Several medicinal plants have the potential to be a promising alternative pharmacological therapy for a variety of human illnesses. Many insects, including mosquitoes, are important vectors of deadly pathogens and parasites, which in the world’s growing human and animal populations can cause serious epidemics and pandemics. Medicinal plants continue to provide a large library of phytochemicals, which can be used to replace chemically synthesized insecticides, and utilization of herbal product-based insecticides is one of the best and safest alternatives for mosquito control. Identifying new effective phyto-derived insecticides is important to counter increasing insect resistance to synthetic compounds and provide a safer environment. Solanum genus (Solanaceae family or nightshades) comprises more than 2500 species, which are widely used as food and traditional medicine. All research publications on insecticidal properties of Solanaceae plants and their phytoconstituents against mosquitoes and other insects published up to July 2020 were systematically analyzed through PubMed/MEDLINE, Scopus, EBSCO, Europe PMC, and Google Scholar databases, with focus on species containing active phytoconstituents that are biodegradable and environmentally safe. The current state of knowledge on larvicidal plants of Solanum species, type of extracts, target insect species, type of effects, name of inhibiting bioactive compounds, and their lethal doses (LC50 and LC90) were reviewed in this study. These studies provide valuable information about the activity of various species of Solanum and their phytochemical diversity, as well as a roadmap for optimizing select compounds for botanical repellents against a variety of vectors that cause debilitating and life-threatening human diseases.

1. Introduction
Medicinal plants are traditionally used to treat numerous human infections, and their bioactive compounds have long been important in therapeutic development, particularly in cancer and infectious diseases. Medicinal plant-derived natural products have garnered much interest in recent years as potential bioactive agents for insect vector control. Vector
control is threatened by the emergence of resistance to conventional synthetic insecticides in vectors, among which mosquitoes pose high threats to human and animal health and life, often leading to the transmission of serious diseases, such as dengue, Ebola, filariasis, and malaria, resulting in millions of deaths each year [1–4]. Because chemical control of mosquitoes has been linked to such detrimental outcomes as the development of insect resistance, it is urgently necessary to discover and develop reliable and environmentally sustainable alternatives to current synthetic chemical insecticides.

As an alternative to synthetic insecticides, plant-based insecticide preparations have the advantages of rapid biodegradability and low toxicity to humans and animals [5]. Several plants and their constituents, especially those in medicinal herbs, have been traditionally used as insecticides, due to being rich in various bioactive phytochemicals and providing potential sources of natural mosquito control agents [6–9]. Recently, attention has been given to preparations of mosquito-larvicidal compounds based on herbal origin to enhance insecticidal effects and reduce the probability of development of resistance by the target pest population [10, 11]. While several plants from different families have been reported with mosquito-larvicidal properties, only a few species show promising effects and could be developed into natural insecticidal agents [12].

The *Solanum* family of plants is a large genus within the Solanaceae family that contains up to 2,000 species ranging from food crops to medicinal herbs. The genus *Solanum* has received much interest in chemical and biological studies over the last 30 years. Several steroidal saponins, steroidal alkaloids, disaccharides, flavonoids, and phenols have been implicated in the biological activities [13]. The genus *Solanum* appears to have a lot of potential, although most of the species are unknown or have had little research on their chemical contents. Several reviews of the *Solanum* genus and their phytochemistry have been published. These compounds have been linked to various health-promoting activities in the fight against several noncommunicable diseases, which are the leading causes of death worldwide. Many species belonging to this genus present a huge range of pharmacological activities such as anticancer, hepatoprotective, antimalarial, anthelmintic, and other activities [14]. Plants in this family are recognized for having a wide spectrum of alkaloid compounds, some of which are therapeutically the most potent. Steroidal glycoalkaloids are the most common and important group of nitrogen-containing secondary metabolites identified in Solanaceae plants. More than 350 *Solanum* species have yielded more than 100 different forms of glycoalkaloids [15, 16]. Many medicinal plants belonging to the Solanaceae family are promising therapeutic candidates to develop as bioinsecticidal against vector-borne human diseases such as malaria, leishmaniasis, and dengue fever due to the presence of different phytoconstituents. Various *Solanum* spp. provide a potential source of useful adulticidal drugs because of the presence of phytochemicals that can be used for the treatment of many diseases [17]. Thus, more scientific efforts should be made to identify and develop *Solanum*-based phyto-insecticides. Our literature review revealed 19 *Solanum* medicinal plants used in all parts (leaves, roots, bark, and flowers). The goal of this review is to compile most of the scientific literature on mosquito-larvicidal and insecticidal investigations of *Solanum* plants and their active bioactive chemicals from various scientific sources, including the types of extracts examined, dosages, and effect on target organisms.

2. Source of Data

A comprehensive systematic review of the literature up to July 2020 on Solanaceae plants with larvicidal effects present in standard electronic databases, such as EBSCO, Europe PMC, Google Scholar, MEDLINE, PubMed, Scopus, and Web of Science, was conducted using various keywords (adulticidal, botanical, essential oil, insecticidal, larvicidal, repellency, Solanaceae, *Solanum*, and steroidal alkaloids). The search was restricted to publications having English titles. In addition, a manual search was performed to categorize related articles using references from the retrieved literature.

A total of 51 full-text original research articles published in peer-reviewed journals on Solanaceae plants were retrieved, and data were culled for larvicidal effects. Roles of larvicidal activities were assessed in Solanaceae plant solvent extracts, such as acetone, chloroform, ethyl acetate, hexane, and methanol from seventeen different medicinal plants. Other parts of these plants with significant larvicidal properties against various mosquito vectors were highlighted.

3. Solanaceae Family

*Solanum* L. genus is the largest of the Solanaceae family or nightshades containing approximately 85–90 genera and 2,500–3000 species distributed in tropical and subtropical regions (Table 1) [12, 13]. Local names are given in various languages to describe a specific species for a particular local use. In Saudi Arabia, some species of Solanaceae are found primarily in the Asir Region and Jizan Region of Abha (Figure 1). A recent ethnobotanical study recorded three new collections of *Solanum* spp. in the southwest regions of Saudi Arabia [18].

3.1. Ethnopharmacological Use. Solanaceae is the most economically important family in the genus *Solanum* (Table 2). Solanaceae family offers a diversity of medicinal, culinary, and ornamental applications. The genus *Solanum* has attracted much interest in chemical and biological investigations over the last 30 years. Biologically important products for medicine and food include atropine, hyoscine, solasodine, and withanolide [19–21]. Although rich in alkaloids of medical importance, Solanaceae plants contain alkaloids with toxicity to humans and animals, ranging from mild irritation to fatal outcomes [22–25]. In addition, *Solanaceae* spp. have potential importance as food supplements worldwide [22, 26]. *S. nigrum*, *S. xanthocarpum*, *S. tuberosum*, and *S. lycopersicum* are a few economically important species of the *Solanum* genus. Various species in
this genus have completed various pharmacological research to verify and validate their ethnopharmacological usage. However, various reviews of the Solanum genus have been published, most of which focused on a single species [14, 27–30]. Table 3 summarizes the scientific literature and reveals a variety of ethnopharmacologically based traditional insect repellents derived from Solanum plants utilized by local ethnic communities in various countries to avoid mosquito bites.

Solanum genus has several species found in tropical and subtropical areas and is used in folk medicine and dietary supplements. Among them, S. nigrum has been considered ethnobotanically important due to its use in the traditional healthcare system to cure various ailments. The leaves and bitter berries with pungent have been traditionally used against severe ulcers, heart diseases, piles, dysentery, gastritis, and stomachache [27]. S. sisymbriifolium, known as “wild tomato,” is a traditional medicine used by indigenous people of Central and South America to treat veterinary and human diseases. Various parts of the wild tomato have been widely used to prevent and treat numerous diseases, including hypertension, diarrhea, and respiratory and urinary tract infections [31].

S. tuberosum is used in folk medicine to treat burns, constipation, hemorrhoids, corns, cough, tumors, scurvy, and warts and to prevent wrinkles on the face [32]. S. integrifolium is native to Africa; its unripe fruits are eaten daily to check high blood pressure, inflammation, pain remedy to alleviate edema or cure stomach pain, lymphadenopathy, or sore armpits in indigenous medicine [34]. S. villosum is a traditionally important plant used in various systems of medicine for the treatment of leucorrhea, nappy rash, wounds, and cold sores, and as an ointment for sores and abscesses. A well-known traditional herb S. xanthocarpum is widely used in India to manage different ailments, including urolithiasis [35]. S. trilobatum is a widely used plant in the Indian indigenous systems of medicine. It is mainly used to treat respiratory diseases such as bronchial asthma [37]. S. virginianum L. has been used to manage fever, bronchial asthma, and cough for thousands of years [48].

In traditional medicine in Peru, S. mammosum is used to treat fungal infections and respiratory disorders via topical application. S. incanum is commonly found in Africa and is used as a folklore remedy for sore throat, angina, stomachache, colic, headache, wounds, pain relief in toothache, cure of snake bites, and sexually transmitted disease in wounds [49]. S. elaeagnifolium is called silverleaf nightshade and traditionally is used for the treatment of sore throats as an antiseptic agent, toothaches, and gastrointestinal disorders.
Table 2: Common and scientific names of *Solanum* spp.

| Common name                  | Scientific name          |
|------------------------------|--------------------------|
| Silverleaf nightshade        | *Solanum elaegnifolium*  |
| Scarlet eggplant             | *S. integrifolium*       |
| Sticky nightshade            | *S. sisymbriifolium*     |
| Potato                       | *S. tuberosum*           |
| Black nightshade             | *S. nigrum*              |
| Red nightshade               | *S. villosum*            |
| Yellow-fruit nightshade       | *S. xanthocarpum*        |
| Thai nightshade              | *S. virginianum* L.      |
| Indian ginseng (ashwagandha) | *Withania somnifera*     |
| Nipplefruit nightshade       | *S. mammosum*            |
| Garden tomato                | *S. lycopersicum*        |
| Jasmine nightshade           | *S. laxum*               |
| Mullein nightshade           | *S. verbascifolium*      |
| Jerusalem cherry             | *S. pseudocapsicum*      |
| Thorn apple                  | *S. incanum*             |
| Turkey berry                 | *S. torvum*              |

Table 3: List of various phytochemicals and ethnopharmacological uses from *Solanum* plants.

| Species name | Medicinal uses                                                                 | Parts used | Phytochemicals                               | Country used                  | References |
|--------------|--------------------------------------------------------------------------------|------------|----------------------------------------------|-------------------------------|------------|
| *S. sisymbriifolium* | Used as contraceptive febrifuge, to treat syphilis, hypertension, diarrhea, and respiratory and urinary tract infections, and as analgesics Used to treat burns, constipation, hemorrhoids, corns, cough, tumors, scurvy, and warts, to prevent wrinkles on face, pain, acidity, and swollen gums, and to heal burns | Whole plants | Solamargine and  \( \beta \)-solamarine, cuscohygrine, sisyrbifolin, neolignan | Paraguay, India, Brazil, Peru, and Argentina | [31]       |
| *S. tuberosum*           | Used to treat Liver disorders, diarrhea, inflammatory conditions, chronic skin ailments (psoriasis and ringworm), fever, hydrophobia, painful periods, and eye diseases | Tubers, skins, raw juice | Solanidine, demissidine, \( \alpha \)-chaconine, \( \alpha \)-solanine, solavilline, solasamine | Europe and South America | [32]       |
| *S. nigrum*              | Used to treat leucorrhea, nappy rash, wounds, and cold sore Used to treat high blood pressure and edema or to cure stomach, lymphadenopathy, and inflammation, and as pain remedy to alleviate edema Used to treat urolithiasis, respiratory disorders (expectorant, coughs, bronchial asthma, and chest pain), gonorrhoea, pest repellent, tympanitis, misperistalsis, piles, and dysuria | Whole plants | Glycoprotein | Kenya, China, India, and Pakistan | [27]       |
| *S. villosum*            | Used to treat leucorrhea, nappy rash, wounds, and cold sore Used to treat high blood pressure and edema or to cure stomach, lymphadenopathy, and inflammation, and as pain remedy to alleviate edema Used to treat urolithiasis, respiratory disorders (expectorant, coughs, bronchial asthma, and chest pain), gonorrhoea, pest repellent, tympanitis, misperistalsis, piles, and dysuria | Whole plants | Solanidine, \( \alpha \)-chaconine, (d) \( \alpha \)-solanine | Africa, Central and South America, China, India, and Pakistan | [33]       |
| *S. integrifolium*       | Fruits                  | Saponins, solanacarpine, solanacarpidine, solancarpine, solasonine | South-East Asia including India, Malaysia, and tropical Australia | [34]       |
| *S. xanthocarpum*        | Whole plants            | Saponins, solanacarpine, solanacarpidine, solancarpine, solasonine | South-East Asia including India, Malaysia, and tropical Australia | [35, 36]   |
| Species name | Medicinal uses | Parts used | Phytochemicals | Country used | References |
|--------------|----------------|------------|----------------|--------------|------------|
| **S. trilobatum** | Used to treat cough and cold, respiratory disease (chronic bronchitis and tuberculosis), and male fertility, and to cure snake poison, dyspnea, anorexia, worm infestation, skin diseases, hemiplegia, edema, urinary calculi, amenorrhea, and urinary tract disorders. | Leaves | Sobatum, solasodine, solanine, tomatidine, diosgenin, soladunalinidine | China, Myanmar, Thailand, Vietnam, Sri Lanka, Peninsular Malaysia, and southern India | [37–39] |
| **S. virginianum** | Used to treat sore throats, chest pain and catarrh, stomach and respiratory complaints, fever, influenza, painful and difficult urination, bladder stones, and rheumatism | Whole plants | Arabinogalactan, chlorogenic and caffeic acid, khasianine, solasonine, solamargine, beta-solamargine, solanocarpine, and solanocarpidine | India, Sri Lanka, South-East Asia, Malaysia, tropical Australia, and Polynesia | [40] |
| **S. mammosum** | Used to treat fungal infections and respiratory disorders (asthma, cough, cold, and sinusitis), skin ulcer, scabies, furunculosis and rashes, insecticide, and rat poison | Leaves, fruits, and seeds | Indioside D, solamargine, tomatine, solasonine, diosgenin, solamargine, and β-solamargine | Northern and South America, Caribbean islands, and Africa | [41] |
| **S. lycopersicum** | Used to treat skin and cardiovascular diseases, cancer, burns, scalds and sunburn, rheumatism and severe headaches, filarial worm swellings, incipient leprosy spots, and toothache. To cure cold and infant, typhoid, pneumonia, sore throats, an antiseptic agent, toothaches, and gastrointestinal disorders | Fruits | Lycopene, zeaxanthin, esculoside A, beta-carotene | South and Central America | [42] |
| **S. elaegnifolium** | Used to treat sore throat, angina, stomachache, ear inflammation, snake bites, wounds, liver disorders, skin ailments (ringworm), warts, inflammatory conditions, painful periods, and fever | Whole plants | Solanine, solasonine, solasodine, kaempferol 8-C-beta-galactoside, β-solamargine, and solanidine | Asia, Africa, Australia, and tropical and subtropical America | [43] |
| **S. incanum** | Used to treat sore throat, angina, stomachache, ear inflammation, snake bites, wounds, liver disorders, skin ailments (ringworm), warts, inflammatory conditions, painful periods, and fever | Whole plants | Khasianine, incanumine, solasodine, kaempferol, isoquercitrin, yamogenin | Africa, Middle East and Far East Asia, and Arabian Peninsula | [44] |
| **S. jasminoides or S. laxum** | Used to kill insects | Aerial parts | Steroidal glycosides—inunigroside A; steroidal sapogenol—jasminoside A, solasodine, laxumin A, laxumin B | Uruguay, Brazil, South America, Paraguay, Uruguay, and Argentina | [13] |
| **S. pseudocapsicum** | Used to treat boils and gonorrhea, male tonic and abdominal pain, somnolence, and diabetes | Bark, fruit, leaves, and seeds | Solanocapsine, solacasine, solateinemine, O-methylsolanocapsine, episolacapine, and isosolacapine | India, Nepal, and the Philippines | [45] |
| **S. torvum** | Used to treat fever, wounds, tooth decay, reproductive problems, and arterial hypertension | Fruits and leaves | Chlorogenin, torvoside A-L, chlorogenone | Thailand, India, West Indies, and South America | [46] |
| **S. verbasicum** | Used to treat diarrhea, dysentery, eczema, edema, gout, headaches, ulcers, fever, hematuria, and toothache | Leaves and roots | Pentanone and γ-sitosterol | India and China | [47] |
Phytochemical analysis of berry extracts S. elaegnifolium revealed the presence of kaempferol 8-C-β-galactoside that possesses medicinal proprieties [50]. S. verascofolium is used in Chinese folklore for diarrhea, dysentery, eczema, edema, gout, headaches, ulcers, fever, hematuria, and toothache [45]. Despite being a poisonous plant, S. pseudocapsicum is used in traditional medicine to treat boils and gonorrhea and relieve abdominal pain, and as a male tonic [47]. S. torvum is another commonly used Solanaceae herb in traditional medicine. The plant extracts have been widely used to treat fever, wounds, tooth decay, reproductive problems, and arterial hypertension [46]. Thus, leaves, fruits, roots, and aerial parts of Solanum plants can benefit humans by enhancing their health when consumed as part of a daily diet, nutraceutical, or biopharmaceutical.

3.2. Phytopharmacology and Insecticidal Properties of Solanaceae spp. Medicinal Solanaceae plants have traditionally been used as insecticidal, anti-infectious, and antimicrobial agents [51, 52]. Table 4 shows the different types of test organisms, bioassays, and doses applied to investigate the mosquitoicidal activity of crude plant extracts from the Solanum genus. Crude and chloroform-methanol extracts of S. tuberosum at very low concentrations are effective in mosquito control [54]. Volatile oils of S. xanthocarpum were effective as insect repellents, giving rise to >5 hours of protection against Culex quinquefasciatus without apparent dermal irritation to human skin [72]. Chloroform-methanol extract of S. villosum green berries was used as a biocontrol agent against Aedes aegypti [90]. S. villosum green berries had the greatest biocidal activity against St. aegypti, aegypti, and Cx. quinquefasciatus in chloroform and methanol extracts. As a result, crude extracts or protein fractions/isolated bioactive phytochemicals from S. villosum could be utilized as a possible biocontrol agent against these mosquitoes, especially because of its larvicidal impact [58, 59, 90]. S. integrifolium chitin-binding lectins (CBLs) inhibit Spodoptera frugiperda (sf21) insect cell growth by binding to carbohydrates and depolymerizing mitochondrial membrane potential [60].

Table 5 summarizes detailed investigations of the mosquito-larvicidal efficiency of various Solanum species. Some examples are highlighted (according to the author’s viewpoint) as follows: S. xanthocarpum extracts show various larvicidal and pupicidal activity against Cx’s first-to-fourth instars. Cx. quinquefasciatus fruit aqueous extract exhibits 100% killing after 48-hour exposure compared with its root extract [61, 62]. The previous study has reported that the fruit extract of S. xanthocarpum and copped Mecocyclops thermocyclopoides could serve as a potential highest mortality rate against dengue vector Ae. aegypti [63]. This mosquitoicidal efficiency may be caused by detrimental effects of the S. xanthocarpum active principle compounds (solanocarpine and solanocarpidine) on the mosquito larvae. Similarly, S. xanthocarpum fruit extracts had larvicidal action against An. stephensi and Cx. quinquefasciatus, as well as one culicine species, Ae. aegypti. The toxic concentrations of fruit extract against An. culicifacies, An. stephensi, and Ae. aegypti were found to be 0.112 and 0.258%, 0.058 and 0.289%, and 0.052 and 0.218%, respectively, at the LC50 and LC90 levels. It was discovered that crude extracts have larvicidal capability due to their volatile oil content, implying that they could be used as an environmentally friendly, effective larvicidal in managing various vector-borne epidemics [66, 97]. Methanol leaf extract of S. trilobatum is effective against Ae. aegypti, Cx. quinquefasciatus, and An. stephensi pupae and larvae with an LC50 value of 125, 128, and 117 ppm, respectively [73]. Chloroform: methanol (1:1 v/v) extract of S. nigrum mature leaves is toxic against Cx’s early 3rd instar larvae of the Cx. vishnui group and An. subpictus [56].

The seed hexane extract of S. trilobatum exhibited (38%) acaricidal and insecticidal activities against the adult of H. bispinosa (Ixodidae) and hematophagous fly H. maculata Leach (Hippoboscidae). Therefore, this study provides the first report on the parasitic activities of plant extracts from southern India [75]. The leaf extract of S. trilobatum was found to have an oviposition deterrent effect, reducing egg-laying by An. stephensi by 18 to 99% and providing 70 to 120 minutes of mosquito bite protection skin repellent activities. S. trilobatum leaf extract had dose-dependent oviposition deterrent and skin repellent effects. Several solvent extracts of S. trilobatum were tested against the filarial vector Cx. quinquefasciatus; petroleum ether had the highest larvicidal activity, with LC50 values of 203.87 and 165.04, respectively, after 24 and 48 hours, followed by acetone and chloroform extracts [96]. According to the findings, S. trilobatum leaf extract is an efficient oviposition preventive and cutaneous repellent against A. stephensi [72]. The crude extract of the leaves or fruits of S. incanum and W. somnifera has an equal effect on the A. messinae mortality (96% mortality). However, the percentage mortality of the termite was 100% with 135 μg from the crude extract of S. incanum leaves. Based on findings, both crude extracts have the potential to be used as termite control agents in termite breeding areas in the field or infested homes [80].

The larvicidal efficacy of S. torvum was tested against An. stephensi and Cx. quinquefasciatus, with the results indicating that the leaf methanol extract of S. torvum had the highest LC90, ranging from 70.38 to 210.68 ppm. As a result, isolated plant metabolites from S. torvum from southern India have the potential to be used as environmentally safe and long-lasting mosquito repellents [85]. The mosquito repellent effect of S. lyceopersicum esculentum leaf hydro-ethanolic extract on the larvae of multiple mosquito species was tested at varied concentrations of 50, 100, 150, 200, and 250 ppm, with larva mortality seen within 24 hours. The hydro-ethanolic extract caused complete mortality in mosquitoes at 200 ppm in 18–19 hours, and the study found that S. lyceopersicum esculentum may kill mosquitoes at a lower concentration [77]. The insecticidal effects of methanolic extracts of S. elaegnifolium seeds were investigated further against S. littoralis, and 100% larval mortality was observed with the strongest growth inhibition (59.68%) compared to leaves [110]. Methanolic extracts from the leaves and seeds of S. elaegnifolium also showed insecticidal efficacy against P. operculella and T. castaneum. Seed extract
Table 4: Different types of test organisms, bioassays, and doses used to study the mosquitocidal activity of crude plant extracts from Solanum genus.

| Species name | Species tested | Types of bioassays                                      | Dose References |
|--------------|----------------|---------------------------------------------------------|-----------------|
| S. sisymbriifolium | *Anophelinae* (insects and larvae) | Biocidal assay | 0.005–5 g/ml [53] |
| S. tuberosum | Cx. quinquefasciatus and An. stephensi | Larvicidal assay | 1.1–0.5% (AE) [54] |
|              | Cx. quinquefasciatus and An. stephensi | Mosquito-larvicidal assay | 2.5, 5, and 10 ppm [55] |
| S. nigrum | Cx. quinquefasciatus | Larvicidal assay | 1–3% [56] |
|              | Cx. quinquefasciatus | Mosquito-larvicidal assay | 15, 20, and 25 mg/L [57] |
|              | An. subpictus | Larvicidal assay | 200 ppm [58, 59] |
|              | S. aegypti | Larvicidal assay | 0.1–0.5% and 15, 25, and 30 ppm [58, 59] |
| S. integrifolium | Spodoptera frugiperda | Mosquito-larvicidal and pupicidal assays | 50–650 ppm [61] |
|              | Cx. quinquefasciatus | Larvicidal assay | 1–5 ml [62] |
|              | Callicea larvae | Larvicidal assay | 100, 150, 200, 250, and 300 ppm [63] |
|              | Ae. aegypti | Mosquito-larvicidal assay | 0.82 mg/ml [64] |
| S. xanthocarpum | Cx. quinquefasciatus | Mosquito-larvicidal assay | 62.5, 125, 250, 500, and 1000 mg/L [65] |
|              | Cx. quinquefasciatus | Larvicidal assay | 7500–20 000 ppm [66] |
|              | An. stephensi | Larvicidal assay | 1:1, 1:2, and 1:4% [67–69] |
|              | Cx. quinquefasciatus | Larvicidal assay | 7500–20 000 ppm [67–69] |
|              | An. stephensi | Larvicidal assay | 15, 20, and 25 ppm [71] |
|              | Cx. Vishnui and L. acuminata | Mosquito-larvicidal assay | 0.01, 0.05, 0.01, and 0.02% [72] |
|              | Cx. quinquefasciatus | Mosquito-larvicidal and pupicidal assays | 1500, 3000, 4500, and 6000 ppm [75] |
| S. trilobatum | Ae. aegypti, Cx. quinquefasciatus, and An. stephensi | Larvicidal and pupicidal assays | 50, 100, 150, 200, and 250 ppm [74] |
|              | Ae. aegypti and Cx. quinquefasciatus | Larvicidal assay | 100, 200, 300, 400, and 500 ppm [74] |
|              | Haemaphysalis bispinosa and Hippobosca maculata | Acaricidal and insecticidal assays | 46.88 to 3000 ppm [71] |
|              | An. stephensi | Skin repellent assay | 0.01, 0.05, and 0.02% [73] |
|              | Callosobruchus chinensis and Bougainvillea glabra | Insecticidal assay | 1, 2.5, 5, and 10% [84] |
| Solanum Mammosum-Silver Nanoparticles (Sm-AgNPs) | Ae. aegypti | Larvicidal assay | 0.05, 0.06, 0.07, and 0.08 ppm [76] |
| S. lycopersicum | Ae. aegypti and Cx. quinquefasciatus | Larvicidal activity | 50, 100, 150, 200, and 250 ppm [77] |
| S. elaegnifolium | Tribolium castaneum and Phthorimaea operculella | Insecticidal assay | 2% extract (5 μl spray) [78] |
| S. incanum | A. messinae and M. najdensis | Insecticidal assay | 2.5–135 µg/ml [80] |
| S. laxum—laxumin A | Schizaphis graminum | Insecticidal assay | 50–500 μm [81] |
| S. laxum—Lucimin | Schizaphis graminum | Repellent assay | 50–500 μm [82] |
| S. Jasminoides | Phlebotomus papatasi and Bougainvillea glabra | Insecticidal assay | — [83] |
| S. surattense | Callosobruchus chinensis | Insecticidal assay | 1, 2.5, 5, and 10% [84] |
| S. torvum | An. stephensi and Cx. quinquefasciatus | Larvicidal bioassay | 1.25 to 400 ppm [85] |
| S. verbasicum | Cx. quinquefasciatus | Larvicidal activity | 100, 300, 500, or 1000 ppm [86] |
| S. asperum | Biomphalaria glabrata | Molluscidal activity | 10, 50, and 100 μg/ml [87] |
| Nicotiana glauca | Pieris rapae | Larvicidal assay | 0.7 mg to 2.8 mg/ml [88] |
| S. elaegnifolium | Tribolium castaneum | Repellent and antifeedant assay | 200 μl/disc (2% extract) [89] |
**Table 5: Insecticidal efficacy of Solanaceae plant extracts and their fraction/compound as adulticides.**

| Solanum spp. | Part used | Target insect species | Effect | Extract/compound fraction | Bioactive compound | LC$_{50}$, LC$_{90}$ | Reference |
|--------------|-----------|-----------------------|--------|---------------------------|--------------------|----------------------|-----------|
| *S. sisymbriifolium* | F | Anopheles funestus and Anopheles gambiae<br> An. stephensi (malaria vector)<br> Culex quinquefasciatus (filaria vector) | Insecticidal | Total alkaloid fraction | Solamargineβ-solamarine | 0.45–0.75 mg/ml | [53] |
| *S. tuberosum* | T | An. stephensi (malaria vector)<br> Cx. quinquefasciatus (filaria vector) | Mosquito-larvicidal | Aqueous, chloroform: methanol (1:1) | NI | 1.18–1.30 mg/l | [54] |
| *S. nigrum* | B, L | An. stephensi (malaria vector)<br> Cx. quinquefasciatus (filaria vector) | Mosquito-larvicidal | Silver nanoparticle (AgNP) | Alkaloids | 1.26–2.44 ppm | [55] |
| *S. villosus* | B | Aedes aegypti (dengue vector) | Mosquito-larvicidal | Chloroform:methanol | Steroids | 21.02 (3rd instar) ppm | [90] |
| *S. integrifolium* | F | Spodoptera frugiperda | Insecticidal | Chitin-binding lectins (CBLs) and crude | Polysaccharide | 1 µg/ml | [60] |
| *S. xanthocarpum* | L | Cx. quinquefasciatus<br> (filaria vector)<br> An. stephensi (malaria vector)<br> Cx. quinquefasciatus (filaria vector) | Mosquito-larvicidal and pupalcidal | Crude ethanol | NI | 155.3–448.4 ppm, 667.1–1,141.6 ppm | [61] |
| *S. xanthocarpum* | F | Aedes aegypti (dengue vector) | Mosquito-larvicidal and pupalcidal | Crude ethanol | Solanocarpidine<br>Solanocarpine | 252.3, 435.2 ppm<br> 79.5, 462.1 ppm | [63] |
| *S. xanthocarpum* | L | Cx. quinquefasciatus<br> (filarial vector) | Mosquito repellent effect | Volatile oil | Volatile oil | 8% repellency; 311 minutes of protection<br> 99.4% repellency; 123 minutes of protection | [72] |
| *S. trilobatum* | L | An. stephensi (malaria vector) | Oviposition deterrent and skin repellent | Leaf extract | Volatile compounds | 227.9 ppm, 411.4 ppm | [72] |
| *S. xanthocarpum* | WP | Cx. quinquefasciatus<br> (filarial vector)<br> Ae. aegypti (dengue vector)An. stephensi (malaria vector)<br>Cx. quinquefasciatus (filaria vector) | Larvicidal and pupalcidal | Chloroform fraction, crude | Quinine, terpenoids, and other compounds<br> Alkaloids<br>Saponins | ~100% mortality | [91] |
| *S. xanthocarpum* | F, R | Calicica larvae<br> Ae. aegypti (dengue vector)An. stephensi (malaria vector)<br>Cx. quinquefasciatus (filaria vector) | Larvicidal<br> Larvicidal | Crude aqueous | NI | 116.6–127.8 ppm | [73] |
| *S. trilobatum* | L | An. subpictus Cx. vishnui group<br> Ae. aegypti (dengue vector)An. stephensi (malaria vector)<br>Cx. quinquefasciatus (filaria vector) | Adulticidal | Crude methanolic | NI | 3.68–5.64 mg/l, 24.74–44.33 mg/l | [56] |
| *S. nigrum* | L | An. subpictus Cx. vishnui group<br> Ae. aegypti (dengue vector)An. stephensi (malaria vector)<br>Cx. quinquefasciatus (filaria vector) | Larvicidal | Chloroform:methanol (1 : 1 w/v) | Phytosteroids | 644.7–747.2 ppm, 1,882.4–2,220.0 ppm | [90] |
| *S. villosus* | L | Mosquito-larvicidal | Leaf protein | Polypeptides | 0.82 mg/ml | [92] |
| *S. virginianum* | WP | Aedes aegypti (dengue vector) | Insecticidal | Methanolic | NI | 0.82 mg/ml | [92] |
| Solanum spp. | Part used | Target insect species | Effect | Extract/compound fraction | Bioactive compound | LC₅₀, LC₉₀ | Reference |
|-------------|-----------|-----------------------|--------|---------------------------|-------------------|------------|-----------|
| S. nigrum   | B, L      | *Ae. aegypti* (dengue vector) | Larvicidal | Crude | Eugenol (E)-6-hydroxy-4,6-dimethyl-3-heptene-2-one | Leaf: 9.8 ml/l, 26.4 ml/l; Green berry: 51.4 ml/l, 459.8 ml/l; Black berry: 9.9 ml/l, 56.1 ml/l | [93] |
| S. nigrum   | L         | *Cx. quinquefasciatus* (filaria vector) | Mosquito-larvicidal | Crude | AlkaloidsSteroids | 0.08%, 0.37% | [57] |
| S. nigrum   | B         | *Cx. quinquefasciatus* (filaria vector) | Mosquito-larvicidal | Crude, chloroform: methanol (1 : 1, v/v) | Aromatic amide compounds | 61.5 mg/l, 297.0 mg/l | [55] |
| S. xanthocarpum, Withania somnifera | F | *Ae. aegypti* (dengue vector)*An. stephensi* (malaria vector)*Cx. quinquefasciatus* (filaria vector) | Synergistic larvicidal | Crude aqueous | | | [65] |
| S. xanthocarpum | WP | *Ae. aegypti* (dengue vector)*An. culicifacies*An. stephensi (malaria vector)*Cx. quinquefasciatus* (filaria vector) | Larvicidal | Methanolic | Edible oils | 91.7–450.6 ppm, 379.0–1,881.0 ppm | [94] |
| S. xanthocarpum | NI | *Ae. aegypti* (dengue vector)*Cx. quinquefasciatus* (filaria vector) | Mosquito-larvicidal | Ethanol | | | [95] |
| S. mammosum | NI | *Ae. aegypti* (dengue vector) | Larvicidal | Aqueous silver nanoparticles | Steroidal alkaloids | 1,631.3 ppm, 4,756.2 ppm; 0.06 ppm, 0.08 ppm | [76] |
| S. trilobatum | L | *Ae. aegypti* (dengue vector)*Cx. quinquefasciatus* (filaria vector) | Mosquito-larvicidal | Acetone | Cyclodecanol and other compounds | 189.5 ppm, 444.3 ppm; 67.4 ppm, 371.8 ppm | [74] |
| Solanum spp. | Part used | Target insect species | Effect | Extract/compound fraction | Bioactive compound | LC₅₀, LC₉₀ | Reference |
|--------------|-----------|----------------------|--------|--------------------------|-------------------|-----------|-----------|
| S. trilobatum | AP        | Cx. quinquefasciatus (filarial vector) | Mosquito-larvicidal | Acetone, chloroform, petroleum ether | NI | | [96] |
|                |           |                      |        |                          |                   |           |           |
| S. xanthocarpum | R         | An. stephensi (malaria vector) | Larvicidal | Petroleum ether | NI | 0.93 ppm, 8.48 ppm | [67] |
| S. xanthocarpum | R         | An. stephensi (malaria vector) | Larvicidal | Petroleum ether with temephos (1:1) | NI | 0.02 ppm, 0.09 ppm | [69] |
| S. xanthocarpum | F         | Cx. quinquefasciatus (filarial vector) | Larvicidal | Carbon tetrachloridepetroleum ether | NI | 1.27 ppm, 59.45 ppm | [97] |
| S. xanthocarpum | R         | Cx. quinquefasciatus (filarial vector) | Larvicidal | Petroleum ether | NI | 38.48 ppm, 80.83 ppm | [66] |
| S. xanthocarpum | R         | Cx. quinquefasciatus (filarial vector) | Larvicidal | Temephos:plant (1:1) | NI | 0.01 ppm, 0.02 ppm | [67] |
| S. xanthocarpum | F, R       | An. culicifacies/A. stephensi (malaria vector) | Larvicidal | Fruit, root | NI | 0.05–1.16 ppm, 0.22–3.58 ppm | [98] |
| S. villosum | L         | Cx. quinquefasciatus (filarial vector) | Larvicidal | Chloroform:methanol (1 : 1 v/v) | NI | 39.19 ppm | [58] |
| S. villosum | L         | An. subpictus | Larvicidal | Chloroform-methanol | Glycoalkaloids | 23.47–30.63 ppm | [59] |
| S. lycopersicum | L         | Culex and Aedes spp. | Larvicidal | Aqueous ethanolic | NI | 100% mortality at 250 ppm | [77] |
| S. nigrum | L         | Ae. aegypti (dengue vector) | Larvicidal | Crude aqueous | NI | 0.027–0.032%, 0.027–0.212% | [99] |
| S. elaeagnifolium | F         | Blattella germanica | Repellent effect | Ethanolic, hexane | NI | 50 mg/ml | [100] |
| S. elaeagnifolium | L, B       | An. labranchiae | Larvicidal effect | Aqueous, ethanolic | Glycoalkaloid extracts | LC₅₀ (24 h) 209.8, 123.4 ppm | [78] |
| S. elaeagnifolium |          | Fasciola hepatica/Galba truncatula Mull. | Molluscicidal activity | Total saponin fraction:Total alkaloid fraction | β-solamareine | 0.94 mg/L /14.67 mg/L | [101] |
| S. incanum | F, L       | mesina/Microtermes majdensis | Insecticidal | Crude hexane | β-chaconine, α-solamine | 40% mortality at 67.5 µg/ml | [80] |
| Solanum spp.                  | Part used | Target insect species                                      | Effect                           | Extract/compound fraction                | Bioactive compound                      | LC₅₀, LC₉₀ | Reference |
|------------------------------|-----------|------------------------------------------------------------|----------------------------------|------------------------------------------|-----------------------------------------|------------|-----------|
| *S. jasminoides*             | WP        | *Phlebotomus papatasi* (Leishmania vector)                  | Larvicidal and repellent effect  | Branch                                   | NI                                      | Median survival = 8 days (confidence interval: 17.1–18.9) | [83]       |
|                             |           | *Ae. aegypti* (dengue vector) *An. culicifacies* *AAn. culicifacies* *CAAn. stevensi* (malaria vector) *Cx. quinquefasciatus* (filaria vector) |                                   |                                           |                                         |            |           |
| *S. nigrum*                  | F         |                                                            | Mosquito-larvicidal               | Aqueous, hexane                          | NI                                      | <20 ppm, <100 ppm                           | [102]      |
|                             |           |                                                            |                                   |                                           |                                         |            |           |
|                             | L, SD     | *Agrotis ipsilon*                                          | Antifeedant, insecticidal         | Ethyl acetate (5%)                       | NI                                      | Maximum insecticidal = 66.5–75.3%           | [103]      |
|                             |           |                                                            |                                   |                                           |                                         |            |           |
| *S. pseudocapsicum*          | L         | *Ae. aegypti* *Cx. pitiens*                                | Larvicidal                        | 70% ethanolic                            | NI                                      | Maximum insecticidal = 3.37 mg/l            | [105, 106] |
|                             | L, SD     |                                                            |                                   |                                           |                                         | Reduction in oviposition = 2–5 eggs/pair  | [84]       |
|                             | R, S      | *Callosobruchus chinensis*                                  | Pesticidal                        | Aqueous extract, aqueous suspension      | NI                                      | 46.04 ppm                                    | [107]      |
| *S. surattense* and *S. trilobatum* | L         | *Cx. quinquefasciatus* (filaria vector)                     | Insecticidal                      | Ethyl acetate, petroleum ether           | NI                                      | 4.3 μM and 6.1 μM                            | [81]       |
|                             |           | *An. stephensi* (malaria vector) *Cx. quinquefasciatus* (filaria vector) |                                   |                                           |                                         | 70% mortality at 24 hours                 | [82]       |
|                             |           |                                                            |                                   |                                           |                                         | 100% mortality at 72 hours               | [75]       |
|                             | L         |                                                            | Larvicidal                        | Methanolic                               | NI                                      | 70.38–210.68 ppm                           | [85]       |
| *S. trilobatum*              | L         | *Hippobosca maculata*                                      | Insecticidal                      | Hexane                                   | NI                                      | 495.61–432.77 ppm, 1.914.84–1.872.33 ppm  | [75]       |
|                             | L, SD     |                                                            |                                   |                                           |                                         | 100% mortality at 72 hours               | [86]       |
| *S. verbascum*               | L         | *Cx. quinquefasciatus* (filaria vector)                     | Larvicidal                        | Various solvents                         | NI                                      | 80% mortality at 72 hours                  | [57]       |
|                             |           | *Leptinotarsa decemlineata* *Empoasca fabae*               |                                   |                                           |                                         |            |           |
| *S. tuberosum*               | T         |                                                            | Insecticidal                      | Crude sample                            | Chaconine, Solanine                      | 100% defoliation                           | [108]      |
| *S. laxum*                   | WP        | *Schizaphis graminum*                                      | Insecticidal                      | Steroidal glycoalkaloid fraction        | Laxumin A and B                          | 4.3 μM and 6.1 μM                            | [81]       |
|                             | AP        |                                                            |                                   |                                           | Lucamin                                  | 70% mortality at 24 hours                 | [82]       |
| *S. nigrum*                  | B         |                                                            | Mosquito-larvicidal               | Chloroform: methanol (1:1, v/v) solvent  | NI                                      | 80% mortality at 72 hours                  | [57]       |
| Solanum steroidal alkaloids and glycoalkaloids | SA        | *Tribolium castaneum*                                      | Larvicidal                        | Isolated compounds in diet              | Steroidal glycoalkaloids                | 89–100% larvicidal effect                  | [109]      |
Table 5: Continued.

| Solanum spp. | Part used | Target insect species | Effect | Extract/compound fraction | Bioactive compound | LC50, LC90 | Reference |
|--------------|-----------|-----------------------|--------|---------------------------|--------------------|-----------|-----------|
| S. nigrum    | L         | Lymnaea acuminata     | Mosquito-larvicidal | Aqueous                  | Aliphatic amide compounds | LC50 55.45 and 11.59 ppm, respectively at 72 h. 32–48% mortality at 72 hours of 4th larval instars | [70] |
| S. nigrum    | L         | Cx. quinquefasciatus  | Mosquito-larvicidal | Ethyl acetate            | Glucosiausarin     |           |           |
| S. asperum   | L         | Biomphalaria glabrata | Molluscicidal activity | Methanolic extract Alkaloidal fraction Solanandaine Solasonine Solamargine | Solanandaine Solasonine Solamargine | LC90 44.1; 17.3; 399.7 72.063 6 | [87] |
| Nicotiana glauca | L     | Pieris rapae          | Larvicidal effect | Total alkaloid anabasine | Anabasine          | EC50 1.202 mg/larva 0.572 mg/larva | % repellent effect: Seeds: 94% after 2 hrs Leaves: 74% after 2 hrs | [88] |
| S. elaeagnifolium | S, L | Tribolium castaneum  | Insecticidal (repellent assay) | Methanol (seed and leaves) | Glycoalkaloids |           |           |

AP: aerial part; B: berry; F: flower; L: leaf; LC50: 50% lethal concentration; LC90: 90% lethal concentration; LC100: 100% lethal concentration; mg/l: milligrams per liter; mg/ml: milligrams per milliliter; ml/l milliliter per liter; µg/ml: micrograms per milliliter; µM: micromoles; NI: not identified; ppm: parts per million; R: root; S: stem; SA: Solanum alkaloids; SD: seed; SX: S. xanthocarpum; T: tuber; v/v: volume/volume; WP: whole plant; WS: W. somnifera.
inhibited oviposition and egg hatching the most (95.9% and 98.6%, respectively), with an aphid mortality rate of 23.6% [79]. These findings suggested that numerous Solanum species might be used as plant-based mosquitocidal. They could be a valuable source for developing novel natural repellents as an alternative to chemical repellents in the future. The structure of phytochemicals with promising mosquitocidal and insecticidal effects from Solanum species is summarized in Figure 2.

3.3. Solanaceae spp. Phytochemicals with Insecticidal Properties. For decades, Solanum species have been widely used in healthcare systems as a source for various phytochemicals, including steroidal alkaloids. Solanum is distinguished by the presence of the steroidal alkaloid solasodine, which is a potential starting material for the manufacture of steroid hormones. Because of the wide spectrum of biological activities such as antibacterial, anti-inflammatory, antioxidant, and anticancer, Solanum alkaloids have been a topic of interest in pharmacological and therapeutical investigations. Because of metabolites such glycoalkaloids, some of the Solanum species are poisonous. Several pharmacologically important lead compounds are found in Solanum species, including steroidal alkaloids such as solasodine, solasonine, solamargine, and other medicinally important alkaloids; solasodine and its glycosylated derivatives, such as solamargine and solanine; and other chemicals with medicinal potential for developing new drugs against various human diseases.

S. xanthocarpum is an important source of many pharmacologically and medicinally useful alkaloids. Recent GC-MS analysis showed that several essential oils from leaves, fruits, roots, and stems of S. xanthocarpum were responsible for larvicidal activity [111]. Six important phytosteroids (1, 2-benzenedicarboxylic acid, dibutyl phthalate, phytol, lauric acid, 3,7,11,15-tetramethyl-2-hexadec, and 7-hexadecanediol) with larvicidal activity against early 3rd instar larvae of the Cx. vishnui group were identified from mature leaves of S. nigrum using GC-MS [32]. A short polypeptide (15 amino acids) from mature leaves of S. villosum exhibited a moderate larvicidal effect. Further studies will be needed to determine its mode of action and appropriate formulations for field applications [90]. Eugenol and (E)-6-hydroxy-4,6-dimethyl-3-heptene-2-one in S. nigrum crude extract were proposed as being the main compounds responsible for mosquito-larvicidal activity [93]. The GC-MS analysis of acetone leaf extract of S. tilobatum revealed cyclodecanol (12.42%), β-sitosterol (10.25%) and 2-tetradecycloxyanate (6.07%) as the major components and were possibly responsible for larvicidal activity against Cx. quinquefasciatus and Ae. aegypti [74].

β-Solamarine isolated from the methanolic extract of seeds of S. elaeagnifolium was found to have molluscicidal activity against G. truncatula and F. hepatica. The median lethal concentration of β-solamarine in molluscicidal activity (LC50) was 0.49, and the study emphasizes that this glycoalkaloid may be used as molluscicides [101]. Another mosquitocidal investigation revealed that the leaf extract of S. tilobatum possesses oviposition deterrent and skin repellent activity against An. stephensi. Both oviposition deterrent and skin repellent activity were dose-dependent [112]. Two major compounds of steroidal glycoalkaloids were isolated from the fraction C MeOH extract of S. sisymbriifolium and were identified as solamargine (1) and β-solamarine. The toxicity of fraction C is 10-fold higher than that of Anopheles larvae. These two steroidal alkaloids were known to possess molluscicidal activity where they could be used as a molluscicide in the future [53].

Luciamin, a spirostanol saponin, was isolated from the Ethanolic extract of the aerial parts of S. laxum and was tested against the aphid S. graminum by incorporation in artificial diets. Luciamin showed a deterrent (toxic) activity against the insect and is the first spirostanol glycoside reported to have this activity. Luciamin’s aphid repelling effect deserves further exploration to determine its biological and economic effects against viral vectors [81]. Two Solanum glycosides isolated from S. laxum were found to have insecticidal effects against S. graminum with LC50 4.3 µM (laxamin A) and LC50 6.1 µM (laxamin B), respectively [82]. The insecticidal effect of the isolated steroidal alkaloids fraction B from S. sisymbriifolium was investigated on Anopheles larvae (A. gambia, A. funestus). Compared with other extracts and fractions, fraction B, which contains solamargine and β-solamarine, appears less hazardous to larvae. As a result, fraction B could potentially be employed as an insecticide in the future [53]. Solanum species steroidal alkaloids are unique in their pharmacological properties and are important lead molecules for drug development [113].

Glucosiastrin, a glucosinolate group of bioactive compounds from S. nigrum, was responsible for larval mortality. Glucosinolate is a plant-derived secondary metabolite and hydrophilic, having potent mosquito-larvicidal properties against Cx. quinquefasciatus and found to be safe for the environment [87]. For several decades, N. glauca has been known for its content of the pyridine alkaloids, such as anabasine, nicotine, and nornicotine. In the P. rapae larval bioassay, the median effective concentrations of anabasine were 0.572 mg/larva. Despite this, the insecticidal activities of the N. glauca extract are likely related to anabasine, as several phytochemical experiments and bioassays have shown [88]. This review intended to collect all of the scientific data on mosquitocidal, insecticidal, and larvicidal investigations on medicinally important Solanum compounds including steroidal alkaloids. Because most of the studies are laboratory-based and do not meet clinical standards, this comprehensive review is expected to bolster investigators in furthering their research into this field, which could lead to the development of plant-based mosquito repellents with significant economic benefits.

3.4. Solanum Plant-Mediated Nanoparticles. Plant extract-based silver nanoparticles have recently been developed to improve the control of mosquitoes without causing any significant harm to humans [114, 115]. According to the recent literature, silver nanoparticles (AgNPs) synthesized from aqueous extracts of S. nigrum and S. mammosum have
Figure 2: Continued.
Tomatidine (TO) and Tomatine (TN). For TO, R=H, For TN, R=Lycotetraose

Solamargine

Silicic acid, diethyl bis (trimethylsilyl) ester

Solanidine

Permethrin

Tomatidine (TO) and Tomatine (TN). For TO, R=H, For TN, R=Lycotetraose

Solasonine

(b)

Figure 2: Continued.
Figure 2: Continued.
demonstrated adulticidal and insecticidal activity against \textit{Ae. aegypti}, implying that AgNPs produced from plant extracts have higher levels of toxicity than the extracts alone [55, 76]. Thus, these herbal-based AgNPs hold great promise as potent larvicides, but their environmental impact requires further investigation for controlling target vector mosquitoes.

4. Conclusion

Mosquito control is an important public health policy in tropical areas. Mosquitoes constitute a part of natural biodiversity, and their total eradication is not necessary, but only the diseases they transmit need to be eradicated. Nevertheless, bites from disease-bearing insects can be
minimized and even avoided altogether. Inappropriate application of chemical insecticides in insect pest control can lead to insect resistance and pose environmental hazards and raises pest resistance to insecticides. Plants contain a variety of larvicidal secondary metabolites, and given their low environmental impact and minimal toxicity to humans, medicinal plants present a promising alternative to synthetic pesticides [116,117]. *Solanum* spp. constitute a large and diverse genus (~2,000 species) of flowering plants, which provide food sources, eggplant, potato and tomato, ornamental flowers and fruits, and herbal medications. Solanum species grow in various habitats and can be annuals and perennials, vines, subshrubs, shrubs, and small trees.

*Solanum* spp. contain a diversity of phytochemicals that can be culled for their insecticidal properties, particularly mosquito larvicide, adulticide, and repellent. Although crude extracts have higher insecticidal potency than pure components, probably due to synergy among their bioactive constituents, optimal utilization of crude extracts is limited by an inability to control their contents, which can vary depending on plant species, cultivation conditions, the season of harvest, and extraction methods and solvents used. Thus, an understanding of the mechanism of insecticidal activity of the major bioactive compounds can lead to consistent and optimal formulation and adjustment to match the target insect pests of interest.

The review highlights current knowledge of phyto-compounds (glycoalkaloids, phytosteroids, plant proteins, and volatile oils) reported as larvicides, adulticides, and repellents against a variety of insect pests, against vectors of important human diseases (dengue, filaria, and malaria). The exquisitely low larvicidal activity of silver nanoparticles formed from plant fruit and aqueous leaf extracts indicates the synergism between traditional medicinal herbal knowledge and modern (nano)technology. As a result, the usage of environmentally beneficial and cost-free plant-based products for insect/mosquito control is now unavoidable. Although the evaluation of phytochemicals is still in its early stages, with much more research needed to characterize promising agents and discover new ones, some of the findings presented in this review suggest that *Solanum* genus-based botanical phytochemicals should not be dismissed as a potential future alternative to synthetic insecticides. Hence, *Solanaceae* plants should be mined for their inexpensive, eco-friendly, safe, and effective alternatives to current chemical larvicides.

**Data Availability**

The data used to support the findings of the study can be obtained from the corresponding author upon request.

**Conflicts of Interest**

The authors declare no conflicts of interest.

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