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Weeds as Wealth: An Ethnobotanical and Phytochemical Review of Medicinally Important Weeds and their Therapeutic Relevance to Human Health

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Generally, common men treat weeds as obnoxious plants, but most of the weeds have phytochemicals having different types of therapeutic applications. In this review, we have assessed the ethnobotanical utility, major phytochemicals, pharmacological proof and safety concerns of fifteen medicinal weeds representing thirteen plant families. These species contain various groups of constituents, such as coumestans, lignans, flavonoids, saponins, sesquiterpenes, steroidal glycoalkaloids, cardenolides and several classes of alkaloids. Different investigations support a range of biological activities pertinent to liver, urinary, respiratory, wound-healing and metabolic disorders. Most of the evidence is not consistent and remains predominantly preclinical for most of the species. Most of the literature we have is of traditional knowledge, and traditional use cannot be interpreted as proof of efficacy or safety. Direct clinical evidence is very limited. A few weeds such as Datura, Argemone and Calotropis contain several chemicals, which can be toxic to human beings. If we successfully authenticate them botanically, standardize the extracts, implement marker-based quality control, evaluate their toxic components, and conduct well-designed clinical studies, then these weeds will be the future of medicine and easily accessible bioresources for ethnopharmacological research.

Keywords: weeds, ethnobotany, phytochemicals, traditional medicine, drug discovery, human health, toxicity, medicinal plants

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1. Introduction

Weeds are plants growing in places where they are not wanted, particularly in crop fields, roadsides, wastelands and other disturbed habitats. Their agronomic importance is usually discussed in terms of competition and yield loss. Ethnobotanical research, however, shows that weeds can also be important sources of food, household remedies and medicinal raw materials. Their abundance, rapid regeneration and close association with anthropogenic habitats make them easily accessible to local communities (Stepp, 2004; Stepp & Moerman, 2001).

The connection between traditional plant use and modern pharmacology is well established. Ethnomedicinal knowledge can help prioritize species for chemical and biological investigation, while plant-derived natural products continue to provide pharmacologically useful molecules and structural leads for drug discovery (Fabricant & Farnsworth, 2001; Nasim et al., 2022). This approach is particularly relevant to common weeds because they are frequently overlooked despite their wide distribution and long history of use.

The present narrative review examines fifteen commonly occurring medicinal weeds with four objectives: (i) to summarize their documented ethnobotanical uses; (ii) to identify major reported phytochemicals; (iii) to relate these constituents to experimentally reported biological activities; and (iv) to highlight safety concerns and research gaps. The review distinguishes traditional use from pharmacological evidence and gives greater weight to peer-reviewed reviews, experimental studies and available clinical evidence. This distinction is essential because promising laboratory activity does not by itself establish therapeutic efficacy in humans.

2. Ethnobotanical Profile of Weeds

We have selected fifteen weeds of thirteen different families. Asteraceae and Solanaceae are each represented by two species, while the remaining families are represented by one species each. Most are annual or perennial herbs; these fifteen weeds show taxonomic as well as ecological diversity, ranges from shrub, grass and sedge, examples are shrub *Calotropis procera*, the grass *Cynodon dactylon* and the sedge *Cyperus rotundus*. This illustrates that medicinally used weeds are not confined to a single lineage or growth form (Biswas et al., 2017; Chen et al., 2022; Dhawan & Olweny, 2020; Dinda et al., 2015; He et al., 2017; Islam et al., 2023; Kumar et al., 2010; Mishra et al., 2014; Patocka et al., 2024; Pirzada et al., 2015; Sharma et al., 2021; Timalsina & Devkota, 2021; Wadhwani et al., 2021; Yaduvanshi et al., 2011; Zhou et al., 2015; Zhu et al., 2017).

Traditional preparations are generally simple and use locally available material. Examples include fresh leaf juice or paste for wounds, decoctions of roots or whole plants for urinary or digestive complaints, and direct dietary use in the case of *Portulaca oleracea*. Species-specific reviews document such practices for *Eclipta prostrata, Boerhavia diffusa*, *Tridax procumbens, Euphorbia hirta, Portulaca oleracea* and several other weeds (Dinda et al., 2015; Islam et al., 2023; Kumar et al., 2010; Mishra et al., 2014; Patocka et al., 2024; Sharma et al., 2021; Timalsina & Devkota, 2021; Wadhwani et al., 2021; Yaduvanshi et al., 2011; Zhou et al., 2015; Zhu et al., 2017). These records are valuable as ethnobotanical evidence, but they do not constitute clinical proof of efficacy. Table 1 summarizes the principal traditional uses while explicitly flagging species with important safety concerns.

Table 1: Ethnobotanical Profile of Selected Medicinal Weeds

Species (Family)	Common Name	Part Used	Traditional Use
Eclipta prostrata (Asteraceae)	False daisy / Bhringraj	Whole plant, leaf	Traditional liver and hair-care uses; skin complaints
Boerhavia diffusa (Nyctaginaceae)	Punarnava	Root, whole plant	Diuretic preparations; traditional liver and kidney support
Phyllanthus niruri (Phyllanthaceae)	Bhui amla	Whole plant	Urinary stones; traditional use in jaundice and liver disorders
Achyranthes aspera (Amaranthaceae)	Prickly chaff flower	Root, seed, whole plant	Urinary complaints, cough and inflammatory conditions
Tridax procumbens (Asteraceae)	Coat buttons	Leaf juice	Fresh application to cuts and wounds; haemostatic folk use
Euphorbia hirta (Euphorbiaceae)	Asthma weed	Whole plant	Traditional respiratory and gastrointestinal uses

Cynodon dactylon (Poaceae)	Doob grass	Whole plant, juice	Wounds, bleeding disorders and folk antidiabetic use
Cyperus rotundus (Cyperaceae)	Nagar-motha	Rhizome / tuber	Digestive complaints, fever and inflammatory conditions
Solanum nigrum (Solanaceae)	Black nightshade	Leaf, ripe berry	Traditional liver and skin uses; anti-inflammatory folk use
Portulaca oleracea (Portulacaceae)	Purslane	Whole plant; edible	Food-medicine; antioxidant and metabolic-health folk uses
Calotropis procera (Apocynaceae)	Apple of Sodom	Latex, root bark	Topical folk use for pain and skin complaints; latex is irritant/toxic
Argemone mexicana (Papaveraceae)	Mexican poppy	Latex, aerial parts	Topical folk use for skin complaints; seed oil is toxic and unsafe
Tribulus terrestris (Zygophyllaceae)	Gokhru	Fruit	Urinary and reproductive-health tonic in traditional medicine
Sida cordifolia (Malvaceae)	Bala	Root, whole plant	Traditional respiratory, tonic and anti-inflammatory uses
Datura metel (Solanaceae)	Thorn apple	Leaf/flower in historical preparations	Historical respiratory and analgesic use; highly toxic

Note: *Uses listed in Table 1 are ethnobotanical or traditional reports. They should not be interpreted as recommendations for self-medication, particularly for Datura metel, Calotropis procera and Argemone mexicana.*

3. Phytochemical Profile

The reviewed weeds contain chemically diverse secondary metabolites. Their composition can vary with plant part, developmental stage, geography and extraction method, so a compound reported in one study should not be assumed to occur at the same concentration in all samples. Importantly, the presence of a bioactive phytochemical does not by itself establish clinical efficacy (Biswas et al., 2017; Chen et al., 2022; Dhawan & Olweny, 2020; Dinda et al., 2015; He et al., 2017; Islam et al., 2023; Kumar et al., 2010; Mishra et al., 2014; Nasim et al., 2022; Patocka et al., 2024; Pirzada et al., 2015; Sharma et al., 2021; Timalsina & Devkota, 2021; Wadhwani et al., 2021; Yaduvanshi et al., 2011; Zhou et al., 2015; Zhu et al., 2017). Major groups include:

- Alkaloids - *Datura metel* contains tropane alkaloids such as atropine, hyoscyamine and scopolamine; *Argemone mexicana* contains isoquinoline/benzophenanthridine alkaloids including sanguinarine; and Sida species contain several alkaloidal constituents. These compounds can be pharmacologically active, but they also account for important safety concerns in some species (Dinda et al., 2015; Islam et al., 2023; Patocka et al., 2024; Sharma et al., 2021).
- Flavonoids and other polyphenols - these are widely reported in *Eclipta prostrata*, *Tridax procumbens, Euphorbia hirta, Cynodon dactylon* and *Portulaca oleracea*. Antioxidant, anti-inflammatory and antimicrobial effects are frequently observed in experimental systems (Biswas et al., 2017; Kumar et al., 2010; Timalsina & Devkota, 2021; Yaduvanshi et al., 2011; Zhou et al., 2015).
- Saponins and phytosteroids - steroidal saponins are prominent in *Tribulus terrestris*, while *Achyranthes* species contain saponins and ecdysteroid-related constituents. Reported diuretic, anti-inflammatory and tonic effects are mainly supported by preclinical evidence (He et al., 2017; Zhu et al., 2017).
- Cardenolides - *Calotropis procera* contains cardenolides such as calotropin and uscharin. These compounds have attracted interest for cytotoxic and other biological activities, but they are also central to the plant's cardiotoxic potential (Iyadurai et al., 2020; Wadhwani et al., 2021).
- Lignans - phyllanthin and hypophyllanthin are important marker constituents reported in Phyllanthus materials. Experimental studies have linked lignan-rich preparations with hepatoprotective and other biological effects, whereas human evidence remains limited for many proposed indications (Dhawan & Olweny, 2020).
- Steroidal glycoalkaloids - *Solanum nigrum* contains compounds such as solanine, solamargine and solasonine. Their biological effects are dose- and composition-dependent, and safety is influenced by plant part and maturity (Chen et al., 2022).
- Sesquiterpenes - *Cyperus rotundus* rhizomes contain volatile sesquiterpenes, including cyperene and related compounds. Anti-inflammatory, analgesic and gastrointestinal activities have been reported predominantly in experimental studies (Pirzada et al., 2015).

Table 2 summarizes representative phytochemicals and the level of biological activity most commonly reported for each species. The term 'reported bioactivity' indicates experimental or traditional evidence and should not be read as a statement of proven clinical effectiveness.

Table 2: Phytochemical Profile and Reported Bioactivity

Species	Major Phyto-chemicals	Chemical Class	Reported Bioactivity / Evidence
Eclipta prostrata	Wedelolactone, demethy-lwedelolactone	Coumestans	Hepatoprotective, anti-inflammatory and hair-growth related activity; mainly preclinical
Boerhavia diffusa	Punarnavine, boeravinones	Alkaloid, rotenoids	Diuretic, anti-inflammatory, hepatic and renal effects; mainly preclinical
Phyllanthus niruri	Phyllanthin, hypophyllanthin and related lignans	Lignans	Antilithiatic evidence with limited human studies; other activities largely preclinical
Achyranthes aspera	Achyranthine, ecdysterone, saponins	Alkaloid, ecdysteroid, saponins	Anti-inflammatory and diuretic activity; mainly preclinical
Tridax procumbens	Flavonoids, tannins, carotenoids	Polyphenols and pigments	Wound-healing and antimicrobial activity; preclinical evidence
Euphorbia hirta	Quercitrin, tannins, triterpenes	Flavonoids, polyphenols, triterpenes	Antidiarrhoeal, anti-inflammatory and respiratory-related activity; mainly preclinical
Cynodon dactylon	Flavonoids, phenolics, sterols	Polyphenols and sterols	Wound-healing and hypoglycaemic activity; preclinical evidence
Cyperus rotundus	Cyperene, cyperotundone and related volatiles	Sesquiterpenes	Digestive, anti-inflammatory and antipyretic activity; mainly preclinical
Solanum nigrum	Solanine, solamargine, solasonine	Steroidal glycoalkaloids	Hepatoprotective and cytotoxic activity; dose/composition dependent
Portulaca oleracea	Omega-3 fatty acids, betalains, oleraceins	Fatty acids, betalains, alkaloids/polyphenols	Antioxidant, anti-inflammatory and metabolic effects; evidence varies
Calotropis procera	Calotropin, uscharin	Cardenolides	Cytotoxic and analgesic activity; significant cardiotoxicity risk
Argemone mexicana	Sanguinarine, dihydrosanguinarine, berberine, protopine	Isoquinoline alkaloids	Antimicrobial/cytotoxic activity; seed oil can cause epidemic dropsy
Tribulus terrestris	Protodioscin and other steroidal saponins	Steroidal saponins	Traditional diuretic/tonic use; clinical evidence for sexual-performance claims is inconsistent
Sida cordifolia	Alkaloids including ephedrine-type constituents; flavonoids	Alkaloids, flavonoids	Traditional respiratory/tonic activity; composition varies and safety/regulatory caution is needed
Datura metel	Atropine, hyoscyamine, scopolamine	Tropane alkaloids	Anticholinergic/antispasmodic activity; severe toxicity and narrow safety margin

Note: *Most activities in Table 2 are supported mainly by in vitro or animal studies. Human clinical evidence is limited or inconsistent for many indications.*

4. Human Health Applications

When the species are grouped by traditional indication or experimentally studied organ system, several recurring therapeutic themes appear. These themes are useful for prioritizing research, but the evidence should be interpreted according to its level: ethnobotanical report, in vitro activity, animal study or human clinical study (Biswas et al., 2017; Chen et al., 2022; Dhawan & Olweny, 2020; Dinda et al., 2015; He et al., 2017; Islam et al., 2023; Kumar et al., 2010; Mishra et al., 2014; Patocka et al., 2024; Pirzada et al., 2015; Sharma et al., 2021; Timalsina & Devkota, 2021; Wadhwani et al., 2021; Yaduvanshi et al., 2011; Zhou et al., 2015; Zhu et al., 2017).

4.1 Hepatoprotective Applications

Eclipta prostrata, Boerhavia diffusa and *Solanum nigrum* have substantial preclinical literature describing hepatoprotective or liver-related biological effects (Chen et al., 2022; Mishra et al., 2014; Timalsina & Devkota, 2021). *Phyllanthus niruri* is also widely used in traditional medicine for liver complaints, but robust clinical evidence liver complaints, but robust clinical evidence for treating human liver disease remains insufficient.

Therefore, these species are better regarded as candidates for further pharmacological and clinical investigation than as established hepatoprotective therapies (Chen et al., 2022; Mishra et al., 2014; Timalsina & Devkota, 2021).

4.2 Renal and Urinary Applications

Phyllanthus niruri has one of the more developed human evidence bases among the reviewed weeds for urinary stone disease. A systematic review found limited evidence of modest benefit, but also emphasized the small and heterogeneous nature of the available studies (Dhawan & Olweny, 2020). *Achyranthes aspera* and *Tribulus terrestris* are traditionally used for urinary complaints and have supportive preclinical data, yet large, well-controlled clinical trials are still lacking (He et al., 2017; Zhu et al., 2017).

4.3 Respiratory Applications

Euphorbia hirta, Sida cordifolia and *Datura metel* all have a history of use in respiratory complaints (Dinda et al., 2015; Islam et al., 2023; Kumar et al., 2010; Sharma et al., 2021). Their phytochemistry provides plausible pharmacological explanations for some traditional observations, but this does not establish safe therapeutic use. *Datura metel* is especially hazardous because its tropane alkaloids can cause severe anticholinergic poisoning. Its historical use should therefore be described as ethnobotanical information rather than as a contemporary treatment recommendation (Islam et al., 2023; Sharma et al., 2021).

4.4 Dermatological and Wound-Healing Applications

Tridax procumbens and *Cynodon dactylon* have experimental evidence supporting wound-healing activity, including animal wound models (Biswas et al., 2017; Yaduvanshi et al., 2011). *Calotropis procera* and *Argemone mexicana* also have long-standing topical folk uses, but their latex or alkaloid-rich preparations can be irritating or toxic. These species therefore require careful formulation and toxicological assessment before any therapeutic development (Iyadurai et al., 2020; Patocka et al., 2024; Sharma et al., 2023; Wadhwani et al., 2021).

4.5 Antidiabetic and Metabolic Applications

Portulaca oleracea is nutritionally distinctive because it is edible and contains omega-3 fatty acids, betalains and other antioxidant constituents. Experimental and some human studies have explored its metabolic effects, although results depend on preparation and study design (Zhou et al., 2015). *Cynodon dactylon* has also shown hypoglycaemic activity in streptozotocin-diabetic rats, supporting its status as a preclinical research candidate rather than a clinically established antidiabetic treatment (Singh et al., 2007).

4.6 Nutraceutical and Dietary Relevance

Portulaca oleracea illustrates the food-medicine continuum because it is consumed as a leafy vegetable as well as used traditionally for health-related purposes (Zhou et al., 2015). This nutraceutical framing should not be generalized to all weeds in the review. Toxic species such as *Datura metel, Argemone mexicana* and *Calotropis procera* must not be treated as edible or casually medicinal resources (Islam et al., 2023; Iyadurai et al., 2020; Patocka et al., 2024; Sharma et al., 2021; Sharma et al., 2023; Wadhwani et al., 2021).

5. Toxicity and Safety Considerations

Traditional use does not guarantee safety. *Datura metel* can produce severe antimuscarinic toxicity because of atropine, hyoscyamine and scopolamine (Islam et al., 2023; Sharma et al., 2021). *Calotropis procera* contains cardenolides and an irritant latex; serious cardiac toxicity has been documented after inappropriate exposure or ingestion (Iyadurai et al., 2020; Wadhwani et al., 2021). *Argemone mexicana* seeds and seed oil contain toxic alkaloids, especially sanguinarine-related compounds, and contamination of edible oil with Argemone oil is a recognized cause of epidemic dropsy (Patocka et al., 2024; Sharma et al., 2023). *Solanum nigrum* also requires correct botanical identification, plant-part selection and maturity assessment because steroidal glycoalkaloid content can vary (Chen et al., 2022). For all medicinal weeds, safe development requires authenticated plant material, standardized extracts, dose-response studies, interaction assessment and formal toxicological evaluation.

6. Discussion

The combined ethnobotanical and phytochemical evidence support the central idea of 'weeds as wealth', but only when the phrase is used critically.

Traditional use can serve as a practical hypothesis-generating tool for selecting species, and modern natural-product research provides methods for testing those hypotheses (Fabricant & Farnsworth, 2001; Nasim et al., 2022; Stepp, 2004; Stepp & Moerman, 2001). In several cases, there is a biologically plausible relationship between traditional use and experimentally observed activity. For example, wound-healing studies on *Tridax procumbens* and *Cynodon dactylon* support their folk application to wounds, while the anticholinergic pharmacology of Datura alkaloids helps explain its historical respiratory use (Biswas et al., 2017; Islam et al., 2023; Sharma et al., 2021; Yaduvanshi et al., 2011). Such agreement is scientifically interesting, but it is not equivalent to clinical validation.

The major limitation across the reviewed literature is the uneven evidence base. Many studies use different plant parts, extraction solvents, doses and experimental models, making direct comparison difficult. Botanical misidentification, chemotypic variation and insufficient chemical standardization can further reduce reproducibility. Future work should therefore prioritize quantitative marker profiling, standardized extraction, bioactivity-guided fractionation, mechanism-based assays and rigorous toxicology. Where preclinical evidence is strong, adequately powered controlled clinical studies should follow. Research should also document traditional knowledge ethically and recognize that sustainable use does not mean indiscriminate harvesting or promotion of toxic species (Dinda et al., 2015; Fabricant & Farnsworth, 2001; Islam et al., 2023; Iyadurai et al., 2020; Nasim et al., 2022; Patocka et al., 2024; Sharma et al., 2021; Sharma et al., 2023; Wadhwani et al., 2021; Zhu et al., 2017).

7. Conclusion

The fifteen weeds reviewed here show that common ruderal and agricultural plants can contain diverse bioactive molecules and preserve valuable ethnobotanical knowledge. Their potential spans drug-lead discovery, pharmacological research and, for suitable edible species, nutraceutical development. At the same time, the current evidence base is largely preclinical, and several species have important toxicity concerns.

The most scientifically defensible view is therefore not that weeds are ready-made medicines, but that they are accessible biological resources worthy of careful investigation. Converting 'weeds as wealth' from a traditional concept into evidence-based application will require accurate taxonomy, standardized phytochemistry, toxicological assessment and high-quality clinical validation.

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