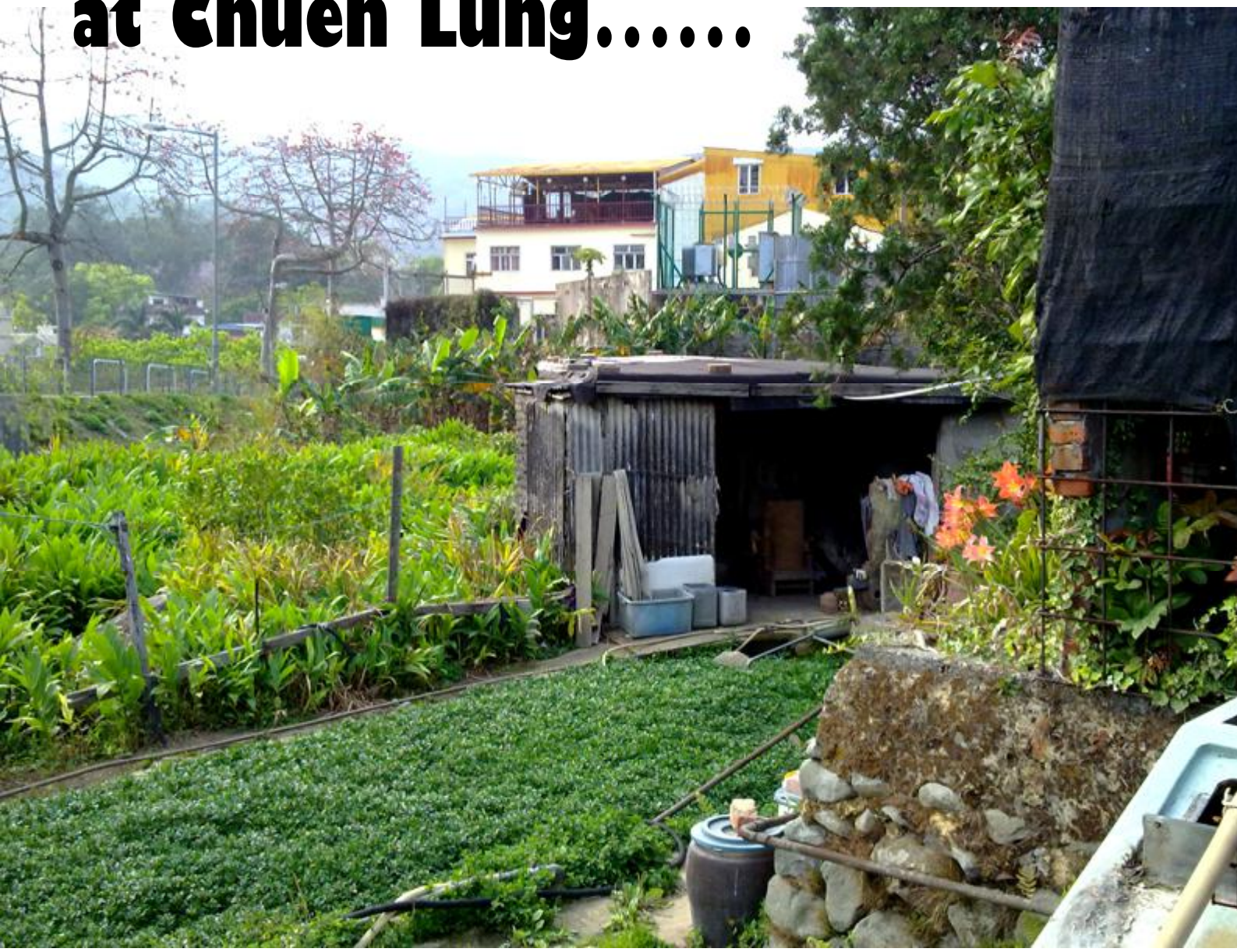
When S. natans Meets L. minor at Chuen Lung……



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Form 5

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Date:

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Introduction

On the 18th March 2011, we visited Chuen Lung village during a Biology fieldtrip. We visited watercress (*Nasturtium officinale*) farmland owned by an organic farmer, Mr. Law. Interestingly, we found the ditches between rows of watercress are dominated by a very tiny floating plant, while there were only a few larger floating ferns. We wondered why there was such distribution. On the same day, we visited the Ho Koon Nature Education Cum Astronomical Centre. Surprisingly, in the backyard pond of the centre, there were quite a number of populations of the larger floating ferns. Out of curiosity, we collected samples of these two plant species to school for further investigation.

After some research, we knew that the very tiny floating plants were Lemna Minor (L. minor), a very popular kind of lemna in Hong Kong, while the larger floating ferns were Salvinia natans (S. natans), a rare water fern species in Hong Kong. S. natans used to be quite thriving in the ponds in Sai Kung. However, the number of populations has been reducing in recent years. What is the reason behind the domination of two species in different places? Is the dwindling trend of population of S. natans due to interspecific competition? In light of this, we decided to investigate the competition for minerals between S. natans and L. minor.

Objective

1. Investigate the competition between the S. natans and L. minor for minerals (nitrate and phosphate).

2. Find out the reasons for domination of S. natans and L. minor in Ho Koon Nature Education Cum Astronomical Centre and Chuen Lung watercress farmland respectively.

3. Raise public's awareness towards conservation of environment, especially plant species and water quality.

Abstract

In our study, S. natans and L. minor are our investigation targets.Our objectives are divided into 3 parts: First, to find out the reasons for domination of S. natans and L. minor in Ho Koon Nature Education Cum Astronomical Centre and Chuen Lung watercress farmland respectively, we went to fieldtrip to interview and take water samples from both sites to find out the abiotic factors of both habitats. Second, to investigate the competition between the S. natans and L. minor for minerals, we carried out the experiment to observe the competitiveness of 2 species. After our experiments, it shows the competition relationship L. minor and S, natans. Also, we discovered that L. minor will growth poorly and even die under insufficient supply of nitrate and phosphate. On the other hand, the S.natnas grows better that L. minor in insufficient supply of nitrate and phosphate. We hope to raise public's awareness on ecological conservation through this project, such as learn to appreciate plants and improve water quality.

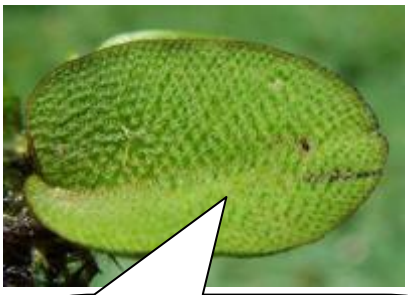
Habitats of investigation

Map from Google Earth

Description of the Two Plant Species

A. *Salvinia natans*

✧**Kingdom:** Plantae
✧**Family:** Salviniaceae
✧**Genus:** Salvinia Ség.
✧**Common name:** Floating watermoss
✧**Habitat requirement:**
Still, standing and open water
High humidity
Bright light
Temperature 20°C- 28°C
✧**Dominant regions :**
Cental Europe, South America, Asia and Africa

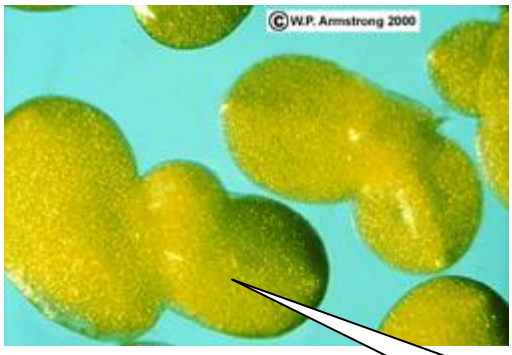


Small hairs and papillae:
Serve as water proofing

1 branch contains 3 leaves
✧**2 leaves float on water:**
Small, round in shape
1-2cm diameter
Air cavities in the leaves help the tiny plant to stay afloat
✧**1 leaf submerge in water:**
Downward growth
Divide into numerous root-like branches to serve as roots

B. Lemna Minor

✧**Kingdom:** Plantae
✧**Family:** Araceae
✧**Genus:** Lemna
✧**Common name:** Duckweed



Leaf: 1-3 mm diameter

Methodology

A. Field Study

1. Observation during the fieldtrip

During the field trip, we need to find out the abiotic factor of the habitat to simulate the natural habitat of the 2 species. We have interviewed the owner of the Watercress land, Mr. Law. He said he had used organic fertilizer to enhance plant growth which contains disposed fish bone, fish head etc. This indicates the habitat of L. minor contains nitrate and phosphate. Besides, the mineral contents of water samples there were measured.

B. Experiment

Our experiment is carried out by 2 methods, measurement and observation:

(1) Measuring the total leaf area of samples

Rules for sketching the total leave area of S. natans:

1. The third leaf, which is developed into root-like structure is not counted
2. Yellowish, brown or black leaves are regarded as dead leaves, which are also not counted

Rules for counting no. of squares occupied by S. natans:

1. For a complete square, one square counts as one unit of area
2. For incomplete square, more than half counts as one unit of area; less than half is not counted

Rules for filling L. minor into pits:

1. Overlapping of L. minor should be avoided.
2. White, yellowish, brown or black leaves are regarded as dead leaves, which are also not counted

(2) Observation

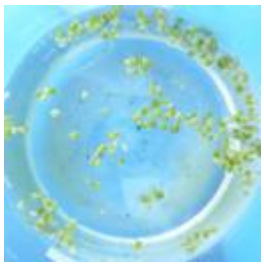
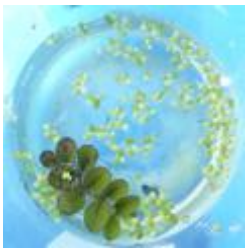
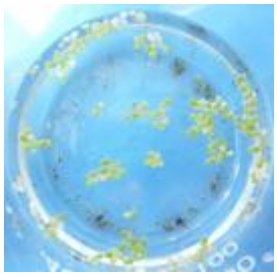
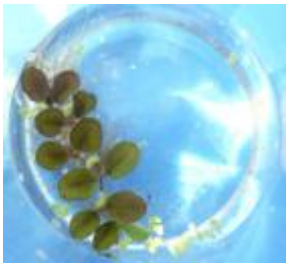
During the experiment, we observe the color of the leaves, length of roots in order to find out the effect of the deficiency of certain mineral salts. Yellow, brown leaves and short roots both mean lacking of such minerals restrict the growth of 2 species.

Importance of minerals

A. Phosphate

Adequate phosphate allows a fast rate of growth and development in the plants. When phosphate ions are limited, the most striking effects are a reduction in leaf expansion and leaf surface area, as well as the number of leaves. Root growth will be affected too due to deficiency of phosphate. Moreover, the inadequate supply of phosphate slows down the process of carbohydrate utilization, while carbohydrate production through photosynthesis continues. This results in the development of dark green color or even purple color.

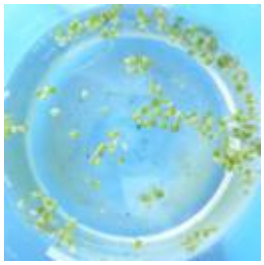
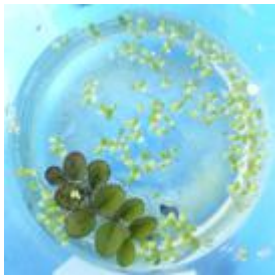
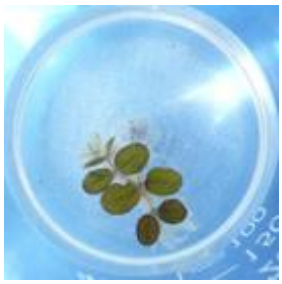
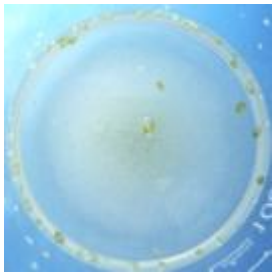
A comparison table to show the effect of inadequate supply of *Phosphate* PO_4^{3-} to lemna in the solution without *Phosphate* PO_4^{3-}

Species / Solutions	S. natans (monoculture)	L. minor (monoculture)	Mixed culture
Complete Culture solution			
Culture solution without *Phosphate* PO_4^{3}			

B. Nitrate

Nitrogen is essential for growth and reproduction of all plant since it is a basic constituent of proteins. A plant supplied with adequate nitrates grows rapidly and produces large amounts of succulent, green foliage. A nitrogen-deficiency plant is generally small and develops slowly because it lacks the nitrogen necessary to manufacture adequate structural and genetic materials. It usually becomes pale green or yellowish , because it lacks chlorophyll. Some would even die.

A comparison table to show the effect of inadequate supply of *Nitrate* NO_3^- to lemna

Species / Solutions	S. natans (monoculture)	L. minor (monoculture)	Mixed culture
Complete Culture solution			
Culture solution without *Nitrate* NO_3^-			

Experimental Results

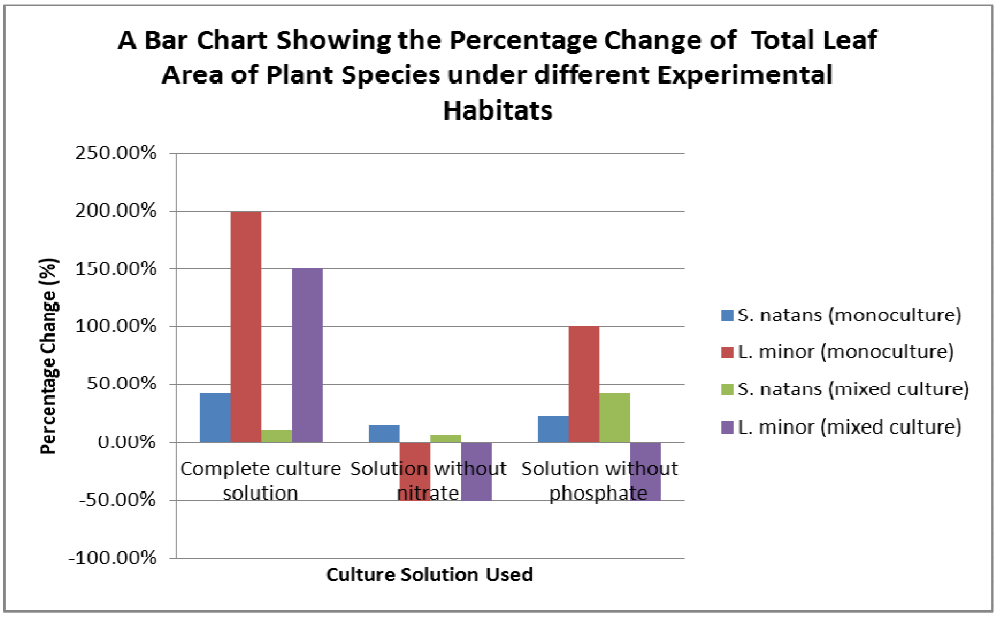
A. Observed results

At the beginning, all the lemna grow in the same condition such as under same light intensity. All the big lemna used at the beginning of the experiment have green leaves while the leaves of the Lemnaoideae are small and green. The roots are short.

Observations of different lemna at the end of the experiment (30 March)

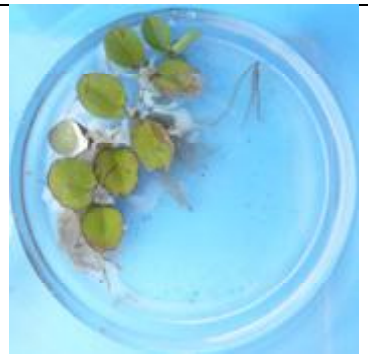
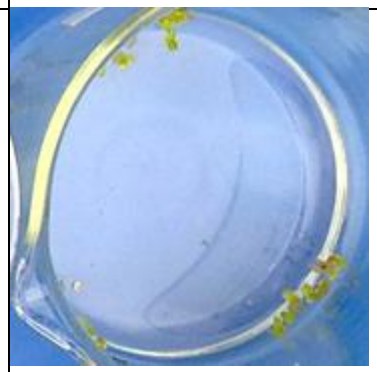
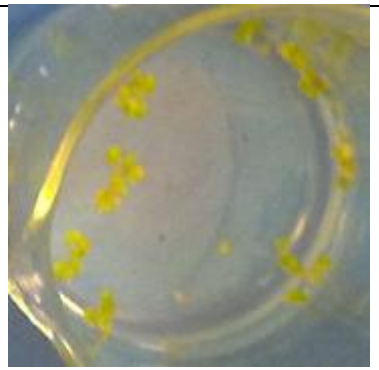
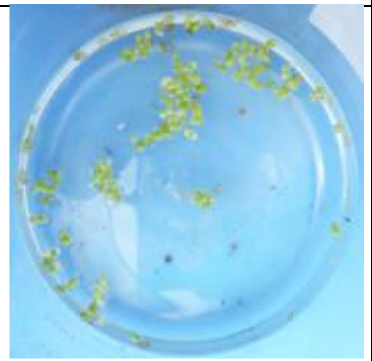
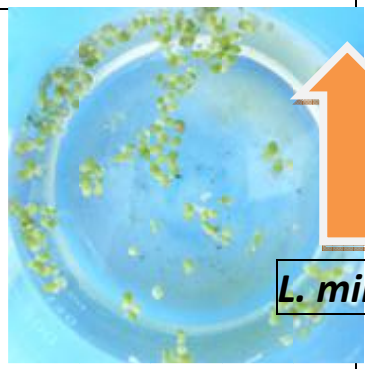
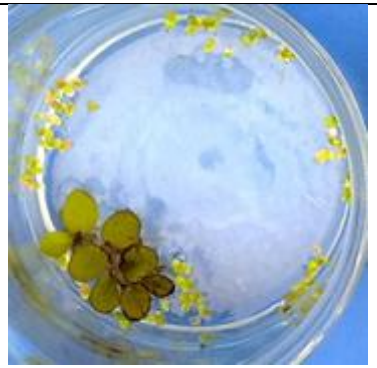
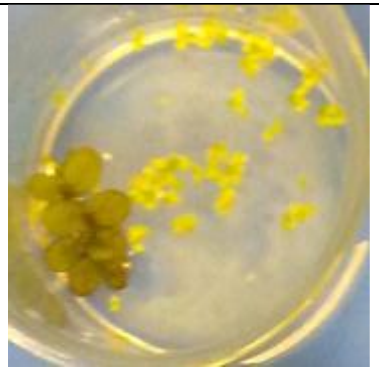
Solutions / Species	Complete culture solution	Culture Solution without nitrate	Culture Solution without phosphate
***S. natans* (monoculture)**	New leaves appear and original leaves become bigger. Roots become longer.	Poor growth. Some leaves turn brown.	Poor growth. Some leaves become rotten and turn dark green color. Leaves expanse slightly.
***L. minor* (monoculture)**	Healthy growth. More leaves and leaves are larger. The roots are longer.	Very poor growth. Large amount of leaves turn white. Some even die and stick on the inner surface of beaker.	Increase in number of leaves but some leaves turn white. The growth of root is poor.
***S. natans* (Mixed culture)**	Larger leaves and growth of new leaves. Roots become longer.	Very poor growth. Some leaves turn brown and die.	Dark green leaves. Slightly increase in the leaves' size
***L. minor* (mixed culture)**	More and green leaves. The growth of roots is good. They become longer.	Very poor growth. Nearly all leaves turn white and die. No growth on roots.	Do not have great change in number and size of leaves. Poor growth on roots.

B. Bar Chart



C. Photo Series

Complete Culture Solution

Species / Date	21 March 2011	25 March 2011	29 March 2011	3 April 2011
S. natans (monoculture)				
L. minor (monoculture)				
Mixed culture				

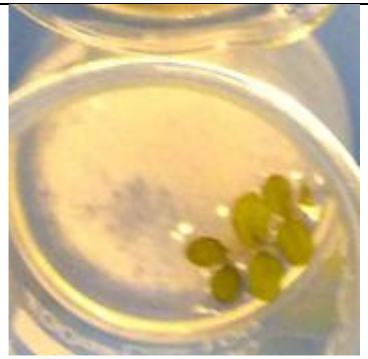
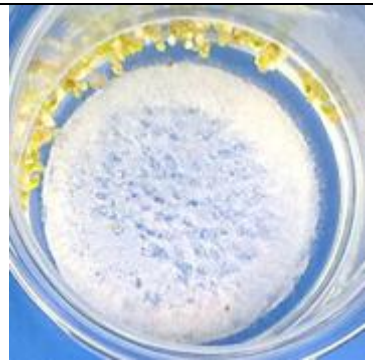
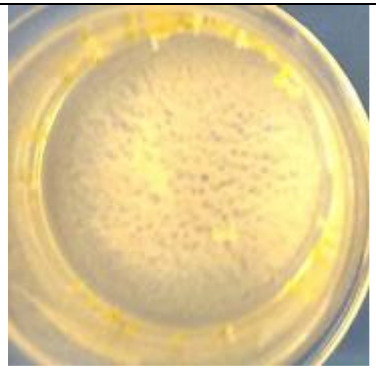
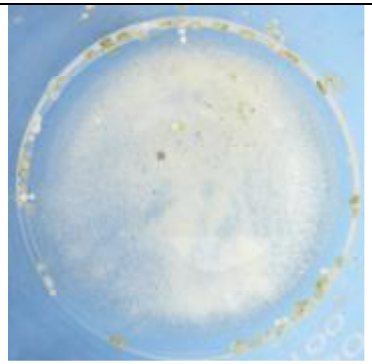
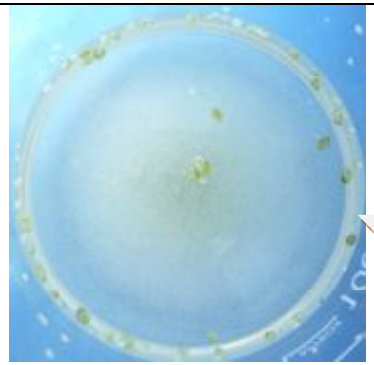
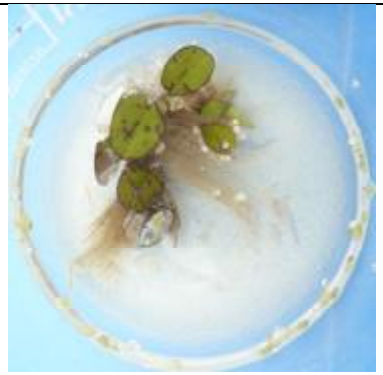
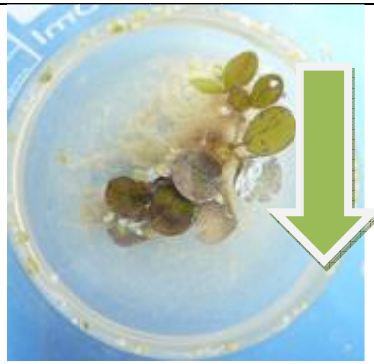
Trend

S. natans

L. minor

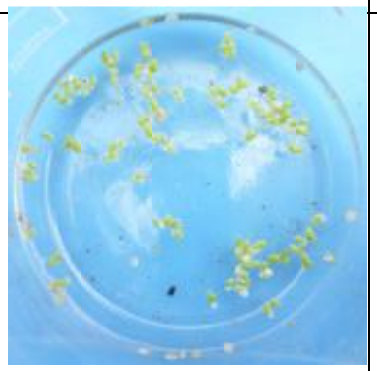
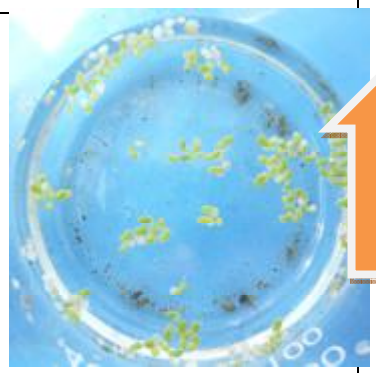
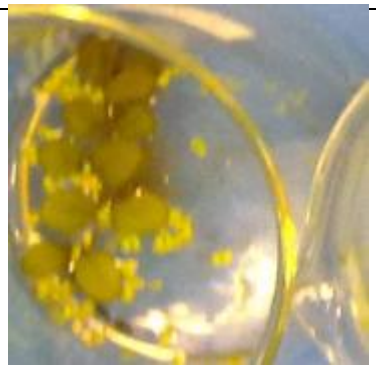
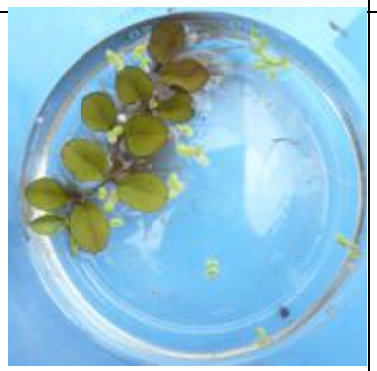
S. natans *L. minor*

Culture Solution *without* Nitrate NO_3^-

Species / Date	21 March 2011	25 March 2011	29 March 2011	3 April 2011
S. natans **(monoculture)**				
L. minor **(monoculture)**				
Mixed culture				

Trend

Culture Solution *without* Phosphate PO_4^{3-}

Species / Date	21 March 2011	25 March 2011	29 March 2011	3 April 2011
S. natans **(monoculture)**				
L. minor **(monoculture)**				
Mixed culture				

Trend

Analysis of results

A. In complete culture solution

⇨Experimental result

For monoculture of L. minor, initially, the total leaf area (TLA) was about 1 pit. The final TLA of L. minor were 3 pits. It's increased by 200%. For monoculture of S. natans, the TLA of it increased by 42.57%. When two species were mixed to culture, the TLA of L. minor increased by 150% while that of S. natans increased by 11.11%.

⇨Interpretation and Underlying principal

We observed that both species grow well under our experimental habitats.

By comparing the growth of S. natans and L. minor under monoculture, the growth rate of L. minor is faster than that of S. natans. It shows that L. minor's demand for resources are lower than that of S. natans.

By comparing the growth of of S. natans and L. minor under mixed culture, the growth rate of S. natans is slower than that of L. minor. It shows that competition exerted a larger negative influence on the growth of S. natans than that of L. minor.

B. In the solution without nitrate

⇨Experimental result

For monoculture of L. minor, initially, the total leaf area (TLA) was about 1 pit. The final TLA of L. minor was only a half pit. It decreased by 50%. For monoculture of S. natans, the TLA of it increased by only increase 15.19%, which is the least among 4 setups of monocultivation.

When two species were mixed to culture, only about 30% of L. minor can survive while the TLA of S. natans slightly increase by 7.25%.

⇨Interpretation and Underlying principal

Obviously, depletion of nitrate leads to stunted growth of S. natans and even death of L. minor. Nitrogen is major and crucial element for the growth of plants. Healthy plants often contain 3-4% nitrogen in their body, much higher than those of other nutrients except carbon, hydrogen and oxygen. The importance of nitrogen is that, it is the fundamental element of protein and it can be illustrated by a simplified equation as follows:

Nitrogen compound → Amino acid → Polypeptides → Protein

On the other hand, the high nitrate content of the living habitat of L. minor, that is Chuen Lung watercress farmland, can explain why absence of nitrate could lead to shrinking growth of L. minor. The ammonium ion concentration in the water sample there is 6.8ppm. We think that the nitrate content in the backyard pond water of Ho Koon is much lower than this level. This can explain why depletion of nitrate exerted greater effect of L. minor than that of S. natans.

C. In solution without phosphate

⇨Experimental result

For monoculture of L. minor, initially, the total leaf area (TLA) was about 1 pit. The final TLA of L. minor was 2 pits. It increased by 100%. For monoculture of S. natans, the TLA of it increased by 22.82%

When we adopted mixed cultivation, only half of L. minor can survive while the TLA of S. natans increased by 42.57%.

⇨Interpretation and Underlying principal

Similarly, without phosphate ions, L. minor's growth is seriously disturbed while S. natans can still survive. Phosphate is also a main element for plant growth, but it is not as significant as nitrate. It is an essential component for building up plants DNA. Moreover, deficiency of phosphate will cause the poor growth, especially in roots.

As the phosphate concentration of the water sample of the habitat of L. minor, that is Chuen Lung watercress farmland, is slightly higher the normal (7.2ppm), it can tell why L. minor is also affected greatly in absence of phosphate. The situation is worsen when L. minor was mixed-ltivated.

Out of our expectation, the S. natans grow better when mixed-cultivated with L. minor. A possible explanation for this abnormal phenomenon is that, the dead bodies of L. minor die were decompose to provide some phosphate salt to S. natans.

Conclusion

In our experiments, we successfully show the competition between L. minor and S. natans. In complete culture solution, L. minor growth in an incredible rate and dominant the habitats. However, in the condition with insufficiency supply of nitrate and phosphate, the population of L. minor decrease significantly and even die. Base on our investigation, the natural environment wgere L. minor live is a watercress field with rich supply of nitrate and phosphate. This help to explain the stunted growth of L. minor. On the opposite side, the S. natans growth better than that of L. minor. One possible explanation is that the S.natans has larger body which can store more nutrients.

According to our experimental results, we deduced that L. minor depends more on nitrate and phosphate while S. natans can tolerate low nitrogen and phosphorous environments. We deduced that the latter can still growth a little under insufficiency supply of nitrogen and phosphorous due to its ability of prior storing nitrates and phosphates.

Further Discussion

1. Possibility for competition of light between the two species:

In our experiment, the main objective is to considered the possible competition for mineral ions, but overlooked the possibility for competition for light (ample amount of light is supplied and large space is provided for growth). We observed that the air sacs of S. natans is much larger than that of L. minor, so S. natans has “taller body” than L. minor. It means S. natans is more likely to have shading effect on L. minor, thus out-compete S. natans if the two species were densely populated with overlapping. In our further studies, in order to obtain a more complete investigation of competition for resources between the two species, light factor should also be taken into account.

2. Possible explanation for sole dominance of S. natans and L. minor in Ho Koon and Chuen Lung watercress farmland respectively

For L. minor, it dominates in the ditches of Chuen Lung watercress farmland. During our fieldtrip, we had also interviewed the farming strategies of watercress. Mr. Law said that he use organic fertilizer instead of chemical fertilizer. Actually, it is the mixture of disposed fish bone, fish intestine and chicken hair with river water. When we opened the tank contain the organic fertilizer, a distinctively pungent smell came out and we all chocked. This smell is probably the smell of ammonia. We conceived that this organic fertilizer contains high nitrate and phosphate concentration. That is because when fish bones, fish intestine and chicken hair were decomposed by bacteria, the proteins and the phosphate groups in DNA were converted into nitrates and phosphates, which are water soluble and can be absorbed by plants. During the process of fertilization, some nitrates and phosphates may leach into the ditches beside the watercress. It provides sufficient nutrients for the growth of L. minor, thus, it dominates in the ditches.

You may ask why the nutrients will not trigger the growth of S. natans in the ditches. It is because S. natans usually survive in still freshwater, just like the backyard pond of Ho Koon. The water there is clean and standing.

C. Possible application of our findings - effectiveness on purifying water (Bioremediation)

We found that L. minor has a faster growth rate than that of S. natans, indicating a faster rate of the

absorption of minerals. Thus, L. minor is a more effective water purifier to eliminate the water pollution problem caused by leaking of fertilizers, especially those rich in nitrate and phosphate contents. It can be used for bioremediation, which refers to the absorption of excess fertilizer and pollutants from contaminated water.

Modification and improvement

1. Use a smaller beakers to carry out experiment

As smaller beakers are used, Lemna are easier to grow all over the surface of water. Thus increase the rate of competition of minerals and the results of competing for light can be obtained.

2. Use more accurate method to outline the shape of leaves instead of man

3. Using high quality microscope with grid lines for counting the amount of small Lemna

The method of counting small lemna by small circle is only an approximation of area, overlapping may occur. Using high quality microscope with grid lines for counting can eliminate the problem of overlapping.

Source of errors

1. The outlining of the shape of the leaves of species A is by manual drawing, the shape may not exactly same as the species
2. There may be overlapping of leaves of species B when take in counting.
3. The result is obtained by manual counting, careless mistake will be made

Limitations

1. Time is limited for further growth of 2 species to obtain more details and accurate results.
2. The habitat in the experiment is not as same as the natural habitat, so the reference value is limited.
3. The measurement of the growth rate of the 2 species is based on total leaf area rather than total biomass. The former is not as comprehensive as the latter in reflecting the actual growth of plants.
4. Only the 2 major minerals (nitrate and phosphate) are chosen for investigation, other elements or trace elements such as magnesium, iron …etc. are not involved in the scope of study. The experiment cannot fully reflect the whole picture of competition for minerals between the two species.

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