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Ecology of *Nymphaea pubescens* Willd.

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Abstract

In an aged shallow pond at Biratnagar, Nepal, importance value index of *Nymphaea pubescens* ranged between 258 (July) and 75 (October). The productivity of the *Nymphaea* association was 681.6 g/m^2/yr. The water samples had higher values of pH, nitrogen and ammonia in June (initial phase of growth), but higher values of electrical conductivity, dissolved solids, turbidity, nitrite, nitrate, phosphorus and potassium in November (senescence phase of the plant). The C/N ratio of the base-layer soil was 15.79:1 in June, but 17.27:1 in November. In comparison to other plant parts, highest concentrations of nitrogen (3.73% in July), and potassium (2.04% in August) occurred in leaves; and phosphorus (1.4% in September) in rhizome and roots. Fresh seeds had 90% germination and 8 month old air-dried rhizomes had 86% sprouting when immersed in water.

***Key words*:** Biomass, germination, nutrient, productivity, rhizome.

Introduction

Nymphaea rubra Roxb. ex Andrews

Nymphaea pubescens Willd. (*Nymphaea rubra* Roxb. ex Andrews) of the family Nymphaeaceae is a floating-leaved rhizomatous herbs. It mostly grows in shallow water. It is distributed in south and south-east Asia (including Bangladesh, India, Java, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka), Africa and Hungary (Panda & Das, 2004). In Nepal, it is called 'Koka', 'Bhentha', or 'Seto-kamal' and occurs between altitude 60 to 500 m (Jha & Jha 2000). At Biratnagar (lat. N 26° 20', long. E 87° 16'; altitude 72 m, msl), the plant sproutes from rhizome in June and enteres into flowering-fruiting phase in August. After maturation of seeds in September–October, the plant enteres into the senescence phase in October-November. *N. pubescens* is a fragrant night-flowering species. The rhizomes with root are eaten as vegetables; the leaves are used as fodder. Most parts of the plant are used medicinally.

The present study deals with monthly variations in importance value index (IVI), diversity indices, and biomass of *N. pubescens* and associated species occurring in an aged shallow pond (area 150×50 m; depth of water in centre 1.2 during rainy season) at Biratnagar (retaining water only during the rainy season) along with monthly changes in concentrations of nitrogen, phosphorus and potassium in different parts of the plant and physico-chemical properties of water and mud of the pond. In general, climate of Biratnagar is tropical and monsoonic with three distinct seasons *viz*, rainy (mid-June to October), winter (November to February), and summer (March to mid-June). Average meteorological data indicate 1225, 5, and 188 mm rainfall; 25, 10.4 and 19.6°C minimum air temperature; 32.2, 25 and 33.6^0 C maximum air temperature; and 6, 3.8 and 7.3 km/h wind speed during rainy, winter and summer season, respectively.

Materials and Methods

Nymphaea pubescens and the associated species of the shore area (20 cm 1.2 m to water depth) were sampled by laying ten quadrats of 50×50 cm size randomly for determination of IVI, diversity indices, and biomass at monthly intervals (first week of July, August, September and October) in 2011. The IVI was calculated as the sum of relative frequency, relative density and relative cover (Curtis and McIntosh 1951), and diversity indices were determined as per the method of Simpson (1949), and Shannon & Weaver (1949). The net primary productivity (NPP) was calculated by summing the positive increments in dry biomass on successive sampling dates (Singh & Yadava 1974). The turnover rate was determined as per the method of Dahlman & Kucera (1965) as T =A/B, where, T= turnover rate, A= NPP, B= maximum biomass; and turnover time as: 1/T×12.

Seeds of *Nymphaea pubescens* were collected from pond (Kanchanbari, Biratnagar) in the last week of September, 2010. Those seeds were evaluated for germination immediately after collection. As seeds did not germinate on filter paper saturated with distilled water, seeds (25) were placed in 500 ml beakers (in triplicate) filled with distilled water, and kept as such until germination became static.

Plant and mud samples were analysed for nitrogen by Nessler's reagent method (Willard *et at*., 1974), phosphorus by chlorostannous-reduced molybdophosphoric blue color method (Furman, 1962), and potassium by flame photometer method (Piper, 1944). The texture of the mud was determined by sieving and weighing method (Piper, 1944), and organic carbon by Walkley and Black (1934) method.

Among the physico-chemical parameters of water samples, pH was determined by digital pH meter; conductivity by electrical conductivity meter (Willard *et al.*, 1974); turbidity (nephelometric method), phosphorus (vandomolybdo-phospheric acid colorimetric method), total nitrogen (macro Kjeldahl method), nitrate and nitrite (UV spectro-photometric method), and potassium (atomic absorption spectrophoto-metric method) by APHA's (1990) methods; and total dissolved solids by the method of U.S. Geological Survey (1974).

Results and Discussion

IVI, diversity indices, biomass and productivity

Nymphaea pubescens completed its life-cycle between July to October (rainy season) and during this period IVI of *N. pubescens* decreased from 258 in July to merely 75 in October (Table 1). Only *Marsilea minuta* (IVI 42) was present in association with *N pubescens* in July, whereas 6, 4, and 7 species were present in association in August, September and October, respectively. The species next to *N. pubescens* in IVI value were *Eichhornia crassipes* (55) and *Panicum paludosum* (40) in August; *Utricularia aurea* (95), *P. paludosum* (590) and *E. crassipes* (34) in September; and. *U. aurea* (68), *E. crassipes* (66) and *P. paludosum* (37) in October.

The values of Simpson's and Shannon-Weiner's index of diversity were minimum (0.24 and 0.40, respectively) in July and maximum (0.81 and 1.76, respectively) in October (Table 1).

Table 1. Monthly variations in IVI (mean ± SE; n=10) of macrophytes and diversity indices in *Nymphaea pubescens* association

	July	August	September	October
IVI				
Alternanthera philoxeroides	-	16±1	-	13±1
Eichhornia crassipes	-	55±3	34±2	66±3
Ipomoea aquatica	-	-	-	11±1
Leersia hexandra	-	29±2	-	-
Marsilea minuta	42±2	-	-	30±2
Nymphaea pubescens	258±7	143±5	112±5	75 ±4
Panicum paludosum	-	40±2	59±3	37±2
Sacciolepis indica	-	17±1	-	-
Utricularia aurea	-	-	95±4	68±3
Diversity indices				
Simpson's index	0.24	0.70	0.71	0.81
Shannon-Weiner's index	0.40	1.11	1.29	1.76

The biomass of *N. pubescens* ranged between 52 (July) and 413.6 g/m^2 (September) (Table 2). The species next to *N. pubescens* in biomass value were *Marsilea minuta* (5.2 g/m^2) and *Sacciolepis indica* (10.4 g/m^2) in July and August, respectively; *Utricularia aurea* (44 g/m^2) and *Panicum paludosum* (41.6 g/m^2) in September; and *Eichhornia crassipes* (193.6 g/m^2), *U. aurea* (100.8 g/m^2) and *P. paludosum* (76.8 g/m^2) in October.

Table 2. Monthly variations in biomass (g/m^2) (mean ± SE; n=3) in *Nymphaea pubescens* and associated species

Species	July	August	September	October
Alternanthera sessilis	-	1.60±0.56	-	1.60±0.56
Eichhornia crassipes	-	1.60±0.56	1.60±0.56	193.60±6.22
Ipomoea aquatica	-	-	-	6.40±1.13
Leersia hexandra	-	0.40±0.28	-	-
Marsilea minuta	5.20±1.02	-	-	21.60±2.08
Nymphaea pubescens	52.00±3.22	408.00±9.03	413.60±9.09	245.6 ±7.01
Panicum paludosum	-	5.60±1.06	41.60±2.88	76.80±3.92
Sacciolepis indica	-	10.40±1.44	-	-
Utricularia aurea	-	-	44.00±2.97	100.80±4.49
Total	57.20	427.60	500.80	646.40

The productivity of *N. pubescens* association was 681.6 g/m^2/yr in which percentage contributions of the associated species were in the order: *N. pubescens* (53) > *E. crassipes* (28) > *P. paludosum* (10) > *U. aurea* (8) > others (1) (Table 3). The turnover rate of *N. pubescens* was 87.42% and turnover time 14 months. On the other hand, turnover rate and turnover time of *E. crassipes* were 99.17% and 12 months, respectively and that of *P. paludosum* 92.70% and 13 months, respectively (Table 3).

Table 3. Productivity, turnover rate and turnover time of major macrophytes in *Nymphaea pubescens* association

Macrophytes	Productivity (g/m^2/yr)	Turnover rate (%)	Turnover time (months)
Eichhornia crassipes	192.00	99.17	12
Nymphaea pubescens	361.60	87.42	14
Panicum paludosum	71.20	92.70	13
Utricularia aurea	56.80	-	-

Nutrirnts

The range of nitrogen concentration was between 1.84 (July) and 3.64% (October) in rhizome and roots, and between 1.93 (October) and 3.73% (July) in leaves, whereas nitrogen concentration in flowers and seeds was 1.89 and 1.64%, respectively (Table 4).

Table 4. Monthly variations in percentage concentration of nitrogen, phosphorus and potassium in different parts of *Nymphaea pubescens (*mean ± SE; n=3)

	July			**August**			**Sept**			**October**		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
Rhizome and roots	1.84 ±0.78	1.00 ±0.57	1.25 ±0.64	2.27 ±0.86	0.85 ±0.52	1.75 ±0.76	2.17 ±0.84	1.40 ±0.67	2.00 ±0.81	3.64 ±1.10	0.57 ±0.43	0.75 ±0.50
Leaves	3.73 ±1.11	1.10 ±0.60	1.95 ±0.80	2.84 ±0.69	2.04 ±0.96	0.47 ±0.82	2 .27 ±0.86	0.65 ±0.45	0.75 ±0.50	1.93 ±0.80	0.57 ±0.43	1.90 ±0.79
Flowers	-	-	-	-	-	-	-	-	-	1.89 ±0.79	0.39 ±0.36	1.25 ±0.64
Seeds	-	-	-	-	-	-	-	-	-	1.64 ±0.73	0.36 ±0.34	0.50 ±0.40

Germination

Seeds of *Nymphaea pubescens* were round in shape, pink to black in colour, and weight of 500 fresh seeds was 1.15 g. Fresh seeds of both species started germinating three days after submergence in water and germination became static after 8th day of submergence. In general, total germination of seeds was 90%.

Pond water and mud

The pH value of water samples of *N. pubescens* association was more (6.33) in June than November (5.93). Otherwise, values of conductivity (170 ds/m), turbidity (24 NTU) and total dissolved solids (85.3 mg/l) were more in November than June (Table 4). Total nitrogen (4.37 mg/l) and ammonia (1.17 mg/l) contents of water samples were more in June, whereas water samples had higher concentrations of nitrate (0.05 mg/l), nitrite (0.01 mg/l), phosphorus (1.12 mg/l) and potassium (44..3 mg/l) in November than June.

The pH of the mud samples of *N. pubescens* association was 5.9 in June but 5.8 in November (Tables 5, 6). The mud was silty-sandy loam in which proportion of sand and clay particles decreased but silt particles increased slightly in November than June. There was no change in phosphorus concentration (0.003%) between June and November but a slight increase in nitrogen and potassium concentration was noted in November. The range of organic carbon was 3 (June) and 4.49% (November), whereas C/N ratio was 15.79:1 in June but 17.27:1 in November.

Table 5. Variations in physico-chemical properties of water before emergenc (June) and after senescence (November) of *Nymphaea pubescens*(mean ± SE; sn=3)

	June	**November**
pH	6.33±1.45	5.93±1.40
Conductivity (ds/m)	103.40±5.87	170.90±7.54
Turbidity (NTU)	2.86±0.97	24.00±2.82
Total dissolved solids (mg/l)	51.00±4.12	85.30±5.32
Total nitrogen (mg/l)	4.37±1.20	0.98±0.56
Ammonia (mg/l)	1.17±0.62	0.38±0.34
Nitrate (mg/l)	0.01±0.05	0.05±0.12
Nitrite (mg/l)	0.001±.03	0.01±0.01
Total phosphorus (mg/l)	0.39±0.36	1.12±0.60
Potassium (mg/l)	5.81±1.38	44.30±3.89

Table 6. Variations in physico-chemical properties of mud before emergence (June) and after senescence (November) of *Nymphaea pubescens* (mean ± SE; n=3) (Table 6 is not mentioned in the text)

	June	**November**
pH	5.9±1.40	5.8±1.38
Texture (%)		
Sand	37.1±3.51	30.7±3.19
Silt	42.7±3.76	50.8±4.11
Clay	20.2±2.58	18.5±2.48
Nutrients (%)		
N	0.19±0.24	0.26±0.28
P	0.003±0.03	0.003±0.03
K	0.01±0.10	0.04±0.03
Organic carbon (%)	3.00±1.00	4.49±1.22
C/N ratio	5.79:1	17.27:1

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