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FULL PAPER

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Morphology and comparative ecology of the fairy ring fungi, *Vascellum curtisii* and *Bovista dermoxantha*, on turf of bentgrass, bluegrass, and Zoysiagrass

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Abstract We identified the causal fungi of fairy rings as *Vascellum curtisii* and *Bovista dermoxantha* on the turf of bentgrass, bluegrass, and Zoysiagrass. Observing the fairy rings developed in the turfgrass study site in Chiba City for 5 years from 1998, *V. curtisii*, producing sporophores during June and November except midsummer, formed darker-green rings than the adjacent turf and withered the three kinds of turf. *B. dermoxantha* produced sporophores exclusively in midsummer. The fungus formed dark green rings on the three kinds of turf but withered only bentgrass and bluegrass. The optimum mycelial growth temperature of *V. curtisii* was 30°C. Whereas that of *B. dermoxantha* ranged between 35° and 40°C. The infection test of the fungi to the seedlings revealed that *V. curtisii* damaged Zoysiagrass more severely than bentgrass and that *B. dermoxantha* was more injurious to bentgrass than Zoysiagrass.

Key words *Agrostis* · Fairy rings · *Poa* · Turfgrass disease · *Zoysia*

Introduction

Fairy rings on turf are caused by 54 recorded species of Basidiomycetes (Couch 1995). Shantz and Piemeisel (1917) divided these into three types: I, those that kill the grass or badly damage it; II, those which stimulate grass growth only; and III, those that cause no damage to the turf. Fairy rings due to *Marasmium oreades* (Bolt.: Fr.) Fr., a type III fungus, have been fully studied and reviewed, including practical control methods, by Smith et al. (1989). In Japan, four fungi have been reported as causal organisms: *Lycoperdon perlatum* Pers., *Lepista sordida* (Schuml: Fr.) Sing. (Tahama 1980; Tani 1991), *M. oreades*, and *Agaricus campestris* L.: Fr. (Tani 1991).

In 1989, on the turf in Chiba City, the middle part of Japan, we recognized fairy rings caused by two species of Lycoperdaceae. These two species differed in sporophore occurrence (sings) and symptoms according to seasons and turfgrass species. The aim of this study is to give full descriptions of the species and to comparatively present differences in their sporophore occurrence and symptoms based on field observations as well as experimental results. This is the first report describing symptoms on the turf of bentgrass and bluegrass caused by Lycoperdaceae in Japan.

Materials and methods

Field observations and identification

Field observations were made on turf in Chiba Prefectural Agriculture Research Center, Chiba City. Bentgrass (*Agrostis palustris* Huds.), bluegrass (*Poa pratensis* L.), and Zoysiagrass (*Zoysia matrella* Merr.) were grown separately. The turf of *A. palustris* and *Z. matrella* was established in 1990 and the *P. pratensis* turf in 2000.

Observations were made every 7 days from Apri1 to December during 1998 and 2002. The number of sporophores was counted for each fungus each time except 1998. The days when more than 20% of total sporophores occurred were defined as peak occurrence days. Changes in symptoms were also recorded. Weather data in Chiba City were obtained from the automated meteorological data acquisition system. Morphology of sporophores was observed using optical and scanning electron microscopes. Fungal species were identified according to the description of Kreisel (1973).

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Table 1. List of fungal isolates used

Fungus	Isolate code	Origin			
		Location in Japan	Year	Turfgrass	Source for mycelial isolation
Vascellum curtisii	Vp6	Chiba	1998	*Agrostis palustris*	Fruit body
Vascellum curtisii	Vp10	Chiba	1998	*Zoysia matrella*	Fruit body
Vascellum curtisii	Vp13	Chiba	1998	*A. palustris*	Fruit body
Vascellum curtisii	Vp16	Chiba	1998	*A. palustris*	Mycelial strand
Vascellum curtisii	Vp24	Chiba	2002	*Poa pratensis*	Fruit body
Bovista dermoxantha	Lp1	Chiba	1998	*A. palustris*	Fruit body
Bovista dermoxantha	Lp2	Chiba	1998	*A. palustris*	Fruit body
Bovista dermoxantha	Lp10C	Chiba	1998	*A. palustris*	Mycelial strand
Bovista dermoxantha	Lp18	Chiba	2001	*P. pratensis*	Fruit body
Bovista dermoxantha	Lp19	Osaka	2001	*A. palustris*	Fruit body
Bovista dermoxantha	Lp21	Chiba	2001	*Z. matrella* and *Lolium perenne*	Fruit body

Fungal culture

Eleven fungal isolates listed in Table 1 were used. Nine of them originated from inside the tissues of sporophores. The other two, Vp16 and Lp10C, were isolated from mycelial cords grown on soil blocks taken beneath withered turfgrass in rings. They were maintained on modified Czapek Dox agar (mCZ) medium [15 g glucose, 15 g sucrose, 5 g yeast extract (Difco, Detroit, MI, USA), 5 g polypepton (Nihon, Osaka, Japan), 1 g KH_2PO_4, 0.5 g $MgSO_4 \cdot 7H_2O$, 0.5 g KCl, 0.01 g $FeSO_4 \cdot 7H_20$, and 15 g agar in 1 l distilled water], and transferred several times.

Isolates were grown on mCZ medium at eight different temperatures ranging from 0° to 50°C in the dark for 7–14 days with five repetitions. Morphological observations were made on hyphae and colonies of isolates Vp16 and Lp10C on mCZ medium.

Inoculation

Turfgrass seedlings

Seedlings of *A. palustris* and *Zoysia japonica* Steud., substituting for *Z. matrella*, were used to examine the influence of the fungi in terms of color change of the turf surfaces. Seeds of *A. palustris* and *Z. japonica* were sterilized in 70% ethanol for 1 and 3 min and in 3% and 5% sodium hypochloride solution for 10 min, respectively, and washed three times in sterilized water. They were incubated at 25° and 30°C under fluorescent light (3000 lux) 16 h/day for 7 and 14 days to sprout, respectively.

Infection behavior of fungi on turfgrass seedlings

The infection behavior of the fungal mycelia to the seedlings was observed. Disks (5 mm diameter) of mCZ medium cultures of isolates Vp16 and Lp10C taken from the colony periphery were grown in plant culture test tubes (24 mm diameter and 100 mm height) containing water agar at 28°C for 7 days. Seeds of *A. palustris* and *Z. japonica* were aseptically grown on moist glass filter paper in Petri dishes. About ten seedlings of each kind were then transplanted to a test tube and incubated at 28°C. The seedlings of each kind were harvested from three tubes every 3 days for 30 days, and leaves and roots were separately observed under a microscope.

Influence of temperature on color changes of turf inoculated with fungi

Seeds of *A. palustris* and *Z. japonica* were sown densely on the whole surface of commercial soil (Metro Mix 350; Scotts, Sierra Horticultural Products, Marysville, OH, USA; water content 65%) in polyethylene ice-cream cups (120 mm in diameter). After sprouting, plants were trimmed to ~5 mm high, and mycelial disks of isolates Vp16 and Lp10C were inoculated onto the periphery in the Petri dish. Each cup was incubated at 15°, 20°, 25°, 30°, 35°, 40°, and 45°C with triplicates. After 7 days, plants were trimmed again and the color of the turf surfaces was measured five times with a chroma meter (CR-300; Minolta, Tokyo, Japan). The a* value measured by the meter among L*, a*, and b* values in CIE LAB color space by the Japanese industrial standard (1994) was used. The large extent of minus a* value indicates vivid green, zero dull, and the large extent of plus a* value vivid red. Thus, the extent of green color is indicated by the extent of a minus a* value.

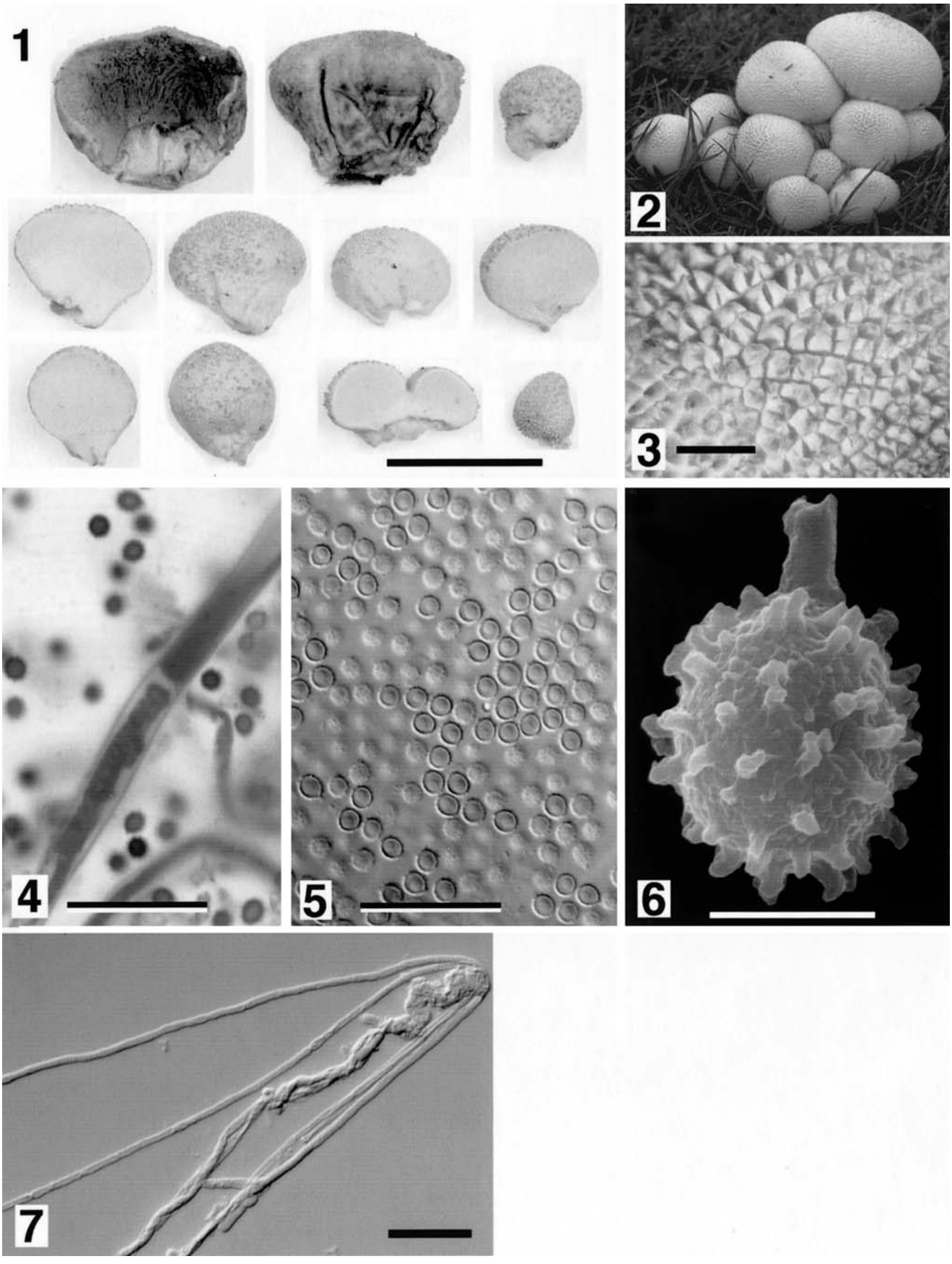
Results

Morphology

The two species of Lycoperdaceae were identified as follows.

Vascellum curtisii (Berk.) Kreisel [=*Lycoperdon curtisii* Berk. & Curt.; *L. wrightii* Berk. & Curt.] (Smith 1974; Homrich and Wright 1987).

Sporophore 1–2(–4) cm broad, globose to subglobose or pear shaped, white when young, becoming golden-wheat to grayish-yellow with age, with an ostiole on the top (Figs. 1, 2). Exoperidium deciduous tapering toward the end and



Figs. 1–7. Morphological features of *Vascellum curtisii*. **1** Sporophores. **2** Sporophores occurred on *Zoysia matrella* turf in the study site. **3** Exoperidium of the sterile outer layer. **4** Paracapillitium, which is acyanophilic with cotton blue [1% (w/v) cotton blue in lactic acid and phenol]. **5** Spores under a differential interference microscope. **6** Scanning electron micrograph of a spore with a pedicel. **7** Generative hypha and mycelial strand. *Bars* **1** 20 mm; **3** 2 mm; **4,5** 20 μm; **6** 2 μm; **7** 50 μm

convergent fibrils (Fig. 3), soon lost, endoperidium white, thick. Gleba white and olive-brown at maturity, powdery, distinct diaphragm separates chambered subgleba. Paracapi11itim hyaline 3.5–4.0 μm wide, thin with septa (Fig. 4). Spores mostly subglobose and sometimes globose, 3.5–4.0 × 3.0–3.5 μm in size, verruculose, occasionally with short pedice1 (1–3 μm, Figs. 5, 6). This fungus had generative hyphae lacking clamp connection, mycelial strands, and bobbin-1ike structure (Fig. 7). The colonies of this fungus were pale yellow, thin, and forming secta.

Bovista dermoxantha (Vittad.) de Toni [=*B. pusilla* (Batsch: Pers.) Pers.; *L. pusillum* Batsch ss. Hollós non Batsch.] (Moyersoen and Demoulin 1996; Jeppson 1998).

Sporophore 0.5–2.0 cm broad, globose to subglobose, white when young, and becomes golden-yellow and fragmented with age (Fig. 8), frequently with rhizomorph (Fig. 9). Exoperidium thin, papyraseous, granulous with persistent capi11itia, rimose-areolate when mature (Fig. 10), endoperidium thick, white, and yellow at maturity. Gleba white and olive-ye11ow at maturity, subgleba mostly absent, rarely present with obvious diaphragm of linear hyphae. Capi11itium ye11ow-brown, 5.0–5.5 μm wide, branched, thick with abundant pores, ending with narrow tips (Fig. 11). Spores globose, 5.5–6.0 μm in diameter, yellow, verruculose frequently with pedicels [(4.0–)5.5–6.0 μm; Figs. 12, 13). The fungus showed generative hyphae without clamp connection, and aged hyphae sometimes formed a chlamydospore-like structure (Fig. 14). The colonies of this fungus were white, thick, and woolly.

Note: Specimens of the two fungi from the study site were identified by Hanns Kreisel, Germany. The morphology of the specimens of *V. curtisii* was in accordance with the descriptions by Smith (1974) and Homrich and Wright (1987). The morphology of the specimens of *B. dermoxantha* was identical to the descriptions by Moyersoen and Demoulin (1996) and Jeppson (1998), except the number of septa in the capillitia; the septa were not observed in the specimens from Chiba, whereas either report described the presence of abundant septa in the capillitia.

Sporophore occurrence and symptoms in the field

Five-year observations revealed that sporophore occurrences of *V. curtisii* and *B. dermoxantha* and appearances of symptoms varied according to seasons and the turf species *A. palustris*, *P. pratensis*, and *Z. matre11a* (Fig. 15). Sporophores of both fungi occurred from June to November. On the *A. palustris* turf, the peak occurrence of *V. curtisii* was in June, July, and September, and no sporophore was observed from 2000 onward. On the turf of *P. pratensis* and *Z. matrella*, the peaks were in September, whereas *B. dermoxantha* culminated in July and August on the three kinds of turf. On the turf of *A. palustris* and *P. pratensis*, the sporophores of this fungus occurred more densely than those of *V. curtisii*.

V. curtisii caused a color change to dark green and withered all three kinds of turfgrass: *A. palustris*, *P. pratesis* (Fig. 16), and *Z. matrella* (Fig. 17). *B. dermoxantha* also induced a color change and withered turfgrasses on the turf of *A. palustris* (Fig. 18) and *P. pratensis* (Figs. 19, 20) but did not wither the *Z. matrella* turfgrass (Fig. 21).

V. curtisii and *B. dermoxantha* caused a color change to dark green or withered turfgrass in rings or arcs 40–200 cm in diameter. The mycelia of *V. curtisii* densely developed in the thatch layer (the organic layer; ~0.5 cm on the *A. palustris* turf and 1.5–2.0 cm on the *Z. matrella* turf) and in the soil at ~2 cm depth from the surface (Fig. 22), whereas the mycelia of *B. dermoxantha* were scantily developed between ~0.5 and 4.0 cm depth. The sporophores of the two fungi as well as their fairy rings were sometimes mingled or formed very close to each other (Fig. 23). Fairy rings of each fungus were transitory. The withered part on the turf of *A. palustris* and *P. pratensis* enlarged outside and was not restorable in and after October, or was masked by the adjacent healthy grass, and the rings disappeared by November. On the *Z. matrella* turf, withered parts of fairy rings were inconspicuous in winter, masked by adjacent withering turfgrass.

There was no relationship between signs and symptoms and precipitation from June to November through 1998–2002. However, lower temperatures minimized the damage of withering turfgrass; in 2001, the average temperature in August was the lowest in the past 10 years, and the turfgrass of *A. palustris* withered by *B. dermoxantha* recovered more rapidly than in the other 4 years.

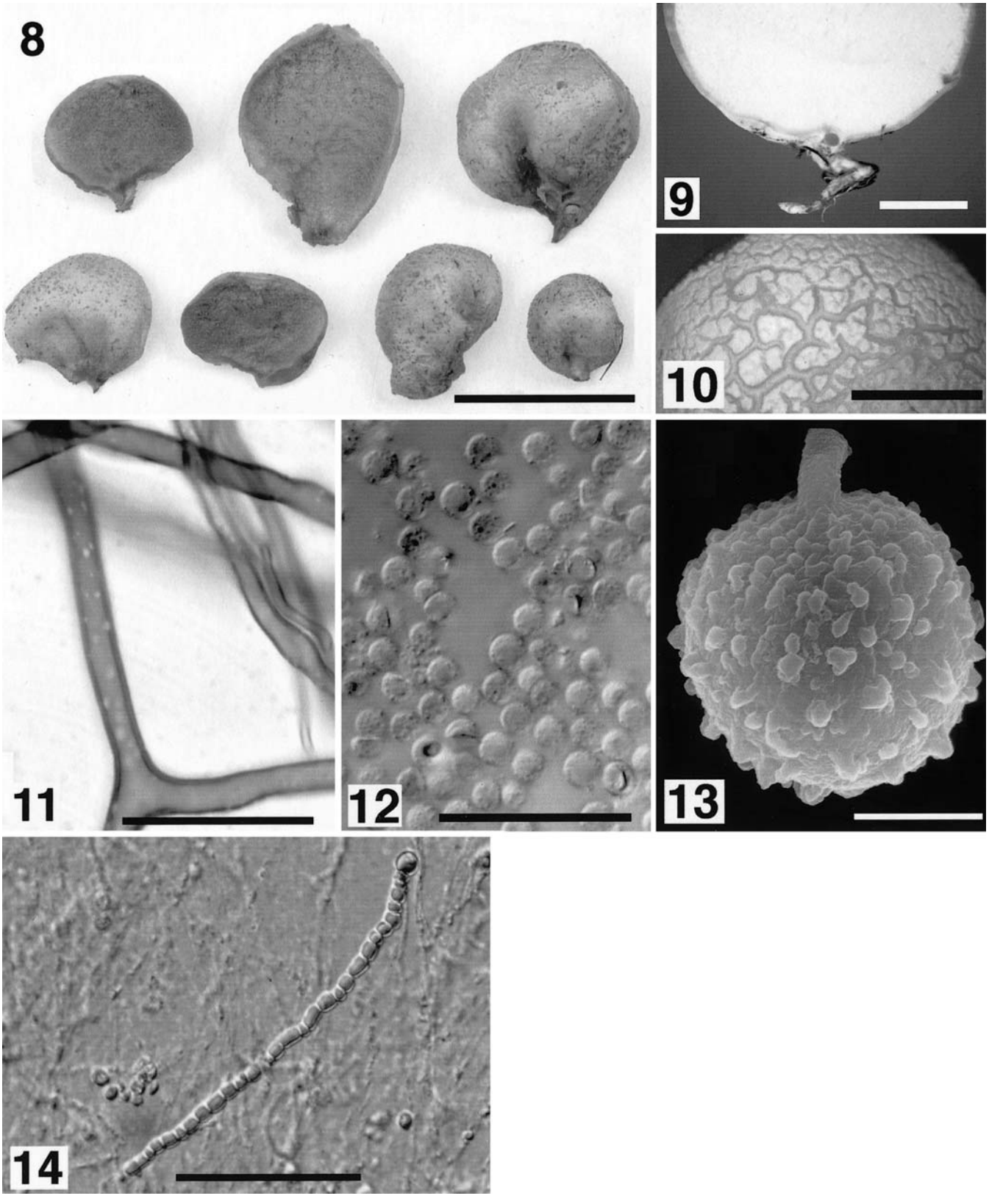
Influence of temperature on mycelial growth

Figure 24 shows mycelial growth of *V. curtisii* and *B. dermoxantha* at 0° to 50°C. Five isolates of *V. curtisii* grew at temperatures ranging from 15° to 35°C and grew most rapidly at 30°C. The minimum growth temperature of the six isolates of *B. dermoxantha* was 10° or 15°C and the maximum was 40°C. The optimum growth temperature was 35° or 40°C.

Infection of the fungi on turfgrass seedlings

The leaves and roots of *A. palustris* and *Z. japonica* cultured with either fungus were examined. The mycelia of *V. curtisii* entered the intercellular spaces of the green leaves of *A. palustris* (Fig. 25), and were observed to converge onto the wounds on the green leaves of *A. palustris* (Fig. 26). They captured the root hairs by the mycelial strand (Fig. 27), and the epidermal cells of the roots were disjointed on day 27 (Fig. 28), whereas they entered the intercellular spaces of the green leaves of *Z. japonica* (Fig. 29), and the epidermal cells were disjointed on day 9, earlier than the case of *A. palustris*.

In contrast, the mycelia of *B. dermoxantha* entered the intercellular spaces of the green leaves of *A. palustris*, and the epidermal cells of the roots were disjointed on day 3 (Fig. 30), the earliest among all the cases. On day 15, only the steles and root cap parts remained. The mycelia were on



Figs. 8–14. Morphological features of *Bovista dermoxantha*. **8** Sporophores. **9** Rhizomorph by which the sporophore was attached to the soil and the sporophore cut in half. **10** Exoperidium and endoperidium of the sterile outer layer. **11** Capillitia, which are cyanophilic with cotton blue. **12** Spores under a differential interference microscope. **13** Scanning electron micrograph of a spore with a pedicel. **14** Clamydospore-like structures of the hypha. *Bars* **8** 20 mm; **9,10** 5 mm; **11,12** 20 μm; **13** 2 μm; **14** 50 μm

V. curtisii

Turf (Area)	Year	Sporophore no./100 m²
A. palustris (1,860 m²)	1998	—[1]
	1999	9.6
	2000	0.0
	2001	0.0
	2002	0.0
P. pratensis [2] (300 m²)	2000	0.0
	2001	51.3
	2002	7.3
Z. matrella (5,675 m²)	1998	—[1]
	1999	17.9
	2000	1.9
	2001	9.7
	2002	15.2

B. dermoxantha

Turf	Year	Sporophore no./100 m²
A. palustris	1998	—[1]
	1999	207.3
	2000	153.3
	2001	84.5
	2002	168.3
P. pratensis [2]	2000	0.0
	2001	160.7
	2002	68.3
Z. matrella	1998	—[1]
	1999	3.8
	2000	3.3
	2001	9.6
	2002	8.7

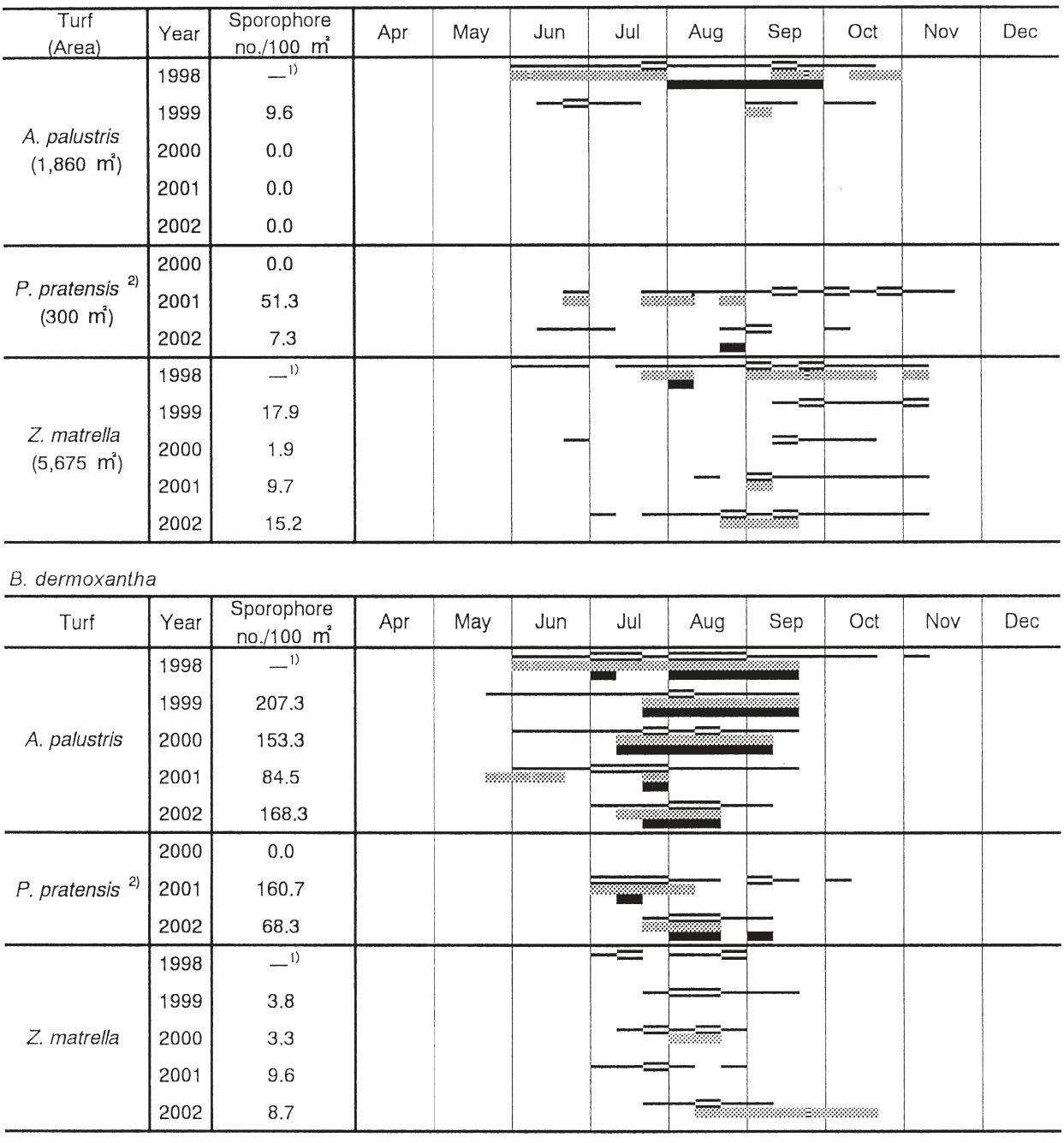


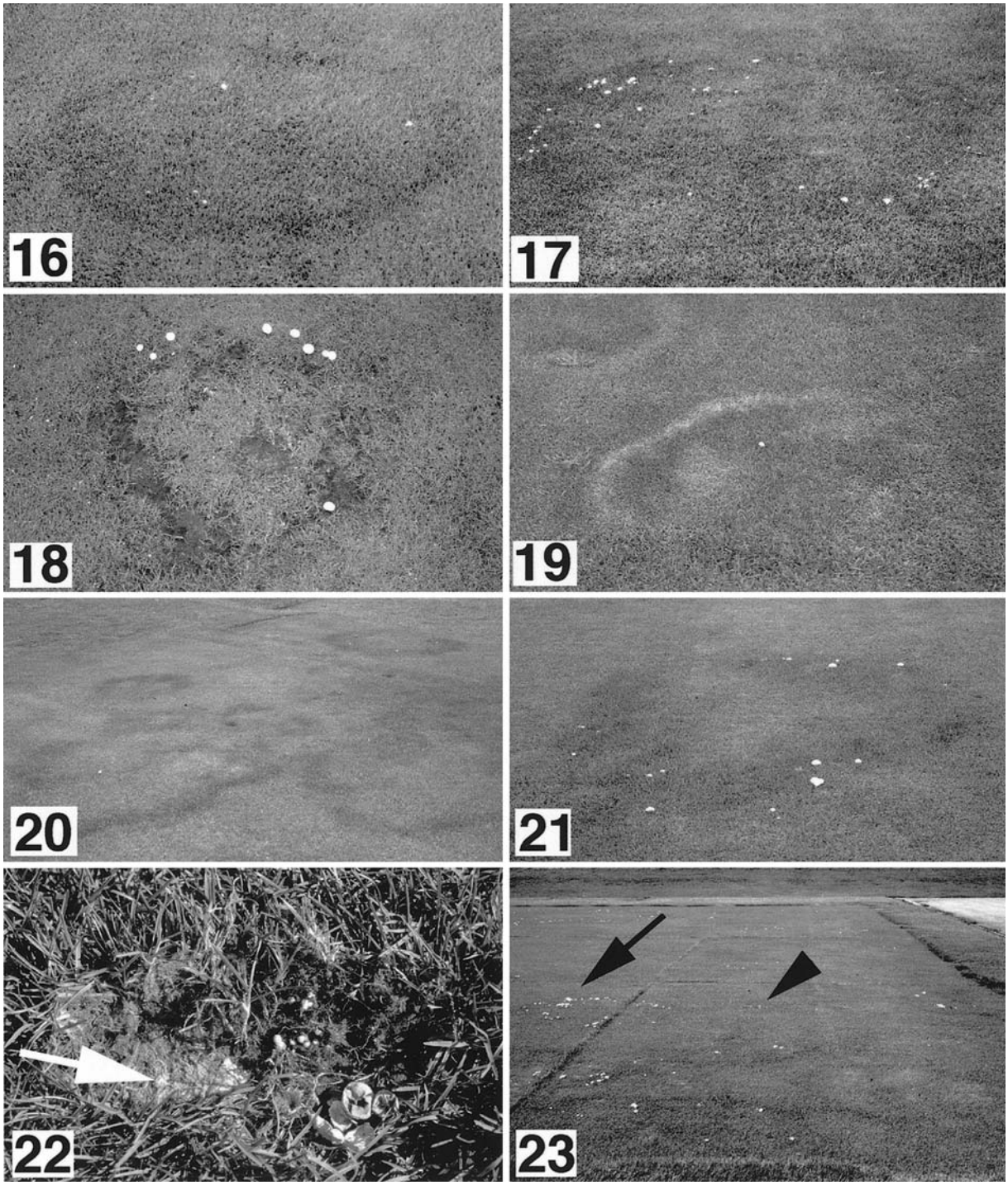
Fig. 15. Sporophore occurrence and symptoms of *Vascellum curtisii* and *Bovista dermoxantha* on the turf of *Agrostis palustris*, *Poa pratensis*, and *Zoysia matrella*. — and ═, sporophore occurrence and the peak (more than 20% of total sporophores occurred in a year), respectively. The *double lines* in 1998 were estimated. Turfgrass became dark green ▒ and withered ■. 1), Sporophore number was not counted; 2), turf was established in 2000

the yellow leaves of *Z. japonica* and the epidermal cells were disjointed on day 18.

V. curtisii damaged *Z. japonica* earlier than *A. palustris*. *B. dermoxantha* was injurious to *A. palustris* earlier than *Z. japonica*. Inoculated fungi were reisolated from yellow leaves and identified as *V. curtisii* or *B. dermoxantha* based on the morphology of hyphae and colony.

Influence of temperature on color change of turf surfaces inoculated with the fungi

Figure 31 shows the a* values of the turf surfaces of *A. palustris* and *Z. japonica* cultured with *V. curtisii*, *B. dermoxantha*, or none (control) at seven different temperatures for 7 days. The turf surfaces of *A. palustris* with *B. dermoxantha* were less greenish than those with *V. curtisii* at



Figs. 16–23. Fairy rings on turfs in the study site. **16,17** Sporophores of *Vascellum curtisii*, dark green turfgrass in rings on turf of *Poa pratensis* and *Zoysia matrella*, respectively. **18** Sporophores of *Bovista dermoxantha* and withered turfgrasses on *Agrostis palustris* turf. **19** Sporophores of *B. dermoxantha*, and dark green and withered turfgrasses on *P. pratensis* turf. **20** Fairy rings (sporophores and dark green rings) caused by *B. dermoxantha* in different sizes on *P. pratensis* turf. **21** Sporophores of *B. dermoxantha* and dark green turfgrass on *Z. matrella* turf. **22** Dense mycelial mat (*arrow*), primordia of *V. curtisii* in the soil of *P. pratensis* turf, and senescent sporophores. **23** Fairy rings of *V. curtisii* (*arrow*) and *B. dermoxantha* (*arrowhead*) occurred closely in the field

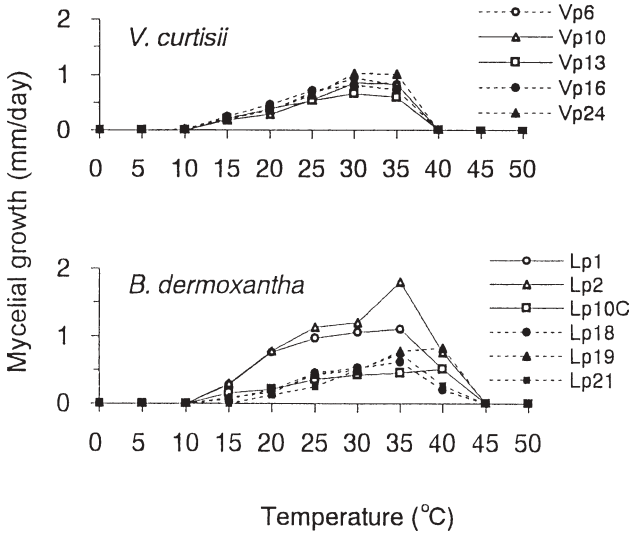


Fig. 24. Mycelial growth rates of *Vascellum curtisii* and *Bovista dermoxantha* at temperatures ranging from 0° to 50°C on modified Czapek Dox agar

25°, 30°, and 35°C. The turf surfaces of *Z. japonica* with *V. curtisii* were less greenish than those with *B. dermoxantha* at 25° and 40°C.

Discussion

Among the Basidiomycetes causing fairy rings on turf, seven Lycoperdaceae have been identified, i.e., *Lycoperdon curtisii* (Shantz and Piemeisel 1917), *L. gemmatum* Fr. (Bayliss-Elliott 1926), *L. hiemale* Bull.: Pers. em. Vitt. (Smith 1957), *L. perlatum* Pers.: Pers. (Smith 1957; Gregory 1982), *L. spadiceum* Pers. (Smith 1957), *L. marginatum* Vittad. (Haliskey and Peterson 1970), and *L. giganteum* Batsch: Pers. (Gregory 1982). In Japan, Tahama (1980) described *L. perlatum* as the related fungus damaging *Zoysia*grass but denied the direct association of this fungus with fairy rings. The occurrence of *V. curtisii* in Japan was reported previously (Ponce de Leon 1970; Smith 1974). Our survey revealed that *V. curtisii* acted as type I fungus causing damage to turfgrasses. According to Shantz and Piemeisel (1917), the sporophores of this fungus commonly occurred on cultivated and disturbed land growing *Bouteloua* and *Bulbilis* spp. in Colorado (USA), but the fungus showed little effect in stimulating the vegetation. The fungus acted as a type III fungus. *V. curtisii* had been considered to be identical to *V. pratense* (Pers.: Pers.) Kreisel (Ponce de Leon 1970) [=*L. hiemale* Bull]. *L. hiemale* was reported by Smith et al. (1989) as type II fungus, which made bowling greens, lawns, and golf courses greener. *Bovista dermoxantha* was classified as type I on the turf of *Agrostis palustris* and *Poa pratensis* but type II on *Zoysia matrella* turf, based on our field observation. This fungus was separated from *B. pusilla* and is now an independent species (Jeppson 1998). There has been no report on *B. dermoxantha* as a fairy ring causing fungus, and this is the first report of this fungus causing fairy rings in the world. There were no reports on *V. curtisii* and *B. dermoxantha* as fairy ring-causing fungi in Japan, and this report shows the first occurrence of the fungi on the three turfgrass species in Japan.

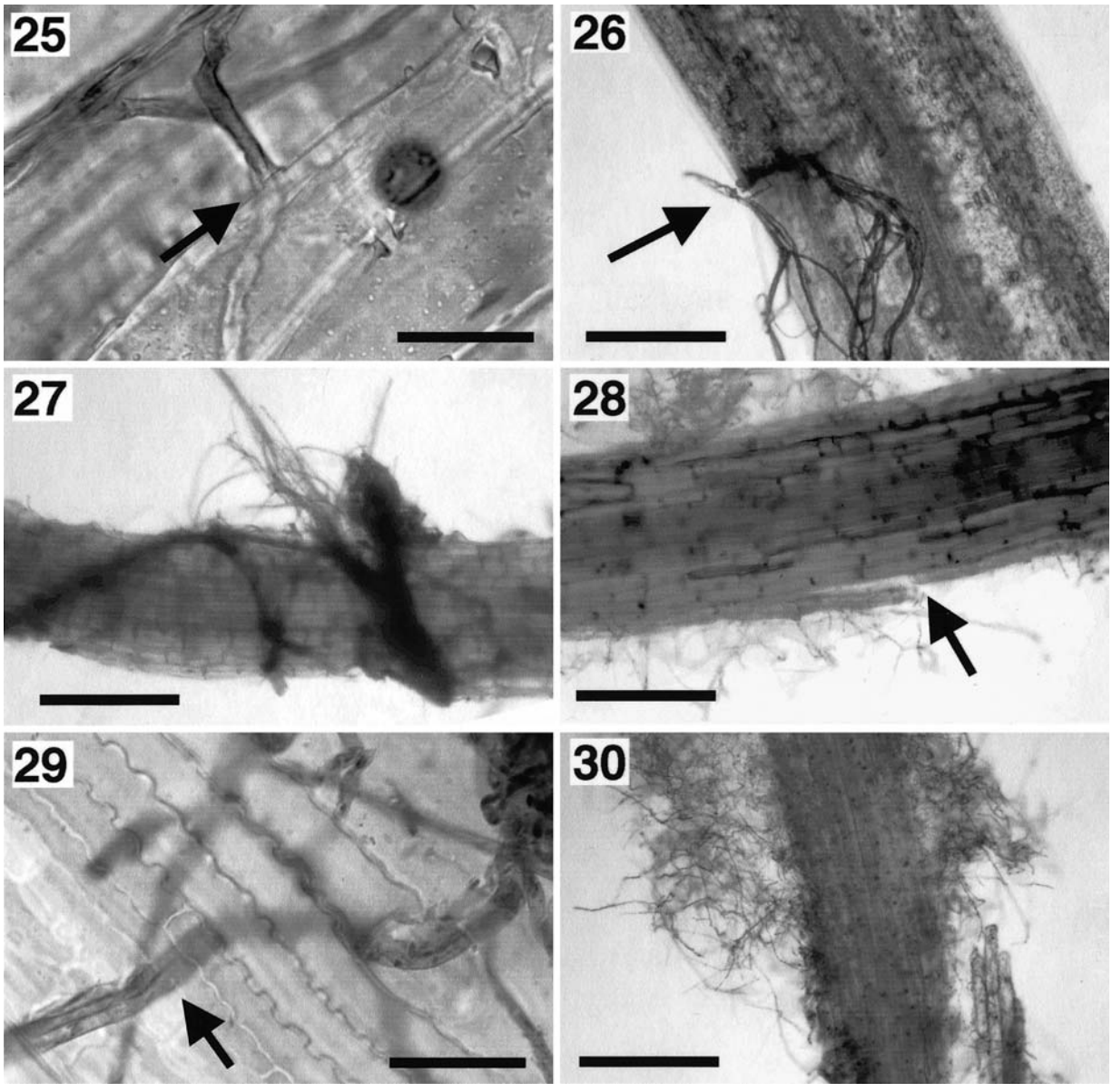
V. curtisii and *B. dermoxantha* were both thermophilic, having an optimum temperature range of 30°C and 35° to 40°C, respectively. The difference in their temperature response seemed to be related to the time lag of the sporophore occurrence in the field; sporophores of *V. curtisii* were absent in midsummer while those of *B. dermoxantha* occurred in midsummer.

The degree of disease injury by facultative parasites is more severe at the temperatures far from the optimum for turfgrass growth (Beard 1973). This finding agrees with the fact that *V. curtisii* and *B. dermoxantha* changed the turf colors of *A. palustris* to dark green in the field when the turfgrasses were stressed with high temperatures. *A. palustris* is a cool season turfgrass with an optimum temperature range from 17° to 24°C. The color change examination of the turf surfaces of *A. palustris* revealed that the two fungi damaged the turfgrasses at temperatures from 30° to 45°C, above the optimum temperature range of *A. palustris*, and *B. dermoxantha* damaged it more severely than *V. curtisii* at 30° and 35°C. In the field, these two fungi also changed the turf color of *Z. matrella*, the warm season turfgrass having an optimum temperature range between 27° and 35°C. The color change examination of the turf surfaces of *Z. japonica* showed that these fungi damaged the turfgrass from 30° to 40°C, and *V. curtisii* damaged it more severely than *B. dermoxantha* at 40°C.

V. curtisii withered *A. palustris* stressed with high temperatures. In contrast, this fungus withered *Z. matrella*, even when temperatures were optimal for the plant. The infection tests of the seedlings showed that *V. curtisii* was more injurious to *Z. japonica* than to *A. palustris*. *B. dermoxantha* withered the *A. palustris* turf severely but not the *Z. matrella* turf. From the result of the infection tests, *B. dermoxantha* was damaging to *A. palustris* earlier than *Z. matrella*.

From the field observations, the dense mycelial mat of *V. curtisii* was suspected to form an impervious zone for water and cause withering of turfgrasses. Also, as Smith et al. (1989) reported, the dense mycelia might have degraded soil nitrogen, causing the accelerated plant growth. This rapid plant growth might lead to more rapid depletion of moisture than in the adjacent areas without dense mycelia. The roots of *A. palustris* and *Z. matrella* in the field might be also directly damaged by the mycelia of *V. curtisii* and also *B. dermoxantha*. The death of turfgrass caused by by *Marasmius oreades* was explained by the following complex aspects: forming an impervious zone for water by the mycelia (Smith et al. 1989), secreting toxic compounds to grass (Lebeau and Hawn 1963; Ayer et al. 1988), and direct penetration to root tissues by the mycelium (Filer 1965).

One of the unique aspects of the two fungal species was that the symptoms, i.e., color change to dark green and withering plants, were transitory and did not occur in the same place in the following year. The mycelia of the impor-



Figs. 25–30. Leaves and roots of *Agrostis palustris* and *Zoysia japonica* seedlings cultured with the mycelia of *Vascellum curtisii* or *Bovista dermoxantha* and stained with 0.1% (w/v) toluidine blue solution. **25** Hyphae of *V. curtisii* entering the intercellular space (*arrow*) of leaves of *A. palustris*. **26** Mycelia of *V. curtisii* converging onto the wound (*arrow*) on a leaf surface of *A. palustris*. **27** Mycelial strand of *V. curtisii* capturing root hairs of *A. palustris*. **28** Mycelia of *V. curtisii* and disjointed epidermal cells (*arrow*) of *A. palustris* root. **29** Hyphae of *V. curtisii* entering the intercellular space (*arrow*) of leaves of *Z. matrella*. **30** Mycelia of *B. dermoxantha* and disjointed epidermal cells of *A. palustris* root. *Bars* **25** 20 μm; **26–28** 200 μm; **29** 20 μm; **30** 200 μm

tant fairy ring fungi such as *M. oreades* (Bayliss 1911; Bayliss-Elliott 1926; Shantz and Piemeisel 1917) and *Agaricus arvensis* (Edwards 1984) were persistent, and their fairy rings developed outward every year (Smith et al. 1989; Couch 1995).

The present study showed that there were differences between *V. curtisii* and *B. dermoxantha* in their sporophore occurrence and symptoms, which varied according to season and the turfgrass species. The difference in the optimal growth temperatures corresponded well with their difference in sporophore occurrence. The infection behavior of the fungi on the turf seedlings in the experiments also explained the symptoms according to the turfgrass species in the field.

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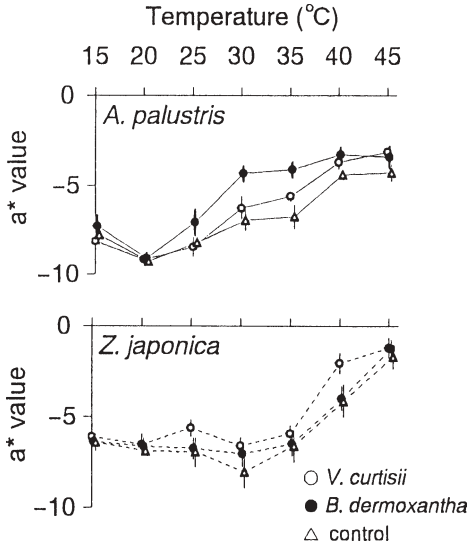

Fig. 31. a* value of turf surfaces of *Agrostis palustris* and *Zoysia japonica* grown with *Vascellum curtisii* or *Bovista dermoxantha* at seven different temperatures for 7 days. Uninoculated turfgrasses were used as controls. The more the a* value rises, the less greenish is the grass

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