Modern Approaches in Oceanography and Petrochemical Sciences
DOI: 10.32474/MAOPS.2019.02.000142
ISSN: 2637-6652
Mini Review

Possible Means of Overcoming Sedimentation by Moss Sperm Cells

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Received: February 05, 2019 **Published:** February 11, 2019

Abstract

A model for overcoming the gravity by moss sperm cells is proposed here. It is based on the assuming that the tip of constantly coiled sperm cell slips on surface of moss tissue, to which the cell is pressed by tensile strength of water. This tip and the cell mass center don't coincide. Therefore, there appears a torque expressing gravitaxis of physical nature. In puddles the cells can successfully overcome the gravity detecting thermal fluctuations of their velocities, which expresses gravikinesis of physical nature. It can considerably improve fertilization of mosses.

Keywords: Antheridia; Archegonia; Moss sperm cells; Water film; Sedimentation

Introduction

Bryophytes are the only plants; which sperm cells must move on considerable distances (it may be 10 or even 100 centimeters) to fuse with oocytes. When distanced from archegonia secreting special attractants, the spermatozoa move diffusively and thus the speed of their translocation is very low [1]. Therefore, bryophytes have different means to increase the speed of their translocation. Thus, in some bryophyte species the contents of the antheridium explosively discharge into the air to a height of several centimeters from the male plant. In many species thanks to the presence of special fat, which lowers the surface tension, the sperm mass released from the antheridia on the water surface forms a thin layer quickly spreading the cells around [2]. Bryophytes can also harness the power of a splash to spread the sperm. Some of them have even so-called splash cups. In several cases the splash cups are very striking and the moss *Polytrichum juniperum* Hedw., is a good example of this. Its antheridia are surrounded by a flat disk made of leaves, radiating around them like the petals of a sunflower. Sperm, released from the antheridia, accumulate in the cups. A raindrop plummeting onto this disk can splash the sperm as far as ten inches [2-4]. Many bryophytes including *Ceratodon purpureus* (Hedw.) Brid. and *Bryum argenteum* Hedw. use small insects *Folsomia candida* Willem (Collembola: Isotomidae) to spread their sperm and to help pollinate their oocytes [5]. But in each case the sperm to reach their target usually must translocate by itself on considerable distance (within several centimeters) in thin water films covering moss tissue during and after rain. Usually antheridia and archegonia are situated on the upper parts of bryophytes. Thus, the sperm should swim at first downwards (from antheridia) and then upwards (to archegonia). Gravity can distance the sperm cells from oocytes during the second stage (upward) of their travel while they are out of the radius of the action of the archegonia attractant. Therefore, overcoming sedimentation by sperm is an important problem for bryophyte insemination. Let us narrow down our attention only to mosses, which belong to bryophytes. Now, there is not any report about the existence of special cell receptor of gravity in moss sperm. Thus, a question can be raised: whether these cells can overcome sedimentation without any special cellular mechanism for gravity perception, as it has been shown for unicellular microplankton with front-rear asymmetry [6,7] or proposed for picoplankton with antipredator behavior [8], or for plankton cells detecting fluctuations of their cell velocities [9].

Moss spermatozoa have a rather bizarre shape, which can be described as a coil of about 1,5 turns [10]. Two flagella attached to the same end of the spermatozoid cell. Thanks to their shape, moss spermatozoa are poor swimmers in unbound liquid. But their movement takes place commonly in thin water films, where is the other situation. In enough thin film the spermatozoa should move in water medium lightly slipping on the surface of moss tissue, to which they are pressed by tensile strength of water. It is natural to assume that there may be the situation, when only the tip of the coiled cell slips on rigid surface of the tissue. This tip and the cell mass center don't coincide. Therefore, there appears a torque turning flagellated end of the cell upwards or downwards dependently which cell end is slipping on the surface. It is also naturally to assume that when the sperm cell is got in the thin water film, it for a long time with equal possibilities is orientated with its distant or flagellated end slipping on moss surface. So, it creates the condition under which a half of the cells express positive gravitaxis of physical nature described by Roberts & Deacon (2002) and the other half express negative gravitaxis correspondingly.

Thus, the first (downward) stage of moss sperm travel successfully goes for the half of the cells expressing positive gravitaxis or being washed off by rain independently from the sign of their gravitaxis. The upward stage of the travel successfully goes for the cells expressing negative gravitaxis. But between the downward and upward stages of the sperm movement there may be the stage when the sperm cells are got in a puddle. There their movement we can model as in unbound liquid. There they are poor swimmers, as mentioned above. So, in this situation their main task is to overcome gravity and remain near water surface waiting on rain drops which plume them further upwards. Two ends of the moss sperm cells have similar shape and dimensions. Therefore, they cannot considerably express gravitaxis of physical nature. There is not any report about antipredator behavior of moss sperm. But it is natural to assume that the moss sperm cells have intracellular receptors monitoring their asymmetrical shape, which should change with the changings of their cell's velocities. So, it can realize the detection of the thermal fluctuations of their cell's speeds [5]. Thus, according to [5] moss sperm cells may be able to overcome sedimentation in different natural water pools.

The slipping of the bigger parts of motile cells in thin water films can induce gravitaxis of physical nature also of many asymmetrical microorganisms living on surface of stones, fungi, different plants (including also tree bark). In unbound water their gravitropism of physical nature should have the opposite sign. Thus, we can conclude that the spiral shape of moss spermatozoa can also serve as an adaptation to successfully overcome the gravity and thus to considerably improve fertilization. This finding may stimulate further research in this field.

References

1. Maggot H and Walton J (1942) On the dehiscence of the antheridium and the part played by surface tension in the dispersal of spermatocytes in Bryophyta. Proceedings of the Royal Society of London, B Biological Sciences 130: 448-461.
2. Brodie HJ (1951) The splash dispersal mechanism in plants. Canadian Journal of Botany 29(3): 224-234.
3. Kimmerer RW (2003) Gathering Moss: A Natural and Cultural History of Mosses. Oregon State University Press, Portland.
4. Reynolds DN (1980) Gamete dispersal in Mnium ciliare. Bryologist 83(1): 73-77.
5. Rosentiel TN, Shortlidge EE, Melnychenko AN, Pankow JF, Eppley SM (2012) Sex-specific volatile compounds influence microarthropod-mediated fertilization of moss. Nature 489: 431-433.
6. Roberts AM & Deacon FM (2002) Gravitaxis in motile micro-organisms: The role of fore-aft body asymmetry. J Fluid Mech 452: 405-423.
7. Roberts AM (2006) Mechanisms of Gravitaxis in Chlamidomonas. Biol Bull 210(2): 78-80.
8. Pundyak O (2017) Possible means of overcoming sedimentation by motile sea-picoplankton cells. Oceanologia 59(2): 108-112.
9. Pundyak O (2019) The Perception of Fluctuations of Cell Velocity as a Possible Means of Overcoming Sedimentation by Motile Sea-Plankton Microorganisms. MAOPS 2(3): 155-156.
10. Renzaglia KS, Villarreala JC, Garbary DJ (2018) Morphology supports the setaphyte hypothesis: mosses plus liverworts form a natural group. Bry Div Evo 40(2): 11-17.

DOI: 10.32474/MAOPS.2019.02.000142