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Phytochemical and antimicrobial evaluation of a hemiparasitic mistletoe plant, *Dendrophthoe falcata* (L.F.) Ettingsh, parasitize on *Artocarpus heterophyllus* host tree

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Abstract
The preliminary phytochemical screening in different solvent extracts of *Dendrophthoe falcata* Leaf, tender shoot and bark samples collected from *Artocarpus heterophyllus* host tree, exhibited variations in the presence of phytocompounds depends upon the polarity of solvents and solubility level of phyto components. The results of biochemicals and mineral content analysis in the *Dendrophthoe falcata* plant samples indicate that the leaf sample possess more amount of starch, calcium and magnesium, whereas the tender shoot contain more amount of phosphorus and more amount of protein, reducing sugar, carbohydrate and iron noted in the bark sample than other samples. Zinc was not detected in all the samples tested. The ethanol extracts of *Dendrophthoe falcata* plant samples shows less antimicrobial activity in general as compared to control. Moderate antibacterial activity was observed against *Escherichia coli, Staphylococcus* sp., and *Pseudomonas* sp. However, the bark extract shows inhibitory effect against all organisms tested, whereas the tender shoot extract inhibit the growth of *Escherichia coli* and *Staphylococcus* sp., moderately and the leaf extract inhibit only the *Staphylococcus* sp., as compared to other bacteria, tested. Moderate antifungal activity of *Dendrophthoe falcata* plant sample extracts was noted against *Penicillium sp., Aspergillus niger* and *Aspergillus flavus*.

Keywords: Mistletoe, hemiparasite, *Dendrophthoe falcata*, preliminary phytochemicals, biomolecules, minerals, antibacterial, antifungal, antimicrobial

Introduction
Bioassay or biological assay is used to estimate the activity or potency of a drug or other substances (plant extracts) by comparing its effects on a test organism with that of a standard preparation. The driving force behind much phytochemical research is the discovery of new biological active compounds for medical or agricultural uses. Biological assays then must be carried out in order to identify promising plant extracts, to guide the separation and isolation, and to evaluate the lead compounds. Identification of natural products from plants that may serve as valuable sources of bioactive agents for medicinal and agricultural uses largely depends on bioactivity directed isolation [1]. Presently, herbal plants have been widely used for disease treatment and immunological enhancement. The increasing trend of herbal application in traditional herbal industry is mainly due to numerous beneficial effects of natural sources compared to single synthetic drug. Natural herbal medicines usually offer less undesirable side effect, more efficiency and less toxic to consumers. However, a very limited scientific data can be accessed regarding the beneficial effect of herbal medicine. *Dendrophthoe falcata*, a Hemiparasitic Mistletoe plant, belongs to Loranthaceae family, used in traditional medicine to cure various human health disorders [2, 3]. Various reports indicate that *D. falcata* is a potential source of phytochemicals and bioactive principles involved in various bioactivities [4-11]. Since, *D. falcata* is a hemiparasite, its phytoconstituents, bioactive principles, the range of bioactivities and other health care benefits are varied and influenced by its host plants. Therefore, the present study was carried out to evaluate the qualitative and quantitative phytochemicals and minerals, and antimicrobial potential of *Dendrophthoe falcata* (L.f.) Ettingsh collected from *Artocarpus heterophyllus* host tree.

Materials and Methods

Plant material

The hemiparasitic mistletoe plant, *Dendrophthoe falcata* (L.f.) Ettingsh was collected from the host tree of *Artocarpus heterophyllus*, at Marthandam area, Kanyakumari district, Tamil Nadu. The plant was identified by BSI, Coimbatore, Tamil Nadu, and the voucher specimen is preserved in the Department of Botany, S.T. Hindu College, Nagercoil, Kanyakumari District, Tamil Nadu.

Preparation of dry powder samples

Fresh leaf, bark and tender shoot samples of *D. falcata* were washed to remove the dust and dried separately for about two weeks at room temperature (30 ºC±2 ºC) to get a constant weight. The dried plant materials (leaf, bark & tender shoot) were ground to powder separately by mechanical device, stored and used in this work throughout the study period.

Preparation of solvent extract for preliminary phytochemical screening

The dry powder of *D. falcata* leaf, bark and tender shoot samples were extracted separately with different solvents (acetone, chloroform, ethanol, ethyl acetate and water) at 20% (w/v) level in a Soxhlet apparatus. These extracts were concentrated and used for qualitative preliminary phytochemical analysis.

Phytochemical Analysis

The powdered leaf, bark and tender shoot samples of *D. falcata*, were subjected to qualitative and quantitative phytochemical analysis.

Qualitative Phytochemical Analysis

Preliminary phytochemical screening

The different solvent extracts of *D. falcata* dry plant materials were subjected to preliminary phytochemical qualitative screening following the standard protocols [12, 13] to record the presence or absence of various primary and secondary metabolites such as alkaloids, anthraquinone, anthocyanosides, coumarin, flavonoids, phenol, protein, quinine, reducing sugars, sucrose, saponins, tannin and terpenoides.

Quantitative Biochemical Analysis

Various biochemical compounds such as carbohydrates [14], starch [15], reducing sugar [16], Proteins [17] and minerals such as phosphorus [18, 19], calcium and magnesium [19], zinc and iron [20] were quantified in the leaf, tender shoot and bark samples of *D. falcata.*

Antimicrobial Study

Antibacterial activity

The required amount of Muller-Hinton plates (Hi-media) is prepared as per manufacture instruction. The following pathogens were collected from local hospitals and characterized based on bergey's manual of systematic bacterial classification. The pathogens identified as *Escherichia coli, Staphylococcus* sp. and *Pseudomonas* sp. were used for the antibacterial activities. A sterile cotton swab was dipped into the turbid culture suspension. The dried surface of Muller-Hinton agar plate was inoculated by streaking two more times rotating. Gentamycin was used as the positive control for all the pathogens. Added 2µl of crude *D. falcata* extract to the sterile disc and evaporate the solvent. After drying the discs were placed on the medium and the plates were incubated at 35 ºC for 1h to permit good diffusion and the transferred to as incubated at 37 ºC for 2h for bacterial cultures. The antibacterial activity was recorded by measuring the width of the clear inhibition zone around the disc [21].

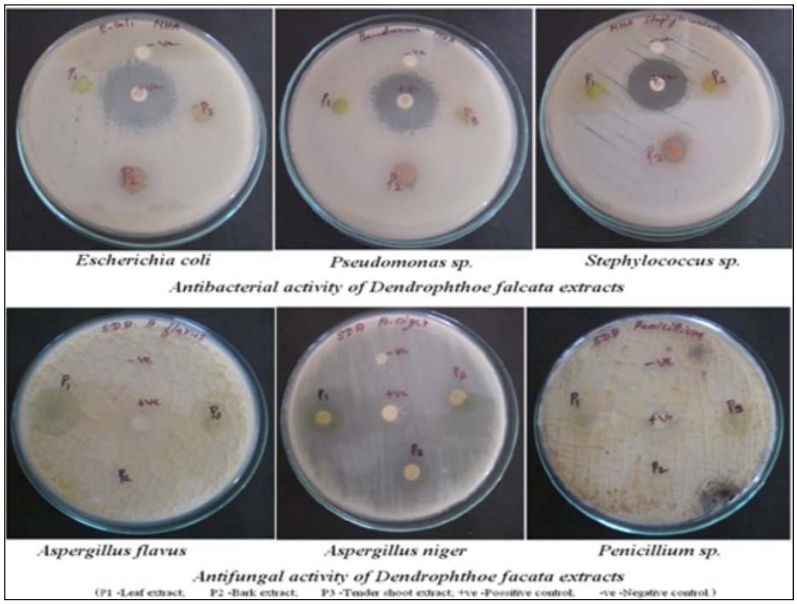

Figure 1: Antimicrobial activity of *Dendrophthoe falcata* extracts of leaf, tender shoot and bark samples collected from *Artocarpus heterophyllus* host tree.

Antifungal activity

The antifungal activity of the *D. falcata* extracts was determined against *Aspergillus niger, Aspergillus flavus, Penicillium* by disc diffusion method [22]. Fluconazole (10mcg disc^{-1}) was used as standard. The filter paper disc impregnated with various extracts (20mg ml^{-1}) individually and the fluconazole disc were placed aseptically on the seeded sabouraud dextrose agar medium which was already incubated with the test organism and incubated at 37 °C for 48h. The antifungal activity of *D. falcata* extracts was recorded by measuring the zone of inhibition (in mm).

Results

Phytochemical Studies

Qualitative preliminary phytochemical screening

The results of the preliminary phytochemical screening of various solvent (acetone, chloroform, ethanol, ethyl acetate and water) extracts of *D. falcata* Leaf, tender shoot and bark samples was recorded and presented in the tables 1 to 3. The results revealed that the presence of alkaloids, anthocyanins, coumaris, flavonoids, phenols, proteins, quinones, reducing sugars, sucroses, steroids, saponins, tannin, and terpenoids in the plant sample extracts. However, there are variations in the presence and absence of phytochemical compounds in various solvent extracts of *D. falcata* Leaf, tender shoot and bark samples.

Table 1: Preliminary phytochemical screening of *Dendrophthoe falcata* Leaf sample collected from *Artocarpus heterophyllus* host tree

Sl. No.	Phytocompounds tested	Solvent extracts of *Dendrophthoe falcata* Leaf sample				
		Acetone	Chloroform	Ethanol	Ethyl acetate	Water
1.	Alkaloids	+	-	++	-	+
2.	Anthocyanins	+++	-	++	++	-
3.	Coumarins	+++	+++	++	-	-
4.	Flavonoids	++	-	+++	-	+++
5.	Phenols	+++	+	+++	-	++
6.	Proteins	+	-	++	-	-
7.	Quinines	-	-	-	++	-
8.	Reducing sugars	+	-	-	-	-
9.	Sucrose	-	-	-	-	-
10.	Steroids	-	-	+	-	-
11.	Saponins	++	-	-	++	-
12.	Tannins	-	+	++	-	-
13.	Terpinoids	-	-	-	++	-

- (Absence); + (Presence) less; ++ (Moderate); +++ (High);

The leaf sample of *D. falcata* possesses most of the compounds analyzed except sucrose and among the extracts more number of compounds present in the acetone (8), ethanol (8) as compared to chloroform (3) ethyl acetate (4) and water (3) extracts. The acetone leaf extract shows high amount of anthocynins, coumarins and phenols; moderate amount of flavonoids and saponins and fewer amounts of alkaloids, proteins and sugars. Ethanol leaf extract contains rich amount of flavonoids and phenols; moderate amount of alkaloids, anthocyanins, coumarins, proteins, and tannins; and fewer amounts of steroids. The anthocyanins, quinines, saponins and terpenoids found moderately in the ethyl acetate leaf extract, while the water leaf extract possess rich amount of flavonoids, moderate amount of phenols and poor amount of alkaloids; and the concentration of coumarins was high and the phenols and tannins were low in the chloroform leaf extract of *D. falcata* (Table 1).

The tender shoot sample of *D. falcata* was analyzed for their preliminary phytochemical constituents and the results are presented in Table 2. Most of the compounds present in the various tender shoot extracts, tested, except reducing sugars, steroids and terpenoids. Among the extracts analyzed, acetone and ethanol extracts shows 8-compounds each, whereas 2-compounds noted in the water (flavonoids and phenols) and ethyl acetate (anthocyanins and quinines) extracts and one compound (coumarin) only noted in the chloroform extract. High concentration of compounds noted in the acetone (coumarins), ethyl acetate (anthocyanins), ethanol (flavonoids and phenols) extracts of tender shoot samples of *D. falcata*, while most of the compounds were found moderate level of concentration in various extracts, i.e., alkaloids in acetone and ethanol; anthocyanins in acetone; coumarins in chloroform and ethanol; flavonoids in water; phenols in acetone and water; proteins in ethanol; sucrose in acetone; saponins and tannins in acetone and ethanol. Low concentration of flavonoids, quinines and sucrose was recorded in acetone, ethyl acetate and ethanol extracts of *D. falcata* tender shoot sample (Table 2).

Table 2: Preliminary phytochemical screening of *Dendrophthoe falcata* tender shoot sample collected from *Artocarpus heterophyllus* host tree.

Sl. No.	Phytocompounds tested	Solvent extracts of *Dendrophthoe falcate* tender shoot sample				
		Acetone	Chloroform	Ethanol	Ethyl acetate	Water
1.	Alkaloids	++	-	++	-	-
2.	Anthocyanins	++	-	-	+++	-
3.	Coumarins	+++	++	++	-	-
4.	Flavonoids	+	-	+++	-	++
5.	Phenols	++	-	+++	-	++
6.	Proteins	-	-	++	-	-
7.	Quinines	-	-	-	+	-
8.	Reducing sugars	-	-	-	-	-
9.	Sucrose	++	-	+	-	-
10.	Steroids	-	-	-	-	-
11.	Saponins	++	-	++	-	-
12.	Tannins	++	-	++	-	-
13.	Terpinoids	-	-	-	-	-

- (Absence); + (Presence) less; ++ (Moderate); +++ (High);

Table 3: Preliminary phytochemical screening of *Dendrophthoe falcata* bark sample collected from *Artocarpus heterophyllus* host tree

Sl. No.	Phytocompounds tested	Solvent extracts of *Dendrophthoe falcata bark* sample				
		Acetone	Chloroform	Ethanol	Ethyl acetate	Water
1.	Alkaloids	-	++	-	-	++
2.	Anthocyanins	-	++	++	+	++
3.	Coumarins	+++	-	-	++	+++
4.	Flavonoids	-	++	-	-	-
5.	Phenols	+++	-	+++	-	+++
6.	Proteins	-	-	-	-	-
7.	Quinines	+	-	-	-	++
8.	Reducing sugars	-	-	-	-	-
9.	Sucrose	-	-	-	-	-
10.	Steroids	-	-	-	-	-
11.	Saponins	++	-	+++	++	++
12.	Tannins	+++	-	+++	-	+++
13.	Terpinoids	+++	-	+++	-	++

- (Absence); + (Presence) less; ++ (Moderate); +++ (High);

The preliminary phytochemical analysis of *D. falcata* bark sample reveals the presence of alkaloids, anthocyanins, coumarins, flavonoids, phenols, quinines, saponins, tannins, and terpenoids and the absence of steroids, reducing sugars, sucrose and proteins in all the solvent extracts tested (Table 3). Among the bark extracts, water bark extract contains 8-compounds, acetone and ethanol extracts contain 5-compounds each and the chloroform and ethyl acetate extracts contain 3-compounds each. Coumarins, phenols and tannins present more in amount and the alkaloids, anthocyanins, quinines, saponins, and terpenoids at moderate level in the water bark extract while all other compounds are not detected. The acetone bark extract shows more amount of coumarins, phenols, tannins and terpenoids, moderate amount of saponins, and low amount of quinines. The ethanol bark extract contain higher level of phenols, saponins, tannins and terpenoids and moderate level of anthocyanins. In chloroform bark extract, the alkaloids, anthocyanins and flavonoids were moderate in concentration while in ethyl acetate bark extract, the coumarins and saponins were moderate in concentration and the anthocyanins were lesser in concentration. Saponins and anthocyanins found in four extracts except chloroform and acetone, respectively. The phenols, tannins and terpenoids found in three extracts –acetone, ethanol and water extracts. Coumarins found in acetone, ethyl acetate and water extracts. Alkaloids present in chloroform and water extracts, whereas the quinines found in acetone and water extracts. The flavonoids noted only in the chloroform bark extract of *D. falcata* (Table 3).

Table 4: Quantification of biomolecules in the leaf, tender shoot and bark samples of *Dendrophthoe falcata* collected from *Artocarpus heterophyllus* host tree.

Biomolecules analyzed	Biomolecules content (mg/g d. wt) in the *Dendrophthoe falcata* samples			One-way ANOVA (between plant samples)
	Leaf	Tender shoot	Bark	F-value
1. Carbohydrate	0.32 ±0.02	0.19 ±0.06	0.89 ±0.04	222.80**
2. Protein	1.46 ±0.46	1.83 ±0.40	4.83 ±1.07	20.27**
3. Starch	9.17±0.12	7.76±0.30	6.18±0.62	41.20**
4. Reducing sugar	0.11 ±0.06	0.12 ±0.05	0.32 ±0.08	10.10*
One-way ANOVA (between molecules) F-value	969.64**	610.93**	65.27**	

*- Significance at 5% level (p=0.05); ** -Significant at 1% level (p=0.01); (n=3);

Quantification biochemical compounds

Various biochemical compounds such as carbohydrate, protein, starch and reducing sugar were quantified in the Leaf, tender shoot and bark samples of *D. falcata* and the data are presented in Table 4. The results indicates that the *D. falcata* bark samples had more amount of carbohydrates, protein and reducing sugar and low amount of starch as compared to the leaf and tender shoot samples. The leaf sample shows more concentration of starch than other two samples and the carbohydrates content was more than the bark sample of *D. falcata*. Amount of nutrients in the *D. falcata* Leaf, tender shoot and bark samples was recorded in the following descending order: starch > protein > carbohydrates > reducing sugar. In this study, the result indicates that the *D. falcata* Leaf, tender shoot and bark samples had more protein content and less reducing sugar content. The values of biomolecules concentration recorded in the leaf, tender shoot and bark samples of *D. falcata* were significant between plant samples and between molecules at 1% and 5% levels of significance.

Table 5: Analysis of minerals in the leaf, tender shoot and bark samples of *Dendrophthoe falcata* collected from *Artocarpus heterophyllus* host tree.

Minerals analyzed	Mineral content (mg/kg d. wt) in the *Dendrophthoe falcate* samples			One-way ANOVA (between plant samples)
	Leaf	Tender shoot	Bark	F-value
1. Calcium	52.08 ±1.08	51.49 ±2.41	42.32 ±1.68	27.51**
2. Iron	00.64 ±0.04	05.49 ±0.59	06.32 ±0.82	82.88**
3. Magnesium	06.74 ±0.56	06.54 ±0.46	04.68 ±0.48	15.37**
4. Phosphorus	04.58 ±0.42	05.82±0.28	03.77 ±0.77	11.32**
5. Zinc	0.00 (ND)	0.00 (ND)	0.00 (ND)	0.00
One-way ANOVA (between minerals) F-value	4430.60**	1045.03**	1055.31**	

**-Significance at 1% level (p=0.01); (n=3)

Quantification of minerals

Minerals such as phosphorus, iron, magnesium, calcium and zinc were analyzed in the *D. falcata* Leaf, tender shoot and bark samples and the results are presented in Table 5. The result of mineral analysis revealed the presence of calcium, magnesium, phosphorus and iron and the absence of zinc in the leaf, bark and tender shoot samples of *D. falcata* and shows significant variations (at p=0.01 (1%) level) between samples and between minerals in their concentration. Among the minerals tested, calcium shows maximum level as compared to other minerals in leaf, tender shoot and bark samples and zinc was not detected in all samples of *D. falcata*. The calcium and magnesium were more (52.08 and 6.74mg/kg d. wt, respectively) in leaf sample and is followed by tender shoot and bark sample. More amount of iron (6.32mg/kg d. wt.) and phosphorus (5.82mg/kg d. wt.) was noted in the bark and tender shoot samples of *D. falcata*, respectively. Mineral content of *D. falcata* Leaf and tender shoot samples are arranged in following descending order: calcium > magnesium > phosphorus > iron > zinc. Similarly, mineral content of *D. falcata* bark sample is arranged following descending order: calcium > iron > magnesium > phosphorus > zinc (Table 5).

Antimicrobial Activity

Antimicrobial activity *of D. falcata* Leaf, tender shoot and bark samples were reported in the tables 6 and 7; figure 1.

Table 6: Antibacterial activity of *Dendrophthoe falcata* leaf, tender shoot and bark samples collected from *Artocarpus heterophyllus* host plant.

***Dendrophthoe falcata* ethanol extracts used**	**Zone of inhibition (mm)**			**One-way ANOVA (between Bacteria) F-value**
	Escherichia coli	***Staphylococcus* sp.**	***Pseudomonas* sp.**	
Leaf extract	0.0±0.0 (NZ)	9.0 ±0.05	0.0 ±0.0 (NZ)	97200.00**
Tender shoot extract	9.0±1.5	9.0 ±3.0	0.0 ±0.0 (NZ)	21.60**
Bark extract	11.0±2.0	11.0 ±1.0	9.0 ±2.0	1.33NS
Standard (Positive control -Gentamicin)	22.0±3.0	22.0 ±3.0	22.0 ±3.0	0.00NS
One-way ANOVA (between plant extracts) F-value	64.26**	24.58**	99.92**	

NZ = No Zone formation; **-Significance at 1% level (p=0.01); NS-Non-significance; n=3;

Antibacterial Activity

The results of antibacterial activity of *D. falcata* Leaf, tender shoot and bark samples were recorded in the table 6; Figure 1. The bacteria such as *Escherichia coli*, *Staphylococcus* sp. and *Pseudomonas* sp. were used for the antibacterial activity study. Antibacterial activity of *D. falcata* was determined by agar well diffusion method. When compared to the control, however, all the test materials showed the lower values. Bark extracts of *D. falcata* showed high activity against *Escherichia coli* (11cm), *Staphylococcus* sp. (11cm) and *Pseudomonas* sp. (9cm) when compared to *D. falcata* Leaf and tender shoot samples. There is no observable zone of inhibition in leaf extract of *D. falcata* against *Escherichia coli* and *Pseudomonas* sp. In tender shoot extract, the *D. falcata* showed less activity as compared to the bark extract. The antibacterial activity trend is noted in the following descending order: bark > tender shoot > leaf.

Antifungal Activity

The result of antifungal activity of *D. falcata* was recorded in the table 7; figure 1. Antifungal activity of *D. falcata* samples were determined by agar diffusion method. The result from the antifungal screening of the extracts of *D. falcata* plant showed that they all had some level of activity against the test fungi (Table 7). The fungi like *Penicillium*, *Aspergillus niger* and *Aspergillus flavus* were used for this antifungal activity study. All *D. falcata* plant extracts showed lower values when compared to control (Fluconazole). Leaf extract of *D. falcata* had high activity against *Penicillium* (11cm), *A. niger* (15cm) and *A. flavus* (15cm), when compared to bark and tender shoot extracts of *D. falcata*. Bark extract of *D. falcata* showed moderate activity against tested fungi.

Table 7: Antifungal activity *Dendrophthoe falcata* Leaf, tender shoot and bark samples collected from *Artocarpus heterophyllus* host plant.

Dendrophthoe falcata ethanol extracts used	**Zone of inhibition (mm)**			**One-way NOVA (between fungus) F-value**
	***Penicillum* sp.**	***Aspergillus niger***	***Aspergillus flavus***	
Leaf extract	11 ±2.5	15 ±1.0	15 ±2.0	4.27NS
Tender shoot extract	10 ±3.0	11 2.0	00±0.0 (NZ)	25.62**
Bark extract	10 ±2.0	12 ±1.5	9 ±1.0	2.90NS
Standard (Positive control:- Fluconazole)	20 ±2.5	20 ±2.5	20 ±2.5	0.00NS
One-way ANOVA (between plant extracts) F-value	11.10**	14.52**	78.93**	

NZ = No Zone formation; **-Significance at 1% level (p=0.01); NS-Non-significance; n=3;

Discussion

Preliminary phytochemical screening of plant is very useful for the determination of the active constituents in different solvent extracts. Dashora *et al*. [10] revealed the presence of carbohydrates, phytosterols, flavonoids, glycosides and phenolic compounds in *D. falcata*. Pattanayak *et al*. [11] reported that the chloroform extract of *D. falcata* had showed positive result for steroids, terpenes, flavonoids, while methanol extract had revealed the presence of steroids, tannins, terpenes, glycosides and flavonoids. Most of the active principles are found in alcoholic and aqueous extracts. The results of the present study also are in agreement with the results of previous reports (Tables 1 to 5).

The biochemical content determined in the leaf, bark and tender shoot samples of *D. falcata* reveals that the *D. falcata* leaf sample has more amounts of starch and less amount of protein, carbohydrate, and reducing sugar content as compared to the bark and tender shoot samples (Table 4). The bark sample of *D. falcata* shows high content of carbohydrate, protein and reducing sugar and less amount of starch content than the leaf and tender shoot samples. The tender shoot sample of *D. falcata* possesses fewer amounts of all the four compounds tested as compared to leaf and bark samples. This study shows that plant parts having rich primary metabolites can be used for the biosynthesis of secondary metabolites or bioactive compounds. The analysis of minerals in the leaf, bark and tender shoot samples of *D. falcata* reveals the presence of calcium, iron, magnesium and phosphorus at varied concentrations while the zinc was not detected or in trace amount (Table 5).

According to reports, the growth of parasitic plants on different kinds of host plants exerts disease curing properties. The evidence of the presence of antimicrobial agents in plants stemmed from the noticeable resistance of such plants to pest attack [23]. Several workers have been carried out in the past to verify the folkloric use of the African mistletoe in the management of microbial infection. Earlier studies by the authors on the crude powder and some of its solvent fractions have established some significant antibacterial properties, though with negligible antifungal activity [7, 24-26].

Bark extracts of *D. falcata* showed high antibacterial activity against *E. coli Staphylococcus* sp. and *Pseudomonas* sp. when compared to leaf and tender shoot sample extracts. There is no observable zone of inhibition in leaf extract of *D. falcata* against *Escherichia coli* and *Pseudomonas* sp. The tender shoot extract of *D. falcata* showed less antibacterial activity as compared to the bark extract. The activity trend is represented as follows: bark > tender shoot > leaf. The antibacterial activity results equally showed some variations in the level of activity exhibited by the test materials against the organisms tested (Table 6).

The antibacterial activity observed in *D. facata* might have arisen as a result of a number of phytoconstituents present in the plant as reported by Ukwueze *et al*. [27]. That is, the phytochemical screening results in this study also followed the same trend as above. The higher antibacterial activity might be due to the presence of high concentration of phytoconstituents such as phenols, saponins, tannins and terpenoids in the ethanol bark sample extract of *D. falcata*. The tender shoot sample ethanol extract shows less antibacterial activity than the bark sample extract due to high concentration of phenols and moderate level of alkaloids, coumarins, saponins and tannins and absence of terpenoids. The less antibacterial activity of leaf sample extract than the bark and tender shoot sample extracts might be due to the presence of high concentration of phenol and moderate level of alkaloids, coumarins and tannins and the absence of saponins and terpenoids. This clearly indicates that no single phytoconstituent could be said to be soly responsible for the antibacterial action of the plant [27]. Among these constituents screened in this study, however, tannins, flavonoids, terpenoids, and alkaloids appear to have the greatest impact on the activity under review [7, 28, 29]. These assumptions are in supports with several documented evidence about the medicinal potentials of these plant secondary metabolites. The varied phytochemical constituents (flavonoids, alkaloids, and saponins) present in the extracts were reported to possess biological activity against microbes [30, 31].

Many authors have demonstrated the antibacterial activity of these phytochemicals [32-34]. Also some researchers devoted to substances extracted from plants have established that such metabolites like terpenoids, alkaloids, etc., significantly inhibit the growth of bacteria (*Escherichia coli*, *Staphylococcus* sps.) and fungi [34-39].

Indeed, metabolites like flavonoids and terpenoids are known to be synthesized in response to microbial infection, and thus have been found *in vitro* to be effective antimicrobial substances against a wide range of microorganisms [40-43]. Thus, the observed antibacterial activity in *D. falcata* may be due to synergy among such constituents like tannins, flavonoids, alkaloids, terpenoids and/or saponins as suggested by Ukwueze *et al*. [27].

Leaf extract of *D. falcata* had high antifungal activity against *Penicillium* sp., A*spergillus niger* and *Aspergillus flavus* as compared to bark and tender shoot extracts. Bark extract of *D. falcata* showed moderate activity against tested fungi (Table 7). As observed in this study, Orji *et al*. [44] reported that the ethanol leaf extract of *Loranthus micranthus* inhibited the growth of *Aspergillus* species and *Penicillium* species which are causative agents of infectious diseases as candidiasis, respiratory micosis, vaginosis, pelvic inflammatory disease, etc., [42, 43]. Various previous reports [7, 24-26] indicate the negligible antifungal activity of parasitic plants (*Loranthus micranthus*). The phytochemicals found in the *D. falcata* plant samples confer the antimicrobial properties of the plant. Yusuf *et al*. [45] reported that the antimicrobial properties were generally found to be more pronounced in the bacteria than in the fungal except for the *Aspergillus* species used. Fungi had been known to possess more complex structure than bacteria and this might confer the resistance on them or provide permeability barrier for the extract to get the fungi. The parasitic plants might have absorbed pharmacological active compounds into their system through their haustorium. The hydroxyl groups of phenol are thought to be responsible for its use as antimicrobial agent [23-46]. However, the optimal harvesting season as well as the host tree of the choice for the parasitic plant determines it as an antimicrobial agent [25-47]. As suggested by Ukwueze *et al*. [27], the observed antimicrobial activity in the *D. falcata* plant samples might be as a result of some interactions among the plant constituents rather than that of any one. The antimicrobial activity exhibited by the ethanol extracts of *D. falcata* justifies their use by traditional practitioner in the treatment of sores, boils and open wounds. However, the inability of the leaf extract to inhibit *Escherichia coli* and *Pseudomonas* sp., and the tender shoot extract to inhibit *Pseudomonas* sp. and *Aspergillus flavus* may be that the pathogens possess another mechanism other than acquisition of resistance for detoxifying the active ingredients of the extracts as suggested by Orji *et al*. [44]. The act that some microorganism possesses diverse mechanisms by which they convert substances that inhibit their growth to non-toxic compounds supports this hypothesis [48].

The antibacterial and antifungal activity of *D. falcata* as recorded in this study may therefore due to the presence of flavonoids, alkaloids, saponins and tannins in the extract. These phytoconstituents particularly tannins and flavonoids are proven to induce an important antimicrobial activity due to their possession of ability to inactivate the microbial adhesions, enzymes, cell envelope transport proteins and so forth as suggested [42, 43].

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