CHAPTER 4

ETHNOBOTANICAL STUDIES

MATERIALS AND METHODS

The sources of data for this research were interviews with person living around the wetlands in different parts of Thailand. The people interviewed were sought for their knowledge of uses of the lotus and water lilies. After locating a community near a wetland or pond with lotus and/or water lilies, an easily accessible person such as a park ranger was approached, and then the next informant was located with his help, and so on, until additional people with relevant knowledge could not be located.

The research started with interviews with people living around the selected wetlands in July 2003 and finished with the collecting of specimens in October 2006. The interviews were with informed consent, open-ended, and semi-structured (Cotton, 1992; Martin, 1995; Bernard, 2002). Questions concerned the gathering of lotus and water lilies local names, preparation and uses, parts of the plant used, status/abundance, cultivation practices, and marketability. Each interview took from thirty minutes to one hour. In addition, participant observation interviews were made with key informants during which the interviewed person was assisted with collection and preparation of lotus and/or water lilies for use and commerce.

Data Analysis

The data from the survey interviews were analyzed with SPSS version 11.5 for windows software. The variation between regions (Northern, Central, Northeastern and Southern Thailand; Figure 2) gender and age groups (<20, 21–30, 31–40, 41–50, 51–60, >60 years) who used *Nelumbo* and *Nymphaea* species differently were analyzed. The average number of uses per informant in these regional, gender and age groups were compared. Data normality was verified with the Komogorov-Smirnov

test. Levene's test was used for analyses of the equality of variances in the number of uses in the groups. The main effect of number of uses was analyzed by one-factorial analysis of variance (ANOVA). Means were compared using LSD tests when there were no difference in variance or Dunnett T3 when there were differences in variance. The main effect and pair wise comparison of means were estimated for significance at a P level <0.01. T-test was used to analyze differences in the number of uses of plants between gender groups.

RESULTS

Fifty nine different localities in Thailand, distributed in four regions and 36 provinces were visited (Table 6). At each locality one to several local people were interviewed totaling 280 person aged 10–88 (average 47) years, of which 145 (51%) were females and 135 (48%) were males (Table 7).

Table 6. Localities visited in Thailand to interview 280 local people about uses of *Nelumbo* and *Nymphaea* species.

Region	Province	Localities	Geographic coordinates
	Chiang Rai	1.Nong Luang Weang Chai.	19°47-52′N, 99°57′E
		2. Nong Luang Mae Jan	20°12′N, 99°48′E
		3. Chiang Sean Basin, Nong Bong Kai.	20°10-18′N, 99°57′-100°11′
orth	~	4. Nong Hang	19°30′N, 99°48′E
Nc	Chiang Mai	5. Wetland and cultivated field in San	18°54′N, 99°04′E
		Sai district.	100011
	ght [©]	6. Wetland in Sarapee district	18°41′N, 99°01′E
	0	7. Cultivated field in Mae rim district	18°53′N,98°54′E

Table 6 (continued)

Region	Province	Localities	Geographic coordinates
	Lampang	8. Wetland in Tambon Donfai, Nam Jang river at Tambon Na Kuao.	18°08′N, 99°36′E
	and a	9. Nong Kham, Nong Lom. Hang Chad District.	18°19′N, 99°36′E
	9	10. Maemo Reservoir	18°25′N, 99°51′E
ਜ	Phayao	11. Kwan Phayao.	19°09-13′N, 99°51-56′E
Nort		12. Nong Leng Sai	19°20-25′N, 99°47-50′E
	Nan	13. Nong Sa Nean.	18°48′N, 100°47′E
		14. Nam Kok oxbow lake	18°32′N, 100°45′E
	Phichit	15. Beung Si Fai	16°24-26′N, 100°20-21′E
	Nakhon Sawan	16. Beung Boraphet	15°40-45′N, 100°10-23′E
	Uthai Thani	17. Community located in Tambon Nong Kha yang	15°19′N, 99°58′E
1 7	Nong Khai	18. Beung Khong Long non-hunting	17°50-18°03′N, 103°59′-
		area	104°43′E
	Sakon Nakhon	19. Nong Han	17°06-15′N, 104°17-20′E
	Burirum	20. Huai Chorakhe Mak non-hunting area	14°53-55′N,103°01-03′E
		21. Huai Talat non-hunting area	14°51-53′N, 103°03-06′E
heast	Khonkaen	22. Nong Waeng.	16°20′N, 102°38′E
Nort	S 114	23. Wetland in Tambon Non Sa Ard,	15°55′N, 102°28′E
		Waeng Yai District	
	the second	24. Wetland in Tambon Rahan na.	15°48′N, 102°25′E
		25. Wetland in Pon District	15°52′N, 102°32′E
	Kalasin	26. Wetland in Tambon buang vichai	16°26′N, 103°37′E
	Ubon	27. Community located in Tambon	14°52′N, 105°25′E
	Ratchathani	buang yai	

Table 6 (continued)

Region	Province	Localities	Geographic coordinates
	Maha Sarakham	28. Wetland in Tambon Na po and Kaeng Leung Chan	16°11′N, 103°19′E
Northeast	Nakhon Ratchasima	29. Community located in Tambon Ngew, Pak Thong Chai district	14°38′N, 101°56′E
8	P. / _	30. Community located in Tambon Phratay,	15°29′N, 102°44′E
	Nonthaburi	31. Cultivated field in Tambon Bang Yai.	13°51′N,100°23′E
		32. Cultivated field in Bang Bua Tong33. Cultivated field in Bang Khoui	13°54′N,100°24′E 13°48′N,100°25′E
	Samut Prakan	34. Bang plee district	13°38′N,100°45′E
	Pathum Thani	35. Cultivated field in Tambon Klong kwa, Sam Khok district	14°06′N,100°31′E
	Ayutthaya	36. Wetland in Tambon Tab Mong Kon, Bang Sai district	14°19′N,100°19′E
Central	Ang Thong	37. Wetland and cultivated field in Po Thong district	14°41′N,100°20′E
0	Suphan Buri	38. Wetland and cultivated field in Song Phi Nong	14°13′N,100°01′E
	8114	39.Wetland in Au Thong district	14°22′N,99°53′E
	Chainat	40. Wetland in Tambon Thamma mun, Manorom district	15°16′N,100°09′E
	Nakorn Pathom	41 Cultivated field in Tambon Bo Phup	13°51′N,100°01′E
	rig	42. Cultivated field in Tambon Saraya	13°49′N,100°17′E
	0	43. Cultivated field in Tambon Mahasawat	15°16′N,100°09′E
	Ratchaburi	44. Wetland in Tambon Khu Bua	13°49′N,100°17′E

Table 6 (continued)

Region	Province	Localities	Geographic coordinates
	Phetchaburi	45. Wetland in Tambon Nong Phup	13°06′N,100°00′E
	Prachuab Khirikhan	46. Khao Sam Roi Yot National Park	12°05-20′N,99°52′- 100°02′E
	Rayong	47. Nong Chamlung	12°47′N,101°41′E
Central	Chon Buri	48. Cultivated field inPhanatnikhom district49. Cultivated field in SattaHip district	13°24′N,101°19′E 12°37′N,100°55′E
	6	50. Culivated field in Bang Lamung district	12°56′N,100°49′E
CF	Chanthaburi	12°42′N,101°51′E	
	Nakhon Sri Thammarat	52. Phru Kroun Kreng.	8°08′N,99°39′E
	Phattahalung	53. Thale Noi non-hunting area	7°15′-8°01′N,100°09-15′E
	Satun	54. Thale Ban	6°25-48′N,100°05-13′E
	Songkhla	55. Community located in Tambon Ta Kriea, Ranod district	7°52′N,100°15′E
South	ธิมหาร	56. Thale Sab non-hunting area	7°15-35′N,100°17-25′E
	Pattani	57. Community located in Tambon Tung Pla, Kok Po district	6°40′N,101°14′E
	0	58. Community located in Tambon Muang Tiae, Mae Lan disrrict	6°43′N,101°07′E
	Narathiwat	59. Phru To Daeng	6°03-21′N,101°50-102°03′I

age portion		male	female	
Below 20	Count	99	5	14
9	6 within age portion	64.3%	35.7%	100.0%
	% within sex	6.7%	3.4%	5.0%
21-30	Count	6	8	14
9	6 within age portion	42.9%	57.1%	100.09
	% within sex	4.4%	5.5%	5.0%
31-40	Count	19	28	47
9	6 within age portion	40.4%	59.6%	100.09
	% within sex	14.1%	19.3%	16.8%
41-50	Count	43	60	103
9	6 within age portion	41.7%	58.3%	100.09
	% within sex	31.9%	41.4%	36.8%
51-60	Count	38	30	68
9	6 within age portion	55.9%	44.1%	100.09
	% within sex	28.1%	20.7%	24.3%
upper 60	Count	20	14	34
9	6 within age portion	58.8%	41.2%	100.09
	% within sex	14.8%	9.7%	12.1%
Total	Count	135	145	280
9	6 within age portion	48.2%	51.8%	100.09
	% within sex	100.0%	100.0%	100.09
right [©]	% of Total	48.2%	51.8%	100.09

Table 7. Age and gender of the informants interviewed totaling 280 persons.

1. Uses of Nelumbo nucifera in Thailand

Twenty different uses of *N. nucifera* were recorded, here presented and first divided into four use categories (ritual, medicinal, food, miscellaneous) and then listed by plant part used (Table 8).

Ritual Uses

Flowers — Flowers were used in Buddhist ceremonies. For this purpose, budding flowers with 40–50 cm long peduncles were harvested during the blooming period from April to May (Figure 65).

Leaves — In an ordination rite before becoming Buddhist priests, men wrapped their cut-off hair in leaves of *N. nucifera* because the plant symbolizes vitality, purity, and virtue. At the beginning of house construction, leaves and flowers were put into the pillar hole to secure prosperity and well-being (Figure 65).

Food Uses

Rhizomes — Rhizomes of *N. nucifera* were cooked as a vegetable called *Pong Bua*. The rhizome was boiled in a soup with pork ribs, soaked in syrup as a confection, boiled in syrup and eaten as a sweet, ground into powder and used in making sweet meats, or stirred with sugar and sweet condensed milk as a candy. Rhizomes were also used to make juice (Figure 61).

Stolons — Especially in central and southern Thailand, stolons were used as vegetable, raw or cooked, but usually boiled with fish in a sour spicy soup, stir-fried with oyster sauce or sometimes mixed with other vegetables or meat, pickled with salt, and eaten with rice. Stolons should be cooked soon after harvesting to keep a good taste (Figure 62).

Leaves — Un-opened young leaves of *N. nucifera* were used as a vegetable, despite their bitter taste. In northern, central and southern Thailand, leaves were eaten raw or steamed and mixed with curried fish and coconut milk in a spicy soup.

Petals — The inner petals of budding *N. nucifera* flowers were used as a vegetable. In Bangkok, petals were eaten raw with a sauce of shrimp paste and chili.

Pods — Pods with young raw seeds were harvested and used as a vegetable. For this purpose, the pod with its peduncle should be picked before the rainy season and floods. *Seeds* — Seeds were mainly eaten in desserts. The attractive part of the seed was the cotyledon, whereas the seed coat and the bitter embryo were usually removed before consumption. The removed embryo was discarded or collected and used medicinally (see in *Medicinal uses*). Both unripe and ripe seeds were used; sometimes they were eaten raw, but if mature and stored dry they should be cooked. For this, they were boiled, sometimes in syrup, or steamed until they were soft, and then put in fried-rice or mixed in desserts. Sometimes the cotyledon was fried and dressed with salt, or coated with sugar to be sold as a confection. Dried seeds were ground into powder and used for baking cookies or other sweets (Figure 63).

Medicinal Uses

Leaf blades — Near Buang Borapet informants used wrapped dried leaves of *N. nucifera* as a cigarette to treat argent sinusitis and rhinitis. Leaves, extracted in a tea, were used to treat sore throats. The middle leaves were sometimes used to treat diabetes; they sliced and steamed as a tea taken three times after which the diabetes symptoms disappeared (Figure 64).

Petioles and peduncles — Dried petioles and peduncles were used as cigarettes to treat sinusitis.

Stamens — In southern Thailand, stamens were used to treat allergies. Stamens, together with whole plants of *Aerva lanata* (L.) Juss. ex Schult. (Amaranthaceae) and rhizomes of *Tradescantia spathacea* Sw. (Commelinaceae), were chopped, boiled in water, and then made into a decoction that was taken. Near Buang Borapet, wrapped dried stamens were used as a cigarette to treat argent sinusitis. In traditional medicine dried stamens were combined with other herbs to treat fever, or used as a cardiac tonic taken as tea. They were also sold in herb drugstores as a heart stimulant or as fragrant herbal tea that benefited health in general. It was more common to collect and re-sell the stamens to drug-stores than to collect them for household consumption (Figure 64).

Pods — The outer membrane of pods was used as smoking materials to treat argent rhinitis.

Embryo — The embryo was used medicinally in tea to reduce high fever, for its dilation effect on cardiac vessels. It was also said to be effective for quenching thirst, decreasing blood pressure, treating oral infections and diabetes, and increasing

peripheral blood flow. Embryos were dried and ground, then filled in capsules that were packed and sold (Figure 64).

Miscellaneous Uses

Leaves — Fresh leaf blades were sold for use as food wrappers, especially for fresh fish or vegetables sold at the market, it can wrap saucy food such as rice with shrimp sauce, which can then be kept as a meal for a journey. Leaves were also sold to China for use as food wrappers. For this purpose they were dried for 2–3 days, packed and exported. Before use they were re-hydrated by letting them absorb the dew during one night. Leaves were used for wrapping lotus flowers during transport to market; they reduced evaporation and kept flowers fresh (Figure 65).

Pods — Pods left over after harvesting stamens were used for cattle fodder, although this was not seen as a favored feed. Young pods were dried and gilded with silver or gold and used for decoration (Figure 65).

Petals — Near Buang Borapet, the petals were ironed and used for wrapping cigarettes to give them a dainty appearance.

Pericarp— Powdered pericarp were mixed in mushroom spawn culture. The mushroom grown with this culture were called *Hed Bua* (*Hed* means mushroom and *Bua* is the local name for *N. nucifera*). Some informants mentioned that the pericarp may be used as fertilizer.

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	as astagany Dant used		infor	mants
Use category	Part used	Use	#	%
Ritual	Flowers	Ceremonies	176	63
Food	Stolons	Vegetable	90	32
Food	Pods	Vegetable	87	31
Miscellaneous	Leaves	Flower wrappers	87	31
Food	Seeds	Desserts	83	30
Food	Rhizomes	Vegetable	73	20
Miscellaneous	Leaves	Food wrappers	14	5
Medicinal	Stamens	Allergy, fevers	16	6
Medicinal	Embryo	Fevers, etc.	8	3
Medicinal	Leaves	Various	9	3
Food	Leaves	Vegetable	6	2
Medicinal	Peduncles	Sinusitis	6	2
Miscellaneous	Petals	Cigarette wrappers	6	2
Ritual	Leaves	Ordination rites	R-4	1
Ritual	Leaves	Protect house	4	1
Miscellaneous	Pods	Fodder	4	1
Miscellaneous	Pods	Decorations	4	ł
Food	Petals	Vegetable		
Medicinal	Pods	Rhinitis	3	
Miscellaneous	Pericarp	Mushroom spawn		hive
Medicinal	Rhizomes	Fevers, etc.	0	



Figure 61. Food from rhizomes of Nelumbo nucifera Gaertn.

- A. People with rhizomes. B. Rhizomes. C. Spicy salad made from rhizomes.
- D. Ground rhizome before it was cooked. E. boiled in soup with pork.
- F. Boiled in syrup as a sweet. G. Cookies made from the powder of rhizome.
- H. Soaked in syrup as a confection. I. Juice.
- J. Sweet meats from ground rhizome.
- K. Stirred with sugar and sweet condensed milk as a candy.



Figure 62. Food from stolon of Nelumbo nucifera Gaertn.

- A. People harvesting stolon.
- B. People with stolon at local market.
- C-F. Different kinds of food made from stolon.
- C. Stolon in spicy soup with fish.
- D. Solon stir fried with oyster sauces.
- E. Fried rice with stolon and seed of lotus.
- F. Stolon spicy salad.



Figure 63. The uses of pods and seeds of Nelumbo nucifera Gaertn. for food.

A. Pod. B. People selling pod. C. Fresh fruits. D. Dry fruits.

- E. Preparing dry fruits before cooking.
- F. Removed pericarp, seat coat and embryo from fresh fruits before cooking.
- G. Fresh seeds after removal of pericarp and embryo.
- H. Thai desserts mixed with seed. I. Fried and dressed with salt as confection.
- J. Fried rice with seeds. K. Seeds boil in syrup.
- L. Thai desserts made from powdered seeds.



Figure 64. The medicinal uses of Nelumbo nucifera Gaertn.

- A. Cigarette from leaves used to treat argent sinusitis and rhinitis.
- B. Leaves wrapped with petal used as cigarette.
- C. Tea from leaves to treat sore throats.
- D. Tea from stamen use as a cardiac tonic.
- E. Dried embryos.

F. Tea from embryos used to reduce high fever and for its dilation effect on cardiac vessels.



Figure 65. Rituals and Miscellaneous uses of Nelumbo nucifera Gaertn.

A. Flowers used in Buddhist ceremonies.

B. An ordination rite before becoming Buddhist priests, men wrapped their cut-off hair in leaves.

C. Leaves used as food wrapper.

D. Dried leaves used in decoration.

E. Leaves used for wrapping lotus flowers during transport to market.

F, G. Young pods were dried and gilded with silver or gold and used for decoration.

Cultivation and harvest of Nelumbo nucifera in Thailand

The most common practice to cultivate *Nelumbo nucifera* was by planting segments of the stolon, but in some cases fields were planted with rhizomes. Seeding was not popular because the resulting plants often differed from the parent, possibly because seeds were highly heterozygous. Stolons were preferably planted in the very sunny start of the summer period from March to May. Fields were plowed and left for 10 days for weeds to die and decompose; then 1000 kg of manure was added to each 0.4 acre and the paddy was smoothed leaving 30 cm of water. The stolon segment, which should be cut below the third joint from the tip, was planted in the mud at a density of one per six square meters giving 45 plants in each 0.4 acre. The best soil for cultivation was clay with abundant organic matter. The leaf appeared after three months, and simultaneously the stolon gradually matured into a rhizome and shortly thereafter flowers could be harvested reaching a maximum production after four months. To maintain productivity and keep plants flowering all year, each 0.4 acre of field was fertilized with 50 kg of basal fertilizer equal formula (15-15-15) every 30 days.

Flowers were ready to be harvested in the third month after planting (Figure 66). Large budding flowers, with 40–50 cm long peduncles, could be harvested every second day during most of the season, but only once every three days in the less productive winter period from November through February. After harvesting flowers for 3–4 months, the plant became less productive and the farmer then forced the stolon to produce new leaves by draining the field and plowing it densely to the depth of the rhizomes, then flooding the field again. After 2–3 months, new shoots appeared and the field could be harvested again.

About 1.5 months after fields started producing floral buds, pods and seeds were harvested, and this continued for 3–4 months. Pods were ready to be harvested when they became dry and gray or black on the top. They were collected with a two meter long picking-pole and piled along edges of fields, where they were subsequently beaten with a wooden stick to release the seeds. Seeds remaining in pods were released by hand. After 2–3 days of drying in the sun, seeds were sorted to discard those not well-developed, while healthy seeds were packed in gunny bags.

The red, single-flowered plant form called *Patum* was particularly popular for seed cultivation because of its size and many-seeded pods.

Following floral bud and pod harvest, stolons and rhizomes were harvested. Stolons could be harvested 2–3 months after the field was planted, but rhizomes mature later, usually after the farmer had added fertilizer to produce a new crop and the soil had dried and started to crack. Stolons were harvested by pulling and shaking young unfolded leaves emerging from 50 cm or shallower water; young leaves emerging from deeper water were said to be attached to older more deeply buried rhizomes. The stolon harvest took place from March through August, in the rainy season with high water levels. When reaching the warm season in January and February, rhizomes were large and rich in starch and sometimes exposed in the cracked soil. Rhizomes were dug from the soil and sold, although some were stacked along the field and kept humid with banana leaves and sprinkled with water to keep them fresh for replanting the field as an alternative to planting with stolons. Some informants said they could harvest rhizomes in deep water, but apparently this was done only by the most skilled harvesters and the amounts harvested in a day were less than when the rhizomes were harvested in a dried lake bed.

Marketing and prices of Nelumbo nucifera products in Thailand

All parts of *N. nucifera* were marketed, either in local markets or - for a few products - on larger or international markets. Prices obtained and prevalence of each commercial activity found in this survey are given in Table 9.

Stolons — Used as a vegetable, they were commercialized in local markets. *Rhizomes* — This vegetable was commercialized in local markets. One person could harvest 17–18 kg of rhizomes per day.

Leaves — Leaves were sold to intermediaries for use as food wrappers. One person could collect 800–1000 leaves, equal to 20–30 kg, in a half-day, often starting at 04.00 a.m. and working until 12.00 a.m. After the leaves were dried for 2–3 days, they were packed and exported to China (Figure 67).

Flowers — Because of the prevalence in ritual uses, flowers were commercialized in all villages and cities and provided substantial cash income to

villagers. Many informants mentioned that they collected flowers from natural wetland stands with the purpose of selling them; when cultivating the lotus plant, 0.4 acre field produced 10,000 flowers per month. The most important market for flowers was the Pak Klong Talad market in Bangkok; there were flower markets in each province. Prices varied over the year being highest from December through February and lowest from April through October; the average price was one *Bath* per flower.

Stamens — In Buang Borapet, 16 informants collected and sold dried stamens from wild stands. They gathered budding or opened flowers from early morning until midday and subsequently separated stamens from flowers and dried them in the sun for 1–3 hours. The harvest took place throughout the year, except in April and May, when wetlands became dry and when plants were heavily attacked by aphids. One person could gather 3–4 kg of dried stamens per day, which were extracted from 3– 4,000 flowers. Dried stamens were sold to intermediary who re-sold them to Chinese drug stores, both in China and Taiwan. The informants usually had standing orders for 200–300 kg, which they could deliver in installments every 2–3 days. This occupation gave a full-time stamen harvester an income of 750–1200 *Bath* per day throughout the year, except for the few months when harvesting was impossible (Figure 67).

Pods — Pods bunched with 4–5 together, or sometimes in bundles of 100, were sold at local markets at varying prices according to size and number of seeds in each pod.

Seeds — The family of one informant in Phichit province purchased fresh mature seed with the seed coat still green and employed villagers to split the seed to remove the seed coat and embryo. Other informants mentioned that they sold fresh and dry ripe seed for food. One kilogram of fresh ripe seeds fetched 15 *Bath*, a kilogram of dried ripe seeds with seed coats fetched 8–30 *Bath*, whereas dry ripe seeds with the seed coat removed fetched as much as 50 *Bath* per kg. One field of 1,618.7 m² usually produced 144–180 kg of dried ripe seeds.

Embryos — For the extraction of embryos 120 kg of fresh ripe seeds produce 1 kg of embryos, which can be sold at local markets.



Figure 66. Harvesting flowers of lotus.

- A. Local people harvesting lotus flowers in a field.
- B. Transportation of flowers to the house.
- C. Lotus flowers
- D. Packing lotus flowers.

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Figure 67. Preparing leaves and stamen of *Nelumbo nucifera* Gaertn. for commercialization.

- A. Harvesting leaves. B. Dried leaves before packing
- C. Pack leaves using Scirpus grossus L. f.
- D. Packing leaves before they are sold. E. Flower harvested by local people.
- F. Stamen dried in the sun. G. People separating stamens from flowers.

Table 9. Prices obtained for various products derived from *Nelumbo nucifera* according to interviews with 280 informants at 59 localities throughout Thailand with indication of number of informants providing information. In October 2007, 1 *Bath*= $0.023 \in$.

Part sold	Unit	Price (Bath) per unit	# of informants	% of informants
Stolons	Kg	20-30	25	8.9
Rhizomes	Kg	10	16	5.7
Leaves	Kg	15	15	5.3
Flowers	1 flower	1	102*	36.4
Stamens	Kg	250—300	16	5.7
Pods	Bunch of 4-5	7–15	50	17.8
Pods	Bunch of 100	100–160	50	17.8
Seeds-fresh	Kg	15	13	4.6
Seeds-dried	Kg	8–30	13	4.6
Seeds w/o seed coat	Kg	50	13	4.6
Pericarp	Kg	6-8	10	3.6
Embryos	Kg	200	11	3.9

*Of these 102 informants, 46 gave information based on harvesting *N. nucifera* flowers from natural wetlands, and 56 gave information based on harvesting cultivated flowers.

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Variation in use of Nelumbo nucifera in Thailand

The use of *N. nucifera* did not vary between genders and age groups, but varied between the different regions of Thailand.

Gender — No significant differences were found in the average number of uses of *N. nucifera* related to the informants' gender (Levene's test for equality of variance, P=0.949 > 0.01; t-test for equality of means P=0.365/2=0.1825 > 0.01).

Age groups — No significant differences were found in the average number of uses of *N. nucifera* know by informants of different age groups (<20, 21–30, 31–40, 41–50, 51–60, >60 years; Levene's test for equality of variance, P=0.062>0.01; F-test in ANOVA, P =0.44 >0.01)

Use variation between regions — Average number of uses (Table 10) varied significantly between the four regions (Welch test in ANOVA, P=0.000 < 0.01). When the uses for food were analyzed separately, the four regions' variance were not equal (Levene's Test, P=0.000 < 0.01) and the average number of uses known by the informants differed (Welch test in ANOVA, P=0.024 > 0.01). When the medicinal uses were analyzed separately (Tables 11), the average number of uses varied significantly between the four regions (Levene's Test, P=0.000 < 0.01; Welch test in ANOVA, P=0.000 < 0.01).

Table 10. Regional variation in Nelumbo nucifera use frequencies by categoriesmentioned by 280 informants at 59 localities throughout Thailand.

Region	Infor	Informants Use categories								11
			Rit	ual	Med	licinal	Fo	od	Misce	laneous
nvrigh	no.	%	no.	%	no.	%	no.	%	no.	%
North	102	36	51	28	27	60	71	28	23	24
Central	72	26	60	33	1	2 e	90	36	57	59
Northeast	54	19	43	23	6	13	31	12	3	3
South	52	19	29	16	11	25	60	24	14	14
	280	100	184	100	45	100	252	100	97	100

Table 11. Variation in average number of different uses of *Nelumbo nucifera* known by 280 informants in four regions of Thailand, specified for all uses mentioned and separately for medicinal and food uses.

Region	# informants	Average number of uses known per informant (+SD)						
		All uses (20 uses)	Medicine (5 uses)					
North	102	2.20 (1.053)	1.09 (0.646)	0.22 (0.488)				
Central	72	3.03 (1.048)	1.39 (0.832)	0.01 (0.118)				
Northeast	54	2.19 (1.083)	1.17 (0.684)	0.13 (0.502)				
South	52	2.19 (1.401)	1.37 (0.715)	0.38 (0.631)				
	280	2.41 (1.182)	1.23 (0.727)	0.18 (0.476)				

Marketing variation between regions — Variance in the number of commercialized products of *N. nucifera* in the four regions was not equal (Levene's Test, P=0.000<0.01). There was also a significant difference between the four regions with regard to average number of commercialized products know per informant (Table 12; Welch test in ANOVA, P=0.000<0.01).

Table 12. Variation in commercialization of *Nelumbo nucifera* in different regions of Thailand given as number of informants mentioning each plant part sold locally or at regional, national, or international markets.

	3			Pla	ınt par	t com	mercia	lized				er of ed
Region	# informants	Stolons	Rhizomes	Leaves	Flowers	Stamens	Pods	Seeds	Seed-coats	Embryos	Total	Average numb commecializ products
North S	102	7	11	14	30	16	33	12	10	11	144	1.41(1.129)
Central	72	12	h	1	49		2	1	S	e	65	0.90 (0.585)
Northeast	54	1	2		16		15				34	0.63(0.958)
South	52	5	3		7						15	0.29(0.536)
Total	280	25	16	15	102	16	50	13	10	11	258	0.92(0.977)

2. Uses of Nymphaeaceae in Thailand

Based on the interviews, data taken from the internet, and personal observations uses of the species of Nymphaeaceae are here presented first by four use categories (food, medicine, ritual use and miscellaneous use) and then by plant part used (Table 13). Of the 280 informants, 117 (42%) used *Nymphaea rubra*, 37 (13%) used *Nymphaea pubescens*, 10 (4%) used *Nymphaea nouchali* and 10 (4%) used *Nymphaea capensis* var. *zanzibariensis*. In addition some uses of *Barclaya longifolia* that were not mentioned in the interviews are included.

Food uses

Peduncles — According to the interview survey, water lilies were mostly used for food. The peduncle of *Nymphaea rubra, Nymphaea pubescens* and *Nymphaea nouchali* were used as a vegetable (Figure 68). Individual young flowers were cut from floating plants at the base of the peduncle just above the rhizome. To prepare them for consumption, the epidermis of the peduncle was peeled off and the naked peduncle was cut to short sections of about 2–5 centimeters or sliced in diagonal cross-sections. The sections were then cooked with fish in spicy sour soup, or thickened with coconut cream, and stir fried with meat or shrimp or sometimes eaten raw.

Seeds — The mature or raw seeds of Nymphaea pubescens and Nymphaea capensis var. zanzibariensis were eaten as a snack or cereal, but only in the southern region.

Sprouts — The sprouts of *Nymphaea rubra* were used as vegetable. They were harvested from the rootstocks and sold to be eaten in the same way as bean sprouts, stir fried with pork or for making soup.

Medicinal use

Rhizome — Rhizomes of Nymphaea rubra, Nymphaea pubescens and Nymphaea nouchali were use as medicine. In southern Thailand, rhizomes of Nymphaea pubescens and N. nuchali, together with whole plants of Lygodium microphyllum (Cav.) R. Br. and Lygodium salicifolium C. Presl, stems and leaves of Ipomoea aquatica Forsk. were used to treat cancer. Thickened stems of *Hydnophytum formicarum* Jack in equal proportion were coarsely chopped and boiled in water, and then a decoction was taken daily as a substitute for drinking water. Near Buang Borapet, the rhizome of *Nymphaea rubra* were dried, scrubbed with water or pounded, and then a decoction was taken as a tonic for potency.

Ritual Uses

Flowers — Flowers of *N. capensis* var. *zanzibariensis* were used in religious ceremonies that worship Buddha. For this purpose, budding and blooming flowers with 5–10 centimeter long peduncles were harvested. Three flowers were put in the small cone made from banana leaves or paper together with scented sticks and tallow candles.

Environmental uses

Plants — *Nymphaea rubra, N. pubescens, N. nouchali, N. capensis* var. *zanzibariensis* were used as ornamentals, as potted plants in front of buildings or grown in pools in ornamental gardens, temples, and public gardens. *Barclaya longifolia* was sold to be planted in aquaria (Figure 68). Species of *Nymphaea* and also many hybrids are of economic importance mainly because of the value of water lilies as ornamental plants in water gardens, for which numerous horticultural varieties have been developed. The Thai water lilies do not have other economic values, except as occasional ornamentals. *Barclaya longifolia* is a highly prized aquarium plant due to color variations of the blade.

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			infor	mants
Use category	Part used	Use	#	%
Nymphaea rubra	0			
Food	Peduncle	Vegetable	115	54
Food	Sprout	Vegetable	4	1
Medicinal	Rhizome (Rootstcok)	Tonic of potency	7	3
Nynphaea pubescens	C			
Food	Peduncle	Vegetable	37	17
Food	Seed	Raw (cereal)	5	2
Medicinal	Rhizome (Rootstcok)	Cancer treatment	3	5 1
Nymphaea nouchali				0
Food	Peduncle	Vegetable	11	6
Food	Flower	Vegetable	4	2
Medicinal	Rhizome (Rootstcok)	Cancer treatment	3	1
Nymphaea carpensis		22		
var. zanzibariensis				
Food	Peduncle	Vegetable	9	4
Food	Seed	Raw (Cereal)	7	3
Ritual	Flowers	Ceremonies	5	2

Table 13. Uses of *Nymphaea* spp. in Thailand. Information obtained in field survey for this study.

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Figure 68. Uses of Nymphaea spp.

A. Harvesting peduncle of *Nymphaea rubra* Roxb. ex Salisb. at Bueng Borapet, Nakhon Sawan Province.

- B. Dessert made from Nymphaea rubra Roxb. ex Salisb. peduncle.
- C. Spicy soup made from peduncle of Nymphaea pubescens Willd.
- D. Spicy soup made from peduncle of Nymphaea rubra Roxb. ex Salisb.
- E. Tubers of Nymphaea rubra Roxb. ex Salisb.
- F. Nymphaea rubra Roxb. ex Salisb. as ornamental plant in aquarium.

Marketing and prices of Nymphaea products in Thailand

Some parts of *Nymphaea rubra* and *Nymphaea pubescens* were marketed, but only in local markets and only for few products.

Peduncle — The peduncle of *N. rubra* was used as vegetable, and commercialized in local markets. Prices were 5–6 *Baht* per kilogram. One person could collect 20–50 kg, in half-day, often starting at 06.00 a.m. and working until 12.00 a.m. Individual young flowers were cut from floating plants at the base of the peduncle just above the ground and then divided into sections about 45 centimeters long and bunched. Five kilograms of peduncle were packed into a plastic bag.

Flowers — Used for treatment as a tonic for potency, the flowers were collected on order. The flower were split to four parts and dried before the intermediary receives them.

Rhizomes — For environmental use as ornamental plants in aquarium. The small rhizomes of *Nymphaea rubra* were ordered and about 100 kilograms were collected each time. During the period from March to January the rhizomes branch off many small tubers that uproot and float on the surface of the water. One person could collect 10–20 kg in a day. About 50 small root stocks equaled one kilogram. The root stocks were washed and soaked with a red lime solution for half an hour to deodorize the rotten smell before packed and sent to the aquarium market in Bangkok. Three days after they were collected the rhizome sprouted and started growing. The informant harvested the sprout for food.

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7. Variation in use of Nymphaeaceae in Thailand

The use of *Nymphaea* spp. did not vary between genders but varied between age groups and the different regions of Thailand.

Gender — There were no significant differences in the average number of uses of *Nymphaea* spp. related to the informants' gender (Levene's test for equality of variance, P=0.19 > 0.01; t-test for equality of means P=0.215/2=0.10>0.01).

Age groups — There were significant differences in the average number of uses of *Nymphaea* spp<u>.</u> known by informants of different age groups (<20, 21–30, 31–40, 41–50, 51–60, >60 years; Levene's test for equality of variance, P=0.643>0.01; F-test in ANOVA, P =0.00<0.01). The age 21–50 years had lower mean number of uses of *Nymphaea* spp. than the age below 20 years and over 51 years.

Use variation between regions — Average number of uses (Table 14) varied significantly between the four regions (Welch test in ANOVA, P=0.000 < 0.01). The southern region had greater mean number of uses of Nymphaea spp. than other regions. When the uses for food were analyzed separately, the four regions variance were not equal (Levene's Test, P=0.000 < 0.01) and the average number of uses known by the informants differed (Welch test in ANOVA, P=0.00 < 0.01). The southern region has greater mean number of use of Nymphaea spp. than other regions (Table 15, 17). When the medicinal uses were analyzed separately (Tables 16-17), the average number of uses varied not significantly between the four regions (Levene's Test, P=0.000 < 0.01; Welch test in ANOVA, P=0.102 > 0.01).

Marketing variation between regions — Variance in the number of commercialized products of *Nymphaea* spp. in the four regions was not equal (Levene's Test, P=0.000<0.01). There was also a not significant difference between the four regions with regard to average number of commercialized products know per informant (Table 18, Welch test in ANOVA, P=0.089>0.01).

Region	Inform	nants	ants Use categories						
		9	Rit	Ritual		icinal	Fo	ood	
	no.	%	no.	%	no.	%	no.	%	
North	102	36	0	0	75	39	42	23	
Central	72	26	0	0	0	0	47	25	
Northeast	54	19	0	0	2	15	28	15	
South	52	19	5	100	6	46	68	37	
	280	100	5 100		13	100	185	100	

Table 14. Regional variation in frequency of use of Thai *Nymphaea* mentioned by 280 informants at 59 localities throughout Thailand.

Table 15. Regional variation in frequencies of uses of Thai *Nymphaea* for food, based on information from 280 informants at 59 localities throughout Thailand.

	N. rubra N. pube		scens N. nouchali		N. capensis var. zanzibariensis				
Regions	peduncle	Sprout	Peduncle	seed	Peduncle	flower	Peduncle	seed	Tot
North	36	3	3	0	0	0	0	0	42
Central	30	0	15	0	INIV	4	0	0	47
Northeast	27	0	1	0	0	0	0	0	28
South	22	0	18	4	10	3	7	4	68
Total	115	3	37	4	11	4	7		18

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Regions	N. rubra	N. pubescens	N. nouchali	
	Rhizome	Rhizome	Rhizome	
North	5	0	0	
Central	0	0	0	
Northeast	2	0	0	
South	0	3	3	

Table 16. Regional variation in use frequencies of Thai *Nymphaea* for medicine based on interviews with 280 informants at 59 localities throughout Thailand.

Table 17. Variation in average number of different uses of Thai Nymphaea. (Nymphaea rubra, Nymphaea pubescens, Nymphaea nouchali and Nymphaea capensis var. zanzibariensis) known by 280 informants in four regions of Thailand, specified for all uses mentioned and separately for medicinal and food uses.

E		Average number of uses known per informant (±SD)					
Region	# informants	All uses (12 uses)	Food (8 uses)	Medicine (3 uses)			
North	102	0.46 (0.62)	0.41 (0.56)	0.05 (0.21)			
Central	72	0.65 (0.67)	0.65 (0.67)	0.00 (0.00)			
Northeast	54	0.56 (0.63)	0.52 (0.54)	0.04 (0.19)			
South	52	1.69 (1.45)	1.44 (1.22)	0.12 (0.42)			
	280	0.75 (0.95)	0.69 (0.83)	0.05 (0.24)			

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Table 18. Variation in commercialization of Thai *Nymphaea* in different regions of Thailand given as number of informants mentioning each plant part sold locally or at regional, national, or international markets.

		Plant part commercialized			Ø		
Region	# informants	Flowers of <i>N. rubra</i>	Rhizomes of N. rubra	Peduncle of <i>N. rubra</i>	Total	Average number of commecialized products perinformant (<u>+</u> SD)	
North	102	3	2	5	10	0.10 (0.359)	
Central	72	0	0	0	0	0.00 (0.00)	
Northeast	54	0	0	2	2	0.04 (0.191)	
South	52	0	3	0	3	0.06 (0.235)	
Total	280	3	5	7	15	0.05 (0.255)	

3. Abundance of Nelumbonaceae and Nymphaeaceae

Of the 280 informants 203 commented on the abundance of Nelumbonaceae and Nymphaeaceae. From these comments, 200 viewed *Nelumbo nucifera* as very important, 57 (25%) of them characterized it as common, 32 (14%) thought that it was abundant, and 71 (31%) thought that it was rare. Of those who commented, 62 (27%) related the abundance of *Nelumbo nucifera* to floods or the dry season because the plants may be dormant or dead during such times.

Thirty informants commented that *Nymphaea rubra* is common, 24 informants thought it was rare, 9 thought it was abundant and 11 informants that its abundance was up to the nature. The other species: *Nymphaea pubescens, Nymphaea nouchali, Nymphaea cyanea* and *Nymphaea capensis var. zanzibariensis* were all thought to be rare.

Concerning changes in abundance of the species in Nelumbonaceae and Nymphaeaceae, the majority of informants thought that there had been a change, especially related to the conversion of the natural wetlands into cultivated fields. Some informants felt that the plants' abundance was negatively affected by the reclamation of wetlands for the expansion of industrial areas and for urban development, a change that also makes the water beds shallow because of decaying aquatic plants. Such changes damage the natural vegetation and destroy the plants stands and make them harder to find, also because more people collect the plants. For people living around the wetland, the loss of the *N. nucifera* and species of Nymphaeaceae means that they have to walk further to collect the products derived from them. As for amelioration of anticipated negative effects of the decline of *N. nucifera* most informants had no suggestions for how to manage and protect the resource because *N. nucifera* mostly grows in wetlands located in protected areas which prevent intervention by the local people. Some informants, however, suggested that renting parcels for cultivation of *N. nucifera* could possibly encourage protective measure on part of the harvesters.

DISCUSSION

Nelumbo nucifera was used for 20 different purposes at the 59 localities surveyed, and the uses involved all parts of the plant (Table 6, 8). A use was defined as at least one record of one part (rhizome, leaf, etc.) used in one of the four use-categories (ritual, food, medicinal, miscellaneous). Stolons and rhizomes are treated as different plant parts even if both represent the stem of the plant; stolons creep on top of the muddy substrate with long internodes whereas rhizomes are underground organs with short internodes. Sometimes the same part of the plant was used in various ways in the same use-category. Leaf blades, for instance, were used medicinally to treat sinusitis, arthritis, and diabetes, but that was counted as only one use; "leaf blades used medicinally," so the count of 20 different uses is conservative. *Nelumbo nucifera* is, therefore, a truly multi-purpose plant and it uses range from nutritional, medicinal and structural to religious ones. The use of flowers in religious ceremonies is by far the most prevalent use of *N. nucifera*, whereas the use of stolons, rhizomes, pods, and seeds for food all are major uses, and the remaining uses were know only by some of the informants (Table 8).

Although medicinal uses were not prominent in this survey, there are several reports in the literature of such uses. For instance, The informants reported no medicinal uses of *N. nucifera* rhizomes, although ancient Thai pharmacopoeia

mention uses of *Nelumbo* rhizomes for enhancing body energy, relieving high internal body temperatures and thirst, treating fevers and sore throats, and as anti-inflammants (Bunyaprapath, 1998). Similarly, this study gathered no information about cardiac uses of leaves, but Trongtorsak et al. (2005) have demonstrated that crude leaf extracts have positive isotropic and chronotropic effects in rats, and accelerated cardiac electricity through the β 1-adrenergic receptors. In agreement with this data the use of stamens as a cardiac tonic, neurotic supplement, nourishment, and restorative was already known in the ancient pharmacopoeia (Bunyaprapath, 1998), in which it was suggested that they should be mixed with stamens from several other plants such as Mammea siamensis T. Anderson (Clusiaceae), Mesua ferrea L. (Iron Wood, Clusiaceae), Minusops elengi L. (Bullet Wood, Sapotaceae), Jasminum sambac Ait. (Oleaceae), Cananga odorata Hook.f. & Thomson (Annonaceae), Michelia champaca L. (Magnoliaceae), Melodorum fruticosum Lour. (Annonaceae), and Pandanus odoratissimus L.f. (Pandanaceae). In addition to this report of medicinal uses of pods to treat rhinitis, this part of N. nucifera was used in traditional Thai medicine to flush the remaining placenta, to treat a crippled uterus, as an astringent, and to treat diarrhea (Suntronjaruennon, 2003). Medicinal uses of the N. nucifera embryo related to cardiovascular conditions were also registered, and additionally the literature reports effect of embryo extract on the cardiovascular system in rats, and they are believed to function partly via $\beta 1$ adrenergic receptors, which produce vasodilatation, transient hypotension, and a positive chronotropic effect. In high oral doses, long-term administration of embryo extract increased peripheral blood flow (Jittiporn, 2002). Traditional Thai pharmacopoeia also mentioned the use of *N. nucifera* embryos to nourish the heart, to treat hematemesis, to prevent ejaculation while sleeping, and to quench thirst (Bunyaprapath, 1998). In general there are several additional medicinal uses of N. nucifera in the literature compared to those obtained in this survey. This may be so because medicinal uses are known by healers and other specialists in the villages, whereas most of the informants were not selected for their specialist knowledge. Also medicinal uses may in general feature more prominently in the older literature than other kinds of plant uses. Overall additional research on the uses of *N. nucifera* may reveal several additional uses, underlining its status as a truly multipurpose plant.

Traditionally, the use of Nelumbo nucifera was based on extraction of products from wild stands. Currently, many people cultivate it because of its multiple uses and potential as a cash crop, attractive because it can be harvested when needed. It may be grown near local markets and there adopted to local demands for cut flowers, stolons, pods, seeds, etc. Important growing areas in Thailand include the provinces of Nakhon Pathom, Nakhon Sawan, Phitsanulok, Suphan Buri, Rayong, and Chon Buri. Seeds were mostly grown in Nakhon Sawan, Phichit, and Phitsanulok provinces. There were two different ways of producing N. nucifera – either by harvesting wild stands or by cultivating them in fields. This can be seen as a double strategy, one providing pesticide free products grown without fertilizers which may be attractive on the food and medicinal markets, and the other producing larger quantities at a lower production cost for a growing market for cut flowers for ritual uses. It may also be seen a historical response to the change from previous times with abundant wetlands to a recent situation in which many wetlands are being converted into cultivated fields and others are subject to reclamation for the expansion of industrial areas.

Many *N. nucifera* products entered households directly for use and consumption, contributing to the non-cash subsistence economy of the villagers. But several products were commercialized in local markets, whereas others, such as flowers used in religious ceremonies, reached national markets in the capital and some international markets through intermediaries. In this survey, the only products said to reach international markets (in China) were dried leaves used for food wrappers and dried stamens for medicinal use. Reaching the markets – either local, regional, or international – provide villagers with cash income, a situation which is attractive and appears promising assuming increasing demands for cut flowers and herbal medicines. Nevertheless, in order to benefit from this situation, villagers would likely need to acquire additional knowledge of marketing mechanisms. A potential export industry based on *N. nucifera* would need additional research into growing techniques, post-harvest storage and handling and market development and also development of industrial standards in the importing countries, such as Japan (Nguyen, 2001).

Although commercial uses appeared to be more frequent in the north, overall there was a rather uniform pattern of lotus uses throughout Thailand (Tables 10–12),

with a few exceptions in ritual and medicinal uses. *Nelumbo nucifera* was more used for ceremonial purposes in the central region of Thailand (Table 10) which is inhabited by people of Mon, Chinese, and Indian origins who adhere more strictly than the average Thai to Buddhist traditions and ceremonies. Regional variation in use of *N. nucifera* in Thailand may also be related to a higher abundance of extensive wetlands with large natural stands of it in the northern and central regions for which reason extractive use of it has been more easy and common there. The northern region of Thailand has large wetlands, such as Bung Borapet and Bung Sri Fai with abundant populations of *N. nucifera*, which are used and harvested by large portions of the population, some of them living from that as an occupation. These wetlands are also close to the populous central region.

The Nymphaeaceae are mostly used for food. The peduncle of these plants can be eaten, particularly of the nocturnal species *Nymphaea rubra*. In past times it was the peduncle of *Nymphaea pubescens* that was a favored food because of its good flavor and its habitat in streams and canals near the villages. But today *N. pubescens* is hard to find, whereas *N. rubra* is much more common in the lakes in protected areas where it may attain considerable abundance. *Nymphaea rubra* and *N. pubescens* have been used in all parts of Thailand whereas *N. nouchali* and *N. capensis* var. *zanzibariensis* have been used in southern region. *Nymphaea capensis* var. *zanzibariensis* was introduced in 1897 by Princess Suthasininat from Bogor Botanical Garden, Indonesia. After introduction, this plant grew splendidly in Thailand. In 1957, Prof. Kasin Suwatabhant, a well-known Thai taxonomist named it 'Suthasinobon' in honor of the Princess Suthasininat (Suvatabandhu, 1979; Sripen, 1999; Chomchalow, 2005).

There are some medicinal uses for *Nymphaea* reported here and it should be mentioned that such uses are rare in the literature.