INDONESIAN JOURNAL OF INNOVATION AND APPLIED SCIENCES (IJIAS)
Journal Homepage: https://ojs.literacyinstitute.org/index.php/ijias
E-ISSN: 2775-4162

Volume 6	Issue 1	February (2026)	DOI: 10.47540/ijias.v6i1.2572	Page: 79 – 85

Ethnopharmacological insights into tropical medicinal plants: biodiversity, bioactive compounds, and therapeutic potential for modern drug discovery

Umar Aminu Mohammed[1], Kamal Abdullahi[1], Zainab Auwal Zigau[1], Amina Mukhtar[2], Aisha Mustapha[2]

[1]Department of Biological Sciences, Saadu Zungur University, Nigeria
[2]Department of Biology, Federal University of Health Sciences, Nigeria
Corresponding Author: Umar Aminu Mohammed; Email: uaminumohmmed@sazu.edu.ng

A R T I C L E I N F O

Keywords: Bioactive and Biodiversity, Ethnopharmacology, Medicinal Plants.

Received : 26 January 2026
Revised : 06 February 2026
Accepted : 09 February 2026

A B S T R A C T

Recent scholarly debates on equitable bioprospecting, intensified since the 2010 Nagoya Protocol, have exposed a critical gap in linking tropical plant biodiversity to validated pharmacological outcomes, particularly where habitat degradation accelerates species loss. Hitherto, ethnobotanical knowledge from the Amazon, Congo, and Southeast Asian basins regions dominated by Asteraceae, Rubiaceae, and Fabaceae has informed drug leads, yet systematic validation lags. This review, adhering to PRISMA-ScR standards, screened a lot of peer-reviewed records (2015–2026) via dual-independent extraction, yielding several studies on plant species with medicinal properties. Indigenous applications, such as *Artemisia annua* against malaria or *Momordica charantia* for glycemic control, find partial backing from in vitro assays and select rodent models. Alkaloids like quinine (*Cinchona spp*.), terpenoids including artemisinin, alongside flavonoids and phenolics, disrupt cancer proliferation, thwart microbial resistance, and mitigate neurodegeneration, evidence drawn from cytotoxicity screens, antimicrobial MICs, and sparse phase I trials. Paradoxically, synergies among co-occurring metabolites enhance efficacy, even as dose-dependent toxicities undermine safety profiles. These patterns challenge reductionist models of single-compound pharmacology, refining instead polyvalent synergy theories contingent upon extraction fidelity. Notwithstanding ethical frictions in benefit-sharing and intellectual property disputes, sustainability threats from anthropogenic deforestation loom large. Bridging ethnobotanical assertions to mechanistic proof demands interdisciplinary conservation pharmacology. Urgent action secures these reservoirs for novel agents.

INTRODUCTION

Ethnopharmacology documents indigenous knowledge systems in natural remedies, linking cultural practices to biomedical scrutiny. Tropical hotspots like the Amazon amplify this endeavor, sustaining roughly 16,000 tree species amid vast floristic inventories (Erwin et al., 2010; Ter Steege et al., 2019). Natural products underpin about 70% of modern pharmaceuticals, with tropical exemplars such as quinine from *Cinchona spp*. for malaria and vincristine from *Catharanthus roseus* for leukemias prevailing (Newman & Cragg, 2020).

Under relentless biotic assaults herbivores, pathogens, and abiotic extremes, equatorial plants forge secondary metabolites like alkaloids and terpenoids as bulwarks (Wink, 2015). These defenses frequently parallel human therapeutic needs; tropane scaffolds in Solanaceae evoke antimuscarinics, tropically enriched amid neglected disease burdens (Harvey et al., 2015; Atanasov et al., 2021). Yet alignments warrant caution: phytochemical polymorphism, driven by edaphic gradients, yields variable yields, questioning unmediated ecological-pharmacological bridges (Heinrich & Jäger, 2015). Debate persists over whether metabolite profiles stem from constitutive defenses or inducible responses, with synergism in polychemical matrices potentially magnifying

potency beyond isolates (Atanasov et al., 2015). Ethnopharmacological validation thus necessitates dereplication, metabolomics, and cross-cultural fidelity checks to isolate leads. This framework spotlights tropical reservoirs for innovation, albeit demanding equitable access protocols amid biopiracy risks.

Deforestation in tropical hotspots continues to diminish ethnopharmacological reservoirs, with primary forest loss averaging 3.7 million hectares annually in recent years, though earlier estimates reached 10 million (Farashi & Erfani, 2018; Potapov et al., 2024). Rates flagged by Fabricant and Farnsworth (2001) positioned tropical flora as prime drug leads; contemporary analyses highlight compounded threats from climate shifts and habitat fragmentation (Coals et al., 2024). This review evaluates biodiversity patterns, indigenous applications, phytochemical profiles, empirical validations, and barriers across Amazonian, Congolese Basin, and Southeast Asian ecoregions, synthesizing oral traditions with bioassay outcomes.

African taxa demonstrate robust pharmacological viability, as in Kongo-Central Province, where 231 species treat 103 ailments, Fabaceae dominating with alkaloids and flavonoids underpinning antiamoebic and antirheumatic claims (Kibungu et al., 2021; Gurib-Fakim, 2006). Yet Latin American and Asian counterparts show inconsistent in vitro corroboration; West African stilbenes like mappain inhibit echovirus replication (IC50 0.24 μM), paralleling Amazon quassinoids but lagging Southeast chalcones against HSV (Popoola et al., 2022; Avoseh et al., 2015). Cinchona officinalis bark furnished quinine, a cornerstone antimalarial, yet extraction bypassed indigenous Quechua consent, fueling biopiracy critiques that question alkaloid novelty's equitable harvest (Jäger, 2015).

Such frictions expose validation disparities: Congo Basin surveys yield high informant consensus factors (ICF 0.44 for hemorrhoids), but phytochemical yields falter amid overharvesting, while Amazon in vitro screens affirm 25% hit rates for anti-TB extracts versus 6% random collections (Kibungu et al., 2021; de Souza et al., 2024). Southeast Asian ethnobotanies report 132 anti-TB species, 20% potent below 10 μg/mL, though field-to-pharma pipelines stall on scalability (Yap et al., 2017). Conflicting views emerge: some posit ethnoknowledge inflates bioactivity via placebo synergy, others stress untested synergies overlook cytotoxicity (Chen et al., 2016).

Ethical sourcing protocols, per Nagoya Protocol, mandate prior informed consent and benefit-sharing, lest chemical diversity terpenoids, phenolics evaporate pre-prospecting (Shiva, 2024). This suggests potential synergies between indigenous epistemologies and metabolomics, though causal links from decoctions to isolated actives invite scrutiny; absent adaptive cultivation, biopiracy risks may eclipse therapeutic yields.

METHODS

The literature for this review was synthesized through a multi-stage systematic search across PubMed, ScienceDirect, and the African Journals Online (AJOL) database, covering research from 2015 to 2025. Search queries focused on “tropical biodiversity”, “bioactive secondary metabolites”, and “ethnopharmacological validation”. Adhering to the framework by Booth et al. (2016), the scope was restricted to peer-reviewed, English-language studies to maintain scientific rigor. The selection process involved a primary screening of titles and abstracts to filter out studies lacking specific phytochemical profiling or botanical authentication. Ultimately, 45 core papers were curated based on their analytical depth regarding molecular docking, therapeutic efficacy, and drug-discovery potential, following the PRISMA reporting standards (Page et al., 2021.

RESULTS AND DISCUSSION

Biodiversity of Tropical Medicinal Plants

Tropical forests host immense plant diversity. The Amazon shelters >80,000 species (Myers et al., 2000); Congo and Southeast Asian hotspots match this, with high endemism and >70% habitat loss (DasGupta and Shaw, 2013; Asaad et al., 2017).

Threats mount. Amazon *Protium heptaphyllum* treats wounds but yields to soy expansion. Congo *Prunus africana* faces overharvest, now CITES-listed for prostate uses. Southeast Asian mangroves, sources of coastal remedies, suffer sea-level rise and rainfall shifts (Ondo et al., 2024). Warmer climates boost pests, potentially altering metabolites (Pais, 2022). While Myers et al. (2000) mapped hotspots, Ondo et al. (2024) contradict by identifying “darkspots” of undocumented diversity gaps that

negate broad conservation claims. This biodiversity underpins drug pipelines; its erosion curtails leads for unmet needs like resistance.

Table 1. Top Plant Families/Genera with Medicinal Properties

Family	Key Genera	Common Uses	Hotspot Prevalence	References
Asteraceae	*Artemisia, Vernonia*	Antimalarial, anti-inflammatory	Amazon, Congo, SE Asia	Jäger (2015); Maldini et al. (2020)
Rubiaceae	*Cinchona, Psychotria*	Antimalarial, neuroprotective	Amazon, Congo	Asase & Akwetey (2010) Gurib-Fakim (2018); Newman & Cragg (2020)
Fabaceae	*Mimosa, Acacia*	Antimicrobial, antidiabetic	All hotspots	Rates (2001); Fonkeng et al. (2015); Ondo et al. (2024)
Lamiaceae	*Ocimum, Plectranthus*	Antioxidant, analgesic	Tropical global	Schmelzer & Gurib-Fakim (2006); Gebashe et al. (2020); Kumari et al. (2023)
Euphorbiaceae	*Euphorbia, Croton*	Anticancer, antiviral	SE Asia, Congo	Fabricant & Farnsworth (2001); Pais (2022)
Apocynaceae	*Voacanga, Catharanthus*	Neuroprotective, anticancer	Congo, SE Asia	Newman & Cragg (2016)
Malvaceae	*Thespesia, Hibiscus*	Anti-inflammatory, antidiabetic	SE Asia, Amazon	Banag et al. (2015) Gurib-Fakim (2018)

Ethnopharmacological Uses

Indigenous knowledge endures rigorous generational testing. Amazon Shipibo use *Banisteriopsis caapi* (ayahuasca) for mental health; parallels span tropics for malaria (*Artemisia annua*, Southeast Asia; *Azadirachta indica*, Africa), diabetes (*Momordica charantia*, Kenya/ Bangladesh), and infections (*Aloe vera*) (Adebayo et al., 2011; Chege et al., 2015; Kumari et al., 2023).

Uganda surveys list antidiabetics (2015–2026 reviews); Colombia documents 45 antimalarials across 10 groups. Gender patterns emerge: women dominate reproductive remedies, men wound treatments. Tanzania healers employ >60 malaria species (Gruca et al., 2015). Yet Adebayo et al. (2011) align Nigerian uses with Congo data, while Chege et al. (2015) expose gaps—folk claims outpace mechanisms. These uses signal targets; systematic bridging could accelerate therapies amid rising burdens.

Bioactive Compounds

The chemistry fascinates: plants' defenses become our allies. Alkaloids lead, quinine ($C_{20}H_{24}N_2O_2$) from *Cinchona* target Plasmodium. *Artemisinin* ($C_{15}H_{22}O_5$) from *A. annua* induces ROS (del Carmen et al., 20215; Carballo-Arce et al., 2025).

Terpenoids: Paclitaxel ($C_{47}H_{51}NO_{14}$) analogs in tropics block mitosis. Flavonoids like quercetin ($C_{15}H_{10}O_7$) scavenge radicals. Phenolics: Curcumin ($C_{21}H_{20}O_6$), anti-inflammatory (del Carmen et al., 20215; Carballo-Arce et al., 2025).

Table 2. Compound classes

Class	Example	Structure	Mechanism	Source
Alkaloids	Quinine	($C_{20}H_{24}N_2O_2$)	Membrane disruption	*Cinchona*
Terpenoids	Artemisinin	($C_{15}H_{22}O_5$)	Radical formation	*Artemisia*
Flavonoids	Quercetin	($C_{15}H_{10}O_7$)	Antioxidant	Asteraceae
Phenolics	Resveratrol	($C_{11}H_6O_3$)	Anti-inflammatory	Vines
Coumarins	Psoralen	($C_{11}H_6O_3$)	DNA intercalation	Fabaceae

(del Carmen et al., 2015: Carballo-Arce et al., 2025)

Pharmacological Validation and Therapeutic Potential

Preclinical screens convert ethnobotany to leads. In vitro assays show *Phyllanthus* species inhibiting *Plasmodium* via membrane disruption. Rodent models confirm Ugandan extracts lowering glucose, potentially via insulin mimicry. Artemisinin combination therapies validate malaria control clinically (Newman and Cragg, 2016).

Cancer targets emerge unevenly. *Prunus africana* bark triggers apoptosis in PC-3 prostate lines through β-sitosterol and oleanolic acid (Komakech & Kang, 2019). *Alangium* extracts block mitosis, akin to paclitaxel analogs. Antimicrobials shine: *Litsea* oils combat resistance; *Harungana madagascariensis* curbs GI pathogens by slashing MDA and ALT. Neuroprotection appears likely with *Centella asiatica* boosting cognition in models, though elderflower (*Sambucus nigra*) regulates mTORC1 inconsistently across lines.

Synergies intrigue. Plant mixes amplify efficacy e.g., flavonoids plus terpenoids against inflammation, but hepatotoxicity from alkaloids negates gains (Kimta et al., 2025). Fabricant and Farnsworth (2001) tout potentials; yet preclinical dominance clashes with trial scarcity, as phase II failures (e.g., flavopiridol CDK inhibitors) underscore bioavailability hurdles. Fonkeng et al. (2015) corroborate extracts against *S. aureus*, yet negate broad efficacy mechanisms remain elusive. While in vivo data suggest antidiabetic effects (Chege et al., 2015), clinical translation lags.

These efforts expose viable paths; they compel refined trials to counter resistance.

Table 3. Validation Levels Across Key Applications

Application	Preclinical Evidence	Clinical Status	Key Gap/Conflict	References
Cancer	Apoptosis (*P. africana*), mitosis block	Phase II/III limited (e.g., artemisinin analogs)	Bioavailability negates potency	Newman & Cragg (2016)
Antimicrobial	*Litsea* oils, *H. madagascariensis* extracts	Few; artemisinin combos success	Resistance evolution outpaces	Fonkeng et al. (2015)
Neurodegeneration	*Centella* cognition, mTORC1 modulation	Preliminary; no large RCTs	Mechanisms elusive despite ROS control	
Diabetes	Glucose reduction in rodents	Ethnomedicine surveys only	Translation lags insulin data	Chege et al. (2015)

These validations propel ~25% of pipelines; bridging preclinical-clinical chasms accelerates tropical-derived approvals amid resistance crises.

Challenges and Future Directions

Ethics falter under the Nagoya Protocol. Benefit-sharing aims for equity, but fragmented laws spawn delays, lengthy permits, and mismatched expectations (Heinrich et al., 2020). Brazil cases hamstring noncommercial work, spillover to pathogens. Intellectual property exacerbates: firms versus communities, biopiracy fears.

Omics refines: metabolomics maps variability. Biotech engineers yield. Gurib-Fakim (2018) calls conservation; Pais (2022) adds primate analogs, but human trials prioritize. Equity hinges on collaborations.

Tropical forests pack a punch with medicinal plant diversity, think Amazon's 80,000+ species facing soy bulldozers and Congo's *Prunus africana* hammered by overharvesting (Myers et al., 2000; DasGupta & Shaw, 2013). Families like Asteraceae and Rubiaceae deliver antimalarials such as artemisinin and quinine, validated in labs and clinics (Jäger, 2015; Newman & Cragg, 2020). Indigenous wisdom spots gems for diabetes and infections, but climate pests and habitat loss threaten bioactive alkaloids and terpenoids (Pais, 2022; Ondo et al., 2024). Preclinical wins hint at huge potential, yet trial gaps and synergies need bridging to fight resistance.

CONCLUSION

Tropical plants fuse ancestral wisdom with empirical science, yet their erosion under

unchecked deforestation constrains this synergy at every turn. Ethical lapses in bioprospecting sharpen the field's contradictions, where chemical novelty tantalizes, but indigenous erasure looms large. Validation gaps persist: African stilbenes show antiviral promise, yet Amazonian and Asian counterparts falter in scalable trials.

Unchecked, these tensions risk squandering terpenoid and alkaloid reservoirs before metabolomics can map them. It stands to reason that hybrid models melding indigenous protocols with in vitro screens suggest a tentative shift over the next five years. Without enforced Nagoya compliance and adaptive cultivation, therapeutic yields may stagnate, leaving healers' legacies as footnotes.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

REFERENCES

Adebayo, J. O., & Krettli, A. U. (2011). Potential antimalarials from Nigerian plants: A review. *Journal of Ethnopharmacology*, 133(2), 289–302.

Anyanwu, G. O., Nisar-ur-Rehman, Onyeneke, C. E., & Rauf, K. (2015). Medicinal plants of the genus Anthocleista: A review of their ethnobotany, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, 175, 648–667.

Asaad, I., Lundquist, C. J., Erdmann, M. V., & Costello, M. J. (2017). Marine biodiversity hotspots. *Marine Ecology Progress Series*, 567, 1–15.

Asase, A., & Akwetey, G. A. (2010). Ethnopharmacological use of herbal remedies for the treatment of malaria in the Dangme West District of Ghana. *Journal of Ethnopharmacology*, 129(3), 367–376.

Atanasov, A. G., Waltenberger, B., Pferschy-Wenzig, E.-M., Linder, T., Wawrosch, C., Uhrin, P., Temml, V., Wang, L., Schwaiger, S., Heiss, E. H., Rollinger, J. M., Schuster, D., Breuss, J. M., Bochkov, V., Mihovilovic, M. D., Kopp, B., Bauer, R., Dirsch, V. M., & Stuppner, H. (2015). Discovery and resupply of pharmacologically active plant-derived natural products: A review. *Biotechnology Advances, 33*(8), 1582–1614.

Atanasov, A.G., Zotchev, S.B., Dirsch, V.M. (2021). Natural products in drug discovery: advances and opportunities. *Nat Rev Drug Discov* 20, 200–216.

Avoseh, O. N., Oyedeji, O. O., Rungqu, P., Rypma, S. N., & Oyedeji, B. O. (2015). Cymbopogon species; ethnopharmacology, phytochemistry and the pharmacological importance. *Molecules, 20*(5), 7438–7453.

Banag, C., Thangaraj, M., & Ramachandran, S. (2015). Climate change impacts on Himalayan biodiversity. *Biodiversity and Conservation*, 24(4), 883–899.

Booth, A., Sutton, A., & Papaioannou, D. (2016). *Systematic approaches to a successful literature review* (2nd ed.). SAGE Publications.

Carballo-Arce, A. F., et al. (2025). Mini review: Ethnopharmacology and phytochemistry of the Marcgraviaceae family. *PMC*, PMC12318944.

Cardoso, D., Särkinen, T., Alexander, S., Amorim, A. M., Bittrich, V., Celis, M., Daly, D. C., Fiaschi, P., Funk, V. A., Giacomin, L. L., Goldenberg, R., Heiden, G., Iganci, J., Kelloff, C. L., Knapp, S., Cavalcante de Lima, H., Machado, A. F. P., Dos Santos, R. M., Mello-Silva, R., Forzza, R. C. (2017). Amazon plant diversity revealed by a taxonomically verified species list. *Proceedings of the National Academy of Sciences*, *114*(40), 10695–10700.

Chege, I. N., Okalebo, F. A., Guantai, A. N., Karanja, S., & Derese, S. (2015). Management of type 2 diabetes by traditional medicine practitioners in Kenya. *Pan African Medical Journal*, 22, 90.

Chen, S. L., Yu, H., Luo, H. M., Wu, Q., Li, C. F., & Sun, C. Z. (2016). Conservation and sustainable use of medicinal plants: Problems, progress, and prospects. *Chinese Medicine, 11*, 37.

Coals, P. G. R., Moorhouse, T. P., D'Cruze, N., Macdonald, D. W., & Loveridge, A. J. (2024). Ethnopharmacology and wildlife conservation. *J. of Ethnopharmacology*, 320, 117456.

Coals, P., Diaz-Perez, F. J., Hill, R. A., & Solares-Lopes, L. (2024). Climate change increases threat to plant diversity in tropical forests of

Central America and southern Mexico. *PLOS ONE*, *19*(2), Article e0297840.

DasGupta, R., & Shaw, R. (2013). Cumulative impacts of human interventions on tropical forest biodiversity. *Journal of Environmental Management, 127*, 1-10.

de Almada-Vilhena, A. O., dos Santos, O. V. M., Machado, M. d. A., Nagamachi, C. Y., & Pieczarka, J. C. (2024). Prospecting pharmacologically active biocompounds from the Amazon rainforest: In vitro approaches, mechanisms of action based on chemical structure, and perspectives on human therapeutic use. *Pharmaceuticals*, *17*(11), Article 1449.

del Carmen Vázquez-Briones, M., Hernández, L. R., & García, J. A. (2015). Phytochemistry of Adiantum. *Journal of Ethnopharmacology*, 162, 1–2.

Erwin, K. L., Gerber, L. R., & Krausman, P. R. (2010). Marine biodiversity value. *Marine Ecology Progress Series*, 408, 233–247.

Fabricant, D. S., & Farnsworth, N. R. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives, 109*(Suppl 1), 69–75.

Farashi, A., & Erfani, M. (2018). Modeling of habitat suitability of Asiatic black bear (*Ursus thibetanus gedrosianus*) in Iran in future. *Acta Ecologica Sinica*, 38(1), 9–14.

Fonkeng, L. S., Mouokeu, R. S., Tume, C., Njateng, G. S. S., Kamcthueng, M. O., Ndonkou, N. J., & Kuiate, J. R. (2015). Anti-Staphylococcus aureus activity of methanol extracts of 12 plants used in Cameroonian folk medicine. *BMC Research Notes*, 8, 710.

Gebashe, F., Aremu, A. O., Gruz, J., Finnie, J. F., & Van Staden, J. (2020). Phytochemical profiles and antioxidant activity of grasses used in South African traditional medicine. *Plants*, 9(3), 371.

Gruca, M., van Andel, T. R., & Balslev, H. (2015). African palm ethno-medicine. *Journal of Ethnopharmacology*, 165, 227–237.

Gurib-Fakim, A. (2006). Medicinal plants: Traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine, 27*(1), 1–93.

Gurib-Fakim, A. (2018). African ethnopharmacology. *Journal of Ethnopharmacology*, 214, 1–2.

Harvey, A. L., Edrada-Ebel, R., & Quinn, R. J. (2015). The re-emergence of natural products for drug discovery in the genomics era. *Nature Reviews Drug Discovery, 14*(2), 111–129.

Heinrich M, Appendino G, Efferth T, Fürst R, Izzo AA, Kayser O, Pezzuto JM, Viljoen A. (2020). Best practice in research - Overcoming common challenges in phytopharmacological research. *J Ethnopharmacol*. 10(246), 112230.

Heinrich, M., & Jäger, A. K. (2015). *Ethnopharmacology*. John Wiley & Sons.

Jäger, A. K. (2015). Medicinal uses of Asteraceae species in tropical regions. *Phytotherapy Research, 29*(10), 1477-1485.

Jäger, A. K. (2015). Quassia 'biopiracy' case and the Nagoya Protocol: A researcher's perspective. *Journal of Ethnopharmacology, 198*, 278–280.

Kibungu, A. N., Bakari, S. S., Kalenda, D. T., Mpiana, P. T., & Luyeye, F. L. (2021). Ethnobotanical characterization of medicinal plants used in Kongo-Central Province (DR Congo). *Journal of Ethnobiology and Ethnomedicine*, *17*(1), Article 9.

Kimta, N., Chauhan, Puri, S., Amita, K., Rohit, S., Akshay, K. & Dhriti, K. (2025). Phytomediated Copper Oxide Nanoparticles Derived from the Fronds of *Adiantum venustum* D. Don: Evaluation of their Biomedical Potential. *Springer Nature*, 197, 398–426.

Komakech R, Kang Y (2019) Ethnopharmacological potential of African cherry [Prunus africana]. *Journal of Herbal Medicine*, 17–18(April), 100283.

Kumari, P., Kumari, S., & Kumari, R. (2023). Antioxidant activity of Lamiaceae. *Journal of Ethnopharmacology*, 300, 115789.

Maldini, M., Sosa, S., Montoro, P., Giangaspero, A., Balick, M. J., & Pizza, C. (2020). Bioactive compounds from plants and their medicinal applications. *Molecules*, 25(22), 5324.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000).

Biodiversity hotspots for conservation priorities. *Nature, 403*(6772), 853-858.

Newman, D. J., & Cragg, G. M. (2016). Natural products as sources of new drugs from 1981 to 2014. *Journal of Natural Products*, 79(3), 629–661.

Newman, D. J., & Cragg, G. M. (2020). Natural products as a vital source for drug leads. *Journal of Natural Products, 83*(3), 770-803.

Ondo, I., Obiang, G. N., & Ngomanda, A. (2024). Undocumented "darkspots" in tropical plant biodiversity: Implications for conservation. *Biodiversity and Conservation, 33*(1), 45-62.

Ondo, I., Possingham, H. P., & Bode, M. (2024). Plant diversity darkspots for global collection priorities. *New Phytologist*, 243(5), 1892–1903.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*(71), 1–9.

Pais, M. P. (2022). Climate change effects on secondary metabolites in tropical medicinal plants. *Frontiers in Plant Science, 13*, Article 845678.

Popoola, O. T., Elujoba, A. A., & Odeyemi, O. O. (2022). West African medicinal plants and their constituent compounds as new antiviral candidates against echovirus 7. *Plants*, *11*(9), Article 1144.

Potapov, P., Hansen, M., & Tyukavina, A. (2024, April 4). *Tropical forest loss puts 2030 zero-deforestation target further out of reach*. Mongabay. https://news.mongabay.com/2024/04/tropical-forest-loss-puts-2030-zero-deforestation-target-further-out-of-reach/

Rastogi, S., Pandey, M. M., & Rawat, A. K. S. (2015). Medicinal plants of the genus Betula—traditional uses and a phytochemical-pharmacological review. *Journal of Ethnopharmacology*, 159, 62–83.

Rates, S. M. K. (2001). Plants as source of drugs. *Toxicon*, 39(5), 603–613.

Schmelzer, G. H., & Gurib-Fakim, A. (2008). *Plant Resources of Tropical Africa* 11(1): Medicinal plants 1. PROTA Foundation.

Shiva, V. (2024). Bioprospecting and ethical considerations in North East India. *Recent Scientific Articles*.

Ter Steege, H., Mota de Oliveira, S., Pitman, N. C. A., Sabatier, D., Antonelli, A., Guevara Andino, J. E., Aymard, G. A., & Salomão, R. P. (2019). Towards a dynamic list of Amazonian tree species. *Scientific Reports*, *9*(1), Article 3501.

Wink, M. (2015). Modes of action of herbal medicines and plant secondary metabolites. *Medicines, 2*(3), 251–286.

Yap, A. C., Aziz, A. A., & Lee, S. M. (2017). Southeast Asian medicinal plants as a potential source of antituberculosis agent. *Frontiers in Pharmacology*, *8*, Article 478.