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Seasonal diversity, distribution and abundance of Araneae in the Thattekkad Bird Sanctuary, Kerala, India

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ABSTRACT: The aim of the present study was to analyze the diversity of spiders across various parts of the Thattekkad Bird Sanctuary, Kerala, a tropical, semi evergreen, low-land forest located between the tributaries of the Periyar river. Survey of the spider fauna was carried out for a period of twelve months. In total, 3286 individuals were collected from the sanctuary, which consist of 89 species of spiders under 59 genera and 18 families. Araneidae was the most abundant family. The most abundant species was *Hippasa agelenoides* of Lycosidae family. Spiders belonging to six feeding guilds, i.e., orb - web weavers, stalkers, ground runners, scattered line weaver foliage runners and ambushers were identified. Relative abundances of spider community strongly differed with the pre-monsoon, monsoon and post monsoon seasons. Diversity indices - Margalef richness index, Pielou's evenness index, Shannon-Wiener and Simpson index were calculated.

KEYWORDS: Araneidae, dominance, guild, seasonal diversity indices

INTRODUCTION

Spiders are scattered everywhere and are found in almost all habitats. They are also considered indicators of ecosystem health (Mathew *et al.,* 2009). They play a key role in maintaining the ecosystem balance due to their high abundance and insectivorous feeding habits (Wise, 1993). The data on the relative abundance, distribution and richness of taxa serve as a reference for ecological studies and as a basis for conservation planning (Raven and Wilson, 1992; Magurran, 2004). For conservation planning efforts, there should be an understanding of the patterns of diversity on regional scales (Uniyal and Shrivastava, 2012). Spiders can be classified into different guilds based on the similarity in their foraging behavior (Cardo *et al*., 2011; Mansoor lone *et al.,* 2015). Spiders belonging to different foraging guilds and populations were high during the monsoon and winter seasons (Deshmukh and Raut, 2014). Prey density mainly depends on the season and the type of vegetation, which can constantly change throughout the year that, in turn affects the diversity and abundance of spiders (Deshmukh and Raut, 2014). The present work aims to examine the spider population and its

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diversity and abundance in the Thattekkad Bird Sanctuary at various seasons of the year to answer the following questions: (1) which of the spider species are more common in the study area?; (2) what is the diversity and abundance of spiders in the study area? and (3) are there seasonal effects on the spider diversity and abundance in the study area?

MATERIALS AND METHODS

Study Area: The Thattekkad Bird Sanctuary is situated at 10°08' N; 76°41' E and covers an area of 25.16 km^2 on the northern bank of Periyar River. The sanctuary borders Forest Reserve of Kuttampuzha and Neriyamangalam Range and the two rivers Periyar and the Edamalayar. The study area has diverse vegetation types, with large trees such as *Albizia lebbeck. Antidesma bunius. Calophyllum apetalum, Canarium strictum, Hydnocarpus pentandrus, Termanalia paniculate, Symplocos cochinchinensis, Oleadioica* and small plants like *Dioscorea spicata, Argyreia cymosa., Almania species, Mukia maderaspatana, Zonia diphylla, Mimosa pudica, Acacia caesia and Clerodendrum infortunatum.* Sampling was conducted over and along nearby human settlement areas and transition and buffer zones.

Sampling methods: Random quadrat sampling was done in all the seasons. Quadrat sampling is commonly used in terrestrial biodiversity monitoring, in which the observer can collects all taxa in a given area (Schoenly *et al.,* 2003; Corti *et al.,* 2013). To get statistically significant results, 5m X 5m random quadrat samples (replicate samples) were taken from each sampling site at the same time. Standard sampling techniques such as sweep netting, beating sheets, active searching and hand picking were adopted. Samples collected from each sampling plot were noted separately. Sampling was done in every month during the period from February 2017 to January 2018 (monsoon, pre-monsoon, and post-monsoon).

Preservation: The collected samples were anesthetized with chloroform and placed separately in vials containing (75%) ethyl alcohol. The collection dates, collection site, and the number of specimens were recorded on each vial. The collected specimens were studied under a Zeiss Stemi 2000-C stereomicroscope and were identified using standard taxonomic keys (Majumder, 2007; Sebastian, 2009). Identified specimens are further verified on the World Spider Catalog online version (2022). Spider photographs from the field were taken with a Canon EOS 20D camera with Canon 100mm macro photo lens.

Statistical analysis: Plymouth Routines in Multivariate Ecological Research (PRIMER 7e) software (Clarke and Gorley, 2015) was used for the multivariate analysis. Diversity indices like Shannon-Wiener index (H'), Margalef's index (d), Pielou's evenness index (J') and Simpson's dominance (λ) were estimated on the species abundance data. The multivariate procedure includes multidimensional scaling (MDS) (Clarke, 1993); Bray-Curtis coefficient (Bray and Curtis, 1957) was used to produce the ordination plots. Other PRIMER protocols used in the present study include K-dominance curve. This is a plot representing the percentage cumulative abundance against log species rank (Lambshead *et al*., 1983). It is a graphical method used for comparing diversity between samples.

RESULTS AND DISCUSSION

A total of 3286 spider specimens were collected during the study period, of which 699 number of specimens were collected during the pre-monsoon, 1580 in the monsoon and 1007 in the post monsoon seasons. There were 89 species under 59 genera and 18 families (Table 1). Among the families, Araneidae was the most abundant family (40.35%) followed by Lycosidae (20.87%), Salticidae (17.43%), Oxyopidae (5.53%), Tetragnathidae (5.38%), Corinnidae (3.86%), Clubionidae (3.59%), Gnaphosidae (1.86%), Theridiidae (1.22%), Thomicidae (1.19%) and Philodromidae (1.03%). Lowest species diversity was noted in Cheiracanthidae (0.09%), Hersilidae (0.09%), Pholcidae (0.12%), Pisauridae (0.52%), Scytodidae (0.79%), Sparassidae (0.58%) and Uloboridae (0.24%).

The collected species exhibited seasonal variations in their abundance. A total of 72 species, 48 species and 56 species were recorded during monsoon (June, July, August, September), post-monsoon (October, November, December, January) and pre-monsoon seasons (February, March, April, May) respectively. Twenty four species did not show any seasonal changes in their number throughout the year.

Six feeding guilds were identified from the collections. Orb web weavers (36%) were the most dominant guild followed by stalkers (30.3%), ground runners (10.1%), scattered line weavers (9%), foliage runners (7.9%) and ambushers (6.7%).

Season-wise diversity analysis shows that the evenness, richness, and diversity indices of spiders were higher during the monsoon season. Shannon diversity was high in the monsoon season (2.78 ± 0.107) and low in the pre-monsoon season (2.12 ± 0.174). Highest dominance of species was observed during the pre-monsoon season (0.1911 ± 0.028), followed by the post monsoon season (0.16 ± 0.027). Evenness was higher in the monsoon season followed by the post monsoon season (0.77 ± 0.027) and 0.73 ± 0.017 respectively). The maximum species richness index of 5.8 ± 0.213 was recorded during the monsoon season (Table 2).

Similarity of seasonal abundance of the spider species was established by Bray-Curtis and MDS analysis. Cluster analysis (Fig. 1) revealed that there is about 70 per cent similarity in the distribution of spiders in the summer season especially in months of February and January. Samples collected in the months of November-December and February-January showed 57.85 per cent similarity in their species composition. In the non-metric multidimensional scaling (nMDS), plot stress value, 0.1 showed a great representation of the seasonal similarity (Fig. 2). The results revealed the influence of various seasons in the diversity pattern of the spider assemblages during the study period.

Samples collected during the months of March, April and May, appeared in entirely different dimensions and exhibited different diversity compositions. Three distinct clusters were formed with 40 per cent similarity. Samples from November, December, January and February formed a cluster with 40per cent similarity, while samples from August, September and October showed 60 per cent similarity in species abundance.

In k-dominance curves, the cumulative relative abundances of species, ranked in decreasing order of their importance in terms of abundance, are plotted against species rank. The k-dominance curve measures the intrinsic diversity, and in this plot, the lower lines represent samples with higher diversity. In the K-dominance curve, the steepest and elevated curve represents a very low species diversity compared to others and it shows a state of disturbed condition. Seasonal analysis depicted relatively high dominance of spiders during the monsoon season.

The higher curve in a k-dominance plot shows lower evenness and richness in spider diversity. In the K-dominance curve of Pre monsoon season gives an information that in these months there is a disturbed state (Fig. 3).

The diversity analysis showed that, there is some seasonal influence on the distribution of spiders. Monsoon and winter seasons are favorable for their richness as compared to the summer seasons. This may be due to the low temperature and more availability of prey. Studies of Valdez-Mondragón (2006) also showed that the species richness is influenced by increased precipitation that promotes flowering and vegetation growth, providing food for insects, the primary prey of most spiders. Maximum spider diversity was recorded in the wet seasons because of the favorable temperature relative humidity and rain fall, which are suitable for the breeding of mature spiders (Khan *et al*., 2017). The present study revealed that June to October are the most suitable months for spiders compared to other months, as shown by the higher abundance of spiders. Studies by Pitta *et al.* (2019) showed that the community composition of spiders was most strongly influenced by habitat type, availability of prey and temperature. Therefore, the availability and the density of insect populations may also be one of the factors that determine the diversity of

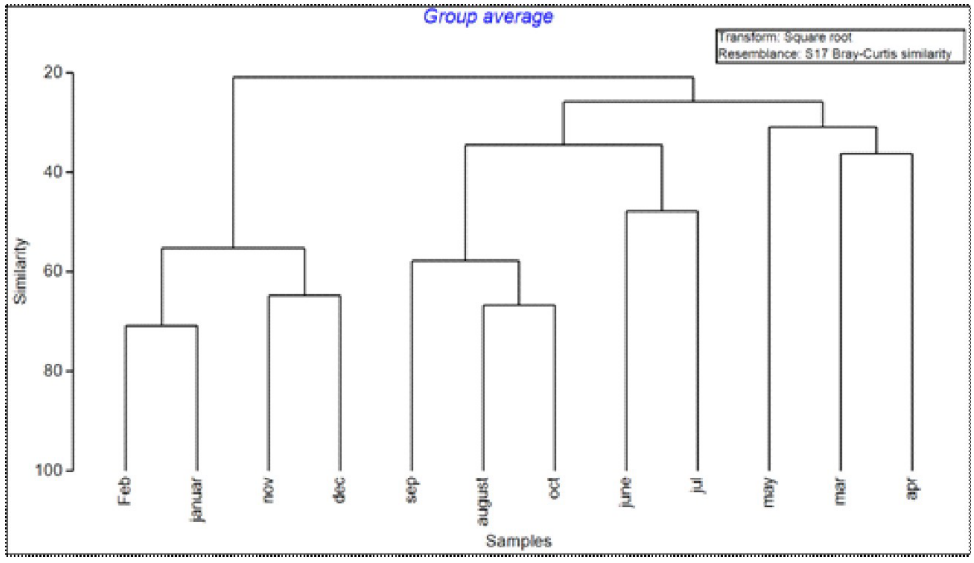


Fig. 1 Cluster diagram showing the similarity of seasonal samples

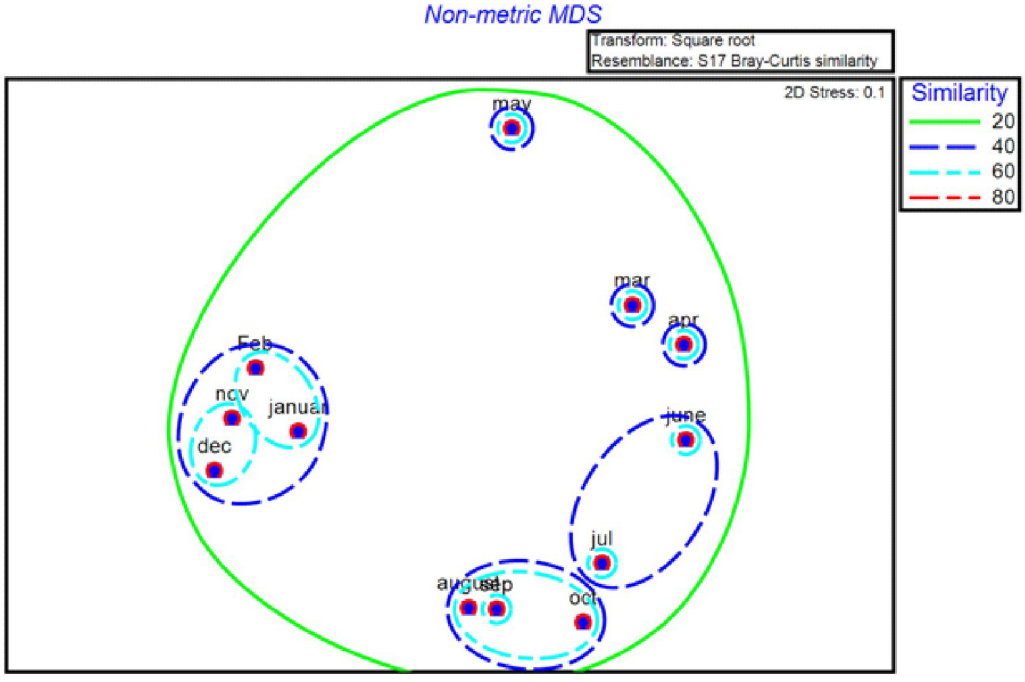


Fig. 2 n MDS plot showing the similarity of seasonal samples

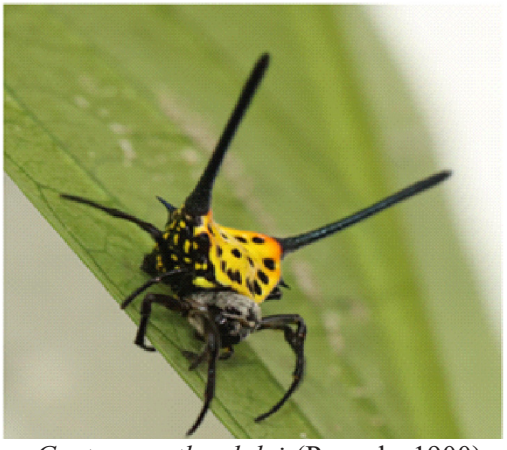
Argiope pulchella (Thorell, 1881)

Anepsion maritatum
(O. Pickard-Cambridge, 1877)

Camaricus formosus (Thorell, 1887)

Leucauge fastigata (Simon, 1877)

Thiania bhamoensis (Thorell, 1887)



Gasteracantha dalyi (Pocock, 1900)

Figs. 4 Common spiders of Thattekkad BirdSanctury, India

Table 1 Checklist of spider species found in Thattekkad Bird Sanctuary

No	Family/ Foraging Guild	Species
1	Araneidae Clerck, 1757/ Orb-web builders	*Arachnura angura* Tikader, 1970
2		*Araneus viridisomus* Gravely, 1921
3		*Argiope aemula* Walckenaer, 1841
4		*A. pulchella* Thorell, 1881
5		*Cyrtophora cicatrosa* Stoliczka, 1869
6		*C. citricola* Forsskal, 1775
7		*Eriovixia excelsa* Simon, 1889
8		*E. laglaizei* Simon, 1877
9		*Gasteracantha geminate* Fabricius, 1798
10		*G. dalyi* Pocock, 1900
11		*Geaspinipes* Koch, 1843
12		*Herennia multipuncta* Doleschall, 1859
13		*Neoscona bengalensis* Tikader&Bal, 1981
14		*N. mukerjei* Tikader, 1980
15		*N. theisi* Walckenaer, 1841
16		*N. vigilans* Blackwall, 1865
17		*Nephila pilipes* Fabricius, 1793
18		*Parawixia dehaani* Doleschall, 1859
19		*Anepsion maritatum* Pickard-Cambridge, 1877
20		*Cyclosa hexatuberculata* Tikader, 1982
21		*Araneus* sp.1
22	Cheiracanthiidae Wagner, 1887/ Foliage runner	*Cheiracanthium melanostomum* Thorell, 1895
23	Clubionidae Wagner, 1887/ Foliage runner	*Clubiona drassodes* Pickard-Cambridge, 1874
24		*C. filicata* Pickard-Cambridge, 1874
25	Corinnidae Karsch, 1880/ Ground runner	*Corinnomma severum* Thorell, 1877
26		*Castianeira zetes* Simon, 1897
27	Gnaphosidae Banks, 1892/ Ground runner	*Poecilochroa barmani* Tikader, 1982
28		*Urozelote spatulusus* Sankaran & Sebastian, 2018
29	Hersiliidae Thorell, 1869/ Foliage runner	*Hersilia savignyi* Lucas, 1836
30	Lycosidae Sundevall, 1833/ Ground runner	*Hippasa agelenoides* Simon, 1884
31		*H. greenalliae* Blackwall, 1867
32		*H. lycosina* Pocock, 1900
33		*Pardosa sumatrana* Thorell, 1890
34	Oxyopidae Thorell, 1869/ Stalkers	*Oxyopes birmanicus* Thorell, 1887
35		*O. javanus* Thorell, 1887
36		*O. bharatae* Gajbe, 1999
37		*O. salticus* Hentz, 1845
38		*O. shweta* Tikader, 1970
39		*O. sunandae* Tikader, 1970
40	Philodromidae Thorell, 1870/ Ambushers	*Thanatus elongatus* Tikader, 1960
41	Pholcidae Koch, 1850/ Scattered line weavers	*Pholcus kapuri* Tikader, 1977
42	Pisauridae Simon, 1890/ Ambushers	*Dendrolycosa gitae* Tikader, 1970
43	Salticidae Blackwall, 1841/ Stalkers	*Epeus albus* Prószynski, 1992

44		*E. sindicus,* Prószyñski, 1992
45		*E. striangulopalpis* Malamel, Nafin, Sudhikumar& Sebastian, 2019
46		*Indopadilla insularis* Malamel, Sankaran & Sebastian, 2015
47		*Brettus cingulatus* Thorell, 1895
48		*Carrhotus sannio* Thorell, 1877
49		*Chalcotropis pennata* Simon, 1902
50		*Hasarius adansoni* Audouin, 1826
51		*Hyllus semicupreus* Simon, 1885
52		*Menemerus bivittatus* Dufour, 1831
53		*Myrmaplata plataleoides* O. P.-Cambridge, 1869
54		*Myrmarachne dirangicus* Bastawade, 2002
55		*M. melanocephala* MacLeay, 1839
56		*Phintella debilis* Thorell, 1891
57		*P. vittate* Koch, 1846
58		*Plexippus paykulli* Audouin, 1826
59		*P. petersi* Karsch, 1878
60		*Telamonia dimidiate* Simon, 1899
61		*Thiania bhamoensis* Thorell, 1887
62		*Thyene bivittate* Xie & Peng, 1995
63		*Evarcha*sp.1
64	Scytodidae Blackwall, 1864/ Foliage runners	*Scytodes fusca* Walckenaer, 1837
65		*S. thoracica* Latreille, 1802
66	Sparassidae Bertkau, 1872/ Foliage runners	*Heteropoda venatoria* Linnaeus, 1767
67		*Olios milleti* Pocock, 1901
68	Tetragnathidae Menge, 1866/ Orb-web builders	*Leucauge decorate* Blackwall, 1864
69		*L. dorsotuberculata* Tikader, 1982
70		*L. granulate* Walckenaer, 1841
71		*L. fastigata* Simon, 1877
72		*L. tessellate* Thorell, 1887
73		*Tetragnatha javana* Thorell, 1890
74		*T. mandibulata* Walckenaer, 1841
75		*T. keyserlingi* Simon, 1890
76		*T. viridorufa* Gravely, 1921
77		*Tylorida ventralis* Thorell, 1877
78	Theridiidae Sundevall, 1833/ Scattered line weavers	*Argyrodes flavescens* O. Pickard-Cambridge, 1880
79		*Chikunia nigra* Pickard-Cambridge, 1880
80		*Chrysso angula* Tikader, 1970
81		*Phycosoma martinae* Roberts, 1983
82		*Theridion zonulatum* Thorell, 1890
83		*Thwaitesia margaritifera* Pickard-Cambridge, 1881
84		*Meotipa* sp.1
85	Thomisidae Sundevall, 1833/ Ambushers	*Indoxysticus minutus* Tikader, 1960
86		*Camaricus formosus* Thorell, 1887
87		*Pistius* sp. 1
88		*Strigoplus netravati* Tikader, 1963
89	Uloboridae Thorell, 1869/ Orb-web builders	*Miagrammopes extensus* Simon, 1889

Table 2. Average seasonal values (mean ± SE) of diversity indices of Thattekkad bird sanctuary during the study period

Seasons	Margalef richness (d)	Pielou'seveness (J')	Shannon Wiener - H' (log_e)	Simpson dominance index (ë)
Pre -monsoon	3.8451 ±0.678	0.711825± 0.041	2.12375±0.174	0.1911± 0.028
Monsoon	5.8730±0.213	0.779425±0.020	2.78025±0.107	0.097035±0.014
Post- monsoon	3.7025±0.720	0.737850±0.017	2.21125±0.176	0.167193±0.027

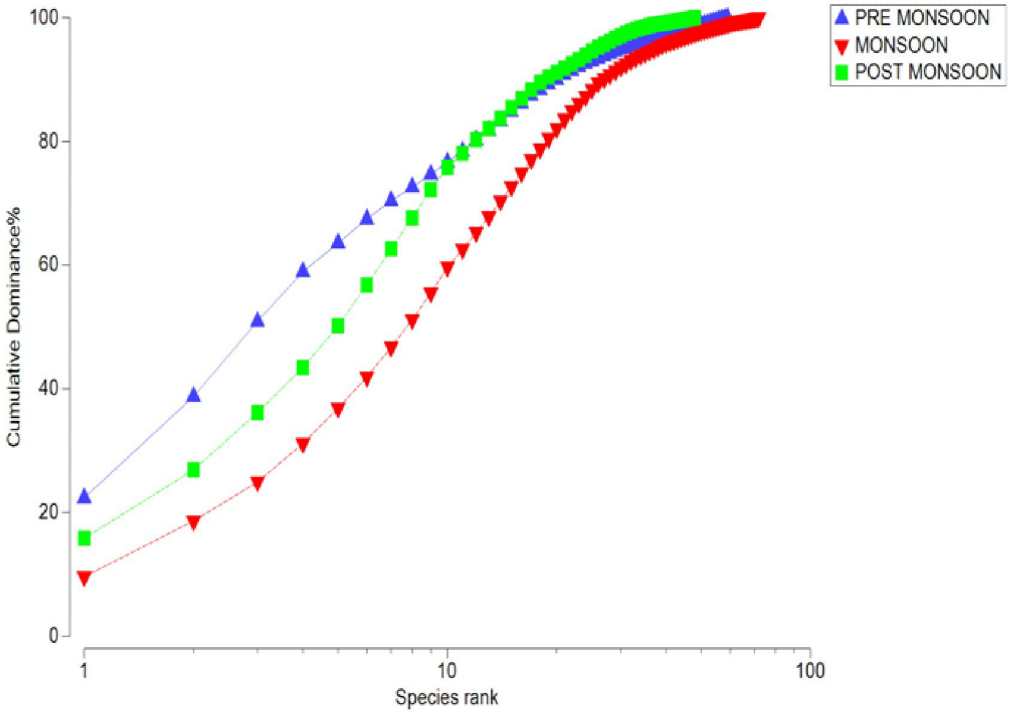


Fig. 3 K - dominance curve showing the seasonal variations

spiders. Dominance curve exhibited seasonal influence on the species composition and abundance of spider communities in Thattekkad sanctuary. The elevated K-dominance curve for the pre-monsoon season provides information that there is a disturbed state showing a low species abundance, which may be due to the environmental stress that makes many intolerant species to become rare (Clarke, 1990). Studies of Deshmukh and Raut (2014) also indicated the influence of similar seasonal variations on the occurrence and diversity of spiders in Salbardi forest, Maharashtra. Forest vegetation plays an important role in species composition and structurally more complex vegetation can sustain higher abundance and diversity of spiders (Sudhikumar *et al.,* 2005). Diverse vegetation hosts a range of insect species, which in turn leads to a large diversity of spiders (Chetia and Kalita, 2012). The floral diversity of about 163 tree species is reported in the Thattekkad Conservation area (Rijuraj *et al.,* 2017). During the monsoon season, some seasonal plants begin to flourish in the sanctuary. This can attract large numbers of insect fauna, which in turn can positively affect spider abundance. Collection of about 89 species indicated that the study area has fairly good population of

spiders and the microhabitats in the sanctuary supports rich spider diversity. So, it is essential to give more emphasis to the spider fauna conservation in these protected areas as they play an important role in the effective functioning of the ecosystem.

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