People using macro-fungal diversity in Oaxaca, Mexico

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Garibay-Orijel, R., Cifuentes, J., Estrada-Torres, A., and Caballero, J. (2006). People using macro-fungal diversity in Oaxaca, Mexico. Fungal Diversity 21: 41-67.

Traditional mycological knowledge of most Mexican ethnic groups has proven to be extensive and profound, consuming nearly 300 species of wild mushrooms. In this paper, we identified the mushrooms used by Zapotecs of Ixtlan, Oaxaca, compiled their traditional knowledge and analyzed their relation to macro-fungal diversity and usage. We collected mushrooms and conducted ethnomycological research between 2000 and 2003. We used participant observation and applied 50 interviews and 47 questionnaires to a randomly selected sample pool of local informants. Forty-three mushroom taxa had local anthropocentric interest and corresponded to 26 folk species. Thirty-seven taxa were wild edibles, three were cultivated edibles, two toxic and one had recreational use. Wild edible taxa represented 38.54% of useful species recorded in the zone. Taxa belonged to 19 families, with *Pluteaceae* being the most represented with six species, followed by *Hydnaceae* and *Hydnangiaceae* with five. From the 20 genera represented, *Amanita* had six species and *Hydnum* and *Laccaria* had five. Informants knew aspects of fungal nature and life-cycle, substrates, habitats and ecological relations of mushrooms with plants. Edible fungi were the most used non-timber forest resource, with 65.96% of informants reported to collect them. On average, interviewees consumed mushrooms 3.04 days a month. Everyone had access to mushrooms independently of age, sex or occupation. The mechanisms involved in the mushroom appropriation process were gathering, purchasing and reciprocal gifts. The mushroom exploitation was composed of different gathering strategies: casual or intentional and randomly or directed. We also found inside-forest promotion of *Tricholoma magnivelare* development, and outside-forest semi-culture of *Neolentinus lepideus*. These people use macro-fungal diversity, mainly for food, in an integrated subsistence system that joins modern and traditional practices.

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Key words: edible fungi, ethnomycology, Sierra Norte de Oaxaca, traditional mycological knowledge, Zapotecs

Introduction

Mexico is ranked fourth in biodiversity worldwide, and is considered a mega-diversity country (Mittermeier, 1988). Some plant and animal groups are known to be exceptionally rich such as *Asteraceae*, *Cactaceae*, *Fabaceae*, *Poaceae*, *Orchidaceae* and *Rubiaceae* (Rzedowski, 1998) and Amphibia, Lepidoptera, Mammalia and Reptilia (Challenger, 1998). However, knowledge concerning Mexican fungal diversity is scarce, like most tropical countries, where only 3.5% of the 200,000 estimated species have been identified (Guzmán, 1998; Bandala *et al*., 2005; Desjardin *et al*., 2005; Palfner, 2005). By these estimates, approximately 2,400 species of ascomycetes and 2,200 of basidiomycetes have been reported in Mexico, from which local people traditionally consume around 300 taxa.

The study of traditional mycological knowledge (TMK) in areas with little taxonomical information commonly results in the description of new species, new edibility records or new records for the region (e.g. Devi *et al*., 1980; Turner *et al*., 1987; Härkönen *et al*., 1993a; Moreno-Fuentes *et al*., 1996; Das *et al*., 2004).

Wild mushrooms are a valuable non-timber forest resource used by mycophilic societies and their use has been documented in many countries around the world (Thoen, 1982; Prance, 1984; González-Elizondo, 1991; Härkönen *et al*., 1993b; Jones and Whalley, 1994; Chang and Lee, 2004). They are sold in traditional markets (Sommerkamp, 1990; Moreno-Black *et al*., 1996; Mariaca-Méndez *et al*., 2001) or commercially exploited as food (Redhead, 1997; Pilz *et al*., 1999) or medicines (Oso, 1977; Rai *et al*., 1993; Vaidya and Rabba, 1993; Chamberlain, 1996).

In Oaxaca, information about fungi is scarce. Former ethnomycological research in this state has focused on hallucinogenic mushrooms (Heim and Wasson, 1958, 1962; Ravicz, 1960; Rubel and Gettelfinger-Krejci, 1976) and more recently on edible ones (Herrera *et al*., 1995; León, 1995; Hunn *et al*., unpublished). León (1995) reported that people in Oaxaca traditionally consume 76 species of mushrooms; while in the Oaxaca North Mountain Range "*Sierra Norte de Oaxaca*" his estimates are 20 species. Córdova *et al*. (2002) have presented a preliminary list of 81 species of potentially edible fungi in the adjacent forests of Ixtlan. Zapotecs have used and managed their forests efficiently, with a mixture of traditional and technical knowledge, but their ethnomycology has been explored only superficially.

Therefore, the aims of this study were to increase the taxonomic knowledge of the Oaxaca North Mountain Range useful fungi; compile TMK of Zapotec and mestizo people from Ixtlan de Juarez; analyze how they relate to their macro-fungal diversity and how they use it.

Materials and methods

Study site

Ixtlan is the principal village of the "*Ixtlán de Juárez*" municipality in the central part of the Oaxaca North Mountain Range, Oaxaca, Mexico (17º 19' 0" N and 96º 29' 14" W) (Fig. 1). The village and surrounding forests are on a hillside at 2,030 m (with many slopes principally between 36.5° and 40.8°) and encompass an area of 19,500 Ha (Gómez *et al*., 1994). Predominant soils are Acrisol, Cambisol and Luvisol associated with Vertisol, Regosol and Litosol (INEGI, 1984). Weather is temperate humid with a mean annual temperature of 15°C, mean maximum temperature of 31°C and mean minimum temperature of 0°C. Rainfall ranges 1000 to 1300 mm concentrated between June and November (Valdés *et al*., 2003).

Fig. 1. Study area location.

The Oaxaca North Mountain Range is oriented in a northeast-southeast direction; running 300 Km long, 75 Km wide in average, 12,700 Km^2 of extension and representing around 10% of the state area. There are extensive *Pinus*, *Quercus* and *Abies* temperate forests, and cloud forests, xerophytic shrub-lands, deciduous forests, sub-alpine prairies and tropical rain forests are also present (García-Mendoza and Colín, 1999).

Although Ixtlan has several types of vegetation, our work took place only in *Pinus*-*Quercus* forests. In these forests, *Pinus oaxacana, P. patula,* and *P. douglasiana,* are among the most abundant pine species, but *P. lawsoni, P. leiophylla* and *P. teocote* can also be found in less quantities. Other conifers include *Cupressus lindleyi, Juniperus deppeana* and *J. flaccida,* mixed with broadleaf trees such as *Amelanchier denticulata, Arbutus jalapensis, Arctostaphylos polifolia, Clethra lanata,* and several oak species as *Quercus castanea, Q. crassifolia, Q. obtusata, Q. peduncularis, Q. rugosa* and *Q. scytophylla* (Flores and Manzanero, 1999; Valdés *et al*., 2003).

The community is composed of 2201 inhabitants, with a distribution of 49.9% men, to 50.1% women. Out of the total, 29.8% speak Spanish, 65.7% are bilingual, and 4.5% speak Zapotec only. Politically and economically, it is the most important village of the zone, with the regional education and health offices located there. Thus, many people work in offices or services. Others work in the forestry community enterprise, and the rest are swidden farmers that cultivate corn, pumpkin and beans. Those that have cattle own no more than 10 cows (INEGI, 2002).

Taxonomic techniques

We collected, described, photographed and dried mushrooms as recommended by Cifuentes *et al*. (1986) and Halling (1996). We analyzed the specimens in the laboratory, and measured microscopic characteristics following Largent *et al*. (1984). We deposited voucher specimens to the mycological collection of the FCME Herbarium at the *Facultad de Ciencias* of the *Universidad Nacional Autonóma de México*. Table 1 lists specimens examined and their collection data. We identified species using the works of Petersen (1971, 1987), Hesler and Smith (1979), Jenkins (1986), Riva (1988), Brandrud *et al*. (1990), Breintenbach and Kränzlin (1991), Mueller (1992), Bessette *et al*. (1995, 2000), Cifuentes (1996), Eyssartier and Buyck (2000), Guzmán and Ramírez-Guillén (2001) and Marijke (2001). We also used the systematic arrangement proposed by Kirk *et al*. (2001).

Table 1. Specimens examined and collection details.

ASCOMYCOTA

Hypocreaceae

Hypomyces lactifluorum (Schwein.) Tul.: MEXICO, OAXACA. Ixtlan de Juarez, comunal lands, *Pinus*-*Quercus* forest, 24-VII-2001, *J. Córdova 509* (ENCB).

BASIDIOMYCOTA

Agaricaceae

Agaricus pampeanus Speg.: MEXICO, OAXACA. Ixtlan de Juarez, *Rancho Torres*, grassland, 20-VI-2003, *RGO 03-6*, (FCME); *ibid.* church atrium, 21-VI-2003, *RGO 03-7*, (FCME); *ibid.* 21-VI-2003, *RGO 03-8,* (FCME).

Boletaceae

Austroboletus betula (Schwein.) E. Horak: MEXICO, OAXACA. Ixtlan de Juarez, 25b road 3 km far Ixtlan, *Pinus oaxacana* forest, 10-VIII-2001, *RGO 01-809*, (FCME).

Cantharellaceae

Cantharellus cibarius # 1: MEXICO, OAXACA. Ixtlan de Juarez, municipal market, 25-IX-2002, *RGO 02-2906a*, (FCME); i*bid. RGO 02-2906b*, (FCME).

Cantharellus cibarius # 2: MEXICO, OAXACA. Ixtlan de Juarez, Ha9, *Pinus*-*Quercus* forest, 22-IX-2002, *RGO 02-2901*, (FCME); *ibid.* Ha10, 7-X-2002, *RGO 02-3021*, (FCME).

Cantharellus cinnabarinus (Schwein.) Schwein.: MEXICO, OAXACA. Ixtlan de Juarez, Ha5, open *Pinus*-*Quercus* forest, 24-VII-2001, *RGO 01-802*, (FCME); *ibid.* 4-IX-2001, *RGO 01-1961*, (FCME); *ibid.* Ha9, 9-IX-2002, *RGO 02-1819*, (FCME).

Cortinariaceae

Cortinarius secc. *Malacii* sp.: MEXICO, OAXACA. Ixtlan de Juarez, near *Rancho Torres*, *Quercus* forest, 21-IX-2002, *RGO 02-2504*, (FCME).

Ganodermataceae

Ganoderma applanatum (Pers.) Pat.: MEXICO, OAXACA. Ixtlan de Juarez, town, 21-VI-2003, *RGO 03-006*, (FCME); *ibid.* 22-VI-2003, *RGO 03-007*, (FCME).

Gomphaceae

Gomphus clavatus (Pers.) Gray: MEXICO, OAXACA. Ixtlan de Juarez, near *Rancho Torres*, *Quercus* forest, 21-IX-2002, *RGO 02-2505*, (FCME).

Hericiaceae

Hericium coralloides (Scop.) Pers.: MEXICO, OAXACA. Ixtlan de Juarez, Ha2, *Pinus*-*Quercus* forest, 29-IX-2000, *RGO 00-519*, (FCME).

Hydnaceae

Hydnum repandum var. *album* (Quél.) Rea.: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus*-*Quercus* forest, 8-IX-2002, *RGO 02-1683*, (FCME).

Hydnum repandum var. *repandum* L.: Fr.: MEXICO, OAXACA. Ixtlan de Juarez, Ha5, *Pinus*-*Quercus* forest, 21-VIII-2001, *RGO 01-1210*, (FCME);

Hydnum repandum var. *rufescens* (Fr.) Barla: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus*-*Quercus* forest, 8-IX-2002, *RGO 02-1658*, (FCME).

Hydnum umbilicatum Peck: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus*-*Quercus* forest, 20-IX-2002, *RGO 02-2085*, (FCME).

Hydnum sp. (*sensu* Cifuentes, 1996): MEXICO, OAXACA. Ixtlan de Juarez, Ha12, *Pinus*-*Quercus* forest, 20-IX-2002, *RGO 02-2902*, (FCME).

Table 1 continued. Specimens examined and collection details.

Hydnangiaceae

Laccaria amethystina Cooke: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus-Quercus* forest, 20-IX-2002, *RGO 02-2030*, (FCME).

Laccaria laccata var. *pallidifolia* (Peck) Peck: MEXICO, OAXACA. Ixtlan de Juarez, Ha2, *Pinus-Quercus* forest, 16-X-2000, *RGO 00-1784*, (FCME).

Laccaria bicolor (Maire) Orton: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus-Quercus* forest, 20-IX-2002, *RGO 02-2137*, (FCME).

Laccaria aff. bicolor (Maire) Orton: MEXICO, OAXACA. Ixtlan de Juarez, Ha6, *Pinus-Quercus* forest, 23-VIII-2001, *RGO 01-1754*, (FCME); *ibid.* Ha11, *Pinus-Quercus* forest, 8-IX-2002, *RGO 02-1653*, (FCME).

Laccaria vinaceobrunnea G.M. Mueller: MEXICO, OAXACA. Ixtlan de Juarez, Ha1, *Pinus-Quercus* forest, 6-VII-2000, *RGO 00-891*, (FCME).

Hygrophoropsidaceae

Hygrophoropsis aurantiaca (Wulfen) Maire: MEXICO, OAXACA. Ixtlan de Juarez, Ha6, *Pinus-Quercus* forest, 15-VI-2001, *RGO 01-41*, (FCME); *ibid. RGO 01-43*, (FCME); *ibid.* Ha8, *Pinus-Quercus* forest, 16-VI-2001, *RGO 01-115*, (FCME).

Pluteaceae

Amanita basii Guzmán & Ramírez-Guillén: MEXICO, OAXACA. Ixtlan de Juarez, Yagu Ha9, edge of *Quercus-Pinus* forest, 3-VIII-2002, *RGO 02-956*, (FCME).

Amanita jacksonii Pomerl.: MEXICO, OAXACA. Ixtlan de Juarez, Ha8, *Pinus-Quercus* forest, 26-VII-2001, *RGO 01-737*, (FCME); *ibid.* Ha5, *Pinus-Quercus* forest, 27-VI-2001, *RGO 01-274*, (FCME).

Amanita laurae Guzmán & Ramírez-Guillén: MEXICO, OAXACA. Ixtlan de Juarez, *Yagu* Ha9, *Pinus-Quercus* forest, 23-VI-2002, *RGO 02-201*, (FCME).

Amanita muscaria var. *flavivolvata* (Sing.) Jenkins: MEXICO, OAXACA. Ixtlan de Juarez, Ha5, *Pinus-Quercus* forest, 26-X-2001, *RGO 01-5043*, (FCME); *ibid.* Ha12, *Pinus-Quercus* forest, 20-VI-2002, *RGO 02-927*, (FCME).

Amanita tecomate Guzmán & Ramírez-Guillén.: MEXICO, OAXACA. Ixtlan de Juarez, Ha10, *Pinus-Quercus* forest, 3-VIII-2002, *RGO 02-975*, (FCME).

Amanita virosa Secr.: MEXICO, OAXACA. Ixtlan de Juarez, Ha8, *Pinus-Quercus* forest, 11-VII-2001, *RGO 01-413*, (FCME).

Polyporaceae

Neolentinus lepideus (Fr.) Redhead & Ginns: MEXICO, OAXACA. Ixtlan de Juarez, forest exploitation zone, *Pinus* forest, 9-IV-2003, *RGO 03-001*, (FCME).

Ramariaceae

Ramaria flava var. *aurea* (Coker) R.H. Petersen: MEXICO, OAXACA. Ixtlan de Juarez, Ha8, *Pinus-Quercus* forest, 26-VII-2001, *RGO 01-700*, (FCME).

Ramaria purpurissima var. *purpurissima* R.H. Petersen & Scates: MEXICO, OAXACA. Ixtlan de Juarez, Ha5, *Pinus-Quercus* forest, 4-IX-2001, *RGO 01-1924*, (FCME).

Ramaria rubricarnata var. *verna* R.H. Petersen & Scates: MEXICO, OAXACA. Ixtlan de Juarez, Ha6, *Pinus-Quercus* forest, 25-VII-2001, *RGO 01-631*, (FCME).

Ramaria cf. *versatilis* Quél.: MEXICO, OAXACA. Ixtlan de Juarez, Ha8, *Pinus-Quercus* forest, 26-VII-2001, *RGO 01-702*, (FCME).

Table 1 continued. Specimens examined and collection details.

Russulaceae
Lactarius corrugis Peck: MEXICO, OAXACA. Ixtlan de Juarez, Ha5, *Quercus-Pinus* joung forest, 9-VIII-2001, *RGO 01-766*, (FCME).
Lactarius deliciosus (L.) Gray: MEXICO, OAXACA. Ixtlan de Juarez, Ha7, *Pinus-Quercus* forest, 26-VII-2001, *RGO 01-680*, (FCME); *ibid.* Ha6, *Pinus-Quercus* forest, 23-VIII-2001, *RGO 01-1794*, (FCME).
Lactarius deliciosus var. *deterrimus* Hesler & A.H. Sm.: MEXICO, OAXACA. Ixtlan de Juarez, Ha7, *Pinus-Quercus* forest, 10-VIII-2001, *RGO 01-870*, (FCME); *ibid.* Ha6, *Pinus-Quercus* forest, 6-VIII-2001, *RGO 01-2573*, (FCME). *ibid*. 8-VII-2002, *RGO 02-544*, (FCME).
Lactarius volemus (Fr.) Fr.: MEXICO, OAXACA. Ixtlan de Juarez, Ha2 *Pinus-Quercus* forest, 28-VII-2000, *RGO 00-25*, (FCME); *ibid.* Ha6, *Pinus-Quercus* forest, 12-VII-2001, *RGO 01-546*, (FCME); *ibid.* Ha5, *Pinus-Quercus* forest, 4-IX-2001, *RGO 01-1903*, (FCME); *ibid. RGO 01-1930*, (FCME).
Sparassidaceae
Sparassis crispa (Wulfen) Fr.: MEXICO, OAXACA. Ixtlan de Juarez, Ha8, *Pinus-Quercus* forest, 26-VII-2001, *RGO 01-749*, (FCME).
Tricholomataceae
Hygrophorus purpurascens (Alb. & Schwein.) Fr.: MEXICO, OAXACA. Ixtlan de Juarez, Ha6, *Pinus-Quercus* forest, 25-VII-2001, *RGO 01-582*, (FCME); *ibid*. 25-VII-2001 *RGO 01-603*, (FCME); *ibid.* 11-VIII-2001, *RGO 01-5115*, (FCME); *ibid.* 11-VIII-2001, *RGO 01-1090*, (FCME).
Hygrophorus russula (Fr.) Kauffman: MEXICO, OAXACA. Ixtlan de Juarez, Ha11, *Pinus-Quercus* forest, 8-IX-2002, *RGO 02-1663*, (FCME).
Tricholoma magnivelare (Peck) Redhead: MEXICO, OAXACA. Ixtlan de Juarez, 25 road in course to the plant nursery just before the road ascend, *Pinus douglasiana* forest, 16-VIII-2002, *RGO 02-1135*, (FCME).

Ethnomycological techniques

We conducted participant observation to increase rapport, observing the use of fungi and collecting local edible species. In order to compile local knowledge we applied 18 open and 32 semi-structured interviews and 47 questionnaires (Bernard, 1995) from 2000 to 2003. We applied the questionnaires to a random sample of informants 20 years or older. This sample was conformed by two sex groups, and three occupational groups: 11 service employee men, 10 service employee women, 8 farmer men, 7 farmer women and 11 forest employee men. Questionnaires were divided in five sections: i) informant's data (name, age, sex, occupation, residence, place of birth, migration history, land tenure and family size); ii) a free list of every mushroom they know; iii) specific information for each species (traditional name, description, developing type, habitat, relations with plants and animals, myths, ways to cook it, preservation, gathering, etc.); iv) informant's

relationships with forests and fungi (If they go to the forests, why? What do they collect? Whether they gather mushrooms and with what frequency? If they like mushrooms and why? If they eat mushrooms and with what frequency? If they buy fungi, where and from whom? What do they do with mushrooms?); and v) perceived ecological parameters of mushrooms (abundance, biomass, spatial distribution and phenology). The fifth part was a combination of qualitative and quantitative questions that allowed us to evaluate the informant's perception of mushroom availability. To avoid misinterpretations, we corroborated all traditional names given with high-resolution printed photographs (20.5 × 25.5 cm) of mushrooms taken in previous ethnomycological work.

Analysis

Qualitative data was based on registers made under participant observation, open and semi-structured interviews. Quantitative data originated from applied questionnaires and we treated them as follows. We categorised and expressed data of nominal nature as percentages. For numeric discrete and continuous data, we calculated means and dispersion measures such as variance and standard deviation.

Because the small sample and the absence of normality in the responses distribution (time spent in forests and mushroom consumption) we used nonparametric tests to determine if there were significant differences between the answers of informant groups (Zar, 1984: 138). To compare men with women responses we used the Mann-Whitney test, which is the nonparametric analogue to the two-sample *t* test (Zar, 1984: 138). To search for significant differences among the three occupational groups we used the Kruskal-Wallis test, the nonparametric analogue to the one factor ANOVA analysis (Zar, 1984: 176). Because of the tied ranks in our data, we used the correction factor to compute the H_c Kruskal-Wallis statistic (Zar, 1984: 179). Then, we compared the H_c with the X^2 approximation (Zar, 1984: 179). Once significant differences were detected, we located them with a nonparametric multiple comparison, computing the standard error with the equation for tied ranks of Dunn (1964) and using the *Q* statistic (Zar, 1984: 200).

Results and Discussion

Known species

Table 2 shows a list of all known fungi with their scientific and traditional name, use category, substrate, developing type, habitat, symbiotic

Table 2. Known mushroom taxa in Ixtlan de Juarez, Oaxaca.

Taxa	Traditional name	Use	Subs.	DT	Habitat	Life form	Reg.
Agaricus bisporus	*Champiñón*	C	Li	E	G	S	-
A. pampeanus	"Beshia sh que cuayo"	E	Li	E	G	S	O
Amanita basii	"Beshia bella", "Beshia beyella"	E	S	E	E	M	O
A. jacksonii	"Beshia bella", "Beshia beyella"	E	S	E	P-Q	M	-
A. laurae	"Beshia bella", "Beshia beyella"	E	S	E	P-Q	M	O
A. muscaria var. *flavivolvata*	"Beshia bella ye tzu"	T	S	E	P-Q	M	-
A. tecomate	"Beshia bella", "Beshia beyella"	E	S	E	P-Q	M	O
A. virosa	*Hongo venenoso*	T	S	E	P-Q	M	-
Austroboletus betula		E	S	E	P-Q	M	O
Cantharellus "*cibarius*" #1	"Beshia de" *de mercado*	E	S	E	D	M	-
Cantharellus "*cibarius*" #2	"Beshia de" *de monte*	E	S	E	P-Q	M	-
Cantharellus cinnabarinus	"Lo biinii"	E	S	E	P-Q	M	-
Cortinarius secc. *Malacii* sp.	"Beshia be tzi"	E	S	E	Q	M	EM
Ganoderma applanatum	*Hongo de artesanía*	R	W	A	Q	P	-
Gomphus clavatus		E	S	E	Q	M	EM
Hericium coralloides	*Barba de viejo*	E	W	A	P-Q	S	-
Hydnum repandum var. *album*	"Beshia beretze"	E	S	E	P-Q	M	-
H. repandum var. *repandum*	"Beshia beretze"	E	S	E	P-Q	M	-
H. repandum var. *rufescens*	"Beshia beretze"	E	S	E	P-Q	M	O
H. umbilicatum	"Beshia beretze"	E	S	E	P-Q	M	M
Hydnum sp.	"Beshia beretze"	E	S	E	P-Q	M	-
Hygrophoropsis aurantiaca	"Beshia de que ya yeri"	E	Li	E	P	S	-
Hygrophorus purpurascens	"Beshia que biarida"	E	S	E	P-Q	M	-
H. russula	"Beshia que biarida"	E	S	E	P-Q	M	-

Table 2 continued. Known mushroom taxa in Ixtlan de Juarez, Oaxaca.

Taxa	Traditional name	Use	Subs.	DT	Habitat	Life form	Reg.
Hypomyces lactifluorum	"Beshia ya wela"	E	F	H	P-Q	P	-
Laccaria amethystina	"Beshia ladhi biinii"	E	S	E	P-Q	M	-
L. bicolor	"Beshia ladhi biinii"	E	S	E	P-Q	M	-
L. aff. *bicolor*	"Beshia ladhi biinii"	E	S	E	P-Q	M	-
L. laccata var. *pallidifolia*	"Beshia ladhi biinii"	E	S	E	P-Q	M	O
L. vinaceobrunnea	"Beshia ladhi biinii"	E	S	E	P-Q	M	O
Lactarius corrugis	"Beshia ni tzi"	E	S	E	P-Q	M	O
L. deliciosus	*Hongo de leche naranja*	E	S	E	P-Q	M	-
L. deliciosus var. *deterrimus*	*Hongo de leche naranja*	E	S	E	P-Q	M	-
L. volemus	"Beshia ni tzi"	E	S	E	P-Q	M	-
Lentinula edodes	*Shitaque*	C	W	A	Q	S	-
Neolentinus lepideus	"Beyere", "Be ya yeri"	E	W	A	P	S	O
Pleurotus ostreatus	*Seta*	C	W	A	Q	S	-
Ramaria flava var. *aurea*	"Beshia culirri"	E	S	E	P-Q	M	O
R. purpurissima var. *purpurissima*	"Beshia culirri"	E	S	E	P-Q	M	M
R. rubricarnata var. *verna*	"Beshia culirri"	E	S	E	P-Q	M	O
R. cf. *versatilis*	"Beshia culirri"	E	S	E	P-Q	M	O
Sparassis crispa	*Cabeza de león*	E	W	A	P-Q	S	O
Tricholoma magnivelare	*Hongo blanco del japonés, Masutaque*	E	S	H	P	M	EM

In traditional name, quoted names are in Zapotec, the rest in Spanish. In Use, C: edible cultivated, E: wild edible, R: recreative, T: toxic. Subs.: substrate; F: fungi, Li: litter, S: soil, W: dead wood, DT: developing type; A: wood attached, E: epigeous, H: semi hypogeous. In Habitat, D: deciduous forests, E: forest edges, G: grass-lands, P: *Pinus* forests, P-Q: *Pinus-Quercus* forests, Q: *Quercus* forests. In Life form, M: ectomycorrhizic, P: parasite, S: saprobic. Reg.: new register for; EM: edibility Mexico, M: Mexico, O: Oaxaca.

relations and knowledge status. People gave information about 43 taxa from 20 genera and 19 families. The most representative family was *Pluteaceae* with six species, followed by *Hydnaceae* and *Hydnangiaceae* with five and *Ramariaceae* and *Russulaceae* with four. Most representative genera was *Amanita* with six species, followed by *Hydnum* and *Laccaria* with five, and

Lactarius and *Ramaria* with four. From these, 14 are new records for Oaxaca, 3 are new edibility records for Mexico and 2 species are cited for the first time in Mexico.

The species reported here outstand the previously estimated edible species (León, 1995) for the Oaxaca North Mountain Range in 185%. These taxa also represent 46.25% of the total edible fungal species reported for Oaxaca by the same author. The 14 new entries represent an increase of 18.42% in the state's known edible mushrooms. The list presented by Córdova *et al*. (2002) of 82 edible mushrooms from Ixtlan' forests now reaches 96 species. Although this number must be considered on a preliminary basis, it is indeed comparable with other places in Mexico: *Nevado de Toluca* National Park, with 94 species (Colón-Tellez, 1987); *Malinche* National Park, with 91 species (Montoya *et al*., 2004).

The species of wild edible mushrooms consumed by Ixtlan inhabitants represent 38.54% of edible fungal resources in the updated list of Córdova *et al*. People in *Malinche* National Park consume 81.32% from the 91 reported edible species in the region (Montoya *et al*., 2004). People from *Toluca* Valley consume nearly 43% (Mariaca-Méndez *et al*., 2001) from the 94 edible species reported by Colón-Tellez (1987). Nahua and Totonac people from the tropical region of *Cuetzalan*, consume 30% of the 40 edible species reported (Martínez-Alfaro *et al*., 1983). Although the number of species used in Ixtlan is considerable and similar to certain regions in Mexico, the percentage suggests some sub-utilization of fungal resources available in the zone.

Thirty-three species grew mainly on soil, six on dead wood, three on litter and one on fungi. Thirty-five species were epigeous, two were semi-hypogeous, and six had wood attached basidiomata. Thirty-one species grew in temperate *Pinus-Quercus* forests, three grew mostly under *Pinus* and five under *Quercus*, two in grasslands, one in low land deciduous forest and one in forest edges. Thirty-three species were mycorrhizal, eight were saprobic and two were parasitic (Table 2). Species useful to people were mainly epigeous and almost all were terricolous and mycorrhizal. Among this group of mushrooms, *T. magnivelare*, *C. cibarius* group and *A. caesarea* complex are in highest demand by national and international markets. If appropriate exploitation models involving TMK and technical knowledge were developed, these resources could potentially present an opportunity to augment limited economic levels of traditional harvest to the mass-export market (Bandala *et al*., 1997). On the other hand, saprobic species could represent opportunities for mushroom cultivation at regional levels. In fact, several people stated interest in mushroom cultivation but due to a lack of technical and financial support, these initiatives are halted.

The 43 identified taxa corresponded to 26 traditional 'species'. Traditional taxa do not always have the same level as taxonomic species (Berlin, 1992). In our case (Table 2), some corresponded to one taxonomic species (*Beshia sh que cuayo*, *Beshia ya wela*, etc.), others to a group of species and varieties (*Beshia beretze*) and others to two or more species (*Beshia ni tzi*, *Beshia bella*, *Beshia cullirri*). Any given informant separated several traditional taxa from related species of the same genus; perhaps they treated them as different colour varieties of the same traditional species. Other ethnic groups in Mexico have more detailed nomenclature, based on complex traditional mushroom classification systems, like the Purepechas of Michoacan (Mapes *et al*., 1981). However, because we did not specifically search the traditional classification, we cannot deny its existence. The asymmetry between traditional taxa and species had serious implications in the analysis and data comparison because traditional taxa meant different things for each informant. To minimise this uncertainty it was necessary to acquire the TMK, relying on the support of visual stimuli, and making sure that in each case there was certainty of what every taxon meant for each informant.

We found three anthropocentric categories, defined by whether they were edible (40 species), toxic (two species) or used for recreational purposes (one species). In the edible category, 37 were gathered from the forests while the remaining three were cultivated and sold in the market. In Mexico, where mushrooms are used mainly as food (Moreno-Fuentes *et al*., 2001), the existence of only one species for an additional use is not unexpected, in contrast to other countries like Japan or China that have a greater tradition of other mushroom use such as for medicinal purposes (Chamberlain, 1996). The recreational usage of mushrooms was in the form of engravings of *Ganoderma applanatum,* and motifs used could be messages, feelings, regional animals, plants, and/or landscapes (Fig. 2). This activity had recreative and social meanings; was done for pleasure; and they were mostly given as gifts to relatives and friends. There was also evidence of engraved mushrooms being sold, although this was only done under special conditions. The use of mushrooms with recreational purposes has not been previously reported in Mexico. Perhaps the most similar examples are the use of *Fomitopsis pinicola* and *Ganoderma* spp. by the Otomies of *Tlaxcala* for decorative purposes (Montoya *et al*., 2002); the use of *Auricularia* spp. as a toy by Chinantecs of *Oaxaca* (Ruán-Soto *et al*., 2004); and the adoration of a Christ image engraved on the hymenia of a *Ganoderma lobatum* fruit body in *Chignahuapan, Puebla* (Guzmán *et al*., 1975). No hallucinogenic rituals were found, as could be expected from the works by Wasson (1957) and Rubel and Gettelfinger-Krejci (1976). Some informants reported the use of hallucinogenic mushrooms with

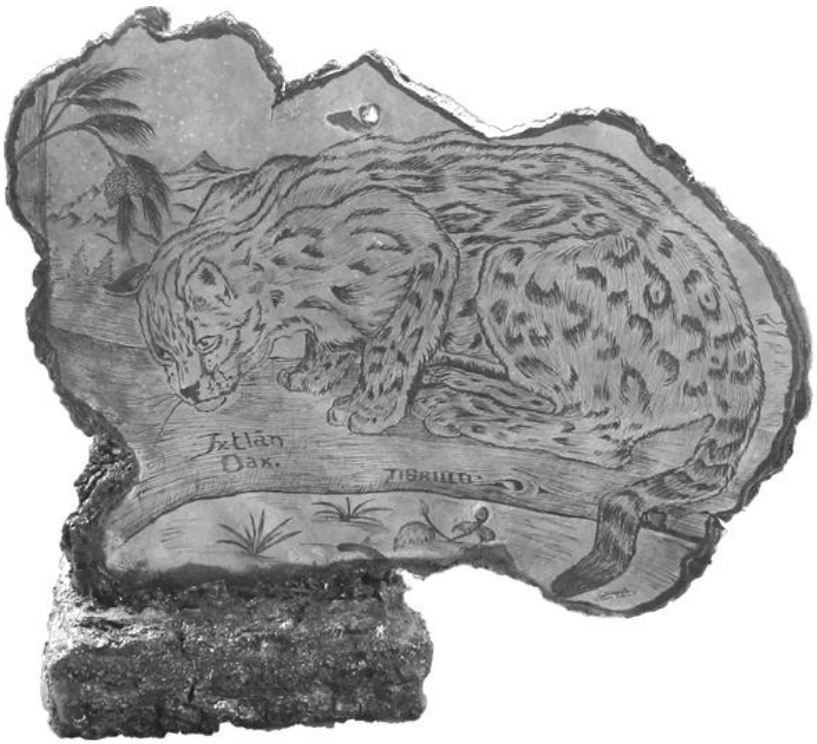

Fig. 2. Handicraft on *Ganoderma applanatum*, "*Tigrillo*" author Leopoldo García P.

divinatory or medicinal purposes in nearby villages, but we could not corroborate this information.

Comments on some species used in Ixtlan

People distinguished *Agaricus pampeanus* by its white colour, round form, pink lamellae when it is young (which becomes dark-brown when mature), and habitat. They put special care while gathering this mushroom since it could be confused with toxic species if the lamellae are not carefully examined. This mushroom grows in grasslands mainly in June and July. This is the first time it is registered for Oaxaca.

Within the *Amanita caesarea* complex (Guzmán and Ramírez-Guillén, 2001), people in Ixtlan usually use a yellow-orange morph (*Amanita basii*) and several red ones (*A. laurae*, *A. jacksonii* and *A. tecomate*). They commonly referred to species of this complex as just one traditional taxon "*Beshia bella*", but while some informants only knew and used one, others treated them as two traditional varieties. They were distinguished by the red, orange or yellow colour of the pileus, yellow lamellae, yellow ring in the stipe and because they

arise from an "egg". People gather them, mainly the red ones, with much care taken in particular to the yellow lamellae. This is because some specimens of *A. muscaria* could resemble a "*Beshia bella*" as the age or rain clears its colour and washes the pileus' scales. All these species grow in the *Pinus-Quercus* forests but we found *A. basii* mainly in open areas, forest edges and secondary vegetation associated with *Quercus* spp. They produce their basidiomata in the rainy season, from late June through October. *Amanita basii*, *A. laurae* and *A. tecomate* are all new records for Oaxaca.

A consensus existed among local users about the toxicity of *Amanita muscaria* var. *flavivolvata*, a mushroom locally characterised by its red pileus with white scales and particularly by its white lamellae which informants took as the unique characteristic to infallibly distinguish it from *A. caesarea* complex. It grows from stands with small trees to mature *Pinus-Quercus* forests throughout the rainy season.

Other toxic species mentioned by some informants was *Amanita virosa*. It is mostly characterised by its all white basidiome, umbrella shape and because it is "closed like an egg" when young. According to them, the resemblance of this mushroom in its early stages of development with *A. pampeanus* is the cause of fatal confusions. Indeed, 20 years ago one Ixtlan inhabitant died due to intoxication with this mushroom. We found it in mature stands of pine forests and in forest edges, from July to October. It is world-wide known as mortally toxic (Laessoe, 1998).

Austroboletus betula was poorly known locally, but at least two families consumed it occasionally. They differentiated it because of its "spongy like bread" pileus and by its stipe with a shiny yellow cotton-like reticulum. In Ixtlan, it is associated with *Pinus oaxacana* and appears in July and August. This is also a new register for Oaxaca.

The taxonomy of *Cantharellus* in Mexico has not been addressed. Species within *C. cibarius* group are particularly difficult to identify because of their great diversity in the country. Two morph-species in this complex were consumed in Ixtlan: a small one (*C.* "*cibarius*" #1), which was typically sold in the market, grows in lowland deciduous forests associated with *Quercus* spp., from July to November; and a bigger one (*C.* "*cibarius*" #2), not sold in the local markets, that grows in pine-oak forests from July to October. Informants described both as little yellow mushrooms with a typical trumpet-form and "little lines" in the body. The criteria to distinguish them were their size, the stipe length and habitat. Some people only knew one of them while others knew both as two forms of the same traditional species called "*Beshia de*".

Cantharellus cinnabarinus was distinguished by its small size (less than 4 cm) and its red-orange colour. People named it "*Loo biinii*" but others placed

it with *C*. "*cibarius*" #1 in "*Beshia de*". It grows mainly in disturbed woods with open areas and small pine trees throughout the rainy season.

Cortinarius secc. *Malacii* sp. seems to be a mushroom widely known in the past, but nowadays its consumption is confined to some elder people, particularly farmers and forest employees. Indeed, because toxic substances have been found in many other species of *Cortinarius* (Tebbet and Caddy, 1984), the consumption of edible ones may be done with caution (Brandrud *et al*., 1990). People recognised it because at the beginning of its development, it resembles a "purple champignon", but when it grows, the pileus becomes extended and brown and by its white club-shaped stipe and white flesh. We found that it grows only in *Quercus* forests particularly associated with *Q. rugosa* in September. Its edibility had not been recorded previously.

Ganoderma applanatum was the most representative of several species of polyporoid mushrooms that people used for handicrafts (Fig. 2). They referred to any large polypore with woody consistence and white soft hymenia as the "handicraft mushroom". These mushrooms grow attached to broadleaf trees, and because of their perennial nature, they are present all year round.

Gomphus clavatus was one of the locally less known edible mushrooms. Informants typified it like a rare lobulated, somewhat amorphous purple mushroom. It was restricted to oak forests; we saw it only during September. This is the first report of its edibility in Mexico although it is eaten in the USA and Canada (Bessette *et al*., 1995).

In Ixtlan, people described *Hydnum repandum* var. *repandum* as a tan-orange, sweet-smelling mushroom distinguished because instead of lamellae it has "like a bath towel" or "little spines". It was the most commonly eaten mushroom of a group of species that varies from the pure white to the red-orange. This group of taxa includes also *H. repandum* var. *album*, *H. repandum* var. *rufescens*, *H. umbilicatum* and *Hydnum* sp. (*sensu* Cifuentes, 1996). People considered all of them as the same traditional species and called them "*Beshia beretze*". They are widely distributed in the region, in *Pinus*, *Quercus* or mixed forests, growing from July to October. *Hydnum repandum* var. *rufescens* is a new record for Oaxaca and *H. umbilicatum* is a new record for Mexico.

Hygrophoropsis aurantiaca was frequently mistaken with the "*Beshia de*". Informants described it like *C. cibarius* but with a frail body and dissimilar shape. Only two informants recognised it as different from *C. cibarius*. It is associated with pine and appears early in the rainy season from late May to July.

People described *Hygrophorus purpurascens* and *H. russula* without differentiation as white mushrooms with a pinky freckly cap. They grow in

mature pine stands mainly near *P. oaxacana* and *P. patula*, from July to October. This is the first report for Oaxaca of the former.

Local people consumed several species of *Laccaria*: *L. laccata* var. *pallidifolia* was the most abundant brown-orange form, and *L. vinaceobrunnea* the most common among the purple ones like *L. bicolor*, *L.* aff. *bicolor* and *L. amethystina*. These species were widely sold in the Oaxaca North Mountain Range, however, very few people used them in Ixtlan. In fact, only two people knew both colour forms. They distinguished the *Laccaria* species by size, characteristic consistence, colours and thin stipe. These fungi are widespread in all the forests, indeed Valdés *et al*. (2003) cited *L. laccata* as the most abundant mushroom in Ixtlan. All the species of *Laccaria* appear from July to November. *Laccaria laccata* var. *pallidifolia* and *L. vinaceobrunnea* are reported for the first time for Oaxaca.

People referred to the *Lactarius volemus* and *L. corrugis as* "*Beshia ni tzi*". Most of the inhabitants of Ixtlan did not distinguish both species and used them as a single traditional taxon. Informants described them as brown-dark-red or orange-yellow mushrooms that secrete "white milk" if they are broken. We found these mushrooms always near *Quercus* spp., regularly in areas with semi-open young forests, from July to October.

Neolentinus lepideus was a lignicolous mushroom that grows on dead logs of pine trees. People distinguished it by its phenology, the firm flesh, the shape and the white-brown pileus with scales. It is associated with pine, and appears in April and May. Here it is reported for the first time for Oaxaca. It was one of the most popular and valued species in Ixtlan. People categorised it as a "special mushroom" with a delicious meat-like flavor and particular consistence. Because of its phenology and scarcity they searched it with special devotion. Those who found it treated it like a prize destined to be a delicatessen meal; occasionally they sold it at high prices, and other times they offered it as a special gift. For these reasons, this mushroom is the best candidate to be cultivated at regional level and to exploit its biological characteristics and potential market. Moreno-Fuentes *et al*. (1996) found an almost identical case in *Neolentinus ponderosus*, a similar species used by the Raramuris of Chihuahua, Mexico.

Practically all *Ramaria* species were used in Ixtlan. Each person had its own recognition criteria. Some of them ate only species of one colour, while others used species of any colour. Some people said that neither those growing in wood nor the white ones should be eaten, but others did consume these kinds. The only criterion shared by all respondents was the form; they did not use thin or compact fruit bodies. People ate no less than eight species, being *Ramaria flava* var. *aurea*, *R. purpurissima* var. *purpurissima*, *R. rubricarnata*

var. *verna* and *R*. cf. *versatilis* the most common. All interviewees considered them as a single taxon with many colours and called it "*Beshia culirri*". They grow in mature and closed stands of *Pinus-Quercus* forests and produce basidiomata from July to October. *Ramaria purpurissima* var. *purpurissima* is a new record for Mexico. All the other species are first records for Oaxaca.

Tricholoma magnivelare was distinguished by its white dirty colour, strong characteristic smell, because at the beginning of its maturation it is "closed" and when matures it "opens", and by its strong association with *P. douglasiana* and *P. teocote*. Some people even distinguished it from *T. caligatum*, a related species with similar habitat, and brown scales in the pileus and stipe. *Tricholoma magnivelare* is always found semi-buried near pine species and produces basidiomata from July to September. This species is a very interesting case because it was not traditionally consumed in Mexico (Bandala *et al*., 1997) whereas it had a high ritual value in Japan (Readhead, 1997). Japanese companies had trained people to recognise and collect it and paid the equivalent of one-week salary for every 1 kg of first class mushrooms. This has lead to an irrational exploitation of the resource in Mexico where populations have decreased considerably (Bandala *et al*., 1997; Martínez-Carrera *et al*., 2002). In Ixtlan, people do not sell it anymore, but it has been incorporated to their culture and today it is not only known and used by many people, it is also much appreciated. Although Martínez-Carrera (2002) has reported its incidental consumption in the Oaxaca North Mountain Range, this is the first record of its traditional use in Mexico.

Informants used a wide range of ecological and morphological details for mushroom identification, including recognition of habitat, substrate, phenology, development, shape, size, colour, smell, ornamentation and consistency. Not all of them were used for all species and the order of importance varied according to which characters were more distinctive to each species. For example, the most important criteria to identify *N. lepideus* were its phenology and substrate followed by its development, colour, consistence and smell. To identify *A. pampeanus*, the main criteria were its habitat and development and then its shape and colour. Other species as *A. caesarea* complex, *Hydnum* spp. and *C. cibarius* group were defined using a combination of shape, size, colours and hymeneal details. Informants always defined traditional taxa varieties by colours; except in "*Beshia de*" where the habitat and size were the most important criteria. When taxonomic identification of species required microscopic details (*A. caesarea* complex, *Hydnum* spp., etc.) traditional taxonomy had less accuracy.

It was very common that persons who did not collect mushrooms used cultivated species sold in the market as *Agaricus bisporus*, *Lentinula edodes*

and *Pleurotus ostreatus*. They also bought fungi from people who came from nearby villages and sold door to door in an activity named "sell for the ranch" by Montoya *et al*. (2003). The species involved in this were *A. caesarea* complex, *C. cibarius* spp, *L. volemus* s.l., *H. russula* s.l. and *Sparassis crispa*. The latter is not gathered traditionally in Ixtlan because it is very rare in adjacent forests.

Traditional mycological knowledge

Mushroom concept, nature and ecology

In general, people in Ixtlan believed mushrooms were different from plants and animals. They said that mushrooms were special organisms with particular dependence on water and with special shapes, colours, consistencies and tastes. This concept of mushrooms as an independent group of organisms, similar to that of modern science after the classification of Margulis and Schwartz (1982), has been found in other studies in Mexico (e.g., Mapes *et al*., 1981; Montoya *et al*., 2002). However, there is no consensus between Mexican cultures, since Mazahuas and Otomies from the *Toluca* Valley believe that mushrooms are "plants" or "like plants" (Mariaca-Méndez *et al*., 2001).

People did not have specific knowledge about fungal reproduction, but several of them associated the "little dust" as their seeds. Some others said that the "cotton-like roots" that mushrooms have in the ground produce them. This is a basic idea of the fungal life cycle, with empirical notions about fungal spores and mycelia. We found these empirical notions in people who are strongly connected with the forests and with special affection to mushrooms, as did Montoya *et al*. (2002).

Regarding the information of substrates on which fungi grow, people mentioned soil, humus, dead or living wood and dead leafs. Informants reported detailed data especially in lignicolous and humicolous species. They mentioned that *N. lepideus* grows on dead logs of *Pinus,* especially *P. patula* and *P. douglasiana*, but never in *P. oaxacana*; and the handicraft mushroom grows on *Quercus* spp. and other broadleaf trees. They also reported that *H. aurantiaca* grows on pine needle litter.

People reported that *T. magnivelare* grows under litter and their fruit bodies are not commonly visible. However, they are capable of finding it because they know the pines with which the species is associated. They also reported that *H. lactifluorum* grows buried under the dead leaves at the beginning of its development, and it becomes evident as it matures. This traditional knowledge allows people to easily recognise these species and favors their optimal exploitation.

Informants recognised four zones where mushrooms can grow. *El monte*, temperate forests especially of *Pinus*-*Quercus* above 2200 m; *tierra caliente*, a term used to define *Quercus* and deciduous forests under 2100 m; *pastizales*, open fields used for cattle feeding; and *rancho*, open areas with corn fields or *milpas*, other cultivars, fruit trees and livestock. They said that almost all fungi grow in *el monte*. A few taxa can develop in open areas: *A. basii* grows along roads and *ranchos*, near the forests; and according to the people, *A. pampeanus* only appears in *pastizales* with cattle dung. Only *C.* "*cibarius*" #1 was reported to grow in *tierra caliente*, and this distinguishes it from *C.* "*cibarius*" #2, which grows in *el monte*. Inhabitants of *Javier Mina*, *Tlaxcala*, have a similar categorization (Montoya *et al*., 2002), extracting mushrooms mainly from *el monte*, and from *el llano* and *milpas*. However, in tropical Mexico the scheme is different: Ruán-Soto *et al*. (2004) reported that the conserved rain forest is not considered a good place to gather fungi. There, people collect mushrooms in open places without original vegetation such as *milpas*, *pastizales* and *acahuales* (places with secondary vegetation).

As found by Montoya *et al*. (2002, 2003), people related with forests pointed out "places" where certain species grow abundantly. They consider this knowledge an individual or family secret. Mariaca-Méndez *et al*. (2001) also documented this trend in the *Nevado de Toluca* National Park.

The relationships between mushrooms and plants or animals influenced different aspects of traditional knowledge. In some cases, they pointed out the edibility of some species: people considered that mushrooms with worms (insect larvae) or chewed by mammals could be edible, while those where worms never enter are toxic. Although these beliefs are common in Mexico (Mariaca-Méndez *et al*., 2001; Montoya *et al*., 2003) they are not true (Piqueras, 1996; García, 2001). In other cases, the name of a species showed its symbiotic relationships: the name of *H. aurantiaca* "*Beshia de que ya yeri*" means yellow mushroom of pine, defining this mushroom as a kind of "*Beshia de*" related with those trees, and reflecting that this is a saprophytic species growing on pine needles. The name of *H. lactifluorum*, "*Beshia ya wela*", means eagle tree mushroom, which reflects the common belief that this species grows around "*palo de águila*" (*Alnus* sp.). People reported some mushrooms need particular trees to grow. *Cortinarius* secc. *Malacii* sp. and *G. clavatus* grow only in *Quercus* forests; and *T. magnivelare* only grows near *P. douglasiana*, and *P. teocote*.

People, forests and mushrooms

Forest employees and male peasants spent more than 100 days/year in the forests, while female and service employees spent less than 25 days/year

(Table 3). Significant differences existed among males and females ($U = 404.5 > U_{0.05(2)17,30} = 344$) and among the three occupational groups ($H_c = 11.464 > X^2_{0.05,2} = 5.991$), in particular this was among service and forest employees ($Q = 3.354 > Q_{0.05,3} = 2.394$). Then, differences in time spent in woods were highly related to work division and gender. Although service employees and women were those with the lowest rates, they went to the woods at least twice a month.

Concerning the activities carried out in forests, 4% of informants took care of cattle, 10% held no forest jobs, 22% went to cornfields, 28% held forest jobs and 58% went to take a walk. The high percentage of people that took walks in forests only for pleasure was an evidence of the tight relationship between Ixtlan inhabitants and their natural surroundings.

Besides wood for industry and building, people extracted many other resources from forests. Among these, mushrooms were the most used nontimber natural resource. Eighty eight percent of the interviewed brought back something to town, i.e. flowers, cacti, bromelids, ferns, mosses, mushrooms, edible weeds, fruit, medicinal herbs, animals, firewood, construction wood, pasture, humus, soil, etc. Among these, 4.26% reported bringing pasture or animals, 8.51% brought some kind of substrates, 27.66% edible plants, 31.91% medicinal plants, 36.17% ornamental plants, 46.81% wood and derivates and 65.96% mushrooms.

Use and management

Almost all people with forest and peasant activities gathered mushrooms (Table 3). In addition, a high percentage of men also collected fungi. However, only half of them collected fungi in specific walks. This means that although the gathering activity was sometimes *exprofeso*, with the objective of satisfying certain necessities, other times it was a result of chance when people were walking in the forests. Intentional mushroom harvest was principally associated with forest employees, peasants and men. The gathering could be casual or intentional, and in the latter case it could be directed or randomly. When someone wanted mushrooms as *A. basii*, *N. lepideus*, *T. magnivelare*, *Cortinarius* secc. *Malacii* sp. and *A. pampeanus*, they went to specific places and visited particular spots. If the desired mushrooms were *Hydnum* spp., *Ramaria* spp. and *Laccaria* spp., because of their abundance, gathering was carried out randomly inside forests.

All informants answered affirmatively when asked if they liked and ate mushrooms. Thirty-one people reported they collected mushrooms, 36 bought them and 12 said that relatives or friends used to give mushrooms to them.

Table 3. Mushroom knowledge and use indicators in Ixtlan de Juarez, Oaxaca.

	Tsf days/year	**Gm**	**N° tt**	**Std. Dev. N° tt**	**Mc days/month**
Female peasants	41.25	71.43%	9.71	3.10	2.37
Male peasants	123.44	100%	10.50	2.45	2.86
Female service employees	7.8	10%	4.90	3.35	2.99
Male service employees	39.37	54.55%	5.63	2.38	3.31
Forest employees	164.67	100%	11.36	2.84	3.42
Peasants	84.76	93.33%	10.13	2.70	2.64
Service employees	24.3	28.57%	5.28	2.83	3.16
Female	22.67	35.30%	6.88	3.98	2.68
Males	110	83.33%	9.03	3.63	3.20
All the informants	78.56	65.96%	8.26	3.8	3.04

Tsf: time spent in forests; Gm: gather mushrooms; N° tt: average number of traditional taxa mentioned; Std. Dev.: standard deviation; Mc: mushroom consumption.

From those that collected, all reported to have eaten them domestically, 20 engaged in exchanging them as gifts with relatives and friends, 3 sold them cooked as different stews and 2 used to sell *T. magnivelare* to a Japanese company but do not do it anymore. Gift exchange of mushrooms was a common activity involving friends and members of one or more families. Due to its reciprocal nature, people considered it a favor they would usually return.

The stated knowledge of Ixtlan inhabitants regarding the existing quantity of mushrooms was low. On average, they were aware of 8.3 traditional taxa. However, this knowledge was heterogeneous and highly dispersed; with a standard deviation of 3.8 traditional taxa. Total number of mushrooms mentioned varied between informant groups, with only forest employees and peasants knowing more than ten species in average (Table 3). This knowledge was more homogeneous among men than in women, with a standard deviation of 3.63 and 3.98 respectively.

People ate mushrooms 3.04 days a month on average (Table 3). We did not find statistical differences by gender ($U = 285.5 < U_{0.05(2)17,30} = 344$), neither by occupation ($H_c = 0.312 < X^2_{0.05,2} = 5.991$). Homogeneity of mushroom consumption between groups is an indicator that it is independent from harvesting and knowledge about species. This is explained by several mechanisms involved in the mushroom appropriation process. Gathering, casual or intentional and randomly or directed; purchase in market or from door to door sellers; and reciprocal gifting with relatives and friends. Because of these processes, everybody had access to mushrooms independently of their age, sex, occupation or economic condition.

Use of macro-fungal diversity was not constrained to gathering. In addition, people applied several management practices over special

mushrooms. These included inside-forest promotion where people found a button of *T. magnivelare,* they covered it with needle litter to prevent it being taken away by someone else or eaten by animals. They also periodically visited sites until mushrooms had reached the optimal size. Outside-forest semi-culture was exemplified with *N. lepideus*, where they protected and watered the buttons, and if possible took trunks or branches to their houses. Once in their homes, they took care of them and harvested fungi for several years. Montoya *et al*. (2002, 2004) also find inside-forest promotion of mushrooms in *Tlaxcala*, where people promote fires to support the growth of *Hebeloma* aff. *mesophaeum*, *Lyophyllum* spp. and *Morchella* spp.

The long-established use and exploitation of mushrooms by Ixtlan people involves a vast traditional mycological knowledge about species. However, this knowledge entails much more than fungal diversity at taxonomical level only. Other related knowledge included: chemical diversity, helpful to differentiate edible from potential toxic species; population diversity, by knowing where important colonies of certain species produced basidiomata abundantly; and ecological diversity, where they recognised the relationship of mushrooms with their substrates, habitats and mycorrhizal hosts.

Conclusions

This paper demonstrates the potential of ethnomycological studies for knowledge of fungal diversity in specific sites. This is particularly important with useful species. In the present work, *Hydnum umbilicatum* and *Ramaria purpurissima* var. *purpurissima* were recorded for the first time to Mexico, and 14 species for Oaxaca. We also describe for the first time traditional use of *Cortinarius* secc. *Malacii* sp., *Gomphus clavatus* and *Tricholoma magnivelare* in Mexico.

The 43 mushroom taxa known by Ixtlan inhabitants is considerably superior to previous estimations of edible mushrooms for the Oaxaca North Mountain Range. Although an important number of species are used, the resource is somewhat underexploited and traditional taxonomic knowledge is not as fine-tuned as in other places of Mexico. People in Ixtlan used mushrooms mainly for food; however, we reported for the first time in Mexico the recreative use of a mushroom (*Ganoderma applanatum*).

TMK had different levels of detail: concept of fungi and life-cycle notions were lax and not shared by everyone; substrate and habitat data were very precise and detailed; information on ecological relationships with plants was specified to the level of plant species-fungal species symbiosis. General aspects of TMK were shared by all informants, but forest employees and peasants gave more profound information about a larger group of species.

Mushrooms were valued as special food by Zapotec people and were the most used non-timber forest resource, with 65.96% of informants gathering mushrooms. On average people knew 8.3 traditional taxa, and on average ate mushrooms 3.04 days a month.

TMK plays a major role in the use and exploitation of wild edible mushrooms for successful resource appropriation and management practices. This includes gathering, purchasing and reciprocal gifting. Gathering strategies were either casual or intentional and randomly or directed; and management practices were inside-forest promotion and outside-forest semi-culture.

Information about useful fungi of Ixtlan inhabitants is in accordance with other ethnic groups of temperate Mexico. It corresponds with ideas about fungi concept, nature, ecology, use and management.

Acknowledgements

This research was sponsored by a doctoral dissertation scholarship assigned to R.G-O. by *Consejo Nacional para la Ciencia y la Tecnología* (grant number 149895) and *Universidad Nacional Autonóma de México* (DGEP). PAEP (2003-201307) and DGAPA IN 206901and IN-223704 gave additional financial resources. The people of Ixtlan de Juarez participated in the research in an always-enthusiastic manner. We are grateful for their support and friendship, especially to Jorge García for his field assistance and Victor Ramírez and Leopoldo Santiago Vargas for their logistic help. We thank Peter Kennedy and Jesus A. Badillo for their revision of the first English version; and to Gerardo Arroyo 0'Grady for its professional review of the final English version.

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(Received 20 August 2005; accepted 1 December 2005)