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Hunting and hallucinogens: The use psychoactive and other plants to improve the hunting ability of dogs

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ABSTRACT

Ethnopharmacological relevance: Cultures throughout the world give plants to their dogs in order to improve hunting success. These practices are best developed in lowland Ecuador and Peru. There is no experimental evidence for the efficacy of these practices nor critical reviews that consider possible pharmacological effects on dogs based on the chemistry of the ethnoverterinary plants.
Aim: This review has three specific aims: (1) determine what plants the Ecuadorian Shuar and Quichua give to dogs to improve their hunting abilities, (2) determine what plants other cultures give to dogs for the same purpose, and (3) assess the possible pharmacological basis for the use of these plants, particularly the psychoactive ones.
Methods: We gathered Shuar (Province of Morona-Santiago) and Quichua (Napo and Orellano Provinces) data from our previous publications and field notes. All specimens were vouchered and deposited in QCNE with duplicates sent to NY and MO. Data presented from other cultures derived from published studies on ethnoveterinary medicine. Species names were updated, when necessary, and family assignments follow APG III (Angiosperm Phylogeny Group, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Bot. J. Linn. Soc. 161, 105–121). Chemical data were found using PubMed and SciFinder.
Results: The Shuar and Quichua of Ecuador use at least 22 species for ethnoveterinary purposes, including all but one of their principal hallucinogens. Literature surveys identified 43 species used in other cultures to improve hunting ability. No published studies have examined the pharmacological active of these plant species in dogs. We, thus, combined phytochemical data with the ethnobotanical reports of each plant and then classified each species into a likely pharmacological category: depuratives/deodorant, olfactory sensitizer, ophthalmic, or psychoactive.
Conclusions: The use of psychoactive substances to improve a dog's hunting ability seems counter-intuitive, yet its prevalence suggests that it is both adaptive and that it has an underlying pharmacological explanation. We hypothesize that hallucinogenic plants alter perception in hunting dogs by diminishing extraneous signals and by enhancing sensory perception (most likely olfaction) that is directly involved in the detection and capture of game. If this is true, plant substances also might enhance the ability of dogs to detect explosives, drugs, human remains, or other targets for which they are valued.

1. Introduction

Dogs (*Canis lupus familiaris*) in the New World originated from multiple Old World lineages that migrated with late Pleistocene humans across the Bering Strait (Leonard et al., 2002). They entered South America with the early human colonists and also were re-introduced by European explorers. Dogs were apparently absent in the Amazon Basin (until the historical period) but present in the Guyanas and the Orinoco River Basin. Following European contact, genetic evidence suggests that newly introduced European dog races began to replace native dogs throughout the America (Koster, 2009). Hunting dogs are now common throughout much of the Amazon region (Fig. 1).

The role of dogs in human societies is diverse. They assist in warfare, detect odors, deter pest and predatory animals, guard property and people, guide the blind and deaf, protect other domesticated animals, provide human companionship, pull sleds, rescue lost and injured humans, and track and retrieve game animals. They also provide food and fur, serve as living blankets, and function in symbolic

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Fig. 1. Hunting dog in a Quichua village in Ecuador.

Fig. 2. Spotted paca (*Cuniculus paca*) in Ecuador.

rituals (Diamond, 1997; Coppinger and Schneider, 1995; Hart, 1995). Dogs play an important role in religions and rituals throughout the world. Ecuadorian Shuar believe that dogs are a gift from Nunkui, the earth mother (Bennett et al., 2002). According to the Quichua, dogs are gifts from sachahuarmi or sacharuna (forest spirits). They believe the canines protect hunters and family members from malevolent forest spirits called mal aire (bad air) and mal ojo (evil eye). They also believe that dogs dream and that they have souls (Kohn, 2007). The Egyptian god Anbu (or Anubis) is often portrayed as a man with the head of a dog or jackal (Gadalla, 2001). Xolotl, twin of the Aztec god Quetzalcoatl, was the dog god and served as a guide to the dead (Fernández, 1992). As part of a burial ritual, Aztec inhabitants of Anahuac killed a dog and laid it beside a human corpse. They believed that four years after death, the dog carried human soul to Chicunauhapan, the ultimate resting place of the dead (Beyer, 1908). Dogs possess social-cognitive traits that allow them to communicate with humans in ways unlike any other animal (Hare et al., 2002).

In lowland areas of the Neotropics, the primary role of canines is to assist in hunting wild game. Hunting efficiency using dogs compares favorably to other forms of hunting (Koster, 2009). The percentage of hunting trips that included dogs varies widely across cultures from a high of 83% (Mayangna and Miskito of Nicaragua) to 3% (Piro of Peru). Hunting success with dogs depends in large part on the targeted species. Although canines can be employed for any terrestrial species, they are particularly effective against pacas (*Cuniculus paca*, Fig. 2), agoutis (*Dasyprocta* spp.), and other animals that thrive in anthropogenic environments. The absence of dogs among some lowland cultures may be due to high mortality rates of dogs, rather than a canine aversion.

Mortality in Neotropical dogs results from the interaction of factors including hunting-induced wounds, malnutrition, microbial pathogens, and parasitic infections. Owing to their importance in hunting, it is not surprising that many cultures have a robust pharmacopoeia especially for dogs (e.g., Bennett et al., 2002; Lans et al., 2000, 2001; Leonard et al., 2002; Jernigan, 2009). Nonetheless, ethnoveterinary medicinal research is incipient (Nobrega Alves et al., 2010). Within many cultures, hunting dogs receive particularly good care (Koster, 2009). A Shuar woman, for example, may nurse a pup along with her own children (Bennett et al., 2002). In training dogs, both the Shuar and Quichua maintain the animals with a minimal diet supplemented with wild plants. While many plant species are employed to target canine illnesses, the majority are used to enhance the hunting ability of dogs. In a study that focused exclusively on ethnoveterinary practices, Jernigan (2009) identified 34 plants, that the Peruvian Aguaruna give to their dogs, most often to improve their hunting prowess. Plants are employed in baths to reduce their scent or to mask odors and thus decreasing their detectability by the targeted prey. Plants also function to clean buccal and nasal cavities to enhance olfaction (e.g., Lans et al., 2001; Sanz-Biset et al., 2009) or to enhance night vision (Wilbert, 1987).

Neotropical hunters employ magic, rituals, and charms to improve their hunting success and similar methods are used on dogs (Koster, 2009; Shepard, 2002). Koster (2009) notes the "occasional" use of hallucinogens, but the use psychoactive plants is actually frequent and widespread in many parts of the Old and, especially, the New World tropics (e.g., Bennett et al., 2002). The employment of psychoactive substances to enhance hunting ability seems to be counterintuitive, yet its prevalence suggests that it is both adaptive and that it has an underlying pharmacological explanation. In this paper, we address three questions:

1. What plants do the Ecuadorian Shuar and Quichua give to dogs to improve their hunting abilities?
2. What plants do other cultures give to dogs?
3. What is the likely pharmacological basis for the use of these plants, particularly the psychoactive ones?

The Shuar and Quichua are the largest indigenous groups in lowland Ecuador. They mostly reside at elevations from 300 to 1200 m in terra firme forests. This territory spans two of Holdridge's (1967) life zones, tropical moist forest and premontane tropical wet forest. Study sites were located in the Provinces of Morona-Santiago and Napo (Fig. 3). Both groups are horticulturists, growing manioc (*Manihot esculenta*) and plantains (*Musa × paradisiaca* L.) as their principle starches. Hunting (Fig. 4) and fishing supplement animal sources of protein from domesticated chickens and pigs. More data on the research sites and the two cultures can be found in Bennett et al. (2002) and Bennett and Alarcón (1994).

2. Methods

The Shuar data analyzed here was published in Bennett (1992a, 1992b, 1994) and Bennett et al. (2002). The Quichua data comes from Alarcón (1988), Bennett and Alarcón (1994) and our unpublished field notes. Voucher specimens are deposited in QCNE in Ecuador with duplicates in NY and MO in the U.S. We located data on ethnoveterinary medicine from other tropical cultures from ethnobotanical monographs, JEP publications, and searches using Web of Science and Google Scholar. Family circumscriptions and species names have changed since many of the data sources were first published.

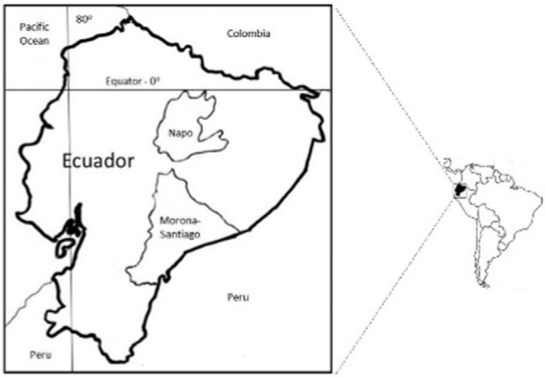

Fig. 3. Provinces of Morona-Santiago, where the Shuar, and Napo, where the Quichua, of this study reside.

Fig. 4. Shuar hunter in Yukutais with blowgun.

Data presented here follows APG III family circumscriptions (Angiosperm Phylogeny Group, 2009). Species names follow The Plant List (2015) except as noted. Author citations are included in the text for species not cited in Tables 1 and 2. Chemical data was found using PubMed and SciFinder.

3. Results

3.1. Shuar and Quichua

The Shuar and Quichua employ at least 22 species for dogs (Table 1). The studies from which these data were drawn did not focus on ethnoveterinary medicines. It is therefore likely that more exist. In most case, the plants have corresponding human uses. However, some species or varieties are especially designated for canines. Four Shuar ethnoveterinary plants carry the name yawá, which means dog in the Shuar language: yawá kunkunari (*Justicia pectoralis*), yawá urints (*Alternanthera paronychioides*), yawá piripiri (*Cyperus* sp.) and yawá maikua (*Brugmansia versicolor*). With the exception of *Brunfelsia grandiflora* D. Don., all the principal Shuar hallucinogens are given to dogs.

Seven of the plants were utilized for purely medical reasons, mostly to treat botfly or other infections. The remaining plants are given to hunting dogs specifically to enhance their hunting prowess. Nine were used for the general purpose of improving hunting ability. A mixture of manioc and akapmas (*Fittonia albivenis*) was said to improve the ability to track game. Kunápik (*Tabernaemontana sananho*) and yawá piripiri (*Cyperus* sp.) appear to initiate hunting predilections in dogs. Quichua give payanshi (*Abuta grandifolia*) to their hunting dogs to keep them quiet and both the Quichua and the Shuar give the potent stimulant wais (*Ilex guayusa*, Fig. 5) to their hunting dogs so that “they will not be lazy.”

3.2. Other cultures

The use of plants to improve the hunting ability is best documented in Ecuador and Peru but examples can be found in other South American countries as well as the Caribbean, Indochina, Papua New Guinea, and the Solomon Islands (Table 2). Examples from the literature revealed 71 citations of 65 species that are used in 54 combinations. Of these, the majority (43) are said to improve hunting ability (e.g., *Dendrobium pulchellum*). Five enhance hunting success for specific game (e.g., *Xanthosoma brasiliense* for wild hogs). Four are believed to make hunting dogs more alert (e.g., *Petiveria alliacea*) and four are said to specifically enhance olfaction. The Secoya of Ecuador apply latex from *T. sananho* fruits to a dog's nose so that “it can smell far.” A mixture of ginger (*Zingiber officinale*) and tobacco (*Nicotiana tabacum*, Fig. 6) is thought to enhance night vision in both hunters and their dogs. Ten plants are employed in baths for hunting dogs. A mixture that includes *T. sananho* and *Brugmansia* sp. is given to dogs so that they “can communicate with their masters.”

3.3. Plants to improve hunting ability

The combined data from the Shuar and Quichua data (Table 1) and the literature (Table 2) omitting those species that are not related directly to hunting or those species that have not been determined to at least the genus, reveals 71 species in 34 families that are given to dogs to improve their hunting ability (Table 3). There is some chemical data for most of the species or from close relatives. By combining the phytochemical data with the ethnobotanical reports of plants use, we classified each species into a likely pharmacological category. Twenty six are depuratives/deodorants (e.g., *Siparuna guianensis*), and many of these also have antimicrobial or anti-inflammatory activity. Ten species are classified as olfactory sensitizers Araceae (e.g., *Caladium schomburgkii*). The largest category was psychoactives, with 25 species. Nineteen of these species are hallucinogens (e.g., *Banisteriopsis caapi*, Fig. 7) and most of the remaining are stimulants (e.g., *I. guayusa*). Two are opthalmic (discussed previously). The remaining are either unknown or difficult to classify.

3.3.1. Depuratives/deodorants

More than half of the depuratives/deodorants have noticeably strong odors (Table 4). *Dendropanax arboreus* has a distinctive odor

Table 1
Shuar and Quichua plants given to dogs. Source of data: when not specified - Bennett et al., 2002; footnotes indicate other sources. Family names follow APG III (Angiosperm Phylogeny Group, 2009). Species names follow The Plant List (2015), except where indicated. SH=Shuar, QU=Quichua, SP=Spanish. For plant parts: BK=bark, FL=flower, FR=fruit, IF=inflorescence, LF=leaf, LX=latex, TU=Tuber.

Species	Family	Voucher	Common name	Use
Fittonia albivenis (Lindl. ex Veitch) Brummitt	Acanthaceae	Bennett 3712	AKAPMAS [SH: derived from akap "liver"]	SH give masticated LF, mixed with *Manihot esculenta* and meat, to improve dogs' ability to track game
Justicia pectoralis Jacq.	Acanthaceae	Pujupet 1009	YAWÁ KUNKUNARI [SH: yawá "dog" kunkunari unknown]	SH mix LF mixed with food, to improve dogs' hunting ability
Alternanthera paronychioides A. St.-Hil.	Amaranthaceae	Warush 44	YAWÁ URINTS [SH: yawá "dog' urints known"]	SH give LF to improve dogs' hunting ability
Tabernaemontana sananho Ruíz & Pav.	Apocynaceae	Bennett 4081	KUNÁPIK [SH: kunápik *Tabernaemontana* sp.]	SH give LX to dogs so that "they won't be vagrants." BK also given to dogs that "don't hunt."
Ilex guayusa Loes.	Aquifoliaceae	Bennett 3659	WAIS [SH: waís from QU: guayusa=*Ilex guayusa*]	SH give LF decoction to hunting dogs
Anthurium eminens Schott	Araceae	Bennett 4543	TACOTA SHIPU [QU: toccata unknown shipu "infested with worms"]	QU grind the IN, then apply it to botfly infections in animals (Alarcón, 1988)
Anthurium gracile (Rudge) Schott	Araceae	Bennett 3705	WANKAT [SH: wankat *Anthurium* or *Philodendron* spp.]	QU apply FR to kill botfly larvae in cattle and dogs (Bennett and Alarcón, unpublished field notes).
Caladium bicolor (Aiton) Vent.	Araceae	Warush 50	USHU [SH: ushu=*Caladium bicolor*]	SH treat animals infested with worms with LF sap
Caladium schomburgkii Schott	Araceae	Utitiaj 16	APINIU WANCHÚP [SH: napiniu may be from napi "snake" wanchúp perhaps *Xanthosoma* sp.]	SH give plant extract to dogs to improve their hunting ability
Cyperus sp.	Cyperaceae	Warush 23	YAWÁ PIRIPIRI [SH: yawa "dog" piripiri "Cyperaceae spp."]	SH give TU given to dogs or mix with saliva and place in dog's eyes to make them become hunters
Euphorbia hirta L.	Euphorbiaceae	Bennett 4010	LOMO PACHINA [perhaps SP: lomo "back" QU: pachina maybe from papachina=*Colocasia esculenta*]	QU give LX to dogs to make them better hunters (Alarcón, 1988)
Manihot esculenta Crantz	Euphorbiaceae	Bennett 3320	MAMA [SH: mama=*Manihot esculenta*]	SH give TU mixed with masticated *Fittonia albivenis* LF to dogs so that they can follow animal trails
Desmodium sp.	Fabaceae	Kunkumas 191	MÍIKMAN [SH: derived from míik "bean"]	SH bathe dogs with a LF decocotion.
Casearia aff. *commersoniana* Cambess	Salicaceae	Bennett 4135	YAMAKAI [SH: also refers to *Ryania speciosa* Vahl var. *speciosa*]	SH treat mange with plant
Salvia angulata Benth.	Lamiaceae	Gómez 397	PURGA PERRO [SP: "dog purgative"]	SH use FL and FR decocotion for a variety of ailments. Common names suggests its ethnoveterinary use
Abuta grandifolia (Mart.) Sandwith	Menispermaceae	Bennett 4400	PAYANSHI [QU: payanshi=*Abuta grandifolia*]	QU give BK decoction to dogs before hunting to keep them quiet (Alarcón, 1988)
Ficus insipida Willd. ssp. *insipida*	Moraceae	Anananch 154	JAPÁ WAMPÚ [SH: japá deer wampúch "light weight"]	SH give LX to dogs, probably as a anthelmintic
Osteophloeum platyspermum (Spruce ex A. DC.) Warb.	Myristicaceae	Palacios 4694	ANYA CASPI (QU: anya "counsel?" huapa "Myristicaceae spp.")	QU give resin to dogs to improve their hunting abilities. (Bennett and Alarcón, 1994)
Virola duckei A.C. Sm.	Myristicaceae	Palacios 1780	HUAPA BLANCA (QU: huapa "Myristicaceae spp." SP: blanca "white")	Employed in same manner as *Osteophloeum platyspermum* (Bennett and Alarcón, 1994)
Brugmansia suaveolens (Humb. & Bonpl. ex Willd.) Bercht. & C. Presl	Solanaceae	Bennett 3312	MAIKUA [SH: maikua=*Brugmansia* spp.] GUANDU [QU: maikua=*Brugmansia* spp.]	QU and SH give extracts to dogs to improve their hunting ability.
Brugmansia versicolor Lagerh.	Solanaceae	Shiki 333	YAWÁ MAIKUA [SH: yawá "dog" maikua *Brugmansia* spp.]	SH give 3 crushed LF every 12 h to make them good hunters
Brugmansia × *insignis* (Barb. Rodr.) Lockwood ex R.E.Schult.	Solanaceae	Bennett 4003	GUANDU LUMACHAG [QU: guandu=*Brugmansia* spp. lumachag "unknown"]	QU apply macerated LF to dogs' noses to make them better hunters (Bennett and Alarcón, unpublished field notes).

Author citation follows TROPICOS (2015).

due to the presence of polyactetylenes. The specific epithets of *Mansoa alliacea* and *Petiveria alliacea*, together with some of their common names, refer to the plants' garlic-like odor. *Siparuna* and *Piper* spp. possess abundant volatile terpenoids compounds that contribute to their strong and distinctive aromas. Cucurbitacins found in *Momordica charantia* produce its characteristic and pungent smell. Sesquiterpenes and monoterpenes in *Renealmia alpinia* and *Z. officinale* contribute to the distinctive ginger aroma of these plants.

3.3.2. *Olfactory sensitizers*

The olfactory sensitizers are dominated by the Araceae (Table 5). This family is characterized by the presence of irritating calcium oxalate crystals. Two other plants were classified in this category *Capsicum annuum* with irritating capsaicins and a *Piper* sp. with unknown chemical components. In addition to applying *C. annuum* around the eyes of their hunting dogs to enhance vision, the Quichua believe that this practice protects the animals from evil spirits.

Table 2
Examples of other plants given to dogs to improve their hunting abilities. Family names follow APG III (Angiosperm Phylogeny Group, 2009). Species names follow The Plant List (2015). Source of data: see footnotes. For plant parts: BK=bark, FL=flower, FR=fruit, IF=inflorescence, LF=leaf, LX=latex, PL=whole plant, RH=rhizome, SD=seed, ST=stem, TU=Tuber.

Species	Family	Common name	Location	Use
Aframomum melegueta K. Schum.	Zingiberaceae	Guinea pepper	Trinidad and Tobago (Lans et al., 2001)	Dried SD ground to a powder, then sprinkled on dog's food
Anadenanthera colubrina (Vell.) Brenan	Fabaceae	huilca	Argentina (Schultes, 1998)	SD snuff given to dogs to make them more alert
Anadenanthera peregrina (L.) Speg.	Fabaceae	yopo	Colombia (Schultes, 1998)	SD snuff given to dogs to make them more alert
Ardisia cf. *denhamioides* S. Moore	Primulaceae	sunun	West Papua (Milliken, 1999)	LF fed to hunting dogs to improve their performance.
Aristolochia rugosa Lam.	Aristolochiaceae	mat	Trinidad and Tobago (Lans et al., 2001)	PL decocotion used to bathe lazy dogs
Banisteriopsis caapi (Spruce ex Griseb.) Morton	Malpighiaceae	–	Peru (Sanz-Biset et al., 2009)	See *Couroupita guianensis* [A]
Brugmansia suaveolens (Humb. & Bonpl. ex Willd.) Bercht. & J. Presl	Solanaceae	–	Peru (Sanz-Biset et al., 2009)	See *Couroupita guianensis* [A]
Brugmansia sp.	Solanaceae	lumu cuchi huandu	Ecuador (Quichua) (Kohn, 2007)	See *Tabernaemontana sananho* [A]
Caladium bicolor (Ait.) Vent.	Araceae	–	Ecuador (Kofan) (Schultes and Raffauf, 1990)	LF placed in dogs nostril to make them better hunters for wild pigs.
Caladium sp.	Araceae	ushu	Peru (Aguaruna) (Jernigan, 2009)	LF fed to dogs
Calliandra angustifolia Spruce ex Benth.	Fabaceae	–		See *Couroupita guianensis* [A]
Capsicum annuum L.	Solanaceae	bird pepper	Trinidad and Tobago (Lans et al., 2001)	Juice from 2 small FR placed in dog's nose so it find game and follow scent
Casearia negrensis Eichler	Salicaceae	ituchi runtu	Peru (Sanz-Biset et al., 2009)[a]	BK and Lf given to dogs to prepare them for hunting
Cecropia peltata L.	Urticaceae	bois canôt	Trinidad and Tobago (Lans et al., 2001)	Dry LF is put in water with *Jatropha gossypiifolia*. Water left open for nine days until larvae are seen, then used to bathe dog.
Colocasia esculenta (L.) Schott [possibly]	Araceae	bolobolo	Papua New Guinea (Flavelle, 1991)	Unspecified part fed to dogs to make them wild, aggressive and sensitive for hunting wild pig
Couroupita guianensis Aubl. [A]	Lecythidaceae	aya uma	Peru (Sanz-Biset et al., 2009)	Depurative decoction including *Banisteriopsis caapi*, *Psychotria viridis*, *P. carthagenensis*, *Brugmansia suaveolens*, *Calliandra angustifolia*, *Tovomita* aff. *stylosa* & *Zygia longifolia*.
Couroupita guianensis Aubl. [B]	Lecythidaceae	ayahúma	Peru (McKenna et al., 1995)	Unspecified part given to dogs to make them stronger and to increase their hunting abilities
Couroupita subsessilis Pilg.	Lecythidaceae	shishim	Peru (Aguaruna) (Jernigan, 2009)	BK and LF inhaled in mouth or nose to improve hunting ability
Croton gossypiifolius Vahl	Euphorbiaceae	blood bush	Trinidad and Tobago (Lans et al., 2001)	Dog bathed in a LF decoction along *Petiveria alliacea* RT and *Renealmia alpinia* LF and RT if dog is not performing as well as in past
Cyperus sp.	Cyperaceae	yawaa pijipij	Peru (Aguaruna) Jernigan (2009)	RT fed to dogs to improve their hunting ability
Cyrtocymura scorpioides (Lam.) H. Rob.	Asteraceae	ruckshun	Trinidad and Tobago (Lans et al., 2001)	Dogs bathed with a LF decoction so that they will be more alert
Dendrobium pulchellum Roxb. ex Lindl.	Orchidaceae	–	Indochina (Bennett, 1995)	FL fed to dogs to make them better hunters
Dendrobium spp.	Orchidaceae	–	Solomon Islands (Anonymous, 2009a)	FL, resembling dog heads, fed to hunting dogs to increase their courage in the chase
Dendropanax arboreus (L.) Decne. & Planch.	Araliaceae	fei jein	Trinidad and Tobago (Lans et al., 2001)[a]	Combined with LF of *Monstera dubia, Siparuna guianensis Solanum* spp. and *Syngonium podophyllum* to bathe dogs
Dracontium sp	Araceae	uchi santanik	Peru (Aguaruna) (Jernigan, 2009)	RT fed to dog to improve hunting ability
Eschweilera subglandulosa (Steud. ex O. Berg) Miers	Lecythidaceae	guatacare	Trinidad and Tobago (Lans et al., 2001)[a]	see *Piper marginatum*
Jatropha curcas L.	Euphorbiaceae	white physic nut	Trinidad and Tobago (Lans et al., 2001)	3 LV mixed with 3 LF of *Jatropha gossypiifolia,* crushed then put in water to bathe dog
Jatropha gossypiifolia L.	Euphorbiaceae	red physic nut	Trinidad and Tobago (Lans et al., 2001)	See *Jatropha curcas*
Mansoa alliacea (Lam.) A.H. Gentry	Bignoniaceae	ajo sacha	Peru (Sanz-Biset et al., 2009)	Stem and root BK macerated with *Petiveria alliacea* as a body odor modifying agent for hunting and fishing
Mansoa sp.	Bignoniaceae	kaep	Peru (Aguaruna) (Jernigan, 2009)	LF, RT, BK and ST tips inhaled in mouth, nose, or fed to dogs to improve their ability to hunt
Momordica charantia L.	Cucurbitaceae	caraaili	Trinidad and Tobago (Lans et al., 2001)[a]	PL used to bathe dogs so that it will catch agoutis.
Monstera dubia (Kunth) Engl. & K. Krause	Araceae	sei jein	Trinidad and Tobago (Lans et al., 2001)[a]	See *Dendropanax arboreus*
Nectandra cuneatocordata Mez	Lauraceae	mantaga	Peru (Aguaruna) (Jernigan, 2009)	RT inhaled in mouth and nose to improve hunting ability
Nicotiana tabacum L. [A]	Solanaceae	tobacco	Trinidad and Tobago (Lans et al., 2001)	LF used to cleans dog's nose to improve its ability to follow a scent
Nicotiana tabacum	Solanaceae	tobacco		Mixture of tobacco and *Zingiber officinale* applied to eyes to improve night vision.

Table 2 (*continued*)

Species	Family	Common name	Location	Use
			South America (Anonymous, 2009a)	
Nicotiana tabacum L. [C]	Solanaceae	–	Ecuador (Runa) (Kohn, 2007)	See *Tabernaemontana sananho* [A]
Petiveria alliacea L.	Phytolaccaceae	kojo root	Trinidad and Tobago (Lans et al., 2001)	Dogs bathed with ground RT to make them more alert
Phrynium sp.	Marantaceae	asin	West Papua (Milliken, 1999)	Pieces of LF fed to hunting dogs to improve their performance
Phyllanthus urinaria	Phyllanthaceae	–	Trinidad and Tobago (Lans et al., 2001)	FR given to bathe dogs for "cross"
Piper hispidum Sw.	Piperaceae	candle bush	Trinidad and Tobago (Lans et al., 2001)	LF used to bathe dogs
Piper marginatum Jacq.	Piperaceae	agouti bush	Trinidad and Tobago (Lans et al., 2001)[a]	LF used to bathe dogs so they will catch agoutis. Some hunters add *Eschweilera subglandulosa* LV.
Piper ovatum Vahl	Piperaceae	pot bush	Trinidad and Tobago (Lans et al., 2001)	Crushed ST and LV or RT put in dog's nose or dog's nose washed with a solution made from those parts of the plant
Piper peltatum L.	Piperaceae	sun bush	Trinidad and Tobago (Lans et al., 2001)	Crushed LF used to bathe dog for "cross"
Piper sp. 1	Piperaceae	ampagpag	Peru (Aguaruna) (Jernigan, 2009)	RT and LF inhaled in mouth or nose or fed to dogs to improve their hunting ability
Piper sp. 2	Piperaceae	shishig	Peru (Aguaruna) (Jernigan, 2009)	LF fed to dogs to improve their hunting ability
(L.) Benth.	Fabaceae	cat's claw	Trinidad and Tobago (Lans et al., 2001)[a]	Given to dogs so that they will follow game tenaciously
Psychotria carthagenensis Jacq	Rubiaceae	–	Peru (Sanz-Biset et al., 2009)	See *Tabernaemontana sananho* [A]
Psychotria viridis Ruiz & Pav.	Rubiaceae	–	Peru (Sanz-Biset et al., 2009)	See *Tabernaemontana sananho* [A]
Renealmia alpinia (Rottb.) Maas	Zingiberaceae	mardi gras	Trinidad and Tobago (Lans et al., 2001)[a]	5–7 shoots of are pounded and put in water to bathe dog; FR attract lice, dog will closely pursue
Saccharum officinarum L.	Poaceae	sugar cane	Trinidad and Tobago (Lans et al., 2001)[a]	FR and LF used to bathe dogs. Deer eat LF, therefore dog can track deer
Sarcoglottis metallica (Rolfe) Schltr.	Orchidaceae	lappe bush	Trinidad and Tobago (Lans et al., 2001)[a]	PL used to bathe dog so that it will track lappe
Schuurmansia henningsii K. Schum.	Ochnaceae	semberekr	West Papua (Milliken, 1999)	SD and LF fed to dogs to improve their performance
Siparuna guianensis Aubl.	Monimiaceae	dead man's bush	Trinidad and Tobago (Lans et al., 2001)[a]	Ssee *Dendropanax arboreus*
Solanum spp.	Solanaceae	devil pepper	Trinidad and Tobago (Lans et al. 2001)[a]	Ssee *Dendropanax arboreus*
Syngonium podophyllum Schott	Araceae	matapal-kit	Trinidad and Tobago (Lans et al., 2001)[a]	See *Dendropanax arboreus*
Tabernaemontana sananho Ruiz & Pav. [A]	Apocynaceae	tsita	Ecuador (Runa) (Kohn, 2007)	Mixture given to hunting dogs so that they can communicate with their masters
Tabernaemontana sananho Ruiz & Pav. [B]	Apocynaceae	kunakip	Peru (Aguaruna) (Jernigan, 2009)	BK and RT inhaled in mouth or nose or fed to dogs to improve hunting ability
Tabernaemontana sananho Ruiz & Pav. [C]	Apocynaceae	–	Ecuador (Secoya) (Schultes and Raffauf, 1990)	LX from FR applied to dogs nose so that they can "smell far" in huntingatex
Tovomita aff. *stylosa* Hemsl.	Clusiaceae	–	Peru (Sanz-Biset et al., 2009)	See *Couroupita guianensis* [A]
Xanthosoma brasiliense (Desf.) Engl.	Araceae	hog tannia	Trinidad and Tobago (Lans et al., 2001)[a]	Hogs eat tubers. Ground tuber sprinkled on dog's food so it can track hogs.
Xanthosoma undipes (K. Koch & C.D. Bouché) K. Koch	Araceae	hog tannia	Trinidad and Tobago (Lans et al., 2001)[a]	See *Xanthosoma brasiliense*
Xiphidium caeruleum Aubl.	Haemodoraceae	walk fast	Trinidad and Tobago (Lans et al., 2001)[a]	LF given to dogs so that they will walk straight
Zingiber officinale Roscoe [A]	Zingiberaceae	ginger	South America (Wilbert, 1987)	See *Nicotiana tabacum*
Zingiber officinale Roscoe [B]	Zingiberaceae	hinde	West Papua (Bennett, 1995)	RH and LF are fed to hunting dogs to improve their performance
Zygia longifolia (Willd.) Britton & Rose	Fabaceae	–	Peru (Sanz-Biset et al., 2009)	See *Couroupita guianensis* [A]
Not determined	Lamiaceae	chiujip	Peru (Aguaruna) (Jernigan, 2009)	LF fed to dogs to improve their hunting ability
Not determined	Zingiberaceae	chiag	Peru (Aguaruna) (Jernigan, 2009)	LF inhaled in mouth to improve hunting ability
Not determined	–	turpentine bush	Trinidad and Tobago (Lans et al., 2001)	Dogs bathed with crushed LF
Not determined	–	goma'uwe	Papua New Guinea (Flavelle, 1991)	Unspecified part fed to hunting dogs to improve their sense of smell
Not determined	Acanthaceae	tsumbaik	Peru (Aguaruna) (Jernigan, 2009)	RT and LF fed to dogs to improve hunting ability
Not collected	–	chijum	Peru (Aguaruna) (Jernigan, 2009)	LF fed dogs to improve hunting ability

[a] Use attributed to Doctrine of Signatures, but see Bennett (2007, 2008) for a discussion of the doctrine.

Fig. 5. *Ilex guayusa* (Aquifoliaceae) leaves known as wais in the Shuar and guayusa in the Runa languages.

Fig. 6. *Nicotiana tabacum* (Solanaceae) plug used by a Quichua shaman in healing ceremonies.

3.3.3. Psychoactives

The psychoactive plants given to dogs are dominated by hallucinogens (Table 6). While most of these are well-known as hallucinogenic plants and are commonly used in shamanistic rituals (e.g., *Anadenanthera peregrina, B. caapi*) the activity of others is yet to be determined (e.g., *F. albivenis, D. pulchellum*). The stimulants *I. guayusa* (caffeine and other methylxanthine alkaloids) and *N. tabacum* also are given to hunting dogs. Quichua heat tabacco leaves, then administer them through the noses of their dogs to keep them active and resilient during the hunting trips.

4. Discussion

Hunting dogs are indispensable to many traditional cultures. The relationship between these animals and humans is far deeper that in modern cultures. This is evident by both the beliefs regarding dogs and by the ethnoveterinary pharmacopoeias devoted to dogs. Under the influence of the hallucinogenic beverage natem (*B. caapi*), one Shuar shaman sees the commonly-reported vision of boas and jaguars, but also dogs (Bennett et al., 2002). The Quichua believe that dogs have souls and that they dream (Kohn, 2007).

The ethnopharmacopoeia for dogs has recently received greater attention from researchers (e.g., Bennett et al., 2002; Lans et al., 2000, 2001; Leonard et al., 2002; Jernigan, 2009). Yet relatively few studies have examined practices that are said to improve hunting abilities. Koster (2009) summarizes non-pharmacological practices to enhance hunting abilities, which include exposing dogs to the flesh or hair of prey before hunting trips and covering a dog with blood from killed prey, rubbing it with stomach contents, or giving it meat from prey animals. Quichua feed agouti bile or its sternum to their dogs so that they can find this prized game species.

Relatively little attention has been given to plants that are said to improve hunting efficiencies in dogs. Yet their use is widespread. Among the Matsigenka of Peru, hunting ability is believed to be acquired only by the use of plants that enhance a hunter's visual acuity, sense of smell, aim, stamina and luck (Shepard, 2002). One quarter of Matsigenka medicinal plant species is used as hunting medicines and these include plants given to hunting dogs to increase olfactory sensitivity.

The effects of psychoactive substances in humans to other animals are not always comparable to other animals. Not surprisingly, nonhuman primates provide are most similar in their responses (Weerts et al., 2007). Dogs respond to commonly-used hallucinogens in a similar manner to humans. Vaupel et al. (1978) showed that beta-phenethylamine and D-amphetamine increased respiration, dilated pupils and produced restlessness in chronically spinalized dogs. Frith et al. (1987) recorded circling, dilated pupils, hyperactivity, rapid breathing, and salivation in dogs given methylenedioxymethamphetamine. These effects potentially could enhance a dog's hunting ability. Scopolamine significantly impaired memory performance of old, but not young dogs (Araujo et al., 2011). Young hunting dogs seem to be preferred by lowland Amazonian people. For many of the plant compounds, pharmacological studies on dogs are lacking. Nonetheless, based on descriptions of the plants uses, their effects on humans, and their phytochemical profiles, one can speculate on their pharmacological effects in canines.

4.1. Ophthalmics

Only two species were cited as nocturnal ophthalmics – agents that improve vision. Wilbert (1987) reported that a mixture of tobacco and ginger is applied to the eyes of both hunters and their dogs to improve night vision. Few studies have examined the effects of plant extracts on night vision. Tetrahydrocannabinol from *Cannabis sativa* L. has been shown to enhance night visions in some studies (e.g., Russo et al., 2004). The effects of tobacco are less clear. While some studies have shown that tobacco smoke decreases night vision, others have shown that nicotine enhances night vision, presumably due to the stimulating effects of nicotine (Anonymous, 2011). There are no studies on the effects of ginger on night vision. Though the atropine containing genus *Brugmansia* was one of the more frequently cited psychoactive plants given to hunting dogs, the reason for its use was never explicitly said to be related to improvement of vision. Atropine is well-known as a mydriatic and homatropine has been shown to improve nocturnal myopia (Koomen et al., 1951).

4.2. Depuratives/deodorants

Depuratives/deodorants plants remove or mask odors and improve the ability of hunting dogs to avoid detection by game. Most of them also possess antimicrobial activity that could prevent the development of characteristic odors associated with infections. Shepard (1999) offers an alternate reason for the use of the sulfurous odor of *Mansoa* among the Matsigenka of Peru. They believe that the plant's odor is similar to the smell of peccaries, a preferred Matsigenka game animal.

Other reasons for the use of depuratives/deodorants transcend the physical effects of moderating odors. The exceedingly fragrant *Siparuna* and *Piper* spp., which are used to bathe dogs, are also employed by the Quichua to cleanse the human body of malevolent spirits. This practice is concordant with their belief that dogs possess souls.

Table 3
Combined data from Tables 1 and 2 minus those species that have an explicitly ethnoveterinary use and are not related directly to hunting or those species that have not been determined to at least the genus. Family plus number of citations for family, species plus number of citations for genus/species. Activity column lists the probable activity in dog based on the plants use and chemistry. Chemistry column lists the compounds likely responsible for the activity.

Family	Species	Activity	Chemistry
Acanthaceae (2)	*Fittonia albivenis* (1/1)	Psychoactive – hallucinogenic (?)	Dimethyltryptamine (?)
	Justicia pectoralis (1/1)	Psychoactive – hallucinogenic	Betaine, coumarin and umbelliferone (Macrae and Towers, 1984; reported to have dimethyltryptamine (DMT)
Amaranthaceae (1)	*Alternanthera paronychioides* (1/1)	Unknown	Unknown – inhibits xanthine oxidase (Chen et al., 2009)
Apocynaceae (4)	*Tabernaemontana sananho* (1/4)	Psychoactive – hallucinogenic (?)	Unknown, indole alkaloids from *Tabernaemontana holstii* (Kingston et al., 2006)
Aquifoliaceae (1)	*Ilex guayusa* (1/1)	Psychoactive – stimulant	Caffeine and other methylxanthine alkaloids (Lewis et al., 1991)
Araceae (9)	*Caladium bicolor* (3/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007)
	Caladium schomburgkii (3/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007)
	Caladium sp. (3/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007)
	Colocasia esculenta (1/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007; Savage et al., 2008; Prychid and Rudall, 1999)
	Dracontium sp. (1/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007; Savage et al., 2008; Prychid and Rudall, 1999)
	Monstera dubia (1/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007; Savage et al., 2008; Prychid and Rudall, 1999)
	Syngonium podophyllum (1/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007; Savage et al., 2008; Prychid and Rudall, 1999)
	Xanthosoma brasiliense (2/1)	Olfactory sensitizer	Calcium oxalate crystals
	Xanthosoma undipes (2/1)	Olfactory sensitizer	Calcium oxalate crystals (Oscarsson and Savage, 2007; Savage et al., 2008; Prychid and Rudall, 1999)
Araliaceae (1)	*Dendropanax arboreus* (1/1)	Depurative, deodorant, irritant	Falcarinol, dehydrofalcarinol, undetermined diynene, falcarindiol, dehydrofalcarindiol, polyacetylenes (dendroarboreols A and B) (Bernart et al., 1999; Hansen and Boll, 1986)
Aristolochiaceae (1)	*Aristolochia rugosa* (1/1)	Depurative, anti-inflammatory, antimicrobial	Aristolochic acid (Heinrich et al., 2009 (?)
Asteraceae (1)	*Cyrtocymura scorpioides* (1/1)	Anti-tumor, vulneray	Sesquiterpene lactones (Buskuhl et al., 2010)
Bignoniaceae (2)	*Mansoa alliacea* (2/1)	Depurative, deodorant	Allyl polysufides (Zoghbi et al., 2009)
	Mansoa sp. (2/1)	Depurative, deodorant	Likely similar to *Mansoa alliacea*
Clusiaceae (1)	*Tovomita* aff. *stylosa* (1/1)	depurative, deodorant, antimicrobial	Xanthones likely (Schultes and Raffauf, 1990)
Cucurbitaceae (1)	*Momordica charantia* (1/1)	Depurative, deodorant, antimicrobial	Momordicin, cucurbitacin b and other triterpenoid saponins (Fatope et al., 1990)
Cyperaceae (2)	Cyperus sp. (2/1)	Psychoactive – hallucinogenic	Ergot alkaloids (Plowman et al., 1990)
	Cyperus sp. (2/1)	Psychoactive – hallucinogenic	Ergot alkaloids (Plowman et al., 1990)
Euphorbiaceae (5)	*Croton gossypiifolius* (1/1)	Depurative, deodorant, antimicrobial	Essential oil dominated by oxygenated sesquiterpenes including alpha-cedrene oxide, spathulenol, valencene, geranyl-pentanoate, alpha-cadinol, germacrene d and longifolene (Suárez et al., 2011)
	Euphorbia hirta (1/1)	Antimicrobial	Flavonols including euphorbins, kaempferol, myricetin, quercitin and rutin (Kumar et al., 2010)
	Jatropha curcas (2/1)	Depurative, deodorant, antimicrobial	Hydrogen cyanide, jatrophine (Duke, 1993; Thomas et al., 2008)
	Jatropha gossypiifolia (2/1)	Depurative, deodorant, antimicrobial	Cyclic octapeptide (cyclogossine b) and cyclic heptapeptide (cyclogossine a) (Auvin-Guette et al., 1997), diterpene jatrophenone (Ravindranath et al., 2003
	Manihot esculenta (1/1)	Carrier	Not applicable
Fabaceae (5)	*Anadenanthera colubrina* (2/1)	Psychoactive – hallucinogenic	Buforenine, n-n-dimethyltryptamine (Schultes and Raffauf, 1990)
	Anadenanthera peregrina (2/1)	Psychoactive – hallucinogenic	Buforenine, n-n-dimethyltryptamine (Schultes and Raffauf, 1990)
	Calliandra angustifolia (1/1)	Psychoactive – hallucinogenic (?), stimulant	Amino acids (McKenna et al., 1995), reported to contain tetrahydroharmaline
	Pithecellobium unguis-cati (1/1)	Psychoactive – hallucinogenic (?), stimulant	Unknown
	Zygia longifolia (1/1)	Depurative, deodorant, antimicrobial (?)	Volatile isoprenes, but poorly known (Geron et al., 2002)
Haemodoraceae (1)	*Xiphidium caeruleum* (1/1)	Antimicrobial (?)	Phenylphenalenone-type compounds (Opitz and Schneider, 2002)
Lauraceae (1)	*Nectandra cuneatocordata* (1/1)	Unknown	Unknown, genus contains alkaloids and terpenes (Schultes and Raffauf, 1990 and lignans, neolignans, and lignoids (Carvalho et al., 1986; Moro et al., 1986; Barbosa-Filho et al., 1989)
Lecythidaceae (4)	*Couroupita guianensis* (2/3)	Depurative, deodorant, antimicrobial, antiinflammatory	Tryptanthrin (Pinheiro et al., 2010)
	Eschweilera subglandulosa (1/1)	Depurative, deodorant, antimicrobial	Ellagic acid derivatives (Yang et al., 1998; triterpenes (Costa and Carvalho, 2003)
Malpighiaceae (1)	*Banisteriopsis caapi* (1/1)	Psychoactive – hallucinogenic	Beta-carboline alkaloids (harmine, harmaline and tetrahydroharmine) (Schultes and Raffauf, 1990; Lopes et al., 2000; Pires et al., 2009)
Marantaceae (1)	*Phrynium* sp. (1/1)	Unknown	Unknown, rosmarinic acid, chlorogenic acid and rutin reported from family (Abdullah et al., 2008)

Table 3 (*continued*)

Family	Species	Activity	Chemistry
Menispermaceae (1)	*Abuta grandifolia* (1/1)	Psychoactive – sedative (?)	Tropoloisoquinoline (Menachery and Cava, 1980) and bisbenzylisoquinoline (Steele et al., 1999) alkaloids
Monimiaceae (1)	*Siparuna guianensis* (1/1)	Depurative, deodorant	Oxoaporphine alkaloid liriodenine, oxidized derivative of β-elemene-curzerenone and phenylpropanoids (myristicin and eugenol methyl ether) (Leitão et al., 1999)
Myristicaceae (2)	*Osteophloeum platyspermum* (1/1)	Psychoactive – hallucinogenic	Unknown, presumably DMT
	Virola duckei (1/1)	Psychoactive – hallucinogenic	Unknown, presumably DMT
Myrsinaceae (1)	*Ardisia* cf. *denhamioides* (1/1)	Unknown	Unknown – triterpenoid saponins common in the genus (Liu et al., 2011)
Ochnaceae (1)	*Schuurmansia henningsii* (1/1)	Psychoactive – stimulant (?)	Alkaloids (Pelletier, 1996)
Orchidaceae (3)	*Dendrobium pulchellum* (2/1)	Psychoactive – hallucinogenic (?)	Unknown, dendrobine and other alkaloids reported from *D. nobile* (Southon and Buckingham, 1989)
	Dendrobium spp. (1/1)	Psychoactive – hallucinogenic (?)	Unknown, dendrobine and other alkaloids reported from *D. nobile* (Southon and Buckingham, 1989
	Sarcoglottis metallica (1/1)	Depurative, deodorant	Unknown, flavonoids (Dong et al., 2008) and prenylated coumarins (Peng et al., 2008) found in the closely related genus *Spiranthes*
Phyllanthaceae (1)	*Phyllanthus urinaria* (1/1)	Depurative	Alcohol (triacontanol), phenolic acid (gallic acid), coumarins (including ellagic acid), flavonoids (astragalin, quercetin, quercitrin, isoquercitrin, rutin, kaempfero), sterols (including β-sitosterol), triterpenes (lupeol acetate and β-amyrin) (Calixto et al., 1998)
Phytolaccaceae (1)	*Petiveria alliacea* (1/1)	Depurative, deodorant	Benzaldehyde, benzoic acid, coumarin, trithiolaniacine (Anonymous, 2009b), cysteine sulfoxide derivatives (Kubec and Musah, 2001)
Piperaceae (6)	*Piper hispidum* (6/1)	Depurative, deodorant	Amide (Alécio et al., 1998); butenolides (Michel et al., 2010); prenylated benzoic acid derivatives (Friedrich et al., 2005; oxygenated sesquiterpenes and sesquiterpenes hydrocarbons including trans-nerolidol, caryophyllene oxide, beta-elemene, trans-beta-caryophyllene, curzerene, and germacrene b (Pino Benitez et al., 2009)
	Piper marginatum (6/1)	Depurative, deodorant, antimicrobial	39 components in essential oil including γ-terpinene, δ-elemene, α-copaene, β-elemene, β-caryophyllene, α-humulene, γ-elemene, 3,4-methylenedioxypropiophenone,and elemicin (Ramos et al., 1986) but highly variable (Andrade et al., 2008); propiophenones (de Diaz and Gottlieb, 1979); flavonoids including marginatoside (Tillequin et al., 1978)
	Piper ovatum (6/1)	Depurative, deodorant, antimicrobial, anti-inflammatory	Delta-amorphene, cis-muurola-4(14),5-diene, and gamma-muurolene51, amides (piperovatine and piperlonguminine) (Silva et al., 2008, 2009)
	Piper peltatum (6/1)	Depurative, deodorant, antimicrobial, anti-inflammatory	4-nerolidylcatechol (Kijjoa et al., 1980; Núñez et al., 2005); aristolactams alkaloids (piperumbellactams a-d and n-hydroxyaristolam and n-p-coumaroyl tyramine (Tabopda et al., 2008)
	Piper sp. (6/1)	Depurative, deodorant, olfactory sensitizer	Unknown
	Piper sp. (6/1)	Depurative, deodorant, olfactory sensitizer	Unknown
Poaceae (1)	*Saccharum officinarum* (1/1)	depurative, deodorant, antiinflammatory	Fatty acids (Ledón et al., 2003); flavone glycosides vitexin, orientin, luteolin-8-c-(rhamnosylglucoside), 4′,5′-dimethyl-luteolin-8-c-glycoside, isomeric pair schaftoside-isoschaftoside, o-glycosides tricin-7-o-neohesperidoside and tricin-7-o-glycoside (Colombo et al., 2006); flavones tricin-7-o-beta-(6″-methoxycinnamic)-glucoside and orientin (Duarte-Almeida et al., 2007); flavones (apigenin, luteolin and tricin derivatives), phenolic acids (hydroxycinnamic, caffeic and sinapic acids) (Duarte-Almeida et al., 2006)
Rubiaceae (2)	*Psychotria carthagenensis* (2/1)	Psychoactive – hallucinogenic	DMT commonly reported (Fatope et al., 1990) but not found in one study (Leal and Elisabetsky, 1996); triterpene (beta-sitosterol and ursolic acid) (Lopes et al., 2000)
	Psychotria viridis (2/1)	Psychoactive – hallucinogenic	DMT (Pires et al., 2009; Callaway et al., 2005) but variable
Salicaceae (1)	*Casearia negrensis* (1/1)	Unknown	Unknown, clerodane diterpenoids (Chen et al., 2008) reported for genus
Solanaceae (11)	*Brugmansia* × *insignis* (6/1)	Psychoactive – hallucinogenic	Tropane alkaloids (atropine and scopolamine) (Fatope et al., 1990)
	Brugmansia sp. (6/1)	Psychoactive – hallucinogenic	Tropane alkaloids (atropine and scopolamine) (Fatope et al., 1990)
	Brugmansia suaveolens (6/2)	Psychoactive – hallucinogenic	Tropane alkaloids (atropine and scopolamine) (Fatope et al., 1990)
	Brugmansia versicolor (6/1)	Psychoactive – hallucinogenic	Tropane alkaloids (atropine and scopolamine) (Fatope et al., 1990)
	Brugmansia sp. (6/1)	Psychoactive – hallucinogenic	Tropane alkaloids (atropine and scopolamine) (Fatope et al., 1990)
	Capsicum annuum L. (1/1)	Olfactory sensitizer	Capsiacins (Fatope et al. 1990; Cichewicz and Thorpe, 1996)
	Nicotiana tabacum (3/3)	Psychoactive – stimulant, MAO inhibitor, ophthalmic	Nicotine (Fatope et al., 1990; Wilbert, 1987)
	Solanum spp.(1/1)	Depurative	Unknown
Urticaceae (1)	*Cecropia peltata* (1/1)	Depurative	Chlorogenic acid and isoorientin (Andrade-Cetto and Cardenas Vazquez, 2010)
Zingiberaceae (4)	*Aframomum melegueta* (1/1)	depurative, antimicrobial	CYP inhibitor (Agbonon et al., 2010); 27 compounds sesquiterpene hydrocarbons (humulene and caryophyllene and their oxides) 17 monoterpenes (Ajaiyeoba and Ekundayo, 1999)
	Renealmia alpinia (1/1)	Depurative, antimicrobial	Labdane diterpenoids (Zhou et al., 1997); triacylglycerols (including oleic, palmitic and palmitoleic acids), sterols, methylsterols and triterpenic alcohols (Lognay et al., 1989); monoterpenes (b-pinene, limonene and b-phellandrene), b-carotene, nerolidol and manool, labdadiene-15,16-dial (i) (Lognay et al., 1991)
	Zingiber officinale (2/2)	Ophthalmic	Phenols (gingerols and shogaols), volatile oils (sesquiterpenes – β-bisabolene, (−)-zingiberene, β-sesquiphellandrene, and (+)-ar-curcumene; monoterpenes – geranial and neral) (Blumenthal et al., 2000)

Fig. 7. *Banisteriopsis caapi* (Malpighiaceae), known as natem in the Shuar and ayahusca in the Runa languages, split stems.

Table 4
Species, arranged by family, that are used as depuratives or deodorants.

Family	Species
Araliaceae	*Dendropanax arboreus*
Aristolochiaceae	*Aristolochia rugosa*
Bignoniaceae	*Mansoa alliacea*
	Mansoa sp.
Clusiaceae	*Tovomita* aff. *stylosa*
Cucurbitaceae	*Momordica charantia*
	Croton gossypiifolius
	Jatropha gossypiifolia
Fabaceae	*Zygia longifolia*
Lecythidaceae	*Couroupita guianensis*
	Eschweilera subglandulosa
Monimiaceae	*Siparuna guianensis*
Orchidaceae	*Sarcoglottis metallica*
Phyllanthaceae	*Phyllanthus urinaria*
Phytolaccaceae	*Petiveria alliacea*
Piperaceae	*Piper hispidum*
	Piper marginatum
	Piper ovatum
	Piper peltatum
	Piper sp.
	Piper sp.
Poaceae	*Saccharum officinarum*
Solanaceae	*Solanum* spp.
Urticaceae	*Cecropia peltata*
Zingiberaceae	*Aframomum melegueta*
	Renealmia alpinia

Table 5
Species, arranged by family, that are used as olfactory sensitizers.

Family	Species
Araceae	*Caladium bicolor*
	Caladium schomburgkii
	Caladium sp.
	Colocasia esculenta
	Dracontium sp.
	Monstera dubia
	Syngonium podophyllum
	Xanthosoma brasiliense
	Xanthosoma undipes
Piperaceae	*Piper* sp.
Solanaceae	*Capsicum annuum*

Table 6
Species, arranged by family, that have probable psychoactive effects.

Family	Species
Acanthaceae	*Fittonia albivenis*
	Justicia pectoralis
Apocynaceae	*Tabernaemontana sananho*
Aquifoliaceae	*Ilex guayusa*
Cyperaceae	*Cyperus* sp.
Fabaceae	*Anadenanthera colubrina*
	Anadenanthera peregrina
	Calliandra angustifolia
	Pithecellobium unguis-cati
Malpighiaceae	*Banisteriopsis caapi*
Menispermaceae	*Abuta grandifolia*
Myristicaceae	*Osteophloeum platyspermum*
	Virola duckei
Ochnaceae	*Schuurmansia henningsii*
Orchidaceae	*Dendrobium pulchellum*
	Dendrobium spp.
Rubiaceae	*Psychotria carthagenensis*
	Psychotria viridis
Solanaceae	*Brugmansia* × *insignis*
	Brugmansia suaveolens
	Brugmansia versicolor
	Brugmansia sp.
	Nicotiana tabacum

4.3. Olfactory sensitizers

Little is known about the mechanism of action of Araceae species on olfaction. Most members of the family contain irritating calcium oxalate crystals (Prychid and Rudall, 1999). Another irritant that is employed to enhance olfaction is *C. annuum*. Frasnelli et al. (2009) showed that capsaicins can enhance olfaction in humans and perhaps the same activity is true for canines. Another plant that was said to enhance olfaction was *T. sananho*. Latex from the fruits or leaves is applied to a dog's nose so that “it can smell far.” Based on the chemistry of the genus it is likely that, the activity targets the brain rather than directly affecting the nose. In addition to Jernigan's (2009) study, Brown (1981) reported the use of *T. sananho* for dogs among the Aguaruna and Vickers and Plowman (1984) noted similar use among the Secoya of Ecuador.

4.4. Psychoactives

The use of psychoactive plants given to improve the hunting abilities of dogs is counter-intuitive. Both the Shuar and Quichua give *I. guayusa*, which contains methylxanthines, to their hunting dogs. The methylxanthine alkaloid theobromine is toxic to dogs (Strachan and Bennet, 1994). Small doses of the related alkaloid caffeine generate benign arrhythmias in dogs; higher doses cause severe arrhythmias (Mehta et al., 1997). There is clearly a dose-dependent response in canines. Small doses may induce alertness in habituated animals. Quichua deliver small nasal doses to their dogs.

The use of psychoactive hallucinogenic preparations is even more beguiling. The use of hallucinogenic plants in hunting medicines is widespread, but best developed in Ecuador and Peru. All the major Shuar hallucinogens with the exception of *Brunfelsia grandifolia* also are given to hunting dogs. These hallucinogens contain serotonin agonists (ergot-like alkaloids from *Cyperus* sp.; N-N, dimethyltryptamine from *Virola* and *Pyschotria*), monoamine oxidase inhibitors (β-carboline alkaloids from *B. caapi*), and anticholinergics (scopolamine and atropine from *Brugmansia* spp.) (McKenna et al., 1998; Perry and Perry, 1995; Shen et al., 2010).

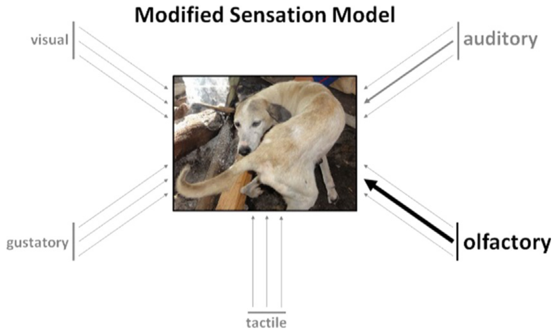

Fig. 8. Modified sensation model. In normal circumstances, arrows representing sensory input would be of the same magnitude. Under the influence of psychoactive plant extracts, we hypothesize that non-hunting related sensations are blocked, while those related to hunting are enhanced. In tropical rainforests this is most likely to be olfaction.

Serotonin agonists can induce hallucinations in both humans and animals (Wink, 2000). Scopolamine hallucinations result from antagonism of ACh receptors (Palfai and Jankiewicz, 1997) and the ensuing hallucinations usually often are visual (Perry and Perry, 1995). A common cerebral anticholinergic effect includes bizarre and aggressive behavior (Palfai and Jankiewicz, 1997). Acetylcholine plays a key role in sustained attention in both serial reaction time and signal detection tasks. The muscarinic cholinergic antagonist scopolamine substantially impairs accuracy of subjects in the tests (Levin et al., 2011). Aghajanian and Marek (1999) argue that the effects of hallucinogens on glutamatergic transmission in the cerebral cortex may be responsible for higher-level cognitive, perceptual, and affective distortions.

4.4.1. Pharmacology

How then can hallucinogens enhance hunting? Much of the psychopharmacological literature suggests that they are more likely to impair ability. Yet, some evidence is supportive. The mode of action of psilocybin, another serotonin agonist, includes thalamic down-regulation and frontal hypermetabolism, which may contribute to drug-induced synesthesia (Stevenson and Tomiczek, 2007). Synesthesia refers to the stimulation of one sensory or cognitive pathway leading to automatic, involuntary experiences in a second sensory or cognitive pathway. This process may be responsible not only for hallucinations but also for the enhanced olfactory, auditory or visual senses in hunting dogs.

4.4.2. Case studies

Other evidence comes from case studies of humans under the influence of hallucinogens. Pedro Kunkumas, a Shuar shaman, said that under the influence of natem (*B. caapi* and *Diplopterys cabrerana* (Cuatrec.) B. Gates) beverages, the body of his patient appears like an x-ray. He can then locate tsentsaks, magical arrows that cause illness, and thus diagnose the patient. Another shaman said that he could hear voices from a long distance under after drinking natem (Bennett et al., 2002). After taking LSD for the first time, two college associates of one of the authors awoke simultaneously. Both were delirious, believing they were about to be run over by a tractor-trailer. Several hours later they recovered and said that it sounded as if the truck was nearly on top of them. Turning on the lights contributed to their hallucination. Under normal condition, the sound of a trucks downshifting or upshifting on a nearby grade was barely audible. LSD appeared to enhance auditory perception just as natem enhances perceptions in shamans.

Jernigan (2009) reports that the Aguaruna give plants (*Brugmansia* sp., *Mansoa* sp., and *T. sananho*) to their dogs because they produce visions of the intended prey. The Shuar believe that *Brugmansia* spp. help dogs obtain supernatural power (Bennett et al., 2002). For the Quichua described by Kohn (2007), the hallucinogenic mixture tsicta (which includes *T. sananho*, *N. tabacum*, and *Brugmansia* sp.) is given to dogs so that they can communicate with their masters and to counsel them.

5. Conclusions

Why give psychoactive plants to hunting dogs? The pharmacological literature suggests equivocal effects of hallucinogens on perception. Moreover, data on the effects of psychoactive plants on dogs is limited deriving mostly from the use of dogs as laboratory surrogates for humans. No studies have investigated the effects of traditional preparations on hunting dogs and the possibility that they can somehow enhance perception that affects the ability to tracking of game animals. Nonetheless, the practice of administering psychoactive plants to canines is well-established. Could such a practice persist if it impaired hunting success? This is unlikely as hunting is a crucial complement to subsistence practices in the lowland tropics. Vollenweider (1994) hypothesized a disruptive effect of activity of psychedelic substances on sensory gating—the filtering of redundant or superfluous stimuli. Riba et al. (2002), in contrast, suggest ayahuasca has a P50 suppressing effect on sensory gating in humans. We hypothesize that hallucinogenic plants alter perception in hunting dogs by diminishing ancillary signals and enhancing others that aid in the detection and capture of game (Fig. 8). If this is true, the implications are significant. Perhaps plant substance could enhance the ability of dogs to detect explosives, drugs, human remains, or enhance the scores of other abilities for which dogs are valued.

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