Probing interaction between insects through diffusion experiments

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Background

The goal of this experiment is to find out the interaction among insects through differences between collective behaviors of semi-social insects and non-social insects. The assumption of our experiment is that behaviors of semi-social insects differ significantly from those of non-social insects. Then we can speculate interactions of semi-social and non-social insects varying degrees. Meanwhile these differences are related to the number of insects.

Some phenomenon of human beings in social life is similar to those of insects, presenting simple principle of animal world. We use two typical animals, bread-beetles(more specifically buffalo beetles whose scientific name is Alphitobius diaperinus, see picture) and drosophilas as objects of our experiments.

Alphitobius diaperinus

The process and result

Experiment 1

The purpose of the experiment

Bread-beetles are semi-social insects while drosophilas are non-social insects. So we think these two kinds of insects would have different collective behavior. This experiment is to explore that.

We plug sponge into the two sides of a test tube. Dump all the drosophilas (or bread-beetles) , which have been put inside before, to one side of the test tube. Then place the test tube horizontally and quickly. And we can observe the phenomenon. Repeat 5 times.

The result of the experiment

The phenomenon is stable. The pictures below show the result of one experiment.

Figure 1 the experiment of drosophilas(at the beginning)

Figure 2 the experiment of drosophilas(after a few seconds)

Figure 3 the experiment of drosophilas(in the end)

Figure 4 the experiment of bread-beetles (at the beginning)

Figure 5 the experiment of bread-beetles (in the end)

The analysis of the result

In the experiment of drosophilas(as figure 1,2,3 show),figure 1 shows the situation when the test tube is just placed horizontally, and figure 1 shows the situation after a few seconds. As we can see, drosophilas gathered to left quickly move to the right. Figure 3 shows the stable situation when drosophilas disperse in the test tube and don't have significant collective behavior.

In the experiment of bread-beetles (as figure 4,5 show), figure 4 shows the situation when the test tube is just placed horizontally, and figure 5 shows the stable situation when bread-beetles have significant collective behavior.

The conclusions of the experiment

The experiment shows that semi-social insects and non-social insects have very different collective behavior. Semi-social insects have significant collective behavior, while non-social insects don't.

The reflection and suggestions

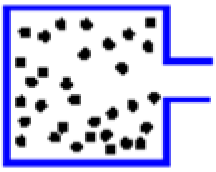
Bread-beetles Is much bigger than drosophilas, and drosophilas behave more actively than bread-beetles. That will influence the effect of the experiment. It would be better to do comparative experiment with two kinds of insects which have similar size and activity. Such as drosophilas and ants, bees and flies.

Experiment 2

The purpose of the experiment

We have known that semi-social insects and non-social insects have very different collective behavior, and semi-social insects have significant collective behavior. Then we explore how the number of bread-beetles influences the phenomenon of the diffusion during a period of time(10 minutes) in the open space.

The procedures of the experiment



Firstly, place bread-beetles in the container. Make sure the outside of the container is large enough. Then let bread-beetles move freely. Let N express the total number of the bread-beetles and R express the number of the bread-beetles in the container. Record N ,R and R/N once a minute in ten minutes.

There are three groups: N=20,50 and 100. Repeat 5 times on every group.

The result of the experiment

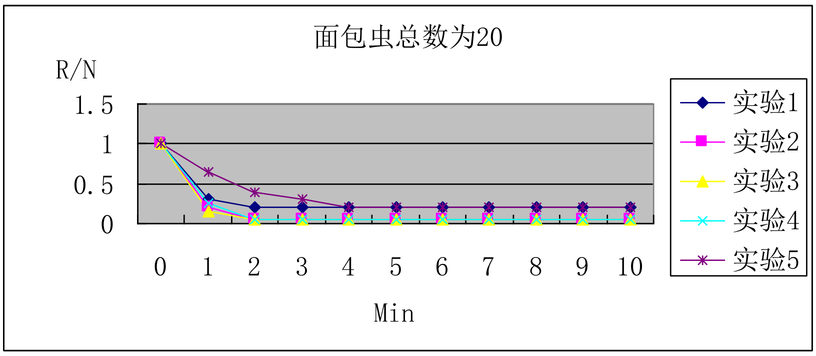


Figure 6 the experiment of bread-beetles (N=20)

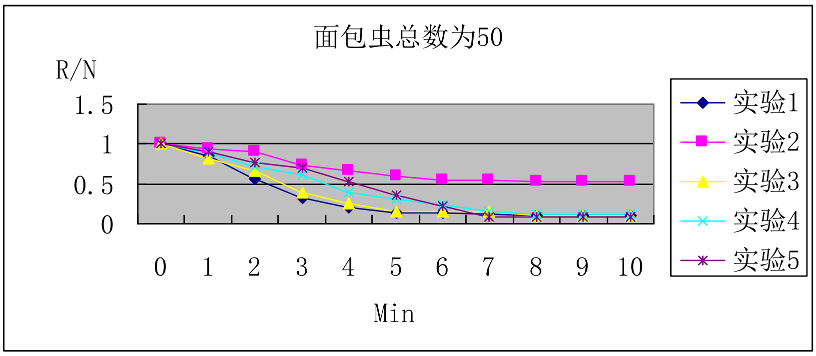


Figure 7 the experiment of bread-beetles (N=50)

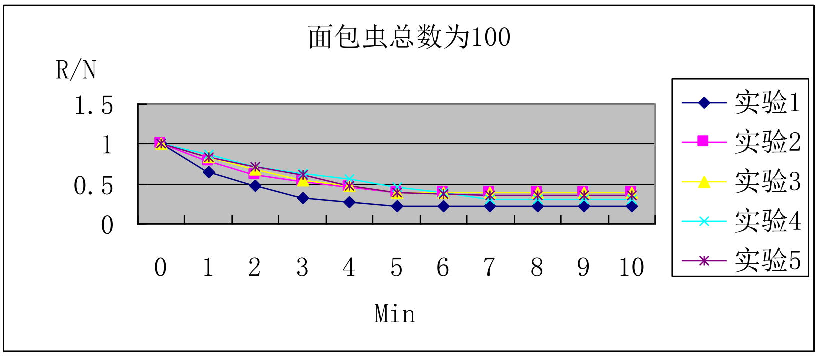


Figure 8 the experiment of bread-beetles (N=100)

The analysis of the result

Analyse R/N at the 10th minute, we can have the results as follows.

描述

			统计量	标准误
R/N (N=20)	均值		.1100	.03674
	均值的 95% 置信区间	下限	.0080	
		上限	.2120	
	5% 修整均值		.1083	
	中值		.0500	
	方差		.007	
	标准差		.08216	
	极小值		.05	
	极大值		.20	
	范围		.15	
	四分位距		.15	
	偏度		.609	.913
	峰度		-3.333	2.000
R/N (N=50)	均值		.1720	.08800
	均值的 95% 置信区间	下限	-.0723	
		上限	.4163	
	5% 修整均值		.1600	
	中值		.1000	
	方差		.039	
	标准差		.19677	
	极小值		.04	
	极大值		.52	
	范围		.48	
	四分位距		.26	
	偏度		2.108	.913
	峰度		4.569	2.000
R/N (N=100)	均值		.3380	.03121
	均值的 95% 置信区间	下限	.2513	
		上限	.4247	
	5% 修整均值		.3406	
	中值		.3600	
	方差		.005	
	标准差		.06979	
	极小值		.23	
	极大值		.40	
	范围		.17	
	四分位距		.13	

偏度	-1.094	.913
峰度	.379	2.000

Table 1 the analysis of R/N

The figure shows confidence interval and mean value.

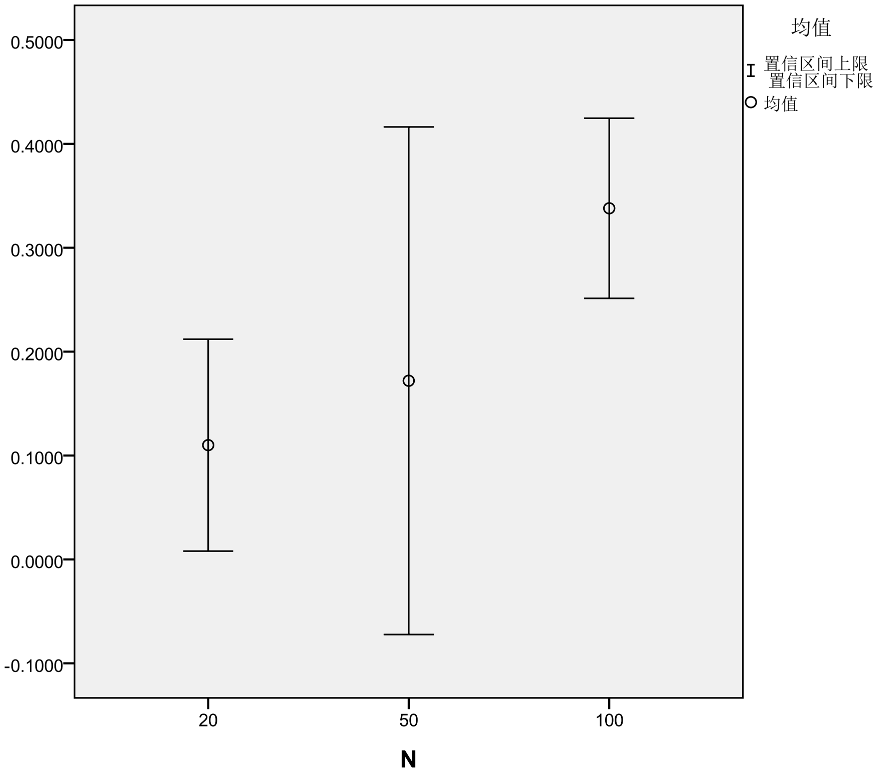


Figure 9 high-low graph(N—R/N)

As we can see, with N increasing from 20 to 100, R/N increases as well. The three groups of mean value seem to be near a straight line. The figure below is the linear regression for the three groups of mean value.

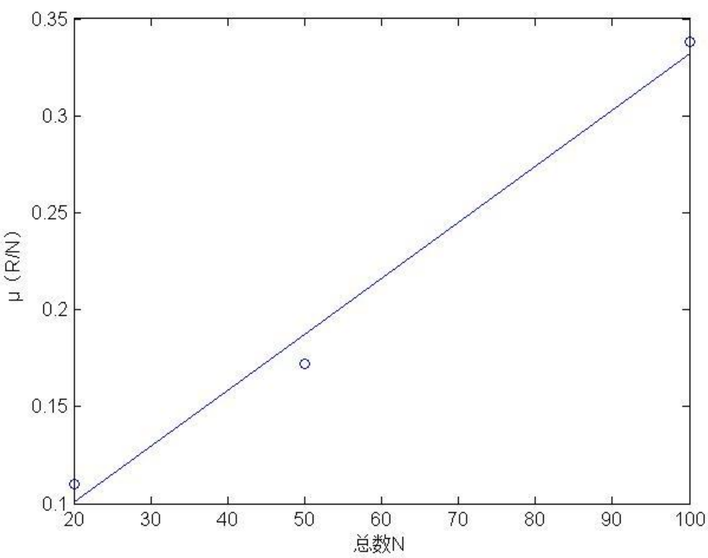


Figure 10 linear regression(N-R/N)

The regression equation isμ(R/N)= 0.0029*N+0.0424,and the goodness of fit is R^2=0.9870.

As we can see, there is a positive linear relationship between N and R/N. In other words, with the increase of N, R/N tends to increase.

The conclusions of the experiment

When bread-beetles diffuse in the open space, there will be more bread-beetles staying in the container and more significant collective behavior if there are more bread-beetles at the beginning.

The reflection and suggestions

The standard deviation of N=50 is too large. We can do more experiment to improve that.

Experiment 3

The purpose of the experiment

Explore how the number of bread-beetles influences the phenomenon of the diffusion during a period of time(30 minutes) in the closed space.

The procedures of the experiment

Firstly, place bread-beetles in area A. Then let bread-beetles move freely. Let N express the total number of the bread-beetles , N1 express the number of the bread-beetles in area A and N2 express the number of the bread-beetles in area B.

Record N ,N1 and N2 once a minute in first 15 minutes. Then record once every 5 minutes. There may be some bread-beetles still moving between two areas at the last time. Let N3 express the number of these bread-beetles.

There are 5 groups: N=20,30,50,70 and 100. Repeat 10 times on every group.

The result of the experiment

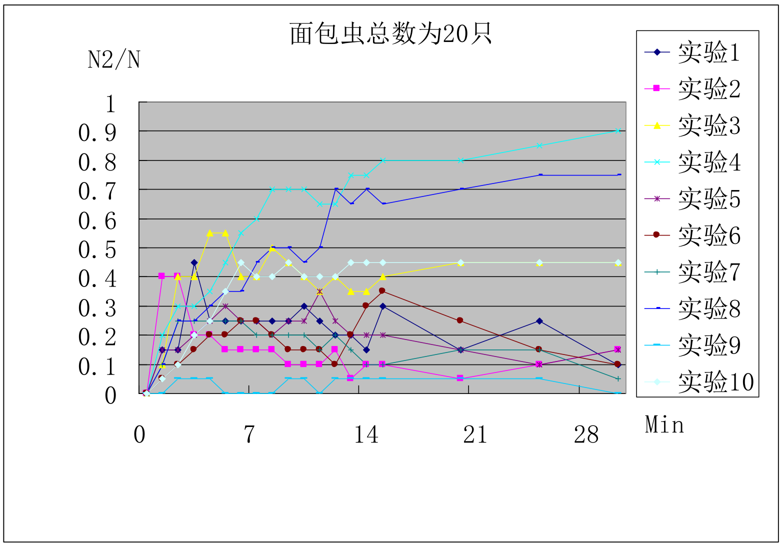


Figure 11 the experiment of bread-beetles (N=20)

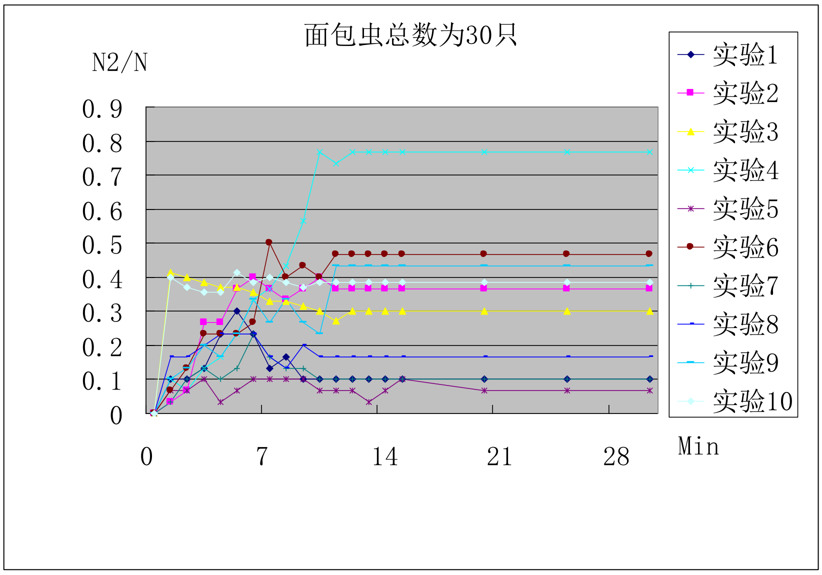


Figure 12 the experiment of bread-beetles (N=30)

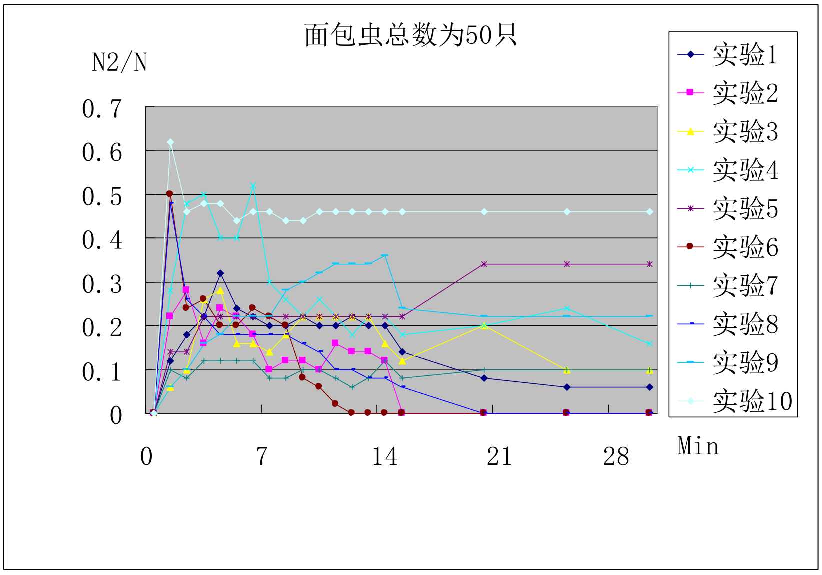


Figure 13 the experiment of bread-beetles (N=50)

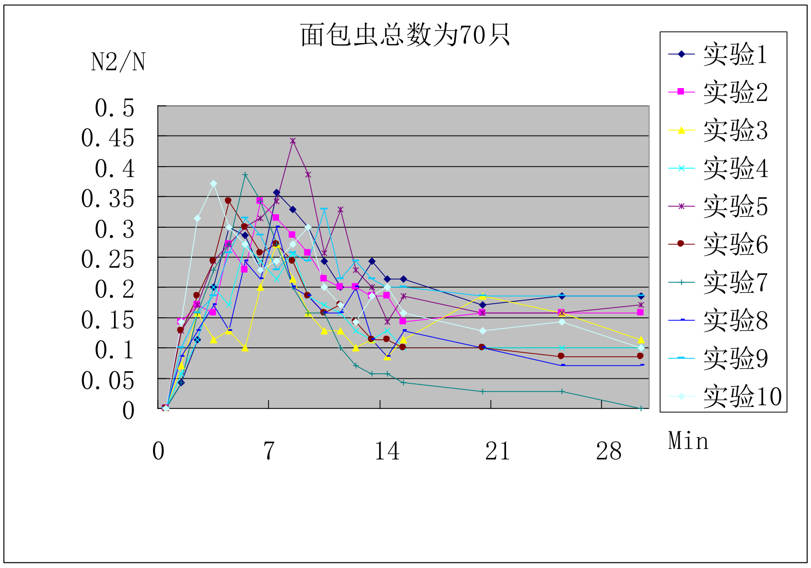


Figure 14 the experiment of bread-beetles (N=70)

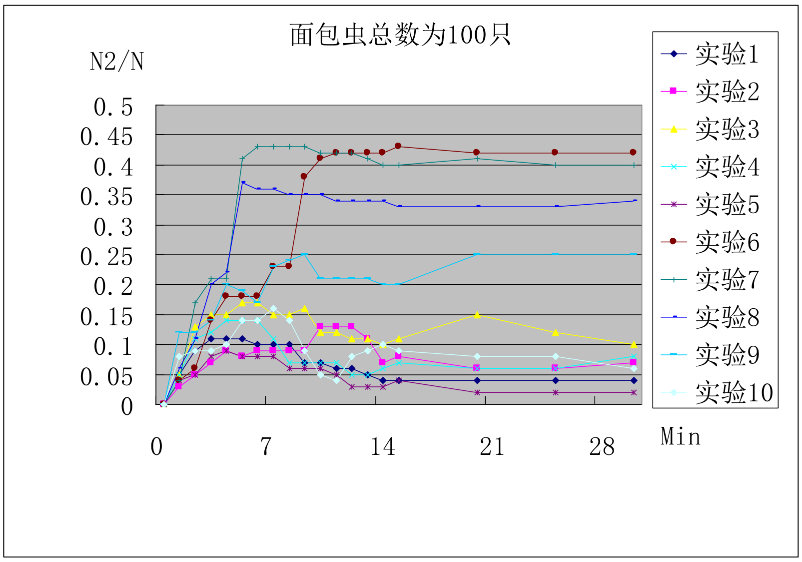


Figure 15 the experiment of bread-beetles (N=100)

总数 N	N3/N									
20	0.35	0.30	0.00	0.30	0.30	0.15	0.10	0.15	0.10	0.15
30	0.10	0.23	0.10	0.13	0.13	0.23	0.27	0.40	0.17	0.17
50	0.24	0.10	0.06	0.12	0.12	0.08	0.06	0.08	0.16	0.06
70	0.03	0.07	0.03	0.14	0.16	0.10	0.11	0.04	0.17	0.04
100	0.07	0.04	0.07	0.14	0.15	0.12	0.08	0.16	0.13	0.06

Table 2 the data of N3/N

The result of the experiment

From figures above, we can come to a conclusion. In a certain range, with the increase of N, the ratio bread-beetles of moving from A to B tends to reduce.

Analyze N2/N at the last time when N=20,30,50,70,100. The results are as follows.

描述

		统计量	标准误
N2/N	均值	.3100	.09911

(N=20)	均值的 95% 置信区间	下限	.0858	
		上限	.5342	
	5% 修整均值		.2944	
	中值		.1500	
	方差		.098	
	标准差		.31340	
	极小值		.00	
	极大值		.90	
	范围		.90	
	四分位距		.44	
	偏度		1.001	.687
	峰度		-.303	1.334
N2/N (N=30)	均值		.3152	.06867
	均值的 95% 置信区间	下限	.1598	
		上限	.4705	
	5% 修整均值		.3039	
	中值		.3333	
	方差		.047	
	标准差		.21716	
	极小值		.07	
	极大值		.77	
	范围		.70	
	四分位距		.34	
	偏度		.796	.687
	峰度		.632	1.334
N2/N (N=50)	均值		.1440	.04915
	均值的 95% 置信区间	下限	.0328	
		上限	.2552	
	5% 修整均值		.1344	
	中值		.1000	
	方差		.024	
	标准差		.15543	
	极小值		.00	
	极大值		.46	
	范围		.46	
	四分位距		.25	
	偏度		1.102	.687
	峰度		.457	1.334
N2/N (N=70)	均值		.1171	.01866
	均值的 95% 置信区间	下限	.0749	

	间	上限	.1593	
	5% 修整均值		.1198	
	中值		.1071	
	方差		.003	
	标准差		.05901	
	极小值		.00	
	极大值		.19	
	范围		.19	
	四分位距		.09	
	偏度		-.591	.687
	峰度		.145	1.334
N2/N (N=100)	均值		.1780	.04995
	均值的 95% 置信区间	下限	.0650	
		上限	.2910	
	5% 修整均值		.1733	
	中值		.0900	
	方差		.025	
	标准差		.15796	
	极小值		.02	
	极大值		.42	
	范围		.40	
	四分位距		.30	
	偏度		.664	.687
	峰度		-1.528	1.334

Table 3 descriptive analysis of N2/N

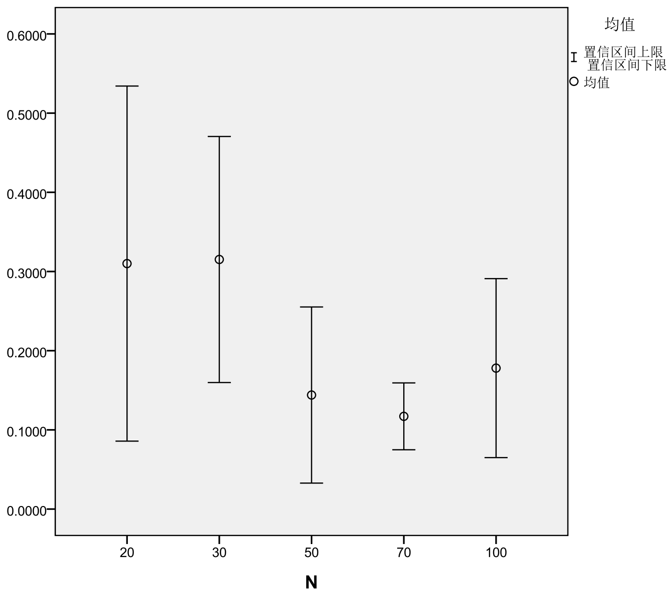


Figure 16 high-low graph(N—N2/N)

As we can see, with N increasing from 20 to 70, the mean value of N2/N reduces. bread-beetles tend to stay in area A. At the same time, the range and standard deviation of N2/N reduce. The behavior that bread-beetles stay in area A tends to be more stable.

However, when N increases from 70 to 100, the mean value of N2/N increases. Perhaps, it is because there are some new groups coming into being when N increases to a certain extent. And that makes it more complicated and unstable.

The figure below is the final result of an experiment when N=100. there is a new and small group coming into being in area B. It leads to the increase of N2/N.However,it doesn't mean that collective behavior is weakened. As we can see from the graph, bread-beetles obviously group into two groups.

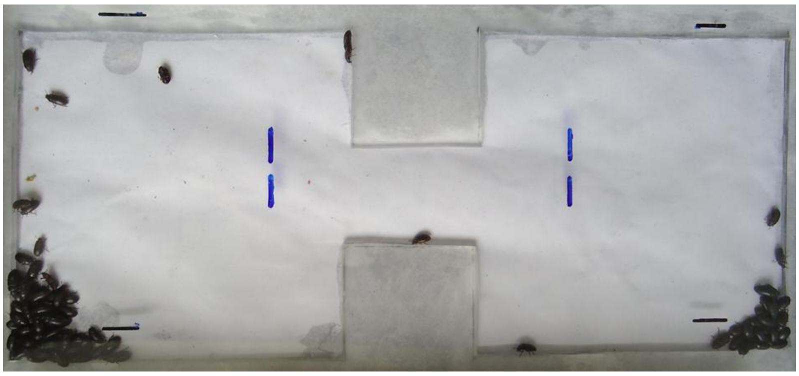


Figure 17 a final result of an experiment(N=100)

The figure below is the linear regression for the 5 groups of mean value of N2/N at the last time.

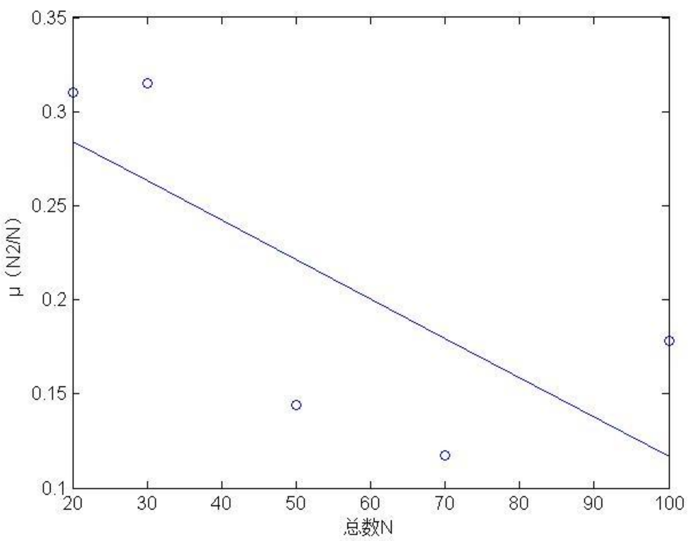


Figure 18 linear regression(N-N2/N)

The regression equation isμ(N2/N)= -0.0021*N+ 0.3258,and the goodness of fit is R^2= 0.5147.

As we can see, there is a negative linear relationship between N and N2/N. In other words, with the increase of N, N2/N tends to reduce.

Besides,N3/N can show the collective behavior to some extent.

Analyze N3/N when N=20,30,50,70,100. The results are as follows.

描述

			统计量	标准误
N3/N（N=20）	均值		.1900	.03636
	均值的 95% 置信区间	下限	.1077	
		上限	.2723	
	5% 修整均值		.1917	
	中值		.1500	
	方差		.013	
	标准差		.11499	
	极小值		.00	
	极大值		.35	
	范围		.35	
	四分位距		.20	
	偏度		-.038	.687
	峰度		-1.172	1.334
N3/N（N=30）	均值		.1930	.02940
	均值的 95% 置信区间	下限	.1265	
		上限	.2595	
	5% 修整均值		.1867	
	中值		.1700	
	方差		.009	
	标准差		.09298	
	极小值		.10	
	极大值		.40	
	范围		.30	
	四分位距		.12	
	偏度		1.260	.687
	峰度		1.666	1.334
N3/N（N=50）	均值		.1080	.01794
	均值的 95% 置信区间	下限	.0674	
		上限	.1486	
	5% 修整均值		.1033	
	中值		.0900	
	方差		.003	
	标准差		.05673	
	极小值		.06	
	极大值		.24	
	范围		.18	
	四分位距		.07	
	偏度		1.573	.687

	峰度		2.577	1.334
N3/N（N=70）	均值		.0890	.01729
	均值的 95% 置信区间	下限	.0499	
		上限	.1281	
	5% 修整均值		.0878	
	中值		.0850	
	方差		.003	
	标准差		.05466	
	极小值		.03	
	极大值		.17	
	范围		.14	
	四分位距		.11	
	偏度		.323	.687
	峰度		-1.617	1.334
N3/N（N=100）	均值		.1020	.01348
	均值的 95% 置信区间	下限	.0715	
		上限	.1325	
	5% 修整均值		.1022	
	中值		.1000	
	方差		.002	
	标准差		.04264	
	极小值		.04	
	极大值		.16	
	范围		.12	
	四分位距		.08	
	偏度		.000	.687
	峰度		-1.720	1.334

Table 4 descriptive analysis of N3/N

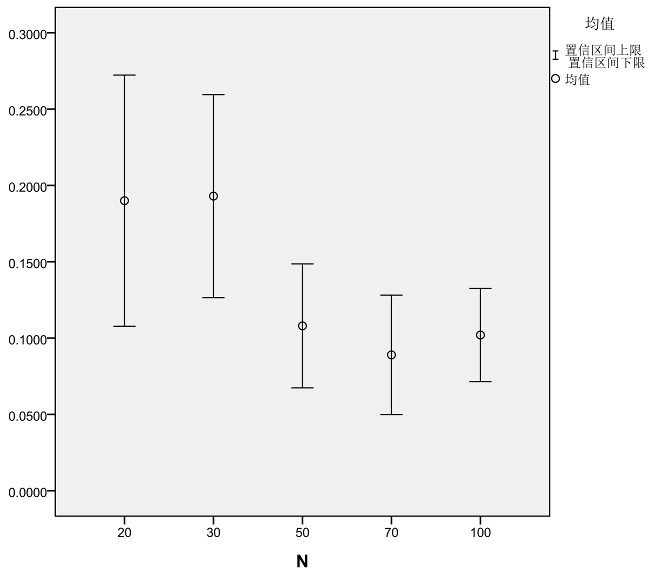


Figure 19 high-low graph(N—N3/N)

As we can see, with N increasing from 20 to 100, the mean value of N3/N overall reduces. Bread-beetles tend to stay together. At the same time, the range and standard deviation of N3/N reduce. The behavior that bread-beetles stay together tends to be more stable.

The figure below is the linear regression for the 5 groups of mean value of N3/N.

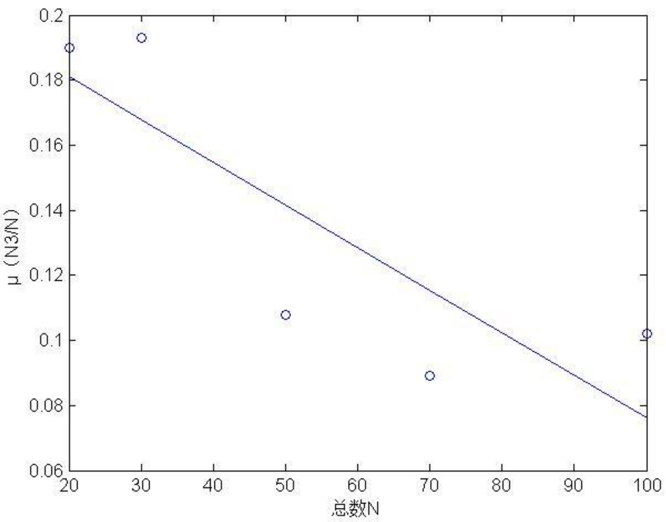


Figure 20 linear regression(N-N3/N)

The regression equation isμ(N2/N)= -0.0013*N+ 0.2073,and the goodness of fit is R^2=0.6883.

As we can see, there is a negative linear relationship between N and N3/N. In other words, with the increase of N, N3/N tends to reduce.

The conclusions of the experiment

In a certain range, with the increase of N, bread-beetles tend to stay together rather than keep moving.

The reflection and suggestions

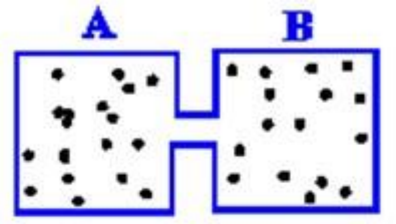
Add up the number of the group of experiment and do more experiment. It is helpful to analyze the influence of N in detail and to reduce the error.

Experiment 4

The purpose of the experiment

When bread-beetles move between areas A,B, they may gather in crowds and groups. It is a kind of collective behavior. We are going to explore how N influences the collective behavior when bread-beetles are moving.

The procedures of the experiment



Firstly, place bread-beetles in area A and B averagely. Then let bread-beetles move freely. Let N express the total number of the bread-beetles , M express the number of the bread-beetles moving between two areas together, M1 express the number of the bread-beetles moving from area A to area B together and M2 express the number of the bread-beetles moving from area B to area A together.

There are 3 groups: N=20,50 and 100. Repeat 5 times on every group.

The result of the experiment

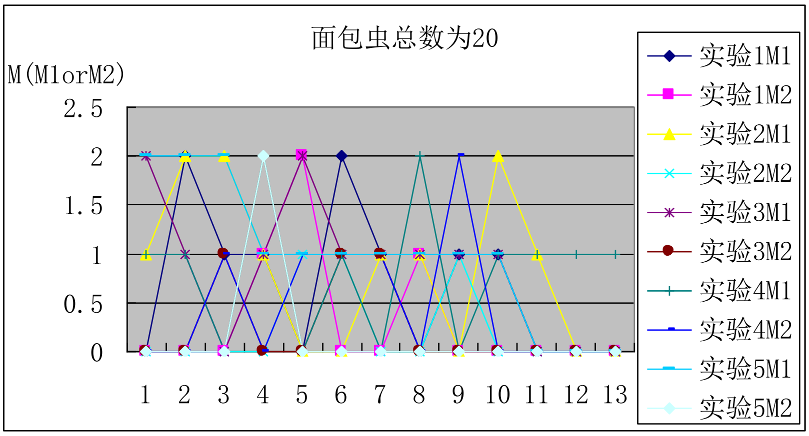


Figure 21 the experiment of bread-beetles (N=20)

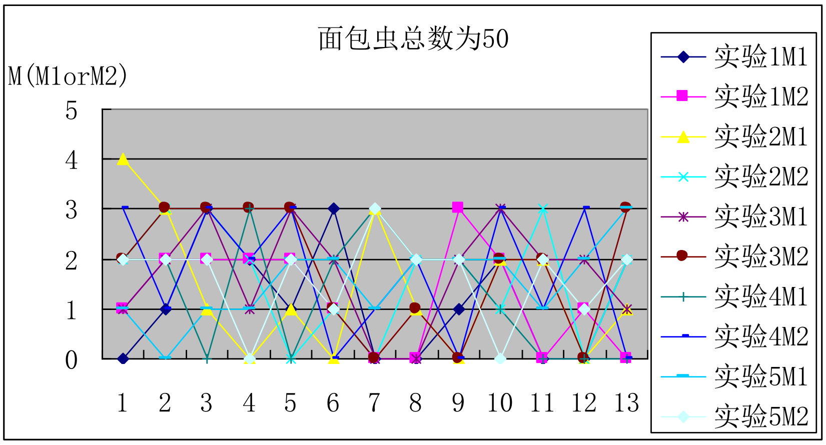


Figure 22 the experiment of bread-beetles (N=50)

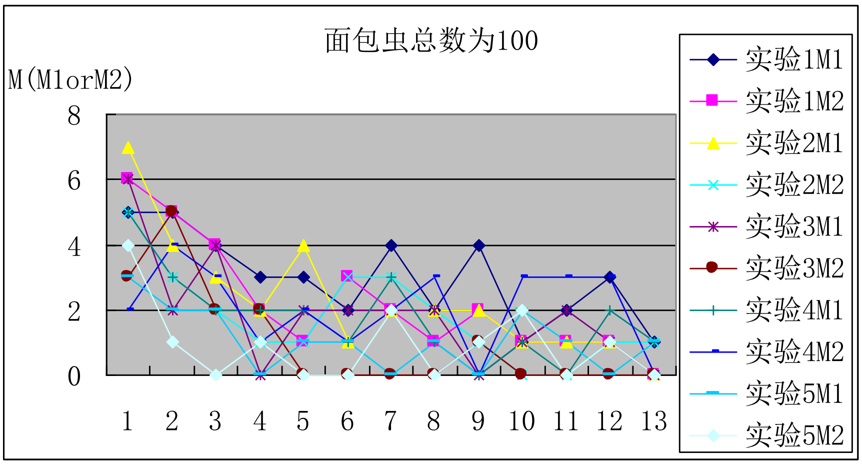


Figure 23 the experiment of bread-beetles (N=100)

The analysis of the result

描述统计量

	样本容量	极小值	极大值	均值	标准差
实验1M1	13	.00	2.00	.6923	.75107
实验1M2	13	.00	2.00	.3077	.63043
实验2M1	13	.00	2.00	.8462	.80064
实验2M2	13	.00	1.00	.2308	.43853
实验3M1	13	.00	2.00	.8462	.68874
实验3M2	13	.00	1.00	.2308	.43853
实验4M1	13	.00	2.00	.8462	.68874
实验4M2	13	.00	2.00	.4615	.66023
实验5M1	13	.00	2.00	1.0000	.70711
实验5M2	13	.00	2.00	.1538	.55470
有效的样本数量	13				

Table 5 descriptive analysis of M1,M2(N=20)

描述统计量

	样本容量	极小值	极大值	均值	标准差
实验1M1	13	.00	3.00	1.1538	1.14354
实验1M2	13	.00	3.00	1.2308	1.01274
实验2M1	13	.00	4.00	1.3846	1.32530
实验2M2	13	.00	3.00	1.6154	1.12090
实验3M1	13	.00	3.00	1.6923	1.03155
实验3M2	13	.00	3.00	1.7692	1.23517
实验4M1	13	.00	3.00	1.3077	1.18213
实验4M2	13	.00	3.00	1.6923	1.25064
实验5M1	13	.00	3.00	1.5385	.77625
实验5M2	13	.00	3.00	1.6154	.86972
有效的样本数量	13				

Table 6 descriptive analysis of M1,M2(N=50)

描述统计量

	样本容量	极小值	极大值	均值	标准差
实验1M1	13	1.00	5.00	3.0000	1.35401
实验1M2	13	.00	6.00	2.2308	1.78670
实验2M1	13	.00	7.00	2.3077	1.84321
实验2M2	13	.00	5.00	1.7692	1.42325
实验3M1	13	.00	6.00	1.8462	1.67562
实验3M2	13	.00	5.00	1.0000	1.58114
实验4M1	13	.00	5.00	1.7692	1.36344
实验4M2	13	.00	4.00	2.0769	1.25576
实验5M1	13	.00	3.00	1.0769	.95407
实验5M2	13	.00	4.00	.9231	1.18754
有效的样本数量	13				

Table 7 descriptive analysis of M1,M2(N=100)

With N increasing from 20 to 100, the number of the bread-beetles moving together tends to increase.

描述

			统计量	标准误
均值（N=20）	均值		.56155000	.100659594
	均值的 95% 置信区间	下限	.33384218	
		上限	.78925782	
	5% 修整均值		.55984444	
	中值		.57690000	
	方差		.101	
	标准差		.318313585	
	极小值		.153800	
	极大值		1.000000	
	范围		.846200	
	四分位距		.615400	
	偏度		-.008	.687
	峰度		-1.942	1.334
均值（N=50）	均值		1.50000000	.068081921
	均值的 95% 置信区间	下限	1.34598799	
		上限	1.65401201	
	5% 修整均值		1.50427778	
	中值		1.57695000	
	方差		.046	
	标准差		.215293939	
	极小值		1.153800	

	极大值		1.769200	
	范围		.615400	
	四分位距		.403825	
	偏度		-.456	.687
	峰度		-1.342	1.334
均值（N=100）	均值		1.80000000	.208056629
	均值的 95% 置信区间	下限	1.32934321	
		上限	2.27065679	
	5% 修整均值		1.78205000	
	中值		1.80770000	
	方差		.433	
	标准差		.657932830	
	极小值		.923100	
	极大值		3.000000	
	范围		2.076900	
	四分位距		1.192350	
	偏度		.193	.687
	峰度		-.315	1.334

Table 8 descriptive analysis of the mean value of M1,M2

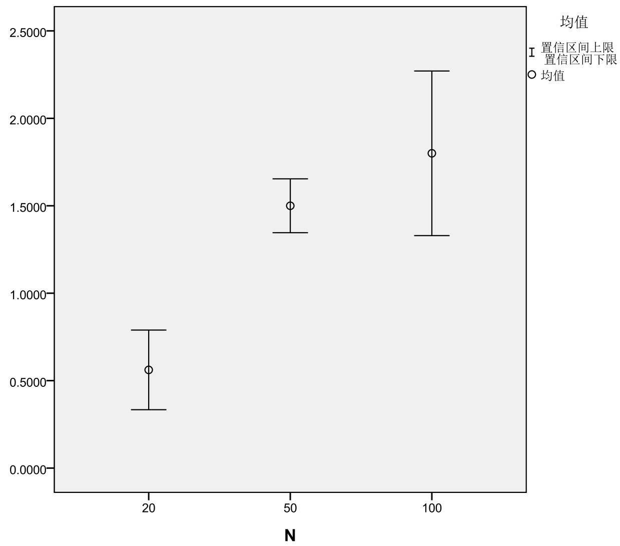


Figure 24 high-low graph(N—M)

With N increasing from 20 to 100, the mean value of the number of the bread-beetles moving between two areas together tends to increase.

The figure below is the linear regression for the mean value.

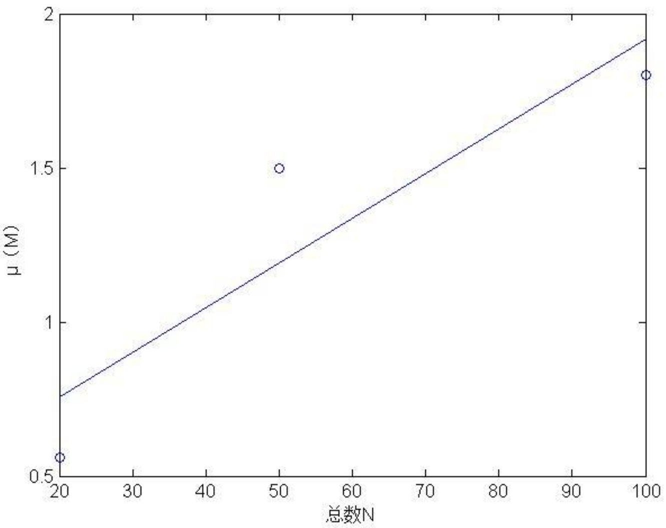


Figure 25 linear regression(N-M)

The regression equation isμ(M)= 0.0145*N+ 0.4648,and the goodness of fit is R^2=0.8242.

As we can see, there is a positive linear relationship between N and M. In other words, with the increase of N, M tends to reduce.

The conclusions of the experiment

In a certain range, with the increase of N, bread-beetles tend to moving together.

The reflection and suggestions

Add up the number of the group of experiment and do more experiment. It is helpful to analyze the influence of N in detail and to reduce the error.

Besides, taking video makes the experiment more easily and less error than taking pictures.

In a certain range, there is a positive linear relationship between the total number of the bread-beetles and the collective behavior. The collective behavior will perform stronger and more obviously if there are more bread-beetles. When the total number of the bread-beetles is larger, bread-beetles tend to stay together, even when they are moving.

The data we gathered and the analysis results of our experiment can explain the assumptions we make at first.

Semi-social and non-social insects show significant differences of collective behaviors. We focused on behaviors of bread-beetles-like insects, then we speculate interactions of semi-social and non-social insects varying degrees. Different number of samples show different results in experiment.

In social life, human beings have similar behaviors like insects. The interactions among human beings will influence numbers of kinds of behaviors such as decision, contact and gregariousness.