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Study on exploring the potential of *Nymphoides peltatum* as animal feed growing in Dal lake of Kashmir Himalaya

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Abstract
The present study was conducted to investigate the biochemical attributes of *Nymphoides peltatum* an aquatic plant at three study sites viz., site I (Ashai Bagh, near residential area); site II (Telbal) and site III (Nehru Park) of Dal Lake, Kashmir. The sampling was done on monthly basis and the entire study period was divided into two phases i.e., the active growth phase (summer- July and August) and the senescence phase (September, October, early November and late November). The biochemical assessment (chlorophyll, amino acids, sugar content, total protein content and starch) of selected macrophyte at three sites revealed that the concentration of chlorophyll-a varied between (3.10 to 5.42µg mL^{-1} at site-I); (0.08 to 2.38 µg mL^{-1} at site-II) and (0.14 to 2.48 µg mL^{-1} at site-III); chlorophyll-b varied between (0.003 to 1.40 µg mL^{-1} 1 at site-I); (0.001 to 1.10 µg mL^{-1} at site-II) and (0.002 to 1.12 µg mL^{-1} at site-III); total chlorophyll concentration varied between (3.33 to 5.6 µg mL^{-1}at site-I); (1.00 to 2.12 µg mL^{-1} at site-II) and (1.18 to 2.67 µg mL^{-1}at site-III). Similarly, the results of proteins follow the same trend decreasing from peak growth phase to senescence phase with (0.88 to 1.14 mg mL^{-1} at site-I); (0.048 to 1.08 mg mL^{-1} at site-II) and (0.053 to 1.124 mg mL^{-1} at site-III). The concentration of starch also follows the same trend highest in peak growth phase and lowest in senescence phase. The results revealed that the biosynthesis of various biomolecules accelerated during the active growth phase at Site-I (July) while as, low range of biomolecules was observed at site-II in the senescence phase (November). The finding of the present study suggests that the macrophyte can be used as a potential source of food and fodder for bovine animals and as fertilizers for agriculture fields and flowering gardens.

Keywords: Potential of *Nymphoides peltatum*, Animal Feed Growing

1. Introduction
Macrophytes also known as aquatic plants grow in a continuous supply of water compose and important community as primary producers and produce high biomass [1-2]. These may be categorized as floating submerged and emergent aquatic plants. Macrophytes have an important and a key role nutrient cycling of water bodies and provide suitable habitats for many animals. They are an important part of lake ecosystems and are habitually regarded as indicators of environmental changes in the lake by playing a significant role in maintaining the structure and function of lake ecosystems [3]. There exists direct relationship between environmental conditions and structure and function of biotic communities as any change in the environment is manifested by changes in the structure and function of the community. Macrophytes constituting ecologically dominant community of shallow lakes and wetlands, therefore, form an important tool for biomonitoring of such ecosystems [4] [5]. In the state of Jammu & Kashmir several aquatic plants like Nymphoides, Rannunculus, Nymphaea, Hydrilla, Azolla, Nelumbo, Trapa etc. species are found in different lakes and water bodies which deplete their water quality and reduce their area [6]. Owing to acute shortage of fodder in the valley, exploitation of these aquatic plants can serve as a direct animal feed after evaluating their nutritional potential. These weeds differ widely in their chemical composition depending upon species, season and location [7]. In order to evaluate the food potential of macrophytes and estimation of their nutritional value, the knowledge of their chemical composition is of vital importance [8, 9]. Keeping this in view, the present study was carried out with an objective to analyze the monthly variations in biochemical constituents viz. chlorophyll content, protein, sugar and starch of aquatic plants *Nymphoides peltat*a in order to evaluate their feed potential.

2. Materials and Methods

2.1. Study area

The present work was carried out in three sites/basins of Dal Lake Kashmir viz.

(1) Ashai Bagh (Site I)

This site is the outlet of west side of the Dal Lake through which the water flows out to the adjacent Nigin Lake. There are number of Houseboats resting in this location. Floating vegetable gardens are also located in this region. This region is also disturbed with sewage water pollution and anthropogenic activities.

(2) Telbal Basin (Site II)

Telbal basin is situated in North side and shallow, open drainage lake is fed by Telbal inlet. The complex land use pattern is reflected in this area, with fields of paddy, orchards and gardens in the lower slopes, and barren hills in upper side.

(3) Nehru Park basin (Site III)

The Nehru park basin is the busiest tourist spot situated in the East side of lake. There are many hotels in the nearby side and people enjoy rides on shikaras, living in houseboats etc.

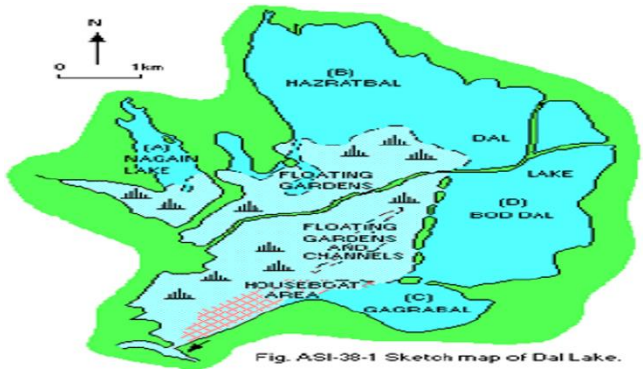

Fig 1: Sketch map of Dal Lake

2.2. Sampling and analysis of pigment content

The entire study period was divided into two phases i.e., the peak growth phase (July and August) and the senescence phase (September, October and November). The experimental plant (*Nymphoides peltatum)* material (leaf) was collected on monthly basis from three sampling locations. The selection was made considering the abundance of macrophytes at the sampling sites and the easiness for recognition and collection. The quantitative estimations of various biochemical constituents' viz. chlorophyll, total carbohydrates, starch and total proteins for macrophytes were worked out on monthly basis for a period of five months. The macrophyte was handpicked from natural habitats, sorted out. The harvested materials were placed in polyethylene bags and transported to the laboratory in cool boxes (temperature 4°C) where they were incised to include only leaves. These were then washed thoroughly and moisture was drained before being analyzed for biochemical characteristics using the methods derived by [10-14].

3. Results

3.1. Biochemical Ananlysis of *Nymphoides peltatum*.

Perusal of data on the Chlorophyll-a content of *Nymphoides peltatum* revealed that the concentration of chlorophyll-a varied between (3.10 to 5.42µg mL^{-1} at site-I); (0.08 to 2.38 µg mL^{-1} at site-II) and (0.14 to 2.48 µg mL^{-1} at site-III). However, the minimum concentration of 0.08 µg mL^{-1} was recorded at site-II (table 2) in November and the highest value of 5.42µg mL^{-1} at site-I in July (table 1). The concentration of chlorophyll-b varied between (0.003 to 1.40 µg mL^{-1} 1 at site-I); (0.001 to 1.10 µg mL^{-1} at site-II) and (0.002 to 1.12 µg mL^{-1} at site-III). Overall, minimum concentration of 0.001 µg mL^{-1} was observed at site-II (table 2) in November and the highest concentration of 1.40 µg mL^{-1} at site-I in July (Table 1). The total chlorophyll concentration varied between (3.33 to 5.6 µg mL^{-1}at site-I); (1.00 to 2.12 µg mL^{-1} at site-II) and (1.18 to 2.67 µg mL^{-1}at site-III) showing the lowest concentration of 1.00 µg mL^{-1} at site-II table 2) in November and maximum concentration of 5.60 µg mL^{-1} at site-I in July (table 1). Carotenoid concentration showed the same trend decreases from summer to autumn with (0.41 to 1.86 µg mL^{-1} at site-I); (0.009 to 1.21 µg mL^{-1} at site-II) and (0.10 to 1.43 µg mL^{-1} at site-III). The concentration of amino acids varied between (3.75 to 4.94 mg mL^{-1} at site-I); (1.31 to 2.88 mg mL^{-1} at site-II) and (1.41 to 3.72 mg mL^{-1} at site-III) showing the same trend decreasing from peak growth phase to senescence phase. Similarly, the results of proteins follow the same trend decreasing from peak growth phase to senescence phase with (0.88 to 1.14 mg mL^{-1} at site-I); (0.048 to 1.08 mg mL^{-1} at site-II) and (0.053 to 1.124 mg mL^{-1} at site-III) with the minimum concentration of 0.048 mg mL^{-1} (table 2) observed in November at site-II and highest of 1.14 mg mL^{-1} in July at site-I (table 1). Free Sugars concentration varied between (12.01 to 14.42 mg mL^{-1} at site-I); (9.11 to 12.92 mg mL^{-1} at site-II); (9.93 to 13.47 mg mL^{-1} at site-III) with the lowest concentration of 9.11 mg mL^{-1} in November at site-II and the maximum concentration of 14.42 mg mL^{-1} in July at site-I (table 1). The concentration of starch showed the same trend highest in peak growth phase and lowest in senescence phase with lowest concentration of 5.22 mg mL^{-1} at site-II (table 2) in November and with maximum concentration of 13.15 mg mL^{-1} at site-I observed in July (table 1).

Table 1: Biochemical parameters of the *Nymphoides peltatum* of Dal Lake (Site I)

Parameter	July	August	September	October	Nov 1st Week	Nov 4th Week
	Peak Growth Phase			*Senescense Phase*		
Chlorophyll a (µg/ml)	5.42±0.45	4.82±0.12	4.32±0.20	3.62±0.23	3.12±0.16	3.10±0.07
Chlorophyll b (µg/ml)	1.40±0.079	0.80±0.06	0.31±0.014	0.10±.0007	0.003±0.0007	0.003±0.0007
Total Chlorophyll (µg/ml)	5.63±0.13	5.13±0.09	4.63±0.08	3.93±0.08	3.43±0.12	3.33±0.10
Carotenoids (µg/ml)	1.86±0.044	1.23±0.063	0.751±0.038	0.62±0.032	0.62±0.032	0.41±0.016
Amino Acids (mg/ml)	4.94±0.11	4.44±0.051	3.95±0.13	3.81±0.15	3.81±0.152	3.75±0.127
Proteins (mg/ml)	1.14±0.08	0.64±0.032	0.24±0.016	0.12±0.01	0.98±0.075	0.88±0.070
Free sugars (mg/ml)	14.42±0.71	13.61±0.71	13.12±0.71	12.42±0.77	12.03±0.75	12.01±0.70
Starch (mg/ml)	13.15±0.71	10.21±0.26	9.71±0.15	8.45±0.13	7.34±0.11	7.05±0.11

Table 2: Biochemical parameters of the *Nymphoides peltatum* of Dal Lake (Site II)

Parameter	July	August	September	October	Nov 1st Week	Nov 4th Week
	Peak Growth Phase			*Senescense Phase*		
Chlorophyll a (µg/ml)	2.38±0.095	1.78±0.09	1.28±0.00	0.58±0.07	0.08±0.007	0.08±0.007
Chlorophyll b (µg/ml)	1.10±0.08	0.501±0.02	0.003±0.0007	0.002±0.00	0.001±0.00	0.001±0.00
Total Chlorophyll (µg/ml)	2.12±0.075	1.52±0.091	1.02±0.048	1.01±0.048	1.01±0.048	1.00±0.048
Carotenoids (µg/ml)	1.21±0.032	0.61±0.029	0.30±0.016	0.098±0.01	0.093±0.001	0.009±0.00
Amino Acids (mg/ml)	2.88±0.153	2.38±0.091	1.87±0.108	1.55±0.105	1.32±0.032	1.31±0.125
Proteins (mg/ml)	1.08±0.085	0.58±0.058	0.098±0.007	0.085±0.007	0.082±0.007	0.048±0.007
Free sugars (mg/ml)	12.92±1.00	11.15±0.72	10.25±0.50	10.18±0.72	9.12±0.71	9.11±0.17
Starch (mg/ml)	10.24±0.19	6.43±0.09	6.35±0.33	5.95±0.16	5.34±0.25	5.22±0.26

Table 03: Biochemical parameters of the *Nymphoides peltatum* of Dal Lake (Site III)

Parameter	July	August	September	October	Nov 1st Week	Nov 4th Week
	Peak Growth Phase			*Senescense Phase*		
Chlorophyll a (µg/ml)	2.48±0.08	1.88±0.09	1.37±0.08	0.68±0.04	0.18±0.007	0.14±0.007
Chlorophyll b (µg/ml)	1.121±0.07	0.591±0.03	0.091±0.02	0.070±0.02	0.002±0.0005	0.002±0.0005
Total Chlorophyll (µg/ml)	2.67±0.049	1.97±0.054	1.47±0.049	1.33±0.031	1.21±0.041	1.18±0.025
Carotenoids (µg/ml)	1.43±0.025	0.73±0.034	0.33±0.022	0.13±0.016	0.12±0.016	0.10±0.009
Amino Acids (mg/ml)	3.72±0.33	3.42±0.12	2.88±0.10	1.62±0.10	1.46±0.08	1.41±0.096s
Proteins (mg/ml)	1.124±0.060	0.942±0.063	0.082±0.008	0.079±0.007	0.069±0.00	0.053±0.00
Free sugars (mg/ml)	13.47±0.34	13.15±0.19	13.05±0.11	12.11±0.17	10.22±0.26	9.93±0.05
Starch (mg/ml)	10.95±0.97	7.22±0.26	6.75±0.18	6.24±0.19	5.92±0.15	5.82±0.16s

4. Discussion

The results revealed that the maximum pigment content (chlorophyll-a, chlorophyll-b, total chlorophyll and carotenoids) of the *Nymphoides peltatum* were observed during peak growth phase (summer season) and decline with decrease in growth activity in the senescence phase. This declining trend can be attributed to the optimum nutrient load and water temperature during the period in promoting greater chlorophyll concentration and photosynthesis [15-18]. Besides, there is a strong positive correlation between concentration of nitrogen and phosphorous and the overall photosynthetic pigment [19-20]. Similarly, the maximum concentrations of proteins in plant tissues were recorded during peak growth phase (summer season) and decline with decrease in growth activity in the senescence phase. The higher concentration of proteins during peak growth phase may be attributed to the fact that the accumulation and subsequent conversion of nitrogen into protein building in the mature tissues during the metabolic process is at its maximum during the peak growth of macrophytes [21-23]. In general, maximum seasonal mean values of sugar in *Nymphoides peltatum* was recorded during peak growth phase whereas minimum value during senescence phase. The observed increase in the sugar content in *Nymphoides peltatum* was recorded during peak growth phase may be due to an increase in the growth rate of macrophyte resulting from the favorable environmental conditions such as temperature [24]. This type of positive impact on the carbohydrate metabolism of aquatic plants has also been supported by various authors [25-26]. Thus, the active growth period in free sugars production in *Nymphoides peltatum* in Dal Lake coincides with the increase in water temperature. On the other hand, during *senescence phase* the decrease in sugars synthesis in *Nymphoides peltatum* suggests that stored photosynthetic products are used for cold season survival [27]. Similarly, high N and P availability in water is probable cause of free sugars. Similar observations have been made during the present investigation as starch concentration has been maximum during the peak growth phase and lowest during the senescence phase. Such drop can be attributed to decreased rate of photosynthesis [28].

5. Conclusion

From the present investigation, it can be concluded that high nutrient load accelerates the growth of aquatic macrophytes as it increases the biosynthesis of various biomolecules, thereby having a positive impact on the productivity of the Lake. The macrophytes are regarded as important biological indicators, which define the degree of water pollution as they scavenge large proportions of nutrients from the lake waters. As a result of the higher concentration of chlorophyll, amino acids, proteins, starch and carbohydrates in fresh water macrophytes of Dal Lake, these could be involved in the food production process, directly as human food, livestock fodder, fertilizer (mulch and manure, ash, green manure, compost, biogas slurry) and as food for aquatic herbivores.

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