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Revisión / Review

Pharmacological potential of parasitic Angiosperms against microorganisms

[Potencial farmacológico de Angiospermas parásitas contra microorganismos]

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Abstract: Parasitic habit plants arouse great interest for their extraordinary growth adaptations and produce different secondary metabolites that allow them to survive the extreme conditions in which they develop. This can provide a range of compounds with multiple uses. However, those plants have been poorly explored and there is very little information about their natural compounds, some healing properties attributed to several communities have been scientifically supported. Articles were consulted in databases (Google Scholar, PubMed, Scielo, Science Direct, Scopus) considering the biological activity reported until June 2021. Parasitic plants present mainly antibacterial activity, some species antifungal moderate activity, and to a lesser extent were found reports of antiprotozoal activity. The composition of parasitic plants should continue to be investigated, which could be an alternative to combat various microorganisms that cause diseases, even resistant to traditional medicines.

Keywords: Parasitic plants; Antimicrobial; Antibacterial; Antifungal; Antiprotozoal.

Resumen: Las plantas parásitas despiertan gran interés por sus adaptaciones extraordinarias de crecimiento, y producir diversos metabolitos secundarios que les permiten desarrollarse en condiciones extremas, lo que puede brindar un abanico de compuestos con múltiples usos. Sin embargo, estas plantas han sido pobremente exploradas y es muy poca la información que se tiene de sus compuestos naturales, se han soportado científicamente algunas propiedades curativas, atribuidas por diferentes comunidades. Se consultaron artículos en bases de datos (Google Scholar, PubMed, Scielo, Science Direct, Scopus), teniendo en cuenta la actividad biológica reportada hasta agosto de 2019. Las plantas parásitas presentan principalmente actividad antibacteriana, algunas especies con actividad antifúngica moderada, y en menor proporción reportes de actividad antiprotozoaria. Debe continuarse indagando la composición molecular de estas plantas, lo que podría ser una alternativa para combatir diversos microorganismos causantes de enfermedades, incluso aquellos resistentes a los medicamentos tradicionales.

Palabras clave: Plantas parásitas; Antimicrobiano; Antibacteriano; Antifúngico; Antiprotozoario.

INTRODUCTION

Different plants have been recognized for their ethnobotanical use since ancient times, thanks to their innumerable chemical properties. Currently, it is not a secret that they produce numerous metabolites or compounds, both primary and secondary, that allow them to develop and survive the constant biotic and abiotic environment attacks. However, plants are not only beneficiaries of their own metabolic products, also many other organisms, in which a number of curative, toxic, and even magical-religious properties have been identified and reported (Sinoriya *et al*., 2011; Zorofchian *et al*., 2013). Due to their high biological, cosmetic, pharmacological and industrial potential, a huge variety of plants have been studied in different scientific knowledge areas to improve the quality of life of humanity.

One of the plant groups that arouses great interest are plants with a parasitic habit, which have been poorly explored in many areas of knowledge. There are mainly studies in morpho-anatomy (Suaza-Gaviria *et al.*, 2016; Suaza-Gaviria *et al.*, 2017), some reports of horizontal gene transfer with its host plant (Bock, 2010; Xi *et al.*, 2013), multiple ethnobotanical uses throughout Latin America, Africa and Asia (Aguilar, 2001; Varela *et al.*, 2004; Blair & Madrigal, 2005; Ferraz *et al.*, 2011; Koua, 2011; Alonso-Castro *et al.*, 2012; Rios *et al.*, 2012; Thomas *et al.*, 2012; Bais & Kakkar, 2013; Ogbonna *et al.*, 2013; Cedeño & Espinosa, 2015; Fitrilia *et al.*, 2015; Sembiring *et al.*, 2015; Hong *et al.*, 2019), and some compounds with different biological activities for medical application. Several studies have been realized with the aim to support scientifically the healing properties that have been attributed by different communities around the world through generations to these parasitic plants, which are distributed in the following Angiosperms families: Lauraceae, Cytinaceae, Loranthaceae, Santalaceae, Viscaceae, Convolvulaceae and Orobanchaceae.

Some experiments report phytochemical profiles in order to determine the chemical composition from evaluated extracts and, in some cases, associated them with the biological activity such as antioxidant, antimicrobial, cytotoxic, and anti-inflammatory. These results relate these species as promising for future research to explore their potentiality to pharmacological alternatives on diseases such as cancer, diabetes, hypertension, leprosy, malaria and tuberculosis. Therefore, a systematic review was carried out in plants with parasitic habit from different families of Angiosperms with medicinal properties, taking into account articles with biological activities tested on several organisms like bacteria, fungi and parasites. The key words used in the databases (Google Scholar, PubMed, Scielo, Science Direct, Springer), until June 2021, were: Angiosperms AND/OR parasitic plants AND/OR hemiparasitic plants AND/OR antimicrobial AND/OR antiprotozoal AND/OR antibacterial AND/OR antifungal AND/OR extract AND/OR inhibition. Only studies between 2000-2021 with the pathogenic species and the inhibition or biochemical mechanisms associated with some biological activity were selected, mainly focused on the antimicrobial activity of extracts, and the action of secondary metabolites with antiplasmodial effects.

Initially, titles and abstracts were reviewed, next full articles, and finally the relevance of each study was analyzed according to the topic to be included in this review. Therefore, a total of 91 articles were reviewed with full reading and 62 joined the eligibility criteria.

Characteristics of parasitic plants

Parasitism is a process that results in drastic morphology, physiology, and even genomics changes, both of the host and the parasite. This type of plant aroused great interest for their parasitic habit. These can be holoparasites, that is, only produce reproductive structures, therefore, they do not have the ability to photosynthesize, depending on their host completely. Despite hemiparasitic plants photosynthesizing their own carbohydrates, they have to obtain water and mineral nutrients from their host. Generally, parasitic plants are devoid of roots or suffer dramatic transformations that it is impossible to recognize them in advanced stages of the establishment on the host, they are known as haustorium (Heide-Jørgensen, 2008; Wanntorp & Ronse DeCraene, 2009). Hemiparasitic seedling spend their main efforts in establish physiological bond with the living tissues of the host, to avoid dying quickly (Kuijt, 1982), because it is the most vulnerable phase of their life cycle (Heide-Jørgensen, 2008; Wanntorp & Ronse DeCraene, 2009). Worldwide these characteristics ca. 4100 species in approximately 19 Angiosperm families (Gómez, 1985), well over 1% of all flowering plants (Sanjust & Rinaldi, 2021). Two of which, Loranthaceae and Viscaceae belonging to the order Santalales, are predominant in tropical landscapes, recurrently parasitizing native trees and tropical crops (Su *et al.*,

2015).

Some chemical compounds such as alkaloids, phenols, flavonoids, tannins and triterpenes, have been identified in their different polar extracts. Some of them have been associated with the biological activities of the mistletoes related to antimicrobial, antioxidant, antituberculosis, cytotoxic, hypoglycemic, hypotensive, myorelaxant activities. Finding reports of antibacterial, antifungal and antiprotozoal activity, mainly. The healing properties have been scientifically validated with the results of several physicochemical tests, many assessments in different human cell lines, *in vitro* and *in vivo* models.

These plants present reports about horizontal gene transfer (HGT) events with their hosts, as occur with a nuclear monocot gene into the genome of the eudicot parasite witchweed *Striga hermonthica* (Yoshida *et al.*, 2010). According to Bock (2010), evidence suggests that it is particularly prevalent between organisms that are either intimately associated or establish at least occasionally cell–cell contacts (e.g. in mutualistic or parasitic relationships), involving mitochondrial genes substantially higher (Mower *et al.*, 2010; Xi *et al.*, 2013). Based on Xi *et al.* words (2013), HGT appears to be facilitated by the intimate physical association between the parasites and their plant hosts. Besides, result in genomic and phenotypic changes that increase fitness substantially. At the same time, parasitic-host interactions influence the metabolites composition, and biological activities too. Several studies have reported divergences in the composition, quantity, and biological activity of the parasitic plant extracts, when the same parasitic species have been collected from different hosts (Bais & Kakkar, 2013; Fozia *et al.*, 2013; Yusuf *et al.*, 2013b; Bais *et al.*, 2014; Ogunmefun *et al.*, 2015; Furuhashi *et al.*, 2016; Hong *et al.*, 2019). Which might be potential resources of antioxidant and antibacterial activities, according to Abbes *et al.* (2014). Even the highest content of phenolic compounds and antioxidant activity was found in parasitic plants studied compared to their host plants, as Iloki *et al.* (2020) found. Indeed, the amount and biological activity of metabolite compounds present in parasitic plants is very diverse and depends on the host plant and also the parasite's organs, as well as on season was collected (Inuwa *et al.*, 2012; Shikha *et al.*, 2013), and on population altitude (Piwowarczyk *et al.*, 2020). However, according to Szurpnicka *et al.* (2020), determining which chemical compounds are responsible for the individual biological activities of mistletoe and how these activities are achieved might become a source of new complementary therapies supporting the treatment of many diseases.

Antibacterial activity

Antimicrobial activity of parasitic plants has been subject of study and multiple published investigations, especially against pathogenic bacteria in humans, both Gram positive and Gram negative. The summary of the results found is compiled in table No. 1, which summarizes for each species of parasitic plant reported, the most active extracts with their respective concentrations ([extract]). Microbiological tests were realized with the well diffusion, disk diffusion, or Minimum Inhibitory Concentration (MIC) methodologies. The diffusion method results are reported in inhibition halo diameter in millimeters (mm), and in MIC as the minimum concentration of the extract where the microbial growth is absent. Likewise, respective results of the methodology used are indicated.

Among the most relevant results (Table No. 1) found the ethanolic (E) extracts from aerial parts of *Dendrophthoe falcata*, tested with topical application on excision and incision wound models in rats, with a powerful healing efficiency associated with high expression of hydroxyproline and hexosamine, which means high rates of collagen synthesis, and therefore high cell proliferation. Similarly, also apolar fractions showed antimicrobial activity against different strains. Which justifies the ethnobotanical use in skin lesion treatments of many of these parasitic plants (Pattanayak & Sunita, 2008). Antioxidant activity from E extract of *D. pentandra* was associated with the glycoside flavanols (Figure No. 1A; Fitrilia *et al.*, 2015). Likewise, the E extract from *Struthanthus concinnus* leaves has good activity against both evaluated strains of *Mycobacterium tuberculosis*. Despite popularly being supplied as an aqueous extract, tea, prepared following the instructions given by the communities: five leaves of *Struthanthus marginatus* in a glass of water (5 g/250 mL) and 8 leaves of *Struthanthus concinnus* in 500 mL of water (2 g/500 mL), this aqueous mixture did not show *in vitro* activity against these mycobacteria. However, folk medicine also uses a mixture of plants to treat tuberculosis and related symptoms (Leitão *et al.* 2013). It is possible that interactions among different species in mixtures improve the therapeutic effects and attenuate the toxicity or adverse effects of some plants, but diverse popular names sometimes do

not exactly correspond to a specific botanical species (Bruschi *et al*., 2011). On the other hand, β-amyrin and taraxerol compounds (Figure No. 1B) were detected with antimycobacterial activity, previously reported (Leitão *et al.*, 2013). According to Orhue *et al.* (2014), ethanolic extract from *Tapinanthus dodonaeifolius* was the most potent against different bacteria, Gram positive and Gram negative, concluding that in the plant could be found precursors for the preparation of drugs. Respecting E extract from *Viscum articulatum* presented very good antibacterial activity, which is attributed to the hydroxyl and carboxyl functional groups of triterpenes, such as oleanolic acid, which constitutes a barrier against herbivorous insects and microbes. Furthermore, its low toxicity makes it an interesting compound for future pharmaceutical research (Patil *et al.*, 2015).

Table No. 1
Summary of antibacterial activity found in parasitic plants

Family	Species	Microorganism	[extract]	Inhibition halo (mm)	Extraction solvent*	Reference
Cytinaceae	*Cytinus hypocistis*	*A. baumanii* DSM 30007	500 µg/disk	10.5 ± 3.5	E	Zucca *et al.*, 2015
		E. faecalis DSM 2570		10 ± 2.8		
		S. aureus DSM 1104		13.0 ± 0.0		
		S. aureus MRSA		13.5 ± 2.1		
		S. epidermidis DSM 1798		18.0 ± 4.2		
Loranthaceae	*Dendrophtho e falcata*	*S. epidermis*	10 µg/disk	MIC	E	Pattanayak & Sunita, 2008
		S.marcescens				
		S. typhi				
		B. subtilis	25 µg/disk			
		B. cereus				
		E. aerogenes				
		K. pneumoniae				
		P. aeruginosa				
		S. pyogens				
		E. coli	50 µg/disk			
		M. luteus				
		S. aureus				
Loranthaceae	*Globimetulla brownie*	*S. aureus*	100 µL/well	10.00 ± 0.95	E	Inuwa *et al.*, 2012
		P. aeruginosa		9.00 ± 0.57		
				9.00 ± 0.57	W	
		K. aerogenes		12.00 ± 0.91		
		Proteus sp		13.00 ± 0.85		
		E. coli		10.00 ± 3.6		
Loranthaceae	*Loranthus micranthus*	*B. subtilis* NCTC 3610	1580 µg/mL	MIC	M	Osadebe & Akabogu, 2006
		E. coli NCTC 9001	1480 µg/mL			
		K. pneumoniae NCTB 418	1630 µg/mL			
		E. coli	12,42 µg/mL		H	Ogbonna *et al.*, 2013
		S. aureus	90 µg/mL		C	
Loranthaceae	*Macrosolon cochichinensi s*	*B. subtilis*	100 µl/well	4.5	M	Tripathi *et al.*, 2013
		K. pneumoniae		8		
		V. cholerae		6.5		

Loranthaceae	*Phragmanthera incana*	*B. subtilis*	12,50 µg/mL	10	AE	Atewolara-Odule & Aiyelaagbe, 2013
		E. coli	25,00 µg/mL	10	M	
		P. aeruginosa	50,00 µg/mL			
		K. pneumoniae	25,00 µg/mL			
		S. aureus	6500 µg/mL			
		A. popoffi	100,0 µg/mL	MIC	M	Puneetha *et al.*, 2014
		P. mirabilis				
		B. cereus				
		P. assamensis	200,0 µg/mL			
Loranthaceae	*Scurrula atropurpurea*	*B. subtilis*	100 µL/well	6	M	Tripathi *et al.*, 2013
		K. pneumoniae		7.5		
		V. cholerae		8		
		E. coli		5.5		
Loranthaceae	*Scurrula fusca*	*S. aureus*	450,0 µg/mL	18.28	AE	Fitrilia *et al.*, 2015
		B. cereus		18.05		
Loranthaceae	*Struthanthus concinnus*	*M. tuberculosis* H37Rv	25 µL/mL	MIC	E	Leitão *et al.*, 2013
		M. tuberculosis ATCC 35338			H	
					E	
Loranthaceae	*Struthanthus marginatus*	*M. tuberculosis* H37Rv	100 µL/mL	MIC	H	Leitão *et al.*, 2013
		M. tuberculosis ATCC 35338			D	
					E	
					H	
Loranthaceae	*Struthanthus vulgaris*	*B. cereus* ATCC 11778	180000 µg/mL	21	E W	Vieira *et al*, 2005
		B. subtilis ATCC 6633		17		
		E. coli ATCC 8739		8		
		K. pneumoniae ATCC 13883		18		
		M. luteus ATCC 9341		28		
		S. typhimurium ATCC 14028		16		
		S. aureus ATCC 6538		27		
		S. epidermidis ATCC 12228		28		
		P. aeruginosa ATCC 25619		18		
		P. aeruginosa ATCC 27853		28		
		S. mutans		MIC		Vittorazzi *et al.*, 2016
		S. aureus				
Loranthaceae	*Tapinanthus bangwensis*	*S. dysenteriae*	100,0	15	C	Efuntoye *et al.*, 2010
		P. aeruginosa		16		
		S. typhi		24		
		E. coli		15		

		S. aureus	µg/mL	17		
		S. typhimurium		10	M	
Loranthaceae	*Tapinanthus dodonaeifolius*	*E. coli*	22.5 µg/mL	MIC	AA	Orhue *et al.*, 2014
		P. aeruginosa	17.5 µg/mL		E	
		S. aureus	70 µg/mL			
		K. aerogenes	8.6 µg/mL			
Loranthaceae	*Tapinanthus sessilifolius*	*S. aureus* ATCC13709	250 µg/mL	MIC	AE	Tarfa *et al*., 2004
		E.coli ATCC 8637	500 µg/mL		H	
					AE	
					M	
		P. aeruginosa ATCC 27853	250 µg/mL		M	
		B. subtilis (ABU)			H	
					AE	
					M	
Loranthaceae	*Taxillus cuneatus*	*S. aureus* MTCC 7443	2000 µg/disk	13.46 ± 0.50	M	Puneetha *et al.*, 2014
		B. subtilis MTCC 121		15.13 ± 0.41		
		E. coli MTCC 7410		12.2 ± 0.72		
		S. typhi MTCC 733		12.43 ± 0.40		
Santalaceae	*Viscum album*	*K. pneumonia*	100 µL/well	6.00 ± 0.58	M	Tripathi *et al.*, 2013
		B. subtilis	30,0 µg/mL	6.67 ± 0.58	W	Yusuf *et al.*, 2013a
		P. aeruginosa		13.67 ± 0.67	E	
		S. mirabilis		6.33 ± 0.33		
		E. coli		9.00 ± 0.00	M	
		K. pneumoniae		8.00 ± 1.15		
		S. typhi		12.00 ± 0.58		
		S. dysenteriae		5.67 ± 0.33		
		B. cereus		13.33 ± 0.88		
		E. faecalis		20.67 ± 0.66		
		S. aureus		12.67 ± 1.20		
		S. faecium		10.67 ± 0.67		
		S. pyogenes		13.33 ± 0.88		
		C. pefringens		10.33 ± 0.33		
		B. cereus		11.17 ± 0.44	M 60%	Yusuf *et al.*, 2013b
		P. aeruginosa		12.17 ± 0.17		
		S. aureus		12.17 ± 0.75		
		E. coli		6.00 ± 0.58		
		S. typhi		6.67 ± 0.58		
Santalaceae	*Viscum articulatum*	*B. subtilis* ATCC 6633	25.0 µg/mL	MIC	E	Patil *et al.*, 2015
		S. aureus ATCC 6538				
		E. coli ATCC 8739	12.5 µg/mL			
		S. typhi ATCC 23654	8.25 µg/mL			
Viscaceae	*Phoradendron robinsonii*	*M. tuberculosis* H37Rv	50 µg/mL	MIC	D:M	Gómez-Cansino *et al.*, 2017
Convolvulaceae	*Cuscuta*	*S. aureus* ATCC	2000 µg/mL	MIC	E 70%	Ferraz *et al.*, 2011

	racemosa	6538				
Convolvulaceae	*Cuscuta reflexa*	*S. aureus*	200 µg/mL	12	E	Shikha *et al.*, 2013
		P. aeroginosa		14		
		E. coli		12		
		E. coli	50,0 µg/mL	12.4	M	Neetu & Arun, 2014
		B. subtilis		18.6		
		K. pneumoniae		13.6		
		S. aureus		13.0		
		S. typhi		17.0		
Orobanchaceae	*Alectra parasitica*	*B. subtilis*	100 µL/well	15	A	Kakpure & Rothe, 2016
		E. coli		7		
		P. vulgaris		18		
		S. typhi		15		
		P. aeroginosa		11		
		S. pneumonia		16		
		S. aureus		17	E	
Orobanchaceae	*Cistanche tubulosa*	*B. subtilis* ATCC 6633	1333.3 µg/mL	MIC	E 80%	Keymanesh *et al.*, 2009
		S. entrica NCTC 5761				
		S. aureus resist. methicillin				
Orobanchaceae	*Orobanche crenata*	*P. aeruginosa* ATCC27853	60,000 µg/mL	20	M	Abbes *et al.*, 2014 Genovese *et al*., 2020
		P. aeruginosa ATCC9027		15		
		E. coli ATCC25922		19		
		E. faecalis ATCC11700		18		
		E. cloacae ATCC13097		19		
		S. typhi ATCC14028		18		
		S. enteritidis ATCC502		28		
		S. salamae ATCC6633		18		
		S. flexnerie ATCC29903		16		
		S. aureus ATCC2592		16		
		S. pyogenes ATCC12344		30		
		L. monocytogenes ATCC19118		13		
		Y. enterocolitica ATCC23715		12		
		P. mirabilis ATCC29906		13		
		B. cereus ATCC11768		15		
		B. cereus (food isolate)		30		
		B. subtilis		25		

		(food isolate)				
Orobanchaceae	*Orobanche foetida*	*S. enteritidis* ATCC502	10,0 µg/mL	25	M	Abbes *et al.*, 2014
		L. monocytogenes ATCC19118		10		
Orobanchaceae	*Striga hermonthica*	*S. aureus*	2000 µg/mL	5.70	E	Koua, 2011
		P. aeroginosa		3.70		
		E. coli		4.00		

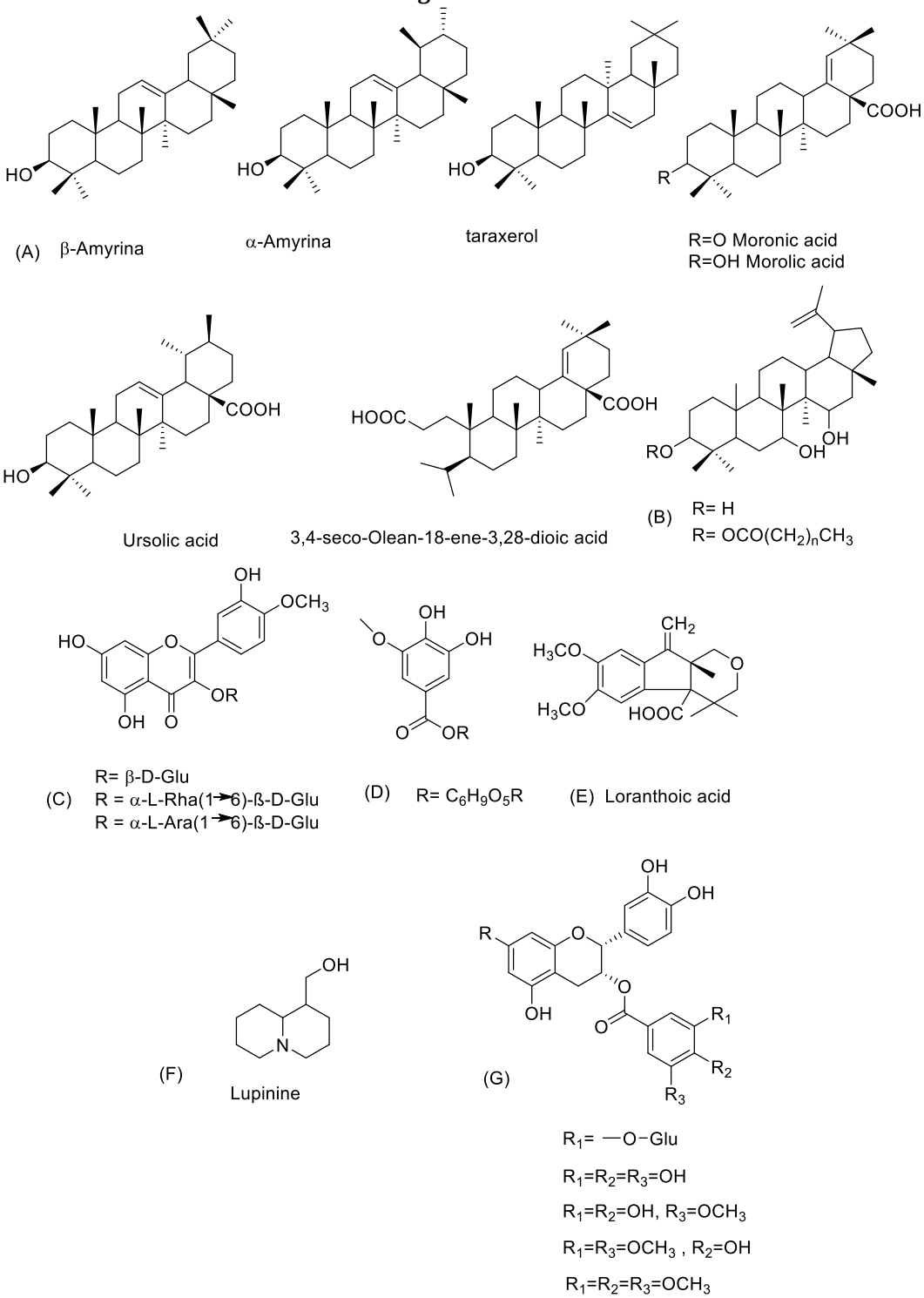
***Solvents used for the extractions: hexane (H), chloroform (C), dichloromethane (D), ethyl acetate (EA), acetone (A), dichloromethane:methanol 1:1 (D:M), acetic acid 5% (AA), ethanol (E), methanol (M) and water (W). Reported extract concentration: [extract]**

On the other hand, the methanolic extract (M) from *Loranthus micranthus* leaves, and particularly the chloroform fraction (CF), presented a great antibacterial response against *Staphylococcus aureus*. According to Ogbonna *et al.* (2013), this activity is associated with the presence of tannins, saponins and alkaloids; and suggest that the mode of action of the CF could be inhibit the peptidoglycans cross-linking in the bacterial wall, as amoxicillin does it. Figures No. 1D-F show the chemical structure compounds isolated from *L. micranthus* (Zorofchian *et al.*, 2013). According to Gómez-Cansino *et al.* (2017), the dichloromethane: methanol extract 1:1 (D:M) from *Phoradendron robinsonii* showed high antimycobacterial activity against common drug resistant strains. Different plants are usually used in traditional medicine in Mexico to treat respiratory problems, including tuberculosis, coughs, and to strengthen the immune system. The infusion of the whole plant is drunk as everyday drinkable water in the treatment of lung and kidney problems (Lara & Marquez, 1996). Since plant remedies used in traditional medicine are complex mixtures of compounds that could have different therapeutic targets, continuing studies on the supported efficacy of these plants in animal models, and even in clinical trials are needed to open the door for discovering new metabolites and drug formulation for the treatment of different diseases (Gómez-Cansino *et al.*, 2017).

Antifungal activity

Antifungal activity was found in the different polarity extracts from following parasitic plants species from Loranthaceae family: *Dendrophthoe falcata* (Pattanayak & Sunita, 2008), *Loranthus micranthus* (Osadebe & Akabogu, 2006), *Phragmanthera incana* (Atewolara-Odule & Aiyelaagbe, 2013; Ogunmefun *et al.*, 2015), *Tapinanthus sessilifolius* (Tarfa *et al.*, 2004), Santalaceae family: *Viscum album* (Yusuf *et al.*, 2013a), *V. articulatum* (Patil *et al.*, 2015), and Orobanchaceae family: *Alectra parasitica* (Kakpure & Rothe, 2016), *Cistanche tubulosa* (Keymanesh *et al.*, 2009), *Striga hermonthica* (Koua, 2011). Said extracts showed activity against plants and animals pathogenic fungi (*Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Candida albicans*, *C. krusei*, *C. tropicalis*, *Dinemasporium* sp., *Fusarium oxysporum*, *Harposporium* sp., *Mycotypha microspora*, *Penicillum notatum*, *P. oxalium*, *Rhizopus stolonifer*, *Sclerotium rolfsii*, *Tricophyton canis*). The microbiological tests were realized with well and disk diffusion methodologies reported as MIC and concentration applied on the disk with its respective mm inhibition halo, and the poisoned medium technique reported as mycelial growth inhibition percentage (Koua, 2011).

Figure No. 1



Chemical structures of phytochemical compounds found as (A) β/α-amyrin, taraxerol, moronic acid, morolic acid, ursolic acid, 3,4-seco-Olean-18-ene-3,28-dioic acid isolated from *Struthanthus marginatus* and *Struthanthus concinnus* (Leitão *et al.*, 2013), and *Phoradendron reichenbachianum* (Rios *et al.*, 2012). (B) 4'-*O*-methoxy quercetin flavonoid from *Cuscuta racemosa* (Ferraz *et al.*, 2011). (C-F) Flavonoid nucleus, phenolic derivatives, loranthoic acid, lupinine alkaloid from *Loranthus micranthus* (Zorofchian *et al.*, 2013), and also (G) flavonoid basic structure from *Dendrophthoe pentandra* and *Loranthus micranthus* (Fitrilia *et al.*, 2015)

The most relevant results with powerful MICs were the E extract from *D. falcata* against *A. fumigatus* [10 µg/disc], *A. niger* [50 µg/disc], *C. albicans* [50 µg/disc], *F. oxysporum* [50 µg/disc] and *C. tropicalis* [100 µg/disc]. According to Pattanayak & Sunita (2008), the antimicrobial potential against fungi and bacteria is confirmed and justify the plant uses and curative properties attributed from ethnobotany. The 80% E extract from *C. tubulosa* had moderate activity against *F. oxysporum* [250 µg/mL], *A. fumigatus* and *A. niger* [666.7 µg/mL]. However, it was a candidate to find anticancer phytochemicals (Keymanesh *et al.*, 2009). The other hand, the 4-methoxy-quercetin flavonoid (Figure No. 1C) was isolated from *Cuscuta racemosa*, which could be attributed to the antimicrobial activity of the plant (Ferraz *et al.*, 2011). The E extract from *Striga hermonthica* showed moderate activity at [2000 µg/mL] against *C. albicans* (3.00 mm). It is widely used in traditional African medicine against dermatosis, diabetes, jaundice, leprosy, pneumonia, even with abortive effects, and proposed for the mosquito's management given its ovicidal and larvicidal properties (Koua, 2011). Likewise, *Viscum articulatum* presented moderate activity against *C. albicans* [12,500 µg/mL] (Patil *et al.*, 2015), in contrast to the powerful antibacterial activity reported (table No. 1). While the ethyl acetate (EA) and E extracts from *Alectra parasitica* at [100 µL/well] showed significant activity against *C. albicans* (18 mm) and *A. niger* (15 mm), respectively. Further investigation on isolation and characterization of the active principles of this plant extracts responsible for the antimicrobial activity is necessary and it would give comprehensive evidence of its bioactive potential. The millennia use of this plant in Indian folk medicine suggests that it represents an economic and safe alternative to treat infectious diseases. It has been used in the treatment of leprosy, tuberculosis, swellings, fever, expulsion of intestinal worms and constipation for centuries in traditional Ayurvedic medicinal practices (Kakpure & Rothe, 2016).

The leaf extracts from *Tapinanthus sessilifolius* showed potent activity against *C. albicans* [62.5 µg/mL], being more used the aqueous extract in some parts of Africa as a remedy for diabetes, epilepsy, hypertension, infertility and varicose veins (Tarfa *et al.*, 2004). *Phragmanthera incana* has been used for centuries in Africa and Europe folk medicine to treat cancer, stomach disorders, diarrhea, dysentery, wounds, hypertension, arthritis, amenorrhea, wounds, asthma, bed wetting, infection, hysteria and other mental disturbances (Atewolara-Odule & Aiyelaagbe, 2013; Ogunmefun *et al.*, 2015). Its extracts showed moderate activity against *Rhizopus stolonifer* [25,000 µg/mL], *A. fumigatus* and *P. notatum* [50,000 µg/mL], as well as the M extract against *C. albicans* and *C. krusei* [12,500 µg/mL], all presenting 10 mm inhibition halos. Likewise, the M extract in poisoned medium reduced the growth percentage of *Harposporium* sp. (16.10 ± 2.00%), *Dinemasporium* sp. (15.80 ± 0.10%) and *Sclerotium rolfsii* (12.20 ± 0.50%) (Ogunmefun *et al.*, 2015). This experiment is relevant due to few reports about fungi species tested, which are nematophagous, saprobes and phytopathogens, respectively. The M extract from *Viscum album* leaves at [30,000 µg/mL] showed moderate activity against *A. flavus* (14.00 ± 0.58 mm), *Penicillum oxalium* (3.00 ± 0.58 mm), *Mycotypha microspora* (2.00 ± 0.00 mm), *Tricophyton canis* (1.67 ± 0.33 mm) and *Fusarium oxysporum* (1.67 ± 0.88 mm), and the E extract against *A. niger* [50,000 µg/mL] with an inhibition halo of 12.00 ± 1.15 mm. These results indicate that this plant is a promising source as a broad-spectrum microbial agent, due to its content of phenols, alkaloids, saponins, flavonoids, terpenoids and phytates (Yusuf *et al.*, 2013a).

The *Loranthus micranthus* 5.5% petroleum ether extract showed moderate activity against *C. albicans* [1730 µg/ml] and *A. niger* [4300 µg/mL]. However, this plant is known in Africa as a multipurpose herb, it is widely used for treatments against cancer, epilepsy, hypertension, infertility, menopause, rheumatism, and also used locally as an antimicrobial and antispasmodic agent (Osadebe & Akabogu, 2006).

Antiprotozoal activity

Reports of this activity were found in the following parasitic plant species: *Tapinanthus sessifolius* (Atawodi *et al.*, 2003) from Loranthaceae family, several species from *Phoradendron* genus (Blair & Madrigal, 2005) from Viscaceae family, and *Striga hermothica* (Koua, 2011; Atawodi *et al.*, 2003; Okpako & Ajaiyeoba, 2004) from Orobanchaceae family, against *Plasmodium* causing malaria, *Trypanosoma cruzi* causing Chagas disease, and *T. congolense* causing sleeping sickness. The experiments were realized with M extracts tested in murine models (Atawodi *et al.*, 2003; Okpako &

Ajaiyeoba, 2004) obtaining antimalarial activity from *Striga hermothica* with 68.5%, and from *Tapinanthus sessilifolius* with 51.3% suppression.

CONCLUSIONS

Very promising results were found in these parasitic plants with antibacterial, antifungal and antiprotozoal potential activities. That motivate to continue investigating the composition of these plants due to the structural diversity of secondary metabolites to formulate new drugs against several pathogen microorganisms. Besides, few studies determine the chemical composition of parasitic plants, in order to identify the chemical compounds responsible for the biological activities that these plants present. According to the literature consulted, it can be concluded that these plants present phytochemical constituents and biological activities that sometimes depend on the host plant species, and the season in which the plant material is collected. A greater antibacterial potential was also found, especially in the Santalales order, it mainly consists of parasitic habit species, in the Loranthaceae, Santalaceae and Viscaceae families.

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