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Pollen Production in Relation to Ecological Class of Some Hydrophytes and Marsh Plants

Somnath Bhowmik*, Badal Kumar Datta

Plant Taxonomy and Biodiversity Laboratory, Department of Botany, Tripura University, Suryamaninagar, India.
Email: *sombhowmik@gmail.com

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ABSTRACT

The knowledge of quantitative production and method of dispersal give some idea about the frequency of presence of particular plant pollen grains in the atmosphere or hydrosphere. Pollen production in terms of number per anther along with the particular anther number per flower, anther length, pollen grain size, mode of anther dehiscence was determined for 51 angiospermous hydrophytes and marsh species occurring in Tripura, India. Pollen production is species specific. The level of pollen production directly related to the anther size and anther number per flower. However, no such correlation could be drawn between pollen production and size of pollen grains. Most of the hydrophytic taxa of the present investigation are anemophilous. The anemophilous taxa are characterized by high pollen production. However no correlation could be drawn from the present study between the high pollen production and mode of anther dehiscence as in all the studied taxa they show only one kind of anther dehiscence.

Keywords: Pollen Production; Hydrophytes; Ecological Class

1. Introduction

Studies on pollen, an organ which is considered to be less influenced by changing ecological condition, are relevant to various branches of Botany as well as to several other disciplines like Agriculture, Forestry, Medicine. Pollen productivity may be referred to as the number of pollen grains per produced per anther of a flower. The total pollen production of a particular plant is dependent upon the number of anthers per flower and the number of flowers per plant. The pollen production in an individual flower is fixed well before anthesis, and thus pollen presentation is a matter of doling out fixed quantities of floral reward. However, plants can alter the presentation schedule by sequential dehiscence of the anther or by a within anther time release mechanism [1]. A plant during its entire flowering period produces large amount of pollen grains most of which are not involved in fertilization. These large amount of pollen released may float in air or water and finally get deposited in earth's surface. The knowledge of quantitative production and method of dispersal give some idea about the frequency of presence of particular plant pollen grains in the atmosphere or hydrosphere [2]. Studies on pollen an organ which is considered to be less influenced by changing ecological condition, are relevant to various branches of Botany as well as to several other disciplines like Agriculture, Forestry, Medicine. Pollen productivity may be referred to as the number of pollen grains per produced per anther of a flower. The total pollen production of a particular plant is dependent upon the number of anthers per flower and the number of flowers per plant. The pollen production in an individual flower is fixe well before anthesis, and thus pollen presentation is a matter of doling out fixed quantities of floral reward. However plants can alter the presentation schedule by sequential dehiscence of the anther or by anther time release mechanism [1]. A plant during its entire flowering period produces large amount of pollen grains most of which are not involved in fertilization. These large amount of pollen released may float in air or water and finally get deposited in earth's surface. The knowledge of quantitative production and method of dispersal give some idea about the frequency of presence of particular plant pollen grains in the atmosphere or hydrosphere [2]. A plant during its entire flowering period produces large amount of pollen grains most of which are not involved in fertilization. These large amount of pollen released may float in air or water and finally get deposited in earth's surface. Waterborne pollen and spores could come in contact with plants, animals and human beings, and affect them [3]. But the literature related to pollen production of aquatic and marshy land plants are scarce except a few [4,5]. The anthesis and Pollen release

*Corresponding author.

are important criteria for subsequent dispersal. Plants can alter the presentation schedule by sequential dehiscence of anthers or by a within- anther time release mechanism [1]. The ecology of anther dehiscence, pollen liberation and dispersal in *Xanthium strumarium* Linn was also reported [6]. The circadian patterns of pollen release in some anemophilous grasses of South India were also reported earlier [7]. The knowledge of anthesis and pollen production is essential to study of pollination, developing a functional model for forecasting pollen concentration and to understand more about the ecological background of pollen dispersal [8-10]. Several workers have, of course, studied the pollen production of terrestrial plants [11-16]. Other studies [17] provided an important contribution to the knowledge in the production of pollen in anemophilous trees but there is no record of pollen production for the hydrophytes and marsh plants and their relation with ecological class. In the present investigation we report the pollen production of 51 hydrophytes and marsh plants. An attempt has been made to correlate the data of pollen production with anther number, anther length, and pollen grain size, mode of anther dehiscence and with special stress on their ecological class.

2. Materials and Methods

The pollen production study was carried out following the standard methods [18,19]. The plants species for the present investigation were collected from different parts of Tripura. In determining pollen productivity we collected the mature and undehisced anthers from plants while they were in peak blooming season. We crushed one anther and dispersed it in 50 drops 50% glycerine. One drop of the mixture was put on a slide and covered with a 22 mm × 22 mm cover glass. The number of pollen grains in this area was counted with an average of five drops for each species. This average was multiplied by 50 to get the number produced per anther. The pollen count was made for ten anthers randomly collected from different flowers of the aquatic plants. Five counting were made of each taxon, and the average number of pollen contained in an anther was derived. The size of the pollen grains (for radio symmetric ones the diameter in the polar view, and for bilateral ones the polar and equatorial axes) was measured in glycerine jelly [20] using standard ocular micrometer. For each taxon under study, pollen grain size was measured for 50 randomly chosen grains. Filament and anther length from mature stamens collected randomly from different flowers were measured through a 10× hand lens. The morphology and pollen grains size were studied. The hydrophytes and marsh plants so collected for the present investigation was grouped into 7 different "morpho-ecologic" classes [21]. These are (I) Floating Hydrophytes; (II) Suspended; (III) Submerged anchored hydrophytes; (IV) Floating leaved anchored hydrophytes; (V) Floating shoots anchored hydrophytes; (VI) Emergent anchored hydrophytes and (VII) Wetland helophytes.

3. Results

3.1. Total Pollen Production

From the pollen production figure obtained for 51 species which were distributed over twenty three families, it is evident that pollen production in terms of number per anther varies rather widely from family to family; genus to genus; species to species; even within the same genus (**Table 1**). The members of Nelumbonaceae, Nymphaeaceae, Convolvulaceae and Alismataceae rank the top most pollen producer among the studied taxa (**Figure 1**). The number of pollen grain per anther varied between 169 pollen grains in *Persicaria orientale* to 52,301 pollen grains in *Nelumbo nucifera*. Highest pollen production per anther was estimated in Nelumbo nucifera (52,301 pollen/anther) followed by *Nymphaea micrantha* (45,350 pollen/anther). Among the 51 aquatic and marsh land angiosperms 12 species with high pollen productivity, 20 with moderate and 19 species low pollen productivity is recorded in the present work. *Nelumbo nucifera*, *Nymphaea micrantha*, *Nymphaea stellata*, *Nymphaea pubescens*, *Nymphaea rubra*, *Ipomoea fistulosa* and *Ipomoea aquatica* show high pollen production. *Floscopa scandens*, *Rumex maritimus*, *Centella asiatica*, *Rotala indica*, *Nymphoides cristatum*, *Hygrophila auriculata*, *Limnocharis flava*, and *Monochoria vaginalis* showed moderate pollen production. While, *Persicaria orientale*, *Polygonum*

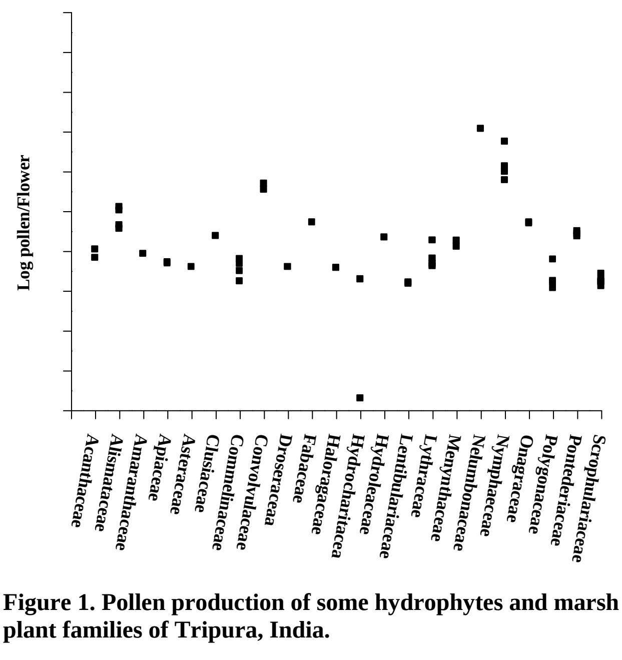

Figure 1. Pollen production of some hydrophytes and marsh plant families of Tripura, India.

Table 1. Pollen production of some hydrophytes and marsh land plants from of Tripura.

Sl.No	Botanical name	Habit	Mode of pollination	Mode of anther dehiscence	Ecological class	No of anther /flower	Length of anther (mm)	Average no pollen/ anther	Pollen log /anther	Average no of pollen/ flower	Pollen size (μm)	Pollen size class
1	*Aeschynomene indica* Linnaeus	S	ENT	L	VI	10	2.2 - 2.6	5236	3.719	52360	33.96 × 25.36	III
2	*Alternanthera philoxeroides* (Martius) Grisebach	H	ENT	L	VII	5	1.5 - 1.7	1698	3.230	8490	22 × 10.22	II
3	*Bacopa monnieri* (Linnaeus) Pennell	H	ENT	L	VII	4	1.85 - 2.23	428	2.631	1712	27.28 × 22 .23	III
4	*Centella asiatica* (Linnaeus) Urban	H	ENT	L	VII	5	1.5 - 1.8	1053	3.022	5265	18.83 × 15.43	II
5	*Commelina benghalensis* Linnaeus	H	ENT	L	VII	6	1.5 - 1.7	796	2.910	4776	36.4 × 19.39	III
6	*Cyanotis axillaris* (Linnaeus) Sweet	H	ENT	L	VII	6	1.65 - 2.2	1056	3.024	6336	37.4 × 20.46	III
7	*Cyanotis cristata* (Linnaeus) D.Don .	H	ENT	L	VII	6	1.4 - 1.5	529	2.723	3174	35.6 × 20.22	III
8	*Dopatrium junceum* (Roxburgh) F.Hamilton ex Bentham	H	ENT	L	VI	2	0.8 - 1.0	921	2.964	1842	35.4 × 21.38	III
9	*Drosera burmnni* Vahl	H	ENT	L	VII	5	1.0 - 1.25	803	2.905	4015	46.2 × 25.08	III
10	*Eichornia crassipes* (Martius) Solms	H	ANE	L	I	6	3.1 - 4.0	3915	3.593	23490	44.22 × 25.52	III
11	*Enhydra fluctuans* Loureiro	H	ENT	L	VI	5	0.48 - 0.55	788	2.896	3940	25.3 × 23.5	III
12	*Floscopa scandens* Loureiro	H	ENT	L	VII	6	2.5 - 2.7	1025	3.011	6150	36.41 × 20.11	III
13	*Hydrilla verticillata* Richard	H	HYD	L	III	3	0.4 - 0.5	652	2.814	1956	22 .00 × 18.92	II
14	*Hydrocotyl sibthorpioides* Lamarck	H	ENT	L	VII	5	1.0 - 1.25	973	2.988	4865	18.74 × 17.82	II
15	*Hydrolea zeylanica* (Linnaeus) Vahl	H	ENT	L	VII	5	2.01 - 2.03	4410	3.645	22050	23.84 × 22.22	II
16	*Hygrophila auriculata* (Schumacher) Heine	H	ANE	L	VII	4	2.2 - 2.3	2753	3.434	11012	36.96 × 29.48	III
17	*Hygrophila salicifolia* (Vahl) Nees	H	ANE	L	VII	4	1.7 - 2.0	1698	3.230	6792	31.73 × 31.27	III
18	*Hypericum japonicum* Thunb. ex Murray	H	ENT	L	VII	21	1.0 - 1.1	1154	3.062	24234	17.21 × 17.86	II
19	*Ipomoea aquatica* Froster	H	ANE	L	V	5	5.2 - 5.8	31520	4.498	350725	73.92 × 73.92	IV
20	*Ipomoea fistulosa* Martius ex Choisy	S	ANE	L	VII	5	6.0 - 6.5	32650	4.514	487425	75.68 × 75.68	IV
21	*Limnocharis flava* (Linnaeus) Buchanon Hamityon	H	ANE	L	VI	23	2.0 - 2.1	4520	3.655	103960	26.87 × 20.69	III
22	*Limnophila sessiliflora* (Vahl) Blume	H	ENT	L	VI	4	1.0 - 1.1	418	2.621	1672	22.26 × 17.34	II
23	*Lindernia anagallis* (N. L. Burman) Pennell	H	ENT	L	VII	4	1.0 - 1.2	668	2.824	2672	21.12 × 19.80	II
24	*Lindernia ciliata* (Colsmann) Pennell	H	ENT	L	VII	2	1.0 - 1.3	657	2.817	1314	18.26 × 20.02	II
25	*Ludwigia adscendens* (Linnaeus) Hara	H	ENT	L	V	10	1.02 - 1.52	5069	3.705	50690	57.2 × 69.52	IV

Continued

26	*Ludwigia octovalvis subsp. sessiliflora* (Micheli) P. H. Raven)	H	ENT	L	VII	8	1.2 - 1.3	2412	3.382	52241	55.25 × 52.78	IV
27	*Monochoria hastata* (Linnaeus) Solm	H	ANE	L	VII	6	3.0 - 5.1	5316	3.725	31896	43.34 × 20.24	III
28	*Monochoria vaginalis* ((Burm.f.) Presler	H	ANE	L	VI	6	3.0 - 4.75	4529	3.656	27174	43.34 × 25.52	III
29	*Murdannia nudiflora* (Linnaeus) Brenan	H	ENT	L	VII	2	0.5 - 0.6	864	2.936	1728	37.9 × 20.58	III
30	*Myriophyllum tuberculatum* Roxburgh	H	ENT	L	V	4	0.5 - 0.7	945	2.975	3780	19.8 × 21.12	III
31	*Nelumbo nucifera* Gaertner	H	ENT	L	IV	224	14 - 15.2	52301	4.718	11715424	57.86 × 49.72	IV
32	*Nymphaea micrantha* Guillemin and Perrottet	H	ENT	L	IV	123	12.00 - 15.6	45350	4.657	5578050	21.12 × 33.38	III
33	*Nymphaea pubescens* Willdenow	H	ENT	L	IV	30	10.5 - 12.7	42309	4.626	606780	22.47 × 34.58	III
34	*Nymphaea rubra* Roxburgh *ex* Andrews	H	ENT	L	IV	48	9.0 - 11.5	40217	4.604	1333920	16.83 × 29.7	III
35	*Nymphaea stellata* F. Mueller	H	ENT	L	IV	36	10.5 - 12.5	43874	4.642	966240	28.07 × 37.61	III
36	*Nymphoides cristatum* (Roxburgh) O.Kuntze	H	ENT	L	IV	5	1.5 - 1.7	2583	3.412	12940	25.48 × 35.72	III
37	*Nymphoides indica* (Linnaeus) Kuntze	H	ENT	L	IV	5	1.9 - 2.1	3678	3.566	18390	35.72 × 32.87	III
38	*Ottelia alismoides* (Linnaeus) Persoon	H	ANE	L	III	12	6.2 - 7.0	3754	3.575	45048	25.3 × 23.5	III
39	*Persicaria hydropiper* (Linnaeus) Spach	H	ENT	L	VI	7	1.0 - 1.2	254	2.405	1778	38.72 × 33.56	III
40	*Persicaria orientalis* (Linnaeus) Assenov	H	ENT	L	VI	7	1.1 - 1.2	169	2.228	1183	37.53 × 35.55	III
41	*Polygonum strigosum* R. Brown .	H	ENT	L	VII	7	1.1 - 1.2	236	2.373	1652	37.62 × 34.44	III
42	*Rotala densiflora* (Roth ex Roemer et Schultes) Koehne	H	ENT	L	VII	4	1.1 - 1.2	1206	3.081	4824	17.16 × 14.96	II
43	*Rotala indica* (Willdenow) Koehne	H	ENT	L	VII	4	1.0 - 1.1	1630	3.212	6520	17.11 × 13.96	II
44	*Rotala rotundifolia* (Buch.-Ham. ex Roxburgh) Koehne	H	ENT	L	VII	4	0.9 - 1.1	1054	3.023	4216	17.10 × 14.52	II
45	*Rumex maritimus* Linnaeus	H	ENT	L	VII	6	1.0 - 1.1	1026	3.011	6156	24.59 × 24.59	II
46	*Sagittria guayanensis* Linnaeus	H	ANE	L	VII	7	2.0 - 2.5	5203	3.716	36421	74.92 × 71.26	III
47	*Sagittria sagitifolia* Linnaeus .	H	ANE	L	I	24	2.7 - 2.8	5338	3.727	128112	72.92 × 70.26	III
48	*Trapa natuns* var *bispinosa* (Roxburgh) Makino	H	ENT	L	I	5	1.1 - 1.2	3690	3.567	18450	52.36 × 58.52	IV
49	*Utricularia aurea* Loureiro	H	ENT	L	II	2	0.5 - 0.6	756	2.879	1512	45.59 × 47.76	III
50	*Utricularia gibba subsp exoleta* Roxburgh	H	ENT	L	II	2	0.6 - 0.7	819	2.913	1638	30.45 × 35.64	III
51	*Vallisneria spiralis* Linnaeus	H	HYD	L	II	1	0.1 - 0.15	620	2.792	620	17.85 × 15.33	II

(Pollen production class: High pollen production: ≥5000 pollen per anther; Moderate pollen production: 1000 - 5000 ≥ pollen per anther; Low pollen production: ≤1000 pollen per anther. Pollen size class: ≤10 µm-I; 10 - 25 µm-II; 25 - 50 µm-III; 50 - 100 µm-IV; 100 - 200 µm-V; ≥200 µm-V. Anther length class: Small anther: ≤1 mm; Medium sized anther: 1 - 5. mm; Large sized anther : ≥5 mm) *strigosum*, *Persicaria hydropiper*, *Limnophila sessiliflora*, *Bacopa monnieri*, *Vallisneria spiralis*, *Dopatrium junceum*, *Myriophyllum tuberculatum* showed low pollen production.

3.2. Correlation between Anther Number per Flower and Total Pollen Production

The total pollen production is directly correlated to the number of anther per flower. There is significant ($p < 0.0001$) positive and linear correlation between the number of pollen grains and of anther per flower (**Figure 2**). By calculating the linear regression we find logy = 318721.66 + 50625.95x (y being the dependent variable: the number of grains per flower; and x the dependent variable: the number of the anther). *Nelumbo nucifera*, *Nymphaea micrantha*, *Nymphaea stellata*, *Nymphaea* pubescens, *Nymphaea rubra* rank the top most pollen producers with their high anther number

3.3. Correlation between Anther Length and Pollen Production

The total pollen production is directly correlated to the anther length. In other words species possessing large anthers have higher rate of pollen production. A positive significant correlation has been found between the anther length and the number of pollen grains produced per anther ($r = 0.95$, $p = 0.0001$; **Figure 3**) using a total of 255 data (5 anthers per plant in a total of 51 species). *Nelumbo nucifera*, *Nymphaea micrantha*, *Nymphaea stellata*, *Nymphaea pubescens*, *Nymphaea rubra*, *Ipomoea fistulosa* where high pollen productivity could be correlated to their large anther size. Among studied taxa Nelumbo nucifera with long anther length had the highest pollen productivity (52,301 pollen/anther). The 4 studied species of *Nymphaea* show a relationship in terms of pollen production and their anther length. *Nymphaea micrantha* with long anther size show high degree of pollen productivity (45,350 pollen/anther) as comparison to other species of *Nymphaea*. *Myriophyllum tuberculatum*, *Murdannia nudiflora*, *Utricularia gibba* subsp *exoleta*, *Utricularia aurea*, *Hydrilla verticillata* and *Vallisneria spiralis* show low pollen productivity with small anther size. By calculating the linear regression we find logy = 3180.96 + 3228.59x (y being the dependent variable: the number of grains per anther; and x the dependent variable: the length of the anther).

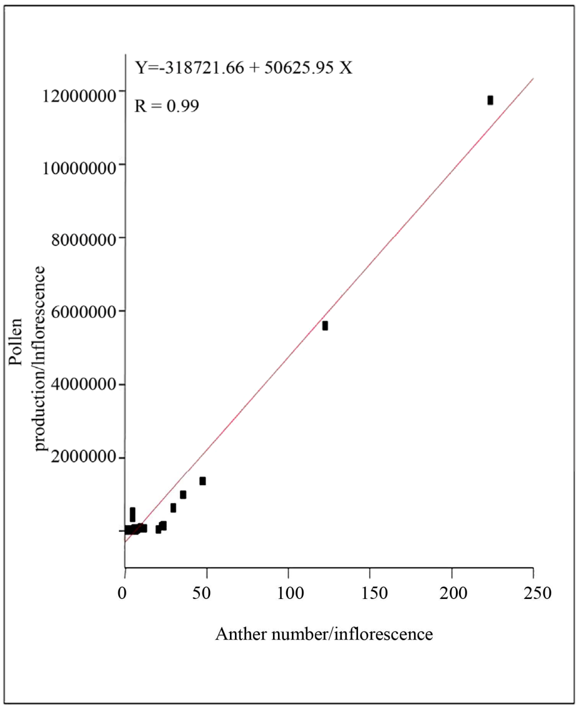

Figure 2. Correlations between anther number and pollen production.

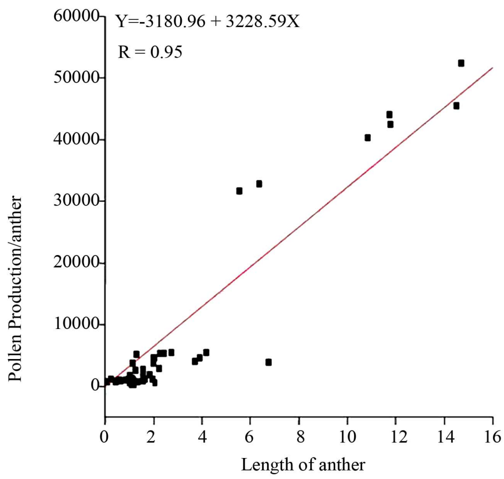

Figure 3. Correlation between anther length and pollen production.

3.4. Pollen Production and Pollen Size

Data on pollen size—polar diameter (P) and equatorial diameter (E) were collected from the pollen grains. Equatorial diameter (E) was taken to assess the size of the pollen grains. In the present study most of the studied taxa were found to posses medium sized pollen grains (25 - 49 µm). Pollen production is not only dependent on the anther size but also on the pollen grain size. However in the present study no direct correlation was found in relation to pollen production and pollen size. Though in, *Alternanthera philoxeroides*, *Centella asiatica*, *Hydrolea zeylanica*, *Hypericum japonicum*, *Rotala densiflora*, *Rotala indica*, *Rotala rotundifolia* and in *Rumex maritimus* where medium anther length with small sized pollen grains could be correlated with moderate pollen production.

3.5. Relation between Pollen Production and Ecological Class with Pollination Mechanism

The 51 studied taxa distributed over 7 ecological classes. From the data (**Figure 4**) it is clear that the plant belongs to Floating Leaves Anchored Hydrophytes (Class IV) produce copious amount of pollen per flower followed by those belonging to the Floating Shoot Anchored Hydrophyte (Class V). The Submerged herbs (Class II) produce the least amount of pollen per flower. In the present investigation most of the aquatic and marshy plants are anemophilous rarely they show hydrophilous mode of pollination.

3.6. Pollen Production and Mode of Pollination

Of the 51 species studied, 38 taxa show entomophilies (ENT), 11 taxa are anemophilous (ANE) and 2 taxa show hydrophilous (HYD) (**Figure 5**). The anemophilous specie of the present investigation produces copious amount of pollen/flower than those of entemophilous species. The flower of the most aquatic plants angiosperms must be elevated above the water surface in order for pollination to occur. Aquatic plants are taxonomically diverse and they are pollinated by a large number of aerial and aquatic mechanisms. Pollination in most aquatic plants including submerged ones, occur in the air either through the biotic pollination or anemophily.

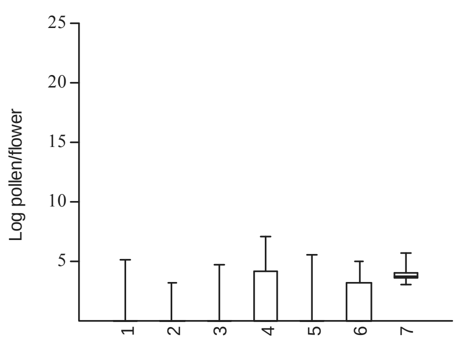

Figure 4. Relation between ecological class and pollen production of hydrophytes and marsh plants.

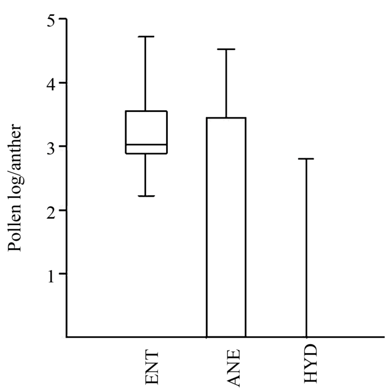

Figure 5. Relation between pollen production and mode of pollination.

3.7. Pollen Production and Anther Dehiscence

Of the 51 species studied, in all species the anther dehiscing through longitudinal slits. There seems to be no correlation between higher rate of pollen production and a particular mode of anther opening.

4. Discussions

Variations in pollen production as are recorded now were also reported by other workers [22-25]. A comparison of data of pollen production of investigated plants with their anther length appeared to be directly related to pollen production. The correlation between the size of the anther and the quantity of pollen grains they contain has already been demonstrated by other authors [13,25]. There is a positive association between anther size and pollen produced per anther [26,27].There was a proportionate increase in the degree of pollen production with the increase in the length of stamen in *Cassia tora* and *Arachis hypogea* of Leguminosae [28]. The production of pollen of the Poaceae family varies greatly and found between 800 (*Cynodon dactylon*) and 13,000 (*Secale cereale*) grains per anther, and suggest that the total production of pollen depends directly on the size and length of the anther, calculating a value of 700 - 1200 pollen grains per millimetre of anther length [23]. In *Oryza sativa* polyploidy causes the number of pollen grains and the size of the anthers to increase, while the ratio between the two decreases [29]. In the present study no correlation between pollen grain size and anther dehiscence with pollen production is established. The grain size seems to be of no importance in Poaceae, Cyperaceae and Amaranthaceae-Chenopodiaceae [13,30].

To represent the phenetic relationships within the twenty three clades of vascular plant families from dicotyledons and monocotyledons, a dendrogram based on pollen production and anther length of selected taxa from respective plant families was constructed which can be thought as a model for the phenetic relationships among the clades (**Figure 6**). The information about this phenetic model is completely contained in the co-phenetic similarities of the clades obtained from the dendrogram. There are two major phenetic hypotheses for the similarities in their palynological characters; these two clades separates two major families viz. Nelumbonaceae and Nymphaeaceae form remaining eighteen families. Furthermore, two clades categorize two families amusingly to form dicotyledons and monocotyledons together viz. Convolvulaceae and Alismataceae. Foremost families from monocotyledons (Commelinaceae, Pontederiaceae) to dicotyledons (Polygonaceae, Droseraceae, etc.) have gather to form a large clade and it is quite considerable. In case of phenon lines, apart from Asteraceae, Droseraceae and Halorgaceae all families are below 90% similar to each other. Dendrogram (**Figure 6**) explains possible clades with respect to their similarities. Convolvulaceae and Alismataceae are forms a distinct clades however, they are quite diverse morphologically. Families like Commelinaceae and Pontederiaceae are belonging to order Commelinales but in present study these two families positioned in unusual manner.

Among the studied plants all the species anther dehisces through longitudinal slits. So no direct correlation can draw from the present study. It was reported that there is no correlation between the rates of pollen production and a particular mode of anther opening [13]. There existed a correlation between pollen production and habit of the plant—an increase in pollen production from herb to shrubs and to trees [2]. In the present investtigation, no such correlation can be drawn between pollen production and the habit of the plant because mostly all the species belong to same habitat group. It has been observed that the rooted hydrophytes with floating leaves produced highest amount of pollen grains than the submerged, marginal and free floating hydrophytes [31].Our investigation also supports these previous observations. Due to self-pollination (Entomophilly) pollen grains production is high in the genus *Nymphaea* [32]. The pollen production is a characteristic of all plants, and is by definition, an integral part of the pollination process [32].The flower of the most aquatic plants angiosperms must be elevated above the water surface in order for pollination

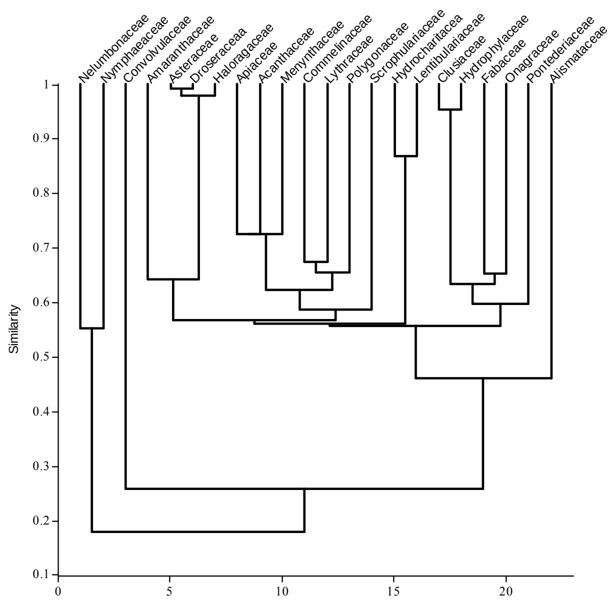

Figure 6. Dendogram showing the phonetic relationship on the basis of pollen production, anther length and anther number.

to occur. Hydrophytes are taxonomically diverse and they are pollinated by a large number of aerial and aquatic mechanisms [33,34]. Pollination in most aquatic plants including submerged ones, occur in the air either through the biotic pollination or anemophily [35]. The high proportion of anemophily mode of pollination in hydrophytes plants is due to systematic affinity rather than functional constraints [36]. Conversely hydrophily is more limited, and is categorized by the location of pollen transport. The association between Hydrophytes and anemophily has long been recognized and was believed to be an adaptive characteristic [37]. The association between anemophily and hydrophytes thus appear to be due systematic affinity, rather than selective pressure of the aquatic environment. Hydrophily, or under water pollination, is relatively uncommon in angiosperms. The hydrophilous mode of pollination and is largely restricted to the monocotyledons. The study of pollen production helped to locate the differences in the biological potential of individual flower in an inflorescence [38]. It is also differed in individual anther of a flower [12] in diploids and tetraploids [29] in anther, flower and plant with reference to dispersal [19], in anther and flower [39], in anther, flower and whole plant [40,41], and in terms of number per anther along with the anther length, filament length, pollen grains size and mode of anther dehiscence [13]. However it is evident that pollen production per flower in a taxon not only depends on the size of anther or the size of the pollen grains but it is also controlled by many other factors such as periodicity, response to light, nutrient availability etc. [38]. Temperature and season also seems to effect pollen production [42]. The effect of temperature is really on the development of the stamens into organs with normal functional theca. The amount of pollen produced by an individual plant might be genetically fixed [24]. Even varieties among cultivated species differ from one another as their pollen production [43]. The amount of pollen in the atmosphere depends not only on pollen production but also on the duration of the flowering season and on environmental factors [44]. It cannot, therefore, be deduced solely from pollen production by the inflorescence. The most important meteorological factors are moisture, minimum temperature, and sunshine hours [45]. After the study it has been concluded that pollen production in aquatic hydrophytes were not related directly with the size of flower and the anther or size of pollen grains but it also controlled by other factors such as periodicity, response to light and nutrient availability [46]. The pollen production may affect the percentage of fruit set in plants [45]. Hence it is of great importance in plant improvement programs. The production of large amount of pollen by a plant during its flowering period may result in the deposition of its pollen grains in a particular area and could be used as an index of the vegetation pattern of that area [2].

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