



## Trends on mexican ethnozoological research, vertebrates case: a systematic review

Tania Vianney Gutiérrez-Santillán<sup>1</sup>; Ulysses Paulino Albuquerque<sup>2</sup>; David Valenzuela-Galván<sup>3</sup>; Francisco Reyes-Zepeda<sup>1</sup>; Luis-Bernardo Vázquez<sup>4</sup>; Arturo Mora-Olivo<sup>1</sup> and Leonardo Uriel Arellano-Méndez<sup>1,\*</sup>

### ABSTRACT

Systematic reviews and meta-analytical approach are a tool used in different social and biological disciplines, but its application in evaluating ethnobiological information is scarce. Thus, through this analytical approach, we seek to answer if there are any patterns in the mexican ethnozoological scientific production. We searched for studies published between 2005 and 2015 in catalogues, repositories and databases. For evaluating significant differences among seven variable datasets, we first used non parametric Kruskal-Wallis tests and then Tukey multiple comparison tests. We also determined the link between researchers and institutions with a multidimensional non-metric scaling analysis. We found 295 published studies, book chapters were the most representative (27%), diffusion articles (20%), impact factor articles (15%) and indexed articles (14%). There are significant differences in the number of publications among the evaluated years, among thematic areas, study focus (qualitative/quantitative), ethnographic and biological methods. Regarding academic linking, we identified 94 author adscription institutions, however, no research networks were identified. Our results suggest that the amount, diffusion and reach of mexican ethnozoological production show a tendency to non-periodic publishing, predilection for qualitative approach, a low use of statistical and ethnobiological analysis, as well as an inadequate selection of biological methods. We suggest this data analysis approach will allow a better standardization for information taking and processing, aiding the discipline in its growth and consolidation.

**Keywords:** Systematic Reviews; Meta-Analysis; Ethnozoology

<sup>1</sup> Instituto de Ecología Aplicada, Universidad Autónoma de Tamaulipas, México.

<sup>2</sup> Departamento de Botânica, Laboratório de Ecologia e Evolução de Sistemas Socioecológicos, Universidade Federal de Pernambuco, Cidade Universitária, Recife, Pernambuco, Brasil.

<sup>3</sup> Centro de Investigación en Biodiversidad y Conservación, Universidad Autónoma del Estado de Morelos, México.

<sup>4</sup> Departamento de Agricultura, Sociedad y Ambiente, El Colegio de la Frontera Sur Unidad San Cristóbal de Las Casas, Chiapas, México.

\* Corresponding author \*

E-mail address: TVGS ([tvgutierrez\\_santillan@yahoo.com.mx](mailto:tvgutierrez_santillan@yahoo.com.mx)), UPA ([upa677@hotmail.com](mailto:upa677@hotmail.com)), DVG ([dvalen@uaem.mx](mailto:dvalen@uaem.mx)), FRZ ([freyes@docentes.uat.edu.mx](mailto:freyes@docentes.uat.edu.mx)), LBV ([l.b.vazquez@gmail.com](mailto:l.b.vazquez@gmail.com)), AMO ([amorao@docentes.uat.edu.mx](mailto:amorao@docentes.uat.edu.mx)) and LUAM ([leo.arellano.mendez@gmail.com](mailto:leo.arellano.mendez@gmail.com))

## INTRODUCTION

Large scale information reviews and synthesis have been used in several disciplines as a new way for research (Kueffer *et al.* 2011), which are of two types: systematic reviews and meta-analyses, they're both useful for large data sets management and study, generating information for the theory development, in general (Lortie 2014). On the one hand, systematic reviews develop explicit methods to evaluate and filter information, allowing a replicable, but usually qualitative, review (Egger and Smith 1997). On the other hand, meta-analyses are statistical models, a mathematically simplified way of reality approaching provided by the data, integrating multiple independent studies, quantifying effects, describing processes structure, identifying patterns; thus allowing to increase the data reliability and identifying information gaps or omissions (ArchMiller *et al.* 2015; Gates 2002; Koricheva and Gurevitch 2014).

This type of approach has been used in social, biomedical and biological sciences (Arnqvist and Wooster 1995; Gates 2002). In ecology, they constitute a tool for the evaluation of research questions and decision-making based on evidence (Gates 2002). They are a promising future, by considering them as a means for primary research follow-up, researchers collaboration, financing funds optimal use, analytical strategies generators and large data sets integrators. Thus allowing us to emit critical recommendations, supporting scientific disciplines theoretical and methodological growth (Lortie 2014; Stewart 2009).

In ethnobiology, the use of meta-analysis has been proposed as a macroscopic approach, to identify knowledge patterns and

the use of natural resources (Albuquerque and Medeiros 2012), becoming a method that helps to understand the socio-ecological systems complexity. Suggesting that ethnobiological information integration, not to be only descriptive, but should be based on analytical support. For example, Torres-Avilez *et al.* (2016), develop a meta-analytical approach to identify patterns in knowledge among men and women concerning the use of medicinal plants at the local, continental and global levels; demonstrating that there is no gender pattern for knowledge at different scales; generating one of the first meta-analysis applications in ethnobiology.

Instead, systematic reviews have had greater application in ethnobiology. This is reflected in compilation studies such as latinamerican ethnobiological production for the last 50 years (Albuquerque *et al.* 2013) and in the evaluation of ethnozoology impact and development in Brazil (Lyra-Neves *et al.* 2015). In Mexico, they have been used to describe trends in knowledge, use, exploitation and domestication of plant resources (Bye and Linares 2000; Caballero *et al.* 1998). Several authors have documented the state of the art of ethnozoology for over a hundred years, reporting an increase in publications, a diversity of thematic areas, several indigenous groups and geographical areas (Argueta-Villamar *et al.* 2012; Brand 1962; Santos-Fita *et al.* 2012a). Also the description of the role of wildlife in traditional medicine (Alonso-Castro 2014).

Ethnozoology has positioned itself as one of ethnobiology's fundamental subdisciplines, focusing on the study of perceptual, cognitive and pragmatic relationships regarding fauna and human communities (Hunn 2011) understanding these relationships is fundamental for the

conservation and exploitation of zooculturally important species of vertebrates and invertebrates (Alves and Souto 2015). The increase in ethnozoological research provides primary information for developing meta-analytical approach and thus identifying trends, that is, the behavior pattern of ethnozoological research elements. In this case, the trends in mexican ethnozoological production regarding contribution variations in a given period of time (2005-2015), the types of generated documents, the diversity of addressed thematic areas, the ethnographic and biological methods used. Meta-analytical approach development allows to visualize a general and real landscape of the discipline, to detect research gaps and thus contribute with other forms of analysis; stating the basis for later studies.

Therefore, we evaluated the trends in ethnozoological production for wild vertebrates in Mexico, emphasizing their reach and diffusion at a national and international level, considering the following hypotheses: 1) Contributions are variable in the analyzed time period, having some years with greater production than others; 2) The different types of publications (indexed articles, divulgation articles, books, book chapters, undergraduate and postgraduate theses) directly contribute to the reach and diffusion, therefore the indexed and impact factor publications have an international effect, while the other document types only have a national level impact; 3) The research diversity from several thematic areas provide a wider access for the discipline, so all the involved areas must meet the methodological criteria at the ethnographic and biological level; 4) The research approach (qualitative/quantitative) is related to the selection of ethnographic and biological methods, so both approaches

must reflect an adequate methodological development; 5) The increase in ethnozoological research reflects the connection between researchers and institutions, this guarantees the discipline's consolidation. All these variables will allow to recognize the current trends of ethnozoology in Mexico, and at the same time, identify if there are any information gaps, allowing us to issue recommendations for its development, standardization and consolidation.

## **MATERIAL AND METHODS**

### **Publishing selection**

We searched for ethnozoological publications for wild vertebrates conducted between 2005 and 2015 following a hierarchical method. In the first place, we made an electronic search in catalogues, repositories and databases at the Web of Science ([www.isiknowledge.com](http://www.isiknowledge.com)), Scopus ([www.scopus.com](http://www.scopus.com)) and the Consorcio Nacional de Recursos de Información Científica y Tecnológica de México ([www.conricyt.mx](http://www.conricyt.mx)). In the second stage, through direct author contributions; this is followed by a review of the publications cited literature, since some of the documents included in this review are not available on the internet. However, we assume that this complementary method may bias the data integration and the results, but we decided to continue in order to integrate as much information as possible.

The publications search was carried out from January to December 2015, collecting publications from 1936 to 2015. Arbitrarily delimiting information between 2005 and 2015, so additionally, to find out if the included data within this time frame was

statistically representative for the minimum sample size, we used the Cochran test (1953); the result was represented by a total of 202 publications with a 95% confidence level, amount reached between 2015 and 2010. Therefore, the established time frame (2005-2015) did not just allow to have a representative sample, but to consider the entire data population.

The search terms were established by using a combination of keywords, fulfilling with one of the criteria for meta-analytical approach development (Gates 2002). The first one was to frame the discipline (Ethnozoology, Ethnobiology, Ethnoecology), the second one was for determining the object of study (mammals, birds, reptiles, amphibians, fish), the third one included thematics (perception, knowledge, use, management, traditional classification) and the fourth one was the geographic region (Mexico).

We made a spatial analysis by using the recorded coordinates within the checked articles. This information was georeferenced, and when there were no coordinates, they were assigned through study zones description (locality, municipality, state) by using the Google Earth software (2016). In order to get the sample spatial representation, we used the publications georeferences, geographic territories (localities, municipalities and federative entities), vegetation types and indigenous territories as layers (De Ávila 2008); using the ArcView GIS Ver. 3.2 software (ESRI 1999).

### **Inclusion criteria, data extraction and variables coding**

The types of publications included in this review were articles with an impact factor, indexed articles (without an impact factor),

dissemination articles, books, book chapters, graduate and postgraduate theses; every publication had assigned an identification number, nationals and internationals. A database composed of four information sets was built. We worked with categorical variables to which a value (coding) was assigned; a variable could work as independent and/or dependent according to the type of evaluating tendency. Some variables were completed with additional information from an online search (e.g. impact factor, indexing). Information sets description, variables and values assignment are shown in Table 1.

### **Data analysis**

A non-parametric Wilcoxon test was run through the STATISTICA software (StatSoft 2004), in order to determine if there are any significant differences in annual production, using data from publications for years. We also performed Kruskal-Wallis ANOVA (K-W) tests for independent groups, followed by Tukey's multiple comparison test (Zar 2010). The significant differences between the types of publications and the years of study, the reach (national or international) and the thematic areas were evaluated. We exclusively analyzed the data corresponding to articles with impact factor, indexed and divulgation; in relation to the reach and thematic areas. In general, methodological aspects were explored by relating the diversity of thematic areas and the research focus (qualitative/quantitative); the objectives and hypotheses establishment and the selection of ethnographic methods. Likewise, the relationship between ethnographic methods and the use of ethnographic tools (types of interviews) was evaluated, as well as the selection of biological field methods for data collection and species taxonomic

**Table 1.** Legend: Variables categorization, the number in parentheses represents the assigned value.

Variable	Type	Description
Year	discrete	Range: 2005 to 2015
Publication types	categorical/ coded	Impact factor article (1), index article (2), scientific diffusion article (3), book (4), book chapter (5), others (6; institutional website and project), postgraduate thesis (7; doctorate, master), undergraduate thesis (8; monographs, professional residency records)
Reach	discrete	international (1), national (2)
Impact factor	discrete	impact factor (1), no impact factor (2)
Discipline	categorical/ coded	ethnology (1), ethnodisciplines (2; ethnobiology, ethnobotanics, ethnoecology, ethnopharmacology, ethnohistory), biology (3), anthropology (4), others (5; medicine, geography, generals)
Objective Hypothesis	discrete	yes (1), no (2)
Ethnographic method	categorical/ coded	yes (1), no (2)
Ethnographical tool	categorical/ coded	statistical (1; random, probabilistic), ethnobiological (2; snowball, stratus, key informants, banking memory, percentage, participatory appraisal), bibliographical (3), unspecific (4)
Research type	discrete	specific interviews (1; open, directed, structured, semistructured, free multiple listing interviews), interview (2), workshops (3), informal (4), bibliographical (5), multiple (6), unspecific (7)
Data analysis	discrete	qualitative (1), quantitative (2), unspecific (3)
Biological method	categorical/ coded	statistics (1; parametric, nonparametric, multivariate), ethnobiological (2; index of cultural importance, use value), multiple (3), biological (4), none (5)
Taxonomical group	categorical/ coded	biological (1; sightings, nets, collections, photocameras, bioassays, biological collections), records (3), ethnobiological (3; biocultural tours, traditional names, field guides, visual stimuli, interviews), multiple (4), unspecific (5)
		mammals (1), birds (2), amphibians and/or reptiles (3), fish (4), combined (5), unspecific (6)

identification.

Finally, ethnozoological study networks were identified through a non-metric multidimensional scaling analysis (NMDS). By identifying universities or institutions with a bigger ethnozoological production contribution, as well as associated researchers. We used the Past 3.07 statistical software (Hammer *et al.* 2001) and as a similarity measure the Euclidean distances, where the variables corresponded to the institutions, and the observations corresponded to the authors.

## RESULTS

### Generalities ethnozoological

We got 295 publications for the 2005-2015 period (Supplementary Material), of which the most representative are the book chapters and the divulgation articles being the 47% of the sample. The main studies contribution comes from the ethnozoological area (63%), but contributions from other disciplines are also available. On the other hand, when analyzing some methodological aspects it is observed that most of the

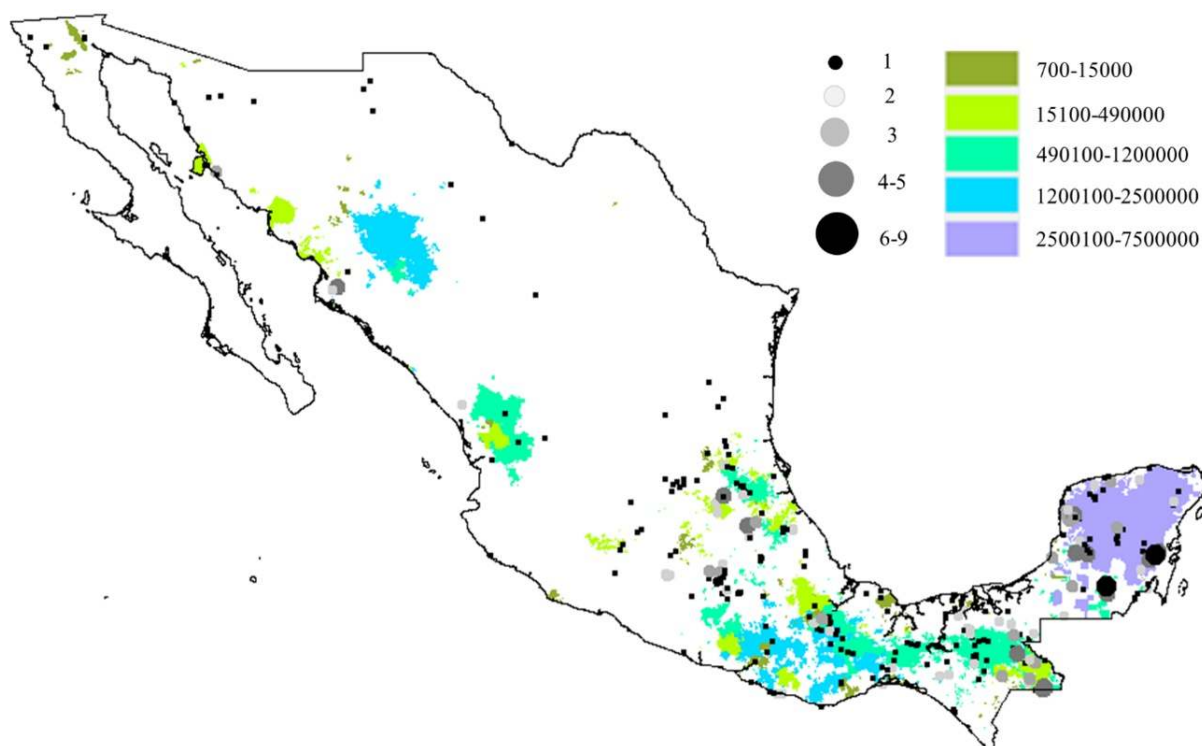
researches are framed to a goal, but only a few state a hypothesis.

Most publications do not report the selection of their ethnographic methods, of which only 2% have chosen representative methods at a statistical level. About the ethnographic tools, a combination of techniques is usually used (e.g. interview, participatory observation, workshops). Continuing with methodological aspects, there is a predilection for qualitative approach research (60%), so the data analysis application at the statistical, ethnobiological and biological level is uncommon (25%). Regarding field biological methods, half the publications don't report which technique did they use. The vertebrate groups with the largest number of studies are mammals and birds (Table 2).

On the other hand, the publications spatial representation is heterogeneous (Fig. 1). The geographic territories information is:

242 localities, in 177 municipalities, in 27 of the 32 states of the Mexican Republic; including the states of: Baja California, Campeche, Chiapas, Chihuahua, Mexico City, Durango, State of Mexico, Guanajuato, Guerrero, Hidalgo, Jalisco, Michoacan, Morelos, Nayarit, Oaxaca, Puebla, Queretaro, Quintana Roo, San Luis Potosi, Sinaloa, Tabasco, Tamaulipas, Tlaxcala, Veracruz, Yucatan and Zacatecas.

The studies in general include these types of vegetation: temperate forests (pine-oak), boreal forests (cloud forest), tropical forests (high, medium and low, evergreen, subperenifolio, deciduous and sub-deciduous) shrubs, as well as agricultural areas. Reported indigenous groups represent 52% (n=32) of the total, corresponding to: Amuzgo, Cho'l, Chinantec, Chontal from Oaxaca, Chontal from Tabasco, Cucupa, Cuicateco, Huasteco, Huave, Huichol, Kiliwa, Maya, Mayo,



**Figure 1.** Distribution of ethnozoological publications and indigenous territories in Mexico (the points represent the number of publications per site, while the colored boxes the indigenous area in hectare).

**Table 2.** Legend: Publications descriptive data

Generalities	Description
Number of Publications between 2005-2015	The years with the larger number of papers are 2010 (n=59), 2011 (n=39), 2014 (n=38) and 2012 (n=31) representing 57% of the total sample. The remaining percentage is represented between the years 2013 (n=29), 2008 (n=22), 2009 (n=19), 2007 (n =17), 2006 (n=16) and 2015 (n=11).
Publication types and reach	There are book chapters (27%), scientific diffusion articles (20%), impact factor articles (15%), index articles (14%), undergraduate thesis (11%), postgraduate thesis (9%), books (3.5%) and others (0.5%). Of the total sample, 75% have a national or local impact, so 25% is at an international level.
Thematic areas	63% (n=188) of the research are developed from ethnozoology, 11% (n=32) from ethnosciences, 20% (n=60) from biological areas, 4% (n = 10) from the anthropological areas and 2% (n=5) from other disciplines.
Methodological aspects	80% of research is based on a research question or objective, however, only 2% poses a hypothesis. In addition, 2% developed a statistical ethnographic method, 27% ethnobiological, 10% bibliographical and 60% non-specific. This is related to the type of ethnographic tool, where 25% use a combination of techniques, 24% doesn't specify, 19% reports some type of interview, 15% only admits using an interview format without specifying what type, 2% organized participatory workshops and 1% used informal information.
Focus and data analysis	There is a predilection for developing qualitative research (60%), 25% of the information is quantitative, but there are a number of papers that don't report any approach (15%). The quantitative approach is related to the data analysis, in this case were considered as quantitative all papers reporting the use of statistical tests (9%), data analysis with ethnobiological indexes (8%), analysis type combinations (7%) and biological indexes (1%).
Biological method and vertebrate classes	Most investigations choose to work more than two vertebrate classes (30%). The best represented class is mammals with 22%, followed by birds with 20%, amphibians and reptiles with 12% and the least worked class are fish with only 2%. Vertebrate classes are associated with field methods and their taxonomic identification, however, it is observed that 50% of the publications do not report the type of biological method, 23% is based on previous species records, 12% in ethnobiological methods, 8% use combined techniques and only 4% report some field technique.

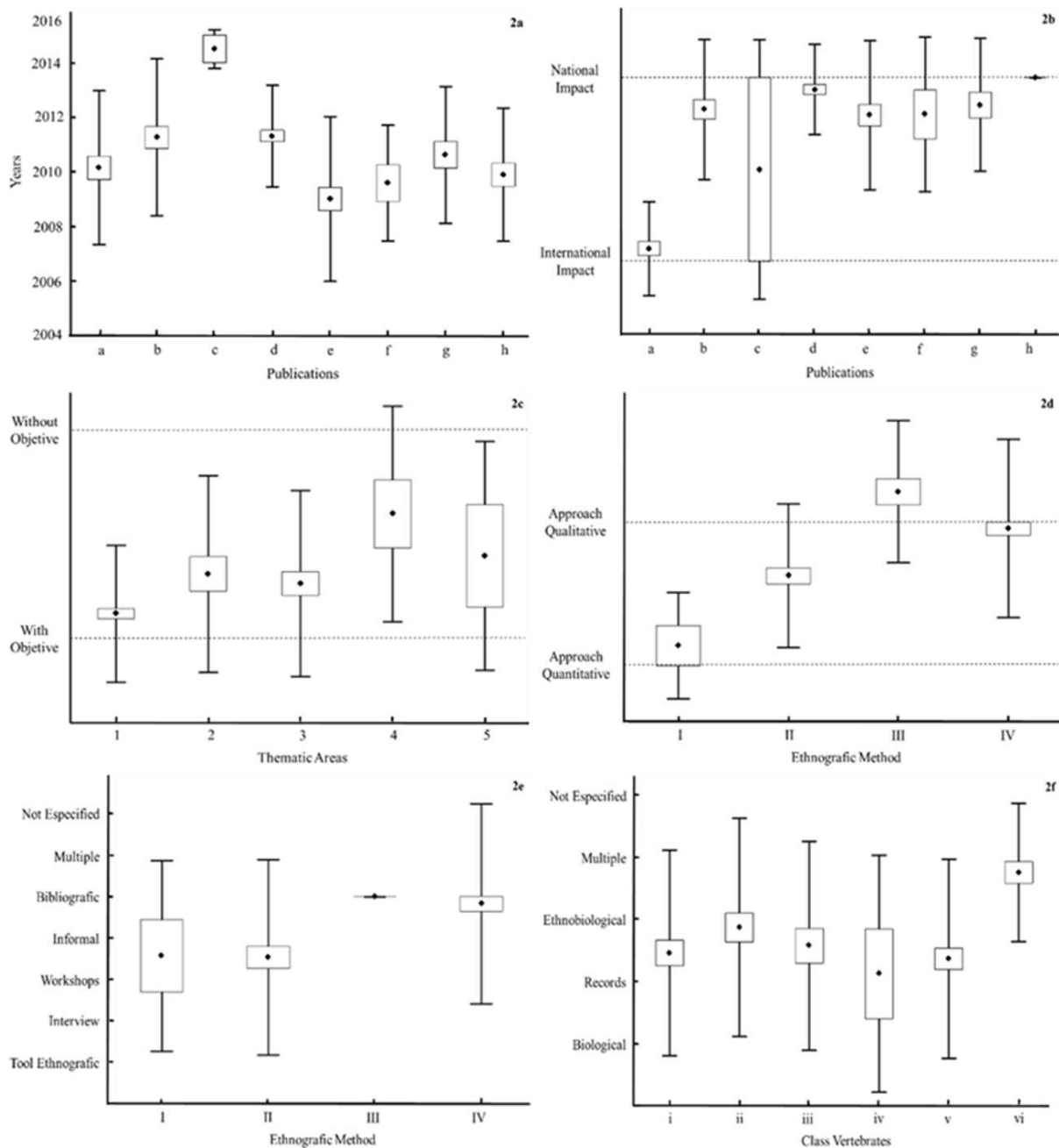
Mazahua, Mazateco, Mixe, Nahuatl, N̄hañhu, Paipai, Pima, Seri, Purhepecha, Tepehua, Tepehuano, Tlahuica, Tojolabal, Triqui, Tselal, Tsoltil, Zapoteco and Zoque; the Afro-Mexican and mestizo populations were also included.

### Meta-analytical approach

Meta-analytical approach ethnozoological

production shows a significant difference in the number of publications between the evaluated years ( $z=14.8870$ ,  $p<0.05$ , Fig. 2a). So do the types of publication when linking to national and international level reach ( $H=140.6785$ ,  $p<0.05$ ; Fig. 2b), as well as with thematic areas ( $H=18.6838$ ,  $p<0.05$ ).

Concerning the publication types, we only analyzed the article corresponding data sets (impact factor, indexed and divulgation),



**Figure 2.** Meta-analysis. 2a. Relation between the evaluated years and the publication types (a = article with impact factor, b = indexed article, c = other, d = book chapter, e = scientific diffusion article, f = book, g = postgraduate thesis, h = undergraduate thesis), 2b. Reach (national or international) and types of publications, 2c. Establishment of research objectives and thematic areas (1 = ethnozoology, 2 = ethnodiscipline, 3 = biological, 4 = anthropology, 5 = another), 2d. Research focus (qualitative / quantitative) and ethnographic method (I = statistical, II = ethnobiological, III = bibliographic, VI = unspecified), 2e. Type of ethnographic tool and ethnographic method, 2f. Biological field method and vertebrate class (i = Mammalia, ii = Birds, iii = Amphibia and Reptilia, iv = Pisces, v = combined, vi = unspecified).

showing a statistical variation in the production and the national and international level reach ( $H=69.4995$ ,  $p<0.05$ ; Fig. 3a). At the international level, the trend is given within the articles published in impact factor journals ( $n=44$ ), in a range between 0.194 and 4.165. The journals with the larger amount of publications are: Human Ecology, Interciencia, Journal of Ethnopharmacology and Journal of Ethnobiology and Ethnomedicine (Table 3). We watched another trend when linking the impact factor, indexed and divulgation articles with thematic areas ( $H=14.9216$ ,  $p<0.05$ ; Fig. 3b). Where the main impact factor articles contribution is encouraged from biological areas; while ethnozoology and the other ethnodisciplines produce a bigger amount of indexed (without impact factor) and divulgation articles.

Mostly, when analyzing the methodological approach variable (qualitative/quantitative) the trend is in the qualitative research development, showing it is significant in relation to thematic areas ( $H=20.0930$ ,  $p<0.05$ ). There are also statistical differences between the different thematic areas and the goals setting or research questions ( $H=22.9639$ ,  $p<0.05$ ; Fig. 2c). On the other hand, when relating the "ethnographic method" and "thematic areas" variables, this didn't show statistical variation, indicating that there is no predilection for any particular method. However, it did show up when analyzing the types of ethnographic methods and the qualitative or quantitative research approach ( $H=35.8335$ ,  $p<0.05$ , Fig. 2d). As well as linking the ethnographic methods with the types of data analysis ( $H=24.5070$ ,  $p<0.05$ ). A methodological section indicative variable is the type of ethnographic tool (type of interview) which, linked to ethnographic methods, shows a variation in the selection

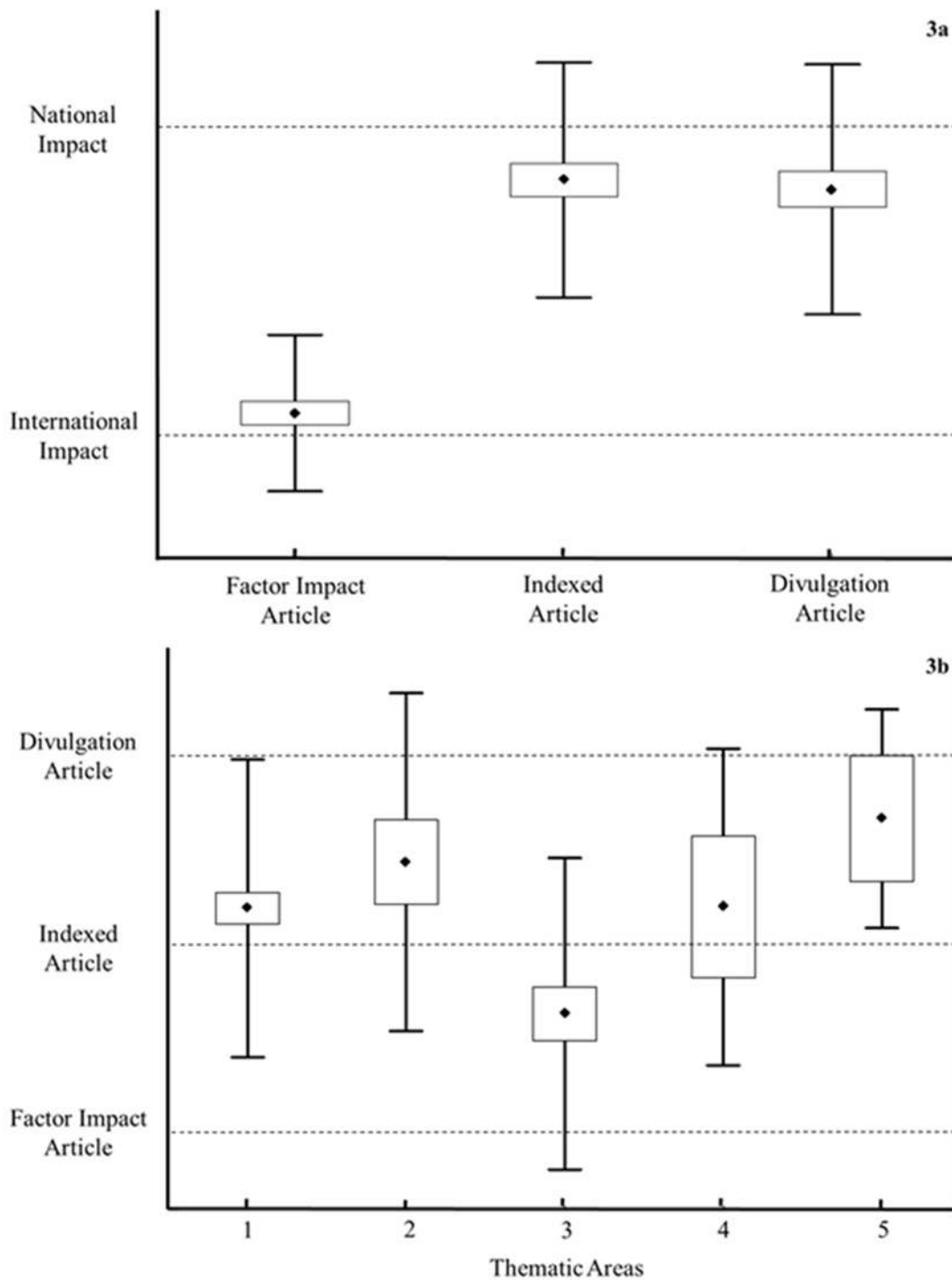
( $H=26.1134$ ,  $p<0.05$ , Fig. 2e). At last, another evaluation parameter was the biological field method for species data collecting, which, when related to biological groups, show statistical differences ( $H=27.1214$ ,  $p<0.05$ , Fig. 2f). The description of the internal heterogeneity between the relationship of the variables is described in Table 4.

### **Ethnozoological academic networks**

There were 94 institutions with affiliated authors, of which 56% corresponded to national institutions and 42% to international institutions. 93% of the citations were concentrated in 58 institutions (national and international), amount obtained from all those institutions that were represented at least twice in the sample.

The result in the NMDS analysis shows the lack of linkage and thus the absence of networks between institutions and authors ( $n=426$ ), from which 72% are represented only once, while the rest rank from 2 to 27 citations, in which they're not necessarily as the primary or correspondence author, in this category we didn't consider if they were interdisciplinary groups leaders, co-participants or students (Fig. 4).

The universities with the highest number of citations are: Universidad Nacional Autónoma de México ( $n=91$ ), Colegio de la Frontera Sur Unidad San Cristóbal de las Casas - Chiapas ( $n=79$ ), Universidad Autónoma de Campeche ( $n=28$ ), Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional - Unidad Mérida ( $n=22$ ) and Instituto Tecnológico del Valle de Oaxaca ( $n=21$ ).



**Figure 3.** Meta-analysis considering only articles with impact factor, indexed articles and scientific diffusion articles. 3a. Relationship between types of articles and reach at national or international level. 3b. Relationship among thematic areas (1 = ethnozoology, 2 = ethnodiscipline, 3 = biological, 4 = anthropology, 5 = other) and article types.

**Table 3.** Citations that correspond to journals with impact factor in which articles of mexican ethnozoology have been published in a period from 2005-2015.

NOTE: The update of the impact factor of the journals was done on October 25, 2017.

Journal	Impact Factor	Number of publications	Citations
Conservation Biology	4.842	(n=1)	Haenn et al. 2014
Biological Conservation	4.022	(n=1)	Naranjo and Bodmer 2007
Journal of Ethnopharmacology	2.981	(n=4)	Alonso-Castro et al. 2011; Jacobó-Salcedo et al. 2011; Jacobó-Salcedo et al. 2013; Alonso-Castro 2014
Journal of Research in Crime and Delinquency	2.545	(n=1)	Pires and Clarke 2012
Biodiversity and Conservation	2.265	(n=2)	Vázquez and Gaston 2006; Reyna-Hurtado and Tanner 2007
Oryx	2.191	(n=2)	Reyna-Hurtado et al. 2009; Amador-Alcalá et al. 2013
The Auk	2.096	(n=1)	Haemig 2012
Journal Ethnobiology and Ethnomedicine	1.903	(n=5)	Santos-Fita et al. 2012, Alcántara-Salinas et al. 2013; Zamudio et al. 2013; García del Valle et al. 2015; Santos-Fita et al. 2015
Human Ecology	1.743	(n=6)	Barragán et al. 2007; Arce-Ibarra and Charles 2008; León and Montiel 2008; Garcia-Alaniz et al. 2010; Mancini et al. 2011; Basurto et al. 2012
Biotropica	1.73	(n=1)	Reyna-Hurtado and Tanner 2005
Acta Oecologica	1.652	(n=1)	Kampichler et al. 2010
Journal of Ornithology	1.468	(n=1)	Haemig 2010
Fisheries Management and Ecology	1.327	(n=1)	Inda-Díaz et al. 2009
The International Forestry Review	1.308	(n=1)	Ibarra et al. 2011
Tropical Conservation Science	1.238	(n=3)	Rodas-Trejo et al. 2008; López del Toro et al. 2009; Oliva et al. 2014
Journal Ethnobiology	1.217	(n=2)	Eckert and Clark 2009; Rodríguez et al. 2012
Wildlife Society Bulletin	0.967	(n=2)	Valdez et al. 2006; Weber et al. 2006
Revista Mexicana de Biodiversidad	0.596	(n=3)	Delfín-Alfonso et al. 2008; Ávila-Nájera et al. 2011; Almazán-Catalán et al. 2013
Revista de Biología Tropical	0.495	(n=2)	Gallina et al. 2012; Lira-Torres et al. 2012
Interciencia	0.221	(n=5)	Enríquez-Vázquez et al. 2006; Romero-Balderas et al. 2006; Monroy-Vilchis et al. 2008; Toledo et al. 2008; García-Grajales 2013

**Table 4.** Variables relation at a statistical level, using Tukey's multiple comparison

<b>Variables</b>	<b>Tukey's multiple comparison</b>
Evaluation period (2005-2015)	The differences are not only shown between evaluated years, but also when relating years with publication types ( $H=30.8811$ , $p<0.05$ ); heterogeneity shown between divulgation periods and indexed articles ( $z=3.9962$ , $p<0.05$ ) and with book chapters ( $z=4.0009$ , $p<0.05$ ; Fig. 2a)
Publication types, and national and international reach	Publication types regarding to national and international reach show a high heterogeneity among all the types of evaluated documents, e.g. impact factor and indexed articles ( $z=6.4048$ , $p<0.05$ ), divulgation articles ( $z=6.0587$ , $p<0.05$ ), book chapters ( $z=7.9578$ , $p<0.05$ ), books ( $z=3.6120$ , $p<0.05$ ) undergraduate thesis ( $z=6.9967$ , $p<0.05$ ) and postgraduate thesis ( $z=5.5429$ , $p<0.05$ ). There is also a statistical difference between publication types and thematic areas, shown between impact factor articles and undergraduate thesis ( $z=3.1689$ , $p<0.05$ ). Another example happened exclusively for document type articles, showing differences between impact factor and indexed articles ( $z=6.3937$ , $p<0.05$ ), and in turn, with divulgation articles ( $z = 6.0481$ , $p < 0.05$ ).
Thematic areas	The bigger difference for "thematic areas" variable, happens between biological areas and ethnozoology ( $z=2.9749$ , $p<0.05$ ).
Methodological aspects	The internal variation between the "ethnographic methods" and "research approach" (qualitative/quantitative) variables is shown between the statistical methods choosing against bibliographic ones, as well as with publications that don't report any method type at all ( $z=3.7296$ , $p<0.05$ ; $z=3.0975$ , $p<0.05$ ). In addition, between ethnobiological methods against bibliographic works, and also with those that don't report any method type ( $z=3.8975$ , $p<0.05$ ; $z=3.4357$ , $p<0.05$ ).
Data analysis	Regarding data analysis, we watched a variation between statistical methods and the ones of the bibliographical type ( $z=3.1097$ , $p<0.05$ ) and those which don't specify no method at all ( $z=2.7681$ , $p<0.05$ )
Ethnographic tools (interviews)	The variation between ethnographic method types and ethnographic tools design (interviews) is present between the researches that don't report the tool type regarding the use of ethnobiological tools ( $z=4.7507$ , $p<0.05$ )
Biological method and vertebrate classes	The difference in biological methods development is shown between the studies that don't report any species and the ones that report mammals ( $z=3.9220$ , $p<0.05$ ), also with herpetological data ( $z=2.9810$ , $p<0.05$ ) and with those that report more than two classes of vertebrates ( $z=4.4242$ , $p<0.05$ ).

## DISCUSSION

### Meta-analytical approach

The results suggest that there are significant differences in most of the analyzed variables, a trend observed when quantitatively analyzing the effect of

variables that can't be perceived descriptively (Adams 2007; Stewart 2009). Our variables categorization based research, allowed the development of the meta-analytical approach with ethnobiological data (Albuquerque and Medeiros 2012; Torres-Aviles *et al.* 2016) establishing variables that explain the effect magnitude and its

variability (Arnqvist and Wooster 1995; Gates 2002; Koricheva and Gurevitch 2014; Stewart 2009). Thus, supporting trends and allowing the identification of information gaps (Egger and Smith 1997; Lortie 2014), that is, research development factors in which we must pay attention either at a conceptual, methodological or analytical level; contributing to the growth of the discipline and generating a new research culture (Adams 2007; Kueffer *et al.* 2011).

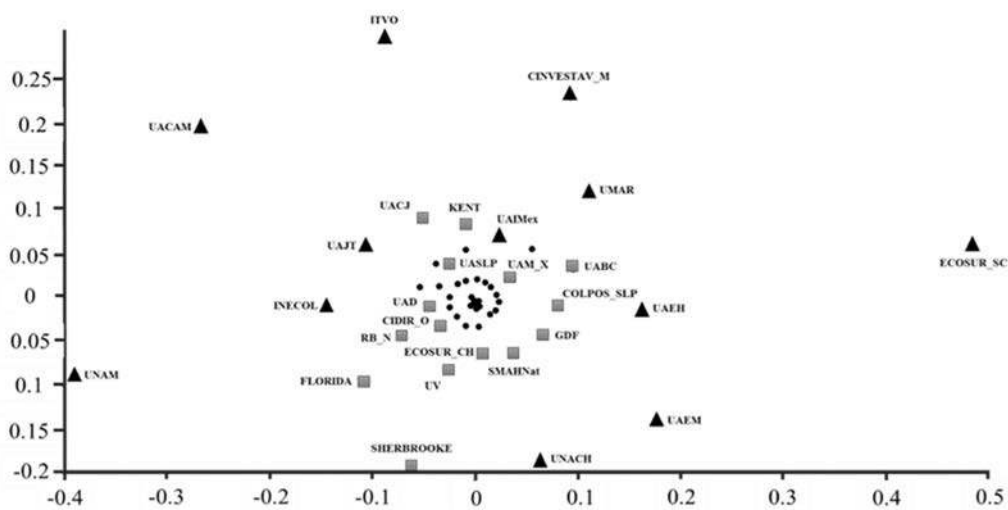
The first step for meta-analytical approach development is integrating primary information, which based on keyword sets meets one of the criteria, on information selection and studies are considered as independent samples (ArchMiller *et al.* 2015; Gates 2002). However, due to the publications diversity, it wasn't possible to include only those in article format, as well as complementing the sample with authors direct contributions. We assume that both factors contribute on generating biases in data integration and the analyzes. But we consider that as a whole the information is integrated to evaluate a more real panorama of the discipline. Emphasizing that all the included contributions had the variables corresponding data.

Regarding the data analysis, we observed that there is a discontinuity in the review period, because there are years in which the number of contributions increases, phenomenon related with the organization of academic events and the publication of chapter format books (Guerra-Roa *et al.* 2010; Moreno-Fuentes *et al.* 2010; Santos-Fita *et al.* 2012a; Vásquez-Dávila 2014). On the other hand, there is a heterogeneity in the publication types, which is determined by the diversity of thematic areas. Identifying a marked tendency between the publication of impact factor articles, biological areas and the application of quantitative

methodologies. While from ethnozoology and anthropology to the publication of indexed articles (without impact factor), divulgation articles and book chapters; as well as the preference for qualitative research, the same trend described in other reviews (Lyra-Neves *et al.* 2015).

The evaluation about methodological aspects detected that the researches no matter the type of manuscript or thematic area are framed under one single goal, however, there are few cases in which a hypothesis is established. On the other hand, we also detected a confusion between the ethnographic method (selection of informants) and the ethnographic tools (interview format); usually assuming, that they're two similar methodological aspects (Albuquerque *et al.* 2014), affecting the informers sample type and their selection; as well as the ethnographic data gathering through interviews or other tools (Lyra-Neves *et al.* 2015).

We also detected that when relating the manuscript types with the thematic areas, there is a tendency in the application of statistical analysis and researches with a biological approach. Meanwhile in ethnozoology is preferred to apply ethnobiological indexes, such as cultural importance and use value. There is no index for ethnozoology to evaluate directly the zoocultural importance, since the ethnobiological indices have been designed for plants and fungi, which are integrated by sub-indices of each biological group and their ethnobiological parameters (Garibay-Orijel *et al.* 2007; Phillips and Gentry 1993a; 1993b; Pieroni 2001; Turner 1988). Therefore, it is essential to design indexes that evaluate zoocultural importance, including animal exclusive variables, explaining their socio-cultural relationship. For example, the role of animals as pets, in



**Figure 4.** Institutions that have a sample contribution of more than 10 publications are represented with the triangle icon, while those that range between 9 and 5 publications with a square icon and those with less than 4 publications within the analyzed sample, with a point icon (stress value: 0.1681).

hunting and captivity activities; including oral tradition, symbolism, myths and arts (Alves 2012); or perceptual, ceremonial, ornamental and medicinal level; variables shared with plants and fungi but that operate differently for animals.

At last, in relation to the application of biological methods for the taxonomic identification of vertebrate species, on the one hand, methods of each biological group are used, but there is also a tendency to use published data on species records. As well as the application of ethnobiological methods, for example, the use of visual stimuli (Albuquerque *et al.* 2014; Alexiades 1996) or based on traditional nomenclature. However, ethnobiological methods don't provide a correct taxonomic identification. Therefore, it's essential to establish field methods to improve taxonomic identifications and their association with traditional nomenclature, knowledge and traditional practices.

Detecting such trends suggest paying attention to the lack of homogeneization

within ethnozoological research, about what's being published (Lortie 2014) and how does this affect at a national and international level (Campos *et al.* 2016). This is not for thematic areas discrimination, nor considering quantitative method is better than qualitative. But there is a need to start framing ethnozoological researches with a more unified focus, independently from the thematic area they come from. This could give more methodological robustness and support in results interpretation (Albuquerque and Medeiros 2012; Campos *et al.* 2016); just as information production that helps for later studies, like meta-analytical approach development or new ethnobiological research programs (Albuquerque and Ferreira-Júnior 2017).

A bigger interest for developing ethnozoological research is evident, but we must consider that, for the discipline to impact at an international level, it is essential to produce indexed and impact factor articles. This publication type has a review from the editorial committee, evaluated by

pairs, many are free access, with high online availability (Ladle *et al.* 2012; Lortie *et al.* 2013; Teixeira *et al.* 2013) and are considered fundamentals of science as a clear and well structured argument to support assumptions (Todd *et al.* 2007). Thus, the publications that don't fit under international publishing criteria, are considered as gray literature (Gates 2002) because they're local, low divulgation, low online access and a lack of an editorial rigor process (Campos *et al.* 2016; Ladle *et al.* 2012). This aspects generate an effect known as academical insularity, in which local authors are redundantly and wrongly cited, without giving credit to original ideas; thus generating a low scientific contribution (Campos *et al.* 2016; Ladle *et al.* 2012; Lortie *et al.* 2012; Teixeira *et al.* 2013).

However, it must be considered that the low ethnozoological research input under indexed and impact factor article formats at a national and international level, is due to a lack of specialized, open access journals, high publishing costs (Campos *et al.* 2016; Ladle *et al.* 2012) and the reduced or null research budget. There are international impact factor journals at the ethnobiology area and even ethnobotanics, but not in ethnozoology, despite being a discipline that has been taking its boom for the last years at an international level (Alves 2012; Alves and Souto 2015). Aspects which directly affect and difficult contributions to the discipline, its consolidation, divulgation and access.

### **Ethnozoological academic networks**

Information macroscopical approach provides a general landscape about ethnozoological research networks within the country. Showing a reduced linkage between researchers and national institutions, and

these to the international level. We can quote the interest for research groups aiming to establish agendas and forming research networks. For example, the thematic network in *Ecología y Patrimonio Biocultural*, supported by Consejo Nacional de Ciencia y Tecnología CONACyT ([http://etnoecologia.uv.mx/Red\\_paginaprincipal.html](http://etnoecologia.uv.mx/Red_paginaprincipal.html)); however, the network approach includes all ethnobiological areas, as well as other disciplines.

The reduced linkage between institutions and researchers reflects the lack of consolidated researchers, low formation of new human capital and thus the recent creation of study groups. This has an indirect influence in its consolidation, publishing, impact and diffusion at a national and international level (Albuquerque *et al.* 2013; Campos *et al.* 2016; Sutherland *et al.* 2013).

However, one of the most outstanding cases about the growth and consolidation of ethnozoology has been shown by the Brazilian scientific community, which can be a reference for Mexico. The Brazilian strategy is characterized by the periodic publication of ethnozoological articles in impact factor journals at ethnobiological discipline areas (e.g. *Journal of Ethnobiology and Ethnomedicine*), as well as in other biological areas (Alves *et al.* 2017; Fernandes-Ferreira *et al.* 2012). The publication of books in format of edited and qualified impact factor chapters (Alves and Rosa 2015), the creation of a publishing house that prints local production books (NUPEEA, <http://www.nupeea.com>), a master's degree postgraduate and doctorate in which ethnozoological themes are included (Programa de Pós Graduação em *Etnobiologia e Conservação da Natureza*, UFRPE) and recently the indexing of the journal *Ethnobiology and Conservation* at InCites Journal Citation Reports.

Ethnobiology in general is a young science compared with others (Campos *et al.* 2016), while ethnozoology is seen as a recently created discipline (Alves 2012; Alves and Souto 2015; Lyra-Neves *et al.* 2015). Therefore, it is essential to generate academical spaces and workshops, where the conceptual and theoretical bases are taught, as well as the right methodologies for the collection of biological and ethnographic data, emphasizing its management and application (Albuquerque *et al.* 2014), also the integration of undergraduate and postgraduate students in order to generate new approaches and research questions (Albuquerque and Medeiros 2012; Sutherland *et al.* 2013). Arousing the interest in other sciences, such as conservation ecology, which currently considers ethnobiology, including implicitly ethnozoology, as a powerful tool to support the understanding of socio-environmental phenomena, which contribute to the conservation of ecosystems and their species (Albuquerque and Ferreira-Júnior 2017; Gavin *et al.* 2015; Huntington 2000; 2013; Saslis-Lagoudakis and Clarke 2013).

## CONCLUSIONS

The meta-analytical approach identified a delay and a bias in mexican ethnozoological publishing, directly affecting its impact at a national and international level. The variables included within the analysis have allowed flows and trends evaluations. Identifying that, although there is no primary information homogeneization, it is possible to make a good data treatment, fulfilling some selection criteria and meta-analytical approach development in ethnozoology and ethnobiology.

Meta-analytical approach helped identifying information gaps at a theoretical-

methodological level, this phenomenon is possibly alike in other ethnobiological disciplines and at other scales. Identifying discipline's weaknesses is not a criticism but an evaluation, with the purpose of designing a reference frame to emit a series of recommendations. This allows a research structuration improvement in the different ethnobiological disciplines, specially ethnozoology, standardization in collecting, processing and analyzing ethnographic and biological data, as well as its publication which impacts nationally and internationally. With this, supporting the discipline consolidation and optimal development in future research.

Our research allowed to reevaluate the primary information contribution, generating a new culture for doing ethnobiological research, by identifying patterns aren't possible at a local scale isolated or descriptively. Proposing its viability to understand socioecological systems, generating data which supports other disciplines, for example, conservation ecology, which is recently showing interest for human-ecosystem interactions in managing and designing biological conservation programs.

## FINAL CONSIDERATIONS

### **Recommendations for an ethnozoological work standardization**

In order to standardize the design, compilation, processing and analysis of data in the ethnobiological, and in particular, ethnozoological works, a series of general recommendations is issued. Considering basic principles in scientific research, ethnobiological methodological aspects, analysis of qualitative and quantitative data; as well as biological groups identification

methods. These considerations should be applied to ensure the success, the right study execution and to give robustness to the collected data. Always paying attention to cultural peculiarities, so each researcher must select methods that meet their objectives better (Albuquerque *et al.* 2014).

1. Research question, goal and hypothesis. We must design questions that promote the ethnozoological discipline, more than the direct importance of the answer. Establishing an agenda in order to improve the general understanding of basic ethnobiology, as suggested in ecology (Sutherland *et al.* 2013). A research question or objective of undergraduate thesis, postgraduate thesis, research project or article, it is recommended to be punctual and not ambitious, as well as having the same level of ethnographic and biological contribution. The hypothesis must be designed a priori, and not a posteriori, considering that it is not always answered in a statistical way, but based on data (qualitative or quantitative). These research sections, are determinant for the ethnographic method design and selection, ethnographic tools, biological field methods and data analysis.

2. Study area selection: It must preferably be done under biological-ecological interest, socio-cultural interest (or both) criteria; avoiding choosing a study site under the researcher's preference criteria. Using maps (Geographic Information Systems, GIS), we analyze potential sites previously unstudied or associating them with certain conditions. Variables of interest are added such as vegetation types, vegetation cover, access paths, amount of inhabitants, native language speaker percentage, among others.

3. Ethnographic sample selection and informant types: We recommend to apply a

combination of methods mentioned on specialized literature (Albuquerque *et al.* 2014; Bernard 2000; Martin 1995). Some suggestions for a qualitative approach are development under participatory research, joint and community action; this approach type is recommended when the goal is to work with key informants or at applied research, because it allows to get closer to the communities. The quantitative approach is based on selecting a representative sample, it can be statistical by using the minimum sample size (Cochran 1953). Using the percentage method, usually by randomly selecting 10% of the total of a population (Bernard 2000), or by applying the snowball technique, which is directed by the informants themselves (Berg 1983). In all cases we must have free, previous and informed consent; as well as recognizing and safeguarding the rights of ownership and custody of informants' knowledge (International Society of Ethnobiology 2006; <http://ethnobiology.net/code-of-ethics/>). We also propose to consider the informants as research collaborators depending on the level of confidence, this is common when working with key informants.

4. Ethnographic tools: are the interview types (structured, semi-structured, multiple free listing, etc.), observation and participative workshops, use of audio and video (Albuquerque *et al.* 2014; Alexiades 1996; Bernard 2000). Its design depends on the research question and the methodological approach, we recommend a tool combination in order to maximize data collection, as well as including all of the interest variables.

5. Databases: Designed in several types of software, and the number of fields depends on the variables and subvariables included within the ethnographic tools. They must be simple and make data management

easy, based on matrix theory we can use binary code (presence, absence) as proposed in macroecology (Arita *et al.* 2008), or we can use ordinal matrix designs (Ryan *et al.* 2000). This matrix type can be designed in any spreadsheet software, with the advantage of organizing either qualitative and quantitative data. We also must consider data organization is related to applied ethnographic tools.

6. Data analysis: May include this analyses: a) ethnobiological, such as cultural importance and use value; b) statistical, descriptive, parametric, non-parametric and multivariate statistics; and c) ecological, richness and diversity indexes, species accumulation curve. Their application is right just as long as the data fulfill the theoretical assumptions of the chosen tests. This recommendations are for quantitative information analysis, while, for qualitative approach we suggest description, narrative, conceptual maps, graphical illustration, etc. Both data analysis approaches are valid and just as important in ethnobiology and ethnozoology.

7. Field biological methods: They directly depend on the biological group, due to this we recommend a field techniques review. Differentiating between sampling designs and monitoring techniques, random walks and transects are used in the designs in general. The techniques go specific depending on the biological group, for example, direct search and visual encounters can be used for amphibians and reptiles, sightings for birds, and tracing footprints and excreta for mammals. We recommend to use simple and quick techniques and designs, which can be combined with ethnobiological tools such as the use of visual stimuli which are designed in previous reviews on the fauna diversity for the site. Another option is specimen

photography, or parts of them in possession of the informants, as well as participatory observation.

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## Supplementary Material (Revised studies)

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