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# Study on the Distribution of Flora and Fauna in the SIPCOT Industrial Park of Gangaikondan, Tirunelvelli District, Tamil Nadu, India

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**Abstract**

The phytosociological study on flora and fauna diversity in Gangaikondan revealed that the diversity of the flora was more than the faunal diversity. Totally 59 floral species and 35 faunal species were listed out in the study site. For plants the species- area curves attained the stable position in 2nd and 3rd quadrats where for fauna it reached the observed species richness in 4th and 5th quadrats.

**Keywords:** Gangaikondan, fauna, flora, SIPCOT.

## Introduction

Biological surveys, focusing on species diversity, are necessary on both national and global scales. National biological inventories provide a finer-grained view of biological diversity and can be used to establish national conservation programs and policies, whereas a global survey will provide much needed information on the extent, distribution, status, and fate of biodiversity worldwide. These efforts can serve not only to tell us the status of biodiversity, but to identify valuable biological resources, some of which are unknown, while others are locally known but have potential for much wider use. Many plants of current or potential commercial value were discovered in the course of routine plant surveys. Inventories and surveys also provide baseline data against which to monitor changes in biological diversity and to trace the environmental impacts of development projects.

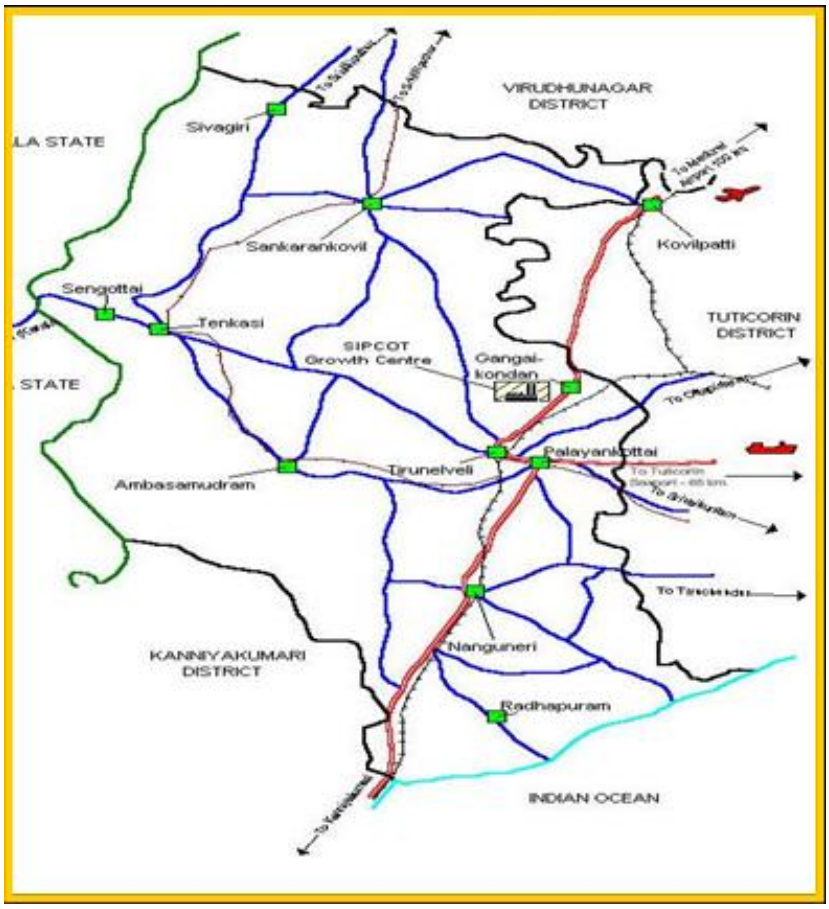
In recent years a great deal of interest has surfaced in the quantification and valuation of biological diversity. The interest is largely motivated by findings from natural scientists that biodiversity is imperiled by human activities (Wilson 1992), especially the destruction of natural habitats (Primack 2000). Biodiversity has, however, proved both difficult to define in practice and difficult to relate to human welfare. Definition and valuation are closely related, of course. We cannot speak meaningfully of valuation without having some notion of what it is that is being valued. On the other hand, a definition that cannot be related to human values may propose "distinctions without differences."

Objective of our study was to screen the list of flora and fauna of the SIPCOT Industrial Park.

## Materials and Methods

### Study Site

The study site was SIPCOT industrial park of Gangaikondan, Tirunelvelli District, Tamil Nadu, India.




**Map 1: Map showing the study site.**

***Sampling***

In the SIPCOT Industrial Park the phytosociological study was carried out using 12 randomly placed quadrats (10m×10m) for trees (individual with DBH more than 30 cm) within them 5m×5m for shrubs and climbers and 1m×1m for herbaceous community.

***Analysis***

The diversity indices were analyzed using PAST and Biodiversity Pro beta Version 2. The species- area were raised with the help of EstimateS.

**Chao 1:** An abundance-based estimator of species richness

**Jackknife 1:** First-order jackknife estimator of species richness (incidence-based)

**ACE:** Abundance-based Coverage Estimator of species richness

**Bootstrap:** Bootstrap estimator of species richness (incidence-based)

**ICE:** Incidence-based Coverage Estimator of species richness

**Results and Discussion**

***Floral Diversity***

In the SIPCOT Industrial Park totally 59 plant species were found. Totally 972 individuals were representing 59 species. *Borassus flabellifer* L. was the dominant species among 59 species. *Cyperus rotundus* L. was having lower number of individuals (4). *Cuscuta sp.* a parasitic species was occurred in the proposed site which was a nuisance one to the common species like *Azadiracta indica*.

***Diversity Indices***

The diversity indices calculated for the SIPCOT Industrial Park showed the higher diversity of plant species. The dominance index of the proposed study site was 0.04. The Menhinick diversity index was also go hand with the Shannon index (Table 2).

***Species – area curve***

The assumption is that the species-area curves should reach the classic asymptotic form at assumption is that the species-area curves should reach the classic asymptotic form at a very early stage and forms a plateau (Chazdon *et al*., 1999).

In the SIPCOT Industrial Park, the species – area curves got stabled within 2nd and 3rd quadrats (Fig 1).

***Principal Component Analysis***

Principal component analysis was carried out by considering the distribution of species in the samples. Most of the species of the project site were following the similar pattern of distribution (Fig 2).

***Correlations***

Kulczynski Comparison was used for assessing species turnover between samples. Spearman's rank correlation coefficient was used to test for relationship between samples. The Mann-Whitney U test was a non-parametric ranking test for whether two independent random samples are drawn from populations having the same distributions. The variance-covariance matrix showed the variance of each sample in the leading (main) diagonal of the matrix and the sample by sample covariance in the other cells.

**Faunal Diversity**

In the SIPCOT Industrial Park totally 35 faunal species were found. Totally 504 individuals were representing 35 species. *Bufo melanostictus* was the dominant species among 35 species. *Danaus chrysippus* and *Acantholepis* were having lower number of individuals (7).

**Diversity Indices**

The diversity indices calculated for the SIPCOT Industrial Park showed the higher diversity of animal species. The dominance index of the proposed study site was 0.07. The Menhinick diversity index was also go hand with the Shannon index (Table 7).

**Species – area curve**

The assumption is that the species-area curves should reach the classic asymptotic form at assumption is that the species-area curves should reach the classic asymptotic form at a very early stage and forms a plateau (Chazdon *et al*., 1999).

In the SIPCOT Industrial Park, the species – area curves got stabled within 4th and 5th quadrats (Fig 3).

**Principal Component Analysis and Cluster Analysis**

Principal component analysis was carried out by considering the distribution of species in the samples. Most of the species of the project site were differed in their pattern of distribution (Fig 4). Most of the species showed above 50% of similarity in their distribution (Fig 5).

**Table 1: List of flora in the in the SIPCOT Industrial Park and its surroundings.**

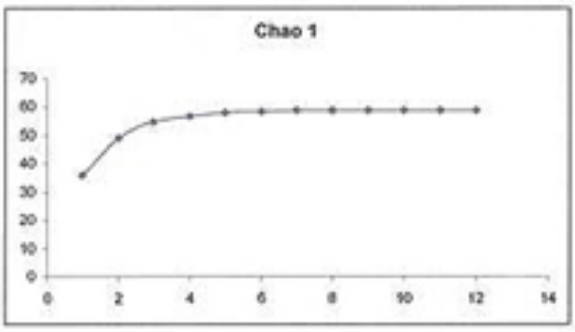
| S.No. | Botanical Name | Common Name |
|---|---|---|
| 1. | *Azadiracta indica* A. Juss. | Vembu |
| 2. | *Boerhhavia diffusa* L. | |
| 3. | *Calotropis gigantea* (L.) R.Br. | Eruku |

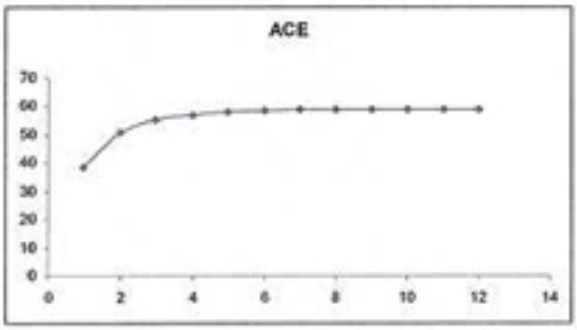
| | | |
|---|---|---|
| 4. | *Borassus flabellifer* L. | Panai |
| 5. | *Cassia siamea* Lam. | |
| 6. | *Cissus quadrangularis* L. | Nanmuga pirandai |
| 7. | *Clerodendrum inerme* (L.) Gaertn | |
| 8. | *Cleome gynandra* L. | |
| 9. | *Cleome viscosa* L. | Naikaduku |
| 10. | *Cocos nucifera* L. | Thenai |
| 11. | *Commelina benghalensis* L. | Thankaipoo |
| 12. | *Cynodon dactylon* (L.) Pers. | Arukanpull |
| 13. | *Cyperus rotundus* L. | |
| 14. | *Cassia fistula* L. | Sarakonai |
| 15. | *Ficus benghalensis* L. | Alamaram |
| 16. | *Ficus religiosa* L. | Arasamaram |
| 17. | *Indigofera uniflora* Buch. | |
| 18. | *Moringa pterygosperma* Goertn. | Murungai |
| 19. | *Jasminum angustifolium* (L.) Willd. | Malligai |
| 20. | *Mangifera indica* L. | Mango |
| 21. | *Ficus racemosa* | |
| 22. | *Delonix regia* (Boj. ex Hook.) Raf. | Myilkonrai |
| 23. | *Carica papaya* L. | Pappali |
| 24. | *Ocimum sanctum* | Tulsi |
| 25. | *Pergularia daemia* L | Veliparuthi |
| 26. | *Parthenium hysterophorus* L. | Parthenium |
| 27. | *Abutilon indicum* (Linn.) Sweet. | Thuthi |

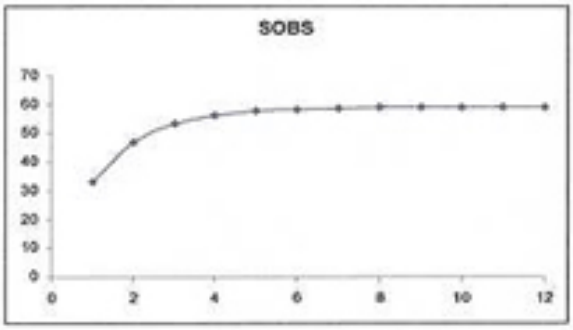
| | | |
|---|---|---|
| 28. | *Tribulus terrestris* Linn | Nerunji |
| 29. | *Prosopis julifera* | Karuvelam |

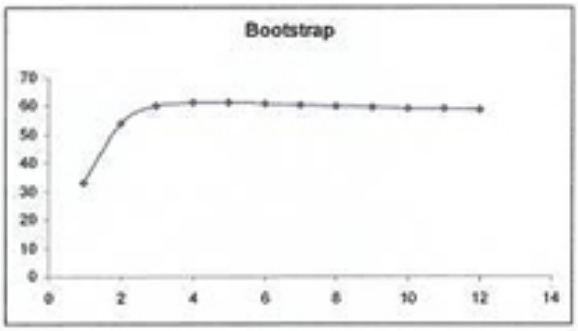
| S.No. | Botanical Name | Common Name |
|---|---|---|
| 30. | *Polyalthia longifolia* (Sonner) Thw. | Nedulingam |
| 31. | *Tamarindus indica* L. | Puli |
| 32. | *Thespesia populanea* (L.) Soland. | Poovarasu |
| 33. | *Aloe vera* (L.) Burm.f. | Sodrukathalai |
| 34. | *Ricinus communis* L. | Athalai |
| 35. | *Croton sparsiflorus* Morong | |
| 36. | *Opuntia* | Kalli |
| 37. | *Ziziphus* | |
| 38. | *Aerva lanata* (L.) Juss. ex. Sch. | Kanupula sedi |
| 39. | *Cassia auriculata* L. | Avarai |
| 40. | *Morinda tinctoria* Roxb | Manchanathi |
| 41. | *Cuscuta* L. | |
| 42. | *Tectona grandis* L. f. | Thekku |
| 43. | *Hibiscus rosa-sinensis* L. | Chembaruthi |
| 44. | *Acacia planiformis* Wight & Arn | Odaimaram |
| 45. | *Samanea samen* (Jacq.) Marrill. | Thungumungi maram |
| 46. | *Millingtonia hortensis* L. | Pannerpoomaram |
| 47. | *Tridax procumbens* L | |
| 48. | *Leucaena leucocephala* (Lamk) Wit. | Subapull |
| 49. | *Agave americana* L. | |
| 50. | *Albizzia lebbeck* Benth. | Vagai |

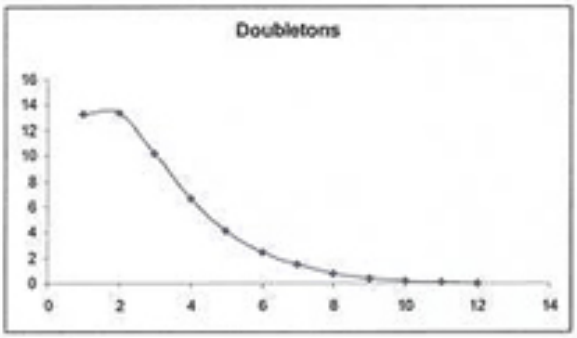
| | | |
|---|---|---|
| 51. | *Terminalia catappa* L. | Vatham |
| 52. | *Typha latifolia* | |
| 53. | *Achyranthes aspera* | Nayuruvi |
| 54. | *Jatropha gossifolia* | |
| 55. | *Musa paradisiaca* L. | Vallai |
| 56. | *Bougainvillea spectabilis* | Kakithapoo |
| 57. | *Eucalyptus* | |
| 58. | *Marsilea* | |
| 59. | *Arundina* | |



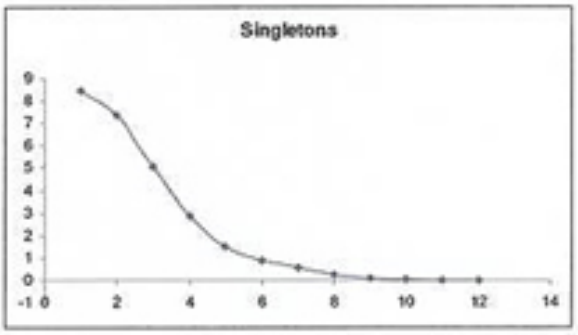



**Fig 1: Observed and Estimated area – curves of the SIPCOT Industrial Park.**

**Table 2: Consolidated details on the floral diversity of the SIPCOT Industrial Park.**

| | |
|---|---|
| Number of Species | 59 |
| Number of Individuals | 972 |
| Dominance | 0.041 |
| Shannon Diversity | 3.33 |
| Simpson | 0.95 |
| Evenness | 0.86 |
| Menhinick | 3.64 |
| Margalef | 7.23 |
| Equitability index | 0.95 |
| Fisher alpha diversity | 20.77 |
| Berger-Parker | 0.08 |

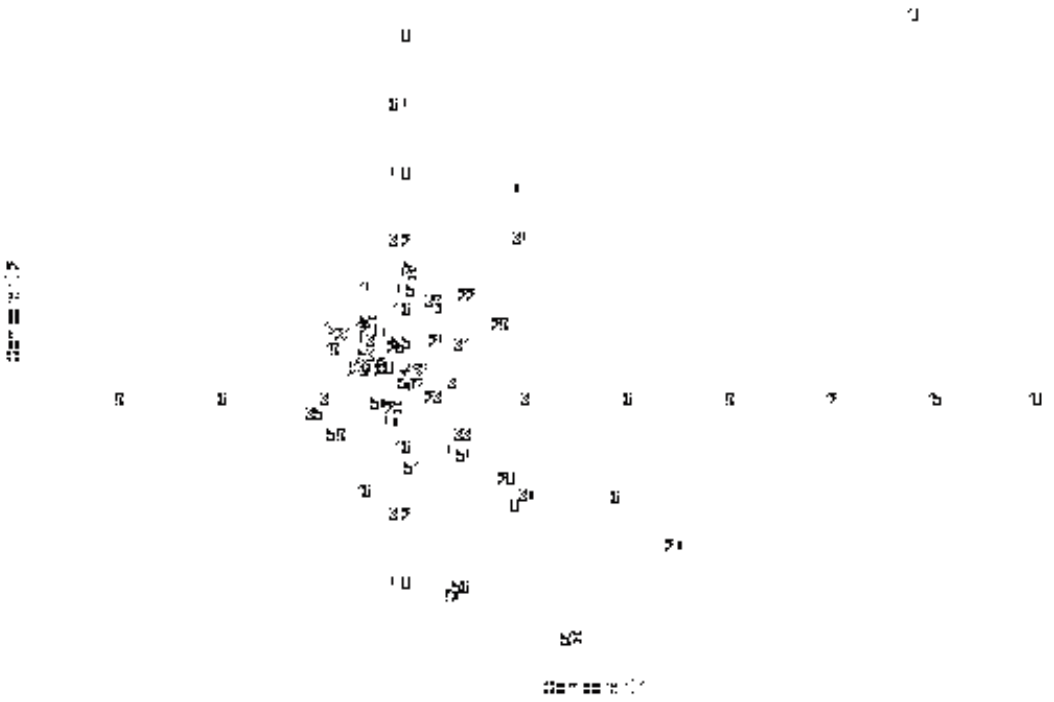


**Fig 2: Principal Component Analysis of floral species distribution in the SIPCOT Industrial Park. Refer table 1 for the species list.**

**Table 3: Kulczynski Comparison**

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample 1* | * | * | * | * | * | * | * | * | * | * | * | * |
| *Sample 2* | 35 | * | * | * | * | * | * | * | * | * | * | * |
| *Sample 3* | 64.17 | 40.66 | * | * | * | * | * | * | * | * | * | * |
| *Sample 4* | 56.47 | 59.71 | 48.61 | * | * | * | * | * | * | * | * | * |
| *Sample 5* | 60 | 50.91 | 61.11 | 43.92 | * | * | * | * | * | * | * | * |
| *Sample 6* | 58.13 | 49.24 | 64.93 | 66.73 | 38.75 | * | * | * | * | * | * | * |
| *Sample 7* | 63.38 | 57.33 | 71.25 | 53.62 | 66.4 | 46.62 | * | * | * | * | * | * |
| *Sample 8* | 63.33 | 54.09 | 61.11 | 53.33 | 60 | 51.67 | 57.34 | * | * | * | * | * |
| *Sample 9* | 65.61 | 59.45 | 64.91 | 52.94 | 65.61 | 54.69 | 64.01 | 53.68 | * | * | * | * |
| *Sample 10* | 67.81 | 58.48 | 61.98 | 63.69 | 64.58 | 53.13 | 67.02 | 54.9 | 63.32 | * | * | * |
| Sample 11 | 65.59 | 56.3 | 51.03 | 55.5 | 45.91 | 60.33 | 59.29 | 62.31 | 61.5 | 44.46 | * | * |
| *Sample 12* | 46.67 | 57.27 | 61.11 | 40.78 | 63.33 | 54.9 | 69.41 | 53.33 | 59.65 | 58.13 | 42.63 | * |

## Table 4: Rank Correlation

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | 1 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | -0.1408 | 1 | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 0.3381 | -0.2732 | 1 | * | * | * | * | * | * | * | * | * |
| Sample 4 | 0.2249 | 0.1709 | 0.0907 | 1 | * | * | * | * | * | * | * | * |
| Sample 5 | 0.2907 | 0.1201 | 0.2398 | -0.0546 | 1 | * | * | * | * | * | * | * |
| Sample 6 | 0.2179 | 0.1652 | 0.3137 | 0.3891 | -0.0705 | 1 | * | * | * | * | * | * |
| Sample 7 | 0.3009 | -0.0091 | 0.2353 | 0.0591 | 0.2849 | -0.1951 | 1 | * | * | * | * | * |
| Sample 8 | 0.4626 | 0.1044 | 0.2376 | 0.1292 | 0.328 | 0.1809 | 0.1102 | 1 | * | * | * | * |
| Sample 9 | 0.2162 | 0.1196 | 0.2846 | -0.0256 | 0.2999 | 0.0856 | 0.1271 | 0.1475 | 1 | * | * | * |
| Sample 10 | 0.5101 | 0.0689 | 0.3127 | 0.2721 | 0.2896 | 0.1298 | 0.3712 | 0.2214 | 0.1771 | 1 | * | * |
| Sample 11 | 0.323 | 0.1352 | 0.1026 | 0.2227 | 0.0639 | 0.2384 | 0.1558 | 0.2088 | 0.2485 | 0.127 | 1 | * |
| Sample 12 | -0.0108 | 0.2924 | 0.1059 | -0.1334 | 0.4251 | 0.133 | 0.3012 | 0.2416 | 0.2356 | 0.2023 | 0.0156 | 1 |

## Table 5: Mann- Whitney

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | * | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | 422 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 534 | 502 | * | * | * | * | * | * | * | * | * | * |
| Sample 4 | 488 | 494 | 598 | * | * | * | * | * | * | * | * | * |
| Sample 5 | 367 | 310 | 410 | 384 | * | * | * | * | * | * | * | * |
| Sample 6 | 442 | 398 | 510 | 474 | 429 | * | * | * | * | * | * | * |
| Sample 7 | 516 | 464 | 592 | 550 | 490 | 590 | * | * | * | * | * | * |
| Sample 8 | 412 | 366 | 468 | 438 | 408 | 474 | 547 | * | * | * | * | * |
| Sample 9 | 518 | 461 | 599 | 558 | 511 | 608 | 697 | 561 | * | * | * | * |
| Sample 10 | 428 | 380 | 496 | 458 | 438 | 502 | 574 | 476 | 600 | * | * | * |
| Sample 11 | 452 | 403 | 535 | 498 | 368 | 450 | 526 | 410 | 531 | 446 | * | * |
| Sample 12 | 348 | 284 | 376 | 356 | 420 | 401 | 457 | 380 | 476 | 410 | 333 | * |

## Table 6: Variance – Covariance

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | 3.6014 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | -0.3141 | 2.4535 | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 0.9696 | -0.5269 | 2.1297 | * | * | * | * | * | * | * | * | * |
| Sample 4 | 0.3939 | 0.3326 | 0.2122 | 2.1321 | * | * | * | * | * | * | * | * |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 5 | 0.6715 | 0.72 | 0.3983 | -0.2721 | 3.1794 | * | * | * | * | * | * | * | |
| Sample 6 | 0.4191 | 1.6108 | 0.9205 | 0.7358 | 0.8545 | 4.1835 | * | * | * | * | * | * | |
| Sample 7 | 1.0009 | -0.358 | 0.3603 | 0.1514 | 0.6826 | -0.8717 | 2.7656 | * | * | * | * | * | |
| Sample 8 | 1.2271 | 0.4906 | 0.4424 | -0.0357 | 0.9077 | 0.8816 | 0.3165 | 2.3308 | * | * | * | * | |
| Sample 9 | 0.1739 | 0.8746 | 0.5488 | -0.3109 | 1.0918 | 1.0529 | 0.322 | 0.5792 | 2.893 | * | * | * | |
| Sample 10 | 1.5798 | -0.2484 | 1.0473 | 0.6888 | 0.2756 | 0.1397 | 0.7934 | 0.3515 | 0.2706 | 3.1473 | * | * | |
| Sample 11 | 0.3349 | -0.1613 | 0.0544 | 0.3936 | -0.0929 | 0.0921 | 0.2826 | 0.0856 | 0.3273 | 0.353 | 1.5675 | * | |
| Sample 12 | -0.6099 | 0.7688 | -0.0561 | -0.5181 | 1.1376 | 0.5362 | 0.6037 | 0.4205 | 1.0465 | 0.13 | -0.1125 | 2.8369 | |

**List of Fauna in the in the SIPCOT Industrial Park and its surroundings**

1. *Ovis aries*- Sheep
2. *Capra aegagrus hircus* - Goat
3. *Canis lupus familiaris* - Dog
4. *Gecko* - Lizard
5. *Felis catus* - Cat
6. *Bos taurus* - Cow
7. *Macaca radiate* - Monkey
8. *Corvus splendens* - Crow
9. *Acridotheres tristis*- Common Myna
10. *Loriculus vernalis* - Parrot
11. *Collocalia esculenta*- Glossy Swiftlet
12. *Tyto alba*- Owl
13. *Columba rupestris* - Pigeon
14. *Dicrurus macrocercus*- Black Drongo
15. *Naja naja oxiana* - Central Asian Cobra
16. *Varanus sp.* - Monitor Lizard
17. *Chamaeleo gracilis* - Graceful Chameleon
18. Bufo *melanostictus* – Indian Toad
19. *Duttaphrynus melanostictus* – Toad
20. Anopheles *rufipes* - Mosquito
21. Anopheles *coustani* - Mosquito
22. *Culex annulioris* - Mosquito
23. *Ficalbia splendens* – Mosquito
24. *Musca domestica* – House fly
25. *Anochetus* - Ant
26. *Technomyrmex* – Ant
27. *Acantholepis* – Ant
28. Ardea *purpurea* - Peria vellai kokku
29. *Ardea cinerea* - Sambal narai
30. *Anaphaeis aurota* - The Pioneer butterfly
31. *Papilio demoleus* – The Lime Butterfly
32. *Pachliopta aristolochiae* – The common Rose Butterfly
33. Troides *Minos* - The Southern Birdwing
34. Danaus *chrysippus* – Plain tiger butterfly
35. *Mycalesis anaxias* – Indian common butterfly

**Table 7: Consolidated details on the faunal diversity in the SIPCOT Industrial Park**

| | |
|---|---|
| Number of species | 35 |
| Number of Individuals | 504 |
| Dominance | 0.07 |
| Shannon index | 2.70 |
| Simpson index | 0.92 |
| Evenness | 0.86 |
| Menhinick | 2.73 |
| Margalef | 4.46 |
| Equitability index | 0.94 |
| Fisher alpha diversity | 11.74 |
| Berger-Parker | 0.131251 |

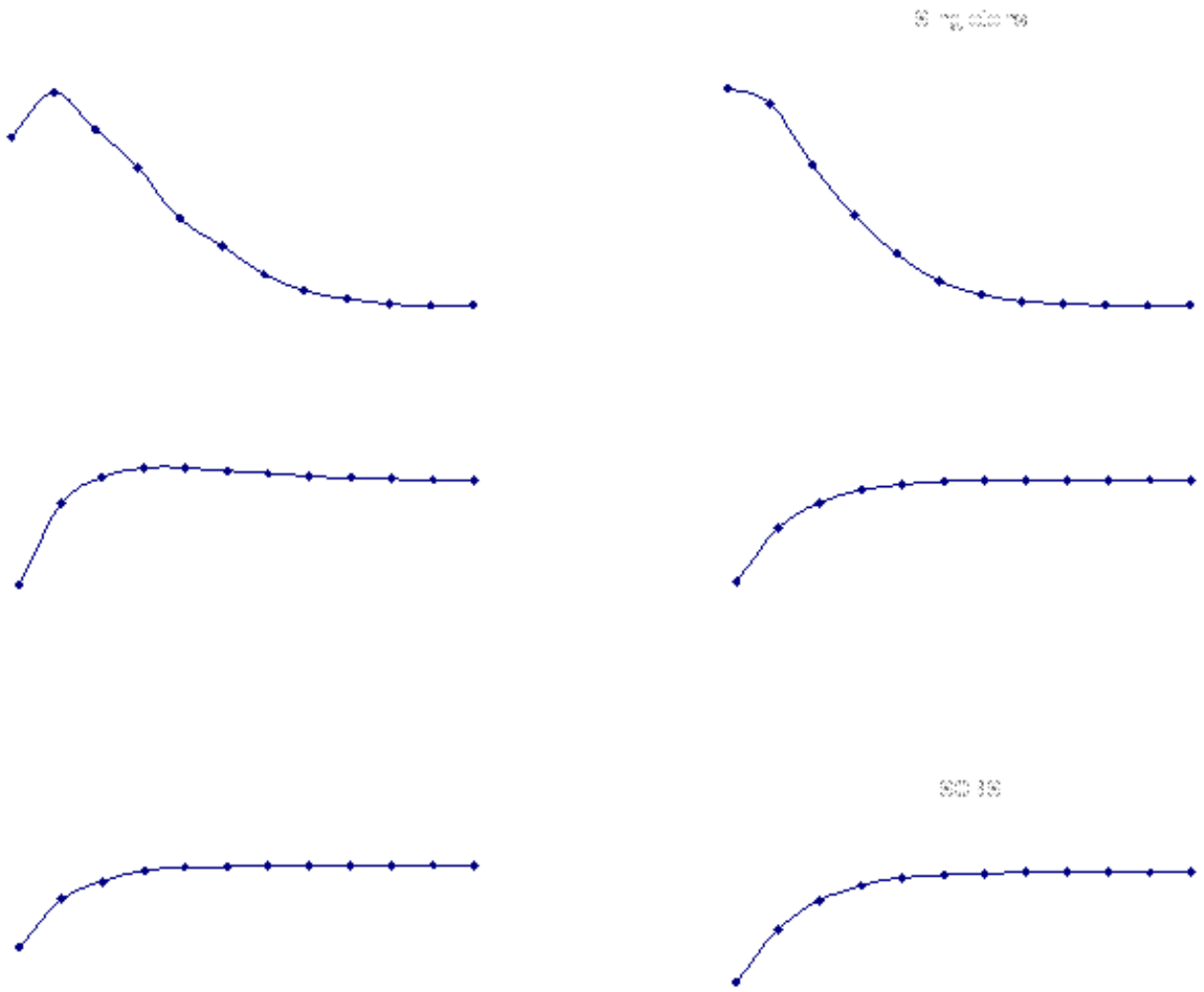


**Fig 3: Observed and estimated species – area curves of fauna in the SIPCOT Industrial Park**

**Fig 4: Principal Component Analysis of faunal species distribution in the SIPCOT Industrial Park.**

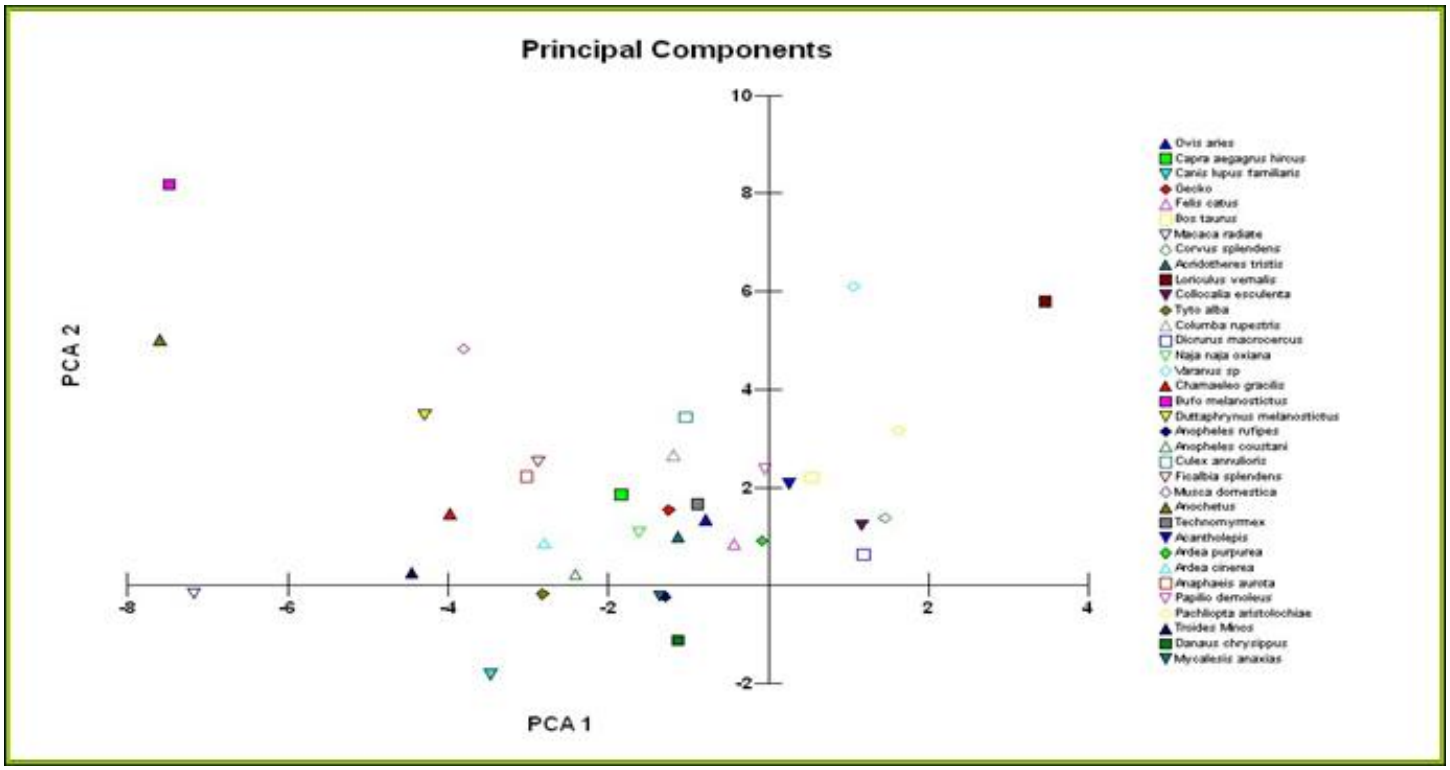
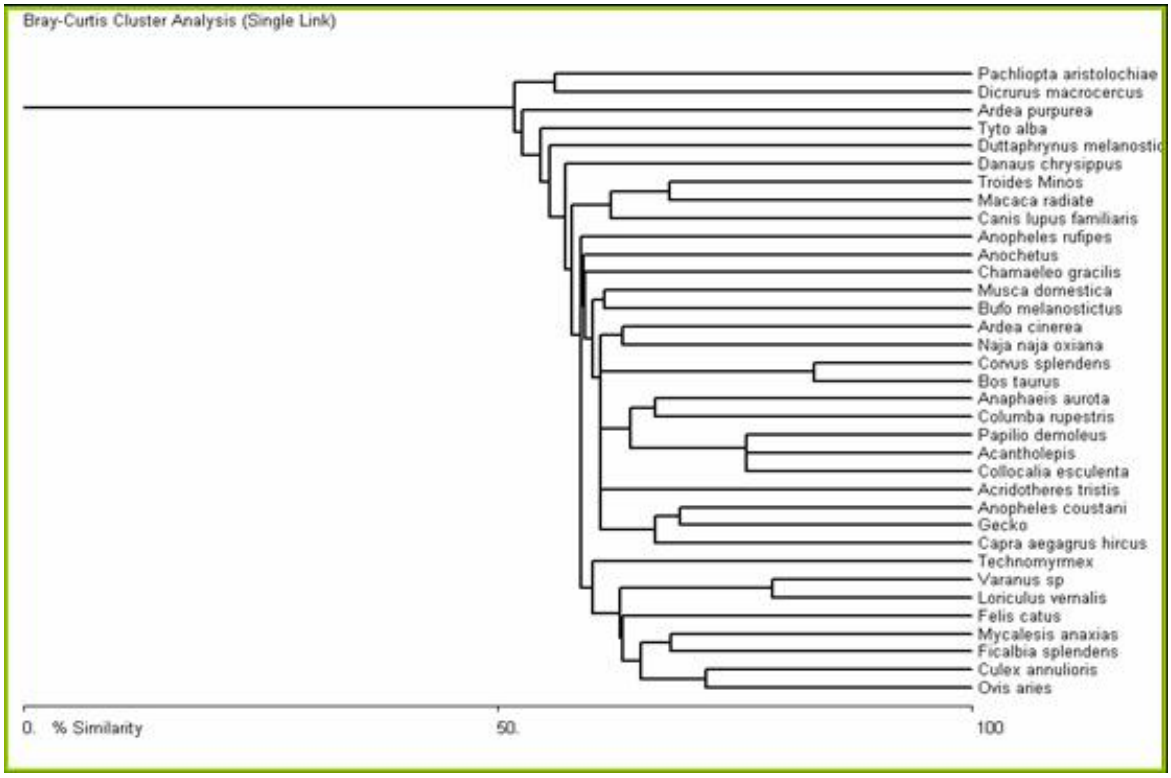



**Fig 5: Cluster diagram produced by the distribution of faunal species in the SIPCOT Industrial Park.**




## Table 8: Kulczynski Comparison

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | * | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | 26.39 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 61.58 | 32.46 | * | * | * | * | * | * | * | * | * | * |
| Sample 4 | 50 | 52.78 | 46.18 | * | * | * | * | * | * | * | * | * |
| Sample 5 | 43.53 | 62.91 | 44.58 | 54.41 | * | * | * | * | * | * | * | * |
| Sample 6 | 65.43 | 59.42 | 76.89 | 56.09 | 46.04 | * | * | * | * | * | * | * |
| Sample 7 | 42.5 | 44.44 | 55.83 | 42.5 | 39.08 | 40.22 | * | * | * | * | * | * |
| Sample 8 | 54.41 | 51.47 | 55.73 | 43.53 | 64.71 | 51.15 | 52.1 | * | * | * | * | * |
| Sample 9 | 55 | 63.33 | 46.18 | 55 | 65.29 | 46.74 | 42.5 | 54.41 | * | * | * | * |
| Sample 10 | 65.29 | 45.75 | 61.3 | 48.97 | 52.94 | 61.38 | 39.08 | 52.94 | 54.41 | * | * | * |
| Sample 11 | 54.64 | 38.1 | 37.22 | 54.64 | 52.1 | 45.96 | 57.14 | 58.61 | 36.43 | 26.05 | * | * |
| Sample 12 | 44.42 | 52.99 | 45.34 | 31.73 | 47.51 | 60.2 | 59.34 | 54.3 | 44.42 | 33.94 | 37.09 | * |

## Table 9: Rank Correlation

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | 1 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | -0.2965 | 1 | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 0.2432 | -0.2781 | 1 | * | * | * | * | * | * | * | * | * |
| Sample 4 | -0.1931 | 0.0992 | -0.1564 | 1 | * | * | * | * | * | * | * | * |
| Sample 5 | -0.1736 | 0.4461 | -0.0585 | 0.1696 | 1 | * | * | * | * | * | * | * |
| Sample 6 | 0.1095 | 0.2658 | 0.3797 | 0.119 | 0.1305 | 1 | * | * | * | * | * | * |
| Sample 7 | 0.0626 | 0.1178 | 0.1882 | 0.1729 | 0.1499 | -0.2383 | 1 | * | * | * | * | * |
| Sample 8 | 0.1022 | 0.1034 | 0.2963 | -0.0303 | 0.4698 | 0.0032 | 0.2838 | 1 | * | * | * | * |
| Sample 9 | -0.1734 | 0.3221 | 0.0091 | -0.0851 | 0.4123 | -0.0065 | 0.0632 | 0.1949 | 1 | * | * | * |
| Sample 10 | 0.4336 | -0.0174 | 0.3579 | -0.0537 | 0.1733 | 0.2 | 0.0519 | 0.1997 | 0.0286 | 1 | * | * |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 11 | 0.1177 | 0.1141 | -0.0479 | 0.3098 | 0.3665 | -0.0052 | 0.3706 | 0.3638 | -0.0653 | -0.0152 | 1 | * |
| Sample 12 | 0.0685 | 0.3791 | 0.2636 | -0.0141 | 0.3849 | 0.2704 | 0.5029 | 0.4091 | 0.2279 | 0.0721 | 0.182 | 1 |

**Table 10: Mann- Whitney**

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | * | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | 179 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 169 | 152 | * | * | * | * | * | * | * | * | * | * |
| Sample 4 | 196 | 176 | 164 | * | * | * | * | * | * | * | * | * |
| Sample 5 | 166 | 150 | 140 | 170 | * | * | * | * | * | * | * | * |
| Sample 6 | 179 | 162 | 141 | 182 | 153 | * | * | * | * | * | * | * |
| Sample 7 | 129 | 118 | 107 | 135 | 112 | 131 | * | * | * | * | * | * |
| Sample 8 | 134 | 122 | 102 | 136 | 113 | 192 | 94 | * | * | * | * | * |
| Sample 9 | 166 | 152 | 134 | 175 | 143 | 208 | 125 | 148 | * | * | * | * |
| Sample 10 | 166 | 151 | 140 | 166 | 144 | 146 | 110 | 102 | 138 | * | * | * |
| Sample 11 | 128 | 118 | 104 | 135 | 110 | 130 | 94 | 90 | 132 | 103 | * | * |
| Sample 12 | 90 | 84 | 66 | 96 | 76 | 145 | 65 | 110 | 106 | 68 | 67 | * |

**Table 11: Variance – Covariance**

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 | Sample 11 | Sample 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample 1 | 3.0555 | * | * | * | * | * | * | * | * | * | * | * |
| Sample 2 | -0.7176 | 2.7529 | * | * | * | * | * | * | * | * | * | * |
| Sample 3 | 0.3723 | -0.8294 | 1.6168 | * | * | * | * | * | * | * | * | * |
| Sample 4 | -0.9933 | 0.4353 | -0.5975 | 2.5748 | * | * | * | * | * | * | * | * |
| Sample 5 | -0.9521 | 0.8294 | -0.1798 | 0.3748 | 2.4571 | * | * | * | * | * | * | * |
| Sample 6 | -0.195 | 1.1412 | 0.6504 | 0.6252 | 1.0429 | 3.7513 | * | * | * | * | * | * |
| Sample 7 | -0.058 | 0.0176 | -0.2034 | 0.0571 | -0.0193 | -0.9807 | 1.963 | * | * | * | * | * |
| Sample 8 | -0.3361 | -0.1176 | 0.521 | -0.3866 | 1.0546 | -0.084 | 0.4664 | 2.5042 | * | * | * | * |
| Sample 9 | -0.9748 | 0.7647 | -0.0714 | -0.7563 | 0.8319 | 0.3151 | 0.1555 | 0.4328 | 2.6639 | * | * | * |
| Sample 10 | 0.637 | -0.3882 | 0.7345 | -0.5387 | -0.2975 | 0.0622 | -0.321 | 0.3445 | -0.4832 | 1.8521 | * | * |
| Sample 11 | -0.3613 | -0.0882 | -0.4076 | 0.3697 | 0.3992 | -0.2521 | 0.2521 | 0.3655 | -0.5252 | -0.3193 | 1.4202 | * |
| Sample 12 | -0.2353 | 0.6765 | 0.1471 | -0.3824 | 0.8824 | 0.3529 | 0.8824 | 0.7647 | 0.6176 | -0.2353 | -0.1471 | 2.1176 |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