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Research Paper

RARITY, AND PRIORITIZATION OF TETTIGONIID SPECIES AND SELECTION OF SITES FOR CONSERVATION OF TETTIGONIIDAE IN TAMILNADU

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Abstract

The present study documents the distribution; occurrence and faunal richness of Tettigoniids in Tamil Nadu, from four different vegetation types viz forest ecosystem, open grassland ecosystem, wasteland ecosystem, and agroecosystems. A total of twenty-six species in five different subfamilies, were recorded. Three faunal properties, viz., species richness, complementarity and taxonomic difference were calculated as a measure of diversity. Root weighting is a fixed weight index where species are valued for differences according to their position in the taxonomic hierarchy. Following this, the tettigoniid species were weighed as per their rarity in Tamil Nadu and their taxonomic distinctness, which provided the necessary pointer for habitats prioritized for conservation. This method gave a higher priority to lowland forest habitats for conserving tettigoniids, followed by the upland forests, grasslands, arablelands and finally the wastelands.

Key words: Conservation, Orthoptera, Tettigoniids, Site selection, and Root weighting.

INTRODUCTION

The burgeoning human population demands has resulted in tremendous loss of biodiversity globally and scientists are pondering on ways to protect if not prevent species extinction. Site selection for conservation of ecologically functional species is gaining momentum and it has been accepted that while the more visible species are protected at a site, many umbrella species automatically get covered. However there are many other species which does great ecological functions, but do not fall under the umbrella species category. Orthoptera forms one such group and is one of the largest orders of the class Insecta. It includes the well-known grasshoppers, locusts, crickets,

katydids and mantids. They form a dominant group of herbivorous insects throughout the world, and their high diversity, functional importance, sensitivity to disturbance and ease of sampling make them potentially useful bioindicators for land management. Tettigoniids or the long-horned grasshoppers or katydids (Superorder: Orthopteroidea; Order: Orthoptera; Suborder: Ensifera; Superfamily: Tettigonoidea; Family: Tettigoniidae) are some of the most conspicuous and abundant members of tropical insect communities. The number of known species of the family Tettigoniidae currently exceeds 6200 and they are assigned to over 1000 genera[1]. Most of them occur in the tropical and subtropical regions of the world. In the Indian subcontinent, about 250 species have so far been recorded, though little is known about the fauna of Tamil Nadu. In the tropics, they form an important component of the food web, being eaten by amphibians, reptiles, birds, rodents, bats, primates and insects. They are known to occur in a wide variety of habitats, ranging from the littoral zone of the seashore to grasslands, forests, and mountaintops, well above the tree line. Hence, the present study aims at providing information on the biodiversity of tettigoniids of Tamil Nadu. We explore the diversity of the tettigoniids within habitats using several diversity indices.

MATERIALS AND METHODS

Study area

The state of Tamil Nadu covers the eastern part of Peninsular India. It experiences dry weather throughout, except during the southwest monsoon from June to August and northeast monsoon from September to November. Five habitats representing upland forests, lowland forests, grasslands, arablelands, and wastelands across altitudinal, latitudinal and longitudinal gradients were surveyed for the tettigoniid species in twenty three districts of Tamil Nadu (Chennai, Coimbatore, Dindigul, Dharmapuri, Kanchipuram, Madurai, Nilgiris Tanjore, Vellore, Salem, Namakkal, Tuticorin, Tirunelveli, Kanyakumari, Karur, Erode, Perambalur, Pudukottai, Ramanathapuram, Sivagangai, Theni, Tiruchirappalli and Virudhunagar).

Sampling sites

During June, 2012 to May, 2014, an inventorying programme was undertaken for biodiversity assessment of Tettigoniidae in Tamil Nadu. A total of 50 sites were chosen

from the 23 districts of Tamil Nadu. Sites were selected primarily on the basis of their position in the altitudinal, latitudinal and longitudinal gradients and described within very brief habitat types viz., upland forests, lowland forests grasslands, wastelands and arablelands (Table 1.). This method of site selection was used for the reason that the temperature and moisture gradients, quite independent of habitat types defined by vegetation, are often of primary importance in determining the distribution and local abundance of most terrestrial animal taxa.

The upland forests selected for this study are natural forests located at altitudes above 900 m (MSL). These forests comprise mostly of shrubs, herbs and tall trees of *Lannea coromandelica* (Hout.) Metr., *Tephrosia purpurea* Pers., *Borassus flabellifer* L., *Albizzia lebbeck* Berth., *Eucalyptus globulus* Labill., *Dendrocalamus strictus* Nees., *Ficus religiosa* L., *Ficus tomentosa* Roxb., *Ficus glomerata* Roxb., *Azadirachta indica* A. Juss., *Santalum album* L., *Ficus bengalensis* L. *Thespesia populnea* Cav., *Tectona grandis* L.f., *Tamarindus indica* L. and *Emblica officinalis* Gaerth. The sites surveyed in Tamil Nadu for upland forests include Mudumalai, Mundandurai, Alagar hills, Yelagiri hills, Kalikesam, Courtalam, Gundukottai, Yerkaud, Sirumalai, Kolli hills, Valparai, Kodaikanal and Ooty.

The natural lowland scrub jungle forests studied include the Guindy Reserve Forest, Tambaram, Melur, Ayyanar forest and Nanmangalam forest and are those located below 900 m (MSL), they comprise mostly of shrubs, and herbs besides *L. coromandelica*, *T. purpurea*, *B. flabellifer*, *A. lebbeck*, *E. globulus*, *D.strictus*, and *T. populnea* and few grass weeds such as C*ynodon dactylon* Pers., *Chloris barbata* Sw., *Cymbopogon flexuosus*, Wats., and *Cyperus rotundus* Linn.

The grasslands surveyed represent an area of open lands with flora comprising of *C. dactylon*, *C. barbata*, *C. flexuosus*, *Dicanthium caricosum* A. Camus., and *C. rotundus*. The grassland sites surveyed include Kodambakkam, Numgambakkam, Towalai, Mettur, Pollachi, Siruvani, Vedanthangal, Kelambakkam, Aliyar Dam, Mukkombu, Jumbukaveri and Arasinampatti.

The wastelands surveyed in Tamil Nadu represent a vast area of open lands, containing a few herbs and shrubs growing irregularly and completely free of anthropogenic interference. Such wastelands selected are located in Panniyan,

Nagamalai, Tuticorin, Chenglepet, Pillayarpatti and Rameswaram. The arablelands selected in this study were mainly those containing crops like *Oryza sativa* Linn., *Sorghum vulgare* Linn., *Zea mays* Linn., *Arachis hypogea* Willd., *Hibiscus esculentus* Linn., *Gossypium hirsutum* Linn., *Solanum melongena* L., *Eleusine coracana* Gaerth., and *Pennisetum typhoideum* Rich. The sites are located in Vakaikulam, Krishnagiri, Kumbakonam, Padappai, Pallathur, Wangal, Srirangam, Thaneerpandal, Papanadu, Theni, Hogenakkal, Salem, Solayar dam and Madurai.

Inventorying protocol

In order to make an inventory of the tettigoniid species, the habitat selected was divided into as many quadrats of 10 x 10 m^2 area and 10 quadrats selected at random making the total area sampled as 100 x 100 m^2 for each site. Sampling was carried out by using sweep net, search method and hand picking of all specimens of tettigoniids encountered. Our earlier studies[2] have shown that among the various techniques, this method provides the best sampling for orthopteroid insects. The species accumulation curve constructed for each habitat types sampled showed that after nineteen sampling efforts (months), no more species were added and the curve reached asymptote. Hence Sampling was done each month from June 2012 to May 2014, between 6-8 AM and between 6-8 PM so as to include also the nocturnal species of tettigoniids. All tettigoniids collected were identified to species level. Records were maintained for the number of individuals of each species collected during every survey trip.

Data analysis

As a measure of α-diversity (diversity within a habitat), the most popular and widely used Shannon's diversity index (H′) was calculated because it is well accepted that all species at a site, within and across systematic groups contribute equally to its biodiversity (Ganeshaiah *et. al*. 1997). In addition, Simpson's diversity index (λ), Hill's first (N_1) and second (N_2) abundance numbers, Margalef's richness index (R_1), Menhinick's richness index (R_2), and Evenness index (E_5) were calculated as per Ludwig & Reynolds (1988) [3].

Root weight for taxonomic hierarchy

Taxonomic difference was calculated by root weight method that gives a set of additive weights reflecting the position of each species in the taxonomic hierarchy. To arrive at taxanomic differences among the tettigoniids, the following weights were assigned: each species = 1 unit weight; each genera = 2 unit weights. The tettigoniids collected belonged to five subfamilies namely Phaneropterinae, Conocephalinae, Pseudophyllinae, Listroscelidinae and Mecopodinae. Based on the gradation of the dispersion measures, the following weights were assigned as per the order of subfamilies written above - 4, 5, 6, 7&7. The last two subfamilies had relatively higher weights because of their poorer representation in this region. This method, although very subjective, was used as no weights derived from taxonomic hierarchy or even based on strict phylogenetic methods could be assigned due to paucity of studies and information on these lines for the tettigoniids [4].

RESULTS

Inventory of tettigoniids of Tamil Nadu

Tamil Nadu form the eastern side of Peninsular India extending 8.5 - 13.5°N, Latitude; 76.15 -80.20°E Longitude and politically divided into 29 districts. Twenty three major districts were surveyed during June 2012 to May 2014 covering various habitats such as grasslands, forestlands, wastelands and arablelands. The extensive survey undertaken in 50 sites has resulted in the recording of 26 species of tettigoniids (Table 2). Fourteen species belonged to the subfamily Phaneropterinae, while 7 species belonged to Conocephalinae and 3 species belonged to Pseudophyllinae. The subfamilies Mecopodinae and Listroscelidinae were represented by only one species each. In terms of the habitat they occupy, the tettigoniids were collected from five different habitat types viz., upland forests, lowland forests, grasslands, wastelands and arablelands in Tamil Nadu.

Species richness

Species richness, which accounts for the number of species in the defined area, for the five habitats surveyed, ranged from 7 to 18. It is evident that the natural lowland forests was the richest with 18 species followed by the upland forests with 15 species,

the grasslands with 12 species, and the arablelands with 11 species, while the wastelands harboured only 7 species.

Since insect species vary in their individual response to the environment, it becomes pertinent to analyse the distribution of each species separately. Table 3 provides data on the presence/absence of tettigoniid species at various sites surveyed. Two commonly available tettigoniid species namely *Conocephalus maculatus* (Le Guillou), and *Elimaea securigera* (Brun.) present in wastelands were also recorded in the forestlands, grasslands and arablelands. *C. maculatus* was observed in almost all the areas surveyed. In both forestlands and grasslands namely *Acanthoprion suspectum* (Burn.), *Holochlora indica* (Kirby), *E. securigera*, *C. maculatus*, and *Euconocephalus incertus* (Walk.) were recorded. *Sathrophyllia fuliginosa* Stal. and *Mecopoda elongata* (Linn.) were encountered both in the lowland forests as well as at high altitude forests. There are certain species unique to a particular habitat. For e.g., *Trigonocorypha unicolor* (Stoll), *Paramorsimus oleifolius* (Fab.), *Mirrollia cerciata* Hebard and *H. indica* were observed only in the lowland forests, while *Euconocephalus pallidus* Redtenbach, *Phaneroptera gracilis* (Brum), and *Hexacentrus major* (Redenbach) were encountered only in grasslands. *Conocephalus longipennis* (De Haan), a member of the subfamily Conocephalinae was represented only in the arableland, especially in rice (*Oryza sativa* Linn.) fields.

Species diversity

The concept of species diversity generally consists of two components, namely species richness and species evenness. The richness indices R_1, and R_2 were computed by using Ludwig and Reynolds (1988)[3] for comparing the habitats. Both these indices were high for the lowland forest (Guindy Reserve Forest) and low for the wastelands (Table 4). Evenness index provides an insight into the relative abundance of the species in the community. The 18 and 12 species of tettigoniids observed in the lowland forests and grasslands respectively had lower values of evenness indices (Guindy and Nungambakkam) than the species observed in the wastelands and upland forests, where the value showed a tendency to approach one. This pattern could be attributed due to the large number of individual (N_0) observed for the few species encountered in these habitats (Table 4). The present analysis indicates higher H^1 value for the lowland

forest and the grassland indicating tettigoniids to be more diverse in these habitats (Table 4). Simpson's diversity index, 'λ', gives high value for tettigoniids species of Chenglepet, followed by Pollachi.

Site selection for conservation

One of the aims of biodiversity inventorying programm is to indicate sites that could be recommended for conservation. The lowland forest ecosystem was the richest with 18 species followed by the upland forests with 15 species, the grasslands with 12 species, arablelands with 11 species and wastelands with only 7 species. Some of the species present in the wastelands, grasslands and arablelands were also present in the forestlands besides having their own unique species. Therefore, in terms of site selection for conservation augmentation, complementary sites have to be selected so that maximum number of species of tettigoniids can be protected. The number of species in all the areas combined represents the tettigoniid complement of Tamil Nadu, a total of 26 in this case. Eighteen species of tettigoniids were present in the lowland forests making the residual complement of 8 species. The residual complement represents the eight species of tettigoniids not present in the lowland forest. The lowland forest ecosystem therefore represents 69.23% of the tettigoniid fauna which could be protected, if we are to select a conservation site for tettigoniids. 5 species, not seen in the lowland forest, were seen in the upland forest indicating an increment of 19.23%. The upland forests represent only 56.72% of the tettigoniid fauna. The grasslands and arablelands offers 7.6% increment, while the wasteland offers only a 3.84% increment. Therefore, given the requirement for the selection of sites so as to conserve the maximum tettigoniid species, our first choice should be invariably the lowland forest, followed by the upland forest. But these two sites do not cover the entire tettigoniids species of Tamil Nadu. To assist the choice among the arableland and grassland, complementarity analysis using taxic differences become a useful tool.

Table 5 provides the species, area, complementarity and taxonomic difference for priority analysis. Taxonomic difference calculated by root weight method gives a set of additive weights (Column W) reflecting the position of each species in the taxonomic hierarchy. Total diversity for the 26 complementary species in each area is given in row T. Scores as percentage of complement are given in row P1. Row P2 gives the diversity

increments for the upland forest, grassland, arableland and wasteland based on residual complement, after selecting the lowland forest ecosystem. Row P3 gives the diversity increment for grassland, arableland and wasteland after selecting the low and upland forests. At this stage, the third site in the priority list is the arablelands as the grasslands do not provide any additional increment while the wasteland occupies the fourth place in the priority list. These analysis indicated that the forest ecosystem represent the maximum diversity of tettigoniids followed by the arableland and wasteland. The grassland does not significantly add to the diversity of the tettigoniid fauna, after selection of the forestland, arableland and wasteland.

DISCUSSION

The need for an in-depth understanding of the varied facets of tettigoniids cannot be over emphasised, as they are known to cause damage to several crops by feeding on various parts of the plant, as well as by causing physical injury to the plant during oviposition. The tettigoniid fauna is relatively large and in most part of the world, it is under studied.

Repeated sampling throughout the length and breadth of Tamil Nadu resulted in the listing of 26 species of tettigoniids belonging to five different subfamilies viz., Phaneropterinae, Conocephalinae, Pseudophyllinae, Mecopodinae, and Listroscelidinae. It is common belief that natural ecosystems, still untouched by man, are characterized by a great diversity of animal and plant species. These heterogeneous conditions form the basis of a stable and well-balanced environment in which population oscillates within certain limits [5]. This study on tettigoniids has again supported the fact that a heterogeneous and undisturbed habitat such as the forestlands and the grasslands harboured greater number of insect species. Also the physical variables of the environment such as that available in the high altitudes of Sirumalai was detrimental to the colonization of tettigoniids, although the habitat was heterogeneous. The availability of host plants in the habitat is vital for insect colonization. The type of vegetation in a habitat influences not only species presence, but also relative abundance [6]. Agroecosystem represents a simplified system in which there are fewer plant species available for the insects. Moreover most of the crops are so selected that they have greater resistance to insect attack and therefore would attract fewer species of

insects. The agroecosystems surveyed for tettigoniids no doubt had lesser species diversity as well as species abundance. On the other hand the wastelands, although harboured fewer species, the number of individuals recorded was high, indicating that these species of tettigoniids successfully colonized the habitat using the available food resources from the environment. Agricultural lands appear to be the most highly disturbed area, wherein spraying of insecticides, deweeding and other cultural practices affect the insect community.

In taxonomically well-known groups, richness is relatively easy to estimate by a direct count of the species encountered, provided that the sampling effort is sufficient. However, most taxa are very difficult to sample in such a way that the proportions of individuals per species in a sample are representative of their true abundance in the community[7], making an accurate estimation of equitability difficult. This is particularly true in extensive surveys where habitat differences exacerbate differences in detectability. For these reasons only species occurrences index was "S" (the observed number of species) used. E_5 approaches zero as a single species becomes more dominant in a community [4]. The 18 and 12 species of tettigoniids observed in the lowland forests and grasslands respectively had lower values (0.38 and 0.59) of evenness indices (Guindy and Nungambakkam) respectively than the species observed in the wastelands (1.1) (Panniyan) and upland forest site (2.25) Kolli hills, where the value showed a tendency to approach one. This pattern could be attributed due to the large number of individual (N_0) observed for the few species encountered in these habitats.

As a measure of α-diversity (diversity within a habitat) the most popular and widely used Shannon's diversity index was calculated because it is well accepted that all species at a site, within and across systematic groups contribute equally to its biodiversity [8]. On the other hand Shannon's index, which has gained great popularity, as it does not assume theoretical distribution, also gives the top rank for the lowland forests. Shannon's diversity index (H^1) indicates that the lowland forest (1.36) was rich in tettigoniids followed by the grassland (1.09), the upland forest (0.61), the arableland (0.51), and lastly the wasteland (0.25). N0 is the number of all species in the sample (regardless of their abundance), N2 is the number of very abundant species, and N1 measures the number of abundant species in the sample. In other words, the effective

number of species is a measure of the number of species in the sample where each species is weighed by its abundance. It was found that N2 is more appealing because it is probability based and is in units of species numbers. N2 is reciprocal of Simpson's index, which is the probability that two individuals drawn at random from a population belong to the same species. If the probability is high that both individuals drawn belong to the same species, then intuitively the diversity of this species population with the habitat is low. As a reciprocal of this probability, Hill's N2 diversity index estimates the number of very abundant species likely to be found in a habitat. Hills diversity number of very abundant (N_2) species indicates high values for the upland forest (Yerkadu = 7.5) followed by the grassland sites (5 in Pollachi, Krishnagiri), the lowland forests and to some extent for the arablelands. However, both N_1 and N_2 are strongly affected by the most abundant species. Simpson's diversity index, 'λ', gives high value for tettigoniids species of grassland (Nungambakkam = 2.17), followed by lowland forest (Guindy = 2.08), the upland forest (Alagar hills =1.55), the arableland (Kanchipuram =1.38), and lastly the wasteland (Chenglepet =1.11).

Insects have a vital role in the terrestrial ecosystem function in terms of both biomass and diversity [9-11], but their species richness patterns have received relatively little attention. An exponentially increasing human population and socioeconomic handship [12] are eroding biological diversity very rapidly relative to background extinction rates [11; 13-14]. Conservation efforts require prioritisation of areas of conservation[15-16]. Understanding regional valuability in species richness is necessary for conservation efforts to succeed in the face of large-scale environmental deterioration[17]. Further, an understanding of the interactions between regional environmental factors and species diversity is fundamentally important in planning conservation responses to ongoing global climate change [18-19].

The lowland forest ecosystem was the richest with 18 species followed by the upland forests with 15 species, the grasslands with 12 species, arablelands with 11 species and wastelands with only 7 species. Some of the species present in the wastelands, grasslands and arablelands were also present in the forestlands besides having their own unique species. Therefore, in terms of site selection for conservation augmentation, complementary sites have to be indicated. Therefore given the requirement for the selection of sites so as to conserve the maximum tettigoniid species,

our first choice would be invariably the forests followed by the grasslands. To assist the choice among the arablelands and wastelands, complementarity analysis using taxic differences become a useful tool. The root weight analysis indicated that the forestlands represent the maximum diversity of tettigoniids followed by the arablelands and the wastelands. The grassland does not significantly add to the diversity of the tettigoniid fauna, after selection of the forestlands, arablelands and the wastelands. Therefore given the need for conserving the tettigoniid diversity of Tamil Nadu, the forestlands and wastelands have to be protected.

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Table 1. Sites selected for sampling the tettigoniid species of Tamil Nadu.

Sites	Altitude M (MSL)	Latitude ºE	Longitude ºN	Habitat type
Alagar hills	350	9.58	78.10	Upland forest
Aliyar Dam	900	10.24	76.40	Grassland
Arasinampatti	129	9.57	78.53	Grassland
Ayyanar forest	800	9.27	77.36	Lowland forest
Chenglepet	56	12.42	80.01	Wasteland
Courtalam	900	8.58	77.21	Upland forest
Guindy	11	13.04	80.17	Lowland forest
Gundukottai	1350	12.32	78.16	Upland forest
Hogenakal	900	12.08	78.13	Agricultural land
Jambukaveri	62	10.47	79.10	Grassland

Kalikesam	900	8.11	77.29	Upland forest
Kelambakkam	19	13.04	80.17	Grassland
Kodaikanal	2200	10.13	77.32	Upland forest
Kodambakkam	11	13.04	80.17	Grassland
Kolli hills	1800	11.13	78.13	Upland forest
Krishnagiri	900	12.32	78.16	Agricultural land
Kumbakonam	500	10.58	79.25	Agricultural land
Madurai	545	9.58	78.10	Agricultural land
Melur	550	9.58	78.10	Lowland forest
Mettur dam	900	11.52	77.50	Grassland
Mudumalai	1350	11.24	76.44	Upland forest
Mukkombu	58	10.50	78.46	Grassland
Mundanthurai	900	8.43	77.29	Upland forest
Nagamalai	545	9.58	78.10	Wasteland
Nanmangalam	17	13.04	80.17	Lowland forest
Nungambakkam	11	13.04	80.17	Grassland
Ooty	2670	11.24	76.44	Upland forest
Padappai	25	12.50	79.45	Agricultural land
Pallathur	53	9.57	78.52	Agricultural land
Panniyan	300	9.58	78.10	Wasteland
Papanadu	350	10.23	78.52	Agricultural land
Pillayarpatti	53	9.57	78.53	Wasteland

Pollachi	900	10.39	77.03	Grassland
Rameswaram	3	9.17	79.22	Wasteland
Salem	500	11.39	78.12	Agricultural land
Sirumalai	1200	10.22	78.00	Upland forest
Siruvani	300	11.00	77.00	Grassland
Solayar dam	400	11.00	77.00	Agricultural land
Srirangam	40	10.50	78.46	Agricultural land
Tambaram	11	13.04	80.17	Lowland forest
Thaneerpandal	124	11.14	78.56	Agricultural land
Theni	900	10.13	77.32	Agricultural land
Towalai	800	8.44	77.44	Grassland
Tuticorin	7	8.48	78.11	Wasteland
Vakaikulam	540	8.48	78.11	Agricultural land
Valparai	1800	10.24	76.40	Upland forest
Vedanthangal	2	12.30	79.56	Grassland
Wangal	81	10.58	78.07	Agricultural land
Yelagiri hills	1372	11.48	78.13	Upland forest
Yerkaud	1020	12.42	78.37	Upland forest

Table 2. List of tettigoniids collected from various habitats in Tamil Nadu.

Species	Subfamily
Acanthoprion suspectum (Burn.)	Pseudophyllinae
Conocephalus maculatus (Le Guillou)	Conocephalinae
Conocephalus melas (De Haan)	Conocephalinae
Conocephalus longipennis (De Haan)	Conocephalinae
Conocephalus sp.	Conocephalinae
Euconocephalus incertus (Walk.)	Conocephalinae
Euconocephalus pallidus Redtenb.	Conocephalinae
Elimaea (Orthelimaea) securigera (Brun.)	Phaneropterinae
Hexacentrus major Redtenb.	Listroscelidinae
Himertula vidhyavathii n.sp	Phaneropterinae
Himertula kinneari (Uvarov)	Phaneropterinae
Holochlora spectabilis. (Walk.)	Phaneropterinae
Isopsera sp.	Phaneropterinae
Elimaea melanocantha (Walker)	Phaneropterinae
Holochlora indica Kirby	Phaneropterinae
Letana infurcata Ingrisch	Phaneropterinae
Mecopoda elongata (Linn.)	Mecopodinae
Mirrollia cerciata Hebard	Phaneropterinae
Mirrollia sp.	Phaneropterinae
Neoconocephalus sp.	Conocephalinae
Paramorsimus oleifolius (Fab.)	Pseudophyllinae
Phaneroptera gracilis (Brum.)	Phaneropterinae
Ladnea sp.	Phaneropterinae
Phaneroptera sp.	Phaneropterinae
Sathrophyllia fuliginosa Stål.	Pseudophyllinae
Trigonocorypha unicolor (Stoll)	Phaneropterinae

Table 3. Provides data on the presence/absence of tettigoniid species at various sites surveyed.

Location	*Conocephalus maculatus*	*Elimaea (Orthelimaea) securigera*	*Mecopoda elongata*	*Euconocephalus incertus*	*Phaneroptera gracilis*	*Himertula vidhyavathii*	*Conocephalus melas*	*Conocephalus longipennis*	*Conocephalus* sp.	*Euconocephalus pallidus*	*Hexacentrus major*	*Himertula kinneari*	*Holochlora indica*	*Elimaea melanocantha*	*Isopsera sp.*	*Holochlora spectabilis*	*Letana infurcata*	*Mirrollia cerciata*	*Mirrollia* sp.	*Neoconocephalus* sp.	*Paramorsimus oleifolius*	*Ladnea sp.*	*Phaneroptera* sp.	*Sathrophyllia fuliginosa*	*Trigonocorypha unicolor*	*Acanthoprion suspectum*
Alagar hills	+	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-		-	+	-	-	-	-	-	-	-
Aliyar Dam	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arasinampatti	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ayyanar forest	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Chenglepet	+	+	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Courtalam	+	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-
Guindy	+	+	+	+	+	-	-	-	-	+	+	-	+	-	-	+	+	+	+		+	-	-	+	+	+
Gundukottai	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hogenakkal	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jambukaveri	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalikesam	+	+	+	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kelambakkam	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kodaikanal	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kodambakkam	+	+	-	+	+	-	-	-	-	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Kolli hills	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Krishnagiri	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Kumbakonam	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madurai	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melur	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mettur dam	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mudumalai	+	+	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-
Mukkombu	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mundanthurai	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-
Nagamalai	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nanmangalam	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Nungambakkam	+	+	-	+	+	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Ooty	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Padappai	+	+	-	+	-	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Pallathur	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panniyan	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Papanadu	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pillayarpatti	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
Pollachi	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rameswaram	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Salem	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sirumalai	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siruvani	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solayar dam	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Srirangam	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tambaram	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thaneerpandal	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Theni	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Towalai	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tuticorin	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Vakaikulam	+	+	-	+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Valparai	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-
Vedanthangal	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wangal	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yelagiri hills	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yerkaud	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

+ Presence of species; - Absence of species

Table 4. Diversity indices of tettigoniids in Tamil Nadu.

Sites	Indices							
	Richness			Diversity				Evenness
	N0	R1	R2	λ	H′	N1	N2	E5
Tambaram	3	0.5939	0.5571	0.3300	1.0702	2.9160	3.0299	1.0594
Kalikesam	6	1.6423	1.3093	0.2619	1.4610	4.3104	3.8182	0.8513
Gundukottai	2	0.7213	1	0.3333	0.6931	2	3	2
Melur	2	0.9102	1.1547	0.3333	0.6365	1.8898	3	2.2475
Ayyanar forest	4	1.3029	1.2649	0.3556	1.0889	2.9710	2.8125	0.9196
Mudumalai	7	1.9136	1.4596	0.2846	1.5149	4.5489	3.5139	0.7083
Sirumalai	3	0.6569	0.6547	0.3905	0.9773	2.6573	2.5609	0.9419
Kodaikanal	2	0.6213	0.8944	0.4	0.6730	1.9601	2.5	1.5623
Yelagiri hills	4	0.9568	0.8341	0.6166	0.7302	2.0754	1.6218	0.5782
Mundanthurai	3	0.6379	0.6255	0.7549	0.4702	1.6004	1.3246	0.5407
Courtalam	4	1.2073	1.1547	0.3030	1.1437	3.1384	3.3	1.0756
Yerkaud	4	1.6743	1.6329	0.1333	1.3297	3.7798	7.5	2.3383
Kolli hills	2	0.9102	1.1547	0.3333	0.6365	1.8899	3	2.2475
Srirangam	3	0.6569	0.6547	0.6619	0.5940	1.8113	1.5108	0.6296
Ooty	2	0.417	0.6030	0.4909	0.6555	1.9261	2.0370	1.1198
Panniyan	3	0.4926	0.3939	0.5208	0.8169	2.2635	1.9199	0.7280
Nagamalai	2	0.7213	1	0.3333	0.9631	2	3	2
Tuticorin	3	0.9618	1.0606	0.3929	0.9003	2.4602	2.5455	1.0583
Nanmangalam	2	0.7213	1	0.5	0.5623	1.7548	2	1.3249
Towalai	2	0.910	1.1547	0.3333	0.6365	1.8899	3	2.2475
Mettur dam	3	1.2427	1.3416	0.2	1.0549	2.8717	5	2.1370
Pollachi	2	0.3898	0.5547	0.8462	0.2712	1.3115	1.1818	0.5836
Valparai	5	1.3138	1.0912	0.3952	1.1677	3.2147	2.5301	0.6909
Vedanthangal	2	0.6213	0.8944	0.6	0.5004	1.6494	1.6667	1.0266
Vakaikulam	5	1.4771	1.2909	0.2476	1.3624	3.9057	4.0384	1.0456
Hogenakal	2	0.4809	0.7071	0.5714	0.5623	1.7547	1.7500	0.9937
Siruvani	2	0.3607	0.5	0.6	0.5623	1.7547	1.6667	0.8833
Madurai	3	0.7385	0.7746	0.3714	0.9701	2.6383	2.6923	1.0329
Theni	3	0.8049	0.8660	0.4091	0.8877	2.4295	2.4444	1.0104
Salem	3	1.1162	1.2247	0.2667	1.0114	2.7495	3.75	1.5719
Krishnagiri	4	1.2511	1.2060	0.2	1.3421	3.8271	5	1.4149
Kumbakonam	3	0.6379	0.6255	0.8300	0.3557	1.4272	1.2048	0.4793
Kelambakkam	3	0.8049	0.8660	0.3333	1.0114	2.7495	3	1.1432
Guindy	16	2.4994	0.7960	0.4778	1.3605	3.8979	2.0928	0.3771
Nungambakkam	7	0.8936	0.2439	0.4599	1.0917	2.9793	2.1745	0.5934
Chenglepet	6	0.7886	0.2519	0.9047	0.2479	1.2813	1.1053	0.3744
Padappai	6	0.8659	0.3344	0.7155	0.5126	1.8086	1.3976	0.4917
Alagar hills	5	0.7862	0.3928	0.6444	0.6138	1.8474	1.5519	0.6513
Kodambakkam	7	1.4595	0.8963	0.2939	1.4113	4.1014	3.4015	0.7743
Papanadu	3	0.8341	0.9045	0.3636	0.9348	2.5466	2.75	1.1315
Jambukaveri	3	0.8341	0.9045	0.5273	0.7595	2.1373	1.8966	0.7883
Mukkombu	2	0.3607	0.5	0.6	0.5623	1.7547	1.6667	0.8833
Thaneerpandal	2	0.4551	0.6667	0.7778	0.3488	1.4174	1.2857	0.6845
Wangal	2	0.7213	1.0	0.5	0.5623	1.7547	2	1.3249
Aliyar Dam	2	0.3235	0.4264	0.8268	0.3046	1.3561	1.2094	0.5880
Pallathur	3	0.6792	0.68824	0.45029	0.8785	2.40734	2.2202	0.8674
Pillayarpatti	2	0.9102	1.1542	0.3333	0.6365	1.88988	3	2.2474
Arasinampatti	2	0.3789	0.5345	0.4615	0.6931	2	2.1666	1.1666

Solayar dam	3	0.910	1.0	0.3611	0.9369	2.5520	2.7692	1.1399
Rameswaram	2	0.3789	0.5345	0.6373	0.5195	1.6813	1.5689	0.83504

N0 - Number of species, R1 - Margalef richness index, R2 - Menhinick richness index, λ - Simpson's diversity index, N1& N2 - Hill's diversity numbers, H' - Shannon's diversity index, E5 - Evenness index.

Table 5. Species richness and priority analysis through root weighting of tettigoniid species for site selection.

Species	Weights (W)	Lowland Forests	Upland Forests	Grasslands	Arablelands	Wastelands
Acanthoprion suspectum	9	+				
Conocephalus maculatus	8	+	+	+	+	+
Conocephalus melas	8		+			
Conocephalus sp.	8		+			
Elimaea securigera	7	+	+	+	+	+
Elimaea melanocantha	7		+	+		
Euconocephalus incertus	8	+		+	+	
Euconocephalus pallidus	8	+		+	+	
Himertula vidhyavathii	7	+	+	+	+	+
Himertula kinneari	7		+			
Holochlora indica	7	+				
Holochlora spectabilis	7	+	+		+	
Ladnea sp.	7		+	+		
Letana infurcata	7	+				
Mecopoda elongata	10	+	+	+	+	+
Mirrollia cerciata	7	+				
Mirrollia sp.	7	+	+	+	+	
Neoconocephalus sp.	8		+			
Phaneroptera gracilis	7	+	+	+		+
Phaneroptera sp.	7	+	+	+	+	
Paramorsimus oleifolius	9	+				
Sathrophyllia fuliginosa	9	+	+			
Trigonocorypha unicolor	7	+				
Hexacentrus major	10	+		+		+
Isopsera sp.	7				+	+
Conocephalus longipennis	8				+	
T	201	141	114	93	84	57
P_1	-	**70**	57	46	42	28
P_2	-		**22**	7	8	4
P_3	-			0	**8**	4
	-					

T - Total diversity, P_1 - Percentage of the complement, P_2 - Diversity increment after selecting the lowland forest, P_3 - Diversity increment after selecting the lowland, and upland forest