ECOLOGICAL ANALYSIS ON THE KILAVARAI FRESHWATER RIVER IN KODAIKANAL, TAMIL NADU, INDIA

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Synopsis

PREAMBLE

India has a unique topography and climate regimes that supports and sustain different wetlands habitats. The natural wetlands in India consists of the high altitude Himalayan lakes, followed by wetlands situated in the flood plains of the major river systems, saline and temporary wetlands of the arid and semi arid regions and coastal wetlands such as lagoons, backwaters, estuaries, coral reefs, marine wetlands and mangrove swamps. Among these different wetlands, the freshwater habitats play an important role in the ecological functions in various ways and they are highly complex and interactive (Biggs *et al*., 2017).

Wetlands are considered to have unique ecological features that provide numerous products and services to humanity. Ecosystem goods provided by the wetlands mainly include water for irrigation, fisheries, non-timber forest products, water supply, and recreation. Major services include carbon sequestration, flood control, groundwater recharge, nutrient removal, toxics retention and biodiversity maintenance. Many wetlands function as valuable habitats that support concentrations of plants, birds and other animals. However, wetlands are often exposed to various forms of anthropogenic disturbance that degrade their value as wildlife habitat. Moreover, wetlands can reduce the severity of droughts and floods by regulating streamflow and can provide vital water resources to support agricultural production.

Since some wetlands are significant to plants and animals diversity with territories that extend across international borders or serve as habitat for many threatened species, they are of international importance (Gell *et al*., 2016). However, knowledge of wetland locations and its extent remains poorly developed for many regions of the world. The identification and study of wetlands is especially urgent for arid areas, where these habitat types are especially rare and often threatened.

Rivers and streams are the most important life sustaining systems of nature. They play a major role in the transfer of materials from terrestrial environment to ocean realm. Of the

total quantity of materials transported by rivers, a substantial part is detained within its channels and adjoining environments as fluvial deposits.

Man has changed the nature of many of the world's rivers by controlling their floods, constructing large impoundments and using rivers for disposal of wastes. With ever-increasing human population and economic developments, these life support systems are under immense pressure owing to various kinds of anthropogenic activities, among which indiscriminate extraction of sand and gravel is most disastrous, as this activity threatens the very existence of the river ecosystems.

The floristic explorations and taxonomic studies can provide efficient and convenient information about the nomenclature, distribution, ecology, utility of various plant species, and thus about an ecosystem. Taxonomy is an integrated and, perhaps, intuitive science of identifying, naming and classifying plants. This may be considered as the oldest of sciences in the world (Reid *et al*., 1989), but often this branch of botany is considered as old-fashioned and out-dated and the appearance of many subjects making use of modern technologies and sophisticated instruments, only added contempt to the neglect.

The taxonomic study provides resourceful and opportune information about the nomenclature, distribution, ecology, utility of diversities in plant species, and thus consequently about an ecosystem. Floristic study of any given area helps to evaluate the plant wealth and its potential values. The local plants identification is very important to introduce the specific species of local area and their occurrence, growing seasons, finding new species and also the effect of climatic conditions like over-grazing, drought and temperature etc., on vegetation (Ali, 2008; Ahmad *et al*., 2016).

Phytosociology is defined as the study of composition, development, geographic distribution and environmental relationship of plant communities (Mueller-Dombois and Ellenberg, 1974). The phytosociological study deals with the description and classification of plant communities, while plant community does not represent a system of organization (Odum, 1971). It incorporates mainly the composition of vegetation over that terrain because it provides detailed information about composition of tree, shrub and herb communities, and also the functional aspects. It is assumed that the dominating plant species actually determines the structure of a community and not any other characteristic (Hanson and Churchill, 1961; Odum, 1971).

The data generated through phytosociological studies will also be valuable in the identification of plants of conservation importance. In addition to that it also provides knowledge and baseline data on the structural and dynamics, external impacts/threats, biological response to change interaction of species/inter linkages between species, successional status of key species and ecological restoration of degraded micro/macro habitats in a community (Chauhan, 1993). Great efforts are being taken for the identification, sustainable utilization and ecological conservation of our plant wealth of economic interest at global as well as national levels by employing the appropriate ecological principles.

Riparian zones are the interfaces between aquatic and terrestrial ecosystems. As ecotones, they encompass sharp gradients of environmental factors, ecological processes and plant communities. Natural riparian zones are the most diverse, dynamic and complex biophysical habitats on the terrestrial portion of the planet. They are analogous to a semi-permeable membrane, regulating the flow of energy and materials between adjacent environmental patches (Naiman *et al.*, 1998). Riparian zone has a set of characteristics uniquely defined by space and time scales and by the strength of interactions between adjacent ecological systems (Risser, 1993). The complex interactions among hydrology, geomorphology, light and temperature influence the structure, dynamics and composition of riparian ecosystems (Brinson, 1990). Riparian plant communities were given an important role in the river continuum concept which predicts that the load and quality of organic matter and the biota in the stream/river channel from the headwaters to the lower river courses increases with riparian vegetation and river width. Riparian vegetation functions as a cover for wildlife and corridors for species migration, dispersal (Merriam and Lanoue, 1990), a breeding ground for birds and small mammals.

River and streams provide important ecological functions and services. These functions translate into health, safety, and welfare of humans. By protecting, conserving, and minimizing direct physical alterations such as dams and vegetation clearing, these ecosystems provide substantial ecological functions, services and value to society. Natural and human disturbance to stream and river affect both the structural and ecological functions of these systems. New set of land use, watershed development practices have caused both direct and secondary impacts to river and stream. So there is required proper management and monitoring processes in streams/rivers.

OBJECTIVES OF THE STUDY

The present study was carried out in the Kilavarai freshwater river situated in upper Palni Hills of Southern Western Ghats of Kodaikanal in the Dindigul district of Tamil Nadu, India, with the following objectives.

- To explore the riparian floristic diversity of the Kilavarai freshwater river.
- To provide the artificial key and description for the Angiospermic and Pteridophytic plants to be recorded based on their morphological characters.
- To categorize the recorded plants based on IUCN data.
- To assess the plant's community ecology based on Phytosociology aspects.

]MATERIALS AND METHODS

The plant diversity and phytosociology studies of the Kilavarai freshwater river were carried out for the present study. The field trips were conducted at regular intervals during November 2014 - November 2018 at different riparian zone of study area such as Vanderavu huts, Kilavarai, Nattampatty, Polur and Kumbur and along the riparian zone. Herbaria for the plant specimens which have been prepared and deposited in the Post Graduate and Research Department of Botany, Saraswathi Narayanan College, Madurai. All the collected plants species were identified, using standard keys and floras. Among the plants collected that belong to the Angiosperms families were arranged according to the classification of Bentham & Hooker, (1862-1883) with necessary alterations. Pichi-Sermolli's (1977) system was followed for the categorization of Pteridophytes. For phytosociological analysis, a total of 30 quadrats of 10m×10m ($20m^2$) size were laid in each sampling point separately and the herbaceous vegetation and seedlings of tree and shrub also encountered in the quadrats area were enumerated and their respective individuals were recorded. From this data, various vegetation diversity indices were calculated.

RESULTS AND DISCUSSION

India has tremendous biodiversity, genetic as well as species and ecosystems. It contains over 5 percent of the world's biodiversity on 2 percent of earth surface. This diversity of landforms and climates resulting in different habitats ranging from tropical to temperate and from alpine to desert (Pimm and Raven, 2000). The current rate of tropical deforestation is 0.8% per year, and the rate of committing tropical forest species to extinction is predicted to lie between 0.1 and 0.3% per year (Rosenzweig, 1995). To know the exact rate

of extinction of a species from a particular area and develop the suitable conservation strategies on them, study about the biological resources habiting in a particular area is important. In such manner, the present investigation was carried out to document the floral wealth of the Kilavarai freshwater river of Southern Western Ghats.

By the present investigation, a totally 534 species belonging to 332 genera distributed among 123 families includes, both Angiospermic and Pteridophytic plant species were recorded. It includes 498 taxa of Angiosperms belonging to 308 genera of 104 families and 36 Pteridophytic species of 24 genera belonging to 19 families. As compare with a monumental work carried out in Palni hills to document the entire floral wealth of the same, Matthew have reported a total of 2478 species of Angiosperm from the study area, by the present research work, it was stated that altogether 54 species of Angiosperms noted which have not been reported by Matthew in his Flora of Palni Hills.

Among 498 taxa of Angiosperm, dicotyledons were represented by 359 species of 230 genera belonging to 86 families and monocotyledons were 139 species of 78 genera belonging to 18 families. Among the class dicotyledons, 156 species belonging to 98 genera distributed among 46 families were grounded under polypetalae, 153 species belonging to 101 genera distributed among 22 families under gamopetalae, and the remaining 50 species of 31 genera belonging to 18 families were monochlamydeae. Among 359 species of dicotyledons, in polypetalae, Fabaceae (6.63%) was found to be dominant and largest family comprising 33 species, in gamopetalae, Asteraceae was found as dominant family with 36 species (7.23%), in case of monochlamydeae, Polygonaceae was found as dominant family with 10 species (2.01%) and among the plants recorded under dicots, *Solanum* was represented by 10 species and which were found to be the dominant genus.

In case of monocotyledons, Poaceae (12.45%) was recorded as dominant family with 62 species followed by Cyperaceae (5.42%) comprising 27 species and it was also documented that *Cyperus* was found as dominant genus among the plants recorded under monocots with 10 species.

Regarding the habits of the plant species recorded, herbs (323 species) were found to be more in number than shrubs (86 species) followed by climbers (45 species) and trees (44 species).

In this current research, among 498 species of Angiosperms collected from Kilavarai freshwater river, 1 species (*Hedychium coronarium*) was found as threatened, 3 species (*Gyrocarpus americanus*, *Vanda spathulata* and *Smilax zeylanica*) were identified as vulnerable, 2 species (*Hydrocotyle conferta* and *Actinodaphne bourneae*) were found as endangered and 85 species as least concern according to the checklist published by IUCN (IUCN, 2019). According to the report published by ENVIS (2008), the 14 species were identified as narrow endemic to Tamil Nadu state.

The present investigation also includes with the documentation of Pteridophytic species present in Kilavarai freshwater river. It was noted that a total of 36 Pteridophytic species belonging to 25 genera distributed among 19 families were noted and documented. Among the families recorded, Adiantaceae (16.67%) was found to be dominant and largest family comprising 6 species. Of the Pteridophytic species recorded, *Adiantum* was represented by 6 species and which was found to be the dominant genus. Regarding the habitats of the Pteridophytic species recorded, terrestrial species (27 species; 75.00%) were found to be more in number than epiphytic (5 species; 13.88%). 3 species (8.34%) were found as both epiphytic and lithophytic species and 1 species (2.78%) was recorded as purely lithophytic.

The results obtained by the present research work have also indicated that, of the 279 plants studied for physosociological analysis in 3 different seasons, 243 plants were noted in Season I, 277 plants were recorded in Season II and 234 plants during Season III. Among them, a total of 218 species were occurred in all the 3 seasons studied, 36 plants were present at 2 seasons and 26 plants at single season only.

The different plant species were recorded for three consecutive seasons I, II, & III on July 2015, December 2015 and April 2016, with respect to their Frequency, Density, Abundance, Relative Frequency (RF), Relative Density (RD), Relative Abundance (RA), Imporatant Value Index (IVI) and Shannon's Index (SI).

The findings of current research work also exhibits the Raunkier's frequency class A was observed with 95.07% of species recorded, followed by B class with 4.52%, C class by 0.41% and other two frequency classes (D and E) could not observed in season I. In Season

II, the Raunkier's frequency class A was observed with 94.59% of plants, followed by B class (4.67%), C class (0.36%) and other two frequency (D and E) classes could not observed as in case of season I. In Season III, the Raunkier's frequency class A was observed with 96.13% of species recorded, followed by B class (3.87%), and other three frequency (C, D and E) classes could not observed.

The density values were categorized into five classes i.e., density A = 0 - 2, B = 2 - 4, C = 4 - 6, D = 6 – 8, E = 8 – 10. In season I, the maximum density value A was observed with 96.71% of plants among the total species recorded. The B value was noted by 2.47%, C by 0.82%. None of the classes D and E noted in this season. In Season II, the density class A was observed with 94.59% of plants, and B by 2.52%. In this season the density class of C, D and E were noticed with 2.17%, 0.36% and 0.36% respectively. In Season III, the density class A was noticed in 95.71% of species, followed by B (3.43%), C (0.43), E (0.43%), and D class could not observed.

The abundance values were categorized into five classes i.e., A = 0 - 8, B = 8 - 16, C = 16 - 24, D = 24 – 32, E = 32 – 40. The abundance class A was noticed in 90.12% of the plants, followed by B (6.99%), C (2.89%) and other two abundance (D and E) classes could not observed in season I. In Season II, the abundance class A was observed by 87.00% of the recorded species, followed by B (9.03%), C (2.17%), D (1.44%) and E (0.36%). In Season III, the plants comes under abundance class A were noticed with 90.56 % of the plants noted, followed by B (6.86%), C (1.72%), D (0.86%), and E class could not observed.

The values of relative frequency, relative density and relative abundance are the magnification of the quantitative characters such as frequency, density and abundance respectively.

The IVI values were categorized into five classes i.e., A = 0 – 2.5, B = 2.5 - 5, C = 5 – 7.5, D = 7.5 – 10, E = 10 – 12.5. The plants have been categorized into class A recorded maximum with 88.48% of plants, and it was followed by B (9.06%), C (0.82%), D (1.64%) and E class could not observed in season I. In Season II, the IVI class A was noted in 90.98% of species, B by 7.22%, C with 1.08%, D with 0.72% and E class could not observed. In Season III, the IVI class A was noticed by 86.26% of plants, followed by B (10.31%), C (3.01%), E (0.42%), and D class could not observed.

Comparatively, the maximum Shannon Index was noticed by *Chrysopogon aciculatus* (0.1004) during April 2016, and the minimum in species like *Opilia amentacea*, *Rhododendron arboreum*, *Meliosma pinnata*, *Cheilanthes bullosa*, *Streblus asper*, *Osbeckia wightiana* and Hedyotis articularis (0.0009), during December 2015 (Season II).

SUGGESTIVE CONCLUSIONS

- Further studies are to be needed to explore the entire floral wealth of the Kilavarai river.
- Researches must be carried out to document the diversity of other plant groups like Gymnosperms, Bryophytes, etc.
- Conservation strategies must be taken on plant species existing with less frequency, otherwise there must be the possibility of the extinction of particular species.

SUMMARY

In the present study, the recorded families were broadly arranged in the sequence of Bentham and Hooker's classification and Pichi-Sermolli's system, for Angiosperms and Pteridophytes respectively. Totally 534 species belonging to 332 genera distributed among 123 families includes, both Angiospermic and Pteridophytic plant species were recorded. It includes 498 species of Angiosperms belonging to 308 genera of 104 families and 36 Pteridophytic species of 24 genera belonging to 19 families.

By the present research work, it was stated that altogether 54 species of Angiosperms noted which have not been reported by Matthew in Flora of Palni Hills.

Among 359 species of dicotyledons, in polypetalae, Fabaceae (6.63%) was found to be dominant and largest family comprising 33 species and 17 families were represented by single species. Among the species recorded by the current study, in gamopetalae, Asteraceae was found as dominant family with 36 species (7.23%) and 5 families were represented by single species (0.20% each). In case of monochlamydeae, Polygonaceae was found as dominant family with 10 species (2.01%) and 10 families were documented by single species

(0.2% each) only. Among the plants recorded under dicots, *Solanum* was represented by 10 species and which were found to be the dominant genus followed by the genus *Crotalaria* with 8 species.

In case of monocotyledons, Poaceae (12.45%) was recorded as dominant family with 62 species and 6 families were represented by single species (0.2% each). From the present research work, it was also documented that *Cyperus* was found as dominant genus among the plants recorded under monocots with 10 species.

Regarding the habits of the Angiospermic plant species recorded, herbs (323 species) were found to be more in number than shrubs (86 species) followed by climbers (45 species) and trees (44 species).

In this current research, among 498 species of Angiosperms collected from Kilavarai freshwater river, 1 species was found as threatened, 3 species were identified as vulnerable, 2 species were found as endangered and 85 species as least concern according to the checklist published by IUCN. According to the report published by ENVIS, the 14 species were found as strict endemic to Tamil Nadu state.

The present investigation also includes with the documentation of Pteridophytic species present in Kilavarai freshwater river. It was noted that a total of 36 Pteridophytic species belonging to 25 genera distributed among 19 families were noted and documented. Among the families recorded, Adiantaceae (16.67%) was found to be dominant and largest family comprising 6 species and 11 families were represented by single species (2.78%). Of the pteridophytic species recorded, *Adiantum* was represented by 6 species and which was found to be the dominant genus, and it was followed by the genus, *Pteris* with 3 species. Regarding the habitats of the Pteridophytic species recorded, 27 species were found as terrestrial, each of 3 species were found as both epiphytic and lithophytic species respectively and 1 species was recorded as purely lithophytic. The data pertaining to the IUCN status of Pteridophytic species recorded from the study river, it was predicted that 5 species were categorized under Least Concerned and the remaining 31 species were not evaluated.

The results obtained by the present research work have also indicated that, of the 280 plants studied for physosociological analysis in 3 different seasons, 243 plants were noted in

Season I, 277 plants were recorded in Season II and 233 plants during Season III. Among them, a total of 217 species were occurred in all the 3 seasons studied, 36 plants were present at 2 seasons and 27 plants at single season only. The different plant species were recorded also with respect to their Frequency, Density, Abundance, Relative Frequency (RF), Relative Density (RD), Relative Abundance (RA), Imporatant Value Index (IVI) and Shannon's Index.

Thesis will be presented in 7 chapters as Preamble, Review of literature, Materials and Methods, Result and Discussion, Taxonomic Treatment, Conclusion and Summary along with Bibliography and Appendix.