Hum Ecol (2008) 36:149–159
DOI 10.1007/s10745-007-9153-2

Stradivarius in the Jungle: Traditional Knowledge and the Use of "Black Beeswax" Among the Yuquí of the Bolivian Amazon

Allyn MacLean Stearman · Eugenio Stierlin · Michael E. Sigman · David W. Roubik · Derek Dorrien

Published online: 19 December 2007
© Springer Science + Business Media, LLC 2007

Abstract Native Amazonians traditionally use two methods to feather, or fletch, arrows—they either tie feathers to the shaft or use an adhesive. This paper discusses the latter method, analyzing the use of "black beeswax" arrow cement, derived from an insect product, the wax–resin *cerumen* of native stingless bees (Meliponini). Such mixtures of beeswax and plant resins, prepared by cooking, have a long history of human use in the Old World: in encaustic painting, *beaumontage* for furniture repair, sealing waxes, and varnishes for fine musical instruments. This study explores the special properties of meliponine cerumen, containing a resin compound, *geopropolis*, which makes an excellent arrow cement. Like their Old World counterparts, native Amazonians discovered that cooking a mixture of cerumen and plant resins from bee nests produces an adhesive that dries to a hard finish. We compare both raw and cooked samples of cerumen with infra-red spectroscopy. The wax–resin compound yields adhesive material that is tough, flexible, and has many qualities of both sealing wax and varnish. The Yuquí of the Bolivian Amazon provided the cerumen samples for this analysis, and we describe their methods of preparing and applying arrow cement. We also discuss how social change and globalization negatively affect Yuquí traditional knowledge, which survives, in this case, largely because there is a modest market for bows and arrows in the tourist trade.

Keywords Cultural uses of beeswax · Black beeswax · Arrow cement · Yuquí Indians · Indigenous Amazonians

A. M. Stearman (✉)
Department of Anthropology, University of Central Florida,
Orlando, FL 32816, USA
e-mail: stearman@mail.ucf.edu

E. Stierlin
Aguaragüe, Casilla 1402, Santa Cruz, Bolivia

M. E. Sigman · D. Dorrien
National Center for Forensic Science and Department
of Chemistry, University of Central Florida,
Orlando, FL 32816, USA

D. W. Roubik
Smithsonian Tropical Research Institute,
Apartado 0843-03092,
Balboa, Ancón, Panamá

Introduction

As globalization impacts indigenous peoples everywhere, traditional knowledge is often an unfortunate victim of rapid acculturation (Kuhnlein and Receveur 1996; Twarog and Kapoor 2004). Traditional culture has great difficulty resisting the onslaught of outside influences, particularly when these are viewed as having greater currency or efficacy in today's world (Allen 2002). This issue is no more evident than in the realm of subsistence technology, where native peoples are eager to relinquish items such as axes, canoe paddles, and bows and arrows for chain saws, outboard motors, and shotguns (Hames 1979; Hames and Vickers 1983; Hill and Hawkes 1983; Lyon 1991; Silva and Strahl 1991; Yost and Kelley 1983). As a consequence, many facets of traditional technology are being lost as each new generation moves farther away from the tools of the past. This paper explores one rapidly disappearing art among indigenous Amazonians:

the use of wax and resin products obtained from native bees. These materials are used in the manufacture of hunting arrows, and more specifically, in the creation of cement, or adhesive, for the application of feathers to the arrow shafts.

In the Amazon region, a number of styles are used in fletching, or the attachment of feathers to arrows, but there are basically only two techniques employed. The feather is either tied or glued to the shaft (cf. Métraux 1963b: V:239–240). In the former and more widespread technique, the feather is left whole, or is split along the rachis, or spine, and is placed on both sides of the arrow shaft to which it is tied with string or fiber. The second type of fletching technology employs cement to attach feathers to the arrow shaft, and is the subject of this study. This form of fletching is normally accomplished by gluing the split halves of a feather to the shaft, most commonly using a preparation of plant resins and wax harvested from native honey-making, social bees classified as Meliponini.[1]

Although numerous anthropologists working among native peoples in the Amazon region have described the cultural applications of a black or dark wax or resin-like product, many seem unaware that it is commonly derived from native stingless meliponine bees. The material is often identified simply as "wax" (Lowie 1963:I:488; Métraux 1963a:I:296; 1963:III:417; 1963:V:240), a "resinous substance" (Romanoff 1984:102–103), or a "resin" or "rosin" (Chicchón 1992:132; Lowie 1963:I:488; Métraux 1963b: V: 240; Murphy and Quain 1955:35). Even reports that clearly identify its origin as native meliponine bees provide little information as to how this material is manufactured or applied (cf. Clastres 1998; Dwyer 1975; Hernández de Alba 1963; Hill 2006: personal communication; Holmberg 1969; Kelm 1983; Kozák et al. 1979; Lyon 1991; Nordenskiöld 1912, 1929; Posey 1979; Ribeiro 1988; Schwarz 1948; Vellard 1939).[2] The literature also fails to examine unique chemical and physical properties of the wax–resin compounds of meliponine bees that result in practical applications by native Amazonians in many of their technologies, including as an effective arrow cement.

We address the biological and chemical properties of wax and resin compounds produced or collected by bees, and that have become part of a repertoire of cultural uses. We then describe the traditional knowledge employed by native Amazonians in the collection, preparation, and application of these particular wax–resin substances in the fletching of arrows. The Yuquí of the Bolivian Amazon, who use these substances regularly in the production of hunting weapons, are the focus of this study.

Cerumen ("beeswax") and Geopropolis of the Meliponini

Native Amazonian stingless bees, the Meliponini, do not require stinging defenses to protect their nests and colonies (Michener 2000; Roubik 1989, 2006; Schwarz 1948). A few species use their mandibles to inflict small wounds or grasp the hair of an intruder (*Partamona*, *Trigona*), while others may secrete small amounts of formic acid that can burn and blister the skin (*Oxytrigona*, see Roubik et al. 1987; Roubik 2006; Schwarz 1948; and Szabó and Stierlin 2005:84). Generally, however, Meliponini depend on constructing their nests in such a fashion as to discourage intruders (Schwarz 1948; Roubik 1989, 2006). They also differ significantly from the familiar Old World honeybees (*Apis mellifera*) in that they mix similar amounts of plant resins with the wax that they secrete from epidermal glands located on the dorsal side of the abdomen (Roubik 1989). To build a nest, Meliponini use natural terpenoids in plant products to mix with their secreted wax (Roubik 1989;

[1] Bees, along with wasps and ants belong to the order Hymenoptera, and are further classified as Apidae and other families. The Apidae includes the *Apis mellifera* (the well-known honeybee), the remaining nine *Apis* species, and the hundreds of species of tropical bees that belong to the Meliponini and have no sting (Michener 2000; Schwarz 1948), most of which inhabit the Amazon Basin and are native to this region. *Apis mellifera* is an introduced bee species brought to the New World by Europeans for honey production, and although it is a stinging bee, it is known for its gentleness. In 1956, the highly aggressive *Apis mellifera scutellata* was introduced experimentally to Brazil from Africa because of its purported honey-producing qualities, but the species was accidentally released into the wild where it proliferated in tropical America. These "Africanized" honeybees successfully invaded the Amazon forests, competing with the native Meliponini for resources.

[2] Allan Holmberg, who studied the Sirionó of lowland Bolivia in the early 1940s, is one of the few anthropologists who has commented on the actual preparation and application of meliponine cerumen as an adhesive. He notes:

> The only native "chemical industry" is the making of glue from beeswax (*iríti*). This product is used extensively in arrow-making. The crude beeswax collected from the hive is put in a pot, mixed with water, and brought to a boil. While it is cooking, the dirt and other impurities are removed. The wax is then cooled and coagulated into balls about the size of a baseball. When desired for use, the wax is heated and smeared over the parts to be glued (Holmberg 1969:18).

Schwarz 1948) and also often collect soil, seeds, or small stones or sand to further strengthen the wax used in nest construction (Roubik 2006).[3] These resins and other additives frequently darken the wax, hence the common name "black beeswax" (Kozák et al. 1979; Posey 2002; Schwarz 1948; Stearman 1989). It also has a plastic texture that differs markedly from the relatively brittle wax found in *Apis* hives (Schwarz 1948), which normally does not contain these substances and so is white and has a light, wafer-like texture (Michener 2000). Thus, the wax that Meliponini make is called *cerumen*, because it is not the same as the wax of honeybees.

Meliponini also make a substance known as *geopropolis*, so named because it contains organic and inorganic earth components along with plant resins and some secreted wax (Nogueira-Neto 1953). Just as the term cerumen is used to distinguish the wax–resin mixture of stingless bees from the beeswax of *Apis*, geopropolis is the term used to distinguish the sticky resin mixtures of meliponine bees from the *propolis* of honeybees.

Bees gather plant resins from leaf nodes, flowers, oozing wounds of woody stems, and buds of trees and shrubs and, like pollen, these are carried back to the nest in a basket-like receptacle on the hind legs, called the *corbicula* (Krell 1996; Roubik 1989). Resin stands up better under conditions of high ambient temperatures, having a melting point almost twice that of beeswax, melting at 100–120°C as compared to beeswax at 61–66°C (Krell 1996; Mattera 2001), and with oxidation through exposure to ultraviolet light or heat (see below), becomes much harder and more brittle than wax.

Many honey-making social bees collect propolis and geopropolis, which have various applications including plugging holes to control access to and the temperature of the nest, improving the structural integrity of the nest, protecting the colony from predators, and preventing parasite invasion (Grout 1973; Krell 1996). Propolis and geopropolis also function to prevent disease in the nest and have been described as having "anti-microbial, anti-viral, wound-healing, immune-stimulating, anti-inflammatory, and anesthetic activities" (Salatino et al. 2005). Finally, bees use propolis and geopropolis to encase dead predators too large to move out of the nest, such as mice and beetles, which remain there indefinitely in a mummified state (Grout 1973; Krell 1996).

[3] There also may be an economic reason that Meliponini collect these materials: to make the sticky substance go a little farther. Stingless bees can collect tar or vertebrate excrement to build nests, if nothing else is available, and a few build with mud.

The Beeswax–Resin Connection

That bees often make use of a combination of wax and natural plant resins, substances that together have both strength and plasticity, may well have been the impetus for human interest in doing the same. Combining beeswax or cerumen—for millennia the only wax with cultural uses (Tulloch 1980)—with plant resins found in nature but much more readily available from bee nests as propolis or geopropolis, is a practice that has great antiquity (Mattera 2001; Schwarz 1948). Early Mediterranean peoples, for example, used a mixture of honeybee wax cooked with resins that was applied hot to the hulls and decks of their ships to protect them from the ravages of salt water and the elements. Early seafarers discovered that hot beeswax penetrated the wood while resin hardened the wax into a varnish-like finish, providing a waterproof coating. This procedure eventually led to the inclusion of pigments in the hot wax and resin preparation, and the substance was used to paint colorful emblems on Greek warships. The pigmentation of beeswax tempered with resin further evolved into what is known as encaustic painting, or the production of works of art by using a form of wax–resin paint that is also applied hot, hence the term *encaustic* [Gr. *enkaustikos*, to heat or to burn], to substrates such as wood, canvas, or even marble statuary (Mattera 2001).

Another product with a long history that combined both resin and beeswax with pigment was a substance known to European furniture-makers as *stopping*, or *beaumontage* (Sheperd 2003). Today, a similar product is sold in the form of a crayon and is used for the same purpose, to fill in scratches and dents when restoring furniture. Once again, the combination of beeswax and resin yields a material that is plastic but that will dry to a resinous finish that optically blends with the original varnish (Sheperd 2003).

Varnishes, used in furniture-making and to finish stringed instruments such as violins and cellos, are yet another outgrowth of the ancient knowledge of mixing waxes, and in this case, their more fluid counterparts—oils—with plant resins. Formulas used in preparing varnishes became jealously guarded secrets, but basically included plant resins combined with drying oils such as linseed, and often, honeybee propolis, another source of resins, gums, and oils. Beeswax was routinely added to a varnish to offset, or temper, the brittleness of the resin. Such plasticity was needed for a finish that would provide a protective coating on an instrument that resonates (Krell 1996; Tomas 2006).

Sealing wax, popular during the Middle Ages, again was a product that contained both beeswax and plant resin. Although candle wax, at that time made from beeswax, was often used to seal letters and documents when genuine sealing wax was unavailable, it was an inferior substitute. True sealing wax was tempered with resin, which imparted a higher melting temperature and hardness, and thus made a tougher, better adhesive and seal (Peregrin 2002; Shepherd 2003; Watson 2006).

The nature of the particular material being produced largely depended on the ratio of beeswax to resin. The form taken could include waterproofing for wood, encaustic painting, beaumontage in furniture repair, or sealing wax. When the wax/resin mixture was prepared with a greater proportion of beeswax, plasticity and adhesive qualities improved. When a hard, tough, resilient finish for furniture and stringed instruments was needed, a varnish was produced. It had a higher proportion of resins, and a hard, shiny surface was the result. In the case of varnish, the addition of beeswax, propolis, and similar bee substances with the latter's interesting mix of plant resins, gums, and other organic constituents, provided the durable satin finishes desired for fine stringed instruments and furniture, and the necessary plasticity that prevented them from chipping and crazing (minute surface cracking). The great violin maker Stradivarius also knew of these unique blends of oils, resins, beeswax, and propolis, and used them in creating the secret varnish formulas for his highly prized stringed instruments (Aebi and Aebi 1979; Jolly 1978).

The wax–resin products described above all involve subjecting beeswax and resin to heat. Heating, or cooking, causes specific chemical reactions affecting the chemical properties of each material expressed in the resulting product—harder or softer in texture, or darker or lighter in color.

The Chemistry of Beeswax, Cerumen, Propolis, and Geopropolis

The chemistry of beeswax and cerumen, and the resin-based bee products, propolis, and geopropolis, is complex and has been studied mostly in relation to their economic uses (Kolattukudy 1976; Krell 1996; Tulloch 1980; Velikova et al. 2000). Beeswax, for example, is made up of more than 300 compounds (Tulloch 1980). Both beeswax and plant resins contain large, long-chained hydrocarbon molecules known as polymers. Beeswax is composed primarily of straight-chain alcohols, containing an even number of carbon atoms (C_{24}–C_{36}), which are esterified with straight-chained carboxylic acids having an even number of carbon atoms up to C_{36}. Approximately 20% of the hydrocarbon content by weight is comprised of molecules containing an odd number of carbons, ranging from C_{21} to C_{35}. Propolis, pigments and unidentified materials account for 6% of beeswax (Stecher 1968). Propolis may contain a large number of chemical components, some of which are smaller in size and have lower boiling points or higher vapor pressures (referred to as the volatile components). Other components are much larger in size and non-volatile. Geopropolis stored by stingless bees in their nests has been reported to contain 94 volatile compounds, including pinene, trans-verbenol, copanene, bourbonene, caryophyllene, spathulenol and caryophyllene oxide (Pino 2004). In a related study, Sahinler and Kaftanoglu (2005) reported the major volatile constituents from East Mediterranean propolis of *Apis mellifera* to include aromatic acids, esters and other derivatives responsible for the antibacterial, antifungal, antiviral and anti-inflammatory properties of propolis reported above. The important constituents included benzyl cinnamate, methyl cinnamate, caffenic acid, cinnamyl cinnamate and cinnamoylglicine, fatty acids, terpenoids, esters, alcohols, hydrocarbons and aromatic acids.

A commonality of constituents of propolis and geopropolis reported is the presence of many that contain carbon–carbon double bonds. Double bonds provide sites where molecules can form new bonds, or cross-links, that form interwoven chemical networks. Increased cross-linking can facilitate the hardening or drying of a substance. The greater the cross-linking (to the limit of the reaction points), the harder and more brittle the substance becomes (Seymour and Carraher 1981). Carbon–carbon double bonds also provide sites where oxidation at adjacent carbon atoms can lead to a darkening in color. Both cross-linking and oxidation can occur when the substance is left standing for long periods but may occur more rapidly with the aid of heating or exposure to ultraviolet light.

Thus, after cooking, resins become harder and more brittle when they cool. Beeswax, on the other hand, does not contain significant amounts of carbon–carbon double bonds and cannot participate in crosslink formation. Consequently, even after being cooked, it will retain much of its softness and plasticity, and unlike resin, does not dry to a hard surface (cf. Sheperd 2003; Kay 1983). However, because both plant resins and beeswax are composed of chemically similar hydrocarbon chains, they are "miscible," or mutually soluble when heated, forming a mixture that is interspersed at the molecular level. When the mixture cools and hardens, the composite substance not only does not separate but has integrated to form a new material with new properties. As noted above, the relative proportions of beeswax and resin control final results varying from a harder, shinier, and more brittle product (more resin) to one that is softer, stickier, and more plastic (more beeswax).

Significantly, only tropical social bees that build large colonial nests, such as the Meliponini of Amazonia, regularly combine wax with resins. Meliponines build all nest structures using some resin components, while honeybees build all their nest elements solely from secreted wax. The pure wax secreted by meliponine bees is simpler in composition, softer, and has a relatively lower melting point than that of *Apis mellifera* (Blomquist et al. 1985; Roubik 1989). These characteristics may contribute to the need for the Meliponini to add resins and many other substances to their wax to strengthen the structures of the nest. Unlike honeybees, a tropical meliponine nest comprises both wax and large amounts of resins and other substances, making it an ideal source of raw materials from which indigenous peoples can prepare a number of wax–resin products without additional inputs. Like their Old World counterparts who developed numerous useful beeswax and plant resin compounds, native Amazonians such as the Yuquí of lowland Bolivia, also discovered that the most critical part of the process is cooking.

In an effort to understand the more complex meliponine cerumen when compared to *Apis* beeswax and the chemical processes that occur when meliponine cerumen is cooked to create arrow cement, Stearman and Stierlin collected raw and cooked samples of *Apis* wax and meliponine cerumen provided by the Yuquí along with specimens of the bees that produced these products.

Eighteen raw cerumen samples from 13 meliponine species and one raw *Apis mellifera scutellata* (Africanized honeybee) beeswax sample were collected (see Table 1) during 19 gathering trips carried out by 14 Yuquí. From these samples, six were tested: the *Apis* beeswax and five samples of raw meliponine cerumen from three species, *Melipona rufiventris flavolineata* (one sample), *Trigona silvestriana* (two samples), and *Melipona rufiventris* (two samples). The five samples of Meliponini were chosen based on Yuquí arrow-makers' evaluation of the cerumen as suitable for making arrow cement.

Six samples of arrow cement were tested: four samples manufactured from the raw meliponine samples noted above (*Melipona rufiventris flavolineata* [one sample], *Trigona silvestriana* [2 samples] and *Melipona rufiventris* [one sample]) produced by the Yuquí arrow-makers and Stearman, who participated in the process to learn it first-hand; one 4-year-old sample of unknown meliponine origin provided by Stierlin from the Sirionó, a people related to the Yuquí; and one sample from previously prepared arrow cement identified by the Yuquí arrow-maker as originating from *Melipona rufiventris* that was included because it bore a strong resemblance in hardness, odor, and color to the Sirionó sample.

Table 1 Meliponini Cerumen and Apis Beeswax Samples Collected

Yuquí Name	Scientific Name
Yiti (1)[a]	*Tetragonisca angustula*
Isarabí (1)	*Tetragona clavipes*
Eruchimbé (1)	*Partamona ailyae*
Eracõquichaé (1)	*Tetragona goettei*
Yejorembé (1)	*Trigona hypogea*
Quigüeté (2)	*Melipona rufiventris*
Chiichiiyá (also called Eruguasué) (2)	*Trigona silvestriana*
Eriquiorubí (2)	*Scaura latitarsus*
Tisoa (2)	*Scaptotrigona aff. nigrohirta*
Quigüeguá (2)	*Melipona rufiventris flavolineata*
Quigüejuá (1)	*Trigona fuscipennis*
Eretõ (1)	*Trigona mazucatoi*
Erubususã (1)	*Melipona grandis*
Erubususãboá (1)	*Apis mellifera scutellata*

[a] Indicates number of cerumen or beeswax samples collected

Sigman and Dorrien ran tests on the 12 samples using Fourier transform infrared spectroscopy to obtain qualitative information about the types of chemical functional groups (carbon–carbon double bonds, esters, carboxylic acids, etc.). The tests were done with the aid of an attenuated total reflectance accessory that allowed infrared spectra from the materials to be collected through simple surface contact with the accessory, thus obviating the need for more elaborate sample preparation techniques. Sigman then made eight comparative analyses from the 12 tests. Significant results (all Yuquí-collected Meliponini are of Quigüeté [*Melipona rufiventris*]) are presented below.

Figure 1 compares new, raw *Apis mellifera scutellata* beeswax collected by the Yuquí with raw *Melipona refuventris* meliponine cerumen. This figure shows the infrared spectra from the two samples stacked with the meliponine sample on top. Significant differences between the *Apis* and Meliponini are highlighted by arrows drawn between the two spectra. The arrows are labeled to reflect the important chemical functionality responsible for the indicated peaks. The meliponine sample contains "free" alcohols that are not present in the *Apis* sample (labeled "Alcohol O–H"). Much of the alcohol component in the *Apis* sample is chemically bonded in the form of esters, as reflected by the "ester C=O" carbonyl groups noted in both spectra. Additional evidence for the "free" alcohol is seen in the "alcohol C–O" band present in the meliponine sample, but absent in the *Apis* sample. Other important differences between the samples can be observed in the 500–1500 wavenumber region of the spectra. These differences verify the presence of resins and other organic materials in the meliponine cerumen.

Figure 2 compares two samples of meliponine cerumen, also *Melipona rufiventris*–one raw and one cooked–with the cooked sample originating from the raw one. The cerumen (sample 21a) from which the black beeswax arrow cement (sample 21b) was manufactured was cooked for about 10–15 min. The raw, uncooked sample (bottom trace in Fig. 2) shows the presence of both "ester C=O" and "carboxylic acid C=O" bands, reflecting the presence of these chemicals in the sample. Upon cooking, the "ester C=O" band is seen to decrease and the "alcohol O–H" and

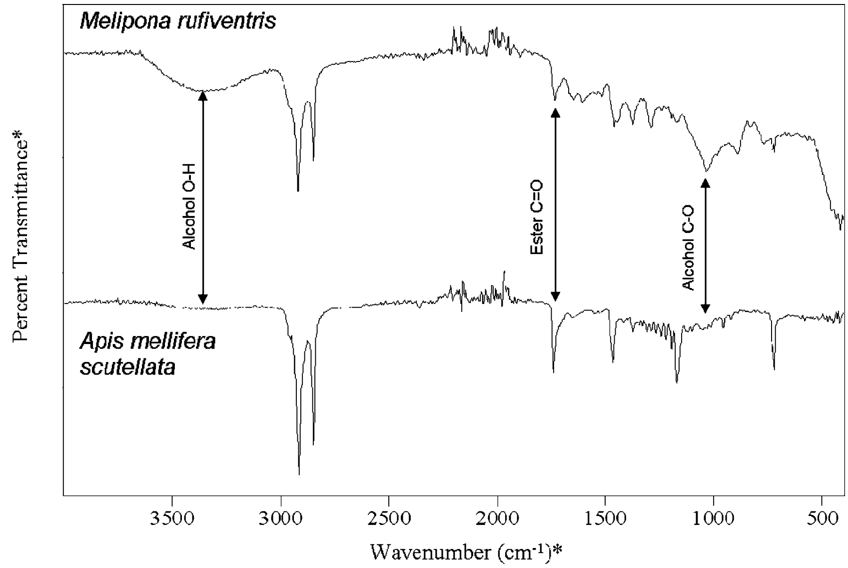

Fig. 1 Comparison of raw Meliponini (*Melipona rufiventris*) cerumen and *Apis mellifera scutellata* beeswax samples. *Asterisk:* Two spectra are shown in the figure. The ordinate scale shows the percent of the incident light transmitted by the sample. Each spectrum scales from 100% transmittance at the top of the spectrum to near 10% transmittance at the bottom. Each peak (*shown pointing down*) corresponds to a wavelength of light, traditionally reported in reciprocal centimeters (cm^{-1} or wavenumbers) in infrared spectroscopy (the abscissa scale). The location of each peak in the spectrum is associated with a specific type of vibration in the sample, e.g. alcohol O–H, etc.

"alcohol C–O" bands increase. These changes are evidence that the esters in the sample have undergone a chemical reaction, hydrolysis, to form carboxylic acid and "free" alcohol.

The conversion of esters into carboxylic acid and alcohol components results in an increase in interactions between the components of the mixture and may partially account for the increase in sample viscosity as a result of cooking. In addition, the sample of raw cerumen was almost black in color, indicating that the cerumen had experienced oxidation and was probably quite old when it was collected.

Figure 3 compares the cooked cerumen sample from Fig. 2 (sample 21b, cooked for 10–15 min) with a cooked sample (29) from the same type of bee, *Melipona rufiventris*, but collected by a different informant from a different source and cooked for a much longer period of time, about four hours. The results show that the sample that was cooked for a longer period of time contains less "free alcohol," although the ratio of the ester to carboxylic acid carbonyl stretching bands in the two samples are remarkably similar. In addition, the sample that was cooked for a longer period of time possesses fewer carbon–carbon

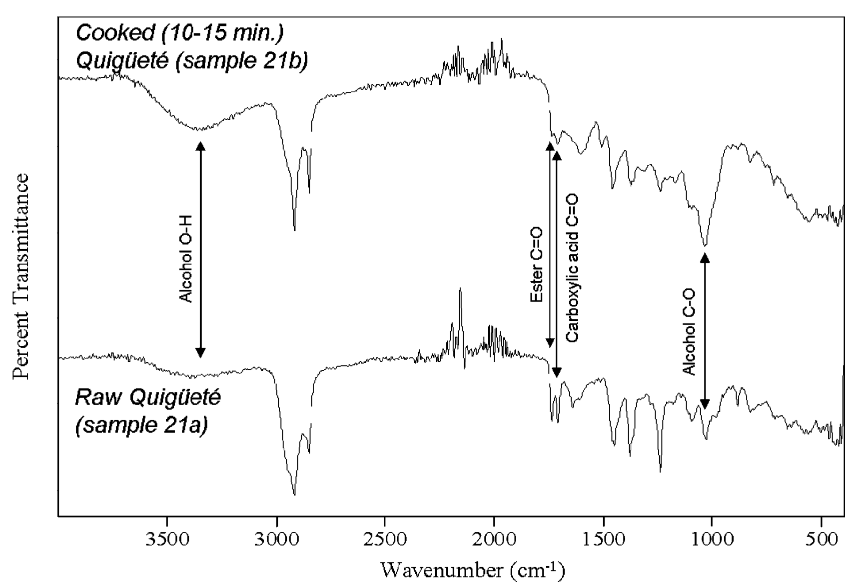

Fig. 2 Comparison of cooked and raw Quigüeté (*Melipona rufiventris*) cerumen samples

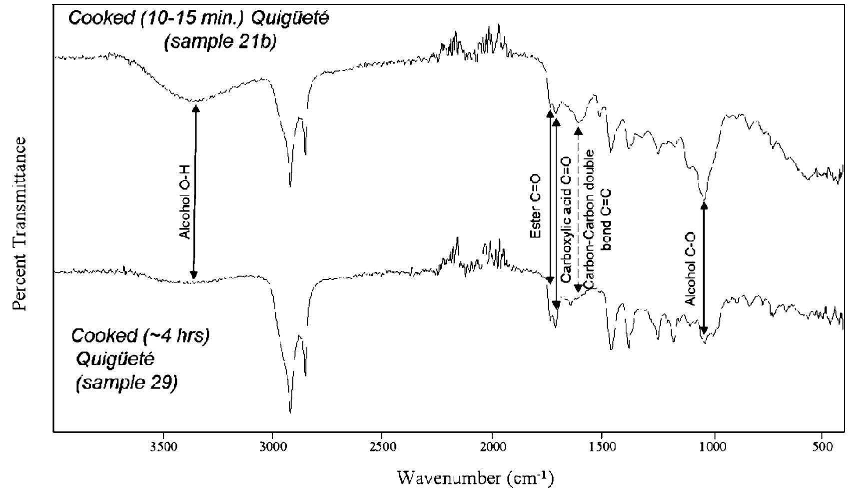

Fig. 3 Comparison of cooked Quigúeté (*Melipona rufiventris*) cerumen samples at different cooking time periods

double bonds (indicated by a dashed line in the figure). Two interpretations could be consistent with these observations: (1) cooking for longer periods of time leads initially to alcohol formation and subsequent alcohol loss through further reaction or evaporation from the sample; and (2) chemical constituents containing carbon–carbon double bonds are lost from the sample, possibly through cross-link formation. Both of these interpretations are consistent with the observed increase in sample viscosity upon prolonged cooking, as discussed above.

Finally, Fig. 4 shows the cooked meliponine black beeswax cement sample that had been collected from the Sirionó by Stierlin 4 years prior to the 2006 fieldwork. Sample 25 from the Sirionó was compared with sample 29 from the Yuquí that had been cooked for about 4 h. As noted above, sample 29 was selected because it bore a close visual and tactile similarity to the Sirionó sample that is of unknown meliponine origin. Both samples were also extremely dense and had a similar asphalt odor. Additionally, both samples were made by individuals who are known among their respective peoples for making well-prepared arrow cement. The tests reveal that in spite of coming from different ethnic groups and from different regions of Bolivia, the samples show considerable similarity, indicating that the bee products were similar in composition to begin with and were processed in a similar fashion.

Traditional Yuqui Knowledge of Black Beeswax Preparation and Use

The Yuquí are a small, remnant group of Tupi-Guaraní speaking foragers who live in the Chapare region of lowland Bolivia. They manufacture a bow 2 m long and two styles of arrows of comparable size. Arrows are distinguished primarily by the type of attached tip. One is made from a large piece of sharpened bamboo fashioned into a “lanceolate” shape, and the other consists of a long, slender black palm point (*Bactris* or *Astrocaryum*) to which

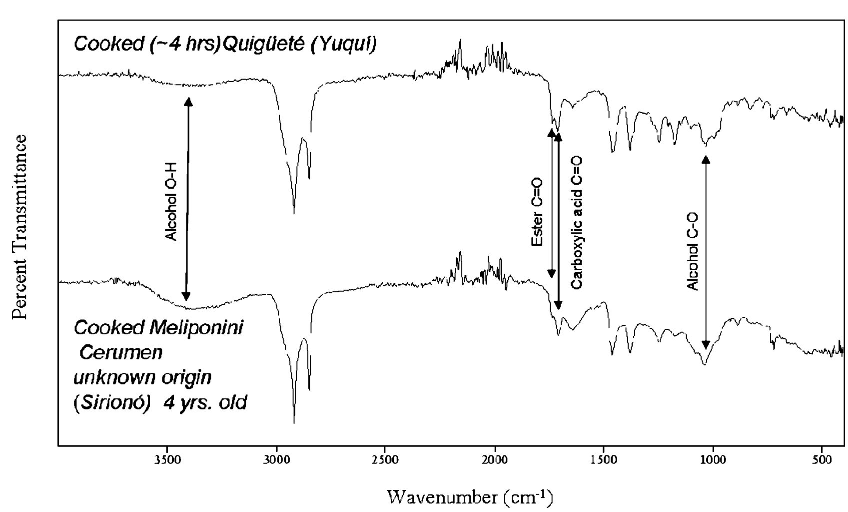

Fig. 4 Comparison of Yuquí Quigüeté (*Melipona rufiventris*) and Sirionó (unknown Meliponini source) cooked cerumen samples

a barb is attached, also made of black palm wood. Cement from meliponine cerumen is used in the construction of both arrows (Stearman 1984, 1989).

The Yuquí have distinct preferences in terms of the kind of cerumen, called *irití*, used for arrow-making. One criterion is simply that the amount of cerumen is enough to make a cake of cement, regardless of bee species; but the other, more important criterion concerns properties of the cerumen itself. Cerumen used in making arrow cement must be flexible and plastic. Thus, it is noteworthy that the most preferred type is from the bee called *Quigüeté* (*Melipona rufiventris*), which means "true honey" (bees and their honey are given the same name), a species that is both ubiquitous and prolific in its production of cerumen. Another bee of special interest to the Yuquí is the *Seyarõ* (probably *Lestrimellita*), whose cerumen, they claim, dries especially hard and brittle. Consequently, it is used to coat the string binding that attaches the barb to the tip of the arrow, giving it a smooth, glasslike surface.

When the Yuquí need material for arrow cement, they set aside, rather than dispose of, the masticated cerumen from which honey, pollen, brood provisions, and bee larvae have been extracted and eaten. Geopropolis, frequently harvested together with other nest products, also may be saved along with the masticated cerumen by simply kneading it into the cerumen. Geopropolis may be mixed with cerumen to increase the resin content and hence strengthen and harden the arrow cement. In scrutinizing cerumen for arrow cement, the Yuquí will often pull on it like taffy to see if it has the necessary plasticity. If not, it will be mixed with other meliponine cerumens that are perhaps newer, and therefore more plastic, to give the desired consistency.[4] The cerumen material is then pressed together by hand into balls of varying sizes, normally that of a tennis ball, and stored until arrow cement is made. The color may vary from a light caramel color to almost black, depending on the age of the cerumen and the types of resins and other organic compounds that comprise it.

To manufacture the black beeswax cakes used in arrow making, the Yuquí cook the mixture–they do not simply melt it—and thus its basic chemical composition is altered. The cerumen balls are placed in a container—traditionally an old clay pot. But today, an aluminum cooking pot or a metal can is used. The cerumen is brought to a boil while being stirred constantly with a stick, and cooked until the mixture turns very black and begins to thicken, as water, low molecular weight alcohols, and other volatiles evaporate. Viscosity is tested by allowing the substance to drip off the point of the stick used to stir the liquefied cerumen. When it loses a watery consistency and drops off the stick in large globules, it is considered ready. This process, at minimum, takes approximately 10–15 min for a resulting cake that is 7 cm in diameter and 2 cm thick. However, several older Yuquí arrow-makers stated that they prefer to cook cerumen much more slowly and for a much longer period of time, until the mixture is tar-like, and has the odor of asphalt.

Once the mixture reaches the desired consistency, the container is removed from the fire, with the mixing stick left standing in it. After about an hour, the mixture is deemed cool enough to remove from the can. In a rather ingenious bit of mastery, the pot or can is then briefly returned to the fire and heated rapidly, which loosens the wax from the surfaces of the can but leaves the remainder of the cake in a solid state. The bottom and sides of the cake are released from the container, and it can be easily removed by simply pulling on the stick. The resulting cake is very shiny, black, hard, cement.[5] By cooking the cerumen with its wax and resin components, the Yuquí have intermingled the two substances at the molecular level, creating what is akin to a varnish or sealing wax.

Interestingly, the onyx-like blackness of most arrow cement is not the natural color of raw cerumen, which, as noted earlier, is often caramel-colored. The derived color is the outcome of cooking. Cerumen collected by the Yuquí for making black beeswax cement contains some small amount of sugar from the honey that remains in the mixture, combined with other organic materials including pollen. Under conditions of high heat, these tend to scorch and burn, darkening the cooked material and giving a pungent asphalt-like aroma. More important, by cooking the wax–resin mixture, more energy is absorbed and consequently more cross-linking may occur, along with the loss of volatile components. With cooking, the material undergoes oxidation and the associated darkening in color. Black beeswax continues to harden and darken over time through the process of natural oxidation, often acquiring a "bloom" or a white cast on the surface as it ages.

When the arrow-maker is ready to use his black beeswax cake, he holds it near the coals of a low fire, heats the

[4]A number of native Amazonian peoples are reported to add additional substances to the cerumen in preparing black beeswax such as charcoal (Clastres 1998; Hill 2006 personal communication), soot (Ribeiro 1988), chicle or gum from Sapotaceae (Chicchón 1992; Dawson 1975; Kensinger 1975; Rabineau 1975; Ribeiro 1988), rubber (*Hevea brasiliensis*) (Dawson 1975; Kensinger 1975; Rabineau 1975; Vellard 1939), clays heavy in organics (Vellard 1939), and plant resins other than geopropolis (Clastres 1998; Hernández de Alba 1963; Vellard 1939).

[5]The strength and durability of meliponine black beeswax cement are borne out by the following observation:

> The sáliva had an adhesive (*peramán*) made of black wax and vegetable resin prepared with heat. They used it to glue arrow points to the shafts and, according to Gumilla (1745, vol.2), even to mend broken bones! (Hernández de Alba 1963:IV:404).

working edge, and then rubs the softened mixture on the arrow shaft where the feather will be affixed. Skilled arrow-makers spread the mixture cleanly and evenly on the shaft and avoid smearing it on the feathers during the fletching process. While the cement is still warm, the carefully split halves of the feather are set into the soft mixture and properly spaced and angled. Then a small palm thread, animal fiber (Métraux 1963b: V: 236), or even human hair, if nothing else is available (Garland 2006: personal communication), is wrapped evenly at intervals through the barbs of the feather and pressed into the warm wax–resin mixture. The arrow-maker then carefully uses his thumb to smooth the soft black beeswax over the fiber wrapping, leaving it virtually invisible. The surface is now smooth and glossy black, and needs only to dry and harden. The arrow will be placed in an upright position against the house or a tree where it will remain until properly cured, a hardening process involving exposure to natural ultraviolet light and the resulting additional oxidation, and then is ready for use.

Conclusion

As native Amazonians like the Yuquí increasingly interact with the outside world and become engaged in a cash economy, their needs and wants change as a reflection of their participation in the globalization process. As a result of acculturation, traditional knowledge, such as the preparation of black beeswax by indigenous artisans, is rapidly disappearing. Among the Yuquí even elder males now hunt with firearms, relying on bows and arrows only when they are unable to secure ammunition. As is often the case with so many native crafts today, the making of bows and arrows has been preserved largely because there is now a small market for them in nearby towns where a few tourists may arrive, or the local people buy them out of curiosity (see Graburn 1977; Zorn 2004).

However, young Yuquí show little interest in learning or perfecting the skills of their parents and grandparents, viewed as anachronistic and without value in the modern world. Many Yuquí youth, both males and females, are leaving their community to find work in near or distant localities that offer the attractions of earning cash and participating in Bolivian national life. As a consequence, even acquiring the knowledge to make bows and arrows for sale may not appeal to them. To the contrary, some do not wish to be associated with these indicators of their indigenous origins.

In the last decade or so, those dozen or so older Yuquí who continue to manufacture bows and arrows, and to manufacture black beeswax cement necessary for their construction, now concentrate on making more portable miniature sets of about a half meter in length. For greater interest and visual variety, miniature sets include arrow types that originate with other ethnic groups such as the Tsimane and Yuracaré. The traditional 2-m bow with its two arrows are made less frequently now because they are difficult to transport. Thus, tourists visiting the area are reluctant to purchase them. In addition, the small sets take relatively little time to make, can be made with less care and fewer materials, and bring in almost as much money as the large bow and arrows (~$US 4 for the small set; ~$US 6 for the traditional set).

When Stearman and Stierlin visited the Yuquí settlement in 2006, for the first time two Yuquí women were observed making miniature bow and arrow sets for sale in local towns. Although there are no specific taboos among the Yuquí that prohibit women from making or handling weapons, this was viewed by the larger group as a novelty and a little unsettling. When Stearman queried the two women about their work, they responded that they had watched men make bows and arrows all of their lives, and that preparation of the cement and arrow-making was nothing they could not replicate. They commented that the knotted bags they make for sale take almost a month to complete, whereas they can make several sets of miniature bows and arrows in just a few days. Furthermore, the bow and arrow sets are of greater interest to tourists and local people because these items appeal to peoples' perceptions of the exotic and primitive. Thus, they bring in more money than do string bags.

Only time will tell if Yuquí youth will find some incentive to carry on the crafts of their ancestors. If not, traditional knowledge such as the manufacture of black beeswax arrow cement will pass from memory, along with countless other areas of unique human endeavor, such as the elusive varnish formula of beeswax and propolis that gave Stradivarius' violins their incomparable quality.

Acknowledgments An abbreviated version of this paper was presented at the 5th Annual Meetings of the Society for the Anthropology of Lowland South America (SALSA), Santa Fe, New Mexico, January 12–14, 2007. The authors would like to express their appreciation to Andrés Campiglia, Stuart Fullerton, P. E. Kolattukudy, John Walker, and Elayne Zorn for their helpful insights, suggestions, and editorial comments during the development of this paper. We are also grateful to the anonymous reviewers of *Human Ecology* not only for their careful reading of the manuscript which improved the clarity of the argument, but also for assisting in locating additional useful sources on the topic of "black beeswax." The authors take final responsibility for any errors of omission or interpretation.

References

Aebi, O., and Aebi, H. (1979). *Mastering the Art of Beekeeping*, Vol. 2. Unity, Santa Cruz, California.

Allen, C. (2002). *Hold Life Has: Coca and Cultural Identity in an Andean Community.* 2nd ed. Smithsonian Institution, Washington, D.C.

Blomquist, G. J., Roubik, D. W., and Buchmann, S. L. (1985). Wax Chemistry of Two Stingless Bees of the *Trigonisca* group (Apidae: Meliponinae). *Comparative Biochemistry and Physiology* 82B: No 1137–142.

Chicchón, A. (1992). Chimane Resource Use and Market Involvement in the Beni Biosphere Reserve, Bolivia. Unpublished Ph.D. Dissertation. University of Florida. Gainesville, Florida.

Clastres, P. (1998). *Chronicle of the Guayaki Indians*. Zone Books, New York.

Dawson, A. (1975). Graphic Art and Design of the Cashinahua. In Dwyer, J. P. (ed.), *The Casinahua of Eastern Peru, The Haffenreffer Museum of Anthropology. Brown University Studies in Anthropology and Material Culture, Vol. 1, Haffenreffer Museum of Anthropology.* Providence, Rhode Island, pp. 131–149.

Dwyer, J. P., ed. (1975). *The Casinahua of Eastern Peru*. The Haffenreffer Museum of Anthropology. Brown University Studies in Anthropology and Material Culture. Volume One. Haffenreffer Museum of Anthropology. Providence, Rhode Island.

Graburn, N., ed. (1977). *Ethnic and Tourist Arts: Cultural Expressions from the Fourth World*. University of California Press, Berkeley.

Grout, R. A., ed. (1973). *The Hive and the Honey Bee*. Dadant. Hamilton, Illlinois.

Hames, R. (1979). A Comparison of the Efficiencies of the Shotgun and the Bow in Neotropical Forest Hunting. *Human Ecology* 7(2): 219–252.

Hames, R. B., and Vickers, W. T. eds. (1983). *Adaptive Responses of Native Amazonians.* Studies in Anthropology. Academic, New York.

Hernández de Alba, G. (1963). The Achagua and their Neighbors. In Steward, J. H. (ed.), *Handbook of South American Indians. Vol. IV.* Cooper Square, New York, pp. 399–412.

Hill, K., and Hawkes, K. (1983). Neotropical Hunting Among the Aché of Eastern Paraguay. In Hames, R. B., and Vickers, W. T. (eds.), *1983, Adaptive Responses of Native Amazonians. Studies in Anthropology.* Academic, New York, pp. 139–188.

Holmberg, A. R. (1969). *Nomads of the Long Bow. The Sirionó of Eastern Bolivia. American Museum of Natural History.* Natural History, Garden City, New York.

Jolly, V. G. (1978). Propolis Varnish for Violins. *Bee World* 59(4): 158–161.

Kay, R. (1983). *The Painter's Guide to Studio Methods and Materials*. Prentice-Hall, Englewood Cliffs, New Jersey.

Kelm, H. (1983). *Gejagte Jäger.* Vols. 1 and 2. Museum für Völkerkunde. Frankfurt am Main.

Kensinger, K. M. (1975). Studying the Cashinahua. In Dwyer, J. P. (ed.), *The Casinahua of Eastern Peru. The Haffenreffer Museum of Anthropology. Brown University Studies in Anthropology and Material Culture, Vol.e 1. Haffenreffer Museum of Anthropology.* Providence, Rhode Island, pp. 9–86.

Kolattukudy, P. E., ed. (1976). *Chemistry and Biochemistry of Natural Waxes*. Elsevier, Amsterdam.

Kozák, V., Baxter, D., Williamson, L., and Carneiro, R. L. (1979). The Héta Indians: Fish in a Dry Pond. Anthropological Papers of the American Museum of Natural History. Volume 55: Part 6. New York.

Krell, R. (1996). *Value-Added Products from Beekeeping. FAO Agricultural Services Bulletin No. 124. Food and Agriculture Organization*. United Nations, Rome.

Kuhnlein, H., and Receveur, O. (1996). Dietary Change and Traditional Food Systems of Indigenous Peoples. *Annual Review of Nutrition* 16: 417–442.

Lowie, R. H. (1963). The Northwestern and Central Gê. In Steward, J. H. (ed.), *Handbook of South American Indians. Vol. I.* Cooper Square, New York, pp. 477–517.

Lyon, P. (1991). Feathers are for Flying. In Reina, R., and Kensinger, K. (eds.), *The Gift of Birds. Featherwork of Native South American Peoples*. Pennsylvania University Museum, Philadelphia.

Mattera, J. (2001). *The Art of Encaustic Painting. Contemporary Expression in the Ancient Medium of Pigmented Wax*. Watson-Guptill, New York.

Métraux, A. (1963a). Ethnography of the Chaco. In Steward, J. H. (ed.), *Handbook of South American Indians. Vol. I.* Cooper Square, New York, pp. 197–370.

Métraux, A. (1963b). Weapons. In Steward, J. H. (ed.), *Handbook of South American Indians. Vol. V.* Cooper Square, New York, pp. 229–263.

Michener, C. D. (2000). *The Bees of the World*. The Johns Hopkins University Press, Baltimore.

Murphy, R. F., and Quain, B. (1955). The Trumaí Indians of Central Brazil. In Esther, S., and Goldfrank, J. J. (eds.), *Monographs of the American Ethnological Society.* Augustin, Locust Valley, New York.

Nogueira-Neto, P. (1953). A Criação de Abelhas Indígenas Sem Ferrão. Chacara e Quintais. São Paulo.

Nordenskiöld, N. E. H. (1912). *La vie des Indiens dans le Chaco (Amerique du Sud)*. Translated by H. Beuchat. Revue de Geografie. Vol. 6, part 3. Paris.

Nordenskiöld, E. (1929). L'apiculture Indienne. *Journal de la Société de Américanistes* 21:169–182.

Peregrin, T. (2002). "Comments on Sealing Wax." Cited at http://codesmiths.com/shed/workshop/recipes/sealingwax.htm.

Pino, J. A. (2004). Volatile Constituents of Propolis from Honey Bees and Stingless Bees from Yucatán. *Journal of Essential Oil Research*. May. Printed on-line.

Posey, D. A. (1979). Ethnoentomology of the Gorotire Kayapó of Central Brazil." Unpublished Ph.D. Dissertation. University of Georgia. Athens, Georgia. University Microfilms International. Ann Arbor.

Posey, D. A. (2002). Kayapó Ethnoecology and Culture. In Kristina Plenderleith (ed.), *Studies in Environmental Anthropology. Vol. 6*. Routledge, London.

Rabineau, P. (1975). Catalogue of the Cashinahua Collection. In Dwyer, J. P. (ed.), *The Casinahua of Eastern Peru. The Haffenreffer Museum of Anthropology. Brown University Studies in Anthropology and Material Culture. Volume One. Haffenreffer Museum of Anthropology.* Providence, Rhode Island, pp. 87–109.

Ribeiro, B. G. (1988). *Dicionário do Artesanato Indígena*. Editora Itatiaia Limitada. Editora da Universidade de São Paulo. Belo Horizonte, Brasil.

Romanoff, S. A. (1984). Matses Adaptations in the Peruvian Amazon. Unpublished Ph.D. Dissertation. Columbia University. New York. University Microfilms International. Ann Arbor.

Roubik, D. W. (1989). *Ecology and Natural History of Tropical Bees*. Cambridge University Press, New York.

Roubik, D. W. (2006). Stingless Bee Nesting Biology. *Apidologie* 37: 124–143.

Roubik, D. W., Smith, B. H., and Carlson, R. G. (1987). Formic acid in caustic cephalic secretions of *Oxytrigona*. *Journal of Chemical Ecology* 13: 1079–1086.

Sahinler, N., and Kaftanoglu, O. (2005). Natural Product Propolis: Chemical Composition. *Naturap Product Research* 19(2): 183–188.

Salatino, A., Weinstein Teixeira, E., Negri, G., and Message, D. (2005). Origin and Chemical variation of Brazilian Propolis. *Evidence-Based Complementary and Alternative Medicine* 2: 133–38, March.

Schwarz, H. F. (1948). *Stingless Bees (Meliponidae) of the Western Hemisphere*. Bulletin of the American Museum of Natural History. Volume 90. New York.

Seymour, R. B., and Carraher Jr, C. E. (1981). *Polymer Chemistry. An Introduction*. Marcel Dekker, Inc., New York.

Sheperd, S. (2003). Beeswax: More than You Think. *WoodCentral*. www.woodcentral.com/cgi-bin/articles.pl.

Silva, J. L., and Strahl, S. D. (1991). Human Impact on Populations of Chachalacas, Guans, and Curassows (Galliformes: Cracidae) in Venezuela. In Robinson, J. G., and Redford, K. H. (eds.), *Neotropical Wildlife Use and Conservation*. University of Chicago Press, Chicago, pp. 37–52.

Stearman, A. M. (1984). The Yuquí Connection: Another Look at Sirionó Deculturation. *American Anthropologist* 86: 3630–650, September.

Stearman, A. M. (1989). *Yuquí: Forest Nomads in a Changing World*. Holt, Rinehart and Winston, Fort Worth.

Stecher, P. G. Ed. (1968). *Merck Index*, 8th edn., Merck Rahway, New Jersey.

Szabó, H. E., and Stierlin, E. (2005). *Pueblos y Miel: El Conocimiento Sobre las Abejas Nativas Entre Los Ayoreos de la TCO Guayé*. Aguaragüe, Santa Cruz, Bolivia.

Tomas, O. A. (2006). "…On Varnishing a Violin." http://www.cranfordpub.com/otis/on_varnish.htm.

Tulloch, A. P. (1980). Beeswax—Composition and Analysis. *Bee World* 61: 247–62.

Twarog, S., and Kapoor, P. eds. (2004). *Protecting and Promoting Traditional Knowledge: Systems, National Experiences and International Dimensions*. UNCTAD. Geneva.

Velikova, M., Bankova, V., Marcucci, M. C., Tsvetkova, I., and Kujumgiev, A. (2000). Chemical composition and biological activity of propolis from Brazilian meliponinae. *Z Naturforsch [C]* 55(9–10):785–789, Sept.–Oct.

Vellard, J. (1939). *Une Civilisation du Miel: Les Guayaki du Paraguay*. Librairie Gallimard. 5e édition. Paris.

Watson, N. (2006). George Waterston and Sons, Ltd. 1752–2002. "Seal of Success." Chapter 1: 1752–1796. The Scottish Printing Archival Trust. http://www.scottishprintarchive.org/org_comp3.html.

Yost, J. A., and Kelley, P. M. (1983). Shotguns, Blowguns, and Spears: The Analysis of Technological Efficiency. In Hames, R. B., and Vickers, W. T. (eds.), *(1983). Adaptive Responses of Native Amazonians. Studies in Anthropology*. Academic, New York, pp. 189–224.

Zorn, E. (2004). *Weaving a Future: Tourism, Cloth, and Culture on an Andean Island*. University of Iowa Press, Iowa City.