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Patterns of Style, Diversity, and Similarity in Middle Orinoco Rock Art Assemblages

Philip Riris * and José Oliver

Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK; j.oliver@ucl.ac.uk

* Correspondence: p.riris@ucl.ac.uk

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Abstract: The area encompassed by the Orinoco river basin is home to some of the largest and most diverse rock art sites in lowland South America. In this paper, we aim to formally describe the spatial distribution and stylistic attributes of rock engravings and paintings on both banks of the Orinoco, centred on the Átures Rapids. Drawing on an exhaustive literature review and four years of field survey, we identify salient aspects of this corpus by investigating patterns of diversity and similarity. Based on a stylistic classification of Middle Orinoco rock art, this permits us to discuss potential links, as well as notable discontinuities, within the assemblage and possibly further afield. We consider the theoretical implications of our work for the study of pre-Columbian art and conclude with some suggestions for advances in methods for achieving the goal of deriving broader syntheses.

Keywords: South America; Orinoco; petroglyphs; pictographs; rock art; survey; similarity analysis; archaeology; network analysis; Amazonia

1. Introduction

Rock art, both painted and engraved, figures prominently in anthropological, archaeological, and naturalist writings on the indigenous societies of the Orinoco River (von Humboldt 1810; Chaffanjon 1889; Koch-Grünberg 1921; Koch-Grünberg [1907] 2010; Cruxent 1950, 1953, 1955; Tavera-Acosta 1956; Sujo Volsky 1975; Scaramelli 1992; Greer 1995b; Costas Goberna et al. 1996; Tarble de Scaramelli and Scaramelli 2010; Riris et al. 2017; Scaramelli and Scaramelli 2017). The span of the river located roughly between the Maipures Rapids and the mouth of the Meta has been highlighted as an area with an especially broad range and high diversity of rock art sites and motifs. Archaeologists have noted this separately for pictographs (painted rock art; Greer 1995a, p. 55) and petroglyphs (Dubelaar 1986, p. 126), while underlining the clear inter-relatedness of the known sites in this region (Dubelaar 1986; de Valencia and Sujo 1987; Greer 1995a, 1995b; Scaramelli 1992; Tarble de Scaramelli and Scaramelli 2010; Riris 2017). Recent work has introduced the possibility that the Middle Orinoco rock art corpus may have been created over a period of up to nine millennia, suggested by the recovery of ochre in situ with securely dated cultural deposits at the Cerro Gavilán rockshelter (Scaramelli and Scaramelli 2017). Evidence of long-term habitation adjacent to significant clusters of rock art stands alongside depictions of possible parallels to indigenous myth and ritual practices in the art (Scaramelli 1992; Lozada Mendieta et al. 2016; Riris 2017). Although the relationship between art in rockshelters and secondary burials remain unclear (Greer and Greer 1998), numerous associations indicate that widespread shared cultural practices and aesthetic norms surrounding rock art may have been present from a very early date, and until comparatively recently, in the history of the Orinoco River.

A number of issues with Middle Orinoco rock art pose challenges to the traditional goal of documenting change through time. Red ochre pigment associated with stylistically-early pictographs (Scaramelli and Scaramelli 2017) is without doubt the most common colour in use at most painted rock art sites and is unlikely to be temporally diagnostic on its own. While Cerro Gavilán is one of the only sites in the entire Orinoco basin where dated remains are directly associated to rock art (cf. Sanoja 1977), the great diversity of motifs and long occupational sequences from the early Holocene to the present limit conclusive extrapolations beyond this site. Finally, the relationship between petroglyphs and pictographs is unclear and petroglyphs do not necessarily map on to major archaeological cultures in the same way as proposed for pictographs (Greer 1995b), despite apparent parallels (Riris 2017). Although a relative chronology for painted rock art has been derived from cross-referencing superimposed motifs (Greer 1995b), our experience and field records show that, in the context of the entire regional rock art record, superimposition is relatively rare, especially in the case of petroglyphs. Rock art in the Middle Orinoco tends to form spatial, as opposed to cumulative, palimpsests (Bailey 2007). In this paper, we aim to update the overview of rock art distribution and stylistic variability in the Middle Orinoco (Figure 1), as well as propose some advances in methodology that can overcome these limitations and generate new insights in the process. Although chronology is a persistent challenge in the study of rock art, this should not preclude analyses that take place in geographical or topological spaces (Franklin 2007; Jennings 2016).

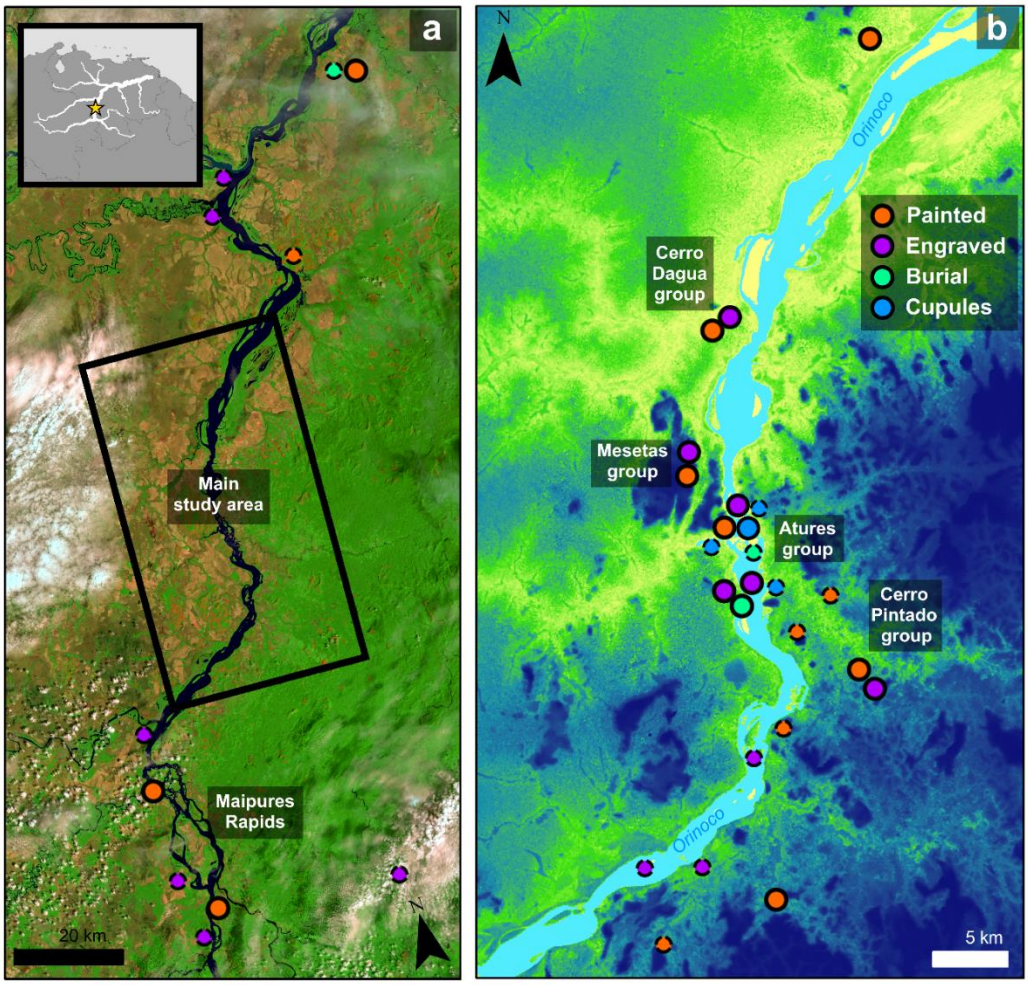

Figure 1. Major clusters of rock art, mortuary sites, and cupules in the Middle Orinoco (**a**) and Átures Rapids (**b**) reported on in this paper. Locations are approximate and may represent more than one site. Broken outlines indicate reported sites with incomplete or no data.

As a visual medium, rock art traditions likely contributed to identity formation among the pre-Columbian societies of northern South America and the neighbouring regions (Williams 1985; Reichel-Dolmatoff 1987; Tarble and Scaramelli 1999; Pereira 2001; Koch-Grünberg [1907] 2010; Valle 2012; Riris 2017). It is probable that Orinoco rock art centred on establishing and maintaining ties between human and non-human actors, as well as the supernatural, in social contexts and places of significance (Boglar 1976; Williams 1985; Overing 1996; Scaramelli 1992; Riris 2017). Recent research across South America has echoed this emphasis on interaction (see papers in Troncoso et al. 2017), focusing especially on rock art as structuring contact and information flow among prehistoric societies (Gallardo et al. 2012; Valenzuela et al. 2014). In parallel, ethnography and linguistics have been key to establishing and cross-referencing rock art taxonomies, through which stylistically-related assemblages are grouped on a broad geographical scale (Urbina 1994; Rivas 1993; Delgado de Smith et al. 1999; Pereira 2010; Castaño-Uribe 2011; Valle 2012; Paez 2018). Overall, ethnographic analogy has seen a renewed prominence in regional rock art studies (Leal-Xavier 2008; Hugh-Jones 2016; Valle et al. 2018). Nonetheless, the challenges outlined above undercut the viability of using information from contemporary or recent historical contexts to inform on the meaning of rock art traditions, which are of unknown age and occur on a large geographical scale. In other words, due to the vast spatiotemporal distribution of rock art, in many cases beyond the scale of any single ethnographic, archaeological, or linguistic entity, explaining the record with recourse to these factors alone remains challenging.

In this paper we focus on a group of rock art sites centred on the Átures Rapids and the Middle Orinoco margin to begin to trace an alternative to traditional approaches. Our aim is to emphasise the relational properties of pre-Columbian rock art in explicitly formal analytical terms. We propose that this can unveil evidence of enduring contacts and interaction among and between the pre-Columbian people who produced the rock art record. We report on the results of numerous completed surveys in the area, which have culminated in a large and representative database of rock art sites. This enables us to dissect relationships within this assemblage from a quantitative perspective, informing ongoing debates on style and tradition in South American rock art studies, as well as highlighting some tentative correlations with pre-Columbian material culture. We outline our data collection and analytical strategy before presenting and contextualising our results. In the absence of direct information on the artistic intent, usage, or meaning of rock art, we propose to treat the presence of widespread shared iconographic conventions as a proxy for past cultural selection, which can ultimately inform on the formation and spread of stylistic convention on a large scale.

2. Materials and Methods

2.1. Rock Art Survey and Classification

Our data collection consisted of both field- and desk-based surveys. To date we have conducted four seasons (2015–2018) of fieldwork in and around the Átures Rapids, on both the Colombian and Venezuelan banks of the Orinoco (see Riris 2017 for the latter). Sites in the field were targeted based on published and grey literature, as well as information from collaborating archaeologists (F. Scaramelli, pers. comm.) and local contacts in the area (J.C. García, pers. comm.). We also carried out opportunistic pedestrian surveys in the surroundings of known sites, including the rocky perimeters of islands, exposed outcrops of rapids, and rock faces bordering river channels. Digital photographs of rock art were taken using Nikon D3100 DSLR cameras with metric scales of individual motifs and, where possible, whole panels. Geographical coordinates of boulders, cliff faces, and rock shelters bearing rock art were recorded with a handheld GPS unit ($\pm$10 m accuracy). In cases where the size and/or accessibility of sites placed limits on traditional survey techniques, we supplemented our ground-based photography with aerial surveys using a DJI Phantom 2 Vision+ drone (see Riris 2017). Three-dimensional orthomosaics of large panels were generated from the aerial imagery to provide an in situ record of the rock art. Finally, we collated the extant literature on the rock art of the Orinoco from published reports, theses, books, and journal articles. We preferred cases

where descriptions are of high enough quality to allow counts of the site content (e.g., Greer 1995a, 1995b; Scaramelli and Scaramelli 2017; P. Novoa Alvarez pers. comm.) and excluded partial reports (e.g., Tavera-Acosta 1956). Site location information was collected where possible and estimated from descriptions and published maps where not directly stated. These diverse sources of data were compiled into a site inventory, which includes site-level attribute and bibliographic information (see Supplementary Materials for full motif counts by sites).

To understand the distribution, variation, and diversity in our sample of Middle Orinoco rock art, we carried out a qualitative stylistic categorisation of all the motifs included in the inventory. Our classification aimed to describe, at a basic level, the range of stylistic variation between the motifs and across our site inventory. Although every engraved or painted motif is in some sense unique, we aimed to create a basic scheme that was able to account for significant within-group variation while being both transferrable and extendable in our ongoing work in the region. The emphasis of classification is therefore on finding "common differences" (Wilk 2004) to define the range of variation, within which consistent forms of artistic expression unfolded in the Middle Orinoco (Layton 1992; Conkey and Hastorf 1993; Conkey 2006). Our classification therefore does not currently correspond to or imply any temporal schema (see Greer 1995b).

Our analysis relies on a working definition of style and variability in the context of rock art (Tarble and Scaramelli 1999; Wilk 2004; Franklin 2007). For present purposes, we define an individual rock art site as a group of motifs, engraved or painted, on a single substrate such as a cliff face or freestanding boulder. The motifs within a site can be distributed between one or more panels, which we distinguish between based on the facing and degree of spatial segregation between clusters of motifs. We define our typology of motifs with reference to our field data and the published literature, while acknowledging that a range of possible factors can be responsible for the observed variation at the motif level. This includes, but is not limited to, the aims, tools, technique, mental template, knowledge, experience, bodily position, taste, and beliefs of its makers, which collectively constitute a *style* and its range of variation (Maynard 1976; Layton 1992, p. 184; Franklin 2007). Middle Orinoco rock art is composed of a relatively restricted number of motif forms, which repeat over large regions of geographical space. We argue that this provides the main impetus for a classification of motifs focusing on how individual elements combine in distinctive ways to form this style. Types are intended to be mutually exclusive and refer to a consistent set of elements shared by all motifs within that group, while accounting for the fact that elements have an internal range of variation themselves. Our approach is therefore flexible, yet relatively conservative, since adding a new motif type to our database was only considered in the presence of a clear outlier in terms of morphology, meaning a combination of elements into a novel form of motif.

Individual motif types are therefore intentionally generic and broadly applicable and, for the sake of data management, we have opted to separate them into groups, within which we number each type consecutively. For example, the type *Geometric1* is defined as: "[an] enclosed regular geometric shape, internally subdivided". This effectively covers any non-representative geometric shape with approximately equal internal angles and some degree of internal subdivision. An irregular shape, however, would make a motif a *Geometric2*, while a lack of internal subdivisions would make it a *Geometric7*. The largest two groups (Geometric and Human) consist of eight and eleven distinct types (*Geometric1*, *Geometric2*, . . . *Geometric8*, *Human1*, *Human2*, . . . *Human11*). As noted, the level of within-motif variation is not standardised, since the composition of elements within a motif can vary substantially. On one end of this spectrum, *Composite1*- and *Composite2*-type motifs encompass an extremely broad range of combined elements, yet they are still consistent enough as a practice to merit distinct types. Conversely, there are a relatively limited number of ways in which a more "formal" motif, such as a *Scroll2*, can realistically be made. While the conjunction of specific sets of motifs can be a significant element of a rock art composition, the potential complexity of this information, in the context of sites numbering in the hundreds of motifs, precluded its inclusion. Our subsequent analyses aim to account for this factor. Figure 2 shows examples of some of the most common engraved and painted motifs.

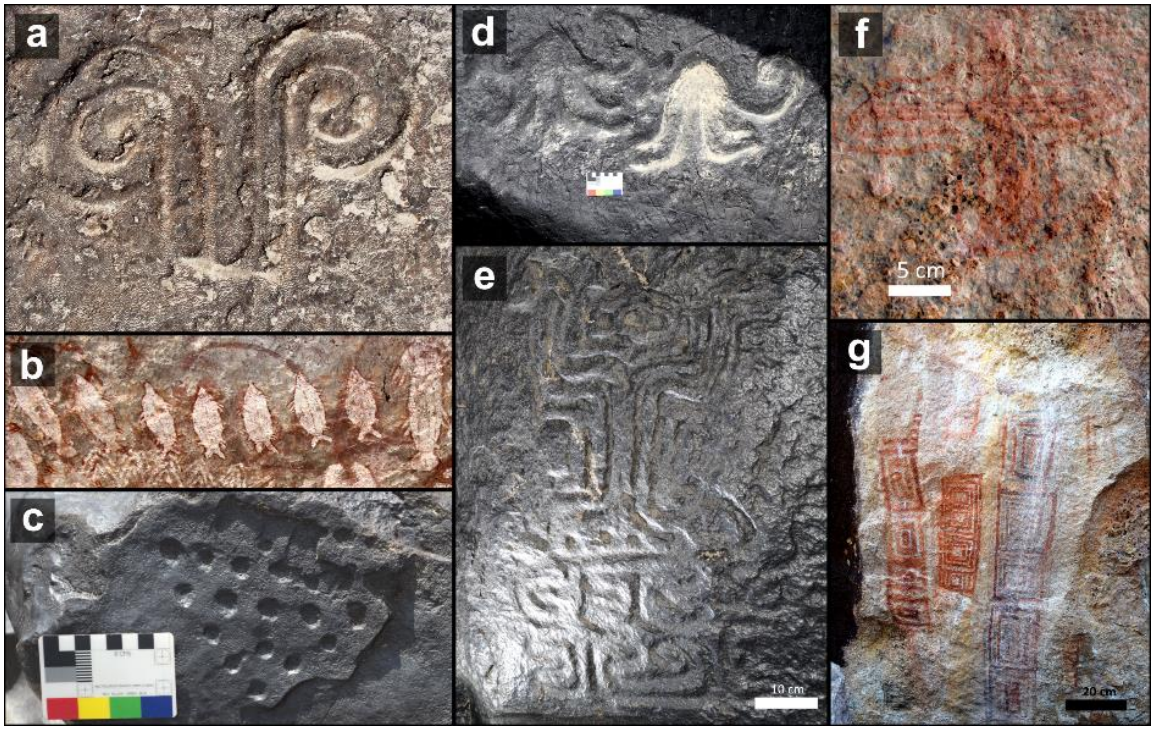

Figure 2. Examples of common Middle Orinoco rock art motifs. (**a**) A single-ended double scroll, Picture Upper (Scroll2), (**b**) Fish in profile with and without internal subdivisions, Cerro Gavilán II, (Fish1 and Fish2), (**c**) Dots arranged in a geometric shape, Yavarivén II, (Dots1), (**d**) Quadrupeds in profile, Raudal Zamuro, (Animal2), (**e**) Meandering composition of different motifs, including scrolls, spirals, and geometrics. Common enough to warrant a separate category, Yavarivén II, (Composite1), (**f**) Concentric cross motif, Cerro Pintado 8, (Cross1), (**g**) Internally subdivided regular geometric shapes and a chained variant, Cerro Dagua II, (Geometric1 and Chain3).

Although consistent classification ultimately relies on the rigour of the individual analyst, we note that this issue is generally applicable to most studies of prehistoric rock art, including previous large-scale classifications of Orinoco rock art (see Dubelaar 1986). Data collection was completed over a relatively short period of time by the lead author and the database was continuously updated and re-evaluated in the context of emerging data. Given these factors, we feel confident that the data is at least internally consistent on a stylistic level. A key strength of our approach is the provision of all data and means of analysis as supporting information. We invite the exploration of the data and methods and encourage their extension to other regions and contexts with outstanding rock art records.

Our surveys resulted in a database of 1457 individual motifs distributed across 35 sites (18 painted, 17 engraved) that contain at least 63 separate panels. Motifs were cumulatively added to a table of counts as encountered and classified by morphology and degree of elaboration. Our classification resulted in 22 groups of motifs subdivided into 71 different motif types. The group of "Human Figures" has the largest range of variation (10 types), followed by non-representative geometric motifs (8 types). Classification was completed within a short time frame by one author (PR) to ensure consistency and, where possible, to constrain motifs as much as possible to the forms previously defined. Only when a motif was a clear outlier in terms of style and shape did we consider adding a new type to the database. Our overall approach to classification is therefore relatively conservative and our classification of rock art style, while ultimately resting on the rigour of subjective analysis, provides an internally consistent point of entry to the rock art of the study area. We note that Middle Orinoco rock art, while highly variable, is in reality composed of a relatively restricted number of total forms given the size of the corpus.

Nonetheless, 236 motifs (16.1%) could not be classified due to damage, degradation, poor source image quality, or a combination of these factors. We focus on the remaining 1221 motifs. Among the new sites presented here, we can show to only a single unambiguous case of superimposed petroglyphs in the Raudal Yavarivén cluster, while superimposed pictographs are unfortunately absent from the sample of new sites here. Finally, we note that we did not encounter any records of sites hosting both pictographs and petroglyphs (excluding special cases such as painted rock shelters with cupules/mortars on the floor like Cueva Gavilán I or Cerro Dagua). Each entry in the inventory is therefore either a painted or an engraved rock art site.

2.2. Quantitative Analysis

Our data collection and classification permit us to examine the structure of the Middle Orinoco rock art record in greater depth. We characterise its distribution and variability through a descriptive analysis of rock art motifs using classical summary statistics and quantitative measures of both diversity and similarity. This enables, on one hand, insights into the overall structure of the rock art assemblage, and on the other, direct comparisons between pairs of sites in terms of their stylistic similarity. In turn, we aim to show how stylistic similarity can support inferences about the degree of interconnectedness of pre-Columbian artistic traditions, as expressed in the rock art record.

The Shannon index (H) is an established measure of diversity in ecology and, in principle, has a general applicability to categorical count data of any kind (Jost 2007). We propose that it can help understand how rock art may have accumulated differently between specific locations. The index H is weighted by the relative abundance of each motif at the sampling locations (i.e., individual rock art sites) and can easily be converted into the true diversity of a site (the effective number of rock art motifs), typically denoted as H′. It provides an initial point of entry to understanding the structure of our assemblage that is more robust, and therefore potentially more informative, than using simple counts, measures of richness, or non-weighted equivalents (Jost 2007).

To characterise similarities, we employ and compare two correlative indices, motif co-presence and the Jaccard coefficient. These measures identify the amount shared stylistic conventions between sites in our sample. For analytical purposes, we only count motifs that make up at least 5% of the site assemblage as present in the co-presence index. While this choice penalises very large sites, given the extreme skew of our count data (Figure 3a), we find this an acceptable compromise. The Jaccard coefficient is a classic similarity measure, simply defined as the intersection of shared motifs between two sites divided by their union. It has seen use as a clustering metric in rock art studies (Layton 1992). Unlike our definition of co-presence, it lacks an arbitrary exclusion threshold and also employs relative abundance as a weighting metric (Chierichetti et al. 2010). Similarity as defined per this index scales from zero to one, with the top end of the range reflecting pairs of identical sites. In both indices, therefore, sites with a greater number of shared motifs are treated as more similar and, hence, have a stronger connection. Sites are 100% self-similar, but for presentation purposes we exclude this information.

3. Results

Motif counts are highly skewed towards only a handful of rock art sites, with 70.6% of the total number of motifs (n = 863) in our database and more than 90% of the total types of motif (n = 65) occurring in the following five largest sites: Cueva Gavilán I, Abrigo Agua Linda, Cerro Pintaito I, and Picure Upper, and Raudal Mesetas (Figure 3). There are only six motif types that do not occur in these exceptionally large rock art sites. This implies that a large proportion of the total variability in the assemblage is captured in a relatively small number of locations. In contrast, the representation of motif types in the bottom 30 sites drops to nearly 80% (n = 57). Most sites have only a small number of motifs, with over half of our sample of sites (51%) possessing ten or fewer motifs in total. Within this subset of very small sites ($\leq$10 motifs), only 50% of the total types of motif are encountered. This represents a sharp drop-off. Furthermore, there may be a marked difference between painted and

engraved rock art, with the largest petroglyph site (Picure Upper) having less than half the number of motifs as the next largest pictograph site (Abrigo Agua Linda). These differences bear out in a comparison of each class, pictograph sites are on average much larger ($\bar{x}$ = 47.9 for painted rock art versus 21.1 for engraved), but with an attendant larger standard deviation (σ = 90.9 versus 31.3).

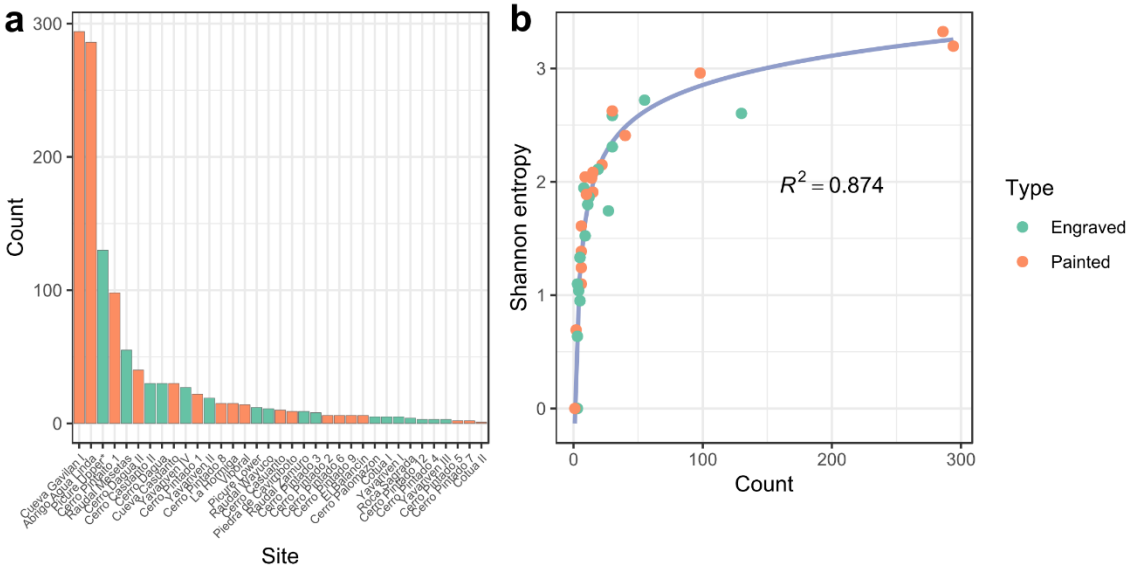

Figure 3. Descriptive attributes of the Middle Orinoco rock art assemblage. (**a**) Counts of rock art motifs per site by type of art. The distribution of counts is log-normal. (**b**) Diversity of each rock art site against site motif count, fitted to an exponential function. Diversity is clearly non-linear with respect to the size of rock art sites. The adjusted fit of an exponential model improves for paintings (R^2 = 0.9021) but not for engravings (R^2 = 0.776) when the site types are considered separately.

Medium (~100 motifs) sites are where Middle Orinoco rock art diversity appears to begin flattening out, indicating that most motif types ought to be represented in a site of this size (close to 90%). Past this point, having accounted for most of the variability and causing diversity to flatten out as observed (Figure 3b), adding motifs is more likely to be "more of the same". Inverting this inference, if motifs are added to a medium-sized site, potentially doubling or tripling its size, they are proportionally less likely to be novel and more likely to be duplicates. This also indicates that the distinguishing factor for large sites in our sample is due to possessing rare or unique motifs unlike any other in the sample. These seemingly only arise in large accumulations of rock art. At the other end of the size spectrum, we find that a much narrower range of 31 motifs out of 71 types (43%) are present at the "small" and least diverse rock art sites. The most common motifs within this group are concentric circles, simple lines, and quadruped animals in profile. Unique and very rare motifs are effectively absent from small sites, confirming their near-exclusive presence in large sites. In summary, this suggests the existence of the following: (1) A possible baseline range or "vocabulary" of motif types that even small rock art sites in the Middle Orinoco are likely to have, (2) an intermediate size range of sites that are representative of variability in the majority of the corpus, and (3) a few large sites that possess a small number of uncommon motifs in addition to the range of motifs likely to be encountered in the intermediate category. Although we cannot tell at present whether these patterns are a function of site size alone, taken together, it may suggest the presence of a "rich get richer" dynamic (Barabási and Albert 1999) in the formation of the rock art record.

In terms of spatial distribution, both petroglyph and pictograph sites can frequently occur within only a few tens of metres of each other, but never close enough to be considered a single mixed panel of rock art. For obvious reasons of taphonomy, pictographs are never found in seasonally-submerged areas of the river and its margin and only four cases of open-air painted

rock faces or freestanding boulders were recorded in sheltered locations. Conversely, no engravings were recorded in rock shelters and they occur exclusively on freestanding boulders or open-air rock/cliff faces, which includes submerged riverine locations. Our results accord well with previous research in the region that identifies this kind of spatial segregation between different site types, possibly related to their possible function as markers of different practices (Scaramelli and Tarble 2000; Tarble de Scaramelli and Scaramelli 2010; Riris 2017; Tarble and Scaramelli 1999). Following these works, an association between pictographs and mortuary deposition appears plausible, although not all mortuary rock shelters have rock art (and vice versa) and some researchers doubt any direct connections (Greer and Greer 1998). Both classes of material (bone and paint) preferentially preserve in these environments and poorly outside them, raising the issue of whether this pattern is a product of taphonomy or human agency. Similarly, petroglyphs can survive open air exposure and the seasonal high energy water flows of rivers. Our field observations indicate that fracturing and spalling of granite bedrock and boulders is frequent and widespread enough to adversely affect petroglyph sites, although it remains unclear whether there were also cultural selection biases towards rock faces where petroglyphs are likely to be preserved. The granite bedrock is not completely homogenous and certain areas are both more protected from the action of the river and composed of less granular and apparently harder stone (Riris 2017). It is also not possible to exclude recent (late pre-Columbian or Colonial-era) reworking as responsible for the excellent preservation of certain groups of motifs (see Koch-Grünberg [1907] 2010).

These differences in the diversity and distributional patterns of our sample warrant further examination. Figure 4 displays comparisons of each pair of rock art sites, measuring similarity based on the simple co-presence of motif types (a) and more formally with the Jaccard coefficient (b). The sites are organised from left to right in increasing number of similarities to other sites. Interpreting these indices alongside one another should be done with caution, as they capture fundamentally different aspects of the distribution of motifs among our sample. For example, the sites of Cerro Dagua II and La Hormiga rank among the highest for co-presence, but are only slightly above average in Jaccard similarity. Equally, the most "Jaccard-similar" sites (Yavarivén III and Cotua II) are small and share a single motif in common, a highly variable type (Composite1) that is composed of relatively large areas of faint and meandering geometric lines and which only occurs in rapids. Similarity in this specific case would appear to be an artefact of the classification procedure, since no Composite-type motifs are identical, and the type refers more to the practice of conjoining geometric and/or representative motifs together across large surfaces (Figure 2e). In the interest of observing how such patterns may behave across the entire sample of rock art, we elect to not exclude small sites for now.

Close reading of the similarity coefficient suggests that it may highlight spatial subsets within the data, specifically between the Cerro Dagua and Átures groups (top right). The Cerro Pintado group, being a relatively large and heterogeneous group, has weak stylistic connections to sites in almost every other group, while also possessing numerous within-group similarities. The two largest pictograph sites, Cueva Gavilán and Abrigo Agua Linda, are closely related, yet the largest petroglyph site (Picure Upper) is not particularly like either. Conversely, the co-presence index provides a different perspective. Cerro Dagua I and II stand out as sharing motifs with sites across multiple groups within the study area. These sites score comparably in terms of above-average true diversity (H′ = 13 and 11, respectively), suggesting a potential correlation between site inter-relatedness and high true diversity. This follows from the intuition that the more diverse a site, the more likely it is to share motifs with other sites. There are important inconsistencies in this pattern, as in the Gavilán-Agua Linda-Picure group of sites above, which despite being highly diverse are not well connected by similarity.

Certain sites appear to bridge geographical space through stylistic commonalities with a large number of other sites in both the co-presence and Jaccard metrics. For example, Yavarivén II, Cerro Casuarito II, and Cerro Dagua II all have relatively strong similarities to a larger than average number of sites outside their immediate setting. These three examples also have true diversities of motifs in the middle range (H′ = 8, 10, and 11, respectively). Conversely, large and exceptionally diverse sites,

such as Agua Linda (H′ = 27), are only similar in content to other sites of a similar size, which supports the prior inference that these locations stand out from the rest of the sample. Across the set of Middle Orinoco rock art sites, the above trio could represent sites that structure interaction between localities, brokering links that belie the significant geographic distances between individual groups. A deeper understanding of this aspect of our dataset can be achieved by visualising the correlation matrices (see Figure 4) as a network (Figure 5a).

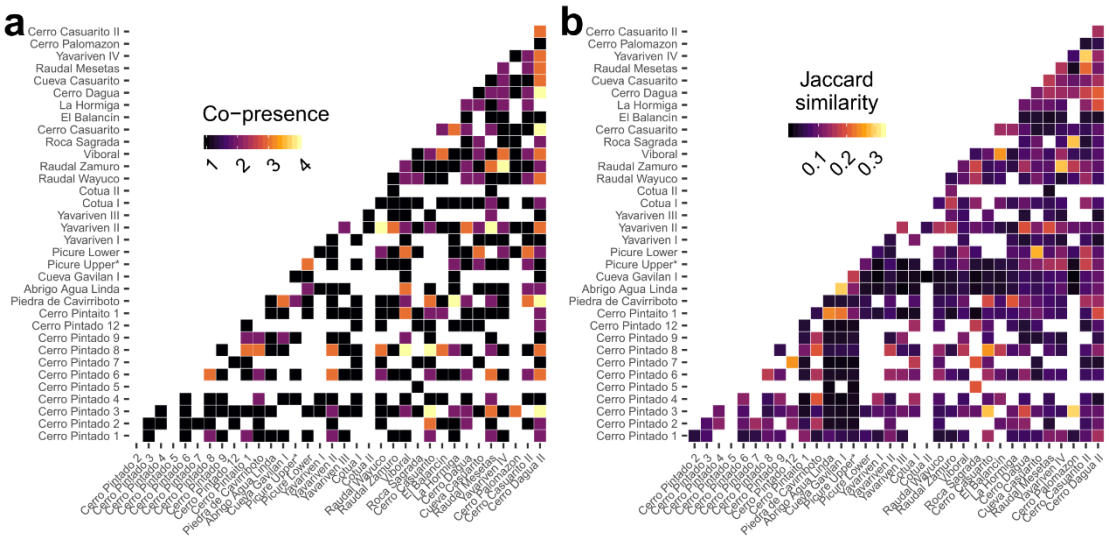

Figure 4. Correlation matrices for co-presence of motifs (**a**) and Jaccard similarity (**b**). Axes are consistent between each matrix to facilitate comparisons. Pairwise comparisons with a value of 0, indicating no similarity, are hollow. Note that many weakly similar sites score very low (dark purple) on the Jaccard index, whereas co-presence has sharper cut-off points.

Exploratory network analysis is useful for highlighting inter-site relationships that are less apparent through other methods, even without deploying formal modelling approaches (Brughmans 2013; Collar et al. 2015; Mills 2017). Network approaches in archaeology have been successfully applied to art in general (Jennings 2016), as well as to large databases of rock art specifically (Valdez-Tullett 2017). We render connections (links) between sites (nodes) by thresholding the Jaccard similarity, where a Jaccard similarity of $\geq$0.1 denotes the presence of a connection between two rock art sites. This allows us to highlight the number of connections present per site (the node degree) at different levels of similarity (Östborn and Gerding 2014).

Our rendering of the Jaccard index in this manner supports the notion that highly diverse sites are not necessarily the most stylistically inter-related to the overall assemblage. A simple visualisation confirms the centrality of the medium-sized Cerro Dagua I and Cerro Casuarito II sites in stylistic terms, while the large and impressive Agua Linda and Gavilán sites hover together on the outside of the network, a pattern which, as noted above, would seem to contradict their stylistic diversity (see Figure 3). The average number of connections per node (degree) in the network is 6.4, with these latter sites having only 3 links each and the former sites having 13 and 12 each. Put into more formal terms, rock art diversity performs poorly as a predictor of the number of connections a site has among the set of all sites (Figure 5b).

Excluding Agua Linda and Gavilán identifies a highly significant relationship between degree and diversity. This implies that, counterintuitively, large and richly elaborated rock art sites might not function as "influencers" as such. We caution against drawing strong conclusions from this finding on its own, as our exploratory network is explicitly based on site-to-site similarity. This means that sites with many motifs recorded nowhere else (e.g., large numbers of *Fish2* at Gavilán and Agua Linda, see Figure 2) will necessarily stand out. Additionally, as the Jaccard coefficient is weighted by count, widespread motifs that are also present at these sites in low numbers could conceivably

have a reduced statistical weight. Further investigation in the future using a variety of metrics and network statistics may help elucidate this apparent contradiction between diversity and connectivity when considering large and exceptional sites. Accounting for factors such as structural network effects and other covariate data should also be a priority in this regard. Networks, together with the correlation matrices, help to underscore the outstanding qualities of large rock art sites, as well as the centrality of "intermediate" sites as hubs in the overall structure of the assemblage. In future work, the mechanism(s) that drove patterns of brokerage among sites (Peeples and Haas 2013) need study through formal modelling.

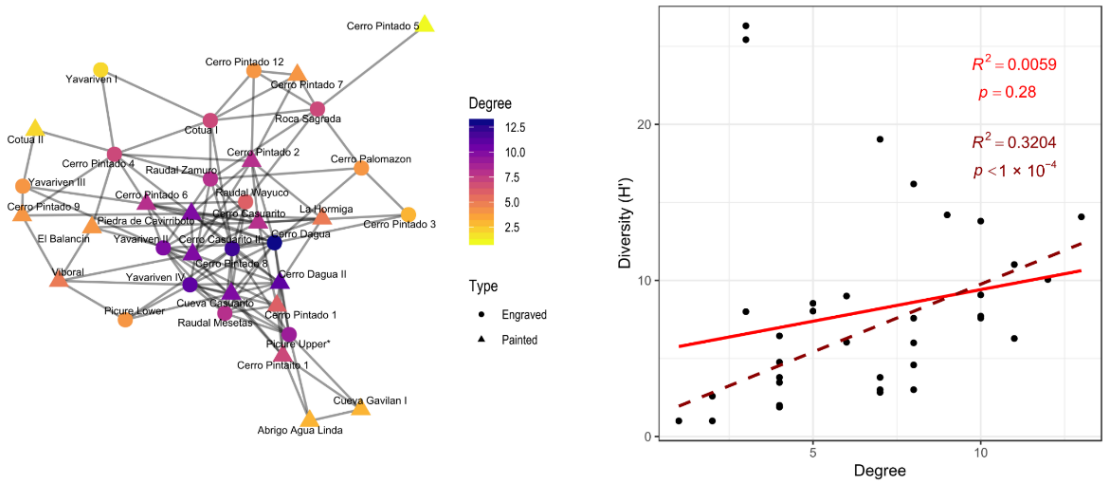

Figure 5. Visualisation of stylistic similarity as a network. (**a**) Network of linkages where Jaccard similarity is $\geq$0.1, a threshold introduced to reduce over-plotting. Points are coloured by their degree (number of links). (**b**) Rock art site diversity does not correlate strongly with its degree in the network (light red), unless the largest and most diverse sites are excluded (dark red). The level of correlation remains relatively low and the most connected sites have moderate true diversity scores.

4. Discussion

As noted at length by preceding reviews (Dubelaar 1986; de Valencia and Sujo 1987; Greer 1995b; Scaramelli 1992; Tarble de Scaramelli and Scaramelli 2010; Riris 2017), Middle Orinoco rock art displays strong stylistic inter-relatedness within an overall pattern of high diversity. Here, we have attempted to quantify this pattern to better identify the degree and range of variation of both similarity and diversity. Our results foreground these attributes of the rock art assemblage and allow contrasts and comparisons to be made between the sites. Our analysis is based on a consistent classification, provided alongside the methods and data in the Supplementary Materials. We do not presume to be authoritative or preclude the validity of prior findings. We hope our work may eventually be compatible for integration with relative chronologies or models of language spread in the Orinoco (see Greer 1995b; Antczak et al. 2017; Paez 2018). Regarding taphonomy, we have noted very few direct correlations between the setting of a site and its level of preservation beyond the obvious case of painted art not surviving open air or direct exposure to flowing water. Taphonomic factors are likely to be complex and site-specific. For present purposes we have assumed that, on average, the effects of differential preservation will cancel each other out on the spatial scale that we have adopted here. Here, we discuss our findings that contribute to an understanding of the rock art corpora of our specific research context and findings that we hope will refine procedure in the study of assemblages composed of a broad range of different site sizes.

In the latter case, site diversity follows an exponential curve per the Shannon index (H) when plotted against motif counts, a property often observed in species count data in ecology (Jost 2007). It is surprising to find that diversity does not necessarily predict site similarity and, hence, the number of connections it possesses when projected as a network. In very general terms, we observe that

archaeological experts and laypeople alike tend to accord great importance to very large rock art sites. This makes sense, insofar as they are aesthetically imposing, uniquely diverse, and often well-preserved. Due to these factors they are frequently afforded special protections. Nonetheless, our results indicate that sites of intermediate size are likely to be more informative for understanding how a group of sites relate to one another. This has implications for the study of rock art more broadly, as large sites are frequently treated as type-sites from which traditions, styles, or complexes are defined and derived (see Franklin 2007; Castaño-Uribe 2011). While these theoretical constructs are predicated on how related to one another a given set of sites (or artefacts) are (Layton 1992; Wilk 2004; Conkey 2006), the results suggest that diversity on its own may not be the best point of departure for understanding the structure of rock art assemblages. This is illustrated by, in our case, how Abrigo Agua Linda and Cerro Gavilán II are somewhat incidental to overall network structure (Figure 5a). Generalising this finding beyond the Middle Orinoco will require a significant quantity of data from other regions of the world. If such information were consistently recorded and analysed, we provide a blueprint for further comparative study (see Supplementary Materials). A broader methodological implication of our approach has arisen through contrasting diversity with similarity against the backdrop of the study of style. First, we have quantified the intuition that large and elaborate rock art sites (>100 motifs, e.g., Cerro Gavilán) stand out from the rest of the assemblage. They appear to be a separate class of site in more than one sense. Second, perhaps unexpectedly, these sites are not prominent elements of stylistic similarity networks, due to their unique content and combinations of motifs. Although, by definition, every node and link will contribute to overall network structure, the most central sites are consistently in the middle range between small (<10 motifs) and large (>100 motifs) sites. Testing the extent to which this inference applies, and what it means, beyond the Middle Orinoco will require more extensive data and formal network analysis. We predict that this will enable theoretical explorations of the significance of rock art "traditions" in the context of how archaeologists understand cultural diversity and similarity (DeBoer and Moore 1982).

Beyond the question of scale in terms of motif numbers, it is worth commenting on the *physical* scale of certain rock art sites in our area, which reveal practices in the production of rock art apparently unique in South America. For the Orinoco, we highlight two motifs in particular, snakes and costumed personages. We have recorded five large zig-zagging snake motifs, in the order of tens of metres long (Figure 6). These possess either straight or spiralling tails and horned or unadorned triangular heads and are all clearly stylistically and conceptually related motifs. The engravings are produced by abrading the top, darkly-weathered layer of the local granite inselbergs (cerros, or hills) and consequently they are barely recessed into the rock at all. Snakes co-occur with a variable set of motifs, but most commonly quadrupeds in profile (Animal2), closed regular geometrics with or without internal subdivisions (Geometric1 and Geometric7), and concentric circles (Circle2). There is no strong evidence for exceptional stylistic similarity at a site level (see Figure 4a), except possibly in the pairings of Dagua-Palomazón and Casuarito-Pintado. The other motif type (Human11), also from Cerro Casuarito, is a category of full-bodied anthropomorphic figures that occur alone or in pairs, and often are accompanied by other figures or motifs, such as is shown in Figure 7. Large-scale images such as these "lord over" a broad landscape, due to their size and prominent placement on cliff faces. Yet when standing next to them, they become visually unintelligible if not invisible, similar to the Nazca geoglyphs (Ruggles and Saunders 2012).

In contrast, petroglyphs of a more typical size (i.e., not monumental in scale), especially those on river boulders and inselbergs across the Átures Rapids, require proximity to become visible. While in a sense all rock art may held to be "monumental", a noun derived from the Latin root monēre (to recall), independent of scale or size, grandiose motifs clearly have a different functional and cognitive valuation in comparison to smaller motifs. Location in relation to the Orinoco is also an important factor. Large-scale petroglyphs located on hill façades of Dagua, Casuarito, Pintado, and Palomazón are visible year-round, while those strewn across the Orinoco river on boulders are seasonal. These are fully visible only during the dry season (December–April) during the period of river lowstand, which

may also have contributed to their generally good preservation (Riris 2017). Thus, we highlight a different periodicity of engagement that suggests a functional distinction between monumental and non-monumental rock art. A notable exception occurs in Picure Island, where monumental petroglyphs are found engraved on a large sloping flat boulder that is submerged throughout most of the year. As noted above, this panel could only be recorded from above via drone photography, a perspective not available to pre-Colombian people (see Riris 2017). Consequently, Picure Island stands out as exceptional, not only because it has monumental dimensions, but because of the seasonality implicit in the visual access to the engravings. This is interesting in light of ethnohistoric evidence singling out this island as an exceptionally important centre of commerce between the fifteenth and eighteenth centuries, where peoples from afar traded goods at specific times of the year (Ojer 1960).

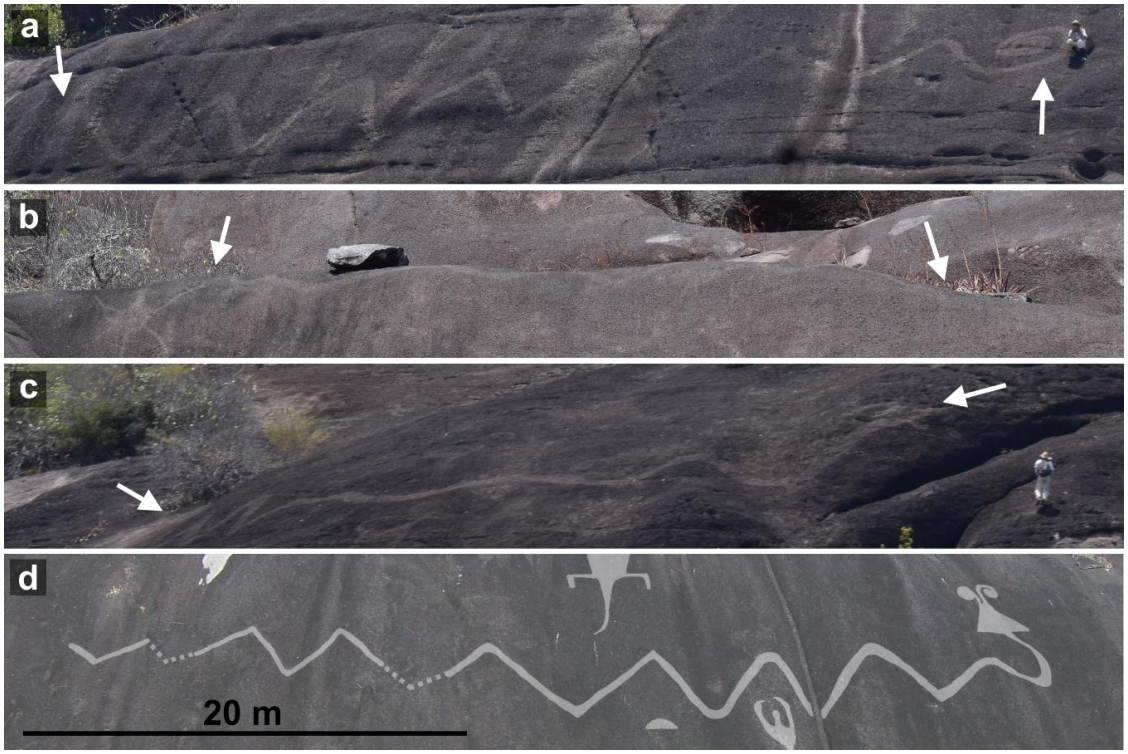

Figure 6. Large snake motifs recorded in the Middle Orinoco, with humans for scale. Arrows indicate extent in absence of enhanced image overlay. (**a**) Cerro Palomazón, (**b**) Cerro Dagua, (**c**) Cerro Casuarito, (**d**) Cerro Pintado.

Large-scale pre-Columbian art has been documented in Venezuela for the better part of a century (Cruxent 1949; Urbani and Urbani 2001), with two known geoglyph sites in Carabobo state to the north of our study area. These geoglyphs are the only reported evidence of art production on a scale comparable to the snake motifs. It would appear that the monumental snake motifs are a unique feature of the Middle and Upper Orinoco river, in that they are clearly related in terms of style, placement, and size, and occur in a relatively small area. Geoglyphs, although larger, do not share any stylistic affinities with one another or to the large petroglyphs. Against the backdrop of long-term inhabitation evident in and around the Átures Rapids (Barse 1989; Lozada Mendieta et al. 2016), the visual prominence of these motifs appears intentional. The overwhelming majority of the monumental figures are located on large granite inselbergs facing outwards across the surrounding landscape, making them visible from far away. Although the snake at Cerro Dagua was placed on the bevelled edge of a cliff face and is therefore relatively hard to see until within a few tens of metres, other large motifs on this panel are quite visible from comparable distances. Our field observations indicate visibility at 500 m at a minimum for the snakes at Casuarito and Palomazón.

A pair of human figures at Cerro Casuarito (Figure 7) display body-length costumes and masked faces that invite comparison with the Warime and Yuruparí rituals documented among the Wóthuha (Piaroa) and Eastern Tukano-Desana, respectively. In these ceremonies, men re-enact and commemorate cosmogonic events, that have been related through mythical narratives, as part of an annual cycle of renewal (Reichel-Dolmatoff 1996; Mansutti Rodríguez 2012). We draw special attention to the following: (a) The prominence and centrality of anacondas as ancestral figures, and (b) the mythical roles taken on by costumed Warime/Yuruparí participants as mythical beings among many native societies of north-western Amazonia and neighbouring regions (see Reichel-Dolmatoff 1987, p. 447; Hill 2009; Wright 2017). Both the snakes and the costumed figures may be analogous to the reproduction of narrative "sequences-in-place" in which myth and storytelling are repeatedly inscribed into the landscape (Hugh-Jones 2016). Moreover, it is worth noting that some Piaroa Warime songs tend to be directed towards hills and other prominent topographic features (Mansutti Rodríguez 2012, p. 61). While the emic significance of rock art is not the focus here, the role of certain classes of rock art may centre on the reproduction of society over time.

Figure 7. Monumental rock art (Cerro Casuarito, Vichada). These petroglyphs are clearly visible 350–400 m away (measured by GPS). The pair of anthropomorphic figures (about 8–10 m tall) display a costume that the Piaroa recognise as the bark-cloths used in the Warime ritual at the onset on the rainy season. The lower is an unidentifiable quadruped (*Animal3*).

It is worth noting further correlations drawn between the archaeological cultures of the Middle Orinoco and its rock art record. Recent work has highlighted stylistic links between rock art and dated material culture, especially ceramics (Tarble de Scaramelli and Scaramelli 2010; 2012; Antczak et al. 2017). Notably, the artefacts found at the Cerro Gavilán rockshelter in stratigraphic association with the earliest dates include ochre similar in coloration to the pictographs in the rockshelter. There are also enough occurrences of superimposed motifs that Greer (1995b) used this site as one of the keys for deriving his relative chronology of pictographs for the Middle Orinoco, with which Scaramelli and Scaramelli (2017)

are in broad agreement. The rock art of this site includes post-European Conquest motifs that, together with the early Holocene dates, indicate that Cerro Gavilán had a long use-life. To what extent the site corpus may have been reworked, renewed, or partially erased over this extreme time span remains an open question. We have previously noted the extent to which the Orinoco River itself has altered the petroglyph record, in some cases destroying it (Riris 2017), raising the issue of how many years a given engraving could realistically be expected to survive.

Our ongoing work in the Átures Rapids aims to understand long term settlement trends and has included an extensive radiometric dating programme. Most of these locate the excavated archaeological layers firmly within the last two millennia before the present (Lozada Mendieta et al. 2016). While we do not aim to directly address questions of chronology here, some relevant finds from the Átures region are worth highlighting. Figure 8 shows two noteworthy artefacts with motifs paralleled in the rock art, a ceramic vessel recovered from a mortuary cave deposit in Cueva Osario several years ago, located inland on the left bank of the Orinoco, and a painted sherd collected recently during the survey of an extensive ceramic deposit eroded from the side of a river bank on Rabo de Cochino island. Neither artefact is directly dated, but both belong stylistically and technologically to the Arauquinoid ceramic series (~1500 to 500 calendar years before present). The motifs on them are notable for being widely distributed in the rock art and are not among the handful of very rarely-occurring motifs (see previous discussion, cf. Riris 2017). At a minimum, the decoration on these two artefacts provides an insight into how multiple types of archaeological evidence may reflect aesthetic conventions in the Middle Orinoco. These finds bolster the notion that rock art was an actively reproduced part of the pre-Columbian landscape and environment in a broader sense (Boglar 1976; Urbina 1994; Pereira 2001; Valle 2012; Hugh-Jones 2016; Wright 2017) and opens a new avenue for tracing the spread and directions of influence of artistic traditions within the Orinoco. Direct comparison with the extant body of ethnographic work on indigenous art in the Orinoco-Negro region may eventually be possible (see Reichel-Dolmatoff 1996; Mansutti Rodríguez 2012) Together with the above questions surrounding the taphonomy and resilience of the rock art record, we suggest that a bias towards later periods is likely to exist in the rock art record.

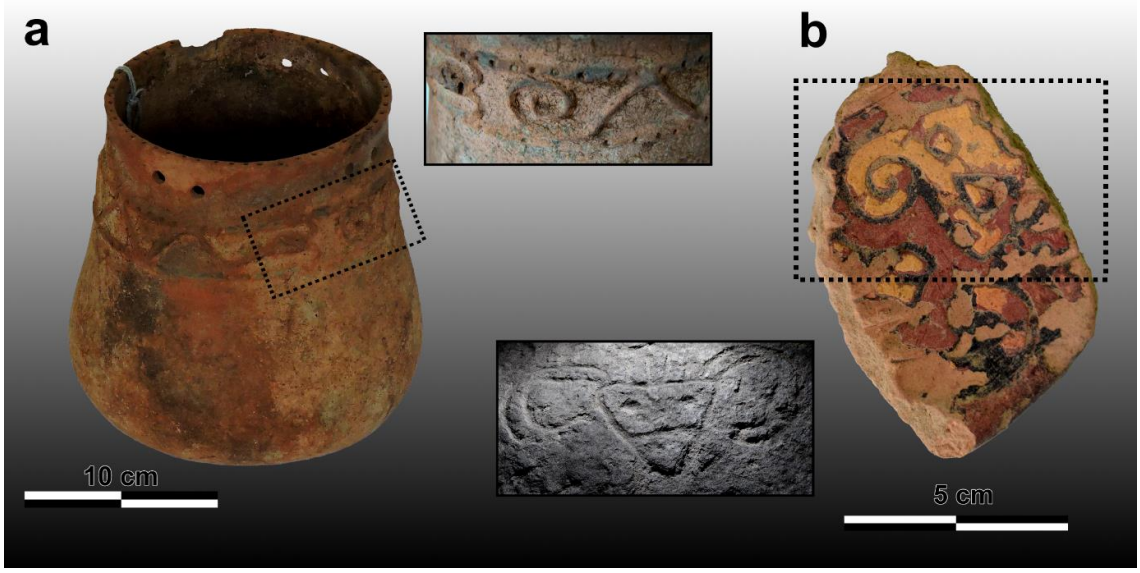

Figure 8. Material culture parallels to rock art recorded in the Middle Orinoco. (**a**) An appliqué zig-zagging snake motif with horned head and spiral tail (inset), collected from a cave burial in Cueva Osario. Currently held at the Museo Etnológico de Amazonas Monseñor Enzo Ceccarelli, Puerto Ayacucho, Venezuela. (**b**) Surface-collected painted rim sherd from the Rabo Cochino site (AM-3), displaying a partial motif similar to the Face2 motif (triangular head with spiral or curved appendages, inset from the site of Picure). Currently held in the IVIC, Caracas, Venezuela.

5. Conclusions

Our systematic approach to documenting and analysing the rock art record of the Middle Orinoco, combing fieldwork with extensive literature surveys and quantitative methods, allowed us to identify large-scale patterns in our data. This permitted us to identify, in detail, how the stylistic content of the assemblage varies in both geographical and topological space and, in particular, how diversity apparently does not correlate with connectivity. We have also highlighted some elements of the assemblage that resonate strikingly with parts of the ethnohistorical and archaeological records, in line with other recent scholarship in this area (see Pereira 2001; Antczak et al. 2017). We hope cross-disciplinary and cross-regional discussions become a more prominent feature of the rock art studies landscape in lowland South America. A critical evaluation of what archaeologists aim to achieve through the study of rock art will also be necessary, if the intuition that large sites are the most important for understanding the structure of a corpus proves to be subverted more broadly. This paper has suggested a path forward and efforts to collate the available information on northern South American rock and elsewhere are ongoing in order to directly tackle these questions through future work.

Supplementary Materials: The following are available online at http://www.mdpi.com/2076-0752/8/2/48/s1, Table S1: rockart_attr_middleorinoco.csv, Table S2: rockart_count_middleorinoco.csv, Code: PR_JRO_arts.R.

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