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Review Article

Applications of *Guadua weberbaeuri* fiber: a systematic review from the perspective of civil construction, between the years 2017 to 2022

Aplicações da fibra de *Guadua weberbaeuri*: uma revisão sistemática sob a ótica da construção civil, entre os anos de 2017 a 2022

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ABSTRACT

The exploration of the potential of Amazonian species, such as *Guadua weberbaueri*, popularly known as bamboo, is verified in several segments. Having its great potential in the application for civil construction, it can still be maximized with the application of nanotechnology. The objective of this study is to verify the research on applications of *Guadua weberbaueri* bamboo fiber for civil construction in the last five years. Through four indexed databases of studies, applying to six descriptors, and cataloguing them, throughout their areas of exploration and year of affiliation, it was possible to weave the data and results obtained. These results pointed to 10 studies that used the species, and these studies were mostly in the area of characterization of biological or physicochemical properties and none corresponded to the area of civil construction. He also noticed that over the last five years, the curve of studies carried out has been increasing. Thus, there was a lack of exploration of the potential of both the *Guadua weberbaueri* species and its fiber as a structural component within civil engineering.

Keywords: Amazônia; Structures; Bamboo; Civil Engineering

RESUMO

A exploração das potencialidades das espécies Amazônicas, como o *Guadua weberbaueri* popularmente conhecido como bambu, é verificada em diversos segmentos. Tendo seu grande potencial na aplicação para a construção civil, ainda pode ser maximizado com a aplicação da nanotecnologia. Este estudo tem como objetivo verificar as pesquisas de aplicações da fibra de bambu *Guadua weberbaueri*, para a construção civil, nos últimos cinco anos. Através de quatro bases de dados indexadas de estudos, aplicando para seis descritores, e os catalogando, ao longo de suas áreas de exploração e ano de vinculação, foi possível tecer os dados e resultados obtidos. Esses resultados apontaram para 10 estudos que utilizaram a espécie, sendo que esses estudos eram, majoritariamente, na área de caracterização das propriedades biológicas ou físico-químicas e nenhum corresponde à área de construção civil. Também percebeu que ao longo dos últimos cinco anos, a curva de estudos realizados é crescente. Assim, verificou-se a carência na exploração do potencial, tanto da espécie *Guadua weberbaueri*, como da sua fibra, como componente estrutural, dentro da engenharia civil.

Palavras-chave: Amazônia; Estruturas; Bambu; Engenharia Civil

1 INTRODUCTION

Amazonian plant species have a diversity of properties, often unique, that cover enormous versatility of applications (REIS et al., 2019). For example, timber species such as copaíba (*Copaifera duckei* Dwyer) and samaúma (*Ceiba pentandra* (L.) Gaertn) include mechanical and physical aspects, such as modulus of rupture and shear resistance of, respectively, 0.069738 and 0.030096 kgf/ cm²; and 1.438139 and 1.107651 kgf/cm², typical of commercialized tropical wood, noting similar harvest relationships between both, with an aspect of economic potential (REIS et al., 2019).

Thus, these species generate possibilities of use from their natural form, even in compositions with mixed materials, such as composites, which are products that act with a composition of optimized mechanical resistance added from the combination of materials from different origins, but combined, have a greater civil mechanical characteristic potential (CASTRO et al., 2019). As a result, composites of Amazonian wood and cement emerged, added with hydrated lime, which demonstrated technical potential for manufacturing and use in civil construction (CASTRO et al., 2019). Uses like this demonstrate the importance of studying composites with native Amazonian species.

Refining the analysis, with attention to mixed composites, a series of potentials stand out, which reflect a range of uses. From the use of bamboo residue to make activated charcoal, to the creation of cement-wood panels, enriched by rice husks, or through soil-cement bricks with the addition of sugarcane bagasse, they reveal fragments of the panorama of solutions that have been created over the last few years (SANTANA et al., 2019; MOURA et al., 2020; LILGE; HASELEIN; SANTINI, 2021). Essentially, a particular use of pineapple leaf fiber composites, with diverse uses, extends the concept of composites, to the level of incorporation of vegetable fibers, an important constructive element (NEGRÃO; PINTO; SILVA, 2020).

It is noted that among the species, bamboo stands out as the largest aspect for breadth in the range of uses, due to the particular nature of its properties (SANTANA et al., 2019; BRAND et al., 2020). Bamboos of the genera *Bambusa* and *Phyllostachys* lead numerous studies that explore their potential in the broadest possible segments, essentially highlighting civil construction and its subareas (SANTANA et al., 2019; BRAND et al., 2020).

Thus, the application of bamboo fibers appears as an important alternative within civil construction (MORAIS et al., 2018). Conglomerate panels from the addition of *Bambusa tuldoides* fibers showed satisfactory mechanical results, both for traction and flexion, demonstrating potential application strategies as an alternative to structural reinforcement, or even as a finishing alternative for coatings (MORAIS et al., 2018).

Essentially to the proposed study, microfibers incorporated into mortars demonstrate particular potential. Constituting the assumptions mentioned above, they represent a growing perspective of exploration, with the addition of cellulose fibers as a composite, an application with extremely advantageous potential use, considering that an incorporation element such as fibers, provides the solidification of materials, increasing their mechanical resistance (PESCAROLO et al., 2021).

Based on the synthesis of technical, environmental, technological and sustainable aspects described above, the present study is justified. Since the bamboo native to the

Amazon, of the species *Guadua weberbaeri*, can demonstrate applications in the most varied fields, however, its versatility for civil construction requires further study, given that it has intrinsic potential for physical-mechanical resistance, for use in the main aspects of the construction segment, such as structural.

Therefore, the objective of this study is to verify the applications of *Guadua weberbaeri* fiber for civil construction in the last five years. Furthermore, the study sought to identify areas of concentration of studies and related studies from indexed databases over the last five years.

2 DEVELOPMENT

2.1 Descriptors and databases

Six descriptors described below were adopted, in order of coverage of the subject, according to greater coverage, to lesser, in relation to the theme analyzed. In relation to the indexed databases, the four main bases were taken for review shown in Table 1. Table 1 correlates the descriptors used, the bases, and the results of each search carried out, for the studies obtained, in the period of the last five years, between 2017 and October 2023, the date for updating results for studies until 2022. The research carried out used terms in English to increase the scope of the results.

Table 1 – Descriptors used in each indexed database

	Data Base				
Descriptor	**SciELO**	**G. Scholar**	**PubMed**	**BVS**	**Total**
Bamboo	148	171,000	2,832	2,660	176,640
Bamboo fibers	14	17,600	321	160	495
Guadua	53	13,600	22	25	13,700
Guadua fibers	5	1,770	5	4	1,784
Guadua weberbaueri	0	295	1	1	297
Guadua weberbaueri fibers	0	35	0	0	35

Source: Authors (2022)

In where: Matches found from the search for related descriptors.

According to Table 1, it is noted that when the scope of the descriptor becomes smaller, fewer studies are obtained. From the total descriptor "Bamboo", 176,640 studies were obtained, in contrast to the more specific descriptor for the research in question "*Guadua weberbaueri* fibers", with only 35 studies. Some of the 35 found were 32 different from each other, as some studies were indexed in more than one database. It can also be seen that for the most comprehensive descriptor, results are found in all bases, while for the most specific descriptor, only one base corresponded to the search. For studies, those that did not include the *Guadua weberbaeuri* species as the main object were excluded, as well as studies outside the chronological interval in question, between 2017 and 2022, were excluded.

2.2 Data cataloging

With the research in the previous databases, for the present study, the studies that were" obtained by the more specific descriptor "*Guadua weberbaueri* fibers" were correlated. The cataloging of studies resulted in Table 2 below, which lists the studies found, with their respective area of analysis concentration, as well as authors, and according to an identification indicator to guide the present analysis performed.

Table 2 – Cataloging of studies obtained from descriptors and databases

Identification	Studies	Concentration areas	Author(s)
E01	Evaluation of fiber quality from native amazonian bamboos *Guadua weberbaueri* and *Guadua aff. Lynnclarkiae* for pulp and paper production	Characterization of biological and/or chemical properties	Pinheiro *et al*. (2022)****
E02	Anatomical characterization of the roots, leaves and culms of *Guadua weberbaueri* in different growing environments	Characterization of biological and/or chemical properties	Rodrigues *et al*. (2020)
E03	Allometric derivation and estimation of *Guadua weberbaueri* and *G. sarcocarpa* biomass in the bamboo-dominated forests of SW Amazonia	Characterization of biological and/or chemical properties	Yavit (2017)
E04	Preparação e caracterização de polpa celulósica de bambu *Guadua weberbauri*	Characterization of biological and/or chemical properties	Nunes *et al*. (2021)

To be continued ...

Table 2 – Continuation

Identification	Studies	Concentration areas	Author(s)
E05	Estudio biométrico de fibras en tres especies de bambú – Estación Experimental UNCP Satipo – Junín	Characterization of biological and/or chemical properties	Palomino e Jerry (2019)
E06	Propiedades físicas y mecánicas en los niveles longitudinales del culmo de tres especies del género guadua nativa de la amazonia peruana	Characterization of physical and mechanical properties	Sotelo e Alexander (2021)
E07	Modificações anatômicas e física de colmos de *Guadua sp.* submetidos a tratamentos preservativos convencionais e naturais	Characterization of biological and/or chemical properties	Lobão *et al*. (2021)*
E08	Wood-bamboo Particleboard: Mechanical Properties	Application: civil construction	Almeida *et al*. (2017)*
E09	Propriedades físicas dos bambus das espécies *Phyllostachys aurea* e *Bambusa tuldoides* após tratamento térmico	Characterization of physical and mechanical properties	Mbamu *et al*. (2020)*
E10	Potential of young bamboos for food industry: production of ingredients from the use of their culms and shoots	Application: food	Rusch *et al*. (2022)*
E11	Produção e utilização de nanofibras celulósicas de taboca (*Guadua spp*) para reforço de compósitos cimentícios	Characterization of biological and/or chemical properties	Morais (2021)*,**
E12	Dinâmica do bambu (*Guadua weberbaueri* Pilger. Poaceae) em função da sazonalidade climática no leste do Acre	Application: forest management	Silva (2020)**
E13	Bambu nativo: alternativa de desenvolvimento econômico e sustentável para o estado do Acre	Application: forest products and economy	Afonso e Silva (2017)
E14	Evaluación del concreto f'c =175 kg/cm^2 reforzado con fibras de *Guadua angustifolia* kunt, para mejorar su resistencia a la compresión. Moyobamba 2020-2021	Characterization of biological and/or chemical properties	Palmira e Jhordan (2021)*
E15	Análisis de la sustitución de fibra de bambú (*Guadua angustifolia*) en fibra de vidrio de materiales compuestos en el sector automotriz de repuestos	Application: industrial	Aruni (2022)**
E16	Identificação e isolamento de uma lectina do colmo da *Guadua angustifolia* Kunth (1822) (POALES: POACEAE)	Characterization of biological and/or chemical properties	Gomes (2022)*,**

To be continued ...

Table 2 – Continuation

Identification	Studies	Concentration areas	Author(s)
E17	Desenvolvimento de modelos biométricos para predição de biomassa aérea de plantios de *Dendrocalamus asper* (*Schultes f.) Backer ex Heyne*. (bambu-gigante)	Characterization of biological and/or chemical properties	Balbino (2022)*,**
E18	Evolução molecular em *Bambusoideae Luerss*. (*Poaceae Barnhart*): taxonomia molecular e caracterização de genoma plastidial de espécies nativas	Characterization of biological and/or chemical properties	Zappelini (2022)*,**
E19	Desempenho estrutural e térmico de painéis modulares intertravados de matriz cimentícia com reforço estrutural de *Bambusa vulgaris*	Application: civil construction	Neto (2021)*,**
E20	Painel modular intertravado de matriz cimentícia com reforço estrutural de *Bambusa vulgaris*	Application: civil construction	Neto (2017)*,**
E21	Estratégias para a conservação ex situ de *Dendrocalamus asper* e micropropagação de espécies do gênero Guadua (Bambusoideae, Poaceae)	Application: biotechnology	Nogueira (2018)*
E22	Towards sustainable futures for nature and people	Application: forest management	Rando *et al*. (2021)*
E23	Caracterização do crescimento e composição química da parede celular de espécies nativas de bambus	Characterization of biological and/or chemical properties	Parma (2017)*,**
E24	Estabelecimento e Cultivo de Células em Suspensão e Uso de Biorreatores como Estratégias de Propagação de Bambus do Gênero Guadua	Application: biotechnology	Queiroz (2021)*,**
E25	Breeding biology of the Olivaceous Flatbill (*Rhynchocyclus olivaceus*) in an Amazonian forest fragment of northwest Brazil	Application: biotechnology	Floriano, Lima e Guilherme (2020)*.**
E26	Antioxidant and Photoprotective Properties of Neotropical Bamboo Species	Application: biotechnology	Grombone-Guaratini *et al*. (2021)*
E27	Estudo e desenvolvimento de protótipo de compósito de bambu de alta densidade para uso estrutural	Application: civil construction	Ferreira (2019)*,**
E28	Evaluacion y utilizacion de la *Guadua sarcocarpa* Londoño & Peterson en el bosque de la unu-macuya	Application: forest management	Cruz e Cárdenas (2011)*,***

To be continued ...

Table 2 – Conclusion

Identification	Studies	Concentration areas	Author(s)
E29	Bamboos flower after the return of an appropriate sun-moon phasing	Characterization of biological and/or chemical properties	Clerget (2021)
E30	Non-Timber Forest Products in Brazil: A Bibliometric and a State of the Art Review	Application: forest products and economy	Silva *et al*. (2020)
E31	Tissue Cultured Regeneration and Ecological Values in Major Bamboo Species	Application: biotechnology	Sharma *et al*. (2022)*
E32	Caracterización ecológica de la gaita (*Rhipidocladum geminatum mcclure*) a fin de diseñar una estrategia de conservación para artesanos del municipio de Zetaquira, Boyacá	Characterization of biological and/or chemical properties	Triana e López (2022)*,**

Source: Authors (2022)

In where: For items marked with (*): the species studied are not related to the species of interest in the present study, the search term sought is only mentioned frequently throughout the text; (**): the study is not indexed as a scientific article; and (***): despite the descriptor, the study is outside the analysis period in question; (****): the article demonstrated multiple results on different bases, being counted as only 1 (one) frequency. Therefore, studies marked with (*) and/or (***) were removed from the analysis.

With the remaining 10 studies selected for analysis, marked in green, in order of frequency between areas, identifications were established. Resulting in Table 3, which characterizes the areas of concentration with their respective identifications for the next analyses.

Table 3 – Relationship between concentration areas and their identification

Concentration areas	Identification
Characterization of biological and/or chemical properties	A01
Application: forest products and economy	A02
Characterization of physical and mechanical properties	A03
Application: forest management	A04

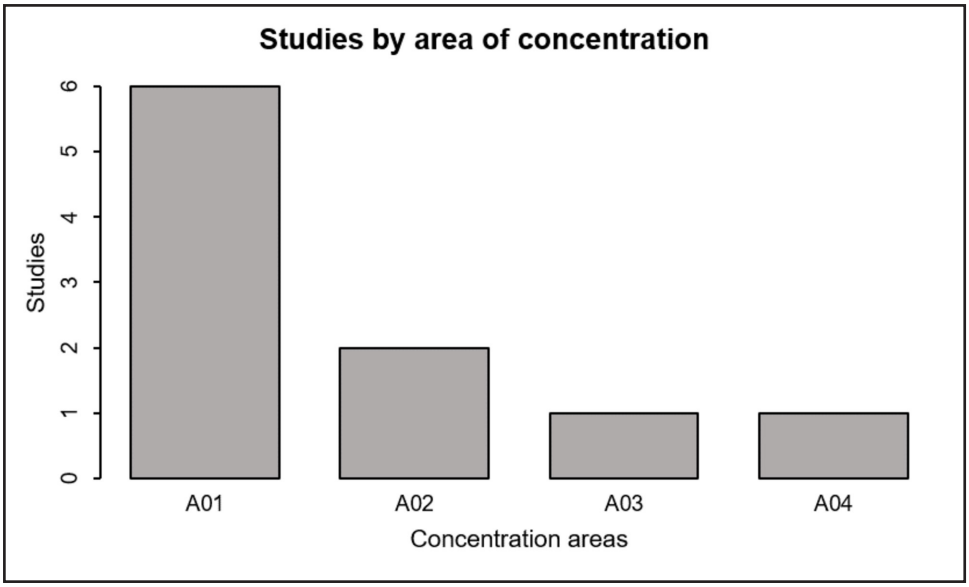
Source: Authors (2022)

In where: Identification corresponding to the areas found in the review results.

2.3 Graphical analysis

With the results of the previous items, it was possible to carry out analyzes using graphic expressions. To execute the graphics, the software R Studio version 3.3.0 was used. Figure 01 lists the studies according to the previously expressed areas of concentration. It highlights the prevalence of studies in the area of characterization of biological and/or chemical properties. Next, the application studies on forestry products and economy contain more results, but in smaller quantities than the studies in A01. In the end, the remaining four areas feature unitary studies on the topic.

Figure 1 – Studies obtained, by areas of concentration



Source: Authors (2023)

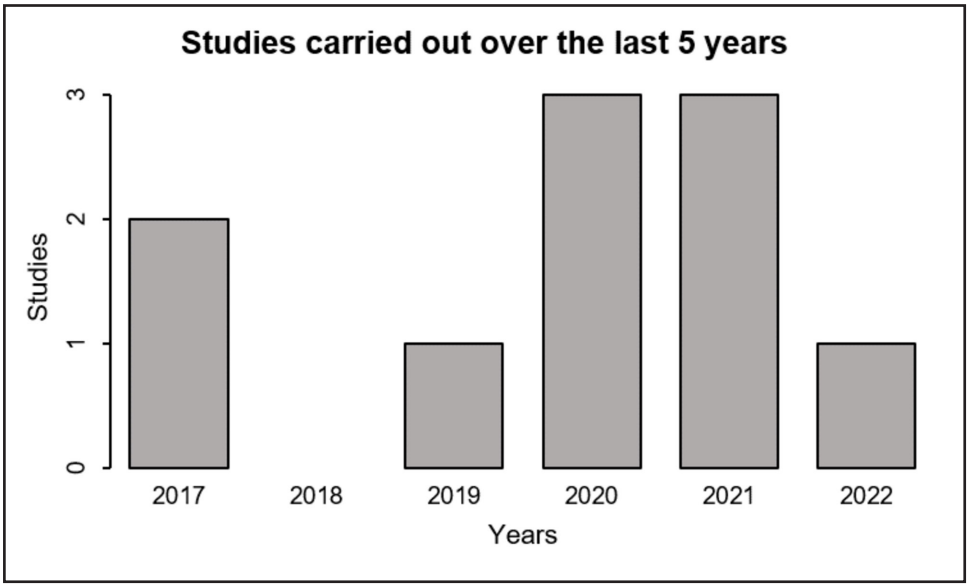
In where: The cataloged studies were organized within the areas of concentration, identified by A01 to A04.

To the present study, the analysis is of interest from the perspective of its application to civil construction. However, as can be seen from Figure 01 and Table 02, no analysis of the area sought, which includes this species, was obtained within the proposed application. Although, the possibility is notable, since it is possible to compare, through Table 01, study E08, in the proposed context, the use of *Dendrocalamus asper* in the particulate wood-bamboo panel, with the use of a nanocomposite of this grass,

added with *Eucalyptus urophylla* (ALMEIDA et al., 2017). In parallel, and even closer to the species under study, studies E11 and E14, which appropriate the incorporation of fibers from *Guadua spp*. and *G. angustifolia*, respectively, for structural reinforcement of cementitious composites, even obtaining positive results for increased resistance (MORAIS, 2021; PALMIRA; JHORDAN, 2021).

For the 10 studies that met the proposed analysis criteria, their chronological analysis was also verified, as shown in Figure 02, with a list of studies over the years, in the proposed period.

Figure 2 – Studies obtained, by year of publication or link in database



Source: Authors (2023)

In where: The cataloged studies were organized according to the years linked for analysis of the review, between 2017 and 2022.

It can be seen from Figure 02 that although in 2018 there were no studies on the topic in question, the general trend is towards growth in exploration of the topic. Considering that in 2022, the analysis was restricted to October of the current year 2023, an increase can be noted, together with past years, reinforcing the hypothesis that over the years, technological refinement has enabled greater application of the species, although not in the area under research – civil construction, but in the general panorama, there are positive responses.

3 CONCLUSIONS

The systematic review research proved to be satisfactorily executed. It was possible to verify that, through the panorama of specific analysis conditions, in the proposed period, the applications and consequent areas required from Guadua weberbaueri fiber in different databases, aiming, primarily, for use in civil construction.

From the review of four indexed databases, using six descriptors, of a macro to micro nature, for analysis, 32 studies on the aforementioned topic were considered. After applying the selection and analysis criteria, 10 studies were within the scope of the proposal for the species. Of these, there was a concentration of studies of the nature of characterizing chemical and/or biological properties, on the other hand, from the perspective of the civil construction area, there were no studies.

Furthermore, it was possible to observe that the areas of study on the topic have been expanding over time. A strong sign of technological advancement and the exploration of alternatives for sustainable development.

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