

#UbirajaraBelongstoBR: social media activism against (neo)colonial practices in palaeontology

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Abstract.

Social media has revolutionized the engagement between scientists and the public, offering platforms to challenge unethical practices and advocate for change. In December 2020, Brazilian paleontologists and supporters initiated the hashtag #UbirajaraBelongstoBR on Twitter (now X) to protest the alleged illicit acquisition and export of the dinosaur fossil named ‘*Ubirajara jubatus*’ from Brazil to Germany. This movement not only demanded the fossil's repatriation but also sparked global discussions on neo-colonial practices in paleontology.

In this study, we analyze 39,728 tweets containing the hashtag #UbirajaraBelongstoBR, collected between December 2020 and February 2023. Employing social network analysis and computational text analysis, we examine the dynamics of this online movement, identify key influencers, and assess its reach and impact. Our results reveal that the campaign transcended the paleontology community, engaging a diverse international audience including scientists, artists, activists, and the general public. Sentiment analysis indicates shifts corresponding to pivotal events, such as official statements and the eventual repatriation of the fossil.

Our findings demonstrate the power of social media in mobilizing grassroots movements and influencing scientific discourse and policy. The #UbirajaraBelongstoBR case illustrates how digital platforms can facilitate international advocacy against unethical scientific practices, highlighting social media's potential to effect change in scientific governance and promote ethical standards. This study contributes to the understanding of digital activism in science communication and underscores the evolving landscape of public engagement in scientific issues.

Keywords — Social Network Analysis, Ubirajara, Palaeontology, Social Movement, illicit fossil traffic.

38 1 Introduction

39 Social media has transformed the way in which scientists communicate their research and communication with
40 both other scientists and non-scientists (Ocon et al., 2021; Entradas et al., 2020; Walter et al., 2019). Social media
41 is also serving an important role in providing a platform, especially for marginalised voices in academia, who are
42 harnessing its power to challenge existing power structures (Yammine et al., 2018). It has also been used to call
43 out unethical practices and other issues in the academy. For example, Elisabeth Bik who is known for posting on
44 wrongful image manipulation in the biomedical literature, that has led to the retraction of several papers, has
45 amassed more than 130,000 followers on Twitter (now X) (Bik, 2022; Shen, 2020).

46 In a similar fashion, Brazilian palaeontologists took to social media in December 2020 to raise their concerns about
47 a newly described Brazilian dinosaur named ‘*Ubirajara jubatus*’ (henceforth Ubirajara¹). Originating from the
48 Araripe Basin, north east of Brazil, Ubirajara has now come to represent the fight against colonial practices in
49 modern palaeontology. The article in which Ubirajara was described raised several ethical and legal concerns over
50 the appropriation and study on this fossil: 1) the authors and the German institution where it was repositied claimed
51 to have obtained the fossil legally although there did not seem to be any legal avenue for such a fossil to have found
52 its way to Germany; 2) the authors did not seem to have involved any Brazilian institutions in the process of
53 acquiring and researching this specimen—also against the law; 3) The region of Brazil where the fossil originated
54 has been targeted by fossil smugglers for years; (4) Some authors in the study had been involved in controversies
55 with irregular fossils from Brazil before (Cisneros et al., 2022a, b; Christakou, 2015; Gibney, 2014; Raja and
56 Dunne, 2023).

57
58 On the 13th December 2020, the same day when the paper describing the fossil had been published, Brazilian
59 palaeontologist Aline Ghilardi published a Twitter thread exposing the case finishing with a tweet saying "Ubirajara
60 belongs to Brazil. #UbirajarabelongstoBR" (Ghilardi, 2020). Immediately after, the hashtag
61 #UbirajaraBelongstoBR, protesting for the return of the fossil to Brazil, took Twitter by storm, along with other
62 social media platforms, such as Facebook, Instagram and YouTube, bringing together both Brazilian and non-
63 Brazilian palaeontologists, paleoartists, students and other members of the general public together. It also fuelled
64 discussions on colonialism in palaeontology, a topic of growing interest and importance in the discipline, e.g.
65 (Monarrez et al., 2021; Raja et al., 2022). Palaeontology as a discipline has been shaped through centuries of

¹ The name ‘*Ubirajara jubatus*’ was removed from ZooBank in November 2022, which means it no longer has any nomenclatural significance (Caetano et al, 2023). In this paper, we will refer to it as ‘Ubirajara’.

66 colonial practices, influencing not only the distribution of fossil data around the world, but also the people who
67 have access to these data (Monarrez et al., 2021; Raja et al., 2022). These practices, including the theft of fossils
68 and exclusion of local scientists as in the case of Ubirajara (Cisneros et al., 2022a), remain to this day and continue
69 to deepen this bias (Raja et al., 2022). The modern materialisation of colonialism in palaeontology is especially
70 directed at the lower and middle income countries which are disproportionately underrepresented in paleontological
71 research and literature (Raja et al., 2022).
72



73
74 **Figure 1: Examples of images shared with the hashtag #UbirajarabelongstoBR by Twitter users. Image**
75 **credits (from left to right, top to bottom): @arturvict (Artur, 2020), @_themingau (Mingau, 2020),**
76 **@Emily_Art (Stepp, 2020), @herbertologist (Herbert, 2020), @valent801 (Valent801, 2020),**
77 **@Brenda7Kauane (Kauane, 2021), @freakyraptor (Alli, 2020), @Waxosaurus (Waxosaurus, 2020),**
78 **@THSpike (Paleonecromante, 2020), @antoniopedroalb (Albuquerque, 2021).**

79
80 Ubirajara is not the only Brazilian fossil studied by foreign researchers that is believed to have been illegally
81 exported and/or acquired. Brazil, especially the Araripe Basin, has been the victim of fossil smuggling for decades,
82 e.g. holotypes of *Irritator challengeri* described in 1996 and *Mirischia asymmetrica* in 2004 (Cisneros et al. 2022a ;
83 Cisneros et al. 2022b). These have however not attracted as much attention from the public and the media until

84 Ubirajara (e.g.), probably because these were published before the “golden age” of social media and science
85 communication on these platforms.

86 In the case of Ubirajara, social media was crucial in the dissemination of information on the specimen and updates
87 on the case. Eventually, the State Museum of Natural History Karlsruhe (SMNK) took to Instagram posting a
88 statement that the fossil was the property of the German state of Baden-Wurttemberg and it would not repatriate it
89 in response to the backlash it was receiving and attracting more criticism. The corresponding research article was
90 permanently withdrawn soon after this when it was found out that the authors lied and misrepresented information
91 on how it was acquired. The Minister of Science of Baden-Wurttemberg, after an investigation, recognized
92 misconduct by SMNK, declared that the export of the fossil to Germany violated Brazilian laws, and that the
93 museum should repatriate it to Brazil, which has now happened (Black 2022). Since the #UbirajaraBelongsToBR
94 movement, several other Brazilian fossils, from the US and Belgium, have been repatriated (Black 2022).

95

96 The #UbirajaraBelongsToBR case shares commonalities with other recent social movements with large online
97 participation, such as Black Lives Matter (BLM), #MeToo, and the Occupy Wall Street movement (Jackson et al.
98 2020). Like these movements, it leverages the reduced coordination costs and enhanced organizational modes
99 provided by social and digital technologies. Scholars like Earl and Kimport (Earl and Kimport, 2011) have
100 highlighted how these technologies not only amplify existing forms of activism but also create fundamentally new
101 ways of operating within social movements. They argue that digital infrastructures personalize online content,
102 giving individuals specific reasons to protest and facilitating their ability to push for change across various
103 platforms. This transformation has demanded a new framework of understanding, as it shifts how activists organize,
104 communicate, and interact in efforts to achieve widespread societal impact.

105

106 Considering the similarity between the #UbirajaraBelongsToBR protest and the other ones cited above, it is natural
107 to study them using similar approaches. For the Occupy Wall Street anti-capitalist movement in the United States,
108 for instance, the movement on Twitter appeared to draw a group of people who were already involved in local
109 politics and other social movements abroad and who were well-connected. Conover et al (2013a; 2013b) use a
110 sizable sample from Twitter to track trends in Occupy member activity, interests, and socialisation over a period
111 of fifteen months, starting three months before the regime's first resistance movements. They find that users who
112 were vocal in the early months of the movement decreased their involvement in Occupy-related activity during the
113 analysis (Conover et al., 2013a). For comparison, related studies looking at the expression of the Black Lives Matter
114 movement on Twitter found that BLM activity on Twitter predicted mainstream news coverage of police brutality,

115 which in turn was the strongest driver of attention to the issue from political elites (Freelon et al. 2016). At the
116 same time, Ince et al. show how that BLM was not a monolithic movement with a single message or way to frame
117 structural racism issues, but rather a movement with "distributed framing" (Ince, Rojas, and Davis 2017), where
118 different hashtags co-occurring with #BlackLivesMatter emphasized different aspects of the movement, such as
119 solidarity towards those protesting, strategic tactics, violent reactions from the police, counter-movement
120 sentiment, among others.

121

122 Here, taking inspiration from studies such as the ones mentioned above, we analyse a collection of all tweets
123 containing the hashtag #UbirajaraBelongsToBR during a given period, and investigate the how the
124 #UbirajaraBelongsToBR movement evolved over time, in terms of its tone, language, and groups of participants,
125 as important milestones in the case of Ubirajara happened over many months. Finally, our results indicate that the
126 #UbirajaraBelongsToBR managed to burst the palaeontology bubble, and to go even beyond science and science
127 journalism.

128 **2 Materials and Methods**

129 **2.1 Data**

130 Tweets posted during the period December 2020 and February 2023 containing the hashtag
131 #UbirajaraBelongsToBR were downloaded using the Twitter API (now unavailable, after the rebrand to X) using
132 the python library Tweepy (Roesslein 2009).

133 The final dataset includes 39,728 tweets that included the hashtag #UbirajaraBelongsToBR and related metadata
134 such as the user account from which the tweet was posted, the tweet type, the data and time, the number of likes
135 and retweets, as well as other information. The preprocessing stage involved the removal of duplicate tweets, along
136 with the conversion of all hashtag text to lowercase. By adopting this approach, we ensured the inclusion of
137 identical hashtags (e.g. #UbirajaraBelongsToBR and #ubirajarabelongstobr).

138 Ethical clearance for this project was obtained at the University of Exeter, including for the publication of user
139 identifiers (e.g. twitter handles), provided that the data did not include any sensitive content. Since it did not include
140 any non-public or sensitive content, the project was approved.

141 2.2 Language detection

142 For tweets with undefined languages, the Google Translate API was used to detect the language of the original
143 tweet and or referenced tweet. When that failed, the detected language by Google Translate API has been used as
144 the final value, by priority of Original Tweet language rather than Referenced Tweet language.

145 2.3 Country detection

146 Over 90% of the returned data by Tweepy listed an undefined country. We used a combination of tools such as
147 pycountry, CountryInfo, and the Google Maps v3 API to infer the country of residence of the users. This was done
148 by using the Location feature which is filled by users in their user accounts. This feature includes different types
149 of data such as addresses, cities, or maybe countries, written in full or as abbreviations (e.g. BRA for Brazil).
150 Countries could only be detected for approximately 50% of the tweets, as many users do not provide any country-
151 specific information in their profile. For the users with undefined countries, we only tagged the language of their
152 tweets. For instance, a user with an undefined country posting primarily in Portuguese was set as “Unknown
153 (Portuguese)”.

154 2.4 Sentiment analysis

155 We also carried out a sentiment analysis for each tweet using Natural Language Processing (NLP) to analyse the
156 polarity in opinions, sentiments and feelings expressed in each tweet. This was done using the function
157 SentimentIntensityAnalyzer() from the Natural Language Toolkit (NLTK) in Python. The foundation of sentiment
158 analysis is a lexicon that associates lexical traits with emotional intensity scores. The intensity of each word in a
159 text may be added together to determine the sentiment score of that text. Words like "loving," "joy," "glad," and
160 "like" carry positive connotations whereas terms, such as that "did not love" is deemed as a negative statement.
161 NLTK returns a list of scores for each of the following four parameters for a string:: Negative, Neutral, Positive
162 and Compound (calculated by averaging the preceding scores). For instance, for 'This was a good movie.' the result
163 will be: ['neg': 0.0, 'neu': 0.508, 'pos': 0.492, 'compound': 0.4404]. In essence, this tool can detect the intensity of
164 positivity and negativity of each phrase according to their words and punctuation (Kumar et al. 2022). It is worth
165 noting that the SentimentIntensityAnalyzer tool is limited in its ability to detect nuanced forms of conversations
166 such as irony or sarcasm, but assuming that the majority of the tweets in our dataset do not fall in that category, it
167 should still produce useful results.

168 2.5 Network analysis

169 We use Gephi, an open source tool for manipulating networks (Bastian et al. 2009), to analyse the interaction
170 between users and explore the structure of their connection, as well as the connections between
171 #UbirajaraBelongsToBR and co-occurring hashtags. This allows us to see the structure of interactions and attributes
172 of members and to recognise regional and global patterns, significant people, and network dynamics.

173 Since we focus on studying interactions between individuals, we only considered tweets that were either a retweet,
174 a quoted tweet or a reply to the original tweet and built a directed network that considers the direction of
175 communication, e.g.. User A replying User B. Each interaction between two specific users was assigned a value
176 depending on the number of times it happened, e.g. if user A retweets a tweet from user B for 5 times, a weight of
177 5 was assigned.

178 We carry out community detection using the Louvain algorithm (Blondel et al., 2008). A community in a network
179 can be roughly defined as a group of nodes more densely connected to each other than to nodes outside the group.
180 For a network inferred from posts and hashtags, these communities are centred around a topic of conversation, or
181 based on shared interests or attributes. Finally, to estimate the centrality of authors in the protest network, we use
182 multiple network science statistics, defined below.

183

184 **Degree centrality:** this is the simplest measure of centrality and counts the number of edges (or connections) a
185 node has. Nodes with a high degree centrality are often hubs or highly connected nodes in a network. In a social
186 network, for example, a person with a high degree centrality might have many friends.

187

188 **Betweenness Centrality:** this measure looks at all the shortest paths between pairs of nodes and counts how often
189 a particular node lies on these paths. Nodes with high betweenness centrality act as bridges or gateways in the
190 network. They are often crucial for ensuring flow or connectivity between different parts of the network.

191

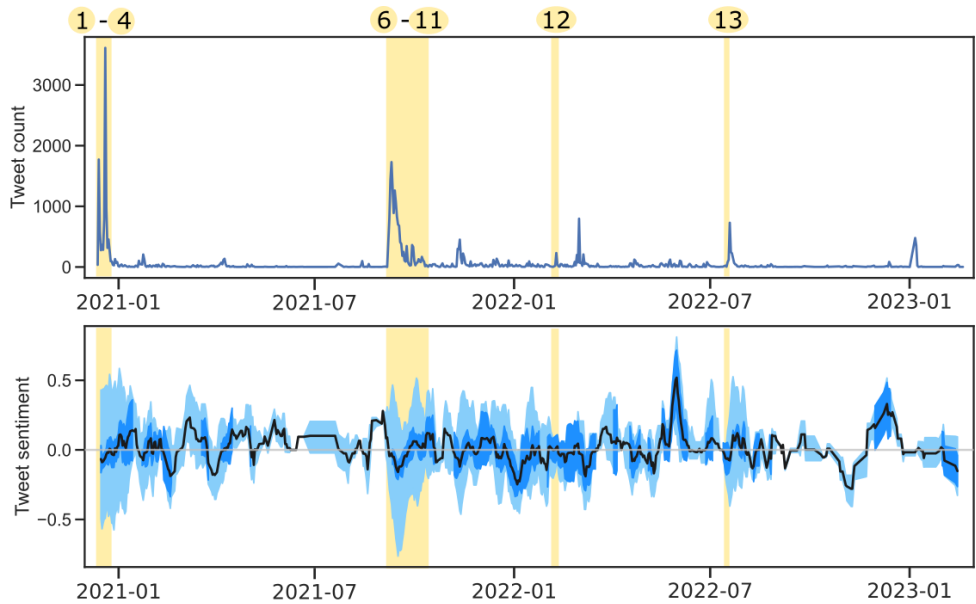
192 **Eigenvector Centrality:** this centrality measure assigns relative scores to all nodes in the network based on the
193 idea that connections to high-scoring nodes contribute more to the score of a node than equal connections to low-
194 scoring nodes. Nodes with high eigenvector centrality are connected to many nodes who themselves have high
195 scores. It's a measure of "influential" connectivity.

196 Each centrality measure gives a different perspective on the importance or influence of nodes within a network.
197 Depending on the research question or the nature of the network, one might be more relevant than the others.

198 3 Results

199 3.1 Protest timeline

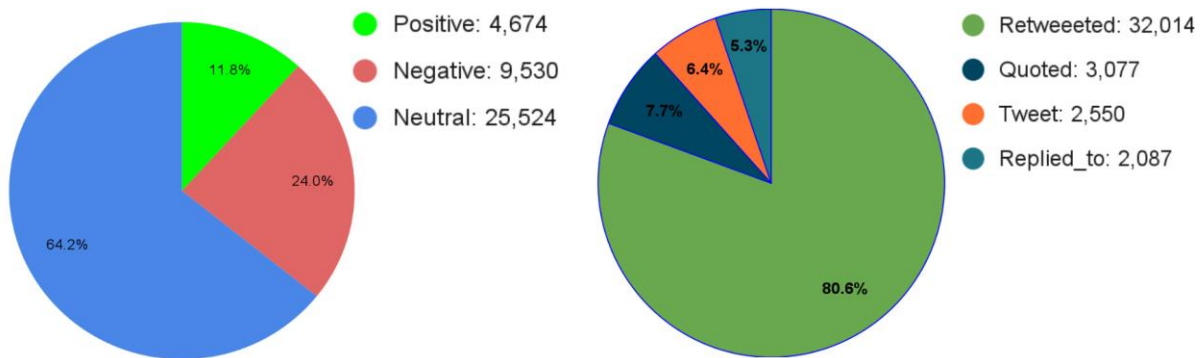
200



- 1 In press article on “Ubirajara jubatus” appears on the journal Cretaceous Research and the hashtag #UbirajaraBelongstoBR is first used on Twitter.
- 2 The Brazilian Society of Palaeontology contacts Cretaceous Research.
- 3 First report on the controversy by international media (National Geographic).
- 4 Article temporarily removed by Cretaceous Research.
- 5 SMNK informs the Brazilian Society of Palaeontology that it will not repatriate the fossil. The Brazilian Society of Palaeontology informs its members.
- 6 SMNK releases a statement on Instagram refusing repatriation of “Ubirajara jubatus”.
- 7 A petition is created at Change.org asking for the fossil to be returned.
- 8 Article withdrawn by Cretaceous Research.
- 9 SMNK Instagram account is deactivated.
- 10 Article in the journal Science reveals that the dinosaur was imported to Germany by fossil dealers in 2006 and purchased by SMNK in 2009.
- 11 The USA repatriates 35 fossil spiders to Brazil.
- 12 Belgium repatriates a pterosaur to Brazil.
- 13 Germany announces that “Ubirajara jubatus” will be repatriated to Brazil.

Figure 2: Timeline of events during the #UbirajaraBelongstoBR protest. The top panel shows the tweet count over time. In the bottom panel, the black line represents the average sentiment of all tweets containing #UbirajaraBelongstoBR, the shaded dark blue area represents the average plus or minus one standard deviation of the tweet sentiment, and the shaded light blue area shows the 5% and 95% percentiles of tweet sentiment on a given day.

208 Figure 2 shows the timeline of the protest, along with the aggregated tweet sentiment over time, plotted with its
209 mean, standard deviation, and 5%-95% interval, respectively in black, dark blue, and light blue. There are two
210 significant moments with a high number of tweets over the selected time duration, namely the start of the protest
211 and the first report on the controversy by international media, and the moment when SMNK informed the Brazilian
212 Society of Palaeontology that it would not repatriate the forum, both of which led to many manifestations on twitter.
213 Specific dates and links to each event are provided in Appendix A.
214



215 **Figure 3: (left) Distribution of tweet sentiment (right) Distribution of Tweet groups**

216

217 The sentiment analysis (Lower panel of Figure 2 and Figure 3) reveals that while a majority of tweets show neutral
218 sentiment, the number of negative tweets is more than two times the number of positive tweets. They also show
219 how most of the tweets related to #UbirajaraBelongstoBR were retweets, i.e. amplified material from other
220 accounts. The overall sentiment is on average neutral, as shown more clearly over time (Figure 2, lower panel).

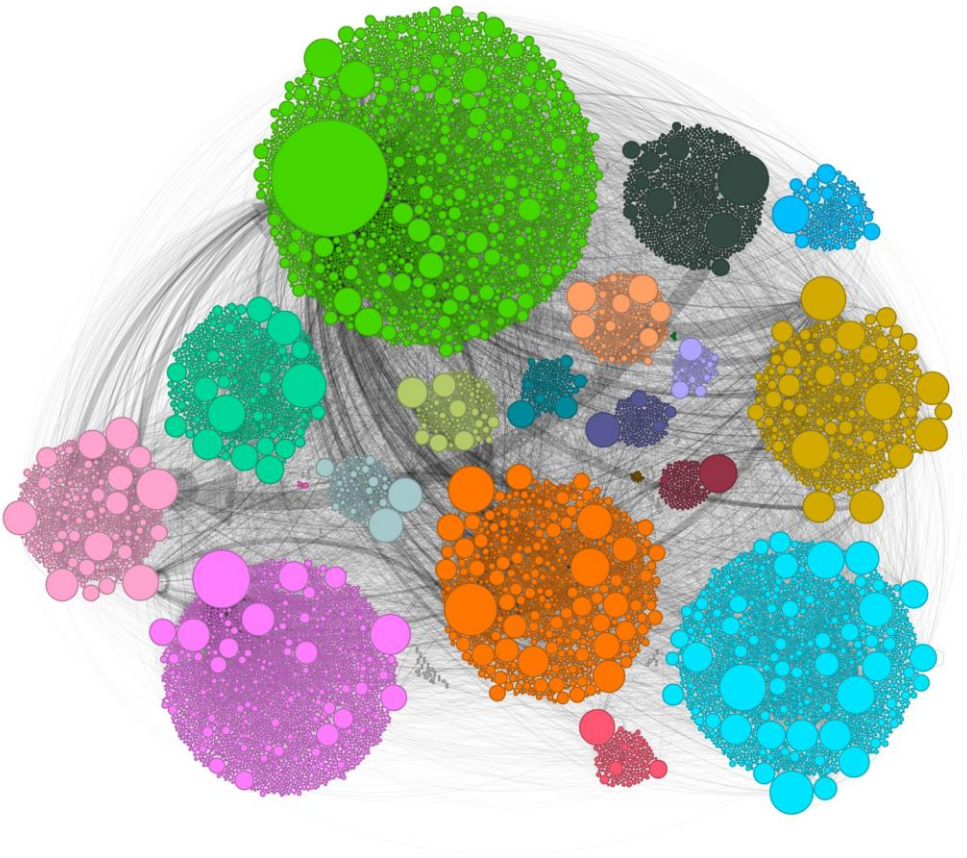
221

222 Our results indicate that although the overall average sentiment is neutral over the whole timeline of the protest,
223 points in time when meaningful events happened, such as in July 2022, when Germany announced that the fossil
224 would be repatriated to Brazil, were moments with more tweets, but also with a higher standard deviation on the
225 overall sentiment, shown as blue shaded areas on Figure 2. These moments of increased standard deviation in
226 sentiment indicate a high number of positive tweets supporting the movement and celebrating small victories, with
227 equal measure of tweets expressing support not with positivity, but with anger and criticism towards the
228 expropriation of the fossil, or towards colonialism in palaeontology.

229

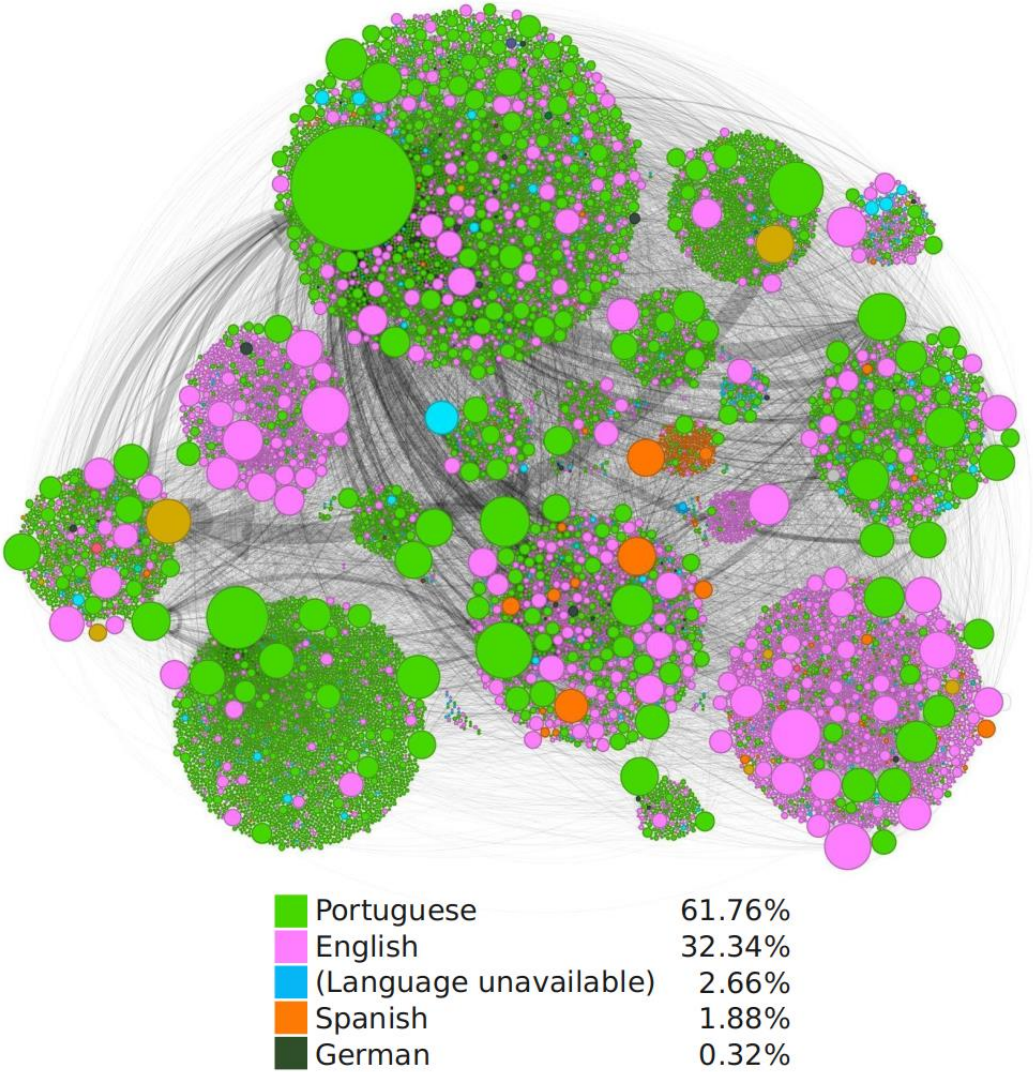
230 There are also two moments with peaks of positive sentiment, namely late May 2022 and early November 2022.
231 Despite the high average sentiment, both periods registered a low tweet count – indicating that the high sentiment
232 comes from a small number of tweets. For May 2022, the high-sentiment tweets included an “Exciting
233 Announcement! 🦖🦖” of a Palaeo video stream, and for November 2022, a sequence of tweets on 3D models of
234 Ubirajara, calling it "one of the most beautiful dinosaurs of Brazil" and giving "shoutouts to helpful souls <3". This
235 very positive language (*exciting, beautiful, helpful, <3*) explains the high sentiment scores for that period.
236

237 **3.2 Social network structure of the protest**



238 **Figure 4: social network of users participating in #UbirajaraBelongstoBR, connected by their shared**
239 **interactions. Node colours indicate communities in the network.**
240

241 The social network of users participating in #UbirajaraBelongstoBR shows that each community involves one user
242 as a leader and some others that follow the leader (Figure 4). The size of each node indicates the in-degree of each
243 user, i.e. the number of people interacting with them, and the colour of each node indicates the community where
244 each user belongs, as identified by the Louvain community detection algorithm. We find several well-separated
245 communities of users, which we describe in more detail below.



246
247
248
249

Figure 5: social network of users participating in #UbirajaraBelongstoBR, connected by their shared interactions. Node colours indicate tweet language.

250 Comparing the social networks of users (Figures 4 and 5) reveals that most of the members in each community
251 share the same language. Most people protesting about Ubirajara were Portuguese speakers as evidenced by 61.76%
252 of the nodes shown in green. There is also a large fraction (32.34%) of users tweeting in English, shown in pink,
253 and smaller proportions of users tweeting in Spanish, German, and other languages.
254 Looking at German in particular, further analysis reveals a total of 170 tweets in German, all of them supporting
255 the hashtag, with 51 tweets adopting a negative tone, 114 of them a neutral tone, and only 5 tweets adopting a
256 positive tone. We also note that 22 tweets are from users self-reporting a location in Brazil, 14 tweets from users
257 self-reporting a location in Germany, and most tweets either in other countries or not reporting any location.
258

Degree Centrality	Betweenness Centrality	Eigenvector Centrality
Alinemghilardi (palaeontologist, 30K followers)	Alinemghilardi (palaeontologist, 30K followers)	Alinemghilardi (palaeontologist, 30K followers)
BiodiversidadeB (scientist, 356K followers)	BiodiversidadeB (scientist, 356K followers)	PaleoCisneros (palaeontologist, 11K followers)
PaleoCisneros (palaeontologist, 11K followers)	Mikannn (journalist, 222K followers)	MMarcosaurus (scientist, 1K followers)
Mikannn (palaeontologist, 222K followers)	PaleoCisneros (palaeontologist, 11K followers)	BiodiversidadeB (scientist, 356K followers)
Pansybeast (artist, 54K followers)	Pansybeast (artist, 54K followers)	oTroianoleo (personal account, 150 followers)

259 **Table 1: Highest centrality users, as calculated using different centrality metrics.**
260

261 We also assess the most central users of the protest network, as measured by the three centrality metrics defined
262 above, namely degree centrality, betweenness centrality, and eigenvector centrality. Despite the differences
263 between how each centrality measure is defined, the three measures point at a roughly consistent set of main actors
264 pushing the conversation: @alinemghilardi, paleontologist and Professor at the Brazilian Federal University of Rio
265 Grande do Norte, @BiodiversidadeB, a Twitter account covering biodiversity content run by João Pedro Salgado,
266 @PaleoCisneros, paleontologist and professor at the Brazilian Federal University of Piauí, @PansyBeast, the
267 account of Julian Francis Miholics, an illustrator who contributed to the protest. The top 5 accounts according to
268 each centrality measure also include @mikannn, corresponding to Miriam Castro, journalist and pop culture

269 influencer, @MMarcosaurus, corresponding to Marcos K. Pinheiro, geoscience student and artist, and
270 @oTroianoleo, historian and archaeologist, all of which supported the protest.
271

272 The high centrality of paleontologists and biodiversity accounts in the protest network draws into question the
273 actual reach of the movement. This can be assessed by examining the users present in each community (Figure 6).
274 The figure shows the type of account for the 10 top members of each community which has over 100 members,
275 from community 1 (with 3064 members) to community 16 (with 151 members). All of these accounts were
276 examined by the authors, and manually categorised into ten categories of users, based on the information available
277 in each account: Palaeontologists, Scientists of other disciplines, Science Journalists, other Science
278 Communicators, Press (e.g. newspapers), other Institutions (e.g. museums), Artists, Politicians, Personal accounts,
279 and Other, which includes deleted users, suspended accounts, and Twitter bots. Each community shows a different
280 composition in terms of accounts, as shown by the different colours on the pie charts. While the largest community
281 in the network is made of mostly palaeontologists, the remaining communities have a diverse breakdown of other
282 account types, from scientists and science journalists to artists, politicians, institutional accounts, as well as many
283 personal user accounts. While it is not possible to examine every account present on the network, this result suggests
284 that the #UbirajaraBelongstoBR did indeed reach beyond the palaeontology bubble, and even beyond science and
285 science journalism. The full table of the highest degree users per community is shown in Appendix B.

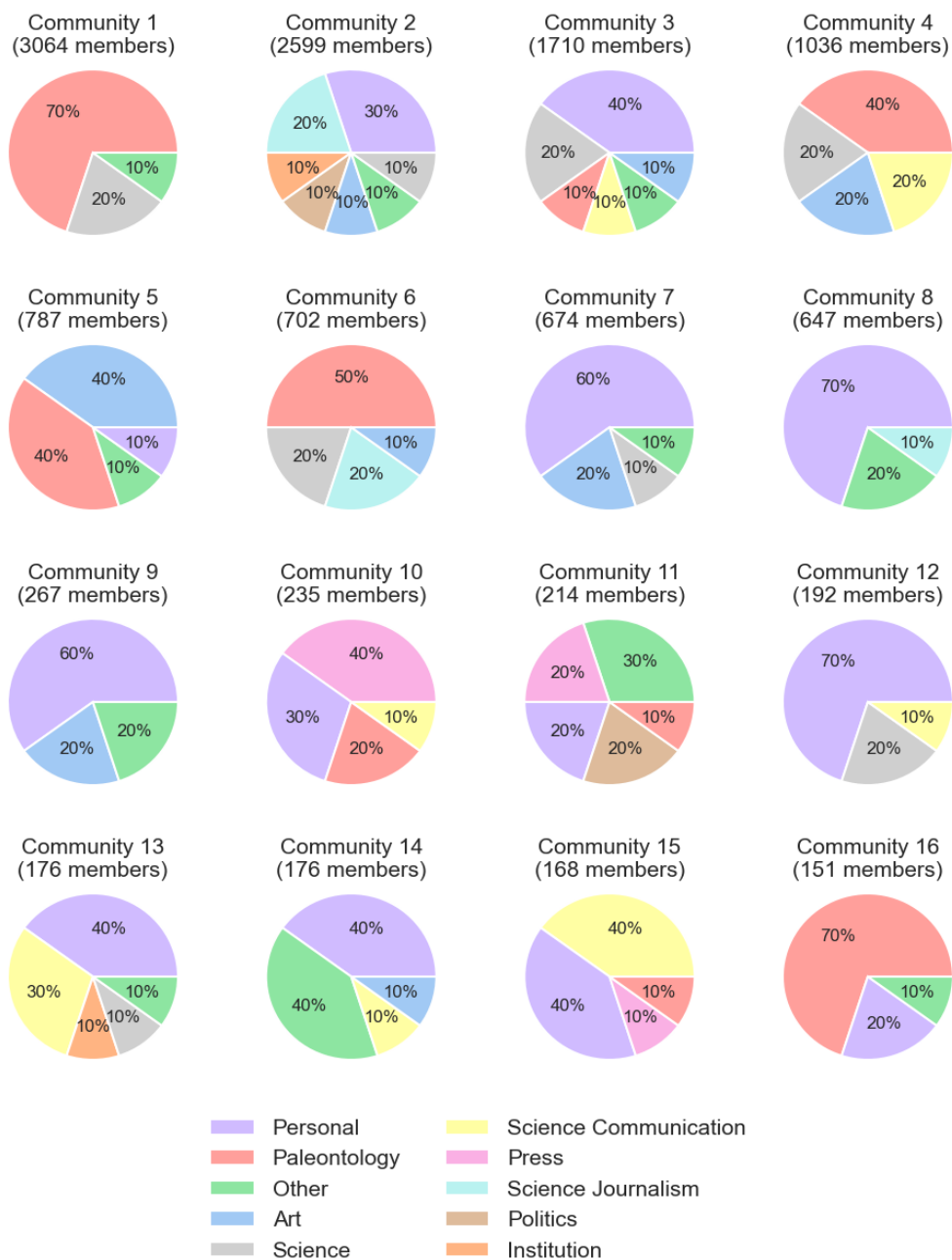


Figure 6: Type of account for the 10 top members of each community with over 100 members.

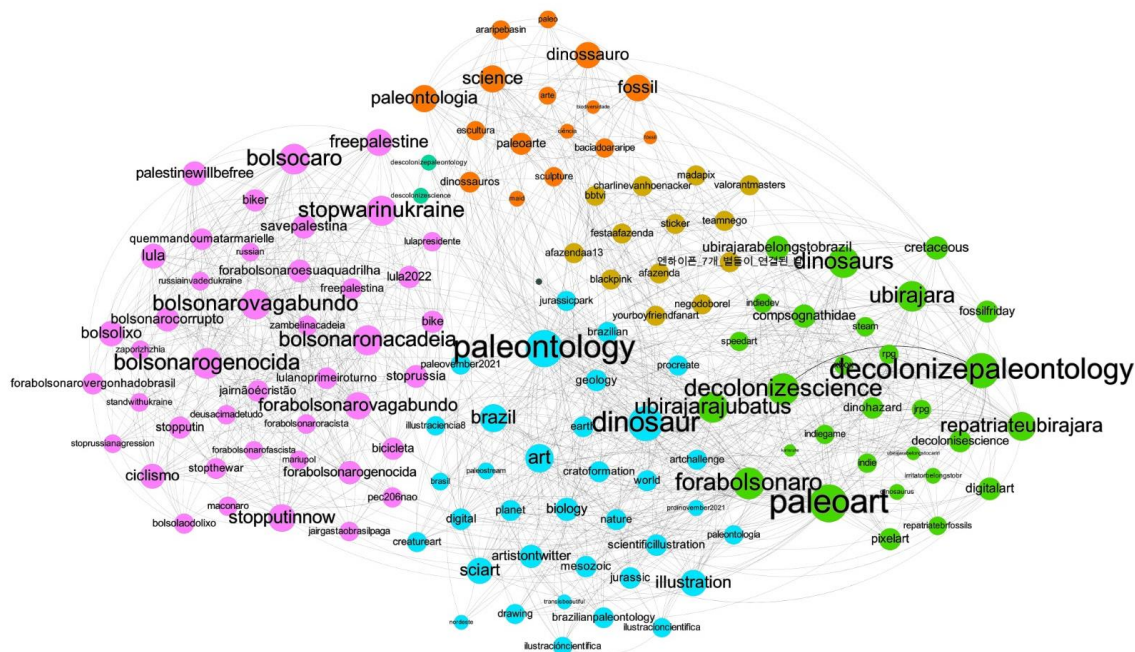


Figure 7: A figure with the network of co-occurring hashtags, with node colour indicating different communities of hashtags used in the same tweets.

The breakdown into communities also allows us to observe how each group of users behaves. While most communities mainly retweet the main tweets with the hashtag, communities 1, 7, 11, and 12 mostly post original tweets. Community 1 includes the main palaeontologists spearheading the movement, with a ratio of original tweets to retweets just over 50%/50%. Communities 7 and 11 mostly show users tagging other users, with tweets similar to “Hey @you look at this! #UbirajaraBelongsToBR”. In community 12, however, over 70% of tweets come from a single user, @bioriderjr, who has since deleted their account. In their tweets, the user messaged Brazilian politicians, science communicators, the German Ambassador and German Embassy in Brazil, as well as Theresia Bauer, who at the time headed the Ministry of Science, Research and Arts for the German state of Baden-Württemberg, demanding the repatriation of the fossil. The full table with the proportions of original tweets versus retweets and quote-tweets is shown in the Appendix.

305 Finally, hashtags such as #paleontology, #decolonizepaleontology, and #paleoart as central and important nodes in
306 the main community (Figure 7). Those hashtags, shared by the palaeontologists who led the movement, appear co-
307 occurring with several minor hashtags, such as #brazil, #art, or #repatriatubirajara. It is also worth noting how the
308 Ubirajara protest hashtags also appeared alongside other protest hashtags relating to international political events,
309 such as #stopwarinukraine and #freepalestine, as well as to Brazilian politics, such as #Bolsonarogenocida,
310 #Bolsonarovagabundo, #Bolsocar, #Forabolsonaro (meaning “genocidal Bolsonaro”, “Bolsonaro bum”,
311 “Bolsonaro expensive”, “Bolsonaro out”, respectively) and #Lula (Lula da Silva, Bolsonaro’s main opponent at
312 the time and current president of Brazil). This spillover of the protest event towards other political topics can be
313 interpreted as an indication of the political leaning of the Twitter users who were concerned about
314 #UbirajaraBelongstoBR.

315 **4 Discussion and Conclusion**

316 The #UbirajaraBelongstoBR movement represents a clear example of the intersection of social media activism and
317 the politics of science and academia, particularly within the realm of paleontology. Our analysis highlights the
318 crucial role of individuals with pre-existing social media influence in amplifying this movement. Such is the case
319 of the paleontologists, scientists, and science communicators shown in Table 1. This pre-existing presence provided
320 a platform that effectively raised awareness and mobilized public opinion, as evidenced in the widespread sharing
321 and engagement with the hashtag. Notably, the involvement of paleontologists brought authoritative voices into
322 the public discourse, lending credibility and urgency to the concerns raised about colonial practices in paleontology.
323 At the same time, the impact of non-paleontologists, including artists and the general public, demonstrates the
324 movement's reach beyond academic circles, enabling a broader societal engagement.

325
326 Our detailed analysis of Twitter data reveals not only the significant role of Portuguese speakers in propelling the
327 discussion but also underscores the contribution of the English-speaking community in a predominantly Portuguese
328 discourse. This bilingual dynamic indicates a broader international concern and engagement with issues of neo-
329 colonial practices in science.

330
331 We also find that fluctuations of retweeting and sentiment correlated to important events in the study case. The first
332 one happens in the period between the release of the *in press* manuscript and its temporary removal by Cretaceous
333 Research two weeks later (2020-12-24). The hashtag #UbirajarabelongstoBR was widely mentioned in local media

334 and also appeared on international outlets around this time (Greshko, 2021). The second fluctuation happens after
335 the announcement by SMNK that the Brazilian dinosaur would not be repatriated (2021-09-09). This is reflected
336 in the negative sentiment of the tweets. The German museum—who lacks a Twitter account— published a
337 statement on Instagram and Facebook declaring the Brazilian fossil to be “property of the State of Baden-
338 Württemberg”, generating great backlash on both platforms. Only two weeks after this announcement, the
339 manuscript was permanently withdrawn by Cretaceous Research and it was revealed that the authors of the
340 manuscript provided false information regarding the export of Ubirajara (Pérez Ortega, 2021). Finally, the last
341 fluctuation, reflecting positive tweet sentiment, is connected to the announcement (2022-07-15) by Germany that
342 the dinosaur would be repatriated (Pérez Ortega, 2022).

343

344 The Ubirajara case is far from being an isolated one (Cisneros et al., 2022b). The Araripe Basin in Brazil has been
345 a hub of illegally exported fossils for museums and private collectors since the end of the twentieth century
346 (Cisneros et al., 2022a). This issue has long been a source of concern for local scientists and authorities, and echoed
347 by the local press but largely overlooked by both the international scientific community and the foreign media. An
348 exception to this trend was a report by the journal Nature (Gibney, 2014) on Brazil’s efforts to fight illegal fossil
349 trade, and the case of the snake-like lizard *Tetrapodophis* in 2015 (Christakou, 2015). The latter represents, to our
350 knowledge, the first instance of an Araripe fossil study whose legal and ethical circumstances were publicly
351 questioned outside Brazil. This case, however, had only a mild presence on social media and did not achieve the
352 repercussions that Ubirajara had.

353

354 As mentioned above, social media activism allows underrepresented voices to attract attention and concentrate
355 discussions around topics that normally would be ignored or misrepresented. The large use of
356 #UbirajaraBelongstoBR on Twitter is a clear example of that, in how it quickly spread and gained attention,
357 collecting efforts from a wide public and forcing the issue to be noticed by stakeholders and news vehicles. This
358 was possible by both the large social media penetration in Brazil and its potential for use as a science
359 communication tool. Some studies point that Brazil is now a leader in science communication on social media
360 platforms, with Facebook, Twitter and YouTube being the main venues (Entradas et al., 2020; Velho and Barata,
361 2020; Velho et al., 2020). Moreover, the integration of artworks through the #Paleoart among others not only
362 enriched the movement’s aesthetic but also broadened its appeal and accessibility, allowing for a more diverse
363 demographic engagement. This inclusion of artistic expressions underscores the multidimensional impact of social
364 media movements, bridging science, art, and activism.

365

366 This paper also adds more evidence to the cultural value and cultural heritage aspect of fossils. The name
367 “Ubirajara”, meaning “lord of the spear” is derived from the indigenous Brazilian language Tupi, and is also the
368 title of one of the final novels of Brazilian writer José de Alencar, telling the story of a young warrior of the same
369 name (Alencar, 1874). Treating of fossils as cultural heritage may also help the community navigate its protection,
370 as argued in the de Araújo-Júnior et al. (2024).

371

372 Historical contexts such as the one of the Araripe Basin and the continuous illegal fossil trade emphasize the
373 systemic issues within paleontological research and highlight the need for stricter enforcing of current regulations
374 and more ethical conduct within the scientific community. Chacon-Baca et al. (2023) highlighted that even though
375 most journals adhere to the Committee on Publication Ethics (COPE), most do not require specifications on legal
376 or ethical requirements in their submission guides for authors. The significant media coverage that followed the
377 spread of the hashtag #UbirajaraBelongstoBR illustrates the power of social media in bringing international
378 attention to local issues, which have been previously overlooked by global audiences and the scientific community
379 alike. The interconnection of the #UbirajaraBelongstoBR movement with broader political movements against
380 Brazil's far-right government at the time also further contextualizes the social and political dimensions of the
381 protest. This alignment suggests that the movement was not only about scientific and ethical issues but also
382 reflected broader societal and political dissent.

383

384 As with any study relying on data collected from social media, our analysis has its limitations: although all tweets
385 with #UbirajaraBelongstoBR from the study period were collected, this study does not include related tweets which
386 did not include this specific hashtag. Tweet language inference is also not 100% accurate, and the anonymity
387 enabled by platforms such as Twitter/X means that even upon close examination it is not always possible to infer
388 a user's language, location, or field of activity (e.g. if they are palaeontologists or not). Finally, after the recent
389 changes in its data access policy, Twitter/X is no longer an easily accessible data source for scientific research on
390 social movements – a phenomenon which reflects the current state of research on online platforms (Freelon et al.,
391 2018). This change in policy was followed by the platform being blocked in Brazil from 30 August 2024 to 8
392 October 2025, which ultimately drove users away from the platform (CBS News, 2024). This further highlights the
393 importance of this study, as an effort to document and archive a social movement that is now obscured by such
394 policies. This is particularly important for a movement like this which was predominantly online, without an equally
395 significant offline component in the form of street protests or anything of the kind.

396

397 Still, this study opens potentially fruitful avenues for future research. One potential direction is the examination of
398 the impact of social media on the governance of scientific research and the enforcement of ethical standards,
399 whether for scientific research or not. Another area could involve exploring the role of digital activism in shaping
400 public policy and international agreements on cultural and scientific heritage, such as the policies around illicit
401 fossil trafficking in the case of Ubirajara. Additionally, further studies could investigate the long-term impacts of
402 such movements on public trust in science and on the practices within the paleontological community.

403 In conclusion, the #UbirajaraBelongstoBR movement not only challenged neo-colonial practices in palaeontology
404 but also showcased the transformative potential of social media as a tool for global awareness and advocacy. This
405 case study serves as a testament to the power of collective action through digital platforms and highlights the
406 evolving landscape of public engagement in scientific discourse.

407

Date	Event
2020-12-13	<i>In press</i> article on “Ubirajara jubatus” appears on the journal Cretaceous Research. [1]
2020-12-13	The hashtag #UbirajaraBelongstoBR is first used on Twitter by Aline M. Ghilardi. [2]
2020-12-14	The Brazilian Society of Palaeontology contacts Cretaceous Research.
2020-12-22	First report on the controversy by international media (National Geographic). [3]
2020-12-24	Article temporarily removed by Cretaceous Research.
2021-09-08	SMNK informs the Brazilian Society of Palaeontology that it will not repatriate the fossil. The Brazilian Society of Palaeontology informs its members.
2021-09-09	SMNK releases a statement on Instagram refusing repatriation of “Ubirajara jubatus”.
2021-09-10	A petition is created at Change.org asking for the fossil to be returned. [4]
2021-09-22?	Article withdrawn by Cretaceous Research.
2021-09-28	SMNK Instagram account is deactivated.
2021-09-29	Article in the journal Science reveals that the dinosaur was imported to Germany by fossil dealers in 2006 and purchased by SMNK in 2009. [5]
2021-10-15	The USA repatriates 35 fossil spiders to Brazil. [6]
2022-02-08	Belgium repatriates a pterosaur to Brazil. [7]
2022-07-19	Germany announces that “Ubirajara jubatus” will be repatriated to Brazil. [8]

409
410 **Table A1: Timeline of the #UbirajaraBelongstoBR protest.**

411
412 [1] <https://www.sciencedirect.com/science/article/pii/S0195667120303736>

- 413 [2] <https://twitter.com/alinemghilardi/status/1338199196348919816?s=20&t=Uv9P5IZAXaSwBFXR1GyYWA>
- 414 [3] [https://www.nationalgeographic.co.uk/science-and-technology/2021/01/one-of-a-kind-dinosaur-removed-](https://www.nationalgeographic.co.uk/science-and-technology/2021/01/one-of-a-kind-dinosaur-removed-from-brazil-sparks-backlash)
- 415 [from-brazil-sparks-backlash](https://www.nationalgeographic.co.uk/science-and-technology/2021/01/one-of-a-kind-dinosaur-removed-from-brazil-sparks-backlash)
- 416 [4] <https://www.change.org/p/ubirajara-belongs-to-brazil>
- 417 [5] [https://www.science.org/content/article/maned-dinosaur-fossil-will-head-back-to-brazil-after-controversy-](https://www.science.org/content/article/maned-dinosaur-fossil-will-head-back-to-brazil-after-controversy-over-import-to-germany)
- 418 [over-import-to-germany](https://www.science.org/content/article/maned-dinosaur-fossil-will-head-back-to-brazil-after-controversy-over-import-to-germany)
- 419 [6] [https://www.opovo.com.br/noticias/cariri/2021/10/15/traficada-aranha-fossil-que-homenageia-pablo-vittar-](https://www.opovo.com.br/noticias/cariri/2021/10/15/traficada-aranha-fossil-que-homenageia-pablo-vittar-retorna-ao-cariri.html)
- 420 [retorna-ao-cariri.html](https://www.opovo.com.br/noticias/cariri/2021/10/15/traficada-aranha-fossil-que-homenageia-pablo-vittar-retorna-ao-cariri.html)
- 421 [7] [https://g1.globo.com/ce/ceara/noticia/2022/02/02/fossil-de-cranio-de-pterossauro-originario-da-bacia-do-](https://g1.globo.com/ce/ceara/noticia/2022/02/02/fossil-de-cranio-de-pterossauro-originario-da-bacia-do-araripe-no-ceara-e-devolvido-ao-brasil-por-museu-da-belgica.ghtml)
- 422 [araripe-no-ceara-e-devolvido-ao-brasil-por-museu-da-belgica.ghtml](https://g1.globo.com/ce/ceara/noticia/2022/02/02/fossil-de-cranio-de-pterossauro-originario-da-bacia-do-araripe-no-ceara-e-devolvido-ao-brasil-por-museu-da-belgica.ghtml)
- 423 [8] [https://mwk.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/land-gibt-dinosaurier-fossil-aus-](https://mwk.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/land-gibt-dinosaurier-fossil-aus-naturkundemuseum-karlsruhe-an-brasilien-zurueck-1)
- 424 [naturkundemuseum-karlsruhe-an-brasilien-zurueck-1](https://mwk.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/land-gibt-dinosaurier-fossil-aus-naturkundemuseum-karlsruhe-an-brasilien-zurueck-1)

Community	Top 10 members by in-degree
1	alinemghilardi, PlantaSim, willibrunow, MaximusSpino, schrarstzhaupt, JoanaOrfao, TewBlack, SerpInFormes, kimim01, pedrowisq
2	boringsuchus, paleoeddye, [suspended user], catalina_leite, pilgrimcetus_, luizacaires3, MatheusKnothe, BRodriguesOhana, o_weverton, MarinesWitzke
3	WryCritic, MF_gadelha, PPaleoartist, DiAmador4, JuliotheArtist, sadtheropod, [suspended user], _PaleoGeek_, PalaeoVsRacism, LionsDenArtwork
4	ProjetoCiencia, tito_aureliano, dpaulocarvalho, kalebmelkor, ruzzibarbara, Pirulla25, bioriderjr, RabelloAnderson, eosauria, paleopirata
5	PaleoCisneros, Machado_DSc, mauritiantales, mathchaos, palaeodaniel, rpocisv, paleoTsimoes, PStewens, Yara_Haridy, RenanBantim
6	Colecionadores2, _themingau, Joseane_sf, Albertossauro, nishi_kazue, tainancia, PedroHTunes, ArqueoPreHist, CoelhoPre, nighthstrange
7	FlavianaJorge, JornalOGlobo, xicosa, elis_sntn, [suspended user], VenomaniaKou, revistapiaui, mwk__bw, wolverinegeo, NatGeo
8	smcarvalho42, giordaness, GabrielBritozz, portsmouthuni, [suspended user], sr_kenway, ikessauro, poeirinhadoalem, capetaman, pauloal97618063
9	mikannn, PrazerCambrãia, Sybylla_, rogan dopraga, CamaradaHidalgo, _ohcrab, lentevermelha, pifalcao, DiegoCrux, analesnovski
10	oTroianoleo, dwnnews, R0dr1got3, paleorocha, Camila_18FJ, vleonelss, mponcci, LutzLeo, AmbBrasilia, dw_brasil

11	antoniopedroalb, lucaskias, PaleoBlogBR, MarcosTeo2, marciolcastro, pteroana, saradrawspaleo, Hypnos_art, Vinsevla1, THSpike
12	FeliPinheir, jutyranus, tylerstoneart, tupaguerra, JersonTatu, DimetroDude, o_eco, almeidacm3, victor_debrito, allen_pancake
13	DaltonPinheiro1, nenel_leonam, MeioDeCultura, casavoguebrasil, MarcusRibeiroM2, saturns005, Brenin_m_b, rosecoloredjoca, C4iman15, jbubadue
14	MMarcosaurus, ValeriaRoman, luc14nobio, sgufmg, rraf aelbio, beccarivictor, Rafa_paleo, ramonsiilvaas, iMalvikaGaur, TomHoltzPaleo
15	brunobittar91, viadescendens, fadelandia, HaruJiggly, ratgroundpear, Nido_Quing, Lillyywho, badwitchmaris, subjetividdfeia, jinkitopia
16	BiodiversidadeB, PerboniRenato, MarjorieMbeller, Akamezinha, galileufanacc, LUNAtichenr, paulamariane27, rozzz_zz, folha_ciencia, PetraDeQuartzo
17	InsetoLand, isisrnd, Leo_Tusi, ttlua, ClelsonFraga, brunojose_, Luigi0131, LyraSid, _themonie_, Bugseelf
18	PesquisaFapesp, AllBrPolitics, Fenix_glacialis, 2XVIINI, LuanMoldanMotta, hummyeonbird, anai_pari_, Rabiaandrea, robsongfreire, anabee
19	KerberLeonardo, PsychoAna_xD, PaleoCameron, Jorllyrey, doralcoelho, [suspended user], MosaFabim, sasimarie, edvardvallek, saurianboy
20	fedkukso, adagamante, HenriqueRandom, peregrino0788, [suspended user], stephanevw, balsedie, centaurus_crux, barroso2501, gustavoburin

Table B1: Top 10 members by in-degree for each community in the protest network.

Community	# Original Tweets / #(Retweets + Quote-Tweets)
1	0.91
2	0.71
3	0.26
4	0.44
5	0.26
6	0.53
7	2.62
8	0.53
9	0
10	0.64
11	2.55
12	3.38
13	0.73
14	0.67
15	0.45
16	0.54
17	0.42
18	0.31
19	0.27
20	0.44

Table C1: Proportion of original tweets versus retweets and quote tweets per community.

7 Code and data availability

Code and data are available at <https://github.com/evoluchico/ubirajarabelongstobr>.

433 **8 Author contributions**

434 CQC coordinated the project and designed the study. MARFK collected the data and carried out the initial analyses,
435 CQC carried the later ones. MARFK and CQC produced all figures. NBR contributed with the literature review
436 and motivation. MARFK wrote the initial material, CQC produced the first draft of the paper, and all authors gave
437 final approval for publication.

438 **9 Competing interests**

439 The authors declare that they have no conflict of interest.

440 **10 Ethical statement**

441 The authors confirm the research received ethical clearance from the University of Exeter's Computer Science
442 department.

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447 by drawing, posting, sharing, retweeting, and supporting the movement.

448

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