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Plant Secondary Metabolites: A Beneficial Resource for both Man and Butterflies-A Review

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Abstract
Traditional healers have long regarded ethnomedicine as a fascinating and appealing topic of study. This makes the proper identification of these plant species all the more vital. It's also worth noting that female butterflies are endowed with the capacity to recognise plants that are conducive to oviposition and, in turn, provide nourishment for their larvae. It is possible that butterflies' ability to choose the correct plant at the right moment demonstrates the relevance of plant secondary metabolites. This class of metabolites is also the foundation for a number of pharmaceutical compositions. As a result, this research aims to emphasise the folklore therapists' use of plant species in the tribal areas of West and East Midnapore, West Bengal, India. The identification of butterflies that feed their larvae on the same plant species was also completed.

Keywords:Butterflies and oviposition; ethnomedicine; secondary metabolites; plant secondary metabolites

1.**Introduction**

Nature has been man's closest friend since the start of civilisation. Even in times of crisis, Nature has been there to help those in need. The ancient systems of medicine (such as Ayurveda, Unani, Siddha, and Homeopathy) remain very popular in spite of the fast urbanisation and contemporary technical advances. Considering that the Rig Vedas reference herbal treatments, and that Indian herbalists such as Maharishi Charaka and Sushruta [1] used them, it's interesting noting how widespread their use has been. Significantly, the WHO has found that 80 percent of individuals in underdeveloped countries choose traditional treatments. [2] Around 8000 kinds of medicinal plants have been discovered among the approximately 17,500 flowering plant species that have been identified as being native to India. [3]

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For forest fringe people, the abundance of nature's resources seems to be a source of ethnomedicine. The rising demand for these plants may be attributed to the widespread usage of traditional herbal remedies, particularly among rural populations. Folklore therapy's use of herbal formulations has become so widespread that effective resource identification and usage is essential.

Insects, on the other hand, are as efficient and possibly even more thorough in their selection of host plants. A wide variety of insect species have evolved a variety of physiological adaptations in order to overcome the plant taxa's defence substrates (i.e., plant secondary metabolic compounds). Four, five, and six] There is an intimate interaction between butterflies and their habitats because of their need on flora, both as adults and as larvae. Nectar resources are required as they mature. The "Botanical Instinct" of butterflies may be shown in their tendency to choose plants that are closely linked to one other for egg depositing. [7] In their larval stages, butterflies often show host plant preference by being either single- or multiple-feeders.

As a result, the larval plant interaction is heavily influenced by their selection of larval host plants. Species-specific secondary metabolites of plants are critical in the selection of larval feeding sources. [8] Additionally, a wide variety of plant secondary metabolites, such as aromatic compounds, nitrogen-containing metabolites like alkaloids, cyanogenic glycosides, glucosinolates, and other isopyrenoids, such as cardiac glycosides, cucurbitacins, iridoid glycosides, and others, are extremely popular among medical practitioners. [9]

Plant Secondary Metabolites (PSMs) play a critical role in the lives of butterflies, and they also serve as the foundation for many folkloric herbal formulas.

2. **StudyArea**

Surveys were undertaken in West Bengal's East Midnapore and West Midnapore, two tribal strongholds. Ethnomedicine is a growing topic in West Bengal, and this research aims to take use of the knowledge of people who live in the region's main tribal areas. Despite their strong religious and cultural connections, their poverty and lack of access to modern medical care have resulted in an increasing reliance on herbal remedies. Herbal compositions based on such in-depth understanding of medicinal plants have given rise to various modern-day medications. [12]

3. **Methodology**

4.Based on informal face-to-face interaction, ethnomedicinal surveys were done with the local population of all castes and faiths with the hope of identifying the most informed individuals (old, aged and experienced people, ojhas, kaviraj and vaidyas). Using a series of semi-structured open ended questions that had been developed in advance, we interviewed a total of 60 informants. In addition to group discussions and casual meetups, if needed, These folk therapists passed on their expertise of folk medicine in a data sheet. No changes were made to the depiction of information supplied by informants, which is notable. These participants' hypotheses about the therapeutic potential of some plants were eventually corroborated by peer-reviewed publications. [3] Photographs of several plant specimens were taken, and the taxonomist's help was used to identify them [13, 14, 15].

5.In the last stage of our research, we looked for butterfly species that feed their larvae on the same plants. Importantly, available literature was used to help characterise larval host plants. [16,17]

6.SecondaryMetabolicconstituentsofethnomedicinalplantspecies

A list of plant secondary metabolites (i.e., alkaloids, terpenoids, glycosides, flavonoids, tannins, cardenolides, and sterols) previously documented from various ethnomedicinal plant species is provided in this paper. **Table1.**

Table 1. List of major phytochemical constituents found in plant species

Sl. No.	Name	Major phytochemical constituents
1	*Hygrophila auriculata* Schumach.	Alkaloids: asteracanthicine, asteracanthine Flavonoids: apigenin 7-O-glucuronide, apigenin-7-O-glucoside Terpenoids: lupeol, betulin, luteolin, luteolin-7-O-retinosides [18]
2	*Aristolochia indica* L.	Terpenoids: α-pinene, pinocarvone, trans-pinocarvol [19]
3	*Calotropis gigantea* (Linn.)Aton f.	Cardiac glycosides: calotropogenin, calotropin [20] Terpenoids: α-amyrin, β-amyrin, α-amyrin methylbutazone, β-amyrin methylbutazone, α-amyrin acetate, β-amyrin acetate, lupeol acetate. [21]
4	*Cryptolepis buchanani* Roem. & Schult.	Alkaloids: buchananine Glycosides: sarverogenin, isosarverogenin Cardenolides: cryptosin, buchanin [22]
5	*Tylophora indica* (Brum. f.) Merr.	Alkaloids: tyloindicines A-J, phenanthroindolizidine alkaloids (tylophorine, tylophorinine, tylophorinidine Flavonoids: quercetin, kaempferol Terpenoids: α-amyrin, β-amyrin [23]
6	*Capparis zeylanica* L.	Glycosides: saponin glycosides Terpenoids: α-amyrin, β-carotene [24]
7	*Quisqualis indica* L.	Tannins: Ellagitannins quisqualin-A, quisqualin-B, [25] , gallic acid [26] Flavonoids: quercetin, rutin [27, 26] Terpenoids : β-sitosterol, lupeol [26]
8	*Ricinus communis* L.	Alkaloids : ricinine Flavonoids : rutinoside, kaempferol derivatives Tepenoids : 1-8 cineole, camphor, α-pinene, β-caryophyllene, epicatechin [28]
9	*Albizia amara* (Roxb.) B. Boivin	Alkaloids: budmunchiamines [29]
10	*Cassia fistula* L.	Glycosides: sennoside-A, sennoside-B Flavonoids: epiafzelechin, epicatechin, biflavonoids, procyanidin B, triflavonoids [30]
11	*Cassia tora* L.	Flavonoids: quercitin, iso-quercitin, emodin, friendlein [31]
12	*Dalbergia sissoo* Roxb. ex DC	Flavonoids: dalbergichromene, dalbergin, dalberginone, methyl dalbergin [32]
13	*Mimosa pudica* L.	Alkaloids: L-mimosine. pinitol Flavonoids: 5 deoxyflavonol derivatives, kaempferol-3-rutinoside, leutolin-3-xyloside, acaetin-7-rutinoside Glycosides: quercetin-7-rhamnoside, quercetin 3-glucoside 7-rhamnoside [33]
14	*Tamarindus indicus* L.	Terpenoids: limonene. caryophyllene, lupanone, lupeol, p-cymene, longifolene [34]
15	*Cinnamomum camphora* (L.)J. Presl.	Terpenoids: cineol, limonene, α-humulene, β-cardinine, D-camphor, α-terpineol, linalool,γ-terpinene, α-pinene, β-pinene, eugenol [35, 36, 37]
16	*Ficus glomerata* Roxb.	Terpenoids:Lanosterol, gluanol acetate, lupeol, α-amyrin acetate, lupeol acetate. Sterols: stigmasterol [38]

17	*Streblus asper* Lour.	Terpenoids: Lupeol, α-amyrin Sterol: β-sitosterol [39]
18	*Oxalis corniculata* L.	Flavonoids: Isoorientin, isovitexin, sertisin, Terpenoids : β-sitosterol, betulin [40]
19	*Cymnopogan citratus* (DC.) Stapf	Terpenoids: citral (geranial and neral) [41]
20	*Portulaca oleracea* L.	Glycosides: Cardiac glycosides, anthraquinone glycosides Flavonoids: kaempferol, quercetin, luteolin, myricetin, genistin [42]
21	*Zizyphus oenopalia* L. (Mill.)	Alkaloids: Zizyphine (A, B, C, D, E, F, I, K, N, O, P), frangufoline, mauritine-D, abyssinine B, A; amphibine B, F [43]
22	*Aegle marmelos* L.	Alkaloids: Aeglin, aegelenine. dictamine, fragrine [44] Terpenoids :α-phellandrene, P-cymene; limonene [45]
23	*Murraya koenigi*(L.) Spreng.	Alkaloids: koenine, koenigine, girininbine, koenimbine, isomahanine, bismahanine. Coumarin glycosides : scopotin, murrayanine [46, 47]
24	*Grewia asiatica* L.	Flavonoids :quercetin, kaempferol, Terpenoid : taraxerol, erythrodiol, lupeol, lupenone, friedlin,β-amyrin [48]
25	*Cinnamomum tamala* (Buch. – Ham.)T. Nees & C. H. Eberm.	Terpenoids :Phellandrene, eugenol, linalool, α-pinene, p-cymene, β-pinene, limonene, phenyl propanoids, furanogermenone [49]
26	*Plumbago zeylanica* L.	Plumbagin [50]

7.**Utilizationofplantsecondarymetabolitesbylarvalstagesofbutterflies:**

Glycosides of the cardiovascular system.

A class of insects specialised in sequestering cardiac glycosides from food sources has been shown to improve insect defences. [51,52] Butterflies that feed on cardiac glycoside-rich Asclepius plants, such as Danainae, are able to integrate these compounds into wing and integument structures. [54,55] The capacity of specialised insects to feed on plant-derived glycosides has been carefully studied. 51 and 52 Insects that have developed the ability to feed on chemically enhanced plant tissues have likely contributed to the diversification of many insect species. Sixty-six to sixtieth.

Flavonoids

Some larval lycaenids store flavonoids from their host plants for integration into their wings, which is the foundation of insect-plant interaction. 61 and 62 Adult butterflies' flavonoid content is closely linked to the percentage of their larval host plant that they ingest. 62, 63, and 64 Flavonoids (especially isovitexin) are being metabolised by larval Pseudozizeeriamaha when it is eating on Oxalis corniculata. Both of these statements are true [65–66]. As a result, the abundance of isovitexin 7-O-glucoside in their larval stages was converted into isovitexin in the pupae. [66] The inflorescence of Medicago sativa is stated to be richer in flavonoid as compared to the solitary leaf of the same plant when fed to lycaenid larvae. [67] It is well-known that herb-feeding lycaenids are capable of manipulating the quantitative defence chemicals present in Fabales, Santalales, and Rosales with great success. When you're 68 and 69 years old, Aristolochiaceae, Apocyanaceae, Asclepiadaceae, and Brassicaceae are known to avoid defence substances like tannins and polyphenolics, which are prevalent in woody plants. [p. 68, p. 69] Caterpillars' ability to resist plant defences by removing harmful chemicals is one of the factors contributing to their unusually wide diet. [70] UV radiation is absorbed by flavonoids, resulting in a brighter, more vibrant colour. [71] Women may store 60 percent more flavonoids than men do, making this a significant difference in health. Flavonoid content in the form of UV patterns on their wings indicates a higher level of female quality and an improved ability to recognise potential mates.

Alkaloids:

Aristolochic Acids (AA), notably AA-I and AA-II, make Aristolochiaceae distinctive in terms of their pharmacological properties. After this, AA-I and AA-II are said to be converted metabolically, whereas AA-II is said to be converted selectively. [72] Larvae of Troidini were able to extract Aristolochic Acids and benzylisoquinoline from their host plants, which they then deposited in their bodies. 73.3 and 74.4 The fact that these butterflies have achieved such a high level of sequestration renders them unappetizing, dangerous, and poisonous to their predators. However, the osmeterial glands of these larvae secrete aristolochic acids when agitated. [52] Mullerian convergence in combination with apostolic colouring gives them ideal examples of mimicry. [75] It's remarkable that Papilionidae use osmeterium for defence reasons in this way. [52,76]

8. PlantSecondaryMetabolites-abeneficialresourceforbothmanandbutterflies

Table 2 lists human reports of the medical effects of the plant species. Intriguingly, the same plants are used as ovipositing substrate by female butterflies at this research location as well. Table2.

Table2.Listofplantspeciesbeneficialforbothmanandbutterflies

Sl. No.	Name	Habitat	Medicinal benefits as reported among humans	Ovipositing butterfly species
1	*Hygrophila auriculata* Schumach.	marshlands	Possess antitumor, antibacterial, antioxidant, hepatoprotective properties [18]	*Junonia orithiya, J.lemonias, J.atlites,J.iphita, J. hierta*
2	*Aristolochia indica* L.	Stream bank, degraded land	Effective against cholera, fever, bowel problems, ulcers, leprosy, snake bites and skin diseases. [77] Also being employed as an abortifacient, antineoplastic [77]	*Atrophaneura hector, A. aristolochiae*
3	*Calotropis gigantea* (Linn.) Aton f.	stream bank, roadsides	Pharmacological activities includes it's use as an antiseptic, anti inflammatory, hepatoprotective, antimyocordial infraction activity and anti diarrhoeal. Plant also beneficial for the treatment of leprosy, tumor and ulcers. [78]	*Danaus chrysippus, Parantica aglea*
4	*Cryptolepis buchanani* Roem. & Schult.	along jungle edges	Used in the treatment of rickets. Decoction of leaves when mixed with honey cures dropsy. Paste of leaves, stem and roots are also applied on ulcers. [3]	*Parantica aglea Euploea core*
5	*Tylophora indica* (Brum. f.) Merr.	wasteland	Possess immunomodulatory, antiimflammatory and anticancer properties [79, 80]	*Tirumala limniace, T. septentrionis, Danaus genutia, D. chrysippus, Parantica aglea*
6	*Capparis zeylanica* L.	hedges	Used as counter irritant and febrifuge. Also effective against cholera and swelling of testicle, boils and small pox. [81]	*Hebomoia glaucippe, Appias libythea, Leptosia nina*

7	*Quisqualis indica* L.	disturbed area	Beneficial against flatulence. Decoction prepared from leaves used to treat asthma and intestinal worms [3]	*Rapala manea, R. varuna*
8	*Ricinus communis* Linn.	wasteland	Useful in the treatment of night blindness, opthalmia, headache, earache, corpulence and cough [3]	*Ariadne ariadne A. merione*
9	*Albizia amara* (Roxb.) B. Boivin	rocky edges	Provides relief from piles, diarrohea, gonorrhea, leprosy, leucoderma,[29] and opthalmia [3]	*Charaxes bernardus, Eurema hecabe*
10	*Cassia fistula* L.	low hill sides	Possess antipyretic, analgesic, [82] anti-tussive and wound healing [83, 84] properties	*Eurema brigitta, E. hecabe, Catopsilia pomona, C.pyranthe*
11	*Cassia tora* Linn.	wasteland	Cures conjunctional congestion caused by liver fire, blurring vision and constipation. Also found to be antifungal, anti inflammatory and antihepatotoxic in nature [31]	*E. hecabe, atopsilia pomona, C.pyranthe*
12	*Dalbergia sissoo:* Roxb. ex DC	riverbanks	Known to exhibit anti microbial, cardiac, antioxidant, antiparasitic, antidiabetic, anti-inflammatory, analgesic, osteogenic, dermatological, gasterointestinal and reproductive effects [32]	*Neptis hylas, Phaedyma columella, Charaxes bernardus*
13	*Mimosa pudica* L.	weed, croplands or pastures	Widely recognised for it's antinociceptive, antihelmintic, hyperglycaemic, immunomodulatory, anticonvulsant, diuretic and wound healing properties [85, 86 87, 88, 89]	*Prosotas nora, P. dubiosa, Junonia orithiya*
14	*Tamarindus indicus* L.	wild or disturbed area	Leaf juice used to treat bleeding piles, painful anuria, pox, dysentery, ulcer and rheumatic pain. Stem used as antipyretic and astringent [3\	*Charaxes bernardus, C. solon*
15	*Cinnamomum camphora* (L.) J. Presl.	Roadsides, forest edges or woodland	Camphor used to treat high fever, measles, delirium, whooping cough, melancholia, chronic bronchitis,	*Graphium sarpedon, G. epycides, Chilasa clytia*

19	*Cymbopogon citratus* Stapf.	disturbed areas	Leaf oil employed to provide remedy against flatulence, spasmodic affection of bowel, gastric irritability, cholera, chronic rheumatism and sprains [3]	*Parnara guttatus, Ampitta dioscorides*
20	*Portulaca oleracea* L.	disturbed area,	Acts as an antiseptic. antispasmodic,vermifuge, antiscorbutic, antibacterial, analgesic, anti-inflammatory, skeletal muscle relaxant, bronchodilator, antipyretic and antiasthma [42]	*Hypolimnas bolina,*
21	*Zizyphus oenopalia* L. (Mill.)	roadside	Widely recognised febrifuge and tonic. Effective in treatment of inflammation of mucus lining of uterus and to cure dysentery [3]	*Tarucus nara,*
22	*Aegle marmelos* Correa.	cultivated dry forest	Known to lower blood glucose levels. [90] Plant possesses antifungal [91] and antispermatogenic effects. [92]	*Papilio polytes, P. demoleus*
23	*Murraya koenigi* (L.) Spreng.	cultivated land	A number of pharmacological activities such as anti-tumor, anti-oxidative, anti-mutagenic and anti-inflammatory have been reported [93, 94]	*Papilio polytes, P. demoleus*
24	*Grewia asiatica* L.	scrubland	Widely recognised as an effective febrifuge, demulcent, Also possess anti diarrohea [48] properties	*Neptis jumbah, N. hylas*
25	*Cinnamomum tamala* (Buch. – Ham.)T. Nees & C. H. Eberm.	riverbed	Is known to be an astringent with carminatine properties. Beneficial for the treatment of itch, diarrhoea, colic, rheumatism, fever, anaemia, nausea and vomiting [49]	*Graphium agamemnon*
26	*Plumbago zeylanica* L.	riverbed	Paste prepared from stem bark effective against piles, Leaf paste applied to swelling and elephantiasis. [3]	*Leptotes plinius*

5. Concludingremarks

Due to their need to survive and thrive at various points in their lives, butterfly larvae may have developed an intimate connection with a small number of plants that produce plant secondary metabolites. Butterflies have been reported to stow away unappetizing or harmful metabolites in order to protect themselves from predators. Aspirin, digitalis, and certain anti-cancer and anti-malarial medications have all come from plant origins, despite their

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widespread usage in contemporary medicine (Grover et al 2002). As a result, ethnobotany may be used to develop new herbal compositions by drawing on the traditional knowledge of the ethnic group's members.

Ethnomedicinal plants that butterflies consume as larvae urge for careful use of these resources by humans.

The already fragile ecology of India's Midnapore districts has been further weakened by a lack of scientific skills and information, as well as by growing urbanisation. [10] From this viewpoint, the current research in East and West Midnaporeis noteworthy.

6. **Acknowledgement**

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