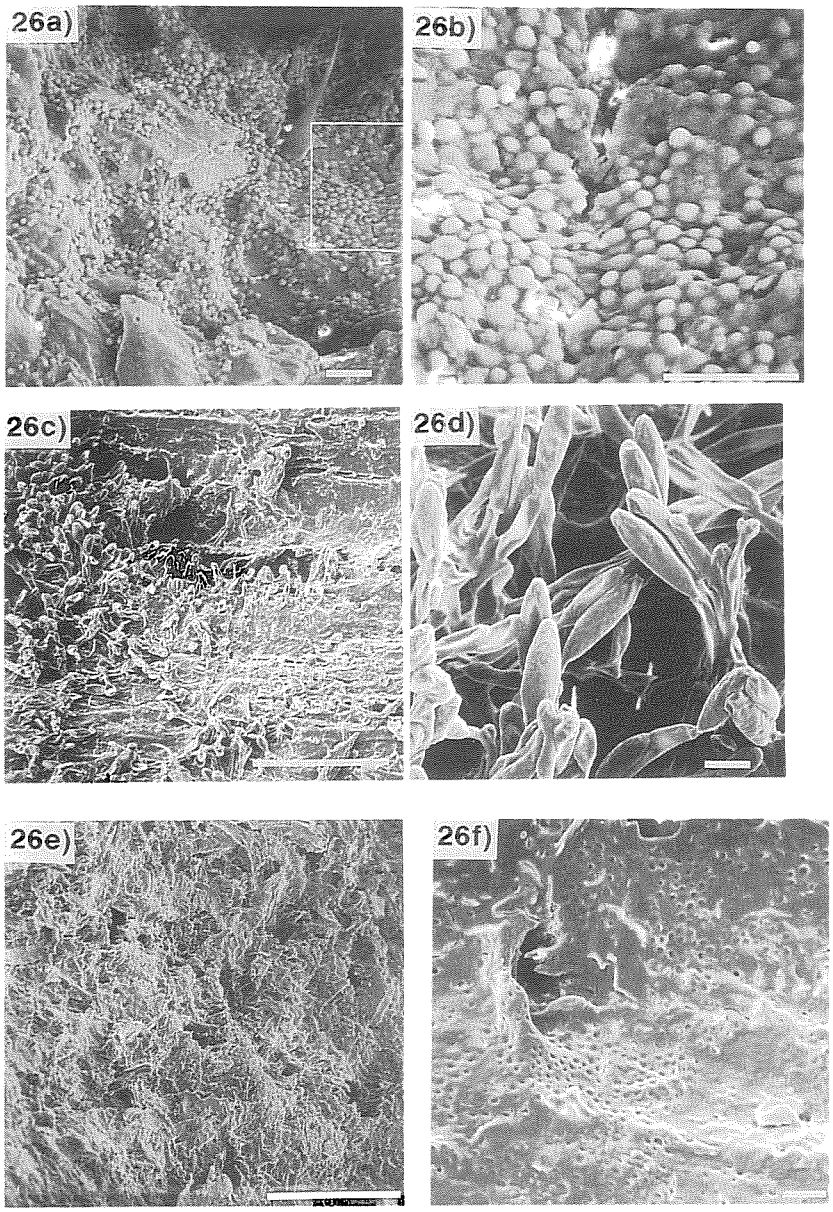

Plate 26. Fungi associated with *C. niponicus* : 26a), small round cells on the wall (late July) ; 26b), high magnification of 26a) ; 26c), rabbit-ear-shaped fungi in pupal cradle (early October) ; 26d), high magnification of 26c) ; 26e), dense mat of fungi at the deep part of pupal cradles (early October) ; 26f), felt-like fungus material in pupal cradles (November). Bars : 26a), 26b), 26d), and 26f)- 10μm ; 26c) and 26e)- 0.1mm

正　誤　表

表題　SEM observations on growing conditions of the fungi in the galleries of several ambrosia beetles (Coleoptera : Scolytidae and Platypodidae).

By　Toshio NAKASHIMA, T. OTOMO, Y. OWADA & T. IIZUKA

頁	誤	正
P.239	C_SO_4	O_SO_4
P.240	stuly	study
	Pupal cradles	pupal cradles
	in the wall.	on the wall.
P.243	few	a few
	14c)	14e)
P.244	23a)	23b)
P.250	3b), broken	3b); 3d), broken
P.252	gallery; 5e)	gallery (early July); 5e)
P.258	(early June)	(early July)
P.259	tunnel an egg	tunnel and an egg
P.262	(late July)	(early July)
	15c) – 1mm	15c) –1 μm