

## Occurrence of an *Ephelis* Fungus on Ishigaki Island and Observations on its Epiphytic Association with Host Grasses

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### Abstract

Distribution of *Ephelis*-infected grasses on Ishigaki, and the frequency at which infected plants were present, were observed over a three year period. Sites with infected plants were most commonly wet areas that had been undisturbed for many years. The frequency of infection varied widely between grass species. In three of the fifteen grasses found to be hosts to this fungus, infected plants were present at many sites, while in other species, infected plants were present at only one or two sites. *Ephelis* infection of three of the grasses was found in only one plant. The number of infected tillers at each site was typically low with apparently a random distribution, and no evidence of spread from sites of infection. Infected plants were characterized by stomata that covered the inflorescence with dense mycelial growth, and in most grasses, by hyphae on the surface of the leaf blades. Infected plants typically showed both infected and *Ephelis*-free tillers. Examination of infected plants of 10 species revealed that the *Ephelis* fungus was essentially an epiphyte, with hyphae in vegetative tillers being located on the surface of the stem apex, including primordial leaves. Hyphae on the leaf blades were also apparently confined to epiphytic growth. Possible mechanisms for infection, the ecological and economic significance of *Ephelis* infection on Ishigaki, and areas for future research are outlined.

**Key words :** Clavicipitaceae, *Ephelis*, epiphyte, grasses

## Introduction

Fifteen species of grasses growing on Ishigaki Island are hosts to a fungus forming a stromata which envelop the inflorescence<sup>11,12,13</sup>. The black appearance of the stromata, and the sterilization of infected tillers, have given rise to the descriptive name "black choke". Leaves of some species infected with this fungus are covered with white hyphal growth. No sexual stage has been observed, but the fungus on all the grass species has been identified as belonging to the anamorphic genus *Ephelis* from the presence of characteristic elongate narrow conidia<sup>13</sup>. Information from conidial morphology and sequence analysis of the ribosomal DNA ITS region in *Ephelis* spp. obtained from different hosts and locations indicate strongly that all the grasses are infected with the same species<sup>10</sup>. In 1904 an *Ephelis* species was reported on *Miscanthus tinctorius* and *Paspalum thunbergii* in Japan and given the name *E. japonica* Hennings<sup>6</sup>. As the description of conidia and stromata of *E. japonica* was similar to that observed in *Ephelis*-infected grasses in Japan in recent years, this may be the correct name to use for the *Ephelis* fungus present in Ishigaki and other locations in Japan. This paper reports on the distribution of *Ephelis*-infected grasses on Ishigaki Island and the frequency at which they were found. Also reported are the results of a study that assessed the nature of the association between the *Ephelis* fungus and host grasses.

## Materials and methods

### 1) Survey of *Ephelis*-infected grasses in Ishigaki

The presence on Ishigaki Island of grasses with *Ephelis* infection stromata on inflorescences and/or white hyphal growth on leaves was recorded over a period of three years.

### 2) Study of the nature of the *Ephelis*/grass association

During April 2-8 1999, *Ephelis*-infected plants of 10 species were identified at previously located sites. The distribution of the infected plants at each site was observed, and the plants sampled for examination. Appearance of stromata was noted, as

were the presence and location of hyphae on leaves. The presence or absence of *Ephelis* stromata on each reproductive tiller of individual plants was also noted.

Hyphal distribution within infected plants was noted. Stems of reproductive tillers were slit open, some internal tissue removed, placed in a drop of aniline blue stain on a microscope slide, covered, heated to boiling, and examined using a compound microscope for the presence of hyphae. Epidermal strips were removed from the leaf blades and sheaths and similarly examined for the presence of intercellular hyphae. The presence of hyphae in stem apices was assessed by dissecting these from terminal portions of non-reproductive tillers, staining with aniline blue, and examining with a compound microscope.

## Results

### 1) Survey of *Ephelis*-infected grasses in Ishigaki

The number of sites where *Ephelis*-infected plants were observed varied markedly for each grass species (Table 1). *Ephelis* infection occurred at many sites in three grasses; *Chrysopogon aciculatus*, *Digitaria violascens* and *Paspalum scrobiculatum*, but only in *P. scrobiculatum* were infected plants common at each site. *Ephelis* infection was recorded at only two sites in three of the 15 grasses (*Brachiaria mutica*, *Chloris barbata*, *Imperata cylindrica* var. *koenigii*), and the number of infected plants was low. The remaining nine species were found only at a single site. In three grasses, (*Cynodon dactylon*, *Eriochloa procera*, *P. urvillei*), *Ephelis* infection was observed only on a single plant. Sites with infected plants were most commonly wet areas that had remained undisturbed for many years. Forest was the least likely habitat where *Ephelis*-infected grasses could be found, with only one species, *Leptochloa panicea* confined to one small site, being located, in spite of intensive surveys conducted over a three-year period. Stromata were observed on 14 of the species, but not on *Cynodon pletostachyurus*, a grass that does not flower in Ishigaki. Leaf infection was observed for 13 of the grasses, with infection being particularly conspicuous on *B. mutica* and *C. pletostachyurus* (Table 1).

Table 1. Grass species with *Ephelis* present on Ishigaki island, their frequency of infection, and symptoms

Grass species	Subfamily	Tribe
<i>Brachiaria mutica</i> (Forsk.) Stapf (Paragrass) <sup>a,c,e)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Chloris barbata</i> Swartz. (Purple top chloris) <sup>a,c)</sup>	Chloridoideae	Chlorideae
<i>Chloris divaricata</i> R. Br. <sup>a,c)</sup>	Chloridoideae	Andropogoneae
<i>Chrysopogon aciculatus</i> (Retz.) Trin. <sup>a,b)</sup>	Panicoideae (Andropogonodae)	Andropogoneae
<i>Cynodon dactylon</i> (L.) Pers. (Bermudagrass) <sup>c,d,f)</sup>	Chloridoideae	Chlorideae
<i>Cynodon pletostachyus</i> (K. Schm.) Pilger <sup>a,c,e)</sup> (Giant star grass)	Chloridoideae	Chlorideae
<i>Digitaria eriantha</i> Steud. (Pangola grass) <sup>c)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Digitaria violascens</i> Link. <sup>a,b)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Eriochloa procera</i> C. H. Hubb. <sup>c,d)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Imperata cylindrica</i> (L.) Beauv. var. <i>koenigii</i> (Retz). Durand et Schinz (Needlegrass) <sup>a,c,d,f)</sup>	Panicoideae (Andropogonodae)	Andropogoneae
<i>Leptochloa panicea</i> (Retz.) Ohwi <sup>a,c,d)</sup>	Chloridoideae	Chlorideae
<i>Panicum crus-galli</i> , Beauv. var. <i>praticola</i> Ohwi <sup>c)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Panicum repens</i> L. <sup>a,c)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Paspalum scrobiculatum</i> G. Forst <sup>a,b)</sup>	Panicoideae (Panicodae)	Paniceae
<i>Paspalum urvillei</i> Steud. <sup>c,d)</sup>	Panicoideae (Panicodae)	Paniceae

a) examined in April 1999 study

b) present at many sites

c) present at just 1 or 2 sites

d) very rare

e) leaf blades conspicuously colonized

f) leaf blades not colonized

## 2) Study of the nature of the *Ephelis*/grass association

Ten species of grasses with *Ephelis* were identified and examined in the April 1999 survey. Several *Ephelis*-infected plants were examined for each species except *I. cylindrica*, for which only a single tiller with a stroma was found. Frequency of infection of *Ephelis*-infected plants at each site, with just two exceptions, was typically low, with perhaps only 1% or less of tillers showing evidence of infection. The first exception was an area of mown turf that had been established for over twenty years, and where many tillers of *C. aciculatus* were infected with *Ephelis*. The second exception was with *P. scrobiculatum* where infected tillers were widespread at several sites. Distribution of infected plants within sites was apparently random, with no evidence of spread from a focal point.

## 3) Stromata characteristics

Stromata in all the grasses were initially comprised of dense white hyphal growth covering the developing seeds, later becoming black (Plate 1). Hyphal growth was absent below the basal branches of inflorescences. Numerous narrow, elongate conidia were present on the stromata. No perithecia were observed.

## 4) Leaf colonization

Hyphae were observed on the leaf blades of 8 of the 10 *Ephelis*-infected grasses examined in the April 1999 survey. In two grass species, *B. mutica* and *C. pletostachyus*, hyphal growth was conspicuous, and infected plants could be readily detected. Hyphal growth on leaves of *C. barbata* and *D. violascens* was sparse and difficult to detect without the use of a stereo dissecting microscope. No hyphae were observed on the leaves of *C. divaricata* and *I. cylindrica*. Hyphal distribution on leaves was noted for the two grasses that were the most conspicuously colonized, *B. mutica* and *C. pletostachyus* (Plate 2). Hyphae were confined almost entirely to the blades; occasionally, sparse hyphae were also present on the sheath, located in close proximity to the ligular zone. Hyphae were never seen on the inner surface of the sheath adjacent to the stem. Hyphae on blades were present as dense, longitudinally orientated masses.

On the upper side of the blades they were located between the ridges containing the vascular bundles. Numerous elongate narrow conidia were produced by hyphae on the leaf blades. The hyphae appeared confined to the surface of leaves, with no hyphae detected in the mesophyll of the leaf blades or sheaths. Leaves of infected tillers of these two heavily colonized grasses were conspicuously shorter than those of *Ephelis*-free tillers.

## 5) Stem apex and stem infection

Hyphae were observed on the surface of stem apices, including primordial leaves, of all nine of the *Ephelis*-infected grass species for which non-reproductive tillers were available for examination. Short hyphae apparently growing intercellularly within young leaf blades were occasionally observed. Hyphae were not seen in tissues from within hollow stems of reproductive tillers, or in tissues removed from nodes of these tillers.

## 6) Distribution of *Ephelis* infected tillers within plants

*Ephelis*-infected plants typically had both infected and healthy tillers. In the stoloniferous grasses *B. mutica* and *C. pletostachyus*, *Ephelis* infection was often confined to just a few tillers arising from one part of the branching network of stolons. In non-stoloniferous grasses, infected tillers appeared to be randomly distributed. In contrast, all the leaves of the infected tillers, with one exception, were colonized by hyphae. The exception was a tiller of *B. mutica* where the four youngest leaves were heavily colonized by epiphytic hyphae, the fifth was sparsely colonized, while the two oldest leaves had no visible hyphae.

## Discussion

In this study it was found that the frequency of *Ephelis* infection for each grass species, both in terms of the number of sites located, and the frequency at which infected plants were infected within sites varied widely. It is certain that there are more sites where *Ephelis*-infected grasses are present than those found in this survey. However, the study provides a good indication of the frequency



Plate 1. Stroma on *Brachiaria mutica* inflorescence



Plate 2. Hyphae on *Cynodon pletostachyus* leaves

of infection of grasses in Ishigaki. In particular, it seems certain that the occurrence of *Ephelis* infection of forest grasses is very rare as these grasses were subjected to extensive surveys over a period of three years. The most common sites were areas of grassland that had remained undisturbed for many years, with few infected plants found in recently established paddocks. However, no infected plants were detected in close proximity to the sea, even in grasslands established for a long period of time. Within sites, infection was typically very low, and no sites were found at which the majority of the tillers were infected.

All of the host grasses were C4 species, and representatives of two sub-families, and three tribes (Table 1). The general appearance of the host species varied markedly, ranging from small-leaved plants that could persist under turf management to tall broad-leaved types. The relationship of the *Ephelis* fungus to all 10 species of grass examined was essentially that of an epiphyte. Hyphae were located on the surface of the stem apices from where they can colonize the developing leaves and inflorescences, and the axillary buds which give rise to new tillers. The epiphytic nature of the association was also apparent by the dense covering of hyphae present on the surface of leaf blades of some grass species. This epiphytic relationship was similar to that reported for other Clavicipitaceous fungi which have *Ephelis* conidia, belonging to the genera *Balansia* and *Atkinsonella*<sup>9,17</sup>.

The epiphytic relationship between the *Ephelis* species and the grasses it colonizes on Ishigaki was illustrated by a comparison of the distribution of hyphae on leaves and reproductive tillers with the hyphal distribution of the endophytic *Epichloë/Neotyphodium* fungi. In leaves, hyphae of these endophytic fungi were typically most concentrated in the sheaths, while *Ephelis* hyphae were almost entirely associated with blades. In the blades of *Epichloë/Neotyphodium*-infected leaves, the hyphae, if present, were mainly concentrated in the basal, oldest, region<sup>7</sup>). In *Ephelis*-infected plants the hyphae tended to be uniformly located along the blades. Hyphae were abundant in the stem of reproductive tillers of *Epichloë/Neotyphodium*-infected plants, and

in the swollen nodes of these tillers. In *Ephelis*-infected plants, hyphae were either apparently absent in these tissues or at least present at low concentrations. The efficiency of colonization of axillary buds was typically high in *Epichloë/Neotyphodium* associations, with endophyte-free tillers being seldom observed. In contrast, healthy tillers were typically present on the *Ephelis*-infected plants examined.

This distribution of infected grasses within sites provides clues as to how plants become systemically infected. One possible mechanism for infection is the penetration of leaves or crowns by hyphae from germinating conidia. Such a mechanism is unlikely, as for systemic infection to occur hyphae would have to penetrate through the densely packed layers of leaf sheaths and then colonize the stem apex. The sparse distribution of infected plants in natural populations of *B. mutica* and *C. pletostachyris*, species with very high concentrations of conidia being produced on the surface of leaves, provides evidence that this is not the mechanism of infection. It is unlikely that infection would occur from *Ephelis* within the soil as Clavicipitaceous fungi are in nature obligate biotrophs<sup>17</sup>). Transmission through the seed appears to provide the most likely explanation of how plants become systemically infected. Vertical seed transmission has been reported for a symptomless *Ephelis* sp. found in association with *Danthonia spicata*<sup>8</sup>). During the vegetative growth of the plant, the fungus inhabits only the external surfaces of the shoot apex and adjoining rudimentary leaves. However, with the change of the host to the reproductive phase, the fungus becomes incorporated into the developing ovary and ovule, penetrating the microphyle to the megagametophyte wall. Hyphae enter the embryo sac at early embryogenesis and remain there during normal embryo development. Since hyphae, however, invade the surface of the embryonic shoot apex before it is enclosed by the coleoptile rim, as the case of in *Neotyphodium*-infected plants, infection of the next generation had already occurred before seed maturation. Following germination, hyphae from the seedling apex may colonize the stem apex of each new tiller. However, vertical seed transmission generally seems unlikely

in grasses infected with the *Ephelis* species present in Ishigaki as developing inflorescences of *Ephelis*-infected grasses in Ishigaki became heavily colonised by hyphae, preventing seed development and dispersal. A possible exception is *P. scrobiculatum*, where stomatal development did not always result in complete colonisation of inflorescences. This is one of the two species of grasses where the incidence of *Ephelis* infection was relatively high at some sites.

Another possible mechanism for new infections with *Ephelis* is horizontal transmission. With this form of transmission, infection might occur by hyphal penetration of stigmata of neighboring uninfected plants, and subsequent growth into developing ovaries and ovules. Hyphae would invade the developing embryo and colonize the surface of the shoot apex, as in the case of the *Ephelis* of *D. spicata*. Horizontal infection via stigmata occurs in other Clavicipitaceous fungi forming associations with grasses<sup>9</sup>). With *Claviceps* species, infection following stigmata penetration is confined to the developing seed and gives rise to fungal sclerotia. Horizontal infection with *Balansia obtecta*, in contrast, produces viable seeds which give rise to systemically infected seedlings. A further example is *Epichloë typhina*, in which, as in *Ephelis* infection of grasses in Ishigaki, stomatal development results in sterilization of the host plant<sup>2</sup>). The relatively low incidence of *Ephelis*-infected grasses on Ishigaki indicates that if horizontal transmission does occur it is either a rare occurrence, or that germination of infected seeds and subsequent growth of infected seedlings are adversely affected, and few plants become established. A complicating factor is that in other Clavicipitaceous fungi which form systemic seedborne infections with grasses following horizontal transmission, hyphae from ascospores and not conidia, penetrate into the stigmata<sup>2,3,9</sup>). To date, no perithecia have been observed on *Ephelis*-infected grasses present in Japan. One possibility is that the dark hyphal masses which develop as stomata age may function as sclerotia, and germinate to produce apothecia and perithecia as occurs with *Claviceps* spp. and *B. obtecta*.

Factors other than the frequency of infection may

influence the incidence of *Ephelis*-infected plants. It is possible that in some grasses *Ephelis* infection gives them a competitive advantage. This may result from enhanced tolerance to insect pests. This hypothesis is supported by insect feeding trials which have revealed the existence of insect feeding deterrence in *Ephelis*-infected grasses in two grasshoppers, *Oxya yezoensis*<sup>14</sup>), and *Aiolopus thalassinus* (Takahashi, unpubl. data), and an armyworm, *Mythimna (Pseudaletia) separata* (Takahashi, unpubl. data). Further evidence of *Ephelis*-induced insect feeding deterrence is by the higher incidence of a mealy bug observed on *Ephelis*-free than on *Ephelis*-infected *Digitaria eriantha* growing in a glass-house. Over time the incidence of infected perennial plants is likely to increase, even in the absence of fresh infection. In long-lived perennial grasses such as *C. aciculatus* and *P. scrobiculatum*, infected plants increase in size, either from growth of stolons in the case of *C. aciculatus*, or from increases in the number of tillers as in the case of *P. scrobiculatum*. Free-standing plants with enhanced competitive advantage relative to non-infected plants, would arise from the death of segments of stolons, and from the fragmentation of the crowns of non-stoloniferous grasses, increasing the frequency of occurrence of infected plants.

Conversely, the low incidence of *Ephelis* infection in most of the host species suggests that infection is not beneficial to the host plant or may even have a detrimental effect on plant survival and persistence. The growth of epiphytic hyphae on leaf blades may cause stress to host plant. Nutrients are required for extensive epiphytic hyphal growth to occur on blades, and these hyphae must receive a continuous supply of water to prevent desiccation. A possible mechanism to ensure a supply of nutrients and water is that the hyphae modify the cuticle and epidermal cells of leaves, allowing movement of nutrients and water from the apoplast to the hyphae where they will be absorbed. Disruption of the cuticle has been reported in *D. spicata* plants infected with the symptomless, seed-transmitted *Ephelis* species, associated with hyphal colonization of the internal surfaces of ovaries and ovules<sup>8</sup>). Modification of epidermal cells and cuticle has also been reported in

grasses infected with the Clavicipitaceous fungi *Myriogenospora atramentosa* Atk. and *B. epichloë* (Weese) Diehl<sup>15</sup>; and *E. amarillans*<sup>16</sup>). Water loss associated with increased permeability of the cuticle and epidermal layer may increase the susceptibility of *Ephelis*-infected plants to drought, and thus provide an explanation why infected grasses are found mainly in wet areas where the effects of water loss will be less damaging.

Infection of grasses with *Ephelis* appears to have little ecological or economic significance in Ishigaki. The typically low incidence of infected plants indicates a lack of a competitive advantage over non-infected plants, even though the presence of the fungus may confer protection against some insects. It is not known if grasses infected with this *Ephelis* species contain alkaloids that are toxic to grazing animals, as are grasses infected with other Clavicipitaceae fungi. These alkaloids have been extensively studied in *C. purpurea*<sup>5</sup>), and in *Neotyphodium*-infected *L. perenne*, *F. arundinacea*, and *F. pratensis*<sup>1</sup>). Their presence has important implication for the health of grazing animals<sup>4</sup>). It seems unlikely that even if such alkaloids were present in *Ephelis*-infected grasses on Ishigaki the concentrations would reach harmful levels as the incidence of infected plants is low.

The findings of this study point to areas requiring further investigations as follows: First, is the *Ephelis* fungus transmitted through vertical and/or horizontal transmission? A second area of research is the presence of alkaloids in *Ephelis*-infected plants. Do all of the grass species contain the same alkaloids? The findings may contribute to understanding of the evolution of biotrophic Clavicipitaceae fungi. It is also possible that infected plants may contain secondary metabolites of pharmacological importance. A third area for research is the effect of epiphytic hyphae on the cuticle and epidermal layer of leaves and the developing inflorescence. Finally, there exists within the gramminicolous Clavicipitaceae fungi, a continuum in the nature of their association with host grasses, ranging from infection being confined entirely to the seed resulting in seed death, to associations in which the fungus grows as a symptomless seed-transmitted endophyte. More detailed information on the Ishigaki

*Ephelis* should contribute to the international effort to better understand this continuum of association and how these associations may have evolved.

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## *Ephelis* 属菌の石垣島における発生および寄主植物との表生関係

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### 摘 要

*Ephelis* sp. はバツカク菌科 Balansiae 族に属する糸状菌の一種である。1997年から1999年の3年間にわたり、石垣島において本菌の分布状況、および個々の草での感染生態を調査した。結果の概要は以下の通りである。

1) 本菌の感染は次に示すイネ科10属15草種において認められた。すなわちパラグラス *Brachiaria mutica* (Forsk.) Stapf、シマヒゲシバ *Chloris barbata* Swartz.、ヒメヒゲシバ *Chloris divaricata* R. Br.、オキナワミチシバ *Chrysopogon aciculatus* (Retz.) Trin.、バミューダグラス *Cynodon dactylon* (L.) Pers.、ジャイアントスターグラス *Cynodon pletostachyus* (K. Schm.) Pilger、パンゴラグラス *Digitaria eriantha* Steud.、アキメヒシバ *Digitaria violascens* Link.、ムラサキノキビ *Eriochloa procera* C. H. Hubb.、チガヤ *Imperata cylindrica* (L.) Beauv. var. *koenigii* (Retz.) Durand et Schinz.、イトアゼガヤ *Leptochloa panicea* (Retz.) Ohwi.、イヌビエ *Panicum crus-galli*, Beauv. var. *praticola* Ohwi.、ハイキビ *Panicum repens* L.、スズメノコビエ *Paspalum scrobiculatum* G. Forst.、タチスズメノヒエ *Paspalum urvillei* Steud.

2) 感染植物は長年にわたって不耕起状態にある湿った場所に多くみられた。感染株の頻度は草種によって以下のように大きく異なった。すなわちオキナワミチシバ、アキメヒシバ、スズメノコビエの3草種での感染は島内各所で観察され、特にスズメノコビエでの感染率は高かった。パラグ

ラス、シマヒゲシバ、チガヤは2カ所で確認され、残りの9草種での感染はそれぞれ1カ所のみであった。特にバミューダグラス、ムラサキノキビ、タチスズメノヒエの感染株はそれぞれ1株ずつのみであった。ジャイアントスターグラスを除いて残りの14草種でミイラ穂症状が確認された。なお、ジャイアントスターグラスは日本では開花しない。葉上への感染は13草種で確認され、その病徴は特にパラグラス、ジャイアントスターグラスで著しかった。

3) 子座ははじめ種子を覆う濃い白い菌糸から成り、やがて黒化する。穂の最も下の小枝より下では菌糸の伸長は認められなかった。子座上には多数の細長い分生子が存在するが、子のう殻は観察されなかった。

4) 1999年4月に観察した10草種のうち8草種で葉上に菌糸が認められた。パラグラスおよびジャイアントスターグラスでの菌糸の生育は特に著しく、発見は容易であった。シマヒゲシバおよびアキメヒシバ葉上での菌糸の生育は悪く、肉眼では観察が難であった。ヒメヒゲシバおよびチガヤでは葉上での菌糸の生育は認められなかった。最も病徴のはげしいパンゴラグラスおよびジャイアントスターグラスの2草種で葉上の菌糸の分布を観察した。菌糸の発育はほぼ葉上に限られているが、時には葉鞘にもみられた。しかし葉鞘の茎に接する内側には菌糸はまったく観察されなかった。葉上の菌糸は長軸に沿って高密度で存

在し、葉表面の菌糸上には多数の細長い分生子が形成されていた。菌糸は葉上に限られ、葉あるいは葉鞘の内部では観察されなかった。本菌に感染した葉は、健全葉に比較してはなはだ短かった。

5) *Ephelis* 感染植物のうち、供試可能な感染茎が得られた 9 草種について観察した結果、すべての草種で葉原基および茎頂部表面に菌糸が観察された。若い葉身では、まれに菌糸のごく一部が細胞間隙を伸長していた。非感染茎の茎および節内部では菌糸は観察されなかった。

6) *Ephelis* 感染株内には、感染茎と非感染茎が

混在していた。匍匐茎型植物であるパラグラスおよびジャイアントスターグラスでは、感染茎は感染部位から第 2 ないし第 3 分けつ茎までに限られた。非匍匐型草種では、感染茎は株内にランダムに分布していた。これに対し、パラグラスを例外として感染茎ではすべての葉表面で菌糸が伸長していた。パラグラスでは、感染茎の最も若い葉が上面を厚い菌糸叢に覆われ、第 5 葉では菌糸がまばらだったが、第 1 および第 2 葉では菌糸はまったく観察できなかった。

キーワード：バツカク菌科, *Ephelis*, エピファイト, イネ科草