



Enhancing National Chi Nan University Campus's Ecological Friendliness by Creating a Butterfly Habitat Using Reclaimed Water

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Abstract. The campus of National Chi Nan University (NCNU), Taiwan is about 150 hectares, and surrounded by dense valleys and forests that provides a habitat for many wild animals. In order to further enhance the ecological friendliness of the campus, the school implemented courses to create habitats for butterflies around the Sun Pond in the campus. The reclaimed water, originated from Water Treatment Factory, in the Sun Pond is used to irrigate the vegetation in the habitat to enhance the ecological conservation value. From 2019 to 2020, a number of 17 species with 670 individuals and food plants for butterflies was planted, and special instruction signs focusing on butterfly ecology were set up, so that staff and students can better understand the actions and goals in ecological conservation of green university. From 2020 to mid-2021, a total of 6 courses with 750 students (13% of the total number of students) visited the wonderful habit. The number of 22 species of butterflies was recorded in the habitat and this number was an average of 132 per 30 minutes, which shows that the construction of the habitats is successful. The creation of the butterfly habitat is in line with United Nations Sustainable Development Goal (SDG) 6 and SDG 15. The habitat has become a distinguished place for environmental education in the university. In the future, more community residents and tourists can experience this fantastic place and realize the efforts and achievements in ecological conservation succeeded by NCNU.

Keyword:

Butterfly Habitat, Reclaimed Water, Green University, Environmental Education, Community Resident.

1. Introduction

The NCNU campus occupies about 150 hectares and is located in the vicinity of valleys and dense forests. Apart from about 30 hectares of preserved forest, the University planted nearly 85% of the native plant species on the campus, providing a habitat for many wild animals. NCNU created a butterfly habitat using reclaimed water to enhance the campus's ecological friendliness. The four major ways to improve campus ecological friendliness are to identify ecological highlights (butterflies are currently the main theme) through ecological surveys and monitoring, as shown in Figure 1. The destruction of natural habitats is the biggest threat to butterfly resources in Taiwan. Through the efforts of campus administration units (Environmental Protection and Occupational Safety and Health Center and General Education Center) and the support of cooperative projects (University Social Responsibility Project and Higher Education Sprout Project), a series of relevant activities and introductory curricula were launched [1-3]. Teachers and students were able to create a butterfly habitat, establish an environment suitable for butterflies, and enhance the biodiversity of butterflies while creating an ideal space for environmental education. Good planning, design, and implementation are just the start of a high-quality butterfly habitat. Further planning and design of the appropriate environmental education experiential activities as well as establishing a complete set of education activities and maintenance management mechanisms are essential to the implementation of the medium- and long-term development plan. Thus, the entire habitat environment would be sustainable in enhancing the ecological friendliness of the campus.



Figure 1. Four major ways to improve campus adopted by NCNU to create a butterfly habitat



Figure 2. NCNU's Field Guide for Butterflies, a Handbook for Butterfly Lovers

2. Discovery of Ecological Highlights by Surveying the Biological Resources of the NCNU Campus in 2018

Butterflies are the most vivid, beautiful, interesting, and amazing insects. From an ecological point of view, butterflies also play an important role in ecological balance, food chain, biodiversity conservation, and as an indicator of environmental health. Four hundred and eighteen species of butterflies have appeared and been recorded in Taiwan, 57 of which are special species that only live in Taiwan with no distribution records elsewhere in the world. In terms of the exciting diversity and number of butterfly species per unit area, Taiwan can be called the butterfly kingdom of the world.

In 2018, the NCNU biological resource survey was conducted, which was planned by Peng Kuo-Tong, Associate Professor of the General Education Center who has expertise in ecological investigation, and staff from the Environmental Protection and Occupational Safety and Health Center. Ecological investigators and narrators who had practical experiences and received long-term training and certification in the Puli area were invited to form the investigation team. Each team consisted of four members. With butterflies as the main subject of investigation and monitoring, the purpose of the survey was to establish the temporal and spatial distribution data of species on campus and to provide basic information on campus conservation, education, and the sustainable management of green campuses. Additional purposes were to improve campus environmental awareness; establish an eco-friendly campus environment; enhance the species identification, investigation, and interpretation capabilities of the faculty, staff, and biological resource survey and interpretation personnel in the NCNU area; and train more biodiversity conservation personnel.

The survey method was based on the line transect method. Along the three planned routes (main road, locomotive route, and administrative and teaching area) for investigation, a 2,000-meter survey route was set up, with an imaginary tunnel of 5 meters on each side and 5 meters above the head as the range. The investigators walked at a speed of about 1 kilometer per hour, recorded the species observed, and kept a tally of the butterflies. The survey frequency was once per route per month from May through November, and the survey occurred during the second half of each month. To ensure adequate sunshine and proper temperature, the survey was conducted after 9 AM and had to be finished before 3 PM. The results are shown in Table 1.

Table 1. Statistics of butterfly species and numbers of butterflies observed in surveys from May to November 2018

Line Month		Butterfly						
		Main road		Locomotive lane		Administrative teaching area		Total
May		22 species	28 species	31 species	45 species			
		115 individuals	176 individuals	219 individuals	510 individuals			
June		37 species	44 species	26 species	57 species			

Line Month	Main road	Locomotive lane	Administrative teaching area	Total
July	371 individuals	363 individuals	217 individuals	951 Individuals
	32 species	37 species	25 species	52 species
August	205 individuals	296 individuals	185 individuals	686 individuals
	41 species	43 species	43 species	72 species
September	158 individuals	352 individuals	215 individuals	725 individuals
	48 species	47 species	40 species	68 species
October	261 individuals	344 individuals	327 individuals	932 individuals
	47 species	43 species	46 species	69 species
November	319 individuals	310 individuals	381 individuals	1010 individuals
	31 species	43 species	26 species	57 species
Total	243 individuals	403 individuals	179 individuals	825 individuals
				122 species
				5639 individuals

The university conducted a total of 24 weekly surveys from May to November 2018. One hundred and twelve species of butterflies in five families were observed including 16 species (14%) of Papilionidae, 15 species (14%) of Pieridae, 44 species (39%) of Nymphalidae, 24 species (21%) of Lycaenidae, and 13 species (12%) of Hesperidae, with six endemic species of *Papilio thainanus*, *Papilio hermosanus*, *Potanthus motzui*, *Neptis taiwana*, *Ypthima formosana*, and White-streaked butterfly (*Penthema formosanum*). To understand and protect the butterfly resources on campus and support global biodiversity conservation and environmental education, NCNU consolidated the survey results and published the Handbook for Butterfly Lovers (see Figure 2). Numerous species and large numbers of butterflies have become the most important indicator of NCNU's high-quality campus environment.

3. Creating a Butterfly Habitat for an Ecological Campus, 2019

Based on the 2018 survey results, NCNU kept in line with the trend of an ecological campus, strengthened the cultivation of a butterfly-friendly environment, and focused on the practical management of a block area from the perspective of beautification. The Sun Pond mainly uses the reclaimed water processed by the sewage treatment plant to irrigate the surrounding vegetation. The Sun Pond is equipped with water quality monitors and solar power generation facilities, which makes it a very suitable location for creating a butterfly ecological habitat as it represents water recycling and reclamation as well as ecology creation. Through the Sun Pond, NCNU has allowed teachers and students to understand the symbiotic relationship between humans and water resources, water environment, technology, humanities, and society. Thus, teachers and students have gained a better understanding of NCNU's goal of a green university and efforts in enhancing campus ecological friendliness.

Associate Professor Kuo-Tong Peng of the General Education Center suggested that NCNU could prioritize planting 18 selected species of herbivorous and nectar-rich plants one

by one, as listed below.

1. Herbivorous plants: nine species including *Aristolochia zollingeriana*, *Dregea volubilis*, *Lonicera japonica*, *Hygrophila pogonocalyx*, *Crateva formosensis*, *Capparis sabiifolia*, *Zanthoxylum ailanthoides*, *Citrus depressa*, and *Senna alata*.
2. Nectar-rich plants: *Eupatorium clematideum*, *Belamcanda chinensis*, *Sambucus formosana*, *Clerodendrum kaempferi*, *Leea guineensis*, *Premna serratifolia*, *Pentas lanceolata*, *Stachytarpheta jamaicensis*, and *Lantana camara*.



Figure 3. 2019 Sun Pond butterfly habitat cultivation activities and maintenance management



Figure 4. Butterfly ecology information bulletin in the Sun Pond

In May 2019, the Sun Pond butterfly habitat cultivation activity (pictured in Figure 3) was carried out. Teachers and students were invited to plant the nectar-rich plants and herbivorous plants (food plants for the butterflies) together. A total of 450 plants of 13 species were planted. In 2020, two main courses, “Introduction to Nature Conservation” and “Wetland Conservation,” and one supplementary course, “Creating A Green Life,” were introduced for students to plant 10 species of 220 herbivores and nectar-rich plants continuously for the butterflies. The courses focused on butterfly investigation, technology learning, and habitat creation management.

Information bulletin boards with a focus on butterflies (pictured in Figure 4) were set up. The main board has a visual interpretation of the common butterfly species in the Sun Pond. Visitors can have a self-guided tour by scanning the QR-code on the board for information. In 2019, participants were given an opportunity to paint the bulletin boards, and in 2020, information boards on 18 species of herbivorous and nectar-rich plants for butterflies were added (pictured in Figure 5).



Figure 5. Information board displaying the characteristics of herbivorous and nectar rich plants for butterflies



Figure 6. Photos of the life cycle of Tirumala limniace taken in the butterfly habitat of the Sun Pond were made into activity handouts

To understand the actual effect of butterfly habitat creation on the ecology, since 2020, surveys to evaluate the effectiveness of the use of herbivorous and nectar-rich plants for the butterflies in the Sun Pond have been conducted every May through October after planting. The survey items include larvae and pupae on herbivorous plants. The survey must be conducted on a sunny day between 9 and 10 AM for 30 minutes. The investigators perform detailed searches to count and record the species and numbers of butterfly larvae and pupae on each herbivorous plant. The life cycle of Tirumala limniace (pictured in Figure 6) has been recorded. The survey of adult butterflies eating nectar on nectar-rich plants must be conducted on a sunny day as well. A 30-minute survey is conducted at 10:00–10:30 AM and 1:00–1:30 PM to record the species and numbers of adult butterflies visiting flowers or eating nectar. Data collections from both surveys are combined, but the larger quantity of the same type is considered as the quantity of the day. The results in 2020 showed that 22 species of adult butterflies visited the flowers or drank nectar, in which *Euploea tulliolus koxinga* showed up most frequently, followed by *Euploea mulciber barsine* and *Catopsilia pomona*. As shown in Table 2, the monthly average frequency of visits by adult butterflies was 132 times per 30 minutes, with a peak of 142 times per 30 minutes in September.

Table 2. Species and Number of Adult Butterflies Visiting Flowers or Eating Nectar

Order	Scientific Name of Species	Month						
		May	June	July	Aug.	Sep.	Oct	Total
1	<i>Euploea tulliolus koxinga</i>	55	61	49	49	49	49	312
2	<i>Euploea mulciber barsine</i>	15	19	22	22	22	22	122
3	<i>Catopsilia pomona</i>	2	8	12	12	12	12	58
4	<i>Phalanta phalantha</i>	1	3	10	10	12	10	46
5	<i>Parantica aglea maghaba</i>	2	5	8	8	8	8	39
6	<i>Zizeeria maha okinawana</i>	2	3	7	7	7	7	33
7	<i>Tirumala limniace</i>	5	12	3	3	5	3	31
8	<i>Euploea sylvester swinhoei</i>	14	8	2	2	2	2	30
9	<i>Cupha erymanthis</i>	1	1	7	7	7	7	30
10	<i>Tirumala septentrionis</i>		6	4	4	4	4	22
11	<i>Argyreus hyperbius</i>	1		3	3	3	3	13
12	<i>Danaus genutia</i>	2		2	2	2	2	10
13	<i>Eurema blanda arsakia</i>	2	1	2	2	2	2	11
14	<i>Graphium agamemnon</i>			1	2	2	2	7
15	<i>Euploea eunice hobsoni</i>		3			1		4
16	<i>Ixias pyrene insignis</i>			1	1	1	1	4
17	<i>Delias pasithoe curasena</i>			1	1	1	1	4
18	<i>Graphium sarpedon connectens</i>			1	1	1	1	4
19	<i>Badamia exclamationis</i>			1	1	1	1	4
20	<i>Jamides bochus formosanus</i>	3	1		1		1	6
21	<i>Arhopala birmana asakurae</i>		1					1
22	<i>Megisba malaya sikkima</i>		1					1
		105	133	136	138	142	138	792

4. Strengthening Campus Ecological Friendliness and Green Campus Environmental Education

4.1. Evolution for Activity and Courses

In 2019, a lesson plan, the "Sun Pond Ecological Observation and Experiential Activity," was developed to promote the environmental conservation benefits of the green university. This lesson plan was extended to teachers and students of other courses as well as school visitors who participated in the activity (pictured in Figure 7). These people had an opportunity to experience the beauty of the NCNU green campus ecology. The design concept of the lesson plan was to apply the "walking into a Green University" idea to lead students into the ecology and life of the Sun Pond. Together with the outdoor guided tours, participants were engaged in the five senses in a learning expedition that attracted their attention, strengthened their memory, created a pleasant and all-around learning experience, and finally aroused their curiosity and immediate awareness.

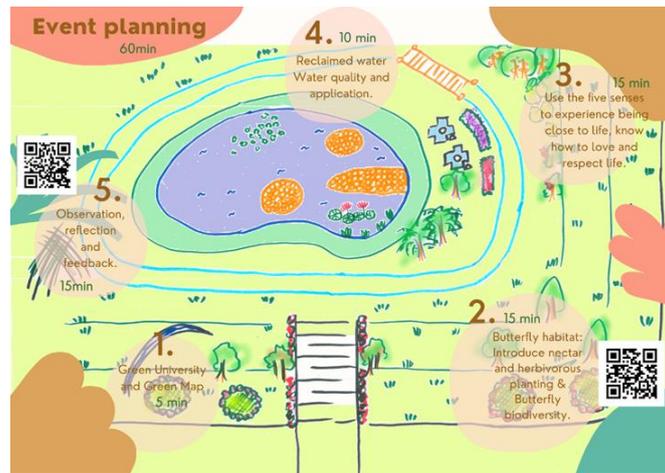


Figure 7. Schematic diagram for activities of ecological observation on Sun Pond

The “Sun Pond Ecological Observation and Experiential Activity” was led by the Higher Education Sprout Project, planned by the NCNU Chinese-language course refinement program, and jointly executed by the Environmental Protection and Occupational Safety and Health Center and the College of Science and Technology USR project. Three pilot sessions were held in 2020, followed by a narrator training workshop in response to the subsequent expansion of the activity. In 2021, the trained narrators worked together and conducted seven sessions. The activity was incorporated into six courses. A total of 527 people participated, and 427 people returned questionnaires.

These sessions and courses cover, appeared as Figures 8 and 9, included Water Conservation, Introduction to Nature Conservation, Creating a Green Life, Freshman Chinese, Locality- Culture and Ecology, Global Environmental Change and Sustainable Development, Aqueduct and Environmental Survey, UN Sustainable Development Goals, and Green Energy, to name a few.



Figure 8. Butterfly investigation technology learning and habitat creation management



Figure 9. The “Sun Pond Ecological Observation and Experiential Activity”

4.2. Feedback and Effectiveness Evaluation

From 2020 to 2021, a total of 527 people visited the Sun Pond butterfly habitat, and 427 of them provided feedback about their experience. Of the 527 people, 42.80% were in the College of Science and Technology, 27.98% were in the College of Humanities, 25.51% were in the College of Management, and 3.70% were in the School of Education. For most students, it was their first time visiting the Sun Pond. The participants’ overall satisfaction from the experiential activity was 4.38 (out of 5), and the narrator satisfaction was 4.78. The participants were most interested in the overall landscape of the Sun Pond and the creation of the butterfly habitats. Students gave extremely high positive feedback on their experiences and perception. The main results of scores and questionnaire were given in Figures 10, 11 and Table 4.

5. Concluding Remarks

Creating a butterfly habitat using reclaimed water to enhance campus ecological friendliness can be achieved through four major ways, as well as a final expansion of the ecological and experiential courses. The importance of butterfly ecological conservation and water resource maintenance is deeply implanted in the participant’s mind. Students located in Puli, a town well-known as the Butterfly Kingdom, would realize the importance of butterfly habitat creation and conservation and understand the efforts behind the recognition of NCNU as a Green University. Consequently, students are willing to participate in joint thinking and carry out joint actions to fulfill the university’s social responsibility, thereby improving the campus ecological friendliness significantly.

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