The Gravitational Effect on Moving Speed of the Slime Molds

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Purpose

■Making a clinostat(operating gravity device)
■Draw a comparison between slime molds' moving speed under normal gravity and microgravity

Background

■Slime molds' moving speed under hypergravity
→Faster than under normal gravity
・Examining how it varies under microgravity
・Making a clinostat in order to simulate microgravity environment

Methods

■Slime molds culture
1.Preparing agar culture
・ϕ90mm, depth 14mm, 1%agar
2.Culture conditions
・Temperature 25℃ (by using incubator)
・Feeding slime molds oatmeal as feed

■Principle and Function of a Clinostat

A clinostat is a device to negate the effects of gravitational pull on a sample. Microgravity is simulated by continuously rotating the sample which changes the direction of the gravitational vector on the sample every time around two independent axes. Time-averaged vector can be approximately 0 by rotating.

Structure

The clinostat we made consists of two independent frames, one positioned inside the other, two motors (geared motor and stepping motor) that rotate the frames and Arduino nano to control the stepping motor.

There are some points that should be taken into consideration: centrifugal effects and so on.

Centrifugal effects can be avoided by rotating at the angular velocity of 1 to 2 rpm. This velocity produces about 0.0005 to 0.002ms^{-2} as the centrifugal acceleration.

Figure1:actual clinostat

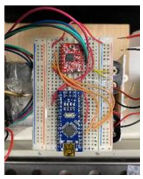


Figure2:Arduino nano

Angular velocity setting

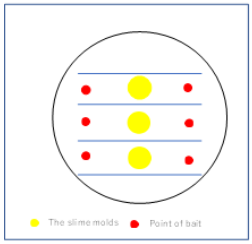
The angular velocity should be set by considering the mechanism of the target; how the slime molds' moving works. If it is too fast or not fast enough, the sample reacts like being under hypergravity or normal gravity. However, this mechanism has not been researched and appropriate values cannot be set. Therefore we referred to a research about the height of cellular molds' fruiting body in microgravity state and set 1 to 2 rpm as the velocity.

Problems associated with the use of the horizontal clinostat

A single-axis clinostat only produces the effect of weightlessness along its axis of rotation. Gravitational effects still occur, they just have no net direction. Therefore microgravity is not simulated.

Two-axis clinostat can average a gravitational pull over all directions.

To tell the truth, two-axes clinostat cannot simulate microgravity completely either because gravitational vector follows the same tracks at regular intervals. Random angular velocity can make the microgravity closer to perfection. The velocity is controlled by Arduino nano (microcomputer).



■Moving speed comparison

①making frames of plastic board and pierce it into agar culture
②putting slime molds on the middle of the frame and feed on both ends of frame
③setting each petri dish on the clinostat and starting the experiment

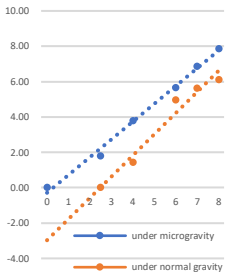
Figure3:the location of slime molds and feed
※measuring the distance that slime molds moved in fixed intervals

Result

Table1:the lapse and the moving distances of the slime molds

		moving time				
under normal gravity		2.5hour	4hour	6hour	7hour	8hour
day25	A	0.0	3.1	6.7	7.2	7.7
	B	0.0	2.0	1.8	4.5	3.9
	C	0.0	1.1	1.4	1.8	5.8
	D	0.0	5.9	6.7	7.3	10.9
	E	0.0	2.1	4.1	5.8	8.8
	F	0.0	1.7	3.5	7.1	7.6
day26	A		0.0			1.5
	B		0.0			0.0
	C		0.0			2.3
	D		0.0			0.0
	E		0.0			1.0
	F		0.0			2.3
day28	A		2.5			14.1
	B		0.0			0.0
	C		0.0			7.8
	D		0.0			0.0
	E		3.3			19.9
	F		0.7			2.0
day29	A		2.9	9.8		10.8
	B		0.6	2.5		3.8
	C		4.8	8.7		10.8
	D		2.5	7.4		9.2
	E		0.0	5.7		7.7
	F		0.0	1.3		2.3
average		0.0	1.4	5.0	5.6	5.8

		moving time				
under microgravity		2.5hour	4hour	6hour	7hour	8hour
day25	A	0.0	0.0	0.0	2.1	2.2
	B	0.0	2.3	1.7	5.2	10.7
	C	3.6	3.0	5.6	7.3	15.1
	D	1.5	7.2	9.2	11.4	16.8
	E	3.0	5.3	5.5	8.9	9.2
	F	2.7	3.2	5.2	6.3	9.5
day26	A		0.0			1.3
	B		1.3			0.0
	C		0.0			0.0
	D		0.0			0.0
	E		8.4			6.8
	F		0.0			0.0
day28	A		10.1			13.6
	B		0.0			5.5
	C		8.6			15.0
	D		3.5			6.4
	E		12.8			19.8
	F		0.0			4.6
day29	A		11.6	15.7		18.0
	B		0.0	0.7		3.1
	C		9.5	9.8		12.7
	D		3.3	7.4		8.8
	E		1.1	3.3		4.5
	F		1.9	3.7		5.7
average		1.8	3.8	5.7	6.9	7.9



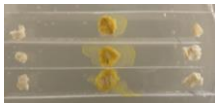


Figure5:movement of slime molds

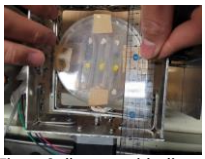


Figure6:clinostat with slime molds

Figure4:the graph above shows that the Table1
※the unit of Table1 and Figure4 are mm.

Discuss

Under microgravity, the slime molds move more slowly than under normal gravity.

▪ From figure4, it is clear that the times the slime molds started moving has a difference. We take it into consideration, and set the regression lines. In this way, we consider the speed when the slime molds started moving.
⇒Like the figure4, we exclude 0 hours later and set the regression lines of the data after 2.5 hours about the points of under normal gravity.

▪ Under microgravity, the slime molds move more slowly than under normal gravity.

▪ Discuss of cause

There are preceding studies which say the slime molds move faster under hypergravity than under normal gravity (Kobe high school students 74th year). They considered that the slime molds felt a load under hypergravity as heavy as an obstacle they were covered with and they moved fast to run away because they detected danger as a cause (state of tension). Therefore, we consider that the slime molds enter a state which is reduces energy consumption under micro gravity (relaxed state).

Conclusion

▪ In comparison with the moving speed of the slime molds under normal gravity, the moving speed of them under micro gravity is slower.

Prospect and limitation

▪ More trials are needed to reach a more accurate result. We would like to do the other experiments using the clinostat that make microgravity environment.

▪ Sometimes we couldn't get the data because the clinostat stopped during the experiments.

Reference

Y Kawasaki et al. Growth of the Cellular Slime Mold, Dictyostelium discoideum , Is Gravity Dependent Plant Physiol. 1990
YAMASHITA Masamichi et al. Tree Dimensional Clinostat and Its Operational Characteristics Biological Sciences in Space. 1997 Vol.11 No.2