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Weed Diversity and Community Structure in Agro-ecosystems of Raibag, Belagavi, Karnataka

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ABSTRACT

Abstract: The present study evaluates weed diversity and phytosociology in cultivated ecosystems of Raibag taluk, Belagavi district, Karnataka. Field surveys conducted during May–July 2024 documented a total of 57 weed species belonging to 48 genera and 22 families. Among these, Asteraceae, Poaceae, and Euphorbiaceae were the most dominant families. Quantitative analysis using the quadrat method revealed that Parthenium hysterophorus, Dinebra retroflexa, Apluda mutica, Euphorbia hirta, and Tribulus terrestris exhibited higher density, frequency, abundance, and Importance Value Index (IVI), indicating their ecological dominance. Weed diversity was influenced by edaphic and climatic factors, particularly black cotton soils and seasonal variations. The study highlights the significant impact of weeds on crop productivity due to competition for essential resources. It also emphasizes the importance of ecological assessment for effective weed management strategies and sustainable agricultural practices.

1. Introduction

Biodiversity is a dynamic and essential resource that provides a wide range of biological benefits to human society. However, rapid changes driven by anthropogenic activities and advancing technological development have raised serious concerns about its conservation. Fundamental research focusing on documentation, verification, and systematization of biodiversity is therefore crucial. Among the major drivers of biodiversity change, biological invasions represent a significant component of global environmental change. Invasive alien species, particularly weeds, have emerged as a major focus of conservation concern due to their ecological impacts and increasing spread (Reddy *et al*., 2008).

Within agro-ecosystems, weeds occupy a unique position as both contributors to floristic diversity and as major constraints to agricultural productivity. While their survival is increasingly threatened in certain contexts (Hulina, 2005), they commonly interfere with crop growth by competing for nutrients, water, and light, thereby reducing yield and quality (Das & Verma, 1997). Weed flora diversity is influenced by factors such as crop rotation (Nikolich *et al*., 2012). Despite their negative impacts, weeds also possess beneficial properties, including uses as food, fodder, medicinal resources, and in soil and water conservation (DWSR, 2011). Nonetheless, they are responsible for substantial agricultural losses, often exceeding those caused by other pests such as insects, diseases, and rodents (Rawat, 1987; Yaduraju *et al*., 2006; Prayaga Murty & Venkaiah, 2011).

Climate change further complicates weed dynamics by influencing their growth, distribution, and competitiveness. Elevated atmospheric CO2 levels and temperature changes may favor certain weed groups, particularly C4 species, over C3 crops, while erratic rainfall patterns can alter weed species composition and trigger multiple germination flushes (Misra, 1963; Gulshan, 2012). Additionally, modern agricultural practices, including excessive herbicide use and simplified crop rotations, have contributed to reduced weed diversity and the emergence of herbicide-resistant populations (Palmer & Maurer, 1997; Bayot *et al*., 1994; Murphy et al., 2006). In contrast, organic farming systems emphasize biodiversity conservation and sustainable weed management through crop rotation and reduced chemical inputs (USDA NOP, 2008).

Weeds, often described as unwanted plants, are highly adaptable and classified based on their life cycle into annuals, biennials, and perennials (Rao, 2000). They propagate through seeds as well as vegetative structures such as rhizomes, stolons, tubers, and bulbs, enabling widespread distribution (Rawat, 1987). Weed diversity within agro-ecosystems can be assessed using parameters such as species richness and evenness (Hooper et al., 2005), with field sampling serving as a key method for quantifying weed communities (Hald, 1999; Davis *et al*., 2005). In this context, the present study aims to survey, collect, document, and quantitatively analyze the weed flora of Raibag Tahsil and its surrounding regions.

2. Study area

Raibag taluk of Belagavi district, Karnataka, is located between 15°23′ to 16°58′ N latitude and 74°15′ to 75°28′ E longitude, at an altitude of about 571 m above sea level. It is bounded by Athani in the north, Jamkhandi and Mudhol (Bagalkot district) in the east, Gokak in the south, and Chikodi in the west, comprising 2 hoblies, 59 villages, 33 Gram Panchayats, and 2 municipalities. The region has a semi-arid steppe climate (Köppen BSh) with low annual rainfall (~589 mm) and an average temperature of about 25.2°C, with peak temperatures in April and lowest in December. The area lies on the Deccan Plateau and is dominated by deep black soil with high moisture retention and red loamy soil suitable for irrigation and horticulture. Agriculture is prominent, particularly banana and sugarcane cultivation. The Krishna River forms the northern boundary, contributing to soil fertility through seasonal flooding, while the region also holds cultural significance with the famous Mayakka Devi fair at Chinchali.

3. Methodology

Selection of Sampling Points

Approximately 20 sampling sites were selected using random sampling methods to evaluate the diversity and distribution of weed species in the cultivated ecosystem, following the approach of Panse & Sukhatme (1985).

Collection of Specimens and Herbarium Preparation

Extensive field surveys were conducted from 2023 to 2024 with regular visits across the study area. Plant specimens were collected in duplicate, and field observations such as habit, habitat, flower colour, odour, and distribution were recorded. The collected specimens were pressed using blotting sheets or newspapers and processed using standard herbarium techniques including drying, poisoning, mounting, and labelling as per Jain & Rao (1977).

Plant Identification

Specimens were identified using regional and state floras (Cooke, 1901–1908, repr. 1958; Blatter & McCann, 1984 repr.; Saldanha, 1984, 1996; Singh, 1988; Yadav & Sardesai, 2002) and pictorial guides (Ingalhalikar, 2005, 2007). Herbarium specimens were preserved using Paradichlorobenzene to prevent insect damage (Lawrence, 1951) and treated with 0.1% Mercuric Chloride to control fungal infection (Ravindranath & Premnath, 1997). All specimens were deposited in the Herbarium of the Department of Botany, Government First Grade College, Raibag and classified according to the APG IV system.

Quantitative Assessment

Phytosociological analysis was carried out using the quadrat method, with 1 × 1 m^2 quadrats laid randomly to study herbaceous weeds (including some climbers). Parameters such as density, frequency, abundance, relative density, relative frequency, relative dominance, and Importance Value Index (IVI) were calculated following Curtis & McIntosh (1950), Curtis (1959), and Odum (1971). Density was determined as the number of individuals of a species per total quadrats studied; frequency represented the percentage occurrence of a species across quadrats; and abundance referred to the average number of individuals per quadrat where the species occurred. Relative values were computed to understand species contribution within the community. The IVI was calculated by summing relative density, relative frequency, and relative dominance, providing an overall measure of species importance in the community structure.

4. Results and Discussions

The weeds are the serious problem in agriculture and they enormously reduce the productivity of agricultural lands by competing with crop plants for water, mineral, nutrients, space and light. Introduction of new high yielding varieties of crops require comparatively larger amount of water and fertilizers. Under favourable conditions of high fertility and abundant soil, moisture the chances of the luxuriant growth of weed increase giving rise to new weed communities.
Weeds are generally aggressive in nature. They produce large number of seeds which are viable and will equip for dissemination. Due to these peculiarities weeds spread quickly in cultivated area where they affect the crop growth by absorption of nourishment from soil. A number of weeds found in cultivated crops are of tropical distributions, which

have been introduced together with seeds and seedlings of cultivated plants. In present survey, around 40 sampling points have been assessed to know the weed composition and diversity.

Floristic Study

The present study on weed diversity and phytosociology in the selected area have been evaluated and documented first time. The names of the families are arranged according to the APG IV system of classification. The analysis of the total weed species found is presented in the Table 1.

Table 1
List of Plant species along with their family

Sl. No.	Scientific Name	Family
1	*Abutilon indicum* L.	Malvaceae
2	*Acalypha indica* L.	Euphorbiaceae
3	*Alternanthera pungens* Kunth	Amaranthaceae
4	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae
5	*Apluda mutica* L.	Poaceae
6	*Bidens pilosa* L.	Asteraceae
7	*Calotropis gigantea* (L.) W.T.Aiton	Apocynaceae
8	*Chloris virgata* Sw.	Poaceae
9	*Clerodendrum phlomidis* L.f.	Lamiaceae
10	*Coccinia grandis* (L.) Voigt	Curcurbitaceae
11	*Commelina forskaolii* Vahl	Commelinaceae
12	*Commicarpus chinensis* (L.) Heimerl	Nyctaginaceae
13	*Convolvulus arvensis* L.	Convolvulaceae
14	*Corchorus olitorius* L.	Malvaceae
15	*Croton bonplandianus* Baill.	Euphorbiaceae
16	*Cucumis sativa* L.	Curcurbitaceae
17	*Cyperus rotundus* L.	Cyperaceae
18	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae
19	*Dicliptera paniculata* (Forssk.) I.Darbysh.	Acanthaceae
20	*Digera muricata* (L.) Mart.	Amaranthaceae
21	*Dinebra retroflexa* (Vahl) Panz.	Poaceae
22	*Euphorbia heterophylla* L.	Euphorbiaceae
23	*Euphorbia hirta* L.	Euphorbiaceae
24	*Euphorbia microphylla* Lam.	Euphorbiaceae
25	*Euphorbia thymifolia* L.	Euphorbiaceae
26	*Impatiens balsamina* L.	Balsaminaceae
27	*Indigofera cordifolia* Heyne ex Roth	Fabaceae
28	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae
29	*Ipomoea palmata* Forssk.	Convolvulaceae
30	*Lactuca sativa* L.	Asteraceae
31	*Lantana camera* L.	Verbenaceae
32	*Leucas longifolia* Benth.	Lamiaceae
33	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae
34	*Mirabilis jalapa* L.	Nyctaginaceae
35	*Oxalis corniculata* L.	Oxalidaceae
36	*Parthenium hysterophorus* L.	Asteraceae

Sl. No.	Scientific Name	Family
37	*Phyllanthus amarus* Schumach. & Thonn.	Phyllanthaceae
38	*Phyllanthus maderaspatensis* L.	Phyllanthaceae
39	*Pluchea lanceolata* (DC.) C.B.Clarke	Asteraceae
40	*Polygala chinensis* L.	Polygalaceae
41	*Rostellularia diffusa* (Willd.) Nees	Acanthaceae
42	*Rostellularia procumbens* (L.) Nees	Acanthaceae
43	*Senna auriculata* (L.) Roxb.	Fabaceae
44	*Senna tora* (L.) Roxb.	Fabaceae
45	*Senna uniflora* (Mill.) H.S.Irwin & Barneby	Fabaceae
46	*Setaria verticillata* (L.) P.Beauv.	Poaceae
47	*Solanum indicum* L.	Solanaceae
48	*Sonchus oleraceus* L.	Asteraceae
49	*Stachytarpheta indica* (L.) Vahl	Verbenaceae
50	*Tephrosia purpurea* (L.) Pers.	Fabaceae
51	*Tragus roxburghii* Panigrahi	Poaceae
52	*Tribulus terrestris* L.	Zygophyllaceae
53	*Tridax procumbens* L.	Asteraceae
54	*Urochloa reptans* (L.) Stapf	Poaceae
55	*Vernonia cinerea* L.	Asteraceae
56	*Wedelia chinensis* L.	Asteraceae
57	*Striga densiflora* (Benth.) Benth.	Orobanchaceae

About 57 species of weeds were encountered in the study area under the 48 genera belonging to 22 families. Among 22 families, Asteraceae, Poaceae, Euphorbiaceae were dominated with 8, 7, and 6 species respectively. This was followed by Fabaceae 5 sp., Acanthaceae, Amaranthaceae, Convolvulaceae and Malvaceae contributed with 3 species each. The family Curcurbitaceae, Lamiaceae, Nyctaginaceae, Phyllanthaceae, and Verbenaceae contributed with 2 species each in the study. Nine families were represented with only one species each, they are Apocynaceae, Balsaminaceae, Commelinaceae, Cyperaceae, Orobanchaceae, Oxalidaceae, Polygalaceae, Solanaceae and Zygophyllaceae. Some of the photos are represent in Photoplate 1-4.

Weed species Diversity

Diversity means variety or variability. Species diversity refers to the variation that exits among the different living forms. It is often represented both richness and abundance into a single numerical value. These are therefore referred as heterogeneity indices. A given value of diversity index can result from different combinations of species richness and abundance. It would be very difficult to separate the relative importance of species richness and abundance. Hence these two indices are widely used to represent the average degree of uncertainty in predicting to which particular species, an individual chosen at random from a sample will belong to.

Species Density, Frequency and Abundance

The study area constitutes variety of weed species, various biotic and edaphic factors have played dominant role in determining its growth and their development. The most dominant species in study area was *Parthenium hysterophorus, Dinebra retroflexa, Apluda mutica, Euphorbia hirta, Tribulus terrestris* and *Alternanthera pungens*. The least dominant weed species were *Rostellularia diffusa, Sonchus oleraceus, Oxalis corniculata*, and *Phyllanthus amarus*

Density and Abundance

The species of *Parthenium hysterophorus* (Dn= 8.5, Ab= 21.63) have highest density and abundance, followed by *Dinebra retroflexa* (Dn= 5.75, Ab= 16.43) and *Apluda mutica* (Dn= 5, Ab= 11.11). Other species showing least density and abundance *Oxalis corniculata, Phyllanthus amarus and Cucumis sativa* (Dn= 0.1, Ab=1) tabulated in Table 2.

Frequency

The species of *Parthenium hysterophorus* (Fr= 40) have highest density and abundance, followed by *Apluda mutica* (Fr=45) and *Dinebra retroflexa* (Frn= 35), Other species showing least density and abundance *Oxalis corniculata, Phyllanthus amarus* and *Cucumis sativa* (Frn=5) tabulated in Table 2.

Table 2
Species composition with their density, abundance and frequency

Scientific Name	Density	Abundance	Frequency
Parthenium hysterophorus L.	8.65	21.63	40
Dinebra retroflexa (Vahl) Panz.	5.75	16.43	35
Apluda mutica L.	5	11.11	45
Euphorbia hirta L.	5.35	17.83	30
Tribulus terrestris L.	5.1	20.40	25
Alternanthera pungens Kunth	3.75	8.33	45
Acalypha indica L.	2.8	5.60	50
Cyperus rotundus L.	3.5	14.00	25
Urochloa reptans (L.) Stapf	3.3	11.00	30
Setaria verticillata (L.) P.Beauv.	3.4	17.00	20
Indigofera cordifolia Heyne ex Roth	2.7	6.75	40
Rostellularia procumbens (L.) Nees	2.75	9.17	30
Senna tora (L.) Roxb.	2.7	10.80	25
Euphorbia microphylla Lam.	2.85	14.25	20
Dactyloctenium aegyptium (L.) Willd.	2.65	10.60	25
Alternanthera sessilis (L.) R. Br. ex DC.	2.15	5.38	40
Chloris virgata Sw.	2.15	10.75	20
Croton bonplandianus Baill.	1.8	6.00	30
Calotropis gigantea (L.) W.T.Aiton	0.95	2.11	45
Clerodendrum phlomidis L.f.	1.6	6.40	25
Euphorbia thymifolia L.	1.45	5.80	25
Lantana camera L.	0.9	2.57	35
Senna uniflora (Mill.) H.S.Irwin & Barneby	1.55	10.33	15
Euphorbia heterophylla L.	1.15	4.60	25
Corchorus olitorius L.	0.65	1.63	40
Coccinia grandis (L.) Voigt	0.95	3.17	30
Polygala chinensis L.	1.1	4.40	25
Tridax procumbens L.	1.1	4.40	25
Abutilon indicum L.	0.75	2.14	35
Ipomoea obscura (L.) Ker Gawl.	1.05	4.20	25
Tephrosia purpurea (L.) Pers.	0.85	3.40	25
Digera muricata (L.) Mart.	0.75	3.00	25
Phyllanthus maderaspatensis L.	0.9	4.50	20
Commicarpus chinensis (L.) Heimerl	0.55	1.83	30
Dicliptera paniculata (Forssk.) I.Darbysh.	0.7	2.80	25
Convolvulus arvensis L.	0.5	1.67	30
Stachytarpheta indica (L.) Vahl	0.5	1.67	30
Striga densiflora (Benth.) Benth.	0.65	2.60	25

Wedelia chinensis L.	0.8	4.00	20
Malvastrum coromandelianum (L.) Garcke	0.4	1.60	25
Mirabilis jalapa L.	0.4	1.60	25
Vernonia cinerea L.	0.6	4.00	15
Impatiens balsamina L.	0.4	2.00	20
Solanum indicum L.	0.35	1.75	20
Ipomoea palmata Forssk.	0.3	1.50	20
Tragus roxburghii Panigrahi	0.3	1.50	20
Senna auriculata (L.) Roxb.	0.65	13.00	5
Leucas longifolia Benth.	0.45	4.50	10
Bidens pilosa L.	0.35	3.50	10
Lactuca sativa L.	0.25	2.50	10
Commelina forskaolii Vahl	0.2	2.00	10
Pluchea lanceolata (DC.) C.B.Clarke	0.2	2.00	10
Rostellularia diffusa (Willd.) Nees	0.35	7.00	5
Sonchus oleraceus L.	0.25	5.00	5
Oxalis corniculata L.	0.15	3.00	5
Phyllanthus amarus Schumach. & Thonn.	0.1	2.00	5
Cucumis sativa L.	0.05	1.00	5
	91.5	**353.6900794**	**1380**

Higher characteristic variations in percentage of frequency, density and abundance. Higher frequency, density and abundance of their species in black cotton soil may be due to availability of more water and richer micro flora. Such soils are very rich in nutrients also similar kind observations have been made by Dubey (1968). Seasonal variations in percentage frequency, density and abundance for the weed crop association of jowar and wheat field have been studied by Pathak (1981), Verma (1981), Vinod Shankar (1980). Such variations in % frequency, density and abundance may be attributed to the mechanism of seed germination as also suggested by earlier workers Thurston (1960), Hall (1974), Shivnath & Gupta (1982) and Sharma (1984).

Due to differences in climatic regimes and to the formation of many niches in a micro-climate. Dubey (1968) and Pathak (1981) described that there are some common weed in the cultivated field which having many adaptations such as hard seed coat, branched creeping habit, rooting at each node, enable the species to collect moisture and nutrients from a larger area of black cotton soil.

Importance Value Index (IVI)

Importance value index (IVI) combines relative density, relative frequency and relative dominance can be used to indicate the ecological influence of each species in the ecosystem. Species with the greatest importance value are the most dominant of particular vegetation. The importance value indexes of herb species are shown in Table 3.

Analysis of IVI of a species can be used to recognize the pattern of association of dominant species in a community. Based on their higher IVI value, the ten dominant and ecologically most significant species are *Parthenium hysterophorus, Dinebra retroflexa, Apluda mutica, Euphorbia hirta* and *Tribulus terrestris*. These species might also be the most successful species in regeneration.

Table 3

Important Value index of species

Scientific Name	RDn	RFr	RAb	IVI
Parthenium hysterophorus L.	9.45	2.90	9.45	21.81
Dinebra retroflexa (Vahl) Panz.	6.28	2.54	6.28	15.10
Apluda mutica L.	5.46	3.26	5.46	14.19
Euphorbia hirta L.	5.85	2.17	5.85	13.87

Scientific Name	RDn	RFr	RAb	IVI
Tribulus terrestris L.	5.57	1.81	5.57	12.96
Alternanthera pungens Kunth	4.10	3.26	4.10	11.46
Acalypha indica L.	3.06	3.62	3.06	9.74
Cyperus rotundus L.	3.83	1.81	3.83	9.46
Urochloa reptans (L.) Stapf	3.61	2.17	3.61	9.39
Setaria verticillata (L.) P.Beauv.	3.72	1.45	3.72	8.88
Indigofera cordifolia Heyne ex Roth	2.95	2.90	2.95	8.80
Rostellularia procumbens (L.) Nees	3.01	2.17	3.01	8.18
Senna tora (L.) Roxb.	2.95	1.81	2.95	7.71
Euphorbia microphylla Lam.	3.11	1.45	3.11	7.68
Dactyloctenium aegyptium (L.) Willd.	2.90	1.81	2.90	7.60
Alternanthera sessilis (L.) R. Br. ex DC.	2.35	2.90	2.35	7.60
Chloris virgata Sw.	2.35	1.45	2.35	6.15
Croton bonplandianus Baill.	1.97	2.17	1.97	6.11
Calotropis gigantea (L.) W.T.Aiton	1.04	3.26	1.04	5.34
Clerodendrum phlomidis L.f.	1.75	1.81	1.75	5.31
Euphorbia thymifolia L.	1.58	1.81	1.58	4.98
Lantana camera L.	0.98	2.54	0.98	4.50
Senna uniflora (Mill.) H.S.Irwin & Barneby	1.69	1.09	1.69	4.47
Euphorbia heterophylla L.	1.26	1.81	1.26	4.33
Corchorus olitorius L.	0.71	2.90	0.71	4.32
Coccinia grandis (L.) Voigt	1.04	2.17	1.04	4.25
Polygala chinensis L.	1.20	1.81	1.20	4.22
Tridax procumbens L.	1.20	1.81	1.20	4.22
Abutilon indicum L.	0.82	2.54	0.82	4.18
Ipomoea obscura (L.) Ker Gawl.	1.15	1.81	1.15	4.11
Tephrosia purpurea (L.) Pers.	0.93	1.81	0.93	3.67
Digera muricata (L.) Mart.	0.82	1.81	0.82	3.45
Phyllanthus maderaspatensis L.	0.98	1.45	0.98	3.42
Commicarpus chinensis (L.) Heimerl	0.60	2.17	0.60	3.38
Dicliptera paniculata (Forssk.) I.Darbysh.	0.77	1.81	0.77	3.34
Convolvulus arvensis L.	0.55	2.17	0.55	3.27
Stachytarpheta indica (L.) Vahl	0.55	2.17	0.55	3.27
Striga densiflora (Benth.) Benth.	0.71	1.81	0.71	3.23
Wedelia chinensis L.	0.87	1.45	0.87	3.20
Malvastrum coromandelianum (L.) Garcke	0.44	1.81	0.44	2.69
Mirabilis jalapa L.	0.44	1.81	0.44	2.69
Vernonia cinerea L.	0.66	1.09	0.66	2.40
Impatiens balsamina L.	0.44	1.45	0.44	2.32
Solanum indicum L.	0.38	1.45	0.38	2.21
Ipomoea palmata Forssk.	0.33	1.45	0.33	2.11
Tragus roxburghii Panigrahi	0.33	1.45	0.33	2.11
Senna auriculata (L.) Roxb.	0.71	0.36	0.71	1.78
Leucas longifolia Benth.	0.49	0.72	0.49	1.71

Scientific Name	RDn	RFr	RAb	IVI
Bidens pilosa L.	0.38	0.72	0.38	1.49
Lactuca sativa L.	0.27	0.72	0.27	1.27
Commelina forskaolii Vahl	0.22	0.72	0.22	1.16
Pluchea lanceolata (DC.) C.B.Clarke	0.22	0.72	0.22	1.16
Rostellularia diffusa (Willd.) Nees	0.38	0.36	0.38	1.13
Sonchus oleraceus L.	0.27	0.36	0.27	0.91
Oxalis corniculata L.	0.16	0.36	0.16	0.69
Phyllanthus amarus Schumach. & Thonn.	0.11	0.36	0.11	0.58
Cucumis sativa L.	0.05	0.36	0.05	0.47
	100.00	**100.00**	**100**	**300.00**

RDn (%) = Relative Density, **RFr (%)** = Relative Frequency, **RAb (%)** = Relative Abundance, **IVI**= Important Value Index

Conclusion

The present study highlights the ecological significance of weed communities in cultivated ecosystems and emphasizes the need for eco-physiological investigations of problematic species. A total of 57 weed species belonging to 48 genera and 22 families were recorded, with Asteraceae, Poaceae, and Euphorbiaceae being the most dominant families. The study area exhibited considerable weed diversity influenced by biotic and edaphic factors, with species such as *Parthenium hysterophorus*, *Dinebra retroflexa*, *Apluda mutica*, *Euphorbia hirta*, and *Tribulus terrestris* showing high dominance and ecological significance based on IVI values, while a few species showed minimal occurrence. These weeds compete intensely with crops for essential resources, thereby affecting productivity and increasing cultivation costs. The findings indicate that the study area provides a favorable niche for weed growth, where their interaction with micro- and macro-climatic conditions influences soil nutrient dynamics and water relations, ultimately impacting crop performance and yield.

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