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A search for natural bioactive compounds in Bolivia through a multidisciplinary approach Part III. Evaluation of the antimalarial activity of plants used by Alteños Indians

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Abstract

A total of 40 plant extracts traditionally used by the Alteños Indians, a native community living between the Andean block and the tropical valleys of Bolivia, were screened for antimalarial activity in vitro on *Plasmodium falciparum* chloroquine resistant (Indo) strain, and in vivo on rodent malaria *Plasmodium vinckei petteri*. Eleven extracts displayed good or moderate activity in vivo, and ten extracts good or very good antimalarial activity in vitro. Results of the screening are discussed here. in relation with the traditional use of plants. © 2000 Published by Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Alteños; Plasmodium; Antimalarial agents; Traditional medicine; Bolivia; Raqaypampeños; Quechua

1. Introduction

Malaria is a plague threatening 55% of Bolivian people and more than 45 000 cases were reported in 1995 (Ministerio de Desarrollo Humano, 1996). With the object of finding new therapeutical alternatives, we studied the antimalarial potential of plants traditionally used in Bolivia by ethnic groups (Muñoz et al., 1998a,b). In this paper we present the results of our antimalarial evaluation of plants, selected within the Alteños ethnia. The Alteños indians, also called Raqaypampeños (8800 people), live over a territory of 40 000 ha in

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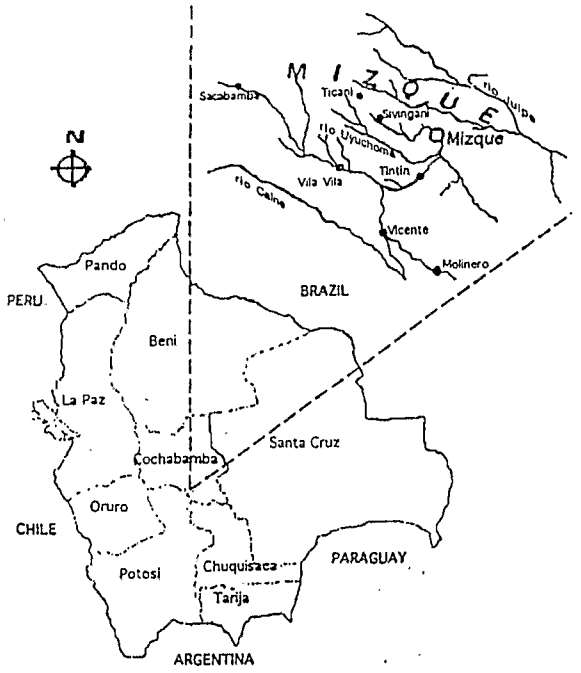
the south of the Mizque province, department of Cochabamba, in semi-arid and arid interandean valleys (from 300 to 2500 m altitude), located between the Andean block and the amazonian part of Bolivia (see map 1). The climate of Mizque is compatible with seasonal malaria transmission: in 1995, 2425 cases were registered, all of them due to *P. vivax*. (Ministerio de Desarrollo Humano, 1996). Health in the communities is ensured by local specialists, called Pampas Jampiris, who do have an accurate knowledge of the flora surrounding their area and of its use.



2. Material and method

The methodologies employed for the ethnobotanical survey, the vegetal samples treatment, and the biological tests are fully detailed in a previous paper (Muñoz et al., 1998a).

The in vivo results were classified as follows:

1. At the dose of 1000 mg/kg per day, when the percent growth inhibition was higher than 50% the activity was considered moderate, in other cases it was considered inactive;
2. At the dose of 500 mg/kg per day, if the extract displayed a percent growth inhibition around 50%, the antimalarial activity was also considered moderate;
3. At the dose of 250 mg/kg per day, if the percent growth inhibition was equal or greater than 50%, the antimalarial activity was considered good;
4. At the dose of 100 mg/kg per day if the percent growth inhibition was equal to 50%, the antimalarial activity was considered very good.

The *Cinchona calisaya* bark extract, used as a positive standard for these assays displayed 91% of inhibition at 250 mg/kg per day while 5 mg/kg of chloroquine inhibited 100% of the parasite growth.

We considered the following range of antimalarial activities in vitro:

1. % Growth inhibition at 10 μg/ml
   Around 90% is excellent
   Around 50% is very good
2. % Growth inhibition at 100 μg/ml
   Around 90% is good
   Around 50% is weak

The IC50 of *Cinchona calisaya* stem bark extract used as the standard drug in the in vitro assays was 0.2 μg/ml. The IC50 of Chloroquine was 74 ng/ml.

3. Selection of plants

One hundred and seventy six different species were indicated by the Alteños to cure or alleviate various diseases and symptoms (Sandoval et al., 1996). Among them, forty were selected for biological evaluation. Details of their traditional use are explained in Table 1.

We decided to study:

1. One species mentioned as being specifically used against malaria, *Randia spinosa*.
2. Five species used to cure fever: *Commelina elliptica*, *Cuscuta grandiflora*, *Stellaria ovata*, *Monnina salicifolia*, *Satureja* sp.
3. Eighteen species used to cure symptoms with a possible relevance to a malaria attack, as digestive troubles or headache: *Aloysia gratis-*

Table 1
Traditional uses of species selected for antimalarial investigation

Species, family vernacular name voucher number	Traditional Alteños use (Sandoval et al., 1996)	Part of plant tested
Aloysia gratissima (Gill. ex Hook). & Arn. Verbenaceae **kutukutu** ES1078	An infusion of leaves and/or flowers is used to alleviate stomach ache.	Leaves
Aloysia triphylla (L'Herit.) Britton Verbenaceae **montecedron** AL156	An infusion of leaves with or without flowers is used to alleviate respiratory problems.	Leaves
Antennaria linearifolia Wedd. Asteraceae **ismuwaqachi** AL112	The entire plant is crushed, and applied as a poultice on boils.	Entire plant
Argemone mexicana L. Papaveraceae **cardosanto** AL1056	An infusion of the flowers is drunk against cough.	Flowers
Aristolochia postrata Duchtr. Aristolochaceae **wijucu** AL319	The whole plant is crushed, boiled in water and is sprayed over the potatoes fields, against 'worms'.	Aerial plant
Aspidosperma pyrifolium C. Martius Apocynaceae **naranjillo** AL135	Branches are boiled for a long time in water, and is sprayed over potatoes fields, against 'worms'.	Bark
Baccharis genistelloides D.C. Asteraceae **kinsa k'uchu** AL35	An infusion of the leaves is used against stomach ache. At higher doses, this infusion can produce abortion.	Leaves
Baccharis rufescens Spreng. Asteraceae **Chiñi tola** AL13	Branches with leaves are crushed, in the form of a paste, which is applied on the thorax, to alleviate lung pain.	Leaves
Berberis chrisacantha Lechi. Berberidaceae **q'ellu khishka** AL22	An infusion of leaves with or without flowers is used to alleviate menstruation pains.	Leaves
Bomarea amoena (Herb.) M. Roemer Alstromeriaceae **o'ka o'ka** AL174	A decoction of the whole plant, especially the fruits has purgative properties.	Fruits
Calceolaria rivularis Kranzl. Scrophulariaceae **orq kachi zapatilla** ES1118	The whole plant is prepared in form of a tea, which is drunk to alleviate stomach ache.	Aerial part
Carica quercifolia (A. St. Hil) Solms-Laub Caricaceae **oraq k'ara lawa** AL365	Leaves and branches are crushed, mixed with water. This water is then sprayed over the potatoes fields in order to get rid of 'worms'.	Leaves and branches
Commelina elliptica H.B.K. Commelinaceae **alqo chupao** AL121	The aerial part of this plant is boiled in a lot of water, and is administered in form of a bath, to calm down fever.	Aerial part
Conium maculatum L. Apiaceae **Jima Jama** AL175	A decoction of roots is used against stomach ache and diarrhoea.	Roots
Cuscuta aff. grandiflora H.B.K. Cuscutaceae **layu layu** ES1112	The aerial part is crushed and applied as a poultice on the thorax, in order to alleviate respiratory disease, or to calm down high fever.	Aerial part
Dunalia brachyacantha Miers in Hooks Solanaceae **kutukutu** AL21	An infusion of some leaves and bark is used to alleviate stomach ache.	Leaves
Eryngium sudicaule Lam. Apiaceae **alqo alqo** AL96	A bath is made out with the entire plant, in order to cure facial paralysis and headache.	Aerial part
Kageneckia lanceolata R. & P. Rosaceae **lluk'i** ES1056	Branches with leaves are crushed in water. This water is sprayed over potatoes fields, to get rid of 'worms'.	Leaves
Lucilia recurva Wedd. Asteraceae **pampak'oa** ES1138	The leaves are prepared in form of a tea, which is drunk to alleviate stomach ache. This 'tea' is also used topically to alleviate insect bites.	Leaves

Table 1 (*Continued*)

Species, family **vernacular name** voucher number	Traditional Alteños use (Sandoval et al., 1996)	Part of plant tested
Monnina salicifolia R. & P. Polygalaceae **waina t'ola** ES1113	A bath is prepared with the leaves, and is administered to calm down high fever, respiratory disease and headache.	Leaves
Mutisia acuminata (Gris.) Cabr. Asteraceae **chinchercoma** AL510	The leaves are prepared in form of a tea, which is drunk to alleviate stomach ache.	Leaves
Myrica pubescens Humb. Bompl. ex Willd. Myricaceae **yuruma** AL170	Leaves are prepared as a tea, which is drunk to alleviate headache, or leaves are prepared in form of a bath, administered in cases of rheumatic pain.	Leaves
Myroxylon peruiferum L.f Fabaceae **quina quina** AL159	The fruits are washed well, then boiled in water. Drops of this water is then introduced in the ear to alleviate earache.	Fruits
Peperomia pellucida (L.) H.B.K. Piperaceae **china tabardillo** ES1102	The whole plant is crushed and mixed with some water, which is heated, then drunk to stop haemorrhages.	Whole plant
Pestinaca sp. Apiaceae **jama jama** ES1123	The roots are prepared in form of a decoction, which is administered against stomach ache.	Roots
Polypodium buchtienii Christ. Rosent. Polypodiaceae **sach'a coca coca** ES1117	An infusion of the leaves is drunk in order to alleviate stomach ache.	Leaves
Randia spinosa (Jacq.) Karst. Rubiaceae **mogomogo** ES1022	A fruit decoction is drunk against malaria.	Fruits
Sapium haematospermum Mull. Arg. Euphorbiaceae **leche leche** ES1176	Crushed leaves are mixed with water. This water is then sprayed over the potatoes fields to get rid of the 'worms'.	Leaves
Satureja boliviana (Benth) Briq. Lamiaceae **chullpa muña** AL164	Leaves are boiled in water. This tea is drunk to alleviate stomach ache.	Leaves
Satureja sp. Lamiaceae **burru muã** AL129	An infusion of the leaves is drunk to alleviate stomach ache, and also to calm down fever.	Leaves
Schinus andinus (Engler) I.M. Johnst Anacardiaceae **luyu luyu** ES1055	Leaves and branches are crushed in water. This water is then sprayed over the potatoes fields to get rid of 'worms'.	Leaves and branches
Schkuria pinnata (Lam.) O. Kuntze Asteraceae **jayajpichana** AL107	A decoction of the whole plant is drunk against stomach ache.	Whole plant
Senecio brasiliensis (Spreng.) Less. Asteraceae **mayowach'a** AL50	Leaves are mashed and applied as a poultice, in order to alleviate headache.	Leaves
Stellaria ovata Willd ex Grisebach Caryophyllaceae **tabardillo** AL117	The aerial part of the plant are prepared in form of a tea, drunk against high fevers.	Aerial part
Tagetes graveolens Schultz. Asteraceae **suyko** ES1109	An infusion of the aerial part of this plant is drunk against stomach ache, and a bath is administered to calm down fevers.	Aerial part
Tagetes nusilla H.B.K. Asteraceae **anis anis** AL322	The aerial part of this plant is prepared in form of a tea, which is drunk to alleviate stomach ache.	Aerial part
Trichocereus pachaoni Britton & Rose Cactaceae **achuma** ES1125	Slice of this cactus are slightly toasted, and applied on painful or inflamed area, wounds, etc.	Aerial part
Tripodanthus cf. *acutifolius* (R. & P.) Van Tiegh Loranthaceae **llave** ES874	Leaves are crushed, and applied in form of a poultice in order to help the healing of broken limbs, or various traumas.	Leaves
Trixis grisebachii O. Kuntze Asteraceae **jatun thian thian** ES1101	An infusion of the aerial part of this plant is drunk against stomach ache.	Aerial part
Vallea stipularis L.f Elaeocarpaceae **manzanilla** AL8	An infusion of the leaves is drunk against stomach ache.	Leaves

sima, *Baccharis genistelloides*, *Calceolaria rivularis*, *Conium maculatum*, *Dunalia brachyacantha*, *Eryngium nudicaule*, *Lucilia recurva*, *Mutisia Mutisia acuminata*, *Myrica pubescens*, *Pestinaca* sp., *Polypodium buchtienmii*, *Satureja* aff. *boliviana*, *Schkuhria pinnata*, *Tagetes graveolens*, *T. lens*, *T. pusilla*, *Trixis grisebachii*, *Vallea stipularis*, *Senecio brasiliensis*.

4. Ten species used to cure a wide range of symptoms with apparently no relation with a malaria attack: *Aloysia triphylla*, *Antennaria linearifolia*, *Argemone mexicana*, *Baccharis rufescens*, *Berberis chrisacantha*, *Bomarea amoena*, *Myroxylon peruiferum*, *Peperomia pellucida*, *Trichocereus* cf. *pachaoni*, *Tripodanthus acutifolius*.
5. Finally, six species used against phytopathogens: *Aristolochia postrata*, *Aspidosperma pyrifolium*, *Carica quercifolia*, *Kageneckia nudicaule*, *Sapium haematospermum*, *Schinus andinus*.

4. Results and discussion

Results of the biological evaluation are displayed in Table 2.

4.1. In vitro results

Twenty nine ethanolic plant extracts were evaluated in vitro. One plant extract (*T. acutifolius*) showed very good antimalarial activity in vitro, with 98% of inhibition at 10 μg/ml comparable to the activity of *Artemisia annua* and of some Simaroubaceae plants (O'Neill et al., 1985). Nine extracts showed good activity with an inhibition greater than 90% at 100 μg/ml (*Baccharis genistelloides*, *B. rufescens*, *Commelina elliptica*, *Dunalia brachyacantha*, *Perperomia pellucida*, *Satureja* sp., *Schinus andinus*, *Tagetes graveolens*, *Vallea stipularis*).

4.2. In vivo results

Thirty nine ethanolic plant extracts were tested in in vivo. In this model, the maximum % of inhibition recorded was of 100%, at the dose of 636 mg/kg per day, for *C. elliptica*, thus demonstrating a good activity. Then ten-plant extract displayed a moderate activity, at the dose of 1000 mg/kg per day. All other extract were considered inactive. Over the 28 extracts tested both in vitro and in vivo, only four extracts (*Baccharis rufescens*, *Commelina elliptica*, *Dunalia brachyacantha*, *Peperomia pellucida*) displayed interesting activity on both tests.

In order to highlight the potential antimalarial activity of the species, we sorted our results with the in vivo results, highlighting the extracts displaying good or moderate antiprotozoal activity.

4.2.1. *Argemone mexicana* L. (Papaveraceae)

The flower extract showed moderate activity in vivo (62% at 1000 mg/kg), and was not tested in vitro. In Bolivia, *A. mexicana* is a medicinal species widely used in all places it grows. The yellow latex is applied on the skin against various dermatitis, while seeds are used for their laxative properties (De Lucca and Zalles, 1992). *A. mexicana* has a large panel of medicinal indications everywhere it grows and was extensively studied. It is known to contain the alkaloid berberine, which has been recommended for the treatment of malaria in association with quinine (Watt and Breyer-Brandwijk, 1962). As this observation was made in the forties, it could be relevant to evaluate the potentiating activity of this plant in combination with classical antimalarial treatment against resistant strains of *Plasmodium*.

4.2.2. *Commelina elliptica H.B.K.* (Commelinaceae)

The aerial part extract inhibited 100% of the parasite growth in vivo at 636 mg/kg (99% at 100 μg/ml in vitro). Many species of *C.* are reported to be used against malaria: *C. paleata* (Holdsworth, 1992), *C. nudiflora* (Hasrat et al., 1997), *C. longicaulis*, *C. elegans* (Ayensu, 1978) *C. communis* (Duke and Ayensu, 1985), *C. erecta* (Macdonald Hocking, 1997) or as febrifuge, i.e. *C. diffusa* (Caceres et al., 1987), *C. communis* was shown to contain *n*-hentriacontanol (Tang et al., 1994). This fatty alcohol, also isolated from the bolivian Solanaceae, *Cuatresia* sp., greatly reduce the virulence of experimentally induced *P. vinckei* infection (Deharo et al., 1992). The presence of this molecule in the genus *Commelina* may explain the reputation

Table 2
Antimalarial activity of selected plants in vivo and in vitro

Voucher number	Scientific name	In vitro		In vivo	
		Concentration (μg/ml)	Percentage of inhibition	dosage (mg/ kg per 4D)	percentage of inhibition
ES1078	*Aloysia gratissima*	100	77	1000	43
AL156	*Aloysia triphylla*	100	69	688	33
AL112	*Antennaria linearifolia*	100	84	200	0
AL10.6	*Argemone mexicana*			1000	62
AL319	*Aristolochia postrata*			880	10
AL135	*Aspidosperma pyrifolium*			1000	toxic
AL35	*Baccharis genistelloides*	100	100	966	33
AL13	*Bacharris rufescens*	100	97	1000	62
AL22	*Berberis chrisacantha*	100	66	1000	13
AL174	*Bomarea amoena*	100	65	1000	1
ES1118	*Calceolaria rivularis*	100	71	1000	43
AL365	*Carica quercifolia*			1000	0
AL121	*Commelina elliptica*	100	99	636	100
AL175	*Conium maculatum*			736	40
ES1112	*Cuscuta aff. grandiflora*			1000	62
AL21	*Dunalia brachyacantha*	100	96	807	70
AL96	*Eryngium nudicaule*	100	77	724	82
ES1056	*Kageneckia lanceolata*	100	70	1000	toxic
ES1138	*Lucilia recurva*			716	1
ES1113	*Monnina salicifolia*			1000	38
AL510	*Mutisia acuminata*	100	50	932	49
AL170	*Myrica pubescens*	100	82	350	47
AL159	*Myroxylon peruiferum*	100	44	1000	35
ES1102	*Peperomia pellucida*	100	95	1000	78
ES1123	*Pestinaca* sp.	100	87	1000	76
ES1117	*Polypodium buchtienii*	100	74	1000	80
ES1022	*Randia spinosa*			1000	0
ES1176	*Sapium haematospermum*			1000	40
AL164	*Satureja boliviana*	100	85	1000	31
AL129	*Satureja* sp.	100	91	715	36
ES1055	*Schinus andinus*	100	93	250	0
AL107	*Schkuhria pinnata*			1000	62
AL50	*Senecio brasiliensis*	10	45		
AL117	*Stellaria ovata*	100	71	911	94
ES1109	*Tagetes graveolens*	100	90	1000	6
AL322	*Tagetes pusilla*	100	73	1000	41
ES1125	*Trichocereus pachaoni*	100	81	1000	17
ES874	*Tripodanthus acutifolius*	10	98	981	0
ES1101	*Trixis grisebachii*	100	80	1000	17
AL8	*Vallea stipularis*	100	96	1000	48

the roots are prepared in form of a light infusion, which is drunk in cases of respiratory disease and malaria. If prepared in a strong decoction, the roots are said to have purgative and anthelmintic properties (Girault, 1984).

4.2.10. Schkukia pinnata (Lam.) O. Kuntze (Asteraceae)

This extract presented moderate activity against *Plasmodium petteri* (62% inhibition at 1000 mg/kg). The entire plant is used in Peru as a diuretic, depurative, antidiabetic, antiinflammatory, against allergies and malaria (Ramirez et al., 1988), while the dried leaves, swallowed with water, are used in Zimbabwe as a remedy for malaria (Watt and Breyer-Brandwijk, 1962). In Argentina, a decoction of dried branch and leaves is used against diarrhoea and to treat respiratory and urinary tract infections (Perez and Anesini, 1994). Leaves, flowers and branches of another species of Schkuhria, *S. pinnata* var. *octoaristata* DC. is also a popular Peruvian remedy against malaria (Ramirez et al., 1988).

4.2.11. Stellaria ovata Wiild. ex Grisebach (Caryophyllaceae)

This extract showed moderate antimalarial activity in vivo (94% inhibition at 911 mg/kg) and a good (71% at 100 μg/ml) in vitro activity. As far as we know, no other biological activity was reported in the literature for this species.

5. Conclusion

Among the 28 plants evaluated both in vitro and in vivo only four species (*B. rufescens*, *Commelina elliptica*, *Peperomia pellucida*, and *Dunalia brachyacantha*) have a in vivo–in vitro correlated activity, thus making these species a priority for further antimalarial investigations.

The only species specifically designated by the Alteños as useful against malaria, *R. spinosa*, did not show any activity in our tests, but it is worthwhile to prepare the extract in the same manner as the Alteños do, using water, and the oral route, because passage through the peritoneal area bypasses the alterations caused by the digestive tract and therefore avoids structural alterations, possibly essential for the antimalarial activity.

Among the five species used against feverish condition by the Alteños, two of them displayed moderate in vivo activity (*Shellamia ovata* and *Cuscuta grandiflora*).

Among the 18 species designated by the Alteños as useful in symptoms with a possible relevance to a malaria attack, as digestive troubles, stomach ache, or headache, three species displayed good antiamlarial activity in vitro: *Baccharis genistelloides*, *Vallea stipularis*, *Tagetes graveolens*, and four a moderate activity in vivo: *Eryngium nudicaule*, *Pestinaca* sp., *Polypodium buchtiennii*, and *Schkunria pinnata*. One extract, *Dunalia brachyacantha* displayed good in vitro activity and moderate in vivo activity.

In the group of the ten species used to cure a wide range of symptoms with apparently no relation with a malaria attack, one species displayed very good activity in vitro, *Tripodenthus acutifolius*, one displayed moderate activity in vivo, *Argemone mexicana*, and two displayed both moderate in vivo and in vitro activity: *Baccharis rufescens*, and *Peperomia pellucida*.

Finally, among the six species used against phytopathogens, only one species, *S. andinus* displayed good in vitro ativity.

For all the promising extracts tested at 1000 mg/kg and displaying a moderate activity such as *Baccharis rufescens*, *Eryngium nudicaule*, *Peperomia pellucida*, *Polypodium buchtienii* and *Schkuria pinnata*, *Stellaria ovata* we suggest that the antimalarial activity should be evaluated at lower doses, prior to any chemical purification.

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of various species of *Commelina* as antimalarial agents, and so forth, the good activity displayed by our extract in vivo and in vitro. Still, the presence of this compound in *C. elliptica* has to be proved.

4.2.3. Baccharis rufescens Spreng (Asteraceae)

Two species of *Baccharis* were retained in this screening, *B. rufescens* whose extract did show moderate activity in vivo (62% inhibition at 1000 mg/kg) and a good in vitro activity (100% at 100 μg/ml), and *B. genistelloides*, showing a good in vitro activity (100% of inhibition at 100 μg/ml), but no activity in vivo. The genus *Baccharis* is widely used in traditional medicine, all over South America, and the list of the reported traditional uses is almost endless!. Only for *B. genistelloides*, the aerial part are reported to be used in Columbia and in Peru for their emmenagogue properties (Hoet, 1980; Hirschhorn, 1981) or for other gynecological ailments (Ramirez et al., 1988), as homeostatic in Columbia (Hirschhorn, 1981), against fever or malaria in Peru and in Brazil (Wasicky et al., 1942; Brandao et al., 1985; Ramirez et al., 1988), for stomach ache, to consolidate dislocation (Yelaseo Negueruela et al., 1995), to alleviate rheumatic pains (Ramirez et al., 1988), and also against diabetes (Felcman and Braganca, 1988). Thus, it seems that the antimalarial activity displayed in our models, correlated with the various traditional uses reported for the genus, indicate that *B. rufescens* is a species with strong biological potential.

4.2.4. Cuscuta grandiflora H.B.K. (Cuscutaceae)

The aerial part of the extract was moderately active in vivo (62% at 1000 mg/kg). No activity was reported in vitro. Germosén-Robineau (1995) reported that in Haiti, the aerial part of *Cuscuta americana* L. to be used against intestinal worms, and was also demonstrated active against *Strongyloides stercoralis*. In Bolivia, species from the *Cuscuta* genus are generally employed to facilitate biliary secretions, and also for their laxative effect. However at higher doses, they do present some gastro-intestinal toxicity that can lead to death (De Lucca and Zalles, 1992), and that might be the case with *C. grandiflora*.

4.2.5. Dunalia brachyacantha Miers in Hook (Solanaceae)

The leaf extract of this species displayed moderate antimalarial activity in vivo (70% inhibition at 807 mg/kg) and a good one in vitro (96% at 100 μg/ml). Withanolides glycosides isolated from this species by Bravo et al. (1999) are under biological evaluation in our laboratory.

4.2.6. Eryngium nudicaule Lam.(Apiaceae)

The aerial part of the extract of this species displayed a moderate activity in vivo (82% at 724 mg/kg), and no activity in vitro. In Bolivia, the aerial part of this species, as well as the one of another *Eryngium*, *E. foetidum* L. is also used in form of a tea against intermittent fevers (Girault, 1984; De Lucca and Zalles, 1992).

4.2.7. Peperomia pellucida (L.) H.B.K. (Piperaceae)

The entire plant extract inhibited 78% of parasite growth in vivo at 1000 mg/kg displaying moderate activity, and was also active in vitro (95% at 100 μg/ml). De Lucca and Zalles (1992) reported that the root decoction of this plant was a good febrifuge. The same author also reported the utilisation of the mashed aerial part of this plant as a dressing for wounds.

4.2.8. Pestinaca sp. (Apiaceae)

The root extract of this species showed good in vitro activity (87% at 100 μg/ml) and moderate in vivo (76% inhibition at 1000 mg/kg). Despite the fact that no ethnobotanical data nor biological were found on this genus in our bibliographical search, the antimalarial activity displayed in our model justifies further biological and chemical investigation, depending upon the possibility of completing the botanical determination of this species.

4.2.9. Polypodium buchtienii Christ. Rosent.(Polypodiaceae)

This species showed good activity in vitro (74% at 100 μg/ml) and moderate in vivo as well (80% inhibition at 1000 mg/kg). In Bolivia, leaves of this species are also chewed against cough, and

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References

Ayensu, E.S., 1978. Medicinal plants of the West Indies. Office of Biological Conservation Smithsonian Institution, Washington, DC Unpublished manuscript.

Brandao, M., Botelho, M., Krettli, E., 1985. Antimalarial experimental chemotherapy using natural products. Ciencia Cult. 37 (7), 1152–1163.

Bravo, J.A., Lavaud, C., Gimenez, A., Sauvain M., Balanza, E., Das, E., Laprevote O., Le Men-Olivier, L., Massiot, G., 1999. Withanolide glycosides from *Dunalia brachyacantha*, Phytochemistry, in press.

Caceres, A., Giron, L.M., Martinez, A.M., 1987. Diuretic activity of plants used for the treatment of urinary ailments in Guatemala. Journal of Ethnopharmacology 19 (3), 233–245.

De Lucca, M., Zalles, J., 1992. Flora medicinal de Bolivia, Diccioniario enciclopédico. Los Amigos del Libro, La Paz, Bolivia.

Deharo, E., Sauvain, M., Moretti, C., Muñoz, V., Richard, B., Ruiz, E., Massiot, G., 1992. Activité antipaludique du *n*-hentriacontanol isolé du *Cuatrecia* sp (Solanaceae). Annales de Parasitologie Humaine Comparée 67 (4), 126–127.

Duke, A., Ayensu, E.S., 1985. Medicinal Plants of China, vol. 14. Reference Publications, Algonac, MI, pp. 52–361.

Felcman, J., Braganca, M., 1988. Chromium in plants comparison between the concentration of chromium in Brazilian nonhypo and hypoglycemic plants. Biological Trace Elements Research 17 (1), 11–16.

Germosén-Robineau, L. (Ed.), 1995. Hacia una Farmacopea Caribe. Tramil, Enda-Caribe, Santo-Domingo.

Girault, L., 1984. Kallawaya, Guérisseurs itinérants des Andes, vol. 107. Editions de l'ORSTOM, Collection mémoires, Paris, France.

Hasrat, J.A., De Backer, J.P., Vauquelin, G., Vlietinck, A.J., 1997. Medicinal plants in Suriname: screening of plant extracts for receptorbinding activity. Phytomedicine 4 (1), 59–65.

Hirschhorn, H., 1981. Botanical remedies of South and Central America, and the Caribbean: an archival analysis. Part 1. Journal of Ethnopharmacology 4 (2), 129–158.

Hoet, P., 1980. The use of certain plants from the traditional pharmacopoeia of Peru. Plantes Medicinales Et Phytotherapie 14 (3), 193–201.

Holdsworth, D., 1992. Medicinal plants of the Gazelle peninsula, New Britain Island, Papua New Guinea. Part 1. International Journal of Pharmacognosia 30 (3), 185–190.

Macdonald Hocking, G., 1997. A Dictionary of Natural Products. Plexus, Medford, USA.

Ministerio de Desarrollo Humano, Secretaria Nacional de Salud. Direccion Nacional de Vigilancia y Control de Enfermedades y Riesgos. Dpto. Nal. de Control de Vectores, 1996. Informe de actividades del Programa de Vigilancia y Control de la Malaria. Secretaria Nacional de Salud, La Paz, Bolivia.

Muñoz, V., Sauvain, M., Bourdy, G., Callapa, J., Bergeron, S., Rojas, I., Bravo J.A., Balderrama L., Ortiz, B., Gimenez A., Deharo, E., 1998. A search for natural bioactive compounds in Bolivia through a multidisciplinary approach. Part I. Evaluation of the antimalarial activity of plants used by Chacobo Indians. Journal of Ethnopharmacology, in press.

Muñoz, V., Sauvain, M., Bourdy, G., Callapa, J., Rojas, I., Vargas, L., Tae, A., Deharo, E., 1998. A search for natural bioactive compounds through a multidisciplinary approach in Bolivia. Part II. Antimalarial activity of plants used by Mosetene Indians. Journal of Ethnopharmacology, in press.

O'Neill, M., Bray, D.H., Phillipson, J.D., Warhust, D.C., 1985. Plants as source of antimalarial drugs. Part I, in vitro test method for the evaluation of crude extracts from plants. Planta Medica 61, 394–398.

Perez, C., Anesini, C., 1994. Inhibition of *Pseudomonas aerguinosa* by Argentinean medicinal plants. Fitoterapia 65 (2), 169–172.

Ramirez, V.R., Mostacero, L.J., Garcia, A.E., Mejia, C.F., Pelaez, P.F., Medina, C.D., Miranda, C.H., 1988. Vegetales empleados en medicina tradicional Nor-Peruana. Banco Agrario del Peru & Nac. Univ. Trujillo, Trujillo, Peru.

Sandoval, P., Choque, J., Uriona, P., 1996. Cartilla popular sobre las plantas utiles de los Alteños de Mizque-Cochabamba. FONAMA-CIBE-UMSA, Cochabamba, Bolivia.

Tang, X.Y., Zhou, M.H., Zhang, Z.H., Zhang, Y.B., 1994. Active constituents of *Commelina communis* L. Chung Kuo Chung Yao Tsa Chih 5 (19), 297–298.

Wasicky, R., Unti, O., Barbieri, E., 1942. Quinine and alkaloids in Brazil. An. Fac. Farm. Odontol. Univ. Sao Paulo 3, 137.

Watt, J.M., Breyer-Brandwijk, M.G., 1962. The Medicinal and Poisonous Plants of Southern and Eastern Africa, 2nd ed. Livingstone, London.

Yelasco Negueruela, A., Perez Alonso, M.J., Esenarro Abarca, G., 1995. Medicinal plants from Pampallakta: an Andean community in Cuzco (Peru). Fitoterapia 66 (5), 447–462.