THE CAP THROWER FUNGUS

George F. Howe*

The daily cycle of growth of ***Pilobolus*** *filaments is discussed with emphasis on the manner in which this fungus aims at the sun. Many of the spore masses are discharged and glued on the leaves of distant plants because of an explosion in each filament at about 9:00 A.M. If the leaf, with spores attached, is consumed by a horse, the* ***Pilobolus*** *spores grow in the dung and another crop of fungus filaments matures. A plan for the laboratory study of* ***Pilobolus*** *is briefly discussed.*

The lens system, biological timing, ballistic aiming, missile firing, and attachment devices of the ***Pilobolus*** *are seen as unmistakable evidences of Divine creation in the world of fungi.*

Certain fungi have been equipped with amazing means for spreading their reproductive spores but *Pilobolus,* the cap thrower fungus, must surely be the most unique. It is able to propell its spores many feet by doing just what its name implies—throwing its cap which contains the spores.

Pilobolus is one fungus that thrives well in the dung of herbivores—particularly horses. A tiny, single-celled spore grows in this material forming a fungus network or "mycelium" that is largely without any dividing cross walls but forms a living tubular system with many nuclei.

Before long this branching mycelium produces some upright stalks called sporangiophores. A new crop of sporangiophores ripens each day for several days if the dung is moist and surrounded by humid air.

As the sporangiophore gets longer, it begins to swell just beneath a black mass of spores found at the tip.[1] A. H. Reginald Buller's drawing in Figure 1 shows how the tip of the tiny sporangiophore swells and enlarges. The sporangiophore is transparent as seen in Figure 2.

Buller recorded the typical development stages as follows: 1. a primordium appears at about noon, 2. the future stipe is visible by afternoon and is orange at its tip, 3. by evening the sporangium (black spore-filled cap) appears and is complete by midnight, and 4. after midnight the subsporangial region begins to swell while the stalk continues to elongate (see Figure 1).

By dawn the amazing finger-like filaments have emerged well above the surface and have become oriented so that they all point toward the sun at a low angle. As the sun "rises" higher in the sky, the filaments remain aimed at the sun and bend, following it upward.

A. H. R. Buller studied the optical properties of *Pilobolus* and found that the transparent subsporangial swelling acts as a miniature lens, focusing all light rays on one apparently light-sensitive spot near the base of the swelling! This lens action is evidently the means by which *Pilobolus* orients itself to the light and aims at the sun (see Figure 3).

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Any ballistics student knows that a bullet will travel the greatest possible horizontal distance if the shell is fired when the barrel points at a 45° angle. As Buller found, such "knowledge" is built right into the firing system of this fungus. The subsporangial cavity expands under turgor pressure until it finally explodes, ejecting the sporangium in a parabolic course. But the explosion does not occur until about 9:00 a.m. (the exact time when *Pilobolus* has followed the sun to an angle of 45° with the horizon!). (See Figure 4)

The explosion occurs because a little ring breaks beneath the sporangium under the tremendous turgor pressure which develops. As the sporangium follows its trajectory, it may be carried more than five feet horizontally. A drop of liquid from the old subsporangium adheres to the sporangium and travels with it. When the sporangium hits some object (a grass blade, for example) the sticky liquid immediately flattens out under the impact and glues the sporangium to the very spot which it hits! (See Figure 5)

A new crop of explosive sporangia develops during the day and these are prepared for firing the following morning as described earlier. The whole process has great adaptive significance because the sporangium usually becomes attached to a leaf where it is likely to be consumed by a horse. The *Pilobolus* cycle will begin again when the spores develop in the dung after having passed through the animal's intestinal tract.

A unique teaching demonstration of this cycle can be prepared by simply placing some freshly collected samples of horse dung in a covered box (such as a shoe box). The samples should be kept damp but not too moist. This may be accomplished by water spray from an atomizer from time to time. In two to four days the cap thrower fungus will grow if any spores are present.

An interesting addition to the experiment may be gained by poking a pin into one end of the box to form a small pin hole. A bright source of light is then placed outside the pin hole. All other sources of light should be eliminated. Instead of following the sun, in this case *Pilobolus* filaments will adjust by aiming at the pin point of light and firing at the appointed time! A

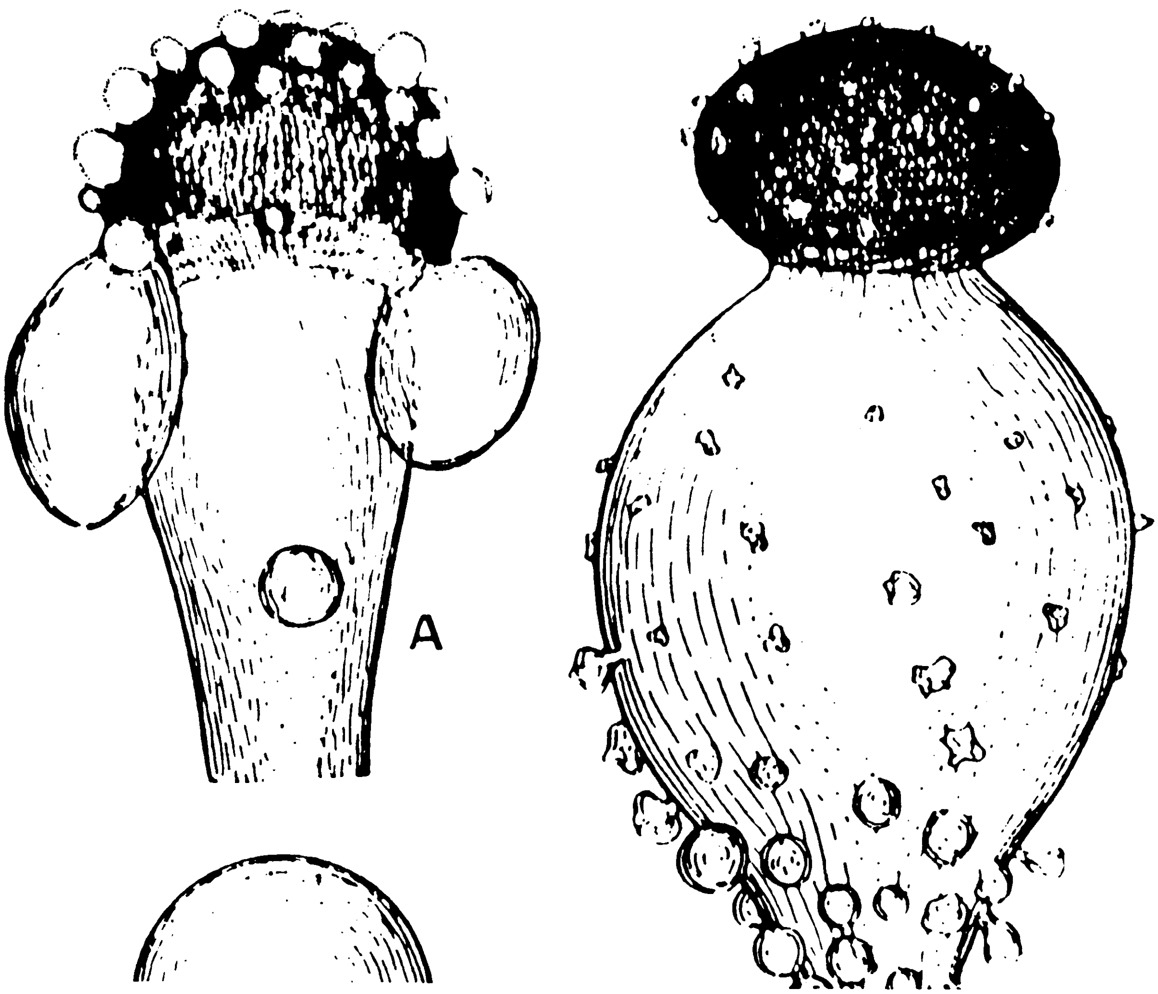

Figure 1. Development of the subsporangial swelling in *Pilobolus.* The black cap containing spores is figured here in both stages. Comparison of right with left shows the growth and swelling which takes place in the region just under the sporangium. Note active excretion of material also figured beneath the sporangium. This line drawing is after A. H. R. Buller, Langeron, M., and R. Vanbreuseghem. 1952. Précis de mycologie. Libraires de L'academie de medecine, Masson et Cie, Paris. p. 301. Used by permission of the publisher, Masson et Cie.

Figure 2. Photograph of *Pilobolus* filaments growing from dung. This photograph was taken of *Pilobolus* filaments raised in a shoe box as described, in the article. The picture was taken in the morning sunlight, showing the manner in which the filaments point toward the sun. Note tiny black spore masses (sporangia) above the crystal clear subsporangial swellings and filaments. Photo by George F. Howe.

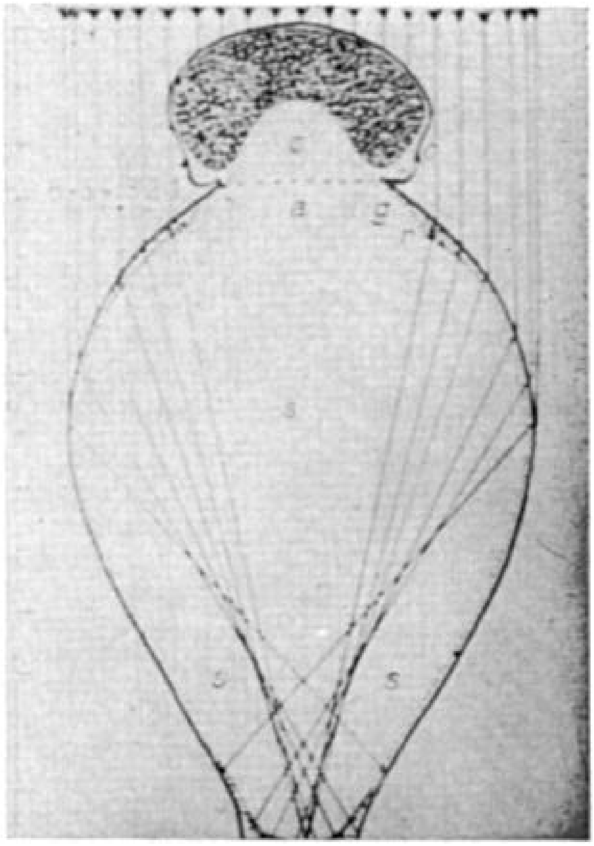

Figure 3. Lens action in *Pilobolus.* A. H. R. Buller produced a drawing showing the course of light rays through the subsporangial swelling of *Pilobolus.* The lens action is obvious with light being focused at a region in the base of the swelling which may be the site of photochemical processes involved in the orientation of *Pilobolus* to sunlight. This line drawing is after A. H. R. Buller, Langeron, M., and R. Vanbreuseghem. 1952. Précis de mycologie. Libraires de L'academie de medecine, Masson et Cie, Paris. p. 302. Used by permission of the publisher, Masson et Cie.

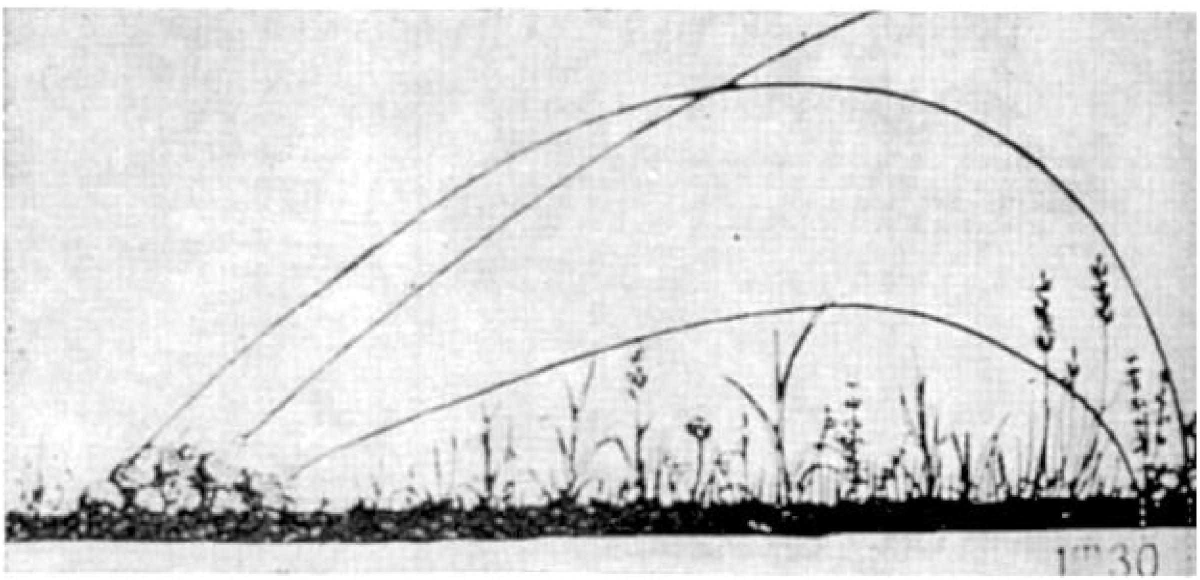

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Figure 4. Trajectory of *Pilobolus.* Here A. H. R. Buller sketched pasture scene in which one group of sporangiophores of *P. kleinii* seen on dung. Explosion of the subsporangial region while the filaments make a 45° angle with the horizon provides for a long trajectory and wide distribution of sporangia. It is obvious from the drawing and French words beneath that under favorable circumstances the sporangium may be fired for a distance of several meters. This line drawing is after A. H. R. Buller, Langeron, M., and R. Vanbreuseghem. 1952. précis de mycologie. Libraries de L'academie Medecine, Masson et Cie, Paris. p. 305. Used by permission of the publisher, Masson et Cie.

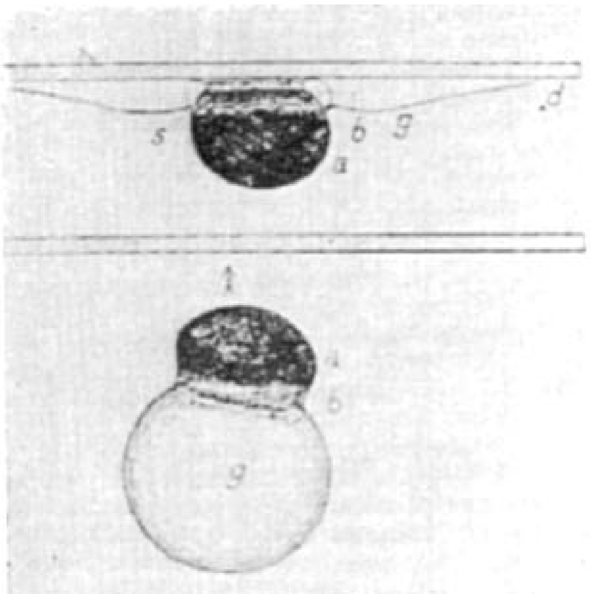

Figure 5. Impact and adhesion of *Pilobolus.* Buller's lower sketch shows a sporangium projectile with a drop of liquid from the old subsporangial region approaching an object such as a blade of grass (traveling in the direction of the arrow). When the sporangium lands (see upper drawing) the material adhering to the sporangium splatters out, acting as a glue cementing the sporangium to the leaf where it may possibly be eaten by a horse. This line drawing is after A. H. R. Buller, Langeron, M., and R. Vanbreuseghem. 1952. Précis de mycologie. Libraires de L'academie de Medecine, Masson et Cie, Paris. p. 306. Used by permission of the publisher, Masson et Cie.

"scatter pattern" of sporangia found glued close to the region surrounding the pin hole of light will be a testimony to the accuracy of *Pilobolus!*[2]

Here in a "lowly" fungus is a light sensing ballistic system that points the sporangiophores unerringly toward a light source (usually the rising sun). Here too is a biological clock which causes the subsporangial swelling to explode at the time when the angle of trajectory will insure the greatest horizontal distance of travel. Here is a fungus that literally "blows its top" at just the right time and in just the right manner to guarantee its spores a better chance to enter the digestive tract of a horse! Here is a fully planned system which fits well with the design expected in a wise Creator's handiwork. But here too is a significant problem to anyone who holds that life developed by chance.

References

[1]Excellent line drawing of this growth process and other steps involved in the development of *Pilobolus* were made by the careful Canadian researcher, A. H. Reginald Buller. Buller produced a series of volumes on fungi. Reference material regarding *Pilobolus* in particular may be found in Part I, chapters 1 and 2 of: Buller, A. H. R. 1934. Researches on fungi. Vol. 6. Longmans Green, London.

[2]The author is indebted to Dr. Ralph Emerson, noted mycologist, for this suggestion regarding classroom use of *Pilobolus.* The author's own introduction to this fascinating fungus came during a lecture by Dr. Emerson at the National Science Foundation Summer Institute of Botany held in conjunction with the Botanical Society of America at Washington State University, Pullman, Washington, 1961.

WHY GENETIC VARIATION BETWEEN NEW GUINEA COMMUNITIES? (MIGRATION-DISPERSION MODEL APPLIED)*

R. DANIEL SHAW**

As members of small populations migrating from a relatively large common source are subjected to premature death through warfare, epidemic disease, and other unusual events, genetic drift is greatly accelerated. Migration coupled with unusual events is offered as the primary mechanism in producing genetic variation between the populations of New Guinea. This theoretical interpretation fits well with the facts, presented in table form, and solves a distribution problem of some complexity.

Introduction

The island of New Guinea offers an excellent opportunity to apply and develop theories and concepts in all areas of anthropology. The diversity in linguistic and genetic make-up displayed by populations on the island is particularly striking. Until very recently, isolation has been a fact of life and is still the key to understanding existing diversity.

From the genetic standpoint, New Guinea provides opportunity to use the Migration-Dispersion theory[1,2] and note its application to living populations. It must be made clear at the outset that this is in no way considered to be a validation of the theory since conclusive evidence necessary for validation is not available. Much of the material is in the form of tribal tradition and folklore which, while apparently supporting the hypothesis, can not be considered conclusive. It is, however, interesting to combine

*The author gratefully acknowledges that a portion of the research involved in preparation of this paper was funded by the New Guinea Research Fund.

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