

## Characterization and Control of *Vascellum curtisii* (Berkeley)Kreisel Causing the Fairy Ring Arcs in the Golf Course in Korea

Dae-Hong Choi<sup>1</sup>, Jung-Han Lee<sup>2</sup> and Hee-Kyu Kim<sup>2, 3\*</sup>

<sup>1</sup>JAYEUNGSESANG Co., Ltd., Ginhae 621-903, Korea,

<sup>2</sup>Deptment of Applied Biology & Environmental Sciences, College of Agriculture and Life Sciences,  
Gyeongsang National University, Jinju 660-701, Korea,

<sup>3</sup>Research Institute of Life Science, Gyeongsang National University, Jinju 660-701, Korea

## 골프코스에서 페어리링의 원인이되는 *Vascellum curtisii*의 특징과 방제

최대홍<sup>1</sup> · 이정환<sup>2</sup> · 김희규<sup>2,3\*</sup>

<sup>1</sup>(주)자연세상, <sup>2</sup>경상대학교 농업생명과학대학 응용생물환경학전공, <sup>3</sup>경상대학교 생명과학연구원

### ABSTRACT

We have found the clusters of tiny spiny puffball-like mushrooms growing gregariously in fairy ring (arcs) rimmed by a zone of darker green grass in the golf courses. Macroscopic as well as microscopic characters were examined for the morphology of fruiting body. Exoperidium is thin and densely spiny with minute fibrillae at early stage. The connivent spines were soft and quite persistent. In age, the fibrillae scumble away with a powdery coating, which leaves white endoperidium becoming pale brown. It's interior was white and fleshy at first, but turns into an olive-colored dust as the gleba, the spore-producing tissue, develops to maturity and loaded with olive-brown spore mass. Then, distinct apical pore developed on the endoperidium. Rudimentary subgleba(sterile base) was narrow, chambered, delineated from the gleba by a membrane in young material. These characters suggested this fungus is a *Vascellum*, a member of the family Lycoperdaceae. The shapes of the spores were globose, echinulate, 3~3.5 $\mu$ m in diameter, thick-walled, and olive brown.

\*Corresponding author. Tel : +82-55-751-5433

E-mail : heekkim@gnu.ac.kr

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Capillitial threads were 8-9 $\mu$ m wide, mostly colorless in KOH solution and thin-walled, which designated as "paracapillitium". This is another character that distinguishes this mushroom from *Lycoperdon* spp. The spines developed on exoperidium were characteristically connivent; their apices joined together in a point, leaving a space below, which gives the appearance of vault to each group of usually 5 to 6 fibrillae. Based on the above characters, this fungus is identified as *Vascellum curtisii* (Berkeley). The characters distinguishable this from *Lycoperdon pulcherimum*, and *Vascellum pretense* are discussed in detail. Control trial was also attempted. Strong vertical raking(SVR) followed by applying 500x detergent solution (Spark, Aekyung Co. Seoul) resulted in excellent control over any other treatments. In this plot, fruiting body was not developed throughout the end of mushroom growing season.

**Key words:** detergent, fairy ring, golf course, vertical raking, *Vascellum curtisii*

## INTRODUCTION

Fairy ring of golf course is one of the distinctive diseases, which is named as the fruiting body has traditionally developed in ring pattern along the thicker green turfgrasses. This and large patch disease are the main target to the golf-course managers. Large patch is most intensively controlled by preventive spray of fungicides. Under this situation, one may expect the fairy ring would have been controlled concurrent. Unfortunately, we have not been that lucky, because the fungicide could not infiltrate through the biomass of the target fungi developed extensively throughout the entire thatch layer and root system rendering it hydrophobic.

We have found the clusters of tiny and spiny puffball-like mushrooms growing gregariously in the periphery of fairy ring (arcs) rimmed by a zone of darker green grass in July, 2008 in the golf courses which have established recently.

This unusual fruiting body was top-shaped with a rudimentary base and was not smooth but covered with numerous fine spines, which was surely responsible for fairy ring arcs and no resemblance to *Marasmius oreades*, known as fairy ring mushroom reported elsewhere in the world (Arora 1986, Schalkwijk-Barendsen 1994). In this article, we identified this mushroom mycologically and also attempted to control the fairy rings environment-friendly.

## MATERIALS AND METHODS

Fruiting bodies were collected from golf course of Gaya CC, where fairy ring pattern was evident and its range was widespread. Macroscopic as well as microscopic characters were examined with fruiting body morphology including peridium, gleba and sterile base as well as spore shape and size with stereomicroscopy, light microscopy and scanning electron microscopy.

The dark green arcs in turfgrass ground were assigned and field plot was designed with five replicates. As soon as the fruiting bodies appear on the arcs, whole area was divided to three plots, where fruiting body was removed from each plots.

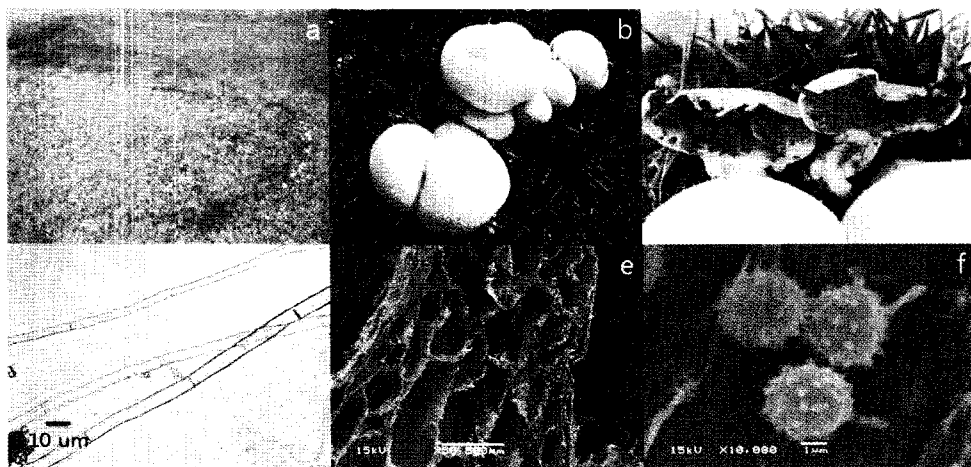
The plots were exposed to strong vertical raking (SVR) or weak vertical raking (WVR). In SVR treatment area, aggressive raking for 4 times at angles perpendicular and parallel to arcs, until thatch layer exposed so that it appears brownish. For WVR, two-time raking was done until surface soil disturbed. After raking treatment, each plot was sprayed with commercial detergent solutions(Spark, Aekyung Co. Seoul) with 500x or 1,000x dilution. Experimental plots were sprinkler irrigated for 15min per day.

## RESULTS

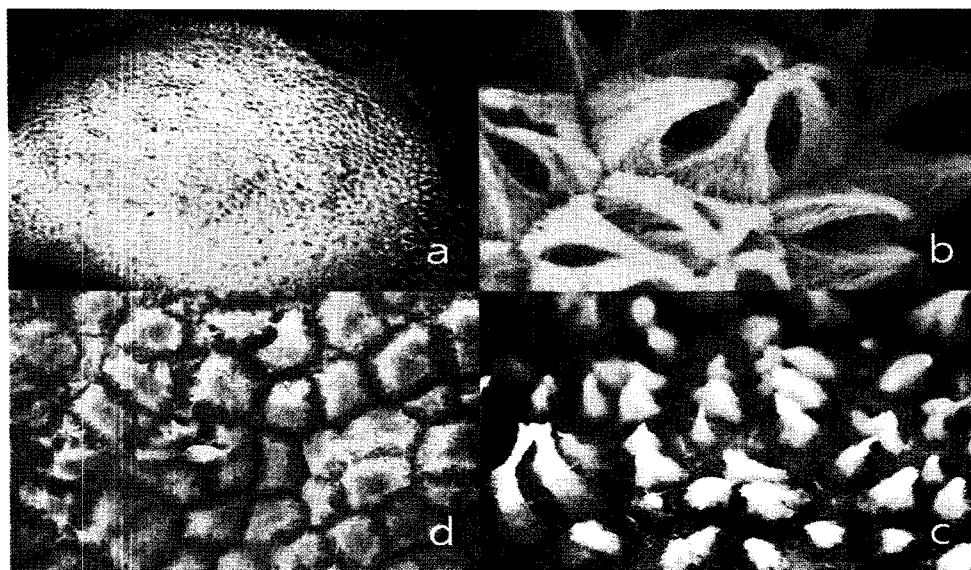
**Macroscopic features:** Fruiting body looked like a small ball or round head with a short base, up to 5cm broad, not cracking in age with white dense short, connivent spines which grows gregariously in clusters, which becomes contorted as it tries to grow shoulder-to-shoulder (Fig. 1b). Gleba, white at first to olive-brown in age(Fig. 1c) and membrane compartment(Fig. 1.e). Sterile base is rudimentary. These characters suggest this fungus should be a *Vascellum* sp. a member of the order Lycoperdales.

**Microscopic features:** Capillitial threads 8-9 $\mu$ m wide, mostly colorless in KOH and thin-walled, which designated as "paracapillitium"(Fig. 1d). This is another character that distinguishes this mushroom from the genus *Lycoperdon*. Spores, globose, echinulate, 3-3.5 $\mu$ m in diameter, thick-walled and olive brown color (Fig. 1f). Exoperidium was thin and densely spiny with minute fibrillae at early stage of mushroom growth. The spines are soft and quite persistent(Fig. 2b). Its interior is white and fleshy at first, but turns into an olive-colored dust as the gleba develops with maturity. In age, the fibrillae worn off and scumbled away with a

powdery coating, which leaves the white endoperidium becoming pale brown. By this time a distinct apical pore developed on the endoperidium (Fig. 2c-d).



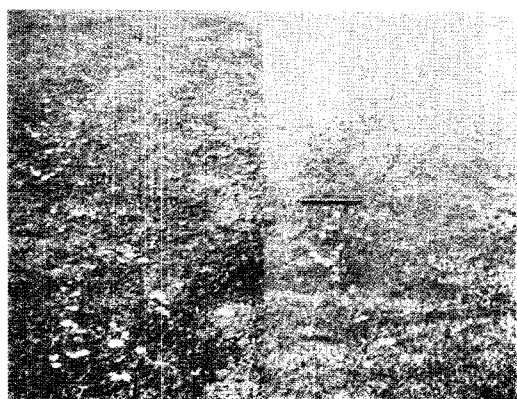
**Fig. 1.** Overview of fairy ring on the golf course and light & SEM micrograph of morphological characteristics of *Vascellum curtisii* developed on ring arc. (a & b), The typical ring arc on the golf course and close-up view of fruiting bodies; (c), Vertical section of fruiting body with gleba is shown olive brown with maturity; (d), paracapillitium in gleba tissue; (e), magnified gleba; (f), where the spores borne by further magnification.



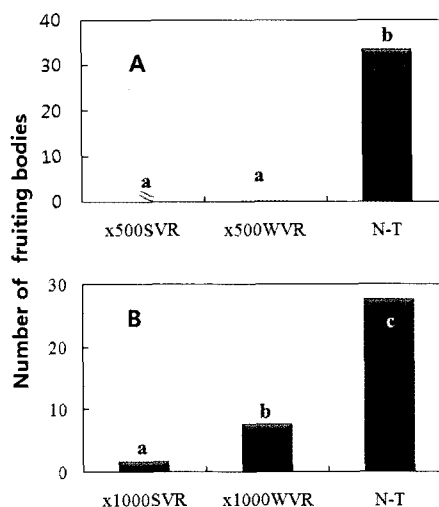
**Fig. 2.** Top view of the fruiting body with connivent spines which are being scrambled away from top center toward margin or edge (a). Intact connivent spines (b), developed throughout the surface in young stage, are shown, which are disintegrated mostly in the center (d), and intermediately worn-off spines (c), in response to the maturing process of the internal gleba, spore producing tissue.

The spines developed on exoperidium were characteristically connivent (Fig. 2), since their apices joined together in a point, leaving a space below, which gives the appearance of vault to about 5 to 6 fibrillae. Subgleba was narrow, chambered, delineated from the gleba by a membrane. Based on the above characters, this fungus was identified as *Vascellum curtisii* (Berkeley) Kriesel.

Control of fairy rings: Strong vertical raking(SVR) by 500x detergent solution resulted in excellent control over any other treatments. In this plot, fruiting body was not appeared throughout the end of mushroom season. At same concentration, weak vertical raking(WVR) provided fairly good results, but with couple of fruiting body still developed.



**Fig. 3.** Effect of strong vertical raking(SVR) and subsequent detergent treatment. (a), Experimental plots before treatments; (b), Subsequent SVR and detergent 500x treatments after 7 days. Control plot (below the red b var) and SVR + 500x plot (above the red b var).



**Fig. 4.** Effect of strong vertical raking and detergent treatment on fairy ring in golf course. (A), 500 x dilutions with strong vertical raking treatment; (B), 1000 x solution with weak vertical raking. Means followed by the same letter are not significantly different by Duncan multiple range test at 5% level.

## DISCUSSION

The macroscopic characters suggest this fungus is a member of the family Lycoperdaceae. This western lawn puffball (or, curtis' puffball) was formerly described as *Lycoperdon curtisii* Berkeley based on broad and sessile fruiting body

without conspicuous rhizomorphs: Spores, globose, echinulated, 3-3.5 $\mu$ m in diameter ; the capillitium, hyaline in KOH, not as rigid as other Lycoperdales fungi at early October in Michigan, U.S.A(Smith 1951). However, this fungus was renamed in the follow-up studies.

Thin-walled and hyaline or colorless threads designate a "paracapillitium" of curtis' puffball. This trait was recognized as a distinguishable character from Lycoperdons, which have "true capillitium" (David 1986, Kuo 2006). Accordingly, it was transferred to the genus *Vascellum*, which also has a characteristic papery membrane separating the sterile base (subgleba) from the gleba. This genus is small and intermediate in size between genus *Lycoperdon* and *Calvatia*. The species epithet was retained as *Vascellum curtisii* (Berkeley) Kriesel. (Kuo, 2006)

This mushroom could be confused with *Lycoperdon pulcherrimum*, also called long-spined puffball, for its dense coating of long, slender white spines, which are joined at tips to form bundles. However, this long-spined puffball is saprobic and found in small groups, not gregarious and in humus or on rotten wood, not in lawns or pastures as the curtis' puffball, in addition to the true capillitium, and the fruiting body of which is pear-shaped with a narrow, stem-like sterile base that makes up about one half of the fruiting body(Meyers, 2003).

Finally, *Vascellum pratense* (western lawn puffball or field puffball) is similar in terms of microscopic characters, i.e. minutely warted to spiny, globose, larger spores 3.5-5.5 $\mu$ m in diameter and habitats, ie. pastures, grassy areas, but its conspicuous sterile base readily distinguish this species from the inconspicuous, or very poorly developed sterile base of *Vascellum curtisii*. Another macroscopic character is that the fruiting body of *Vascellum curtisii* has a distinct apical pore, or small hole at maturity, but that of *Vascellum pratense* has a large pore at top, by rupturing, eventually becoming bowl-shaped. This character and echinulate spores/paracapillitium are the distinct traits by which this fungus can be identified readily as *Vascellum curtisii*. It is known to occur densely cespitose to gregariously in lawns and golf courses in North America( Kuo, 2006). the common name of this mushroom should preferably called 'curtis' puffball to distinguish it from that of *Vascellum pratense*, even though it was called formerly as western lawn puffball(Smith, 1951).

Development of the fairy ring is caused by many saprophytic fungi degrading the organic substrate in the zone of thatch layer and root of turfgrass which releases nutrients to the environment. Then the mycelium absorbs nutrients and grow outward at the same rate in all direction, forming circles of thick green

growth on its outer fringes where the fungi fruits periodically forming "fairy rings". Thus, the mycelial biomass develops extensively and densely in the root zone where hydrophobic condition prevails and turfgrass wilts to die in the center of the fairy ring.

Fairy ring mushroom is not parasitic to turfgrass, but grows saprophytically in the thatch or root system causing this disease more frequently in the recently constructed new golf courses than the old ones where the cool-season grass was growing. This may be due to the fact that Kentucky bluegrass requires more frequent irrigation than Zoysiagrass does under unusually dry weather condition have this year.

Control trials were attempted as suggested by Schalkwijk-Barendsen(1994). Vertical rakings on ring arc areas, followed by detergent solution application were promising as a control method. The practice of SVR until the thatch layer exposed in this experiment, was surely enough for breaking up the hydrophobic dense mycelial mass developed throughout the root system. Here, 500x solution applied at rate 2-3 liter per square meter was effective enough to remove the greasiness of the disturbed mycelial mats resulting in the excellent control. SVR was good practice to render the mycelial system hydrophilic and vulnerable to detergent treatment. However, in the plots treated with 1000x solution and SVR, considerable effect was obtained under this experimented condition, but this treatment did not rule out the further developments of fruiting body completely.

We believe this is the first research attempt that could be directly applied to larger scale experiments in the golf course, if we further work out this control system practically compatible with vertical mower.

## 국문 요약

골프코스에 농녹색으로 형성된 페어리링(arc)에서 군집으로 자라난 말뚝버섯목에 속하는 버섯을 발견하고, 분류학적 특성을 조사한 후 *Vascellum curtisii*로 동정하고, 친환경방제법을 시도하였다. 버섯의 자실체 형태를 관찰한 결과 외피(exoperidium)상에 미세한 섬유상의 침상돌기(spine)가 뾰뚱하게 발달하였고, 촉감은 부드러웠으며 5-6개의 침상돌기(spine)가 끝이 한 곳으로 모아진 모양(Connivent)이 관찰되었다. 자실체는 점점 성숙하면서 spine은 점점 퇴화되어 길이가 짧아지고 약간의 갈색으로 변하면서 결국은 자실체 표면 위에 가루로 남게 된다. 흰색의 내피(endoperidium)는 회갈색으로 성숙된 후에는 중앙 정상부가 약간의 갈색을 띠기 시작하면서 구멍(apical pore)이 발달한다. 내부의 포자형성조직(gleba)은 초기에 다육질의 흰색이었다가,

성숙하면 내부에 올리브 갈색의 기본체(gleba)가 발달하고, 내부에 포자가 발달한다. 포자가 발달하지 않은 하부의 조직(subgleba or sterile base)은 폭이 좁고, 조직내부는 챔버형이며 gleba와는 막(papery membrane)으로 구분되는 것이 특징이다. 포자는 올리브 갈색으로 크기는 3-3.5 $\mu$ m로 구형이며 돌기가 있으며 두꺼운 벽으로 되어있다. 또한 *Lycoperdon* 속과는 구분되는 특징으로 중요한 paracapillitium이 관찰되었는데 폭이 8-9 $\mu$ m로 넓고, KOH에 반응하지 않았으며 무색(hyaline)으로 그 벽은 얇다. 외관상 유사한 *Vascellum pratense*과 *Lycoperdon pulcherrimum*과 구분할 수 있는 특징을 상세하게 기술하고 비교하였다. 방제법은 농녹색의 ring arc를 직각으로 강하게 긁어서 thatch층이 노출되어 갈색을 띄게 될 때까지 균사매트를 파괴시킨 후 세제용액 500배액을 처리하고 1-2주후에 무처리와 비교한 결과 효과가 뛰어났다.

주요어 : *Vascellum curtisii*, 균류, 골프장, 수직 긁기, 합성세제

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