Vázquez López, José Martín; Vibrans, Heike; García Moya, Edmundo; Valdez Hernández, Juan Ignacio; Romero Manzanares, Angélica; Cuevas Guzmán, Ramón
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Interciencia, vol. 29, núm. 4, abril, 2004, pp. 207-211
Asociación Interciencia
Caracas, Venezuela

Available in: http://www.redalyc.org/articulo.oa?id=33909109
EFFECTS OF HARVESTING ON THE STRUCTURE OF A NEOTROPICAL WOODY BAMBOO (Otatea: GUADUINAE)

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SUMMARY

Natural populations of Otatea acuminata (Munro) C.E. Calderón & Soderstr. subsp. aztecorum (McClure & E.W. Smith) R. Guzmán, Anaya & Santana-Michel were studied in the Sierra de Manantlán, Jalisco-Colima, in Western Mexico. The objectives were to compare the structure of otate populations at different harvesting levels, in order to evaluate the changes occurred due to management and to obtain the best prediction factor for culm production. Forty-one 50m² plots were randomly established in harvested and non-harvested stands, and were observed over a 2 year period. There was no significant difference between harvested and unharvested stands, but the latter had higher densities and longer stems on average. Culm diameter and height were significantly different according to soil type in a nonparametric ANOVA. A backward lineal regression analysis identified a prediction model for juvenile culms production. Present exploitation levels by artesans appear to be sustainable.

RESUMEN

Se estudiaron poblaciones naturales de Otatea acuminata (Munro) C.E. Calderón & Soderstr. subsp. aztecorum (McClure & E.W. Smith) R. Guzmán, Anaya & Santana-Michel en la Sierra de Manantlán, Jalisco-Colima, en el occidente de México. Los objetivos fueron comparar la estructura de las poblaciones con diferentes niveles de aprovechamiento, para evaluar los cambios debido al manejo y obtener el mejor factor de predicción en la producción de tallos. Se establecieron 41 sitios de 50m² y se observaron durante 2 años. No hubo diferencia significativa entre sitios cosechados o no, pero éstos últimos tuvieron, en promedio, mayores densidades y tallos más largos. El diámetro y altura de los tallos mostraron diferencias significativas de acuerdo con el tipo de suelo mediante un análisis de varianza no paramétrico. Un análisis de regresión lineal de retroceso identificó un modelo de predicción para la producción de tallos jóvenes. Los niveles actuales de explotación por artesanos parecen ser sostenibles.

Introduction

About 2.5 billion people worldwide use bamboo and there are 1250 known species with more than 1500 possible uses (FAO, 2000). Bamboos are primitive grasses that grow worldwide except in Europe, and nearly half of the species around the world are native to America, including woody and herbaceous bamboos. In Mexico the genera of woody bamboos with the widest distribution are Chusquea, Guadua, Omecac and Otatea (Judziewicz et al., 1999).

One of the most common genera in Mexico is Otatea, a woody bamboo native to Mexico and Central America where it is called ‘otate’ (Guzmán et al., 1984). The name ‘otate’ means solid cane, and is derived from the nahuatl native language. This name is also used in some parts of Mexico for Rhipidocladum racemiflorum (Steudel) McClure, Guadua longifolia (E. Fourn.) R.W. Pohl, Guadua amplexifolia J. Presl (Santamaría, 1978) and Chusquea spp., as well as for some species of the genus Arundo, which is not a bamboo.

Otate is a semelparous plant harvested and non-harvested stands, and were observed over a 2 year period. There was no significant difference between harvested and unharvested stands, but the latter had higher densities and longer stems on average. Culm diameter and height were significantly different according to soil type in a nonparametric ANOVA. A backward lineal regression analysis identified a prediction model for juvenile culms production. Present exploitation levels by artesans appear to be sustainable. This time, they cannot be harvested. The first, second and sometimes third year culm, depending on environmental conditions, are recognized by local people as “new stem” but herein referred to as “juvenile”. These culms are selected for basket manufacturing because of their flexibility. Older culms (herein “mature”), usually more than 3 years old, are hard and are used as a construction material and for stakes in agriculture (Vázquez-López et al., 2000).

KEYWORDS / Bamboo Harvest / Non-wood Forest Product / Otatea / Tropical Deciduous Forest / Western Mexico /


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RESUMO

Estudaram-se populações naturais de Otatea acuminata (Munro) C. E. Calderón & ... all the sites, variation of
densities was greater than that
of height and dbh (Table I),
and in non-harvested sites

208

Data collection
Forty-one 50m² (10 x 5m) plots were randomly established between 1997 and 1999 in harvested (19) and in non-
harvested (22) areas. Every site was north-south oriented on its
10m side. Slope, rockiness, aspect and altitude were registered,
as well as evidences of harvesting levels (number of stumps), fire, and grazing.
Rockiness, fire, and grazing were determined according to
Olvera-Vargas et al. (1996).

Results
Structural characteristics
For all the sites, variation of densities was greater than that
of height and dbh (Table I), and in non-harvested sites

208

Methods
Study site
The study was carried out in
the community of Platanarillo, in the northwestern region of the-state of Colima, Western Mexico, between 19°21'16"N and 103°55'27"W. It is located in
the southeastern part of the Si-
erra de Manantlán, within the
Sierra de Manantlán Biosphere
Reserve, in a canyon with
slopes ranging from 25 to
100% and altitudes from 900
to 1800m. The climate is mid-
latitude tropical sub-humid, ac-
cording to the modified Köppen classification system (García, 1972), with a dry sea-
son Oct to May and a rainy
season Jun to Sep, an average
annual precipitation of 1350mm, and an average
annual temperature of 22°C
(Martínez-Rivera et al., 1991).

Most of the soils are derived from karstic limestone
(Lazcano, 1988). These are
Lithosols, which are rocky,
shallow, and infertile soils.
Regosols overlying igneous
material occupy an important
part of the area; these soils are
deeper with less rocks and
more organic matter (INEGI-
SPP, 1981). Tropical deciduous
forest covers the greatest por-
tion of the study area. Here,
"otatales" are an important compo-
ment of the landscape and
they occupy 800ha, according
to satellite images (IMECBIO,
2000), even though only 300ha
are accessible for harvesting.

Data analysis
A nonparametric ANOVA
was applied in order to find dif-
fences between sites using harvesting levels, grazing inten-
sity and soil types as grouping
variables. The Kruskal-Wallis
test was applied using Wilcoxon
scores (rank sum). Harvest lev-
els were determined by the per-
centage of culms that were
extracted: 0% = Null (0%), 1= Low
(10%), 2= Medium (20%), 3= High
(>20%), and also simply as harvested vs non-harvested.

The test was applied to density,
height and dbh for every factor. Clustered error bars were calcu-
lated for density since it was the
variable with the highest vari-
ation. The best prediction factor
for culm production was identi-
fied with a backward linear re-
gression analysis, using density
of juvenile culms as the depen-
dent variable. Data were ana-
lized with the SPSS program V.
10.0 (SPSS, 1999).
variation was greater than that in harvested sites for juvenile and dry culms. Total density was not significantly different among harvesting levels ($\chi^2 = 0.456$, df = 3, $P = 0.928$), grazing intensity ($\chi^2 = 0.776$, df = 2, $P = 0.679$) or soil type ($\chi^2 = 0.975$, df = 1, $P = 0.324$). Densities of culms by use categories were also not significantly different among harvesting levels ($\chi^2 = 0.456$, df = 3, $P = 0.928$), grazing intensity ($\chi^2 = 0.776$, df = 2, $P = 0.679$) or soil types ($\chi^2 = 0.975$, df = 1, $P = 0.324$). However, the average densities of juvenile and mature culms were consistently higher in harvested stands (Table I).

Comparison of dbh and height did not show significant differences among harvesting levels (juvenile culms dbh: $\chi^2 = 1.153$, df = 3, $P = 0.764$; mature culms dbh: $\chi^2 = 3.187$, df = 2, $P = 0.203$ and dry culms dbh: $\chi^2 = 2.479$, df = 2, $P = 0.289$; juvenile culms height: $\chi^2 = 3.052$, df = 2, $P = 0.217$; mature culms height: $\chi^2 = 5.829$, df = 2, $P = 0.054$ and dry culms height: $\chi^2 = 2.684$, df = 2, $P = 0.261$), but rendered significant differences between soil types (juvenile culms dbh: $\chi^2 = 5.980$, df = 1, $P = 0.014$; mature culms dbh: $\chi^2 = 11.874$, df = 1, $P = 0.001$ and dry culms dbh: $\chi^2 = 11.671$, df = 1, $P = 0.001$; juvenile culms height: $\chi^2 = 3.36$, df = 1, $P = 0.056$; mature culms height: $\chi^2 = 7.138$, df = 1, $P = 0.008$ and dry culms height: $\chi^2 = 3.21$, df = 1, $P = 0.073$). Greatest dimensions were observed in harvested sites (Table I), and the longest culms were found in regosols.

Total density appears to be the best descriptor for the effects of harvesting. We used clustered error bar graphics (confidence interval 95%) to demonstrate differences within the two-year period. There is a considerable change in densities of juvenile and dry culms. Recruitment in 1997 was higher than mortality, whereas in 1999 recruitment decreased and mortality increased (Figure 1). Figures 2 and 3 show this variation in recruitment and mortality broken down by management type. The non-harvested stands show a lower density of mature culms and a higher mortality than harvested ones.

**Harvesting intensity and prediction of shoot production**

Stump density indicated a reduction in harvesting level of juvenile and dry culms in harvested and non-harvested stands (Table I).
(Figure 4); in 1997, 32% of the juvenile culms were harvested, whereas in 1999 only 9% were. As harvesting levels decreased in the studied *Otatea*, the number of healthy culms decreased too. Dry and unhealthy culms increased from 1997 to 1999 (Table II). Linear backward regression analysis identified density of mature culms as the best predictor for shoot production (Figure 5): \( y = 0.1942x + 458.679 \), where \( y \): density of juvenile culms and \( x \): density of mature culms; \( N=41 \), \( R'=0.396 \), \( F=25.578 \) (P<0.05), \( t=5.057 \) (P<0.05).

**Discussion**

Although not significant, data suggest that harvesting increases shoot production (Table I; Figure 4), stimulates growth of rhizomes and roots, and perhaps storage of nutrients. This could be interpreted as compensatory growth (McNaughton, 1983), which increases net primary productivity after harvesting or grazing in many plant species as a result of an increment in relative growth rates of shoots (Olson and Richards, 1988).

Significant differences were found for populations growing on different soils; deeper soils predictably had larger otates. However, mean differences were too small (0.12m in height and 0.14cm in dbh, see Table I) to influence harvesting. Yet, culms were slightly larger in harvested sites. These sites had the highest densities of juvenile and mature culms and the lowest density of dry culms (Figure 3). Similar results were reported by Vázquez-López et al. (2000) using a different sampling method and data analysis.

Under a traditional management system of *Otatea* in the study area there is no planned selection of areas for harvesting. The main criteria for choosing a harvesting site are accessibility and proximity to villages. In practice, there are two additional factors that restrict harvesting and affect the populations. First, recent delimitation of individual land property in communal lands due to new property rights obliges artisans to look for new harvesting zones. Second, a sequential prolonged flowering process from 1993 onwards has diminished the stock of useful otate culms. Before flowering the culms become brittle and unhealthy and have several holes, 3-4.5mm in diameter, likely caused by some Curculionidae species observed in the field that are used afterwards as nests by wasps, probably from the worldwide distributed genus *Psenulus* (Matthews, 2000). Thus, these *Otatea* are no longer useful for basketry nor as stakes. However, even in stands with imminent flowering annual harvesting was lower than recruitment in both years of the study. This suggests that traditional harvesting has been done at a conservative level and does not deteriorate the resource.

This study showed that mature culm density is the best predictor for culm production. This indicates that juvenile culm production is a function of the number of mature culms nearby, though an excess of mature culm limited re-sprouting (Vázquez-López et al., 2000) and recruitment decreased as density increased. This effect may be due to an intraclonal regulation of the new shoot mortality or even self-thinning by mortality of genets (Makita, 1996). Similar results were obtained by Taylor and Qin (1993) in China. In Colombia, most “guaduales” (Guadua’s populations) without management had high proportions of mature and dry guaduas and few juvenile culms (Cruz, 1994). Similar tendencies were encountered by Christanty et al. (1996) in an agroforestry management system in a humid tropical region in Indonesia, as well as by Singh and Singh (1999) in an experimental bamboo plantation in a dry tropical region in India.

Otate’s potential production is considerable. For example,
Figure 5. Relationship between the density of juvenile and mature culms using backward lineal regression analysis

ACKNOWLEDGEMENTS

The authors are thankful to the otate artisans and land owners of Platanarillo, particularly Juan Enciso and Pedro Figueroa for information and logistic support, to Miguel Olvera and Blanca Figueroa for helpful comments, to Manuel Pio Rosales for the statistical analyses. Pia Winland and Cynthia Ayala improved the final document.

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