

Butterflies belonging to family Pieridae from Vansda National Park, Dang, Gujarat, India

Sonal Patil¹ and Sujata Magdum^{2*}

¹ & ²PG Department of Zoology and Research center, KRT Arts BH Commerce and AM Science College (KTHM College), Nashik, Maharashtra, India

*Corresponding Author Email: sujata_magdum@yahoo.com

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Abstract

Vansda National Park falls in northern zone of Western Ghats which is amongst 25 biodiversity hot spots in the world. This area falls under protected forest area and comprises of good diversity of flora and fauna. The study was conducted during the year 2017-2018 to record butterfly species diversity from Pieridae family and their abundance with reference to host plants. The survey was done with foot base wandering transect and visual census method. 19 species of butterflies belonging to 10 genera, and 2 subfamilies Pierinae (13 species) and Coliadinae (6 species), from family Pieridae. Shannon diversity index was calculated which is 2.2185. The abundance of butterflies is positively correlated with the better availability of host plant, which is also statistically calculated with the help of Spearman correlation coefficient. Thus, the documentation supports the conservational value of Vansda National Park.

Key words: Vansda National Park, Western Ghats, protected forest area, butterfly species diversity, family Pieridae, subfamily: Pierinae, subfamily: Coliadinae

Introduction

The faunal wealth of our country is enormously diverse and comprises of approximately 81,000 species which represents about 6.7% of world's fauna. In spite of this, in India, there are many regions yet to be explored to record the fauna and flora. This is especially true for insect diversity, which represent a major proportion of the animal diversity of tropical forests [1, 2, 3]. Like most other organisms, insects are more diverse in tropical region than temperate region [4].

Godfray *et al.* [5] confirms that insects are the most numerous and successful group of organisms on earth and according to them two million species are reported throughout the world. Further according to Leather *et al.* [2] these insect species are mostly omitted from the conservation point of view. In view of this, Bone brake *et al.* [6] in 2010 mentioned that these butterflies are the exception and has attracted many of the entomologists who considered them as most ideal insect for studies. Moreover, very importantly these are excellent bio-indicator [7]. Their highly reactive nature and respond to slightest changes in their habitat disturbs the ecological balance. Hence the conservation of habitats and butterflies must be given priority [8]. In this context it can be stated that studies on butterflies are documented by different researchers in varied regions throughout the world.

Order Lepidoptera includes butterflies and moths and is the second largest order of class Insecta. The word lepidoptera is derived from the Greek words "lepidō" for scale and "ptera" for wings. Scales cover the body and wings of most adult butterflies. This order was first studied by Linnaeus in 1758, who classified them into Papilio, Phalaena and Sphinx, which described butterflies, moths and hawkmoths respectively. It is observed that different scientist follow different modes of classification of butterflies. Some of them classify Lepidoptera into four suborders namely Zeugloptera, Aglossata, Heterobathmiina and Glossata. Few others classify them into only two main suborders- Ditrysia, which includes 97% of known species whereas the second suborder Monotrysia includes only 3% species. There are two informal way of dividing the order into categories namely microlepidoptera and macrolepidoptera.

India's northern Himalayan region, Western and Eastern ghats is rich in flora and fauna and therefore recognised amongst 12 mega-biodiversity nations. The Western Ghats is one amongst the 25 biodiversity hotspots in the world. It stretches from Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu covering an area of 159,000 sq km. [9]. Different groups are reporting different fauna from these regions.

Studies on Indian butterflies were initiated by Fabricius in 1775 and till date 1501 species are reported. Kehimkar [10] reported 9% of the total butterfly species in the India when compared with 18,000 species of butterflies in world. These species belong to 5 families namely Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Hesperidae comprising of 320 genera [11,10].

Of the five families of butterflies mentioned above, family Pieridae is considered in present study. Wallace [12] renamed pierid butterflies of the Indian and Australian regions as Coliadini, which included Rhodocerini and Euchloini. Further, Talbot [13] gave the systematics and classification of family Pieridae from India. Enormous work of Ehrlich and Raven [14], enabled them to report 83 genera with a total of 1100 species from family Pieridae throughout the world. Recently Wahalberg *et al.* [15] described systematics and higher classification of pierid based on molecular data.

Diversity of butterflies indirectly reflects overall plant diversity in a given area, hence they are indicators of ecological balance in an ecosystem. Therefore, information on species composition, diversity, preferred host plants, food plants and distribution pattern of butterflies needs periodic updating in protected areas. Ehrlich and Raven [14] also explained a history of long-term coevolution with plants. Kunte [11] documented the larval host plants of butterflies in the Western Ghats region. Later he added 26 new host plants to the 420 known larval host plants from different regions of the Western Ghats [16].

After perusal of literature we found that the lepidopteran studies in areas of Gujarat have been done by Aldrich [17], Mosse [18] Shull [19] recovered 145 species of butterflies from south Gujarat, Parasharya and Jani [20] listed 193 species from Gujarat. Sharma and Sharma [21] documented the butterfly species abundance, richness and diversity of Gir Wildlife Sanctuary of Gujarat Gandhi and Kumar [22] reported butterfly diversity their habitat preferences and seasonal distribution in fragmented habitats and 5 regions which includes Waghai and Saputara.

In the present investigation it's proposed to document the butterflies from Vansda National Park, the northern protected zone of the Western Ghats in Gujarat state. This is a part of research work which includes documentation and reporting of butterflies from Dang Dist., Gujarat, India. This Zone falls in the bio geographic zone "5 Western Ghat", under biotic province - 5A Malabar Coast" and 5B Western Ghat Mountains".

Vansda National Park and Purna Wildlife Sanctuary together form 4.2% of the total geographical area of the Western Ghats zone represented in Gujarat [23]. After 1986 the forest area of was declared as National Park under the Wildlife (Protection) Act, 1972 by the State Forest Department, Government of Gujarat notification no. GANV/3585/WLP/2076/87594 dated 13.vi.1986). The north eastern boundary of the Park is formed of Waghai-Bilimora railway line along with parallel Ambica-Khapri River while the southern boundary is marked by Navtad-Waghai State Highway. The western side is marked by Navtad-Kala Amba road. There are six villages in and around Vansda National Park; Tekpada, Kilad, Navtad, Kevdi, Kala-Amba and Kayai. Among these six villages, Kilad, Kala-Amba and Kayai are located within the National Park and rest are located on the outer boundary of the National Park. Three- fourth of the Vansda National park falls in Nausari district while one-fourth falls in Dang district.

Throughout the worlds protected areas have entrenched to natural habitats thus to conserve biodiversity within these habitat [24].

Material and Methods

Study Area:

Vansda National Park (Fig.1) is geographically located between 20° 51' 16" and 21° 21' 22" N latitudes and 73° 20' 30" and 73°31' 20" E longitudes in Vansda Taluka of Navsari District, Gujarat, India. The total area is 24 sq.km park with hilly terrain hills of moderate altitudes from 110 to 360 meters above sea levels. The forest habitat is classified as south Indian tropical moist deciduous forests 3A/C, type. The subtypes within the area are southern moist mixed deciduous forests - 3B/C, bamboo brakes - 5/E, and tropical riverine forest - 5/1S1 [25].

Permission for work:

The field work commenced after obtaining permission from Chief Wild Life Warden Gujarat State, Gandhinagar, Letter No. WLP/28/C/268-69 and Gujarat Biodiversity board, Gandhinagar Gujarat, Letter No: GBB/BR/2255-57. The entire field plan has been designed in compliance with terms and conditions of the Wild Life (protection) Act and its amendments.

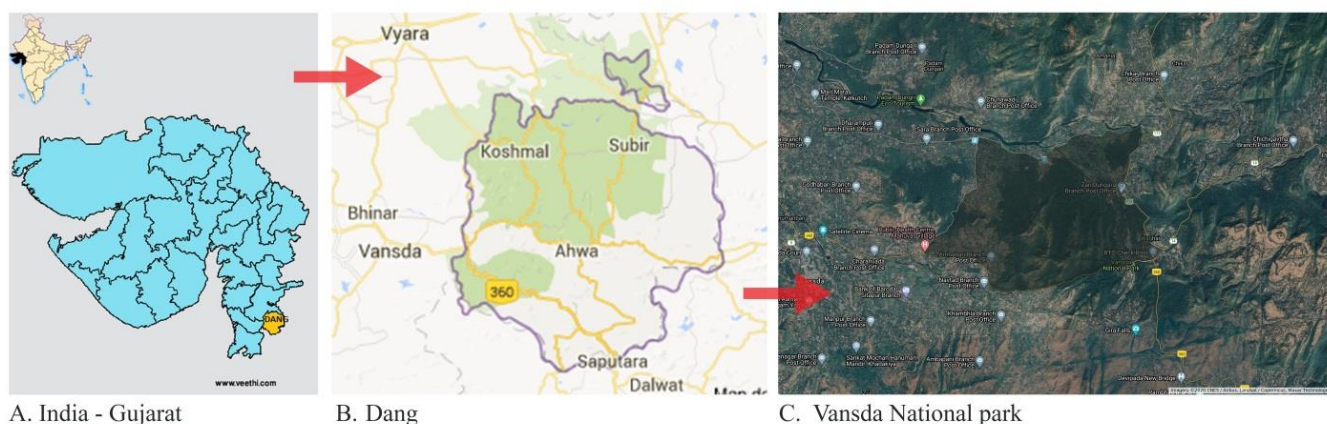


Fig 1: Map of Study Area Vansda National Park .A:www.veethi.com B:www.census india.co.in. C:www.google earth.com

Data collection:

The findings presented here are based on surveys carried out on foot-based random wandering trails for butterflies search and counted by visual census method [26], in morning 9 a.m. till 5 p.m. from 2017 to 2018 which was done bimonthly in the study area. Every effort was made to avoid counting butterfly more than once. Observations included habitat types, viz., closed canopy, shrub land, crop field, along the roads and river/stream beds. Host plants and nectar plants of butterflies were also recorded visually.

Data Analysis:

The diversity indices from in Vansda National Park habitat was calculated using BPMSG diversity online calculator. Chi-square tests of butterfly abundance was performed. Also Spearman's correlation coefficient was also calculated.

Result and Discussion

During 2017-18, the observations were made on sunny days. The typical season was divided into Summer: March, April and May; Monsoon: June, July, August and September, Post-monsoon: October and November, Winter: December, January and February. The availability of the species is recorded and presented in Table 1.

In the present study, emphasis is made to report the species from family Pieridae of Vansda National Park region. In general, the pierids are known as 'whites and yellows', because they possess white or yellow wings having black, orange and red markings. Their fore wings are slightly broad and the wing apex may be narrow and pointed. The hind wings are round and are sometimes toothed. Wings have the radial vein on the forewing with three or four branches and rarely with five branches [27]

Table 1 : Summary of Family Pieridae observed in Vansda National Park

Family	Subfamily	Genus	Scientific names	Common names
Pieridae	Pierinae	Colotis	<i>Colotis amata</i> Fabricius, 1775	Small Salmon Arab
			<i>Colotis danae</i> Fabricius, 1775	Crimson Tip
			<i>Colotis etrida</i> Boisduval, 1836	Small Orange Tip
		Ixias	<i>Ixias marianne</i> Cramer, 1779	White Orange Tip
			<i>Ixias pyrene</i> Linnaeus, 1764	Yellow Orange Tip
		Appias	<i>Appias albina</i> Boisduval 1836	Common Albatross
			<i>Appias libythea</i> Fabricius, 1775	Striped Albatross
		<i>Cepora</i>	<i>Cepora nerissa</i> Fabricius, 1775	Common Gull
		<i>Belenois</i>	<i>Belenois aurota</i> Fabricius, 1773	Pioneer
		<i>Delias</i>	<i>Delias eucharis</i> Drury, 1773	Common Jezebel
	<i>Parerona</i>	<i>Parerona hippia</i> Fabricius, 1787	Common Wanderer	
	<i>Leptosia</i>	<i>Leptosia nina</i> Fabricius, 1793	Psyche	
	Coliadinae	Catopsilia	<i>Catopsilia Pomona</i> Fabricius, 1775	Common Emigrant
			<i>Catopsilia pyranthe</i> Linnaeus, 1758	Mottled Emigrant
		Eurema	<i>Eurema brigitta</i> Stoll, 1780	Small Grass Yellow
			<i>Eurema hecabe</i> Linnaeus, 1758	Common Grass Yellow
			<i>Eurema Blanda</i> Boisduval, 1836	Three Spot Grass Yellow
			<i>Eurema laeta</i> Boisduval, 1836	Spotless Grass Yellow
	<i>Eurema andersonii</i> Huebner, 1819	One spot Grass yellow		
TOTAL	02	10	19	19



1. *Colotis amata* (Small Salmon Arab)



2. *Colotis danae* (Crimson Tip)



3. *Colotis etrida* (Small Orange Tip)



4. *Ixias mariame* (White Orange Tip)



5. *Ixias pyrene* (Yellow Orange Tip)



6. *Appias albina* (Common Albatross)



7. *Appias libythea* (Striped Albatross)



8. *Cepora nerissa* (Common Gull)



9. *Belenois anrota* (Pioneer)



10. *Delias eucharis* (Common Jezebel)



11. *Pareronia valeria* (Common Wanderer)



12. *Leptostia nina* (Psyche)



13. *Catopsilia Pomona* (Common Emigrant)



14. *Catopsilia pyranthe* (Mottled Emigrant)



15. *Eurema* species (Grass Yellows)



16. *Eurema hecabe* (Common Grass Yellow)

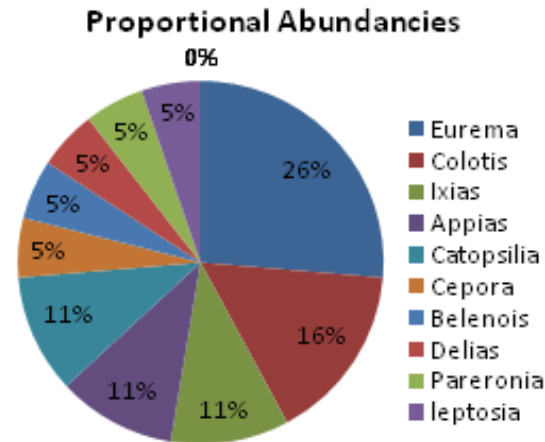


Fig 2 Proportional Abundancies of genera observed in protected area of Vansda National Park

Most of the butterflies keep the wings closed over their backs when they settle, or bask in the sun or at the time of mud puddling, unlike most of the butterflies from other families. However, Varshney [28] had estimated 1,641 species (394 genera) in the Indian region. Gaonkar [29] had marked the subtotal for each family and reported presence of 1,501 species for India, 330 from the Western Ghats and 241 from Sri Lanka. The subfamily-level classification of Indian Pieridae family includes only two groups; Whites and Yellows. The groups are classified into- Subfamily Pierinae comprising of the "Whites". Most members of this subfamily are predominantly white, but some are yellow as well. The second subfamily is Coliadinae which includes yellow butterflies and so is more commonly called "Yellows".

Species composition:

The record of butterflies with in protected area of Vansda park was carried out only by visual census. It provides a poor assessment of the species composition in a particular habitat. However, at the family level the method appears to be more accurate [30]. Many butterfly species can be easily and reliably identified in the field, without killing [31]. Therefore, in the present study, collection of specimen which was strictly avoided as protected area, and adopted only visual census with the aid of binoculars and digital camera. Photographic documentation was done.

In present study 10 genera and 19 butterflies species from family Pieridae were noted in Vanda forest which falls into two subfamilies: Pierinae and Coliadinae. Among these, the genus *Eurema* has the highest recorded 5 species and 3 species were observed for the genus *Colotis*. However, the genera *Catopsilia*, *Ixias* and *Appias* were represented by two species. Genera *Cepora*, *Belenois*, *Delias*, *Pareronia* and *Leptosia* having one species each. (Table 1). Fig 2 gives the graphical representation of 10 genera under study.

Taxonomic Identification of butterflies' was carried out using the characteristics mentioned by Evans[32], Wynter-Blyth [33], Kehimkar [10] Singh [34]. In addition to this all scientific names, common English names and classification of butterflies as mentioned by Varshney and Smetacek [35].

Statistical Analysis:

The diversity indices in Vansda Park using BPMSG diversity online calculator was found to be 0.1413. This is based on the *geometric mean*, and gives "true" diversity of order one. Shannon entropy, which is also known as Shannon diversity index H was 2.1285 indicating the partitioning diversity. As the value is more than zero it can be concluded that the total diversity is very high. If it is found to be zero diversity is considered as low. This is a measure of overall (gamma) diversity into two independent alpha and beta components.

Table 2 : Seasonal occurrence, Host plants and Butterflies from Family Pieridae in Vansda National Park

Sr. No	Scientific names	Status	Seasonal occurrence				Host plants
			Summer	Monsoon	Post Monsoon	Winter	
1	<i>Colotis amata</i>	O	√	√	√		<i>Capparis spp, Salvadoria persica</i>
2	<i>Colotis danae</i>	R		√	√	√	<i>Cadaba fruticosa, Capparis divaricata, Capparis</i>
3	<i>Colotis etrida</i>	C		√	√	√	<i>Cadaba fruticosa, Maerua oblongifolia</i>
4	<i>Ixias marianne</i>	C		√	√		<i>Capparis decidua, Capparis divaricata,</i>
5	<i>Ixias pyrene</i>	C		√	√		<i>Capparis sepiaria, Capparis decidua,</i>
6	<i>Appias albino</i>	C		√	√	√	<i>Drypetes oblongifolia, Drypetes roxburghii, Drypetes venusta</i>
7	<i>Appias libythea</i>	O		√	√		<i>Capparis brivispina, Capparis cleghornii, Capparis sepiaria, Capparis zeylanica, Crateva adansonii</i>
8	<i>Cepora nerissa</i>	C	√	√	√	√	<i>Cadaba fruticosa, Capparis decidua, Capparis rheedii, Capparis sepiaria, Capparis zeylanica</i>
9	<i>Belenois aurota</i>	C	√	√	√		<i>Cadaba fruticosa, Capparis decidua, Capparis pyriformis, Capparis rheedii, Capparis sepiaria, Capparis spinosa, Capparis zeylanica, Maerua oblongifolia</i>
10	<i>Delias eucharis</i>	C	√	√	√	√	<i>Dendrophthoe falcata, Helicanthes elastica, Scurrula parasitica, Viscum spp</i>
11	<i>Pareronia hippia</i>	O	√	√	√		<i>Capparis rheedii, Capparis zeylanica</i>
12	<i>Leptosia nina</i>	C		√	√		<i>Capparis spinosa, Capparis zeylanica, Crateva adansonii, Cleome viscosa</i>
13	<i>Catopsilia Pomona</i>	VC	√	√	√	√	<i>Bauhinia racemosa, Butea monosperma, Cassia fistula, Cassia siamea, Cassia tora</i>
14	<i>Catopsilia pyranthe</i>	VC	√	√	√	√	<i>Cassia auriculata, Cassia fistula, Cassia occidentalis, Cassia tora, Gnidia glauca, Sesbania bispinosa</i>
15	<i>Eurema brigitta</i>	VC	√	√	√	√	<i>Cassia kleinii, Cassia fistula, Cassia obtusifolia, Cassia tora,</i>
16	<i>Eurema hecabe L</i>	VC	√	√	√	√	<i>Acacia spp., Albizia spp., Caesalpinia spp., Cassia fistula, Cassia obtusifolia, Cassia tora, Moulluva spicata, Pithecellobium dulce, Sesbania bispinosa</i>
17	<i>Eurema Blanda</i>	VC	√	√	√	√	<i>Albizia spp., Cassia fistula, Delonix regia, Moulluva spicata, Pithecellobium dulce</i>
18	<i>Eurema laeta</i>	VC	√	√	√		<i>Accacias, Cassia, Leguminous plants,</i>
19	<i>Eurema andersonii</i>	O	√	√	√		<i>Touch me not Plant</i>

Chi-square tests of butterfly abundance was performed for Vansda Park to test if butterfly distributions differed from random expectations, i.e. if individuals distributed among habitat categories according to their relative coverage along the transects.

During the survey of butterflies, their host plants were also recorded. The data is represented into Table 2. Based on the frequency of sightings, butterfly species were divided into four categories, they were VC-very common (> 100 sightings), C-common (50-100 sightings), O-Occasional (10-50 sightings), R-rare (2-10 sightings) [36].

Further it is noted that the abundance of host plants favoured the species in general. The co-relation between host plant and Species diversity was established using Spearman correlation coefficient, r_s . It was found to be 0.3424 which indicates there is positive correlation between the host plants and butterfly species found in Park. The diversity of butterflies reflects the diversity of plants as their larval stages dependent on specific host plants for food [37]. Butterflies have evolved in complex feeding relationship with plants since the development of both larvae and adults takes place on favourable plants [14].

The Sub family Pierinae butterfly members have most of their host plants belong to the families Loranthaceae (Common Jezebel), Euphorbiaceae (Albatrosses), Salvadoraceae (Small Salmon Arab) and Capparaceae (the rest of the group). The Sub family Coliadinae butterfly members have most of their hosts are plants of the families Caesalpinaceae, Apocynaceae, Fabaceae (= Papilionaceae) and Mimosaceae. Thus butterfly diversity defines the local plant diversity, specifically, that of herbs and shrubs within the area [38].

Conclusion

In the present study emphasis was given to record and monitor the butterfly species belonging to family Pieridae. The mode of recording was with the help of visual census method. In doing so the host plants were

also taken into consideration in the study area-Vansda National Park which is protected area. Such study will prove in developing the adaptive mechanism in protecting the different life cycle stages of Pieridae – a step towards conservation of species.

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Conflicts of interest: The authors stated that no conflicts of interest.

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SUPPLEMENTARY DATA- Details of Analysis

Input data:						Results:	
10 Categories/Classes						Diversity Indices	
No	Category	Value	x	x^2	$-x \ln(x)$	Index	Value
1	Colotis	3	15.8%	0.025	0.291	Number of Classes N	10
2	Ixias	2	10.5%	0.011	0.237	Richness R	10
3	Appias	2	10.5%	0.011	0.237	Berger Parker Index p_{imax}	26.3%
4	Cepora	1	5.3%	0.003	0.155	Shannon Entropy ¹⁾ H (nat)	2.1285
5	Belenois	1	5.3%	0.003	0.155	Shannon Entropy ¹⁾ H (bit)	3.0708
6	Delias	1	5.3%	0.003	0.155	Number Eq. 1D (True Diversity)	8.4
7	Pareronia	1	5.3%	0.003	0.155	Shannon Equitability $H/\ln N$	92.4%
8	Leptosia	1	5.3%	0.003	0.155	Simpson Dominance SD	14.1%
9	catopsilia	2	10.5%	0.011	0.237	SD (unbiased - finite samples)	9.4%
10	Eurema	5	26.3%	0.069	0.351	True Diversity 2D (Order 2)	7.1
R1	Simpson Dominance			0.1413		Gini-Simpson Index 1- SD	85.9%
R2	Shannon Entropy			2.1285		Gini-Simpson Equitability	95.4%
						¹⁾ sometimes referred to as Shannon-Weaver or Shannon-Wiener Index	

BPMMSG Tools author: Klaus D. Goepel, BPMMSG. [Contact](#) . Last update: Sep 30, 2019 Rev: 54

ii.)Chi square test

Chi-Square (χ^2) Value = 22.2

Chi-Square Calculator – Results			
Categories	Observed O_i	Expected E_i	Chi-Square Component $(O_i - E_i)^2 / E_i$
Category 1	3	5	0.8
Category 2	2	5	1.8
Category 3	2	5	1.8
Category 4	1	5	3.2
Category 5	1	5	3.2
Category 6	1	5	3.2
Category 7	1	5	3.2
Category 8	1	5	3.2
Category 9	2	5	1.8
Category 10	5	5	0
Total:	19	50	22.2

P-Value from Chi-Square Calculator

Use this tool to calculate the p-value for a given chi-square value and degrees of freedom.

Chi-square Value:

Degrees of Freedom:

P-value Type:

P-value: 0.008266

Calculate Spearman's Rank Correlation Coefficient from the following Data

X	3	2	2	1	1	1	1	1	2	5
Y	5	2	5	8	4	5	3	5	5	8

Solution:

x	y	R _x	R _y	d = R _x - R _y	d ²
3	5	2	5	-3	9
2	2	4	10	-6	36
2	5	4	5	-1	1
1	8	8	1.5	6.5	42.25
1	4	8	8	0	0
1	5	8	5	3	9
1	3	8	9	-1	1
1	5	8	5	3	9
2	5	4	5	-1	1
5	8	1	1.5	-0.5	0.25
---	---	---	---	---	---
--	--	--	--	--	108.5

$$\begin{aligned}
 r &= 1 - \frac{6 \cdot \sum d^2}{n(n^2 - 1)} \\
 &= 1 - \frac{6 \cdot 108.5}{10 \cdot (10^2 - 1)} \\
 &= 1 - \frac{6 \cdot 108.5}{10 \cdot (100 - 1)} \\
 &= 1 - \frac{651}{990} \\
 &= 1 - 0.6576 \\
 &= 0.3424
 \end{aligned}$$

Spearman's Correlation coefficient