

**RITUAL AND THERAPEUTIC USE OF
"HALLUCINOGENIC" HARVESTER ANTS
(*POGONOMYRMEX*) IN NATIVE
SOUTH-CENTRAL CALIFORNIA**

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ABSTRACT.-Red harvester ants of the genus *Pogonomyrmex* played a central role as vision-inducing agents in the religious and medical systems of many indigenous groups in southern and south-central California. The ants were ingested alive in massive quantities in order to induce prolonged catatonic states, during which hallucinogenic visions were reported to manifest. They also played an important role in both curative and preventative medicine, treating a diverse body of natural and supernatural ailments. In this article I present an ethnographic and toxicological overview of the ritual and therapeutic use of red ants, bringing together both published and unpublished accounts in an attempt to reconstruct this poorly-known facet of indigenous California culture. The data presented in this paper strongly suggest that, through either direct or indirect action on the central nervous system, massive quantities of *Pogonomyrmex* venom are capable of producing highly altered metabolic states during which hallucinatory visions are apt to manifest. This topic is of considerable interest, as it is the first well-documented ethnographic example of an hallucinogenic agent of insect origin.

RESUMEN.-Las hormigas granivoras rojas del genero *Pogonomyrmex* jugaron un papel central como agentes para inducir visiones en los sistemas religiosos y medicos de varios grupos indigenas en el sur y centro-sur de California. Las hormigas vivas eran ingeridas en cantidades masivas para inducir estados catat6nicos prolongados, durante los cuales se reportaba manifestarse visiones alucin6genas. Jugaban tambien un papel importante en la medicina curativa y preventiva, empleandose en el tratamiento de diversas aflicciones naturales y sobrenaturales. En este articulo presento una reseña etnogrMica y toxicol6gica del uso ritual y terapeutico de las hormigas rojas, reuniendo informes publicados e ineditos en un intento de reconstruir esta faceta poco conocida de la cultura indigena de California. Los datos presentados en este trabajo sugieren fuertemente que las cantidades masivas de veneno de *Pogonomyrmex* son capaces de producir, por medio de su efecto directo o indirecto sobre el sistema nervioso central, estados metab6licos altamente alterados durante los cuales tienden a manifestarse visiones alucinatorias. Este t6pico es de interes considerable, puesto que es el primer ejemplo etnogrMico bien documentado de un agente alucin6geno derivado de un insecto.

RÉSUMÉ.—Les fourmis moissonneuses rousses du genre *Pogonomyrmex* ont joué un très grand rôle en tant qu'agents hallucinatoires dans la vie religieuse et la médecine de plusieurs groupes autochtones du Sud et du centre-Sud de la Californie. Les fourmis étaient ingérées vivantes en quantité considérable afin de provoquer des états prolongés de catatonie durant lesquels des visions hallucinatoires se seraient produites. Elles ont aussi un rôle dans les traitements curatifs et preventifs visant à soigner un ensemble de maux d'origine naturelle et surnaturelle. Dans cet article, je présente une vue d'ensemble ethnographique et toxicologique des usages rituels et thérapeutiques des fourmis rousses à partir de diverses descriptions, publiées et non publiées, dans une tentative de reconstruction de cet aspect mal connu de la culture autochtone de la Californie. Les données présentées dans cet article suggèrent fortement que par une action directe ou indirecte sur le système nerveux central, des doses massives de venin de *Pogonomyrmex* peuvent provoquer de très grands changements métaboliques créant des états propices à la production de visions hallucinatoires. L'intérêt de ce sujet est considérable car il s'agit là du premier exemple ethnographique bien documenté d'un agent hallucinatoire qui provient d'un insecte.

INTRODUCTION

Dosis sola facit venenum (Only the dose makes the poison)
-Paracelsus, 1564

The ethnographic literature on southern California contains many references to the central importance of hallucinogenic plants in curing, shamanism, and the acquisition of supernatural power. *Toloache* (*Datura wrightii* Regel) and tobacco (*Nicotiana attenuata* Torr., *N. bigelovii* (Torr.) Wats) have received the most attention in this regard, and are considered to have been the primary vehicles for establishing personal contact with the supernatural. Over the last few decades, several brief yet provocative mentions have been made regarding the ritual and medicinal use of "hallucinogenic" red ants in south-central California, but to date little has been written on the subject (d. Blackburn 1976; Sutton 1988; Walker and Hudson 1993).

California anthropologists first became aware of the significance of red ants in the religious/visionary complex of south-central California with the publication of a brief report entitled, *A Query Regarding the Possible Hallucinogenic Effects of Ant Ingestion in South-Central California* (Blackburn 1976). In this article, a short account of Kitanemuk ant eating culled from the unpublished fieldnotes of John Peabody Harrington was presented along with a published Tubatulabal account, followed by a cursory examination of possible biochemical bases of psychoactivity. Few conclusions were reached, and even today the question of the hallucinogenic effects of red ant ingestion remains largely unexamined.

The author's recent analysis of John Peabody Harrington's 1916-1917 "Fort Tejon" Kitanemuk fieldnotes has brought to light the most detailed ethnographic account of medicinal and ritual red ant ingestion known. The discovery of this previously unpublished account prompted a review of the ethnographic litera-

ture on southern California, as well as a survey of relevant biological and toxicological literature in hopes of shedding more light on this wide-spread aboriginal tradition of "myrmecophagy."

In this article I present an overview of the ritual and therapeutic use of red ants in south-central California, bringing together both published and unpublished accounts in an attempt to reconstruct this poorly-known facet of indigenous California culture. A total of 17 indigenous Californian ethnic groups were found to have used red ants as a ritual intoxicant, as a medicine, or both. I balance the ethnographic overview with a detailed discussion of *Pogonomyrmex* biology and toxicology, suggesting possible empirical bases for the reported psychoactive effects generated by Harvester ant ingestion.

IDENTIFICATION, DISTRIBUTION, AND BIOCHEMISTRY

The taxonomic status of the red ant species used in aboriginal California is uncertain. All ethnographic accounts describe them merely as "large red ants"—the sole exception being a Tubatulabal account which refers to "yellow ants" (Voegelin 1938:60). The accounts uniformly emphasize their large size, the fact that they build mounded nests, and the excruciating pain of their sting. It has been suggested by several researchers that the species in question may have been the California harvester ant, *Pogonomyrmex californicus* (Hudson 1979:56; Walker and Hudson 1993:59), or the yellow honey ant, *Myrmecocystus testaceus* (Blackburn 1976:80). Unfortunately, no voucher specimens were collected when the ethnographic accounts were recorded, so the precise taxonomic identity of the ant species must therefore remain tentative. However, the taxonomic and toxicological literature strongly supports the assertion that a *Pogonomyrmex* species was indeed the red ant referred to in the ethnographic accounts. Of all the ant genera present in California and the Great Basin, *Pogonomyrmex* is distinguished by the large size, exceptionally painful sting, and highly biodynamic venom of its representative species.

Red harvester ants are common throughout south-central California and the Great Basin. While *Pogonomyrmex californicus* (Buckley), the California harvester ant, is the most common and conspicuous species, *P. subdentatus* Mayr, *P. salinus* Olsen, *P. brevispinosus* Cole, *P. subnitidus* Emery, and *P. rugosus* Emery also occur throughout the region (Cole 1968; J. O. Schmidt and R. Snelling, personal communications 1995).¹ In keeping with the ethnographic descriptions, these ants are large—the workers of most species average about 5-7 mm in length, while those of *P. rugosus* are larger in size, averaging about 10 mm (Essig 1958:861-862). Many Harvester ant species build conspicuous mounds (10 to 30 cm high) around the entrance to their nests, and live in colonies numbering in the thousands. *Pogonomyrmex* stings are exceptionally intense and piercing—often maintaining this high level for up to several hours—and have been characterized as approximating "ripping muscles or tendons" or "turning a screw in the flesh around the sting site" (Schmidt 1986:487). The venom is also reported to cause a nervous, chilling sensation to sweep upward from the sting site (Schmidt 1986:488).

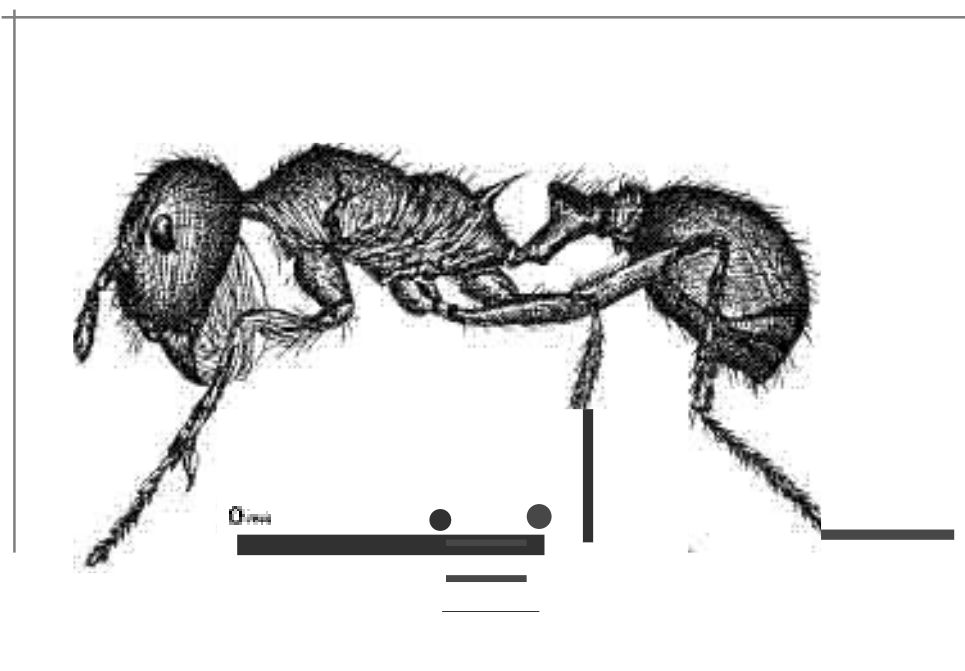


FIGURE 1.—*Pogonomyrmex californicus*, the California harvest ant (after original line drawing by J. Young)

The genus *Pogonomyrmex* belongs to the subfamily Myrmicinae (Hymenoptera: Formicidae: Myrmicinae), along with other, strongly biochemically diverse genera, including *Aphaenogaster* and *Myrmica*. Myrmicinae is the most derived subfamily of stinging ants, characterized by highly complex and potent venoms (Schmidt 1986:430). In fact, *Pogonomyrmex maricopa* possesses the most toxic insect venom recorded to date—five stings can kill a two pound mammal (J. O. Schmidt, personal communication 1995). Unfortunately, the biology of this species is still poorly understood, largely due to the difficulties of collecting the significant quantities of highly purified venom needed for toxicological analysis. However, one thing has become clear over the past few years—the ant's venom gland represents the pinnacle of venom development among the social insects. It is capable of synthesizing extremely complex and potent chemical compounds, many of which are highly pharmacologically active, and were previously thought to occur only in higher plant taxa (Schmidt and Blum 1978a; Wheeler *et al.* 1981; Schmidt 1986).

The morphological, behavioral, and biochemical characteristics of the genus strongly suggest that the red ant species reported ethnographically was a *Pogonomyrmex* species—probably *P. californicus* (see Figure 1). No other genus matches ethnographic descriptions as closely as *Pogonomyrmex*.... in terms of size, mound characteristics, and the potency of the sting. Most importantly, it appears that *Pogonomyrmex* is the only genus toxic enough to induce the altered physiological states described in the ethnographic record—*itid*, the highly toxic *Pogonomyrmex* species in California, is 7 times more lethal than *Manica bradleyi*, the

next most toxic stinging ant (and *P. californicus* is almost 15 times as lethal) (see Table 1 for comparison of mammalian lethality). The implications of these data will be discussed in a later section.

TABLE 1.-Venom quantity, lethality, lethal capacity, and number of stings for an LD₅₀/kg for *Pogonomyrmex* harvester ants compared to other California stinging ant genera.

Species	µg venom/ ant	LD ₅₀ iv (mg/kg)	Lethal Capacity (g mammal/sting)	# stings for LO ₅₀ /kg
<i>P. maricopa</i>	27	.13	208	4.8
<i>P. rugosus</i>	31	.80	39	26
<i>P. californicus</i>	21	.60	35	29
<i>P. brevispinosus</i>	17	.70	24	41
<i>P. montanus</i>	14	.60	23	43
<i>P. slibdentatus</i>	22	1.1	20	50
<i>P. subnitidus</i>	18	1.1	16	61
<i>Manica bradleyi</i>	14	6	2.3	430
<i>Odontomachus</i> sp.	65	~30	2.2	460
<i>Pseudomyrmex gracilis</i>	16	8	2	500

f J. O. Schmidt, unpublished data

RED ANTS IN THE ETHNOGRAPHIC RECORD

Along with *toloache* (*Datura wrightii*) and tobacco (*Nicotiana* spp.), red ants completed the sacred trinity of powerful ritual medicines used in native California, possessing both therapeutic and mind-altering properties. Despite their significance, the use of red ants in either ritual or medicinal contexts is poorly represented in the published anthropological literature on native California, and is discussed only briefly-if at all-in most recent syntheses of California Indian shamanism and ethnomedicine (cf. Bean 1975, 1992a,b; Bean and Vane 1978; Applegate 1978; Walker and Hudson 1993). One reason for the paucity of data is that many of the societies which used red ants were extinct or no longer fully functioning by the time ethnographers arrived in the first quarter of this century. This fact alone makes any precise delineation of the use of red ants exceedingly difficult.

Brief mentions of red ant swallowing appear irregularly in the ethnographic records of several groups, but the data are often vague, confusing, or incomplete. The most complete descriptions come from the unpublished ethnographic fieldnotes of the late John Peabody Harrington, a prolific ethnographer and gifted linguist from the Bureau of American Ethnology who conducted salvage ethnographic research in Southern California during the first quarter of this century. Even at this late date, he was able to locate several individuals who had themselves taken red ants, and were therefore able to provide detailed first-hand accounts of their experiences.

These ethnographic accounts indicate that large quantities of live red ants were

swallowed in order to induce visions and thereby acquire supernatural power in the form of a "dream helper." They were also administered both internally and externally in the treatment of particular physical ailments, such as rheumatism, heavy colds, paralysis, body pain, stomach aches, and various gynecological disorders. For purposes of clarity, I have chosen to treat the two facets of use separately, structuring each discussion around representative ethnographic accounts.²

RITUAL SWALLOWING OF RED ANTS

The use of red ants as a ritual intoxicant has a far more limited distribution than their use in medicinal contexts. Of the 17 indigenous southern and south-central California ethnic groups known to have utilized red ants medicinally, 7 were reported to swallow them in order to induce visions and acquire supernatural power in the form of dream helpers.

The ritual use of red ants appears to have been strongest among the Shoshonean groups along the southeastern edge of the south-central area—the Kitanemuk (Harrington 1986b:r1.98, frs.449-450), Kawaiisu (Zigmond 1977:62, 1986:405), Tubatulabal (Voegelin 1938:5, 46, 67-68), and the various Hokan-speaking Chumash groups, particularly the Interior Chumash (Harrington 1986b:r1.98, frs.608-609, 648-652). Some of the neighboring Southern Valley Yokuts (particularly the Yawelmani) and Southern and Central Foothill Yokuts (Wikchamni, Yawdanchi, Bokninwad, Yokod, and Palewyami) also swallowed ants in order to gain dream helpers and shamanic power (Harrington 1986a:r1.94, fr.387; Driver 1937:99), but the practice among these latter groups appears in a somewhat attenuated form and was likely spread to them by the core groups. The Northern Miwok are also reported to have ingested ants "for vision or power" (Aginsky 1943:440). Although the Miwok lived far to the north, they appear to have shared in many of the cosmological beliefs and religious practices typical of the south-central region (Levy 1978:412).

The presence of this practice among groups to the south is less well established. It is based largely on the testimony of one of J. P. Harrington's Kitanemuk consultants, who indicated that ritual ant swallowing was present among groups to the southeast—probably the Gabrielino and Luiseno-Juaneno—and was integrated into the protohistoric Chingichngish Cult—"that religion [in which] you take ants or *toloache* and they counsel you and teach you everything" (Harrington 1986b:r1.98, fr.443). If visionary ant swallowing did indeed form part of the ritual repertoire of the Chingichngish Cult, it seems odd that the practice is not mentioned in the ethnographic accounts of the Gabrielino (Harrington 1933; Johnston 1962) or the Luiseno-Juaneno (Du Bois 1908; Sparkman 1908).

Exactly where this tradition originated is uncertain. All extant ethnographic accounts were collected from the south-central and coastal core groups mentioned above, among whom ritual ant swallowing was highly elaborated. This distribution suggests that these practices were developed among Shoshonean speakers living in and around the Tehachapi Mountains and southern Sierra Nevada, then passed on to interior Chumash speakers to the west, and then to various Yokuts groups in the southern half of the San Joaquin Valley. Interestingly, the distribution of this tradition is largely coextensive with the Toloache-Dream Helper Com-

plex, a generalized, egalitarian religion that stressed individual contact with the supernatural and the acquisition of one or more dream helpers through ecstatic trance and the use of the hallucinogenic plant *Datura wrightii* (d. Gayton 1928; Applegate 1975,1978; Bean and Vane 1978).

A survey of the ethnographic literature has revealed striking commonalities in the ritual use of red ants, and although there are some discrepancies in detail, the general features of this use complex are quite clear. I have chosen to organize the following discussion of ritual red ant ingestion around a previously unpublished Interior Chumash (or possibly Kitanemuk) account collected at Tejon Ranch in 1916 by John P. Harrington and his wife, Carobeth.³ This account is the most detailed description of ritual ant ingestion known, and appears to be representative of patterns of use for neighboring southern and south-central groups.

Purpose of administration.-Throughout the southern half of California, the possession of a "dream helper" was considered to be a prerequisite for a long and healthy life. These dream helpers were frequently sought through a "vision quest," usually mediated by the ingestion of the hallucinogenic plant *Datura wrightii* (*toloache* or *jimsonweed*), which induces vivid visual, auditory, and tactile hallucinations. If the vision quest was successful, the aspirant saw an animal spirit, a personified natural force, or the spirit of a dead relative who then acted as a life-long spiritual helper and protector (Applegate 1978).

Red ants, like *Datura*, were used by individuals seeking to acquire supernatural power in the form of a dream helper. Quite apart from any "virtues" or specific skills they might confer, dream helpers (and the power they embody) were critically important in leading a safe, healthy, and prosperous life. Possession of a dream helper represented a direct connection with supernatural power—a source of security in an otherwise unpredictable environment. One of J. P. Harrington's Kitanemuk consultants emphasized the importance of supernatural aid in the pre-colonial world of native California, saying, "[We] gave the boys red ants to eat. [We] did this to save them from getting killed... for long ago there used to be lots of fighting..." (Harrington 1986:1.98, fr.449). In a very real sense, the acquisition of a dream helper was viewed as a basic form of preventative medicine.

Those men who sought shamanic power would ingest red ants or *toloache* repeatedly over a period of months or years. If they were fortunate, they gradually acquired multiple or specialized dream helpers who bestowed shamanic skills upon them. Most native southern Californians consulted by early anthropologists were quite explicit about the association between red ant ingestion and the acquisition of shamanic powers, as illustrated by J. P. Harrington's Interior Chumash/Kitanemuk consultant, José Juan Olivas:

[These] are the ants that you take if you wish to become an *hechicero* [curing or bewitching shaman]... You take ants again the following summer and so on every summer till they tell you [that you've had] enough... They give you power to injure or cure people and help you to escape when in peril—you always have these powers if you take the ants successfully. *Toloache* also gives you the power of escaping from danger, but only 2 or 3 times,

and *pespibata* [green tobacco powder] gives it only once... [Harrington 1986b:rl.98, frs.595, 608].

The decision to take red ants was never made in haste, for these creatures were regarded as potent manifestations of supernatural power. While providing the above information, José Juan cautioned, "If [you] are going to take red ants, [you] have to keep your promise. You can't fool this animal. The ant knows you have said it. If you do not fulfill [your promise], you will die soon" (Harrington 1986b:rl.98, fr.489).

Administration and the "Coming of the Animals", -The ritual ingestion of red ants, whether aimed at establishing a relationship with a dream helper or gaining more specialized shamanistic power, was always an individual and voluntary matter. Unlike *toloache* use, it was not tied to boys' puberty ceremonies, and no change of social status occurred. The ants were taken anytime after puberty-usually during the winter months-and the experience could be repeated as often as desired. Since red ants were considered to be more powerful than *toloache*, their ritual use was limited to boys and men.

An elderly post-menopausal woman or old man served as the "ant doctor," and was in charge of the administration. For three days prior to administration the aspirant (and often the ant doctor) observed a regimen of fasting and nightly vomiting to purify the body. Avoidance of meat, grease, blood, and salt was stringently observed, as it was felt that these substances diminished the likelihood that a dream helper would appear. These restrictions suggest that red ants, like all representatives of supernatural power, were believed to be "hostile to blood" and would visit harm upon individuals who had consumed flesh or come into contact with blood or sexual fluids prior to ingestion (d. Applegate 1975:9). This careful avoidance of "contaminating" substances-particularly blood-may explain the universal exclusion of pre-menopausal women from all facets of ritual ant use and vision seeking.

The actual ingestion took place during the daytime at an isolated location, away from the village and fully exposed to the elements. After collecting the ants from a nearby anthill, the ant doctor would lay the aspirant down on his back and quasi force-feed him large quantities of live red ants collected on balls of moist eagle down. She regulated the dose by watching the boy's appearance and behavior closely-when his eyes turned red and he began to experience lassitude she knew that he had ingested enough (Voegelin 1938:67).⁴ The general characteristics of administration are exemplified in the following Interior Chumash or Kitanemuk account provided by José Juan Olivas:

An old woman who no longer has monthlies cares for the eater in the hills... an old man can give them if there is no old woman, but an old woman is preferred because she can pound and prepare his food. The old woman wets something-the down-feather of an eagle is good to use-and sticks it into a vessel containing the ants and 4 or 5 ants cling to it and form a ball. She puts the ball in your mouth and you draw your breath in sharply and thus suck the ball down your throat, swallowing both ants and feather. Then the old woman gives you another and another and another-she goes on

counting until you have taken 50, 60, 80, or 90 balls-just as many as you can stand. Every little while she pauses and asks, "Do you want more?" and if you are brave you say, "Yes, give me more." As you swallow you have a very painful burning sensation in your throat and when you can stand it no longer you say, "That's enough," and she stops giving them to you...

While you are sitting quietly after taking the ants, the old woman who gave them to you says, "Sit here quietly a little while, I am going to get something." You sit perfectly still with drooping shoulders and hanging head, arms hanging loosely at [your] sides... But she does not have to get anything-just says this to fool you. Then she slips up behind you and grabs you, or rather pokes you with both hands, on ribs at sides, just back of upper arms, crying out or grunting as she does so. She does this to startle you. It is necessary to do this because until you are startled in this way the ants do not bite-they are simply clinging together in balls inside of you. When the old woman startles you the ants all bite all at once and immediately you fall as dead. Then she takes you and puts you in the shade so that you lie face down (informant at first said face-down very positively but later said either face-up or face-down), Then she retires some little distance (about 200 ft. or more) and watches you.

If you take the ants in the morning (about 9:00 am) you will come to about noon. When the old woman sees that you are sitting up she comes and asks how you feel and you tell her "all right," and then she asks if you want more. If you have courage you say yes, and take more, perhaps as many as you did the first time, just as many as you can stand. When you have finished, the old woman startles you again and you fall in a faint and lie until sundown, when you revive. Then she asks you how you feel, and if you say you feel all right she knows you mean to take more tomorrow. At sundown she comes nearer so that she can watch you better during the night. The next day if you are brave you take ants in the morning and at noon, as on the previous day. And so on for 2,3, or 4 days.., The ants do not kill you, they give you force to go without food 5 or 6 days... [Harrington 1986b:rI.98, frs.608-609, 648-651].

The focal event in all accounts of ritual red ant use is the dramatic loss of consciousness following ingestion. This deep, death-like sleep was characteristic of all drug-induced visionary experiences in south-eentral California, and held great symbolic significance. Death, dreaming, and the experiencing of supernatural visions seem to have constituted a single conceptual domain in native Californian thought, and the three experiences were sometimes glossed under a single term.⁵The catatonic, near-death state was essential to shamanic and visionary practice, and was understood as a sort of small death in which the aspirant was "killed" by the supernatural agents which he sought to contact. It was during this liminal death-like state that supernatural visions manifested and a dream helper "chose"

the boy, conferring his virtue upon him. J. P. Harrington provides us with a detailed description of the "coming of the animals" and the powers they confer:

If you have enough courage you take ants until the ants run out of your mouth as soon as they are swallowed. This gives you a lot of power if you can do it. When this happens the ants speak to you and tell you [that] you have taken enough... The ants talk to you and ask what you want-[they] give [you] any *virtud* [virtue] that you want.

Then come the animals...The lion can give you *virtud*. Or bear. The coyote, the *gavilan* [sparrow-hawk]. Each can give their *virtud*-all of these, even the rattlesnake, can come and talk to you. Rattlesnake says, "they are going to bite you." That night the rattlesnakes come [and bite you], and you open your eyes and you are well. Also the [ghost] gives *his virtud*, which is that you can become invisible, yell to people who follow to kill you, from [the] distance [issue] challenge and disappear again. The [mountain] lion-very strong, bullets go aside. *Gavilan*-[gives you the ability to] shoot 2 arrows [at once]. Arrows shot at you go aside. Spit on hawk claw and touch it to bowstring as you shoot when in a hurry. A hawk comes and circles, and if enemy does not kill him when he shoots at you, you are o.k. Bullets go aside. The coyote also [gives the ability] to shoot 2 [arrows]. The bear [makes bullets and arrows go] aside. The horse-wear belt of the mane-jump on horse when in hurry and escape. The dog-dog comes and barks when you are in a hurry, and if [they] don't kill [the] dog you are o.k... If ants say you will live, you will live 100 years. They give you *espiritu* [spirit, strength, fortitude]... These are the *virtudes* [virtues] the ants give you [Harrington 1986b:rI.98, fr.649, 651-2].

While most of the virtues conferred by the dream helpers in this account are purely utilitarian, other reports indicate that they were just as likely to be highly specialized shamanic powers that enabled the recipient to cure, bewitch, make rain, or transform into an animal. Such specialized powers were often conferred by poisonous or dangerous creatures, such as Rattlesnake or Black Widow, who bit the vision seeker and transferred their power to him through the medium of their venom. The relationship between poison, power, and medicine will be explored further in a later section.

Although not mentioned in this account, the aspirant always drank hot water after regaining consciousness in order to induce vomiting. The regurgitated ants reportedly came out alive, still clinging together in little balls. It is likely that some form of vision interpretation took place between the ant doctor and the aspirant after he had recovered from this ordeal. Such a practice was reported for the Tubatulabal (Voegelin 1938:68) and Kitanemuk (Harrington 1986b:rI.98, frA50), and was common following *toloache* ceremonies, in which an analysis of the aspirant's visions served to reinterpret idiosyncratic psychic experiences in terms of widely held public beliefs and local cosmology. After coming to mutual agreement on the significance, meaning, and success of the vision experience, the ant doctor would have given the boy instructions for cementing his relationship with the dream

helper, which usually included a series of prayers and offerings of seeds, shell beads, tobacco, and eagle down.

Post-ingestion observances.-For a period of time following the ant eating ritual, the aspirant observed a number of dietary and behavioral restrictions. These restrictions were designed to ensure that the bonds forged between the individual and his dream helper were not broken. The length and severity of the proscriptions corresponded with the degree and type of power sought-men seeking certain highly-specialized shamanic skills underwent lengthier and more rigorous restrictions than those who took ants in order to establish a relationship with a single dream helper or to cure themselves. After this period had passed, a small ceremony was held to formally mark the end of the fast and to reintegrate the individual with his family and community:

[You] must stay alone without speaking to anyone-[the] person who is taking care of you does not talk [for] 4 days... When you take ants for to cure you, you diet 12 days-when you [take them in order to] become [a] medicine man, one month... [You stay for] one month in hills, then [there is a] *fiesta*. The person who administered [the ants] tells the captain that the month is up, and the captain tells the *payaso* [ritual announcer] to cry announcing a *fiesta* [for the next day]. Eater comes in from hills with his head *covered* and man pays many beadstrings to people-[the ant eater's] relatives pay this for permission [for him] to eat meat again. A ceremony is then held in which [the aspirant] eats a small piece of meat [the size of] last joint of finger. Then [he drinks] warm water-eaglefeather-vomits. That night he eats meat [Harrington 1986b:r1.98, fr.650].

Overall, the ritual use of red ants reported ethnographically exhibits great homogeneity among culturally and linguistically distinct ethnic groups. *However*, several minor variations should be noted. The emphasis in this account on multiple administrations *over* a period of several days appears to be atypical, and may reflect attempts to gain specialized or multiple dream helpers. Among all other groups the aspirant is reported to *have* taken the ants only once, usually in the morning, then lapsed into an unconscious state from which he *recovered* later the same day. In addition, Tubatulabal youths are reported to *have* ingested the ants inside of a sweathouse under the supervision of their grandfather in order to "gain power" (Voegelin 1938:67), while among the Kitanemuk a man who "knew how to pray" administered red ants to the boys either individually or in small groups out in the hills (Blackburn 1976:78).

THE THERAPEUTIC USE OF RED ANTS

Reported medicinal use of red ants is more widespread than ritual use. While all groups that used red ants in the acquisition of dream helpers also used them as medicines, the majority employed them only in therapeutic contexts. *However*, inasmuch as indigenous California medicine was integrally connected with religious beliefs and practices, any sharp separation of the two is necessarily artifi-

cial. As we will see below, the relationship between ritual vision induction and therapeutic vision seeking is quite complex, and distinctions between the two rapidly begin to blur.

The Kawaiisu believe that red ants were one of the four medicines given to people at the beginning of time, along with tobacco, nettles, and *toloache* (Zigmond 1981:23). When evaluating the efficacy of traditional remedies, J. P. Harrington's Chumash consultants often declared red ants to be one of the three finest medicines: José Juan Olivas felt them to be the most powerful medicine in terms of the supernatural powers they conferred, followed by *toloache* and tobacco (Harrington 1986b:rI.98, fr.608), while Fernando Librado Kitsepawit ranked them third, surpassed only by *toloache* and sea water (Hudson 1979:56).

Most of the groups occupying south-central California were reported to use ants both internally and externally in the treatment of unspecified illnesses, including: the Kitanemuk (Harrington 1986b:rI.98, frs.124, 384, 415), Kawaiisu (Zigmond 1977:77-78, 1981:23, 1986:405), Tubatulabal (Voegelin 1938:5, 60, 73), Chumash (Hudson 1979:73; Walker and Hudson 1993:60, 89-90), Monache (Wobonuch), Southern Valley Yokuts (Nutúnutu and Yawelmani), Southern and Central Foothill Yokuts (Palewyami, Wikchamni, Yawdanchi, Bokninwad, Yokod)(Driver 1937:99), and Northern Miwok (Aginsky 1943:440). The Owens Valley Paiute and the Entimbich band of the Monache limited the therapeutic use of red ants to external application, while the Wikchamni band of the Central Foothill Yokuts took them only internally (Driver 1937:99).

Unforunately, most ethnographic accounts regarding the therapeutic use of red ants are disappointingly brief, and frequently neglect to specify the conditions that were treated. Despite these lacunae, a survey of the extant literature reveals that they were employed in the treatment of a diverse inventory of conditions, including: paralysis, gastrointestinal ailments, severe colds, pain, arthritis, and gynecological disorders. Red ants were also widely used throughout south-central California as a general tonic. The ants were either swallowed alive (as in ritual use) or applied in great numbers to the exterior of the body, then aroused to anger so they would sting freely. Many groups practiced both forms of administration, choosing between them depending on the condition being treated and the preferences of the individual. Unlike ritual use, both men and women were allowed to use ants for medicinal purposes.

The internal administration of red ants for explicitly therapeutic ends appears to be closely related to their use in visionary contexts. The form of administration is identical, involving various pre- and post-ingestion food proscriptions. Although visions were sometimes sought during medicinal ant ingestion, there was no attempt to gain a dream helper or shamanic powers. Frances Philips, an elderly Tubatulabal woman, has left a record of her experience with therapeutic ant ingestion, which took place between 1875-1885 at the village of *uupulap* on the South Fork Kern River. This account provides a typical example of the therapeutic use of red ants, and highlights the structural similarity between ritual and medicinal uses:

I became sick at *uupulap*; my arm was bent and I couldn't straighten it. So I didn't eat meat for a month, then my aunt gave me red ants. She gave me half a baking-powder can full of little balls of cotton with live red ants

wrapped up inside them. I hadn't eaten anything the day before my aunt gave me those ants... I took the ants in the morning and slept all day; then I woke up and everything was clear and bright. The red ants that are all aroWld here now are the ones I took. I didn't eat any meat for a month; if I had, then when I took the ants they would have killed me.

Those ants are good to take for a bad cold too, wrapped up in eagle down. When you take them you burn inside your stomach, just like fire; you get hot inside; they bite you there, I guess. I slept all day the time I took ants; I was unconscious and I slept outside on the ground and rolled over and over in the dirt. My hair got full of dirt; I didn't know anything. They gave me warm water to drink when I woke up that evening; then I vomited, but nothing came up except water. The cotton and the ants had disappeared. I could straighten out my arm again. After that I just ate acorn gravy and a little bread; no meat or grease for a month [Voegelin 1938: 73].

From this and other accoWlts, Voegelin was able to reconstruct a normative description of therapeutic red ant ingestion among the Tubatulabal. The similarities between the following accoWlt and José Juan Olivás' accoWlt of ritual ingestion are striking:

For heavy colds, paralysis, 4-5 yellow ants [or] large red ants [were] wrapped together in eagle down; 15-20 of these balls swallowed with sips of water, one ball at a time, by man, woman who had abstained from meat for month, fasted for 2-3 days and vomited each morning during fast, previous to taking ants. After swallowing the balls [the] patient [was] frightened, "so the ants would break out of the balls and sting patient"; later remained in stupor 24 hrs., at end of this time given warm water to induce vomiting... If all ants came up alive, patient would recover completely, if half of them were dead he "wouldn't live long," and if all dead he would die shortly... After taking ants patient ate only a little acorn mush for 2-3 days, no meat, grease for month. Live ants also put on sick person's abdomen, "if patient didn't want to drink them" [Voegelin 1938:60].

These accoWlts illustrate several typical features of therapeutic ant swallowing, including pre- and post-ingestion food avoidances, a regimen of purging and fasting for both patient and doctor, the characteristic death-like stupor, and forced post-ingestion vomiting. In the treatment of less serious conditions fewer ants were ingested and no loss of consciousness occurred. A particularly unusual feature of therapeutic ant ingestion is the divinatory or prognostic role accorded to the ants after they have been regurgitated. This trait is also reported for the Kawaiisu (Driver 1937:99) and the Northern Paiute (Steward 1941:331; in Sutton 1988:65).

While visions are not reported in either of these accounts, we know that they played a central role in many therapeutic contexts-especially when supernatural etiology was suspected. The Kawaiisu swallowed red ants in order to ward off supernatural threats. After witnessing a bad omen, both men and women would take red ants in an attempt to counteract the impending misfortune:

When you are out and see something you haven't seen before-a big

deals were not directly therapeutic, they were viewed as a form of general preventative medicine which imparted strength, fortitude, and endurance-traits necessary for a long and healthy life. The practice was common among the Chumash, and appears to have been integrated into the ritual repertoire of the Toloache Complex among the Tubatulabal (Driver 1937:98) and possibly the Monache (Driver 1937:99). The Northern Miwok also employed an ant ordeal to "test strength"-four or five men would lay down in a disturbed ant nest, and the one who endured the longest was given an award by the chief (Aginsky 1943:440).

Fernando Librado Kitsepawit, J. P. Harrington's principal Chumash consultant, related the ant ordeal he underwent as an adolescent. This event took place while constructing an irrigation canal somewhere near Mission San Buenaventura before the secularization of the mission system in 1836:

There was a time when I had the red-ant treatment... While [my mother and maternal grandfather] were digging they cut through an ant nest, and a multitude of ants came out and my mother said that if I was going to die [someday], she wanted me to live to a ripe old age. I was naked. My mother stood me right in the midst of the red ants, and they crawled all over me and bit me, after which I fainted. Thereupon...my grandfather came with a lot of green sycamore leaves, and rubbed me all over freely with the leaves. He then chewed some tobacco and rubbed *this* over my body too. I came to and never suffered any ill effects after that [Hudson 1979:73].

As a rule, no visions were reported, and there was no ritual dimension to the ant ordeal. It was usually supervised by relatives, and as indicated in the previous narrative, the event was often quite informal and spontaneous. No change of status occurred, except among the Mountain Cahuilla who integrated a collective ant-ordeal into clan initiation rites (Strong 1929:176), the Luiseno-Juaneno, and Cupeno, who closed their *Datura* ritual with an ant ordeal (Du Bois 1908:91-92; Strong 1929:317,339), and the Gabrielino, who "tested and hardened" their youths by subjecting them to an ant ordeal involving both internal and external administration in the final stages of the puberty observance (Heizer 1968:36; Johnston 1962:60-61).

In the treatment of particularly serious or tenacious conditions, ants were often swallowed then simultaneously applied to the exterior of the body (usually the abdomen, chest, and/or back). A particularly dramatic example of this dual administration was provided to Carobeth Tucker Harrington by Angela Montes, a Kitanemuk woman who had been given red ants in the treatment of post-partum "cold" (probably referring to uterine hemorrhage, dysmenorrhea, or a similar gynecological disorder):

After Vicente was born, I took cold or for some other reason became very sick. I was suffering great pain in my belly (gesture with both hands to sides of upper part of belly below ribs...). They gave me red ants as a medicine, both externally and internally. First, they put them all over my belly, from navel down...so you could not see my skin for the ants. It is no trouble to get them to stay on, as they begin to bite and hang on very tightly the minute they touch your skin. The pain was intense. At the same time that

the external treatment was applied, I also had to swallow a great many live red ants-I don't not know how many, a lot. They of their own accord cling together in balls and it is these balls of ants that you swallow. This was also very painful. They must surely have bitten me inside, as I felt like something was pricking me between my shoulders. Some days after taking the red ant treatment, a flow of blood came freely from my uterus, and I got well [Harrington 1986b:rI.98, frs.384, 415].

As we have seen, the therapeutic use of red ants appears to have been more widespread and culturally variable than their use in ritual contexts. The few specific accounts we have indicate that red ants were administered internally and/or externally in the treatment of diverse conditions ranging from simple aches and pains to gynecological and obstetric disorders. In addition to these seemingly straightforward, "empirical" therapies, native Californians utilized the visionary potential of red ants in order to harness the power of the supernatural and direct it towards therapeutic ends. These practices reflect a sophisticated understanding of the nature of venom: namely, that poison can often act as a medicine or an hallucinogen, depending on the dose. This quasi-Paracelsan observation largely elides the distinctions between the three concepts, inseparably linking them together under the overarching rubric of supernatural power.

POISON AS POWER, POISON AS MEDICINE

One of the central conceptual tenets underlying red ant ingestion appears to be the equivalence drawn by native Californians between poison, power, medicine, and hallucinogen. In native Californian thought, poison (or venom) was understood to be a sign of potent supernatural power. A defining feature of both poison and power was their dangerously amoral character—poison was power first and foremost, only secondarily was it put to use for either malevolent or beneficial ends (Applegate 1978). Accordingly, many venomous creatures were esteemed as powerful supernatural allies who possessed the ability to confer shamanic powers during the vision quest.

Among the Tachi Yokuts, Black Widow was the supreme dream helper of powerful shamans. The association between the two was so strong that black widows and shamans were called by the same name, *métsa*, meaning "true, real, big, and powerful" (Gayton 1948:24). Among the Kitanemuk the equivalence of these concepts is even more apparent. The word for poison or venom is *pahaviit*—this same term is also used to refer to specialized shaman's dream helpers such as Bear and Rattlesnake (Anderton 1988:452). Given the extraordinary toxicity of *Pogonomyrmex* venom, and a cultural predisposition to equate poison with supernatural power, it comes as no surprise that this species would become identified as ritually and therapeutically valuable based on the potency of its sting. Voegelin's (1938:60) Tubatulabal consultants cited the fact that they "could sting hardest and had medicine" as the primary indicator of therapeutic and supernatural efficacy—less potent varieties were thought to be ineffective.

It is interesting to note that the three "sacred medicines" used in native California—tobacco, *toloache*, and red ants—are all extremely toxic. The cultural his-

tory of these hallucinogenic agents is very old, and it was only through long-term experimentation and use that these potentially deadly substances could be manipulated with impunity for therapeutic or visionary ends.

Although not a "true" hallucinogen, tobacco (*Nicotiana* spp.) is highly psychoactive and is used throughout the Americas in the induction of narcosis and ecstatic trance, usually in shamanic or curing contexts (d. Wilbert 1987,1991). Nicotine, the principal alkaloid in tobacco, is highly toxic. The amount of nicotine contained in an ordinary cigar-if it were extracted and injected internally-would kill a man twice over (Larson *et al.* 1961). Visionary trance is induced by carefully managing the toxic effects of the nicotine alkaloid, pushing the aspirant very close to death then bringing him safely back as the toxic tobacco alkaloids are metabolized (Wilbert 1987:157).

Toloache (*Datura wrightii*) provides another interesting illustration. This solanaceous plant owes its psychoactive properties to a group of neurotoxic tropane alkaloids (including atropine, hyoscyamine, and scopolamine) which acts directly upon the central nervous system. In addition to being highly toxic, these alkaloids are true hallucinogens. Unfortunately, tapping into the plant's visionary powers is risky-by the time hallucinations manifest, the alkaloids are often at near-fatal levels, making poisoning or death a distinct possibility (Levy and Primack 1984:36; Blackwell 1990:36). The Chumash recognized that the visionary substances in *Datura* were also potent poisons-in fact, it was commonly held that rattlesnakes derived their venom by sinking their fangs into a *toloache* root and sucking up the poison before biting a human (Applegate 1975:11)

In recent years, toxicologists and phytochemists have shown that the venoms and assorted toxins found in insects, reptiles, and plants are actually complex secondary defensive compounds that have evolved in order to protect the organism from predation. At certain non-lethal dosages, many of these toxins produce "side effects" which can be therapeutic and/or psychotropic in humans (and often, in other mammals as well). As Schultes and Hofmann (1992 [1979]) have pointed out, natural substances are useful in medicinal and/or visionary contexts precisely because they are toxic. The difference between a poison, a medicine, and an hallucinogen is often merely one of dosage.

HALLUCINOGENIC RED ANTS: POSSIBLE BASES OF PSYCHOACTIVITY

The ethnographic record is unequivocal-in native south-central California Harvester ants were used to induce altered physiological states during which visions manifested. The question remains-to what do these ants owe their vision producing potential? In this section I examine the ethnographic accounts in light of general pharmacology and toxicology, and propose two possible explanations for the reported psychoactivity. First, I consider the possibility that the ants are "true" hallucinogens, containing endogenously-produced, directly hallucinogenic chemicals. Second, I examine the possibility that the psychoactivity is a toxic "side effect" of massive envenomation combined with non-venom factors such as physiological stress and cultural preconditioning. I present data which suggest that certain venom constituents (possibly kinin-like agonists) could interact with neu-

rotransmitters to trigger a cascade of psychophysiological events, including endogenously-produced hallucinations.

Previous reports of extra-botanical hal/ucinogens.-The most obvious explanation of *Pogonomyrmex* psychoactivity would be to postulate the presence of true chemical hallucinogens as metabolites or venom components. The occurrence of such endogenously-produced psychoactive compounds outside of the plant kingdom is rare, but not unheard of. The only animal with clinically demonstrated hallucinogenic potency is the Sonoran Desert toad (*Bufo alvarius*), whose venom contains an unusual enzyme, O-methyl transferase, which converts bufotenine (5-OH-DMT) to the potent hallucinogen 5-methoxy-N,N-dimethyltryptamine (5-MeO-DMT). The activity of this enzyme leads to the production and accumulation of prodigious quantities of 5-MeO-DMT in the toad's cutaneous, tibial, and parotoid glands (Deulofeu and Ruveda 1971; Weil and Davis 1994). Remains of this toad have been found in archaeological contexts at Olmec and Maya sites in Mesoamerica, as well as Moche sites in northern coastal Perú, suggesting that these societies may have recognized the unique nature of *Bufo* secretions and exploited them for visionary purposes (Weil and Davis 1994).

Similarly, cutaneous toxins from the skins of neotropical frogs (mostly *Phyllomedusa*, *Phyllomedusa*, and *Dendrobates*) are reported to produce psychoactive effects when rubbed into self-inflicted burns by the Amahuaca and Matsigenka Indians of the Peruvian Amazon (Carneiro 1970). Analysis of skin secretions from these frogs has revealed the presence of a number of vasoactive and neuroactive peptides (Daly *et al.* 1992; Erspamer *et al.* 1993). Interestingly, recent research indicates that a majority of the cutaneous alkaloids found in *Dendrobates auratus* are not endogenously produced, but are captured from dietary sources, which include alkaloid-rich myrmicine ant species (Daly 1994; Daly *et al.* 1994).⁷

In addition to these well-documented examples, there have been occasional but unsubstantiated reports of an "hallucinogenic" moth (*Myelobia smerintha* Huebner) that induces "marvellous dreams" when eaten in the larval stage (Britton 1984), several related fish species known as the Norfolk Island "dream fish" and the Hawaiian "nightmare *weke*" reputed to possess dream-inducing properties (Ott 1993:410), and a black and red bird called *oconenetl* from Tlaxcala, Mexico, whose flesh was reportedly eaten for hallucinogenic effect by the Aztecs (La Barre 1981; Ott 1993:416).⁸

To date, no directly hallucinogenic constituents have been isolated from any arthropod. However, several pharmacologically interesting compounds have been isolated from the venoms of myrmicine ants. Anabasine, a toxic tobacco alkaloid, was isolated from the venom of *Aphaenogaster fulva*. Although anabasine is a minor alkaloid in tobacco, this marks the first time it has been found in an insect (Wheeler *et al.* 1981). Other alkaloids have been isolated from the poison glands of myrmicine ants, including: dialkylpiperidines, pyrrolidines, dialkylpyrrolidines, and an indolizine (Wheeler *et al.* 1981). Three lactones related to nepetalactone (the principal active agent in catnip, and a possible hallucinogen in humans), and several coniine-related alkaloids have also been reported (Jackson and Reed 1969; Pavan 1959; cited in Blackburn 1976:80).⁹ Although none of these alkaloids is known

to be directly hallucinogenic in humans, their presence is provocative and underscores the need for further toxicological research. Given the extreme plasticity of the ant's venom gland and the preliminary state of our knowledge concerning the chemicals it synthesizes, the possibility remains that a directly psychoactive compound awaits our discovery.

Venom and visions: A possible toxicological basis. -While direct psychoactivity on the part of Harvester ants remains a possibility, I would like to suggest an alternate toxicological explanation of the practices described in this paper. It is possible that the visionary experiences reported ethnographically are not due to direct biochemically-based psychoactivity on the part of the ants, but rather represent an endogenously-produced physiological response to intentional massive envenomation - in short, ant poisoning. There is ample evidence that experiences very similar to hallucinations may be induced by the ingestion of toxic substances which upset the normal metabolism, causing abnormal mental states to develop. Such altered states of consciousness may also be induced without ingesting toxins - long periods of drumming, dancing, fasting, self-induced physical pain, and high fevers have been known to alter normal metabolic functions to such a degree that visions manifest (Schultes and Hofmann 1992 [1979]).

The pre-ingestion practices recorded in the ethnographic accounts indicate that native Californians knew how to carefully manipulate diet and behavior in ways that altered basic metabolic processes and rendered the human body maximally susceptible to altered mental states. The three days of fasting and forced purging that preceded ant ingestion would have produced stress on blood physiology, generating low glucose levels (thereby stressing the brain), and significantly altering the digestive function. Under starvation, the production of digestive enzymes decreases significantly, and the avoidance of meat and grease particularly helps decrease degradative enzyme production. This regimen of dieting and purging would set up a benign microenvironment in the stomach, protecting the ants and their venom from digestive degradation. The synergism of these non-venom factors would certainly potentiate the action of venom constituents, and when combined in a ritual setting, may have predisposed the individual to visionary experiences.

The ethnographic record stresses the fact that the ants were always swallowed alive and unchewed. This mode of administration risks not only ant bites, but also envenomation from the sting apparatus left in the skin, mouth, and stomach, as *Pogonomyrmex* exhibits sting autonomy (Hermann 1971). In fact, many native consultants were aware that the ants "bit the lining of the stomach," and some reported burning or prickling sensations in the throat and/or upper body, and an intense, fire-like burning in the stomach.

This form of live oral ingestion relies on a direct gastrointestinal route of administration and on enteric envenomation from the buccal cavity, the laryngeal tract and the stomach, and possibly the large and small intestines. The buccal cavity is the most propitious site for venom absorption, with a thin epithelium and a rich blood supply. Once the venom is injected, it is not diminished by passage through the liver, but gains access directly to the heart and general circulation.

The stomach and small intestine also represent favorable sites for rapid absorption, and stings in either location would introduce toxic venom components directly into the bloodstream. In addition, *Pogonomyrmex* venom contains potent pro-inflammatory agents that speed absorption by increasing vascular dilation and capillary permeability. The fact that ant ingestion (as well as tobacco and *toloache* use) occurred on an intentionally purged and dieted stomach may have furthered the rapid progress of ants into the small intestine where they could sting the intestine wall, potentially inducing toxic reactions.

Recent toxicological research has shown Harvester ants of the genus *Pogonomyrmex* to possess the most toxic insect venom recorded to date. Their venom has the highest known mammalian lethality of any arthropod ($LD_{50} = 0.1-1.1 \mu\text{g}$ venom/g mouse, $n = 15$ species of *Pogonomyrmex*), and proved to be 5 times more toxic than the venom of the Oriental hornet and 8-10 times more toxic than that reported for honeybee venom. These two venoms are the most toxic venoms reported from insects outside the genus *Pogonomyrmex* (Schmidt and Blum 1978a,b,c; Schmidt *et al.* 1989).

This extreme toxicity is derived from the presence of rich quantities of direct hemolysins and assorted enzymes (including hyaluronidase, phospholipase A_2 and B, lipase, acid phosphatase, and esterases), some of which promote the internal spreading of venom components by opening passages through host tissue matrix (Schmidt 1986:475). In addition, *Pogonomyrmex* is one of the few genera for which the presence of neurotoxins has been physiologically demonstrated (Schmidt and Blum 1978b; Piek *et al.* 1989; Piek 1991). These peptidal compounds appear to have evolved as deterrents against vertebrate predators, and produce a marked reaction in the mammalian central and peripheral nervous systems.

Harrington's account of Chumash ant ingestion states that as many as 90 eagle down balls (each holding 4-5 ants) were ingested in a single session. Assuming this information is accurate, an individual might swallow as many as 450 ants per day for the duration of the ritual. The venom delivered from this number of *Pogonomyrmex* stings (assuming total venom delivery) represents approximately 35% of a lethal dose (LD_{50}) of *P. californicus* venom in an individual with a 100 lb. (45.5 kg) body weight (see Table 1 for precise data on venom quantity and lethality for *Pogonomyrmex* species ants). Such massive sub-lethal doses are clearly in the range of pharmacological activity, and would likely generate a variety of neurological and physiological effects. Unfortunately, there are no clinical data on the reactions of human subjects to massive quantities of hymenoptera venom, and the specific nature of the resulting physiological reactions is therefore uncertain.¹⁰

It is possible that the visions and catatonia reported ethnographically may be triggered by venom constituents that alter the relative levels of endogenous neurotransmitters such as serotonin, norepinephrine, and dopamine in the brain. These synaptic transmitters and their metabolites are present throughout the brain at low baseline levels, and even small fluctuations in relative quantity can lead to pronounced physical and psychic effects similar to those induced by tranquilizing or hallucinogenic drugs. Interestingly, these neurotransmitters are structurally similar to plant hallucinogens: norepinephrine is chemically related to the hallucinogen mescaline, while serotonin is closely related the hallucinogenic indolealkyl-

amines psilocin, DMT, and LSD (Schultes and Hofmann 1992 [1979]; Ott 1993:195).

Recent studies have shown *Pogonomyrmex* venom to be a veritable chemical cocktail, containing many strongly bioactive compounds (presumably peptides and alkaloids). While most of these constituents remain unidentified, the presence of kinin-like agonists has been established (Piek *et al.* 1989; Piek 1991). Kinins are endogenously-produced nonapeptides that appear to have potent and profound actions in the mammalian nervous system. They are implicated in pain production, and are produced by the body in response to trauma or noxious stimuli. Exposure to exogenously-produced kinins (such as those found in ant venom) can also trigger a kinin-producing response in the body (Moniuszko-Jakoniuk *et al.* 1976). The presence of kinins in both frog skin and the venoms of at least nine species of ants and social wasps suggests a toxicological effect in vertebrates, since both groups of animals must defend themselves against vertebrate predators.

Although their actions in the mammalian central nervous system are still poorly understood, it appears that kinins can function as neuromodulators, altering the uptake and release of neurotransmitters and producing marked behavioral changes. Moniuszko-Jakoniuk *et al.* (1976) demonstrated that exposure to bradykinin leads to decreased levels of norepinephrine and dopamine in corpus striatum, an increased level of serotonin in corpus striatum and cerebellum, and a higher level of 5-hydroxyindoloacetic acid in corpus striatum and hippocampus. In mammals, these changes in neurotransmission evoke the following behavioral responses: an initial short period (2-5 min.) of excitation, followed by a pronounced depression of activity, shallow respiration, cognitive slowing, the appearance of deep catatonic sedation, paralysis, occasional convulsions, and an eventual return to normal functioning (Capek 1962; Moniuszko-Jakoniuk and Wisniewski 1974; Moniuszko-Jakoniuk *et al.* 1976; Yazaki 1989).¹¹

The critical question remains—do hallucinations accompany these pathophysiological responses? Unfortunately, no definitive answer is currently possible. We are only beginning to appreciate the complex role of neurotransmission in altered states of consciousness, hallucinogenic experiences, psychiatric disorders, and delusional conditions such as schizophrenia (d. Bird 1990; Pearson 1990; Price *et al.* 1990). However, the toxicological explanation outlined above is at least as plausible as that of direct psychoactivity. We know that certain non-hallucinogenic toxins (such as the nicotine alkaloid), when taken in sufficiently large doses, interact with neurotransmitter systems to produce a cascade of psychophysiological responses that often includes anxiety, agitation, hypotension, stupor, delirium, and hallucinations (Pearson 1990:316; Wilbert 1987).¹²

It is unlikely that the actions of kinins alone can explain the suite of psychophysiological effects generated by red ant ingestion. The more likely explanation is that kinins are but one of the strongly bioactive compounds that produces the altered states recorded in the ethnographic record. Kinins are known to cause lasting disruption of the blood-brain barrier (Walker *et al.* 1995), and may potentiate altered mental and physical states by facilitating access to the brain not only of themselves, but also of all other venom constituents (which may include as-yet unidentified hallucinogenic chemicals). Interestingly, a recent pharmacological study of ritual intoxication induced through the administration of poison frog skin

secretions concluded that kinins, along with other bioactive peptides, were implicated in the resulting intoxication (Erspamer *et al.* 1993).

The purpose of this discussion has been to explore possible bases of psychoactivity for Harvester ants, and thereby stimulate further research into the chemistry of *Pogonomyrmex* venom and its roles in human pathophysiological and visionary states. It is now clear that the ant's venom gland is capable of synthesizing peptides and complex alkaloids, some of which may ultimately prove to be directly psychoactive. Recent toxicological research has also demonstrated that *Pogonomyrmex* species possess a highly toxic venom capable of acting on the mammalian central nervous system and triggering a wide range of psychophysiological reactions. Whether the visionary states reported in the ethnographic record are generated by directly psychoactive compounds or complex toxic reactions is a question that will only be answered through future pharmacological and toxicological research. Whatever the final conclusions, the ritual ingestion of Harvester ants in aboriginal south-central California represents the first well-documented case of the widespread use of an insect as an hallucinogenic agent.

SUMMARY AND CONCLUSIONS

In this paper I have outlined the distribution and major features of the ritual and therapeutic use of red ants in south-central California. There remains no doubt that red ants (almost certainly a *Pogonomyrmex* species) played a central role as vision-inducing agents in the ritual, religious, and medical life of Southern California Indians. These "virtuous" creatures were universally esteemed for their ability to put human beings in direct contact with supernatural power, and paralleled tobacco and *toloache* in terms of their social and religious significance. They were used to induce catatonic, death-like states, during which vivid visions of the supernatural realm manifested. They also played an important role in both curative and preventative medicine, treating a diverse body of ailments. It appears that these red ants were recognized as therapeutically valuable (and therefore, biochemically active) based on the potency of their painful stings. This empirical quality dovetailed with native ideological constructs which equated poison with both curative and supernatural power, potentiating their use in therapeutic and visionary contexts.

Both published and unpublished ethnographic accounts have been examined in light of general biology, pharmacology, and toxicology in order to assess the pharmacological wisdom that informs this exotic and seemingly bizarre practice. The extant ethnographic sources cited in this paper strongly suggest that, through either direct or indirect action on the central nervous system, massive quantities of *Pogonomyrmex* venom are capable of producing highly altered metabolic states during which hallucinatory visions are apt to manifest. While it is possible that kinin-like compounds are implicated, the non-specific nature of the ethnographic accounts, combined with the preliminary state of our knowledge concerning ant venom chemistry makes it impossible to identify a specific pharmacological agent or definite mechanism of action.

NOTES

¹ Justin O. Schmidt generously provided taxonomic and toxicological data based on his *Pogonomyrmex* collections from southern and south-central California. He may be contacted at the following address: Justin O. Schmidt, Research Entomologist/United States Department of Agriculture/Agricultural Research Service/Carl Hayden Bee Research Center/2000 East Allen Road/Tucson, AZ 85719-1596. Roy Snelling also provided valuable information on the current nomenclature of *Pogonomyrmex* species, their distribution, and size. He may be reached at the following address: Roy Snelling/Los Angeles County Museum of Natural History/900 Exposition Blvd./Los Angeles, CA 90007.

² Due to Harrington's non-directive interviewing technique, data on a single subject are often scattered across many pages. In preparing Olivas' account of ritual ant ingestion, several descriptions of the same event (from the same informant) were synthesized to increase clarity. The most complete description was used as the basic structure, and details contained on other pages were inserted where appropriate. Some passages have been lightly edited in order to clarify meaning and to read with more fluidity.

³ John P. Harrington was accompanied to Ft. Tejon in 1916 by his wife, Carobeth, who carried out some ethnographic interviewing among the Kitanemuk and Interior Chumash. Although her notes have been thoroughly mixed with her husband's (and often attributed to him), they are written in a distinctive hand and are easily distinguished.

José Juan Olivas was one of the Harringtons' principal Kitanemuk and Interior Chumash consultants on the Tejon. Although he was born at Satcoy (and was therefore Castac or "Inland" Chumash by both ancestry and language), Olivas came to Tejon Ranch at age twelve and spent most of his life living among the largely Kitanemuk amalgamation of people at Tejon, where he became very familiar with many Kitanemuk cultural practices (Mills and Brickfield 1986:60). In Harrington's notes it is often impossible to determine whether the data provided by Olivas describes a Kitanemuk or an Interior Chumash practice, so the precise attribution of the ant account must therefore remain uncertain.

⁴ Interestingly, exophthalmia (protruding eyes) is characteristic of *Pogonomyrmex* poisoning, and appears to be related to changes in blood pressure behind the eyes (Schmidt 1986:481). The "bloodshot" eyes reported ethnographically might similarly reflect early stages of *Pogonomyrmex* intoxication.

⁵ Evidence of the conceptual similarities between these three states is provided by the semantic domain encompassed by the Kitanemuk verb *-muk*. This intransitive verb can be variously glossed as, "to die, to be intoxicated, to dream of something, to see visions of something." In fact, the incorporated form *manimuk* "to be drunk with toloache" might also be translated as "to die from toloache." (cf. Anderton 1988:411)

⁶ This practice has received support from Western biomedicine, in which Hymenoptera are being used in experimental treatments for degenerative joint disease. The venom of *Pseudomyrmex* has been utilized as an efficacious treatment for chronic rheumatoid arthritis (Schultz and Arnold 1978; Schultz et al. 1978), and there is evidence that a component in honey-bee venom alleviates arthritic pain and associated symptoms (Roy Snelling, personal communication 1995)

⁷ This observation suggests the intriguing possibility that harvester ants, like *Dendrobates*, may be able to sequester psychoactive compounds from dietary sources such as plants.

Although there is no direct evidence in support of this hypothesis, it would not be unusual. Many insects are known to sequester chemicals derived from dietary sources—the moth *Eloria noyesi* feeds on the leaves of *Erythroxylon coca* and sequesters cocaine (J. Ott, written communication 1995), and certain bees have been known to produce intoxicating honeys after sequestering alkaloids from the nectar of hallucinogenic plants such as *Virola surinamensis* and *Atropa belladonna*. Wilbert, personal communication 1995; Ott 1993:404.

8 Both the moth larvae and the Tlaxcala bird examples are based strictly on hearsay—no voucher specimens were collected, the identity of the animals has not been firmly established, and they were never observed in use. The "dream fish" examples appear to relate to a fairly common phenomenon known as ichthyosymptomatology, accidental hallucinogenic fish poisoning (Weil and Davis 1994:2). The resulting symptoms are often impossible to distinguish from poisoning, and the seasonality of the phenomenon suggests that toxicity may be related to unknown environmental factors. Ott (1993:414) classifies most of these examples as "oneirogenic" or dream-inducing substances, and not as true hallucinogens.

9 Blackburn (1976) suggests that the possible presence of nepetalactone-like compounds may provide the key to unraveling Harvester ant psychoactivity. Nepetalactone is the principal active agent in catnip, and appears to be psychoactive in felines. Although catnip has been reported to be psychoactive in humans following smoking of the dried leaves (Jackson and Reed 1969), it is uncertain whether the cat-active lactones are implicated, as cats are normally affected by the mere aroma of the plant (the active compounds being volatile) (Ott 1993:415). Respiratory administration by smoking may involve an altogether different mechanism of action.

10 Although there are no clinical data on the reactions of human subjects to massive quantities of ant venom, there have been several studies (Brown and Bernton 1970; Chipps et al. 1980; Grant et al. 1983) focusing on systemic reactions of hypersensitive individuals to various Hymenoptera stings (ants, wasps, and social bees). While the physiological mechanisms mediating an allergic reaction are different from those which govern a "normal" reaction to large doses of Hymenoptera venom, the symptoms reported in these studies bear a striking resemblance to the physiological effects generated through ritual ant ingestion, namely: lassitude, dizziness, fainting, unconsciousness, and sometimes vomiting.

11 Although the kinins present in Hymenoptera venom appear to be closely related to bradykinin—the most potent kinin in mammals—even slight structural differences may cause significant changes in activity. In addition, ant venoms contain a variety of unidentified agonists that may alter (or even negate) the effects of kinins. There is very little information on the function and mode of action of whole ant venom—let alone these kinin-like constituents—in the mammalian central nervous system, so this discussion must be viewed as highly speculative. Since most of these experimental results were obtained through direct intracerebral administration of enormous quantities of bradykinin (4 µg/rat), their relevance to human pathophysiological events is uncertain. However, the similarities between the effects generated by kinins in laboratory settings and those reported ethnographically for red ant ingestion are striking and extremely provocative, and warrant further investigation.

12A potential argument against this "toxic side-effects" explanation is the observation that toxins often produce a range of severe primary effects (e.g., memory loss, cognitive slowing, convulsions, etc.) that could preclude or overwhelm the hallucinogenic "side effects."

In addition, certain toxins (as well as certain psychoactive compounds) tend to induce hallucinations that are chaotic, disjointed, and poorly remembered upon awakening. One could argue that such substances are not likely to be used in shamanic or visionary practice because the visions they generate do not lend themselves to meaningful interpretation—therefore, the experience would not likely be repeated, and would certainly not be instituted as a widespread ritual practice.

However, the ethnographic facts do not entirely support such observations. Certain substances (such as tobacco), are useful as visionary agents precisely because of their toxic constituents, and severe physiological "primary effects" are considered part and parcel of the "hallucinogenic" shamanic experience generated by these substances (d. Wilbert 1987, 1991). Also, it should be remembered that—in addition to the use of red ants—aboriginal southern and south-central California shamanism was based upon the use of two exceedingly toxic substances: tobacco (*Nicotina* spp.), and the highly toxic hallucinogen *toloache* (*Datum wrightii*).

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BOOK REVIEW

Histoire Illustree du Caoutchouc. J. B. Serier, A. Diez, and A. Van Dyck. Montpellier, France (Cirad-CP, BP5035, 34032 Montpellier Cedex 1): Editions Desjonqueres, 1993. Pp. 96. (Price and ISBN not found).

A most remarkable book has appeared: a pictorial history of rubber. It will be of interest to specialists in the production of this most important economic plant, to teachers, to students and, in fact to the general reader.

The illustrated history begins with the dinosaur age. It then proceeds to: the Aztec use of rubber and the European encounter with the product; the 18th century with the uses in Europe of this new substance; the early French interest in rubber; the Humboldt and Bonpland period, followed by the discovery by Goodyear of vulcanization; the ensuing proliferation of commercial and industrial uses; the effect of rubber on bicycle and motor car transport; the rubber boom and mistreatment of rubber tappers in Africa and South America; the several attempts to procure seed to domesticate Hevea; and many later commercial and scientific events, including such historically significant aspects as the influence on the British and Dutch plantations of Asia from the Japanese occupation in 1945, plus an innumerable series of exceedingly interesting and important aspects of the history of rubber.

As a botanist who has devoted nearly half a century in field work on rubber in the Amazon (taxonomic studies of the sources of rubber) and has published many scientific papers on Hevea rubber, I applaud the authors of this unusual way of presenting the full history of rubber-producing plants and their effect on the creation of our modern world. It is with great pleasure that I recommend this contribution with no reservations as a major step in explaining the history of rubber to a wide audience without recourse to many books, most of them unavailable in many libraries.

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