

## **Biodiversity Issue in Taiwan**

**Shang-Shyng Yang and Jong-Ching Su**

*National Committee for CODATA/Taiwan and Department of Agricultural Chemistry,*

*National Taiwan University, Taipei 10617, Taiwan*

Tel: 886-2-23621519, Fax: 886-2-23679827, E-mail: ssyang@ccms.ntu.edu.tw

### **Abstract**

In order to conserve and protect the very rich biological resources that have evolved in a unique natural environment, the government in Taiwan has set up a special committee and assigned a government agency, both at the cabinet level, to be in charge of planning and implementing relevant programs, respectively. Convening “Prospects of Biodiversity, Biodiversity-1999 and Biodiversity in the 21st Century” symposia have been the main means of building the national consensus to identify issues to be studied, which have motivated scientists to initiate the challenging task with the help of research funding from the related agencies. There are 6 national parks, 18 nature reserves, 13 wildlife protection areas, 24 natural protected areas, 29 major wildlife habitat areas and 9 national forest nature protected areas, totally covering 19.5% of the land area. The Policy Formulating Committee for Climate Changes (PFCCC) has recommended the enforcement of public education on biodiversity (includes elemental schools, middle schools, high schools, universities and social educations), and formulated the working plans on the national biodiversity preservation and bioresources survey. The research programs in progress, supported by the national funding, include surveys on species, habitats, ecosystems and genetic diversities, long-term monitoring of diversity, sustainable bioresource utilization and biodiversity and flora of Taiwan. Increase in the number of scientific publications and

increased emphasis by news media show the increased concern of academicians and public on biodiversity issue. Besides, the material and information databases related to the biological resources of various categories have been established and revised regularly. The following bioscience databases have been established in Taiwan: National plant genetic resources information system, Kuroshio-edge exchange processes, Land use and management, Soil properties, Taiwan wildlife distribution database, Taiwan Agricultural Research Institute plant information system, Distribution and resources of fishes in Taiwan, Herbaria at many sites, Database on non-vascular plants and fungi, Cell bank, Asian vegetable genetic resources information system, Database of pig production, Registry of pure-breed swine, Mating, farrowing, performance and transfer of ownership of pure-breed swine, Food marketing information system database, Food composition table in Taiwan, Heavy metals in soils of Taiwan database, Greenhouse gases emission from agriculture, Global change research in Taiwan, Global change research center, and Taiwan ecological research network databases.

**Keywords:** *Biodiversity, national park, public education, bioscience, conservation policy, database*

## **Introduction**

Taiwan is a tobacco leaf shaped island located due east of Fu-Jian Province of the China across the Taiwan Strait. It has an area close to that of the Netherlands, or 36,000 km<sup>2</sup>, and only about one-fourth of it are arable. The tropic of cancer dissects the center and the east-end of the monsoon belt reaches Taiwan. Thus it has a warm sub-tropic weather with abundant rainfall. The central mountain range, which has over one hundred peaks higher than 3,000 m, runs from the north to the south, and a temporal weather condition is prevalent at the elevated hilly areas. The balmy climate

brings long springs and unfading green growth. Because of these geographic conditions, Taiwan enjoys a very rich fauna and an agricultural productivity of from the tropical to temporal crops.

### **Policy Formulating Committee for Climate Changes**

The rapid economic and industrial growth and tripling of population in the past 50 years have put a heavy pressure on the natural environment. In order to cope with the global change problems, a cabinet level agency, the Policy Formulating Committee for Climate Changes (PFCCC), was established in 1995, and the Member of Official Committee charged the Chairman. The functions of PFCCC were enforced and reformed as the Committee of Sustainable Development. The Vice-president of Executive Yuan charged the Chairman in 2000 and then the President of Executive Yuan charged the Chairman in 2002. The General Meeting of Executive Yuan proved the promotion act of biodiversity on August 15, 2001. The Council of Agriculture (COA) has been charged with the responsibility of biodiversity preservation. Environmental Protection Administration (EPA), National Science Council (NSC), Ministry of Education (MOEd), Ministry of Economics (MOEc), Ministry of Interior (MOI), Ministry of Communication (MOC), and Department of Health (DOH) are the coordination agents. The achievements of the government agencies are listed below:

1. In order to help the formulation of working plans, eighteen National Symposia were held on the biodiversity in the terrestrial and aquatic environments, since September 1994: Botanic Biodiversity and Conservation between Taiwan Strait, Biodiversity and Allelopathy in Pacific Region, Biodiversity between Taiwan Strait, Biodiversity and the Development of Taiwan Aboriginal Habitat, Future of Biodiversity of Taiwan, Forum of Biodiversity, Biodiversity and Bioresources of Sino-America, Future of Biodiversity, Life Original and Biodiversity, Biodiversity

of High Mountain, Biodiversity of National Park, Prospects of Biodiversity (Lin, 1998a), Biodiversity-1999 (Lin, 1999a), Workshop of Biodiversity, Biodiversity Research, and Biodiversity of National Park. Biodiversity in 21st Century: A Training Course in Biodiversity (Lin, 1998b, 1999a, 1999b, 1999c).

2. There are 6 national parks (Table 1), 18 natural reserves (Table 2), 13 wildlife protection areas (Table 3), and 24 natural protected areas, 29 major wildlife habitat areas (Table 4), and 9 national forest nature protected areas (Table 5), totally covering 19.5% of the land area (Lin, 2002, 2002). Kenting is the first national park established in January 1984; it gives an exclusive protection to 18,085 hectares of terrestrial lowland rainforest and 15,185 hectares of adjacent ocean. There are large coral reefs, mountain peaks, lakes, plants, sand dunes, beaches and volcanic rock formation (Fig. 1) (Yuan et al., 1999).
3. The laws of conservation in enforcement are the acts of national park, wild animals conservation, forest, ethnic culture conservation, environmental impact assessment, soil and water conservation, and fisheries. The wildlife conservation law was enacted on June 23, 1989. Changes were made to the law on October 29, 1994. The civilization and resources conservation law was proved in 2001. The law has been

Table 1. Size of National Park

National Park	Size (ha)
Kenting	33,720
Terrestrial area	18,085
Adjacent ocean	15,185
YuShan	105,490
Yang-ming-shan	11,455
Ta-lo-go	92,000
Hsieh-bai	76,850
King-man	3,780

Table 2. Nature reserves in Taiwan

Name	Main protected features	Area(ha)	Location	Date established
Tamsui River mangrove nature reserve	Kandelia mangrove swamp	76.4	Taipei County	June 27, 1976
Kuandu nature reserve	Waterbirds	55.0	Taipei City	June 27, 1986
Pinglin Taiwan Keteleeria nature reserve	<i>Keteleeria davidiana</i> , rare plants & animals, ecosystems	34.6	Taipei County	June 27, 1986
Hapen nature reserve	Broadleaved forest, birds, freshwater fish	332.7	Ilan County	June 27, 1986
Chatienshan nature reserve	Quercus zone, rare plants, animals & ecosystems	7759.2	Taoyuan & Taipei County	March 12, 1992
Yuanyang Lake nature reserve	Lake & wetlands, red cypress, <i>Sparganium falax</i>	374.0	Taoyuan, Hsin-chu & Ilan County	June 27, 1986
Nanao broad-leaved forest nature reserve	Temperate broad-leaved forest, pristine lake, rare plants & animals	200.0	Ilan County	March 12, 1992
Miaoli Sanyi Huoyenshan nature reserve	Nature cliff & Taiwan red pine	219.0	Miaoli County	June 27, 1986
Penghu columnar basalt natyre reserve	Basalt landscape	19.1*	Penghu County	March 12, 1992
Taiwan pleione nature reserve	Taiwan pleione & its environment	51.9	Chiyi County	March 12, 1992
Chuyunshan nature reserve	Broad-leaved forest, coniferous forest, rare plants & animals, forest streams & freshwater fish	6248.7	Kaohsiung County	March 12, 1992
Taitung hungyeh village Taitung cycas nature reserve	<i>Cycas taitungensis</i>	290.5	Taitung County	June 27, 1986
Wushanting mud volcano nature reserve	Mud volcano	4.89	Kaohsiung County	March 12, 1992
Tawushan nature reserve	Wildlife & habitat, virgin forest, mountain lakes	47000	Taitung County	January 13, 1988
Tawu Taiwan amentotaxus nature reserve	<i>Amentotaxus formosana</i>	86.4	Taitung County	June 27, 1986
Watzuwei nature reserve	Kandelia mangrove & wildlife	30	Taipei County	January 10, 1994
Wushihpi coastal nature reserve	Coastal forest & special landscape	311.0	Ilan County	January 10, 1994
Kenting uplifted coral reef nature reserve	Uplifted coral reefs & their ecosystems	137.6	Pintung County	January 10, 1994

\* 19.13 ha at high tidal zone and 30.87 ha at low tidal zone.

Table 3. Wildlife refuges in Taiwan

Name	Main protected features	Area (ha)	Location	Date established
Penghu County cat islet seabird refuge	Seabirds & their environment	36.20	Penghu County	May 24, 1991
Kaohsiung County Sanmin Nantzuhsien river wildlife refuge	Freshwater fish & their habitat	274.22	Kaohsiung County	May 26, 1993
Wuwei Harbor waterbird refuge	Birds & their wetland habitat	101.62	Ilan County	September 24, 1993
Taipei City waterbird refuge	Waterbirds, rare plants & wildlife	245.00	Taipei City	November 19, 1993
Tainan City ssutsao wildlife refuge	Wetland & birds	515.10	Tainan City	November 30, 1994
Penghu County Wangan island green turtle refuge	Green turtle & its egg-laying grounds	23.33	Penghu County	January 17, 1995
Tatu rivermouth wildlife refuge	Rivermouth & coastal ecosystems, birds & wildlife	2669.73	Taichung & Changhua County	February 28, 1995
Mienhua and Huaping islets wildlife refuge	Island ecosystems & birds, wildlife & volcanic landscape	226.38	Keelung City	March 18, 1996
Langyang rivermouth waterbird refuge	Rivermouth & coastal ecosystems, birds & wildlife	206.00	Ilan County	September 16, 1996
Formosan landlocked salmon refuge	Forman landlocked salmon & the environment	7124.70	Taichung County	October 1, 1997
Taitung County Haituan hsinwuliu river fish refuge	Fosters multitude of river fishes & the environment	292.00	Taitung County	December 4, 1998
Matsu islands tern refuge	Island ecosystems, seabirds, wildlife & landscape	71.62	Lanchiang County	January 26, 2000
Yuli wildlife refuge	Virgin forest, endangered wildlife & the environment	11,414.58	Forest Bureau, COA	January 27, 2000

Table 4. Major wildlife habitats in Taiwan

Name	Type	Protected range	Area (ha)	Location	Date established
Mienhua islet major wildlife habitat	Islet ecosystems	Whole islet & 500 m from the low tidal zone	Territ.:13.30 Mar.:188.00 Tot.:201.30	Keelung City	June 12, 1995
Huaping islet major wildlife habitat	Islet ecosystems	Whole islet & 200 m from the low tidal zone	Territ.:3.08 Mar.:22.00 Tot.:25.08	Keelung City	June 12, 1995
Paichung County wuling formosan landlocked salmon major wildlife habitat	River ecosystems	Upstream of Taichia river (Chichia river) in Taichung County	7,095	Taichung County	September 23, 1995
Ilan County lanyang rivermouth major wildlife habitat	Rivermouth ecosystems	Downstream of langyang river (east of Germalang bridge) in Ilan County	206	Ilan County	July 11, 1996
Penghu County cat islet major wildlife Habitat	Islet ecosystems	Large and small cat islets higher than the low tidal zone & 100 m from the low tidal zone	Territ.:10.02 Mar.:26.18 Tot.:25.08	Penghu County	April 7, 1997
Taipei City Chunghsin and Yungfu bridges major wildlife habitat	Bog and river ecosystems	Low tidal bank from Chunghsin and Yungfu bridge to Taipei City and upstream 600 m of Kunghu bridge	245	Taipei City	July 31, 1997
Kaohsung County Sanmin nanzishian river major wildlife habitat	River ecosystems	Main stream and all by-stream of Nanzishian in Kaohsung County	274.22	Kaohsung County	March 19, 1998
Tatu rivermouth major wildlife habitat	Rivermouth ecosystems	Downstram and 2 km from seashore in Taichung and Changhua County	2,670	Taichung and Changhua County	April 7, 1998
Wuwei Harbor major wildlife habitat	Bog and rivermouth ecosystems	Bog, seashore and forest area of Wuwei harbor (1 km from low tidal zone)	101.62	Ilan County	May 22, 1998
Taitung County haituan hsinwuliu river major wildlife habitat	River ecosystems	Upstream of Peinan river from hsinwuliu river chulai bridge to the by-stream of lakulaku hot spring, lidau bridge of wulu river and 5.5 km of wulakushan river	292	Taitung County	November 19, 1998

(to be continued)

Table 4. Major wildlife habitats in Taiwan (continued)

Name	Type	Protected range	Area (ha)	Location	Date established
Matsu islands major wildlife habitat	Islet ecosystems	Whole island and 100 m from low tidal zone	Territ.:11.92 Mar.:59.70 Tot.:71.62	Liangchung County	December 24, 1999
Yuli major wildlife habitat	Forest ecosystems	No. 32 to 37 of national Yuli forest area	11,414.58	Forest Bureau	January 27, 2000
Chilan major wildlife habitat	Forest ecosystems	No. 54 to 71 of national Wulai forest area, No. 39, 40, 45-66, 83, 84, 87-100, 109-118, 127-130, 133 of Taichi forest area, No. 74-77, 81-84 of Ilan forest area, and No. 1-73 of Taiping-shan forest area	55,991.41	Forest Bureau	February 15, 2000
Tanta major wildlife Habitat	Forest ecosystems	No. 27, 28, 78-104, 118-124 of national Lintan Forest area, No. 48-54, 70 of Mugarshan forest area, No. 1-40 of Tanta forest area, No. 136-179, 181-201 of Rantai forest area, No. 15-17, 19-21, 25-27, 30 of Chuoshui river forest area	109,952.0	Forest Bureau	February 15, 2000
Kuanshan major wildlife habitat	Forest ecosystems	No. 13-24, 28-44 of national Kuanshan forest area, No. 24-31 of Yuanping forest area, No. 40-44 of Hsiukuluan forest area	69,077.72	Forest Bureau	February 15, 2000
Kuanyin coast major wildlife habitat	Forest ecosystems	No. 91, 92 of national Heping forest area	519.00	Forest Bureau	October 19, 2000
Kuanwu broad-tailed swallowtail major wildlife habitat	Forest ecosystems	No. 49 of national Taan river forest area	23.50	Forest Bureau	October 19, 2000
Shuoshankeng river major wildlife habitat	Forest ecosystems	No. 101, 106 of national Taan river forest area	670.88	Forest Bureau	October 19, 2000
Juiyen river major wildlife habitat	Forest ecosystems	No. 131-136 of national Puli forest area	2,574.00	Forest Bureau	October 19, 2000
Lulinshan major wildlife habitat	Forest ecosystems	No. 18-20 of national Yushan forest area	494.04	Forest Bureau	October 19, 2000
Manshuiying major wildlife habitat	Forest ecosystems	No. 16 of national Chouchou forest area	1,119.28	Forest Bureau	October 19, 2000

(to be continued)

Table 4. Major wildlife habitats in Taiwan (continued)

Name	Type	Protected range	Area (ha)	Location	Date established
Chachayalaishan major wildlife habitat	Forest ecosystems	No. 28-30 of national Chuochou forest area	2,004.40	Forest Bureau	October 19, 2000
Shuangui lake major wildlife habitat	Forest ecosystems	No. 32-39 of national Yuanping forest area, No. 18-31 of Pingtung forest area, No. 4-21 of Launung river forest area	47,723.75	Forest Bureau	October 19, 2000
Lihjia major wildlife habitat	Forest ecosystems	No. 7, 9, 10 of national Taitung forest area	1,022.36	Forest Bureau	October 19, 2000
Coastal mountain range major wildlife habitat	Forest ecosystems	No. 41, 42, 44 of national Chengkung forest area, No. 70, 71 of Hsiukuluan forest area	3,300.59	Forest Bureau	October 19, 2000
Shuilien major wildlife habitat	Forest ecosystems	No. 142 of national Lintan forest area	339.86	Forest Bureau	March 13, 2001
Tashan major wildlife habitat	Forest ecosystems	No. 22-25, 27-29 of national Alishan forest area	696.38	Forest Bureau	May 17, 2001
Keya rivermouth and hsiangshan wetland major wildlife habitat	Rivermouth and bog ecosystems	Keya rivermouth to Wuminggo, seashor to low tidal zone	1,600.00	Hsinchu City	June 8, 2001
Tainan Tsengwenchi rivermouth major wildlife habitat	Rivermouth and bog ecosystems	Chiutea of upline to river area, Tainan Normal College to seashore, include No. 1, 2 and 4 watergates	634.43	Tainan County	October 14, 2002

enacted to conserve wildlife, protect species diversity and maintain the balance of natural ecosystems.

- There are several research centers concerning biodiversity: The Taiwan Special Species Research and Preservation Center was established by Central Government in 1980, Biodiversity Research Center was establish by National Taiwan University in 2001, Phylogenetic Research Laboratory was set by National Taiwan Normal University in 2001, Biodiversity Center was established by National Sun-yat-shen University in 2001, Biodiversity Research Institute will establish by National Cheng-Kong University in 2002, Biodiversity Research Division will set by National Chung-Hsing University in 2002, and Biodiversity Research Center of Academic Sinica will open in 2002.

5. International Symposia on Terrestrial Ecology and Biodiversity (1994), Biodiversity, Biotechnology and Sustainable Agriculture (1997), Biodiversity Survey and Monitoring of Western Pacific and Asia Areas (1997), Long-term Ecology and Biodiversity in East Asian (1997) and Biodiversity of Pacific Area (1998) were held.
6. Academic researches on recovery of threatened species, taxonomy and life cycles of species were actively engaged. The Council of Agriculture actively promotes research for conservation of native wildlife and has established a wildlife databank. It also promotes conservation of rare species such as landlocked salmon, black bear, green turtle, Formosan serow, emerald tree frog and birdwing butterfly.

Table 5. Nature protected area of national forest

Name	Type	Protected range	Location	Area (ha)	Sealevel (m)	Date established
Shei-Pa nature protected area	Taiwan fir, Taiwan alpine juniper nature forest	special landscape, glacial remnants and wild animals	No. 53-54, 56-64 of Taanchi forest area, No. 78-84 of Pa-shen-shan forest area, No. 25 of Ilan forest area	21,254.09	1,100 - 3,886	1981
Chachi Taiwan oil-pine nature protected area	80 Taiwan keteleeria	with 16-30 cm, 182 trees in 2 ha area	No. 25 of Ilan forest area	7.22	300-400	1992
Dakuanshan nature protected area	Taiwan red false cypress, giant Taiwan yellow false cypress		No. 33 of Tachi forest area	75.00	1,400 - 1,500	1986
Erswei Taiwan serow nature protected area	Taiwan serow		Forest area of Erswei Peitou section	94.02	250 – 400	1981
Chiashen Seder fossil nature protected area	Fossil of manyeh mussel, haisan mussel, chiashen-won carb		No. 4 of Chishan forest area	11.23	20 – 350	1991
18 Lohanshan nature protected area	Special geograph and landscape of geology		No. 55 of Chishan forest area	200	200 – 500	1992
Taitung cycas seashore mountain nature protected area	Taiwan cycas		No. 31, 32 of Chengkung forest area	38	500-800	1981
Kuanshan Taiwan Date palm nature protected area	Taiwan Date palm		No. 4, 5, 12, 25 of Kungshan forest area	54.53	400-500	1981
Tawu Taiwan Keteleeria nature protected area	Taiwan keteleeria		No. 41 of Tawu forest area	5.04	600-700	1981

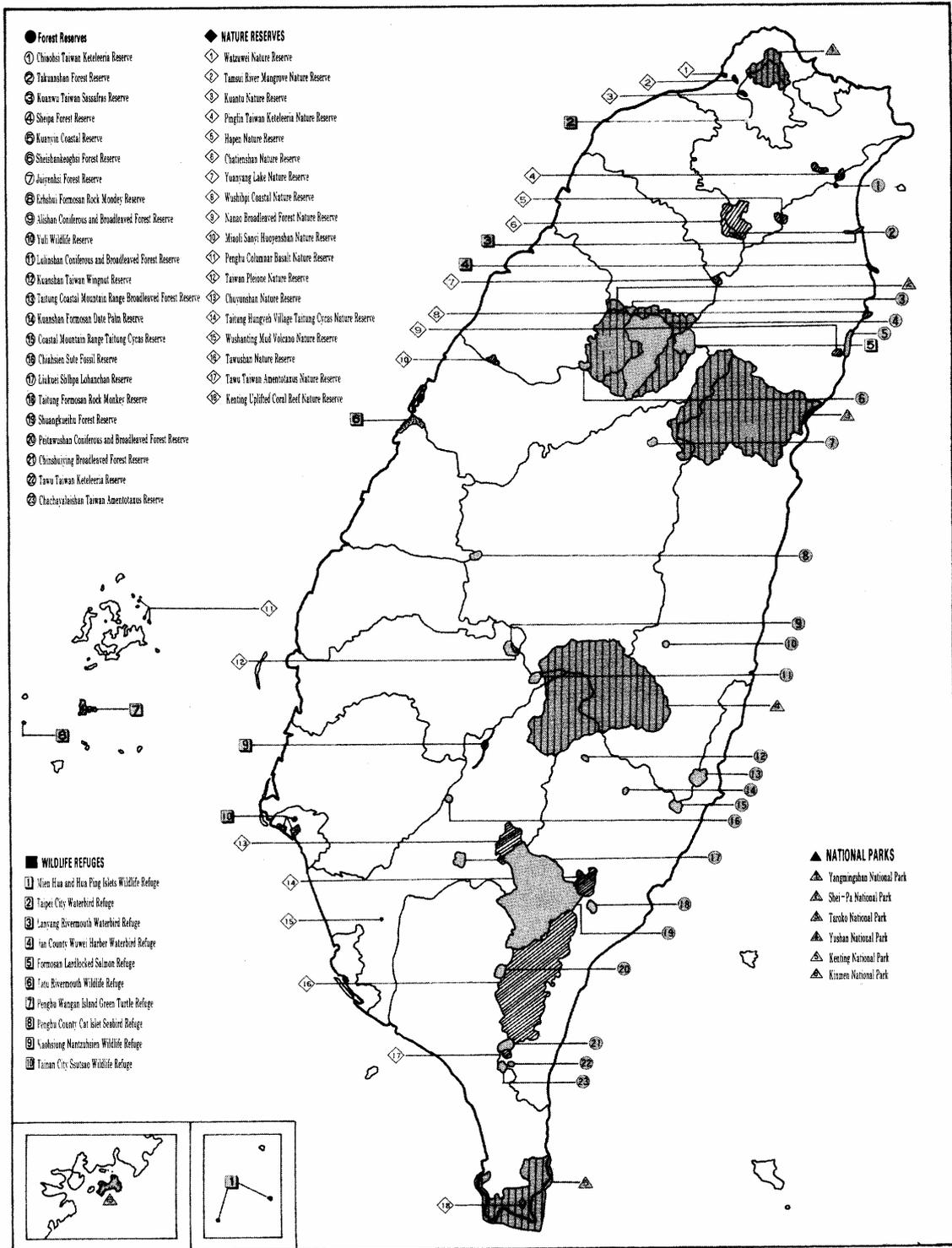


Fig. 1. Natural protection areas in Taiwan.

## **Public Education and Research Programs**

PFCCC has recommended the enforcement of public education on biodiversity, and has formulated the working plans on the national biodiversity preservation and bioresources survey. Each level of education on biodiversity is listed in the following:

1. Biology disciplines, local biology and diversity of species in elementary schools.
2. Effect of human activity on biodiversity, ecology of diversity, and maintenance of ecological environments in middle schools.
3. Genetics of diversity, developing process of biodiversity, and value of biodiversity in high schools.
4. Conservation of biodiversity, sustainable development and biodiversity, conservation of ethnic culture diversity, and research trend of biodiversity around the world in the general education of universities.
5. Measurement of biodiversity, conservation research of biodiversity, and recovery techniques of habitats in the related departments of universities.
6. Local animals, local plants, local ecosystems, forum of biodiversity, recognition of community, recognition of threatened species, conservation of biodiversity and personal action, culture, arts, and biodiversity, and conservation concepts in the social education (Table 6) (Wang and Chou, 1999).

The research programs in progress, supported by the national funding, include the following topics (Biodiversity Center of National Taiwan University, 2002):

1. Surveys on species, habitats, ecosystems and genetic diversities (Tables 7-10) (Hsu and Agoramorthy, 1999; Liu, 1999).
2. Effect of human activity on biodiversity.
3. Biodiversity in the ecosystem maintenance.
4. Long-term monitoring of biodiversity (Yang et al., 1998a, 1998b, 1999a, 1999b, 2000; Yang and Yang, 2001).

5. Population kinetics of threatened species and conservation policy.
6. Sustainable bioresource utilization and biodiversity.
7. Effect of ecosystem fragmentation on biodiversity.

Table 6. Societies related to nature conservation in Taiwan

---

World Threatened Species Conservation Association of ROC  
 Ecology Protection Association of ROC  
 Natural Ecology Conservation Association of ROC  
 Natural Resources Conservation Association of ROC  
 Sustainable Development Society of ROC  
 Wild-land Protection Association of ROC  
 National Park Society of ROC  
 Wild Birds Society of ROC  
 Rive Environmental Association of ROC  
 Light-fly Conservation Association of ROC  
 Environmental Life Promotion Association of ROC  
 Environmental Education Society of ROC  
 Protection Life Association of ROC  
 Chinese Butterfly Conservation Society  
 Zoological Garden Association of Taipei City  
 Wild Birds Society of Taipei City  
 Sustainable Development Society of Taitung County  
 Chi-Hsin Environmental Green Foundation  
 Environmental Protection Foundation of House-wife  
 Greenish Foundation of Taichung  
 Internation Jean Good Education and Conservation Association of ROC  
 Hi-Liu Environmental Greenish Foundation of Taipei City  
 Ecological Conservation Association of Swei-li River  
 Conservation Association of Southern Taiwan  
 Plant Conservation Society of Southern Taiwan  
 River Fishes and Shrimps Conservation Association of Pai-kang Chi  
 Ecological Protection Association of Nan-tou County  
 Natural Ecological Conservation Association of Pingtung County  
 Natural Ecological Conservation Association of Tainan County

---

Table 7. List of coral species recorded in Kenting marine conservation area

---

## **Class Scleractinia**

### **Order Scleractinia**

- Family Acroporidae (62 species)
- Family Thamnasteriidae (3 species)
- Family Pocilloporidae (9 species)
- Family Agariciidae (16 species)
- Family Fungiidae (21 species)
- Family Poritidae (20 species)
- Family Faviidae (38 species)
- Family Merulinidae (2 species)
- Family Pectiniidae (6 species)
- Family Mussidae (11 species)
- Family Caryophylliidae (4 species)
- Family Dendrophylliidae (7 species)

### **Order Stolonifera**

- Family Tubiporidae (1 species)
- Family Clavulariidae (1 species)

### **Order Alcyonacea**

- Family Xeniidae (2 species)
- Family Asteropiculariidae (1 species)
- Family Nephtheidae (4 species)
- Family Alcyoniidae (31 species)

### **Order Gorgonacea**

- Family Subergorgiidae (3 species)
- Family Acanthigorgiidae (5 species)
- Family Plexauridae (3 species)
- Family Ellisellidae (7 species)

---

Source: Hsu and Agoramorthy, 1999.

8. Biodiversity conservation.
  9. Recovery of biodiversity.
  10. Genetics of major crops, economic plants, and economic animals.
  11. Flora of Taiwan.
  12. Bioresources utilization:
-

Table 8. Flora of Chi-tou forest recreation area, central Taiwan

Plant group	Native*		Cultivated		Total
	Number of family	Number of species	Number of family	Number of species	
<b>Vascular plant</b>	<b>162</b>	<b>1,003</b>	<b>86</b>	<b>383</b>	<b>1,386</b>
Ferns and fern allies	29	181	4	5	186
Flowering plants	133	822	85	378	1,200
Gymnosperms	5	6	9	78	84
Angiosperms	128	816	76	300	1,116
Dicotyledons	111	604	61	180	784
Monocotyledons	17	212	15	120	332
<b>Bryophytes</b>		<b>300-400</b>		-	<b>300-400</b>

\* Including naturalized exotic species.

Source: Liu, 1999.

Table 9. Fauna of Chi-tou forest recreation area, central Taiwan

Texa	Number of family	Number of species	Number of endemic species	Percentage of endemic species (%)
<b>Vertebrates</b>	<b>45</b>	<b>138</b>	<b>66</b>	<b>48</b>
Mammals	5	9	7	78
Birds	31	96	52	54
Reptiles	3	20	4	20
Amphibians	3	70	2	29
Fishes	3	6	1	17
<b>Butterflies</b>	<b>10</b>	<b>126</b>	<b>14</b>	<b>11</b>

Source: Liu, 1999.

Table 10. Forest types in Chi-tou area, central Taiwan

Forest types	Area (ha)	Percentage
Natural hardwoods	509	20.5
Coniferous plantations	803	32.3
Hardwoods plantations	142	5.7
Bamboo plantations	775	31.1
Non-forest lands	259	10.4
<b>Total</b>	<b>2,488</b>	<b>100</b>

Source: The Experimental Forest of National Taiwan University, 1999.

- (a). Improvement of productivity by applying genetic engineering technology, such as increasing milk secretion of cow, increasing the number of cow embryo, preservation of species, asexual production of embryo, cell transformation, and gene transformation.
- (b). Enhancement of biological activities for biotechnology applications, such as organic wastes treatment, nitrogen-fixation, chemical pollutants removal, biological control of pests and disease, carbon dioxide assimilation, species improvement, and ecological tour.

The ratio of the number of biodiversity related papers to the total number of biology related papers published annually by the scientists in Taiwan increased from 0.52% in 1989 (70/13,379) to 1.27% in 1998 (722/56,975) (Table 11). During the same period, the number of news articles reporting the biodiversity related issues to the total number of news items also increased from 0.5% to 1.2%. Among the biodiversity related news items, the environmental issue had the highest share (55%), followed by ecology (18%), animals (15%), and plants (4%) (Shih and Cheng, 1999). In addition, the natural and scientific museums had 10 special exhibits on biodiversity, 15 permanent exhibition sites for biodiversity and conservation of species, 13 video-guide tapes, 20 DIY (do it yourself) biodiversity programs, 8 education programs, 9 studio classrooms programs, and 6 theater programs last year (Tables 12-17) (Wang and Chou, 1999).

### **Database in Biosciences**

The following bioscience databases have been established in Taiwan:

1. National Plant Genetic Resources Information System (NPGRIS) - by Taiwan Agricultural Research Institute-National Plant Genetic Resources Center; data cover acquisition, preservation, distribution and research on plant germplasm.

Table 11. Scientific papers on biodiversity and biological sciences

Year	Papers on biodiversity	Papers on biological science	Percentage
1989	70	13,379	0.52
1990	347	21,672	1.60
1991	430	43,617	0.99
1992	666	55,513	1.20
1993	627	53,492	1.17
1994	758	53,578	1.41
1995	580	53,792	1.08
1996	672	61,088	1.10
1997	766	65,397	1.17
1998	722	56,975	1.27
<b>1989-1998</b>	<b>5,638</b>	<b>478,503</b>	<b>1.18</b>

Source: Shih and Cheng, 1999.

Table 12. Special exhibitions concerning biological diversity and species conservation education at the National Museum of Natural Science

Special exhibit title	Content summary
The Black-faced Spoonbill Special Exhibit	Appraisal of value concepts concerning economic development and species conservation
Social Insects of Taiwan Exhibit	Social insect diversity and the biology of socialization
Plague Special Exhibit	Explanation of the relationship between ecosystem disturbances and the plague on Kinmen Island, to increase environmental awareness
Man and Rodent Special Exhibit	Taiwan's rodent diversity, habits and prevention and treatment of rodent related damage
Year of the Pig Special Exhibit	Wild animal use and the development of animal husbandry
Year of the Tiger Special Exhibit	Biology, anthropology and species conservation issues related to the tiger
Fungi Special Exhibit	Fungal diversity and issues concerning the use of fungi
Unique Birds of Taiwan Exhibit	Taiwan's bird diversity and conservation of unique species
Turtle Exhibit	Turtle evolutionary adaptations and conservation of Taiwan's turtles
Year of the Ox Special Exhibit	Wild animal use and the development of animal husbandry

Source: Wang and Chou, 1999.

Table 13. Permanent exhibitions concerning biological diversity and species conservation education at the National Museum of Natural Science

Exhibition topic	Exhibition location	Content summary
The Evolution of Plants	Life Science Hall	Current plant diversity
The Age of Dinosaurs	Life Science Hall	Ancient reptile diversity and radiative adaptation
Dinosaur debate	Life Science Hall	Humanized dinosaurs instill conservation awareness
Extinction	Life Science Hall	Species conservation and extinction events
The Evolution and Adaptability of Mammals	Life Science Hall	Mammal diversity
Population and Food	Life Science Hall	Natural resources use and conservation issues
Color in Nature	Life Science Hall	Outline of biological diversity using color
Sounds in Nature	Life Science Hall	Closely tied to biological diversity is the evolution of animal vocalization methods
Herb Garden (outdoor)	Chinese Science Hall	Plant diversity and uses
The Taiwanese Aborigines- The Austronesian People	Chinese Science Hall	The intimate relationships between man and nature
The Living Tunnel (Microscopic World)	Global Environment Hall	Diversity of animal adaptations
Life on Earth	Global Environment Hall	World ecosystems (Canadian tundra, Manchurian temperate forest, East African savanna, Borneo mangroves, Galapagos Islands, Sonoran desert and Costa Rican rainforest)
Taiwan's Ecology	Global Environment Hall	Taiwan's ecosystems (Ta Jia river basin, Lien-hwa Chyr broad-leaf forest, Anmashan cloud forest and Nanhu Valley)
The Four Seasons	Environment Theater	Biological diversity and the changing seasons
Live exhibits and specimens	Naturalist Center	Taiwan's animal and plant Diversity

Source: Wang and Chou, 1999.

Table 14. Audio guided tours concerning biological diversity and species conservation education at the National Museum of Natural Science

Exhibit title	Content summary
Entering the Amazing World	How did all of today's creatures come into being? This tour encourages visitors to enter the mysteries of evolution.
Early Marine Life	Abundant marine creatures appeared early.
The Earliest Forests	The forest floors of the Devonian Period contained diverse ecosystems, with arthropods as the most dominant group.
Seed Plants	Seed plants evolved explosively in various environments, to develop a closely related plant community.
Flying Reptiles	In the Mesozoic, before birds were abundant, flying reptiles dominated the skies.
Extinction	Extinction is a natural phenomenon. However, human-caused extinctions should be prevented.
Wildlife Crisis	Over time, environmental changes create wildlife extinction crises.
Inherit an Earth with Life	If more concern is not given to the environment and to saving our Earth, it will become like a rotten apple that is slowly decaying. It is up to all of us to ponder what kind of Earth we want to inherit.
Our Earth	If we describe Earth's history of 4.6 billion years in terms of a calendar, various life forms would appear in August, with man appearing just before the end of the year. Man's history has been short but has had great impact on this planet.
Life on Earth	The world contains diverse ecosystems with diverse life forms. In addition to adapting to their external environment, living things maintain close relationships with each other.
Taiwan's Ecology	Due to Taiwan's tall mountains, a number of diverse ecosystems exist in a vertical distribution; with interdependent species.
Galapagos Islands	The Galapagos Islands are the inspiration for evolution theory. Through the process of evolution came today's diversity.
Borneo Mangroves	Mangrove trees grow in saltwater marsh ecosystems. Mangrove trees use survival strategies to adapt to adverse conditions. Other life forms, of which there is diversity, depend on the mangroves for organic matter and sanctuary.

Source: Wang and Chou, 1999.

About 54,000 records of passport data, 27,000 records of characterization data and 1,800 records of image data have been conserved in the NPGRIS database. These accessions represent more than 169 families, 640 genera and 924 species of plant germplasm. Databases are both in Chinese and English. The database can be accessed at <http://www.npgrc.trai.gov.tw> or <http://192.192.196.1>.

Table 15. Hands-on activities concerning biological diversity and species conservation education at the National Museum of Natural Science

Activity	Date
Making Insect Models from Recycled Materials	July 22-August 30, 1986 (Saturdays)
Animals	October-December 1986 (Sundays)
Microscopic World	October-December 1986 (Wednesdays)
Favorite Dinosaurs	April 4, 1990 (Children's Day)
Butterfly Wing Prints	July 10-August 25, 1990 (Sundays)
3D Models of Bees, Ants	July 13-September 15, 1991 (Saturdays)
Beehives and Clay Models	July 13-September 15, 1991 (Saturdays)
Mysteries under the Lens	January 3-March 30, 1992 (Sundays)
Dinosaur Rotating Lanterns	March 28-April 5, 1992
Dinosaur Prints	June 27-August 23, 1992 (Wednesdays)
Chameleons	June 27-August 23, 1992 (Saturdays)
Bird Tracks	January 1-3, 1993
Dinosaur Puzzle	April 14-June 27, 1993 (Wednesdays)
3D Dinosaur Models	January 1-3, 1994
Color Drawings of Insects	May-June, 1995 (Saturdays)
Insect Molds	July-September, 1995 (Sundays)
Dinosaur Skeleton Puzzles	March 29-April 4, 1996
Life in the Cambrian Period	November 3-24, 1996 (Sundays)
Fungi Clay Models	December 18,19,22, 1997
Crafts using Common Wildflowers and Weeds	January 10, 1999

Source: Wang and Chou, 1999.

2. Kuroshio-Edge Exchange Processes (KEEP) – by National Center of Ocean Research, data cover fish larvae biomass, nutrient data, hydrography data, productivity data and enzyme activity data. Databases are both in Chinese and English. Online system: <http://www.ncor.ntu.edu.tw/KEEP>
3. Land use and management – by Global Change Research Center, National Taiwan University. Data cover the cultivated land, fishery, forest, upland, farmland, building, grave – etc. It contains more than 3,900 sheets with 1:5,000 ratios. In

addition, landuse in the seashore of Taiwan is also includes. Databases are both in Chinese and English. Online system: [http://www.gcc.ntu.edu.tw/gcrc\\_databank.manage/geography/land/land-use/land.htm](http://www.gcc.ntu.edu.tw/gcrc_databank.manage/geography/land/land-use/land.htm)

Table 16. Activity sheets concerning biological diversity and species conservation education at the National Museum of Natural Science

Title	Exhibit area
Are we relatives? Why do we look so different?	The Evolution and Adaptability of Mammals
Where do they live? We are brothers.	The Evolution and Adaptability of Mammals
Why are you that big? Why am I this small?	The Evolution and Adaptability of Mammals
Animal Coloration and Survival	Color in Nature
Plants Take to the Land	The Evolution of Plants
Flying	Flight
Evolution of Life	Life Science Hall
Why are they here?	Life on Earth

Source: Wang and Chou, 1999.

Table 17. Studio classroom programs concerning biological diversity and species conservation education at the National Museum of Natural Science

Program title	Classroom Theater topic
Where Have the Butterflies Gone?	Species Conservation
Homeless Turtles	Species Conservation
Interesting Fungi	Species Conservation
The Secrets of Shellfish and Mollusks	Exploring the Ocean
Identifying Mammalian Characteristics Using Fossils	Underground Treasures
Mangroves	Man and the Environment
Swamps and Marshes—Who Lives There?	Man and the Environment
The Sad Song of the Forest	Man and the Environment
The Plum Flower Deer vs. the Panda	Man and the Environment

Source: Wang and Chou, 1999.

Table 18. Theater programs concerning biological diversity and species conservation education at the National Museum of Natural Science

Program title	Content summary	Date
Vote for Favorite Dinosaurs [Show and tell]	Education staff dressed up to humanize the dinosaurs. Using show and tell methods the characteristics and habits of various dinosaurs were introduced.	March 29-April 7, 1991
Black Light Theater [Environmental Conservation Section]	Used fluorescent puppets and sets on a dark stage. Was performed in Taichung Covered the topics of environmental protection and ecosystem and species conservation issues.	January 1-5, 1992
Black Light Theater [Dinosaurs]	Used fluorescent puppets and sets on a dark stage. Was performed in Taichung. Introduced dinosaur diversity and characteristics.	April 3-11, 1993
Paper Shadow Show [Insect Show]	Through the manipulation of insect paper puppets, the use of shadow show principles and a decorated stage, the habits and characteristics of various insects were introduced.	July 1-September 30, 1995
Puppet Theater [Goodbye Dinosaurs]	Using puppets in the form of dinosaurs and other animals, a decorated set and shadow show principles, introduced the relationships between animals and their environment. Also emphasized was the importance of species conservation.	March 31-April 7, 1996
Turtle Exhibit Puppet Show [A Long Story]	Using puppets in the form of turtles and other animals and a decorated set, discussed man's destruction of the environment and its influence on animal survival.	August 8-November 29, 1998

Source: Wang and Chou, 1999.

4. Soil properties – by Global Change Research Center, National Taiwan University.

Data cover 25 parent materials, 26 soil characteristics, 24 soil morphology and soil

formation, 5 drainage, 5 calcareous and 6 slope percent. Databases are both in Chinese and English. Online system: <http://www.gcc.ntu.edu.tw/gcrcdatabank.manage/geography/database/land/soils/landdata.htm>

5. Taiwan Wildlife Distribution Database – by Department of Zoology, National Taiwan University. The database produced distribution maps of wildlife (including 56 species of mammals, 430 species of birds, 30 species of amphibians, and 78 species of moths) in Taiwan using a geographic information system (GIS) through a thorough review on the available literature published between 1978 and 1995. A reference database, including 142 papers or reports on mammal and 130 papers or reports on bird, was created. Distribution database for each species group was established using a 2 by 2 km grid system. ARC/INFO was used to transform distribution data into the GIS format. These data summarized the current available information on wildlife distribution in Taiwan and showed the biodiversity patterns of mammal, bird, amphibian, and moth species. They also indicated the gap areas where vegetation covers are less disturbed by human activities and wildlife survey data are lacking. Can be accessed on the WWW at [http://wagner.zo.ntu.edu.tw/wildlife/index\\_e.htm](http://wagner.zo.ntu.edu.tw/wildlife/index_e.htm)

6. Distribution and Resources of Fishes in Taiwan - by Institute of Zoology, Academia Sinica; data cover basic information and specimen photo of each species, distributional database, bibliographic database, curatorial database, inquiring system for Chinese fish names of the world fishes, and new version of erratum of “Fishes of Taiwan”. It contains more than 220,000 records, mainly in Chinese. The fish specimen collections include the Institute of Zoology, Academia Sinica and the National Marine Science Museum. A total number of 2,109 species, 5,234 lots and 10,590 individuals of specimens are included for ASIZP and 175 families, 1,000

species and 1,444 specimens for NMSMP. Inquiring system for Chinese fish names of the world fishes includes 26,600 species. The fishes of Taiwan comprise total 2,450 species in 250 families. Can be accessed on the WWW at <http://fishdb.sinica.edu.tw>.

7. TAI Plant Information System (TAIS) – Taiwan is well-known for the diversity of its plant species. Since 1928 the continuous botanical surveys have resulted in the housing of about 250,000 specimens of plants in the Herbarium of the Botany Department (TAI), National Taiwan University. The TAI also contains over 800 types which are specimens upon which a unique plant name is based. While TAI'S special emphasis is on the Taiwan Flora, it also contains plenty of specimens from southern China, Pacific islands, Japan, and many other countries.

For a maximal utilization of the specimen information, a computerized data storage and retrieval system is currently developing (as one of the project of the National Digital Archives Program in Taiwan, 2002-2005). Through this program, four major activities will be pursued: (1) digitization of the LABEL information of the TAI Herbarium; (2) photographing type specimens; (3) to digitize representative specimens images for each species and link them to the database for public access; and (4) the creation of useful Web tools for botanists as well as nonspecialists with botanical interests, mainly to allow them to access information describing the geographic distribution of various plant groups.

In addition, Flora of Taiwan (2<sup>nd</sup> edition, 6 volumes, 1993-2002) contains samples of more than 4,000 of vascular plants species from all over Taiwan island and its islets. It is of great interest to botanists, ecologists, commercial users, conservationists, geographers and others. The project also plans to integrate both textual and image based botanical information in a web accessible database. Data contained in the database includes nomenclature, descriptions, keys to taxa,

distribution, specimen citations, illustrations, photos and indices. Data in English, can be accessed from WWW (URL: <http://tai.bot.ntu.edu.tw>).

8. Herbarium, Institute of Botany, Academia Sinica, Taiwan (HAST); data contain more than 38,150 records, both in Chinese and English, can be accessed from WWW (URL: <http://hast.sinica.edu.tw>).
9. Database on non-vascular plants and fungi – by the National Museum of Natural Science (TNM). TNM has established databases of collection on both plants and animals. However, only the databases on non-vascular plants and fungi are currently available for search in English. Fungal and lichen specimens at TNM number over 10,000. This represents the largest collection of fungal/lichen specimens in Taiwan. Database on the collection of non-vascular plants at TNM can be accessed at <http://info.nmns.edu.tw/scripts/EInvas.dll>, and fungal database at <http://info.nmns.edu.tw/scripts/Efungi.dll>
10. Cell Bank - by Cell Culture Lab of the National Taiwan University, College of Medicine; data cover Biomedical and Agriculture, contain 108 cell lines, both in Chinese and English.
11. Asian Vegetable Genetic Resources Information System (AVGRS) and Asian Vegetable Library Information and Documentation (AVLID) - by Asian Vegetable Research and Development Center; contains data on the germplasm conserved at the center including passport, characterization, distribution and seed inventory. AVGRS contains records for 48,826 accessions. AVGRIS will become part of SINGER (System-wide Information Network for Genetic Resources) of the CGIAR (Consultative group on International Agricultural Research). The AVRDC Vegetable Library Information and Documentation (AVLID) contains 39,371 bibliographic records, mainly in English. More than 14,000 of them deal with vegetables of various topics. AVLID also has established a vegetable research

information network that can be accessed at WWW (URL: <http://www.avrdc.org.tw>).

12. Database of Pig Production - by Pig Research Institute, Taiwan, in Chinese, online system: WWW (URL: <http://www.atit.org.tw>), Gopher (URL: <Gopher.atit.org.tw>).

13. Registry of Pure-Breed Swine - by Swine Improvement Foundation of Taiwan; data cover Animal Science, Breed Swine Production, Breed Swine Performance test; both in Chinese and English. It contains the data for each registered purebred swine. These include its pedigree, sex, breed, farrowing date, body measurements, and other observable traits.

14. Mating, Farrowing, Performance and Transfer of Ownership of Pure-Breed Swine-by Swine Improvement Foundation of Taiwan; data cover Animal Science, Breed Swine Production, Breed Swine Performance test; both in Chinese and English. The database contains the mating, farrowing, reproduction and production performance data of purebred swine. These include the mating date, mating method pedigree, the farrowing date, the number of nipples, ear notches made on the newborn, the body weight at birth and when weaned, the pedigree and breed of the animal as well as the data on the owner and breeder.

15. Food Marketing Information System Database (FMISD), Food Technology Information System Database (FTISD), Food Factory Information System Database (FFISD) and Food Statistics Information System Database (FSISD) by Food Industry Research and Development Institute; data cover food science, food technology, food market, food factory, food statistics, culture collection and research. FMISD contains 26,000 records, FTISD contains 1,300 records, FFISD contains 5,500 records, and FSISD contains 1,500,000 records in Chinese, online system: WWW (URL: <http://www.firdi.org.tw>), Gopher (URL: <Gopher.firdi.org.tw>), FTP (139.175.32.3).

16. Food Composition Table in Taiwan - by Department of Nutrition and Food Science, Fu Jan Catholic University, data cover food composition table, nutrient retention factor, contain 780 records, both in Chinese and English.
17. Heavy Metals in Soils of Taiwan Database – by Department of Bioindustrial Systematic Engineering, National Taiwan University. 1542, 4732, and 9954 representative soil samples were taken from a profile containing surface layer (0-15 cm) and subsoil (16-30 cm) of the agricultural land in Taiwan, in every 1,600, 100 and 1 hectares, respectively. The concentrations of Cd, Cu, Cr, Ni, Pb and Zn in soils were measured on 0.1 N HCl and total As and total Hg were measured by the hydration method.
18. Greenhouse Gases Emission from Agriculture – by Department of Agricultural Chemistry, National Taiwan University. Data cover methane, nitrous oxide and carbon dioxide emissions from paddy fields, wetlands, uplands, forest, animal waste treatment facilities, and landfills from 1971 to 2001 in Taiwan. In addition, environmental conditions and greenhouse gases emissions, mitigation of greenhouse gases emission, and estimated of greenhouse gases emission from agricultural production were also included.
19. Global Change Research in Taiwan – by Global Change Research Center, National Taiwan University. Data cover the Joint Global Ocean Flux Study (JGOFS), Past Global Changes (PAGES), Global Change and Terrestrial Ecosystems (GCTE), Land Ocean Interaction in the Coastal Zone (LOICZ), the Tropic Ocean and Global Atmosphere Program (TOGA), the International Global Atmosphere Chemistry Project (IGAC), and the World Ocean Circulation Experiment (WOCE). Online system: <http://www.ncu.edu.tw/English/igbp>
20. Global Change Research Center – by Global Change Research Center, National Taiwan University. The major body holding responsibility in Taiwan for setting up

the networking of data exchange and information distribution, and integrating scientific finding on the assessment of the impact of global change, estimation as to the amount of greenhouse gas emissions and mitigation policies. Seven research divisions are include: atmospheric chemistry, climate change, ocean circulation and costal zone change, past environment change, environmental change and ecology, information and data, and sustainable development and economic-social impacts.

CCRC WWW site is <http://www.gcc.ntu.edu.tw>

21. Taiwan Ecological Research Network (TERN) Databases – Sponsored by Taiwan’s National Science Council, six long term ecological research sites (LTER), covering the representative natural ecosystems of Taiwan, have been established since 1990. Data include meteorological recordings, soil data, vegetation distribution and mapping, spatial data of various types, satellite imageries, digital terrain data, and a variety of data generated by individual researchers. A meta-data catalog is currently under construction. Except for the meteorological data, which is opened to the general public, accessing other types of data require a permission from the data holder. TERN’s web site is <http://lter.npust.edu.tw>.

## References

- Biodiversity Center of National Taiwan University. (2002). *Planning of National Biodiversity Research in Taiwan*. National Taiwan University, Taipei, Taiwan. pp. 149.
- Hsu, M. J. and Agoramoorthy, G. (1999) Conserving the biodiversity of Kenting National Park, Taiwan: Present status and future challenges. In: *Proceedings of the Symposium on Biodiversity – 1999*. p. 62-72. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei, Taiwan.

- Lin, K. C. (2002). Nature protection areas in Taiwan. Council of Agriculture, Executive Yuan, Taipei, Taiwan. pp. 11.
- Lin, Y. H. (2001). *Jewels of Formosa*. Construction and Planning Administration. Ministry of Interior. Taipei, Taiwan. pp. 55.
- Lin, Y. S. (1998a) Present and development of biodiversity in Taiwan. In: *Proceedings of the Symposium on Prospects of Biodiversity*. p. 24-33. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei, Taiwan.
- Lin, Y. S. (1998b) Maintenance of local biodiversity and sustainable utilization of resources. In: *Proceedings of the Symposium on Prospects of Biodiversity*. p. 73-79. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei, Taiwan.
- Lin, Y. S. (1999a) *Proceedings of the Symposium on Biodiversity – 1999*. Council of Agriculture, Executive Yuan, Taipei, Taiwan. 220pp.
- Lin, Y. S. (1999b) Present and development of biodiversity conservation in Taiwan. In: *21st Century: Sustainable Development Action Act of National Park. Training Course in Biodiversity Conservation*. p. 1-11. Lin, Y. S. (ed.). Construction Administration, Executive Yuan, Taipei, Taiwan.
- Lin, Y. S. (1999c) Natural protection area and conservation corridors. In: *21st Century: Sustainable Development Action Act of National Park. Training Course in Biodiversity Conservation*. p. 118-123. Lin, Y. S. (ed.). Construction Administration, Executive Yuan, Taipei, Taiwan.
- Liu, R. Y. (1999) Research of bioresources, interferences and managements in Chi-tao. In: *Proceedings of the Symposium on Biodiversity – 1999*. p. 96-118. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei, Taiwan.
- Shih, C. T. and Cheng, C. C. (1999) Why it need to talking about biodiversity? From local newspapers reports. In: *Proceedings of the Symposium on Biodiversity – 1999*. p. 12-22. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei,

Taiwan.

- Wang, W. M. and Chou, W. F. (1999) Social education in biodiversity and species conservation: Exhibition and learning in National Natural Sciences Museum. In: *Proceedings of the Symposium on Biodiversity – 1999*. p. 119-135. Lin, Y. S. (ed.). Council of Agriculture, Executive Yuan, Taipei, Taiwan.
- Yang, C. K. and Yang, S. S. (2001). Microbial ecology of soils surrounding nuclear and thermal power plants in Taiwan. *Environ. Intern.* 26: 315-322.
- Yang, S. S., Lai, C. M., Sun, L. Y., Luo, Y. C., Fan, H. Y., Yang, C. K. and Wei, C. B. (1998a) Microbial ecology of Tatachia Mountain soil. *J. Chin. Agric. Chem. Soc.*, 36: 229-238.
- Yang, S. S., Lin, I. C., Chang, E. H., Yang, C. K. and Wei, C. B. (2000) Microbial population of nuclear power plant No. 3 and its surrounding area. *Taiwanese Agric. Chem. Food Sci.* 38: 339-346.
- Yang, S. S., Sun, L. Y., Yang, C. K., Wei, C. B., Huang, R. Y. and Hsu, W. F. (1998b) Microbial population at nuclear power plant No. 2 and its surrounding areas. *J. Environ. Protect. Soc. ROC*, 21: 144-158.
- Yang, S. S., Sun, L. Y., Yang, C. K., Wei, C. B., Huang, R. Y. and Hsu, W. F. (1999b) Microbial ecology at nuclear power plant No. 1 and its surrounding areas. *J. Agric. Assoc. China, New Series* 188: 20-31.
- Yang, S. S., Yang, C. K., Chang, E. H., Yang, C. K. and Wei, C. B. (1999a) The effect of thermal power plant on microbial ecology and environmental quality. *J. Microbol. Immunol. Infect.* 32: 269-277.
- Yuan, H. Y., Chin, H. C. and Chang, Y. P. (1999) Introduction of Ecotourism. In: *21st Century: Sustainable Development Action Act of National Park. Training Course in Biodiversity Conservation*. p. 201-237. Lin, Y. S. (ed.). Construction Administration, Executive Yuan, Taipei, Taiwan.