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Ethno-Meteorology in the Rupununi Savannahs, South-western Guyana

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Abstract

This paper looks at the indigenous perspective of the Makushi and Wapishana peoples regarding mainly atmospheric and biological phenomenon as it applies to the weather and seasons. By recognizing signals such as wind direction, rainfall, temperature change, animal, fish and insect behavior, and the flowering and/or fruiting of plants, indigenous people are able to partition the year into local seasons and to make predictions about the weather. Indigenous calendars can and do vary across Guyana as they usually reflect annual changes within local environments, as well as local indigenous lifestyles. This study it is hoped will be able to augment research that is currently ongoing globally into ethno-meteorological knowledge and its potential benefits for natural resource, protected areas, and wetlands management, as well as climate change research.

KEYWORDS: Weather, Seasons, Indigenous calendars, Environment, Natural resource management

Introduction

For millennia indigenous peoples have relied on their considerable local knowledge of seasonal cycles for ensuring a year-round supply of food, shelter, medicines and other resources. The way the environment provides for the continuity of life was understood within unique annual local frameworks and the long-term cycles in which they occur. Plants, insects, wildlife, stars, landscape changes, and the weather all contributed to keeping track of these annual cycles. Indigenous seasonal knowledge is the collective body of knowledge that indigenous people hold about their environment, and the plants and animals within it. It is linked to their culture and way of life, as well as spiritual belief. The knowledge held today is usually the remnant of what was in daily use prior to the European invasion and/or annexation of many areas around the world (Clarke 2007, 2009; O'Conner and Prober 2010).

Recently there has been an increase in global interest in ethno-meteorology as one way to look at different knowledge frameworks as regards the sustainable management of natural resources such as protected areas, wetlands and heritage sites amongst others (ICSU 2002; Borrini-Feyerabend et al. 2004; Walker et al. 2004; Bennett and Zurek 2006; Berkes et al. 2006). This research approach is usually interdisciplinary looking at ways to combine the different branches of Western science (e.g. ecology, conservation biology, and the social sciences), and to look at ways to merge Western scientific points of view with the traditional ecological knowledge (TEK) of indigenous peoples (Gadgil et al. 1993; De Walt 1994; Drew and Henne 2006; Berkes 2012; Cochran et al. 2016). From this it is believed that the result will be improved social and ecological systems obtained from a wider information base with an extended variety of cultural ideals taken into account, which will all aid and strengthen natural resource management (NRM) (Henfrey 2002; Holling et al. 2002; ICSU 2002; Folke et al. 2003; Folke 2004; Walker et al. 2004; Prober et al. 2011; Ens et al. 2014). Additionally TEK is also of interest regarding climate change studies. Phenological changes, particularly dates of first seasonal flowering and fruiting in certain plant species, has already provided some of the earliest indications of climate change in the Northern Hemisphere. In those regions, many long-term scientific and private records of leaf, flowering and fruiting events are available for comparison with current patterns. However, in places such as Australia,

as well as Central and South America, these kinds of written records are rarely available, and few clear biological indicators of climate change have yet been identified (Parmesan 2006; O'Conner and Prober 2010).

Although the inclusion of indigenous perspectives and TEK is widely recognized as needed for more resilient and equitable outcomes to NRM and climate change research, many researchers acknowledge the lack of effective methods for achieving this due to their being virtually no common ground for evaluating these distinct knowledge systems (Nadasdy 1999; Usher 2000; Casimirri 2003; Bennett and Zurek 2006; Houde 2007; Johnson and Murton 2007; Mazzocchi 2008; Raymond et al. 2010). Part of the problem is that TEK is often difficult to communicate to non-indigenous people. This is because this knowledge is usually derived from experience and shared from person to person and generation to generation via cultural transmission, encoded in language, song, spirituality, ceremony and art, and often not fully recorded into written languages (Usher 2000; Casimirri 2003; Hill et al. 2004; Hennessey et al. 2007). The differences are further the result of diverse local understandings of place and time, cause and effect, and the nature-culture divide, as well as the removal of spirituality from Western scientific inquiry (Johnson and Murton 2007; Cochran et al. 2016). Added to this is the fact that TEK is often only useful for a particular locality and is not universal for everywhere or everyone (Clarke 2009). So for example the TEK of the Makushi and Wapishana of southwestern Guyana is mainly useful only for southwestern Guyana, and not for central or northern Guyana. However, Indigenous as well as local knowledge of a particular place, especially when it has been collected, adapted and tested over generations, can make a great contribution to local level ecosystem management and understanding, as well as climate change research (De Walt 1994; ICSU 2002; Casimirri 2003; Raymond et al. 2010).

In recognizing the limitations of local, national and global resource management systems to manage resources, and to ensure both ecological and socio-economic sustainability, there has been a growing awareness of the importance of the traditional knowledge held by indigenous peoples (NRC 1997). One of the central ideas in TEK literature is the development of sustainable resource management through the integration of TEK with Western science. Ecologists, resource managers and researchers have now begun to examine TEK closely, with a view to seeking the integration of this knowledge with contemporary ecological resource management and Western science. As Clark (1998) states, "[it] used to be a question of whether agencies that manage natural resources should integrate traditional knowledge and wisdom into management decisions; now it is one of how." Thus, TEK is now being discussed as a possible important tool for ecologists and scientists, as well as a means to improve resource management, social and environmental impact assessments, and climate change research (De Walt 1994; Huntington 2000; Casimirri 2003).

One form of TEK that is of potentially relevance to NRM is indigenous seasonal knowledge which involves knowledge of the stars, weather, seasonal plant and animal cycles, and their links with indigenous culture, land usage and local resources (Simpson 1997, Folke et al. 2003, Clarke 2009). Traditionally, indigenous people relied on their extensive knowledge of seasonal patterns to acquire a secure and regular supply of animal and plant foods, medicinal herbs, housing materials and other necessary resources. To achieve this they interpreted the stars, weather, and other physical and seasonal indicators to predict biological events that signaled when to pursue subsistence, cultural and other activities (De Walt 1994; Clarke 2007, 2009; O'Conner and Prober 2010). This type of information when examined over a yearly cycle (or longer in some highly variable environments), forms the basis of indigenous ecological calendars, also known as seasonal calendars. When looked at closely they can be seen as timetables that divide the year into local seasons and describe expected weather and biological conditions, as well as local resource availability. Further to this indigenous seasonal knowledge can be seen to comprise detailed local knowledge that has been gained through observation and practice, and refined over time periods lasting from hundreds to thousands of years (Moran 1991; Nicholls 2006).

Indigenous ecological calendars can be seen to differ significantly from the standardized Gregorian or Western calendar which was promoted by the Europeans, and taken by them all over the world. The Gregorian calendar focuses on structural time (Aveni 1989), while indigenous calendars were devel-

oped around cultural, social and ecological time (Aveni 1989; Harrison 2007; Clark 2009). Although the Western calendar contains seasons and can include place-specific seasonal characteristics, its contemporary use is predominantly as a fixed Western system of reference that positions us in time and deals mainly with European social, cultural, and religious concerns (Aveni 1989). However, the diametric opposite of this is indigenous seasonal knowledge which emphasizes concepts of ecological time and cyclical processes that are strongly embedded in the place, culture, spirituality and ecology of that particular domain. Thus, they are closely linked to specific activities that can drive NRM for different areas or localities (Usher 2000). It should be noted here that in many countries the Western calendar has been found to be severely lacking in many areas where it has been recognized to be totally unrealistic regarding local conditions and seasons, or as an accurate division of the year (Elkin 1964; Clarke 2009).

All of this has made TEK the new scientific knowledge frontier; something for Western science to discover, explore, document, test and be used to improve Western conservation, ecology and natural resource management. However, TEK can only be valued and granted validity when it is accepted by and can contribute with certainty to Western science and knowledge systems. Describing this activity as "trading the Other" Smith (1999) notes how indigenous culture is now being commoditized by this trade. One consequence of "trading the Other" is what Aroha Mead calls the "misappropriation of indigenous knowledge" which is already apparent in the corporate patenting of organisms and products identified, developed and produced by indigenous peoples over many generations (Smith 1999). In other areas, such as environmental and natural resource management the focus on the integration of TEK into dominant Western science can have a major effect on indigenous peoples attempting to regain control of their natural resources, as well as for decision-making over those lands and resources on which they depend for their livelihoods and culture (Colchester 1994; Casimirri 2003).

Despite the good-intentions on the part of advocates on the use of TEK researchers still need to be advised about the need to avoid "watering down" indigenous knowledge into non-relevant forms which remove the localized and spiritual nature of indigenous knowledge as a way of life, and changing it to non-indigenous knowledge or just local data (Smith 1999; Hemming et al. 2007, 2010; Ens et al. 2014). The development of de-colonizing methodologies to promote indigenous ways of knowing and doing rather than trying to structure TEK around Western pedagogical and research frameworks are thus seen as a necessity (Ens et al. 2014). Many of these issues could possibly be avoided by actively lobbying for improved indigenous rights and involvement in ecosystem science, management and decision-making from local, national and global levels, as well as lobbying for a greater awareness of the importance and relevance of different knowledge systems other than those of dominant Western science (Colchester 1994; Agrawal 2002, 2003).

The Study Area

The Rupununi savannah (Figure 1), which is an extension of the much larger Rio Branco savannah (all part of the Gran Sabana or Great Savannah of Northern South America), covers an area of approximately 13,000 km^2 (Hills 1973; Daniel and Hons 1984). The savannah itself is divided into the northern and southern savannahs by the heavily forested Kanuku Mountains. Geologically the Rupununi belongs to the Precambrian Lowlands (Daniel and Hons 1984; Gibbs & Barron 1993) and is a part of the Guiana Shield whose mountain ranges are amongst the oldest in the world dating from approximately 1.7-2.3 billion years old (McConnell et al. 1964; Gibbs & Barron 1993). The northern savannah is a rift valley, part of the "Takutu Graben," that is sandwiched between the ancient Iwokrama formation, Kanuku Mountains, and Makarapan Mountain. While the southern savannah's are composed of ancient granites and quartz of the Southern Guyana Granite Complex (Gibbs & Barron 1993).

The Rupununi is composed of a mosaic of savannas, wetlands and forests, intersected and drained by an intricate network of rivers and marshes. This huge diversity of habitats supports a vast biodiversity of terrestrial, bird and aquatic life, and provides a wealth of natural resources for the Makushi and Wapishana peoples that inhabit the area (Mistry et al. 2008). The savannah biome is largely composed of fire climax vegetation and consists of grasses (*Trachypogon spicatus* - Savannah grass; *Andropogon bicornis*

– Pampas grass), sedges (*Bulbostylis sp.* - Caribbean hairsedge or Terrawad; *Rhynchospora nervosa* – Little star; *Scleria sp.* - Razor grass), and shrubs and treelets (*Curatella americana* - Sandpaper tree; *Byrsonima crassifolia* - Mirichi; *Antonia ovata* – Inyak; *Galactia jussiaean* – Milkpea; *Genipa spruceana* – Genipap; *Hirtella racemosa* – Counter; *Lantana camera* – Sweet sage; *Himatanthus articulates* - Sucuba or Cow wood; *Jatropha curcas* – Physic nut (white); *Lippia origanoides* - Fine-leaf thyme or Wild thyme; *Palicourea rigida* – Cappel; and *Roupala Montana* - Bois bandé) amongst others; most of which are resistant to the effects of fire and the frequent burning of the savannah and wet lands. As such, many of these savannah plants need to be burned before they can flower and propagate. Among the tall trees found in the Rupununi savannahs these include: *Ceiba pentandra* – Silkcotton, Ceiba or Kapok; *Hymenolobium petraeum* – Angeline; *Inga alba* – Whitee; *Jacaranda obtusifolia* – Jacaranda; *Macrolobium acaciifolium* – Arapari; *Manilkara bidentata* – Balata or Bulletwood; *Mora excelsa* – Mora; *Peltogyne venosa* – Purpleheart; *Spondias mombin* – Plum; *Tabebuia insignis* – White cedar; and *Vochysia surinamensis* - Iteballi amongst others (Myers 1936; Eden 1964, 1973; Goodland 1966; Delprete 2007, Funk et al. 2017).

Figure 1. The Rupununi with indigenous village lands

Guyana is situated in the Tropic of Cancer so the climate is influenced by the Inter-Tropical Convergence Zone (ITCZ) and consists of two main seasons, dry and wet. However, these seasons are interlaced with each other resulting in there being two dry seasons and two rainy seasons (Bourne & Bourne 2010; Ozanne et al. 2014). One result of these highly variable seasons is a hydrological imbalance that alternates between excessive rainfall that can lead to serious flooding, and extremely dry weather leading to water shortage (Loxton et al. 1958). The seasons are generally from mid-February to mid-May (primary dry), mid-May to mid-August (primary rainy), mid-August to mid-November (intermediate dry), and mid-November to mid-February (intermediate rainy) (Ozanne et al. 2014; L. Alexander pers. comm.). The bulk of the rain, sometimes up to 80%, falls during the primary rainy season from mid-May to mid-August when the savannah can become so flooded some parts resemble huge inland lakes, and the two watersheds of the Amazon and Essequibo Rivers become linked (Lowe-McConnell 1964). The mid-

November to mid-February intermediate rains are usually much shorter and less intense, because the ITCZ does not always penetrate far inland due to the mountains of the central Guiana Highlands which shields the Rupununi savannahs (Bourne & Bourne 2010). This results in the Rupununi mainly receiving only a moderate increase in the frequency of convection storms which are known locally as the cashew rains or Christmas rains (December), and turtle rains (February). The only exceptions to this is during El Niño Southern Oscillation (ENSO) weather events where the Rupununi experiences increased drought conditions, while during the opposite La Niña weather events the Rupununi may experience severe rain and flood conditions. The average amount of rain for the year in the Rupununi is 1500 mm (Hydromet Office 2014).

The two main indigenous groups that live in the Rupununi savannahs, in southwestern Guyana, are the Makushi and the Wapshana. The Pemon Makushi are a tribe of the Cariban linguistic group who live in the north savannahs and the south Pakaraima Mountains; while the Wapishana are a tribe of the Arawakan linguistic group living in the south savannahs. The Makushi and Wapishana it should be noted also have territories that extend into neighboring Brazil. Both groups reside mainly in the savannah or along the main rivers. Historically they lived in the Kanuku Mountains, along the mountain foot and in the high forest, however, this changed with the arrival of Christian missionaries in the late 19th and early 20th centuries who encouraged them to move to more easily accessible savannah locations (Schomburgk 1923; Bridges 1985). Cattle was later introduced into the savannahs from Brazil, along with limited European, coastal Guyanese and Brazilian settlement, with all of its associated changes in indigenous culture. There was also the founding of small to large cattle ranches such as Dadanawa, Karanambu, Good Hope, Central, Pirara, Santa Cruz, and Manari amongst others, as well as the establishment of the administrative centre of Lethem on the right bank of the Takutu River (Baldwin 1946; Turner 1972; Bridges 1985).

Discussion

Agroecosystems and Seasons

The Makushi and Wapishana of the Rupununi, like most of the indigenous peoples of the Guiana Highlands and Amazonia, are horticulturalists who utilize multi-cropping. Common crops grown include: 'bitter' and 'sweet' cassava (*Manihot esculenta*), corn (*Zea mays*), chilli pepper (*Capsicum annuum*), pumpkin (*Cucurbita maxima*), squash (*Cucurbita sp.*), banana and plantain (*Musa sp.*), papaya (*Carica papaya*), sugarcane (*Saccharum sp.*), watermelon (*Citrullus lanatus*), sweet potato (*Ipomoea batatas*), yam (*Dioscorea sp.*), cotton (*Gossypium sp.*), and pineapple (*Ananas comosus*) among others. However, by far the most important crop is 'bitter' cassava (*Manihot esculenta L.* Crantz) from which they make several different types of important subsistence products, including: cassava bread (manioc cakes), farine (cassava meal), tapioca, starch, cassava water (cassava juice), cassareep (from boiled cassava juice), and several types of drinks (Forte 1996; Henfrey 2002; CI 2002; David et al. 2005; Pereira 2019). Cassava is a hardy plant that can not only grow in humid conditions in the forest but also in marginal and acidic soils, and is able to withstand extreme water stress and drought conditions. In fact it is able to grow where no other staple crop can grow and requires very little care through its symbiotic relationship with soil fungi (Katz and Weaver 2003). Thus, indigenous peoples in the Rupununi are extremely knowledgeable about their local environment and have been using sustainable land-use practices for centuries (Evans and Meggers 1960; David et al. 2005; Gomes et al. 2012; Pereira 2019).

All farming is conducted using slash and burn or swidden agriculture. Although originally looked upon by the Western world as the crude efforts of technologically primitive peoples in constrained environments, several studies have now revealed that slash and burn agriculture is a complex and highly effective system of resource exploitation fully adapted to the ecology of local tropical environments (Conklin 1957; Dove 1983). It has now been clearly proved by tropical ecologists that swidden agriculture is an indigenous system that mirrors the creation and filling of natural forest gaps caused from disturbance events such as tree falls and storm or other damage. These anthropogenic gaps are created in the eco-

system and the normal successional processes are prevented from closing the gap so that cultivated crops are grown instead of the normal fast growing forest pioneer plants (Kricher 2011).

For this type of agriculture the farmer first cuts down all of the vegetation in a small patch of forest, creating an anthropogenic gap in the ecosystem. He/she then works to prevent normal successional processes from closing the gap by planting cultivated crops for human consumption. Just as successional areas are temporarily unstable, eventually turning back to forest, so agricultural systems are unstable systems with the farmer laboring to provide stability against nature's attempt to diversify the system (Kricher 2011). The main challenge with this type of agriculture is farming on nutrient-poor tropical forest soils, due to most of the minerals and nutrients being locked in the forest biomass and not the soil itself. This problem is solved by applying fire to burn the cut and dried plant material producing ash and charcoal which fertilizes the soil further (Beckerman 1987; Dufour 1990).

The cycle of agriculture is largely determined by the local rainfall patterns. According to the indigenous calendars of the Makushi and Wapishana many people will begin cutting their farms towards the end of the intermediate rainy season in late January or early-February. This way the cut vegetation has time to dry out for burning by March and planting by early April, before the primary rainy season (mid-May-mid-August). Sometimes when a second farm is needed, particularly for cash crops, people may begin cutting a second farm towards the end of the primary rainy season in late-August. This way the farm will be ready for burning by late-September, and planting by early to late-October before the time of the intermediate rainy season (mid-November-mid-February). However, it should be noted here that occasionally some people will start to cut their main farms in September or October (particularly in high forest areas), just after the primary rainy season, even though they may not want to burn it until February/March (CI 2002; Henfrey 2002; David et al. 2006; Pereira 2019).

As noted above there are four seasons in the Rupununi, two rainy seasons and two dry seasons, which are interlaced with each other (Ozanne et al. 2014; L. Alexander pers. comm.); with the climate being influenced by the passing of the Inter-Tropical Convergence Zone (ITCZ) twice yearly (Bourne & Bourne 2010). However, due to the ITCZ frequently not penetrating far inland during its second pass of Guyana (Bourne & Bourne 2010), there is often confusion with the exact timings of when some of these seasons start and end. One season in particular, the intermediate rainy season, is usually much less intense or even regularly fails during El Niño weather event years leading to some years only having two or three seasons, the primary rainy season and an extra-long dry season consisting of the intermediate and primary dry season's (Agriconsulting 1993; CI 2002). In general the four main Rupununi seasons are:

Primary Dry Season

The primary dry season (Wakamoo donun – Wapishana) lasts from approximately mid-February to mid-May. This season is often referred to as the main, primary or long dry season. During this time there is a steady north-easterly prevailing wind, and temperatures can get to over 35°C (95°F), sometimes up to 40°C (104°F). Mosquitoes, kaboura (blackfly), and sandflies will all disappear from the savannah during this period. Very little rain falls during this season, although sometimes there may be a few showers in March when the cicadas, crickets, mole crickets, frogs and toads start to emerge. April forms part of the transition period for the major change in seasons so there is also usually one to two weeks of rain in April known as the 'Beetle' or 'Sunbee' (cicada) rains, as well as the prevailing north-easterly wind beginning to fade. Once there is enough rainfall the ants and termites may also begin swarming. These are the main reasons that some people think April is the start of the primary rainy season, although it should be noted here that on rare occasions (such as La Niña weather events) the primary rainy season does indeed start with the April showers. Usually, after these brief April showers the rain stops falling, the NE wind returns and the savannah gets back hot and dry until the start of the primary rainy season proper in mid-May. The water level drops steadily during this season with small creeks and many savannah ponds fully drying out resulting in heavy fish predation, and many drinking water holes and wells needing to be deepened. Water is thus a big problem at this time of year. River travel becomes difficult as the water drops, exposing sandbanks and rapids, necessitating portage or

pulling of boats and canoes, making it hard to reach some communities like Katoka, Yupukari, Massara and Annai Villages during the height of the dry season (Forte 1996; CI 2002; Henfrey 2002; David et al. 2006; Rodríguez et al. 2011; Gomes et al. 2012).

There are also many savannah fires and forest fires in the mountains mostly man-made (Figure 2). Although it should be noted here that long ago people set fires according to local "fire calendars" which indicated when to burn, where to burn, how much to burn etc. One major advantage during the primary dry season is that travel and transportation over land becomes easier, with forests, mountains and all savannah areas more accessible. Towards the end of April the "Seven Stars" (Pleiades – "Wiinao" in Wapishana; "Tîmîkan" in Makushi) sets, while in early-May the "Tapir's Jaw Bone" (Taurus constellation – "Kodoiawa'u" in Wapishana; "Waira Mata Ye'pî in Makushi) sets below the western horizon to signify the impending end of the primary dry season (Roth 1924; Lowe-McConnell 1964; Forte 1996; CI 2002; Henfrey 2002; David et al. 2006; Rodríguez et al. 2011; Gomes et al. 2012; Pereira 2019).

Figure 2. Patch burning of the savannah at Yupukari Village in February, 2015.

Primary Rainy Season

The primary rainy season lasts from approximately mid-May to mid-August. This season is often referred to as the main, primary or long rainy season. May month is part of the seasonal transition period with the first of the main rains, the prevailing north-easterly wind stopping completely, and ants and termites resuming their swarming. The rain usually begins to fall mostly during the night at first (Figures 3 & 4), then after a few weeks it starts to get heavier and rains at any time of the day or night; there is also much thunder and lightning at the beginning of this season signifying the change in seasons. In mid-May "the One Foot Man" (Orion constellation) – "Ba'okuz" in Wapishana; "Ipe'pîn" in Makushi, will dip below the horizon indicating the rainy season proper. It should be noted here that it is also believed that the moon can affect the weather (especially during this time) so if during lunar first quarter the "horns" are pointing upwards it is said to be holding back the water and it will not rain, however, if the "horns" are pointing downwards the moon will release the water and it will rain (Forte 1996; Gomes et al. 2012; L. O'Connell pers. comm.; K. Peter pers. comm.)(Figures 5 & 6). Also noted by indigenous people is the fact that when the day is very hot and still or hot, humid and cloudy this means that it will rain either later in the day or during the night (K. Edwards pers. comm.; M. Pablo pers. comm.). Many of these conditions have in fact been proven by meteorological science for the tropics as being due

to tropical convection currents, zones of convergence, and/or tropical low-pressure systems (Goldstein 2002; Sobel 2012).

When the main rains starts falling the water table begins to raise rapidly, the rivers and creeks start flowing, and the savannah and swamps/marshes start to collect water. From June to mid-July there is very heavy precipitation, the creeks and rivers are at full flood, and the savannah and swamps/marshes are fully flooded; known as the flood pulse. As noted before up to 80% of the rain for the year can fall during this season. This is the time when the fishes spawn (local people say the "fish march") and disperse into the flooded savannah and river heads. Large to small rivers, as well as savannah swamps in particular begin to develop large amounts of Filamentous Algae (*Cladophora sp.* and *Spirogyra sp.*) (Figure 7). It is also the time when the climate is very hot, extremely humid, and has little to no wind. By now the savannah and swamps are full of mosquitoes (*Culicidae*) – Masa' (Makushi); Miso (Wapishana); and the creeks and rivers are full of "Black flies" (*Simulium sp.*) the dreaded "Kaboura" which breed in running water and appear in huge swarms or clouds - Nunkî (Makushi); Mario (Wapishana); Pium (Portuguese). Kaboura are also noted for appearing in huge swarms just before rain storms as an indicator of approaching rain (C. Pereira pers. comm.). The wet savannah is also full of "Sandflies" (*Culicoides sp.*) - Kosopa (Makushi); Sorusaba (Wapishana), which also come in huge swarms or clouds, particularly if you keep domestic stock like cattle or sheep. The wet conditions also favor a large increase in flies, in particular the "Common House Fly" (*Musca domestica*) - Ereuwe (Makushi), Tarobaro (Wapishana), "Flesh Fly" (*Sarcophaga sp.*), and "Blow Fly" (*Calliphoridae*) (Forte 1996; Forte and Melville 1997; Henfrey 2002; David et al. 2006; Gomes et al. 2012).

The wind comes with the rain storms during this time and blows mainly from the north-east/east and south, and rarely from the west and north. As there is not much wind most of the time it is usually very hot and humid. This season is called "Tonami" (Macushi), and "Dazarri" (flood) or "Wawunudonun" (rainy season) in Wapishana. Land travel and transportation becomes difficult and some villages become islands in the savannah, e.g. Massara, Semoni, and Yakarinta. Access to farm and hunting areas may often require walking through several miles of flooded savannah and/or forest trails, as well as fording swollen rivers with deep fast flowing water. Travel to and from Lethem by road which may take a few hours from the furthest southern villages in the dry season, can take as long as two days or may be impossible when the floods are at their peak. Conversely travel by river is much easier with people able to get into difficult, formerly dry areas very easily by boat and/or canoe (Forte 1996; Forte and Melville 1997; David et al. 2006; Gomes et al. 2012).

From late-July the precipitation starts easing off, there is a lot of thunder and lightning signaling the ending of the rainy season (the Wapishana say that the thunder and lightning is chasing the fish back to the fishing pools, and the Makushi and other Pemon peoples say that the old people in the sky are traveling back home while firing their shot guns to announce the ending of the rainy season), and the water level begins to drop rapidly with the fish in the flood savannah returning to the rivers and creeks. The wind then begins to blow hard from all four directions (the Makushi have a story about a quail hiding from the wind concerning this). By early August (or depending on how dry it is) people start to light the first savannah fires, also the north-easterly prevailing wind begins to return slowly (Lowe-McConnell 1964; Forte 1996; CI 2002; Henfrey 2002; David et al. 2006; Rodríguez et al. 2011; Gomes et al. 2012; Pereira 2019; R. Roberts pers. comm.; S. Moses pers. comm.).

Figure 3. Thunderheads (cumulo-nimbus clouds) forming in the early evening during the beginning of the primary rainy season in mid-May, 2012, on the Rupununi River. At the start of the primary rainy season it is noticeable that it mainly rains at night.

Figure 4. Rain clouds forming in the early evening over the Kanuku Mountains during the beginning of the primary rainy season in mid-May, 2020.

Figure 5. The New Moon on 27th April, 2020, low in the west with its "horns" pointing upwards. During this time there was no rain in Lethem (See Appendix 1).

Figure 6. The same Moon on 2nd May, 2020, now pointing downwards towards the east. This time the rain was falling in Lethem (see Appendix 1).

Figure 7. Filamentous Algae in the Semonie River in July, 2015. At this time of year most savannah pools and rivers contain large amounts of algae.

Intermediate Dry Season

The intermediate dry season generally lasts from approximately mid-August to mid-November, and is called "Konkombe" in Makushi. From late-August to late-September there is usually moderate precipitation, thunder, lightning, and windstorms, the prevailing north-easterly breeze starts to blow intermittently before blowing fully (although there will still be hot, sunny days without any wind), the water level continues to drop steadily, and the savannah swamps, igapos and varzeas start drying out. By now the larger fish (mainly catfish) such as Lau Lau, Jau, Red-tailed Catfish, Highwaterman, have returned to the Essequibo River, and medium-sized fish such as Tigerfish (Cullet), Arowana (Silver Arowana), Lukanani (Peacock bass), and Biara (Vampire fish) have returned to the Rupununi, Takutu and Ireng Rivers, and ox-bow lakes. When the water level gets low enough the Filamentous Algae (*Cladophora sp.* and *Spirogyra sp.*) in the rivers and savannah swamps starts to disappear (Figure 8). At the beginning of this season there are still huge swarms of mosquitoes, kaboura (blackfly), sandflies and flies, however, they will begin to lessen with the fall in the water table and drying of the savannah. This is also the time of the first major man-made savannah fires and when people begin to burn the grass surrounding their homes to chase away snakes, mosquitoes and other pests, as well as a safety measure to prevent their houses from being accidentally burned down by other people (Figure 9). In October the rains have stopped and given way to the high NE winds of November and December which can also blow throughout the night (Lowe-McConnell 1964; Forte 1996; Forte and Melville 1997; CI 2002; David et al. 2006; Rodríguez et al. 2011; Gomes et al. 2012).

Figure 8. Filamentous Algae in one of the ox-bow lakes near Karanambu Lodge in August, 2015. This is the time when the water level begins to drop rapidly and the algae starts to die off and disappear until the next primary rainy season.

Figure 9. Preventative patch burning at Karanambu Lodge in November, 2015. The idea is that you burn the grass before someone else does, and burns down your property!

Intermediate Rainy Season

The intermediate rainy season generally lasts from approximately mid-November to mid-February, however, this rainy season usually only results in 20% or less of the total rainfall for the year. It further appears to be normal with this season for the rain to start late. When the "Seven Stars" (Pleiades) "Wiinao" in Wapishana, "Tîmîkan" in Makushi; the "Tapir's Jaw Bone" (Taurus constellation) "Kodoiawa'u" in Wapishana, "Waira Mata Ye'pî in Makushi; and "the One Foot Man" (Orion constellation) "Ba'okuz" in Wapishana, "Ipe'pîn" in Makushi reappear on the eastern horizon at sunset this signals the return of intermediate rainy weather. This season usually starts off with high winds in November and December before the rain showers known as the "Cashew Rain," which occur when the cashew (*Anacardium occidentale*) and mango (*Mangifera indica*) trees are blossoming. These showers often continue through December when they are also known as the "Christmas Rains". Long ago when an indigenous constellation known as "the Giant Snake Swallowing its Tail," was visible this symbolized the Winter Solstice (21st December) for the Wapishana and the time to hold indigenous dances like parishara, hummingbird and mari-mari. A short while afterwards when another constellation appeared called "the Giant Snake With its Tail Coming Out of its Mouth," this symbolized the beginning of the "New" yearly cycle, and the time to hold a second round of indigenous dances like parishara, hummingbird and mari-mari. This was before Christian missionaries introduced Christmas Day and New Year's which took their place (Lowe-McConnell 1964; Forte 1996; David et al. 2006; A. Pablo pers. comm.).

Moderate showers can also continue onto late-January/early-February which are known as the "Turtle Rains," and which occur when the river turtles are laying (Forte 1996; CI 2002; Henfrey 2002; David et al. 2006; Gomes et al. 2012). However, if the turtle rains are too severe they can cause the rivers to rise sufficiently to cover the turtle nests destroying the eggs (which happened in February 2021); as in a very good intermediate rainy season the river level can rise by 2.5-3 metres (G. Pereira pers. obs. (at Karanambu)). This season usually sees another increase in the amount of mosquitoes, kaboura (blackfly), sandflies and flies, although this will depend on the amount of rainfall. Fish do not spawn during this season, although some fish species may start, but not complete, the process of egg production (Lowe-McConnell 1964). It should be noted here that the "Intermediate Rainy Season" oftentimes fails, sometimes almost completely, resulting in their being only two or three seasons: a) primary rainy season; b) intermediate dry season; and c) primary dry season. This can happen particularly during drought years caused by El Niño Southern Oscillation (ENSO) weather events. This is why some sources claim that there are only two or three seasons in the Rupununi (Agiconsulting 1993; CI 2002; EPA 2009).

Fisheries

As mentioned above many indigenous communities in the Rupununi live alongside or near to rivers. Although indigenous peoples are locally thought of as being big meat eaters, they in fact consume much more fish protein than meat protein. Thus, fishing is one of the most important subsistence activities conducted by indigenous peoples. Apart from its subsistence importance fish is also traded amongst the local communities (Forte 1996; Forte and Melville 1997; Henfrey 2002; CI 2002; Mistry et al. 2004; Fernandes 2005; David et al. 2006; Gomes et al. 2012). Indigenous peoples of the Rupununi practice many forms of fishing, some of which occur only at certain times, e.g. during the annual flood cycle or are specific to certain locations. Thus, pools in rivers, narrow, flooded river channels, river rapids, small running creeks, pools in seasonally dry creeks, and isolated savannah pools all require different methods of catching fish due to several factors that include the location (clarity of water, main river, mountain stream, swamp, lake, rapids, type of river bottom), type of fish present (large, small, catfish, bottom feeders, predators, fruit eaters), fish movements (spawning, returning to the main rivers and lakes, larger fish returning to the Essequibo River) and the season or time of year. Local fishing methods include the use of arrow and bow, hook and line, rod and line, fish traps, seines, cast net, fish poison (piscicides), hand groping between large rocks, diving with small bow and arrow, chopping with cutlass, and harpooning (Roth 1924; Lowe-McConnell 1964; Forte 1996; Forte and Melville 1997; Henfrey 2002; CI 2002; David et al. 2006; Gomes et al. 2012).

Fishes in the Rupununi are influenced by the water level through the mechanism of annual flood pulses during the rainy seasons (Bayley 1995; Hamilton et al. 2002; Fernandes 2005; de Souza et al. 2012). However, the principle influence on fish stocks and fishing is the primary rainy season from mid-May to mid-August when water levels can raise more than 5m and fish can travel many hundreds of kilometers to spawn at river heads, the flooded savannah, ox-bow lakes, igapós and varzeas (Lowe-McConnell 1964; Fernandes 2005; de Souza et al. 2012). The rise and fall of water levels of the flooded savannah, ox-bow lakes, igapós and varzeas during the primary flood pulse are particularly important as feeding areas for fish where fruits, flowers and insects, are readily found at the water surface (Lowe-McConnell 1964; Junk et al. 1997).

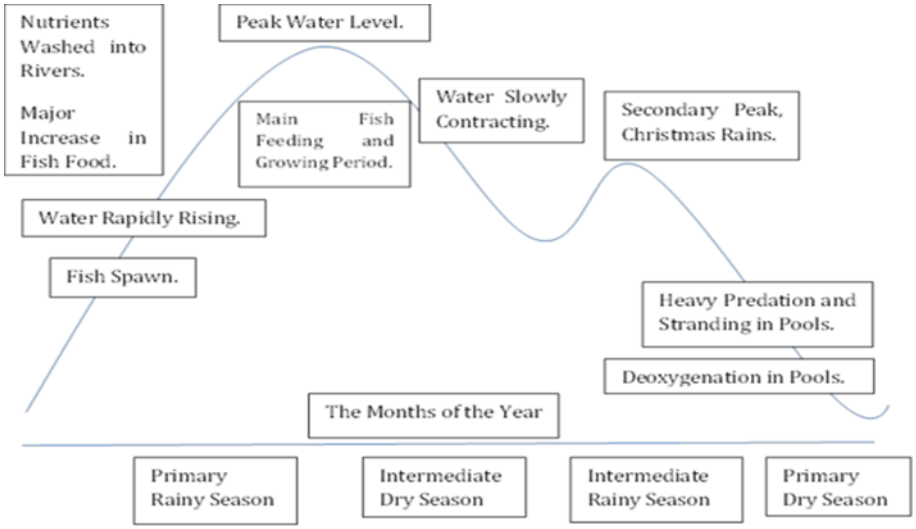
Due to the importance of fishes and fishing they feature prominently in the indigenous calendars of both the Makushi and Wapishana. So important is fish (Kopau) in the diet of the Wapishana that when it is scarce in their meals they will often say, "aona kanoom wa nikan nii" or "we have nothing to eat" (David et al. 2006), a sentiment also echoed by the Makushi (E. Raphael pers. comm.). Apart from being an important food source fish is also an essential part of ritual diets during ceremonies and rites of passage, e.g. couvade, female puberty rites (Henfrey 2002; David et al. 2006; L. O'Connell pers. comm.). While at other times there may be cultural fish prohibitions such as with pregnant and/or lactating women, and small children who must abstain from eating certain species of fishes which are considered spiritually strong, e.g. arapaima and large catfish species (Forte 1996; C. Pereira pers. comm.; K. Edwards pers. comm.). See Table 1 and Figure 10 below for some of the some of the fish biological indicators on Rupununi indigenous calendars

Table 1. Biological Indicators: Fish

Indigenous Name(s)	Scientific Name	English Name	Indicator	Description
Konoi' pî (Makushi); Kopau (Wapishana)	Fish (all species)		The primary dry season.	Fish (several species) in the rivers and creeks start to produce eggs in March and April in preparation for spawning and dispersal during the upcoming primary rainy season (high water pulse) from mid-May to mid-August (Lowe-McConnell 1964).
Purumai (Makushi); Kotii (Wapishana)	Brycon falcatus	Cooti, Kuti, Butter Fish, South American Trout	It is coming towards the end of the primary dry season.	The fins of the Cooti fish start to get sticky from March to April. This is a sign that the primary dry season is coming to an end (David et al. 2006).
Maikan (Makushi); Shiwizu, Zorro (Wapishana)	*Acestrorhynchus microlepis*	Needle Jaw, Fox Fish, Dog Fish, Zorro	It is coming towards the end of the primary dry season.	From March to April the Fox Fish starts to make a croaking noise after it is caught. This is a sign that the primary dry season is coming to an end (David et al. 2006).
Tukoi or Hummingbird Dance	Fish (all species)		It is coming towards the end of the primary dry season.	Towards the end of the primary dry season, from March to April, it was customary years ago to hold the Tukoi or Hummingbird Dance. This dance signified the calling of all the fish species from the 'Master of Fishes' to replenish fish stocks and feed the hungry people. The Glittering-throated Emerald hummingbird was symbolic of the fast darting movements of fish in the water. This dance was often held together with the parishara dance (Butt-Colsen & Armellada 2001).

Paya (Makushi); Daobaro (Wapishana)	*Hydrolycus sp.*	Payara, Vampire Fish, Biara	The end of the primary dry season.	In April Biara fish start to congregate in the deeper river pools with their tails sticking out of the water waiting for the first rains to begin falling to raise the water level for the annual high water pulse and fish migration (fish march) (R. Bartholomew pers. comm.; R. Roberts pers. comm.).
Konoi' pî (Makushi); Kopau (Wapishana)	Fish (all species)		Primary rainy season in May.	Fish (all species) migrate up the main rivers into the river heads, smaller creeks, and/or into the flooded savannah during the high water pulse to spawn and disperse in May/June (Lowe-McConnell 1964; Forte 1996).
Kîmîta (Makushi)	*Prochilodus rubrotaeniatus*	Yakutu	Primary rainy season in May.	When Yakutu are spawning in May during the start of the primary rainy season (high water pulse) they are known to make low-pitched grunting noises described as sounding like motorcycles (David et al. 2006; K. Mandook pers. comm.).
Warapai (Makushi); Wikada (Wapishana)	*Arapaima gigas*	Arapaima, Paiche, Pirarucu (Brazil)	The end of the primary rainy season.	When the high water level starts to drop in late July and early August the Arapaima will make their way back to their specific home pools in ox-bow and savannah lakes to reclaim their nests and raise their young fry (K. Mandook pers. comm.).
Konoi' pî (Makushi); Kopau (Wapishana)	Fish (all species)		The end of the primary rainy season.	Towards the end of the primary rainy season, in August when the water level is dropping rapidly, the larger fish (e.g. Lau-Lau, Red-Tailed Catfish, Blinker etc) will start migrating downriver to make their way back to the Essequibo River. Smaller fish will also start to make their way from the flooded savannah to the rivers, creeks and lakes (Lowe-McConnell 1964; A. Holland pers. comm.).

Figure 10: River Calendar (From Lowe-McConnell 1987)



The actual months of the river calendar depend on when the rainy seasons and dry seasons start, the length of the maximum dry weather, the height of maximum flood, and the amount of time of the full flood (Lowe-McConnell 1987).

Fish do not spawn during the lower secondary peak level in the intermediate rainy season. Also the intermediate rainy season sometimes fails which can mean hardly any upward change in water level during December-January, causing the water level to contract throughout this time into the primary dry season leading to extreme water stress and drought conditions (Lowe-McConnell 1964).

Animals

Another important subsistence activity is hunting with wild meat being highly prized by indigenous people who consider that all meals should always include some form of meat or fish. Thus, the importance of meat protein cannot be underestimated (Forte 1996; Forte and Melville 1997; CI 2002; David et al. 2006; Gomes et al. 2012). In a survey of villages surrounding the Kanuku Mountains Protected Area (KMPA) it was found that approximately 25% of the households participated in hunting activities on a regular basis, in which they hunted on village lands and/or within the KMPA (Hallett et al. 2019). Indigenous people have many different hunting techniques which include: spear arrow and bow, arrow and bow trap, shotgun, shotgun trap, digging out underground animals, snares and traps, lassoing from horseback, pursuit with dogs and burning the savannah or bush to flush out game. Hunters will also sometimes go out in small to large groups on occasion, especially during important holidays or celebrations such as Amerindian Heritage Month, Christmas and Easter when they may need to feed the whole community (Roth 1924, Forte 1996, David et al. 2006; Hallett et al. 2019; S. Moses pers. comm.; K. Peter pers. comm.). Further to this indigenous and local people are well known for keeping unusual and exotic pets (M. Chin pers. comm.; D. McTurk pers. comm.). These are usually the babies of animals that are caught by hunters, fishermen, farmers and others as they go about their normal subsistence activities. In this way indigenous people also learn about the habits and preferences of the animals they encounter or hunt in the forests and savannahs (Barrington Brown 1876; Im Thurm 1883; Roth 1924). It should be noted that another important aspect of subsistence hunting is the sharing of wild meat with family, friends and neighbors (David et al. 2006; Hallett et al. 2019; K. Peter pers. comm.).

Indigenous calendars feature a lot to do with wildlife and the different categories of animals. These calendars usually deal with the main seasons of animals such as when they mate, when they produce young, when they migrate, and when is a good time to hunt for them (Roth 1924; Forte 1996; Henfrey 2002; David et al. 2006; Gomes et al. 2012). Hunting it should be noted is usually conducted throughout the year with much of it being opportunistic hunting when people come across game while they are going to or from their farms, fishing grounds etc (David et al. 2006; Pereira 2019; M. Pablo pers. comm.). See Table 2 for some of the mammal biological indicators on indigenous calendars.

Table 2. Biological Indicators: Mammals

Indigenous Name(s)	Scientific Name	English Name	Indicator	Description
Akuri, Maikupiyu (Makushi); Sokoru (Wapishana)	*Dasyprocta agouti*	Red-Rumped Agouti, Agouti	End of the primary dry season/early rainy season.	The season for Red-Rumped Agoutis is from April to May (Henfrey 2002).
Suyu arai, Anutipi (Makushi), Piraĩĩ (Wapishana); Kariyakî (Makushi), Sowai (Wapishana); Paraka, Praka (Makushi), Bakuru (Wapishana); Kapasi (Makushi), Kapash (Wapishana)	*Tapirus terrestris, Mazama gouazoubira, Tayassu tajacu, Dasypus novemcinctus*	Several Species:- Brazilian Tapir (Bush Cow), Grey Brocket Deer, Collared Peccary, Southern Naked-tailed Armadillo	The primary rainy season.	The season for Tapir, Grey Brocket Deer, Collared Peccary and Southern Naked-tailed Armadillo is during the primary rainy season (Gomes et al. 2012).
Karauta, Pîinkî (Makushi); Bichi (Wapishana)	*Tayassu pecari*	White-Lipped Peccary	End of the primary rainy season/ beginning of the intermediate dry season.	Towards the end of the primary rainy season/beginning of the intermediate dry season from August to September, White-Lipped Peccaries come out of the forests and mountains to visit the savannah (*Mauritia flexuosa*) swamps to eat Ité Palm fruits (Henfrey 2002). Long ago this was also the time to dance the Parishara Dance (Forte 1996; Butt-Colson and Armellada 2001).
Parishara Dance	Peccary Herds	Collared Peccary, White-Lipped Peccary	Beginning of the intermediate dry season	At the beginning of the intermediate dry season in September it was customary many years ago to host a parishara dance. This dance appealed to the 'Master of Animals' to send out his children (the peccary herds), from the forest to the savannah ité palm swamps to feed the hungry people. Often this dance was also held together with the hummingbird dance which appeals to fish.

Kuwatî, Iwaraka (Makushi); Powatu (Wapishana)	*Cebus apella*	Brown Capuchin Monkey, Blackjack	End of the intermediate dry season/ intermediate rainy season.	The season for Brown Capuchin Monkeys coincides with the season for the fruiting of Whitee (*Inga alba*), October to March (Henfrey 2002).
Waikin (Makushi), Aro (Wapishana); Kusari (Makushi), Koshara (Wapishana); Karauta, Pîinkî (Makushi), Bichi (Wapishana)	*Odocoileus cariacou, Mazama Americana, Tayassu pecari*	Several Species:- White-Tailed Deer, Red Brocket Deer, White-Lipped Peccary	Intermediate rainy season.	The season for White-Tailed Deer, Red Brocket Deer and White-Lipped Peccary from November to February (Gomes et al. 2012).
Kuwatî, Iwaraka (Makushi); Powatu (Wapishana)	*Cebus apella*	Brown Capuchin Monkey, Blackjack	The primary dry season.	During the height of the primary dry season from March to May Brown Capuchin Monkeys will suck water from the stems of Kokerite Palm (*Attalea regia*) leaves (C. Melville pers. comm.).
Karauta, Pîinkî (Makushi), Bichi (Wapishana); Paraka, Praka (Makushi), Bakuru (Wapishana); Kuwata (Makushi), Roomi (Wapishana); Arauta Makushi); Suburu, Soburu, (Wapishana)	*Tayassu pecari, Tayassu tajacu, Ateles paniscus, Alouatta seniculus*	Several Species:- White-lipped Peccary, Collared Peccary, Black Spider Monkey, Red Howler Monkey etc	The primary dry season.	During the height of the primary dry season White-lipped Peccaries, Collared Peccaries, Black Spider Monkeys, and Red Howler Monkeys leave the forests and mountains to go to the savannah creeks and main rivers looking for water (Kelvin Peter pers. comm.; G. Pereira pers. obs.).

Insects and Invertebrates

The importance of insects to indigenous cultures has often been significantly ignored or underestimated due to their mainly culinary usage which is looked upon with displeasure by most Europeans, and Western culture in general (Ruddle 1973; Coimbra 1984; De Foliart 1999). Historically, literature collected from the Amazon and bordering areas, such as Lowland South America, suggests that at least 32 groups consistently consumed insects (entomophagy) and other invertebrates (Ruddle 1973; Coimbra 1984; Posey 1978; Dufour 1987; Zent 1992; Onore 1997; Cerda et al. 2000; Paoletti et al. 2000). In the Rupununi, as in other areas throughout Guyana, insects were of importance to indigenous peoples mainly for food (entomophagy) (Im Thurn 1883; Farabee 1918; Forte 1996; Forte and Melville 1997; Henfrey 2002; CI 2002; David et al. 2006). However, it should be noted that due to exposure to Western culture indigenous people, especially the younger generation, in the Rupununi and elsewhere now rely much less on insects and other invertebrates for food, and in fact now mainly refrain from this practice (Forte 1996; Forte and Melville 1997; Henfrey 2002; David et al. 2006; R. Merriman pers. comm.; E. Raphael pers. comm.).

Insects were further of importance as regular seasonal and environmental indicators. Thus, certain insects could tell you what month or time of the year it was, e.g. cicadas and mole crickets emerge in March, ant and termite drones and virgin queens start swarming in April and May with the first rain showers, tropical click beetles and scarab beetles emerge in May with the first heavy rains, lightening bugs and dragonflies appear from June to September (Roth 1924; Forte 1996; Forte and Melville 1997;

David et al. 2006). See Table 3 and Figures 11-21 below for some of the insects and other invertebrates utilized in the indigenous calendars of the Rupununi.

Table 3. Biological Indicators: Insects and Other Invertebrates

Indigenous Name(s)	Scientific Name(s)	English Name(s)	Indicator	Description
Kaa'ta (Makushi); Wam, Waamo (Wapishana)	*Cicadidae*	Cicada, Sun-bee	The primary dry season.	In March the Cicadas start emerging from underground and can be heard calling at night. According to indigenous people March is the month of the Cicadas (David et al. 2006; Gomes et al. 2012).
Kîrîrî (Makushi); Pi'isoro (Wapishana)	*Gryllotalpa spp.*	Mole Crickets	The primary dry season.	In March Mole Crickets start emerging from underground and can be heard calling at night (K. Mandook pers. comm.).
	Macrodontia cervicornis	Sabertooth Longhorn beetle, Giant Jawed Saw-yer	The ending of the primary dry season.	From March to April the Giant Jawed Sawyer beetles start to emerge from underground. Soon after they can be heard sawing through branches on riverside trees. They can also begin emerging towards the end of the pri-mary rainy season (A. Loyola pers. comm.; M. Pablo pers. comm.; K. Butler pers. comm.).
Kuinan (Makushi); Koki (Wapishana)	*Atta spp.*	Acoushi Ant, Leaf-Cutter Ant	The ending of the primary dry season.	From March to May the Acoushi Ants conduct a lot of leaf cutting in preparation for the up-coming primary rainy season (G. Pereira pers. obs.).
Suuyu mi'kî (Makushi); Wuzaõ-matu (Wapishana)	*Solenopsis spp.*	South Ameri-can Fire Ant	The ending of the primary dry season.	In April with the first preliminary showers of the primary rainy season the drones and vir-gin queens start to swarm (Butt-Colson and Armellada 2001). This will continue intermit-tently until July.
Epîkaran (Makushi); Mazi (Wapishana)	*Nasutitermes spp.*	Nailhead Ter-mite	The ending of the primary dry season.	In April with the first preliminary showers of the primary rainy season the drones and vir-gin queens start to swarm (Forte 1996; Butt-Colson and Armellada 2001). This will con-tinue intermittently until July.
Suuyu mi'kî (Makushi); Wuzaõ-matu (Wapishana)	*Solenopsis spp.*	South Ameri-can Fire Ant	The beginning of the primary rainy season in May.	In May/June when the main rains start to fall the South American Fire Ants emerge from underground to move their nests above ground, and may even join their large above-ground nests together with other colonies, to beat the flooding and high water levels (Hastings et al. 2018).

Muna (Makushi); Kaashoro (Rainflies) (Wapishana)	*Syntermes spp.*	Giant Termite	The beginning of the primary rainy season in May.	In May with the first rains of the primary rainy season the Giant Termite (rainflies in Wapishana) virgin queens and drones begin to swarm. This will continue intermittently until July. They are collected and consumed (Roth 1924; Forte 1996; David et al. 2006).
Kuinan (Makushi); Koki (Wapishana)	*Atta spp.*	Acoushi Ant, Leaf-Cutter Ant	The beginning of the primary rainy season in May.	In May with the first rains of the primary rainy season the Acoushi Ant virgin queens and drones begin to swarm. They are collected and consumed. It should be noted that they sometimes swarm in April if enough rain falls (Roth 1924; Forte 1996; David et al. 2006).
Mutu (the large forest click beetle) (Makushi)	*Pyrophorus noctilucus*	Tropical Click Beetle, Candlefly	The beginning of the primary rainy season in May.	In May with the first rains of the primary rainy season Tropical Click Beetles come into season for approximately 2-4 weeks (G. Pereira pers. obs.). They are also sometimes known to swarm and form large 'green balls' floating through the forest (J. Wilson pers. comm.).
Waponkai (Makushi)	*Geotrupidae, Scarabaeidae*	Earth-boring Dung Beetles, True Dung Beetles (Several species of Scarab Beetle)	The beginning of the primary rainy season in May.	In May with the first rains of the primary rainy season several species of Earth-boring Dung Beetles and True Dung beetles (Scarab Beetles) swarm from the ité palm swamps, forests and savannahs (O. Raphael pers. comm.).
Ka'we (Makushi); Tam-tam (Wapishana) (generic Wapishana term for butterfly)	*Phoebis argante, Phoebis philea, Phoebis sennae*	Sulphur Butterflies:- Apricot Sulphur, Orange-Barred Sulphur, Cloudless Sulphur	The beginning of the primary rainy season in May.	Towards the end of May three species of Sulphur Butterflies (*Phoebis sp.*) start migrating together traveling from south to north (K. Edwards pers. comm.; C. Pereira pers. comm.).
Arari, Rari (Makushi); Taruwiin (Wapishana)	*Erinnyis ello, ?*	Caterpillars (2 species):- Cassava Horn-Worm, ?	The beginning of the primary rainy season in May.	Towards the end of May two species of edible caterpillar, one black and one green, sometimes attack people's cassava farms. These caterpillars often form huge swarms which can eat out most of the cassava farms in a village, e.g. the Rupununi in 2019 (Forte 1996; Gomes et al. 2012; M. Pablo pers. comm.).

Katata (Makushi); Chiwao (Wapishana) (generic terms for grasshopper)	*Caelifera*	Grasshoppers, Locusts	The beginning of the primary rainy season in May.	Towards the end of May grasshoppers sometimes attack people's cassava farms. The grasshoppers can oftentimes form huge swarms which will eat out most of the cassava farms in a village. It should be noted that long ago grasshoppers were eaten by some people (B. O'Connell pers. comm.; R. Merriman pers. comm.; E. Raphael pers. comm.).
	Urania leilus	Green-Banded Urania Moth	The middle of the primary rainy season.	In June the Green-banded Urania moth has a migration from south to north (G. Pereira pers. obs.).
	Eulaema polychroma	Orchid Bee	The middle of the primary rainy season.	In June the Orchid Bees start to nest and lay either in trees or human habitations (G. Pereira pers. obs.).
Peppe' (Makushi); Tam-tam (Wapishana) (both are generic words for butterfly)	*Hamadryas februa, Agraulis vanilla*	Butterflies:- E.g. Grey Cracker, Gulf Fritillary etc	The middle of the primary rainy season.	In June several species of butterflies have their season and emerge from their cocoons, e.g. Grey Cracker, Gulf Fritillary etc (G. Pereira pers. obs.).
Pirimo' (Makushi); Sapuzutuz, Sapurutuz, Saporotiz (Wapishana) (generic words for dragonfly)	*Anisoptera*	Dragonflies	The end of the primary rainy season.	From June to September there are large swarms of dragonflies feeding on the Blackfly or Kaboura (*Simulium sp.*) and mosquitoes (D. McTurk pers. comm.; G. Pereira pers. obs.).
Ruku, Rîkî (Makushi); Kirimdar (Wapishana)	*Arsenura armida*	Giant Silk Moth	The primary rainy season.	The season for the edible Giant Silk Moth caterpillars is from May to July. These caterpillars only live on a certain species of tree found in the savannah and savannah bush islands (Forte 1996; M. Pablo pers. comm.; F. Pedro pers. comm.).
	Urania leilus	Green-Banded Urania Moth	The end of the primary rainy season.	In August the Green-banded Urania moth migrates back in the opposite direction from south to north (G. Pereira pers. obs.).
Ka'we (Makushi); Tam-tam (Wapishana) (generic Wapishana term for butterfly)	*Phoebis argante* *Phoebis philea* *Phoebis sennae*	Sulphur Butterflies:- Apricot Sulphur, Orange-Barred Sulphur, Cloudless Sulphur	The end of the primary rainy season.	From August to September the Sulphur Butterflies have their main migration back in the opposite direction from south to north. During this second migration they feed off Arapari (*Macrolobium acaciifolium*) flowers along the big rivers (D. McTurk pers. comm.; G. Pereira pers. obs.).

Aya', Mîri, Ya'kara (Makushi); Wauru, Barara (Wapishana)		Crabs (three species)	The end of the primary rainy season.	The Crab season is August when they migrate (or march) out of the forest, mountains and rivers into the savannah. Many years ago these migrations were very large, however, they are now much smaller, probably due to over-harvesting. The beginning of the Crab season is signaled by the appearance of the "Crab" constellation in the eastern sky. The Wapishana have a "Crab Dance" and story to celebrate the Crab season. In this story they say that the crabs send out the toucans before them (L. O'Connell pers. comm.; M. Pablo pers. comm.).
	Urania leilus	Green-Banded Urania Moth	November	In November the Green-banded Urania moths have a minor migration (G. Pereira pers. obs.).
Ka'we (Makushi); Tam-tam (Wapishana) (generic Wapishana term for butterfly)	*Phoebis argante* *Phoebis philea* *Phoebis sennae*	Sulphur Butterflies:- Apricot Sulphur, Orange-Barred Sulphur, Cloudless Sulphur	November	In November the Sulphur Butterflies have a minor migration (G. Pereira pers. obs.).

Figure 11. Cicadas emerge from their underground nests from March month into the primary rainy season. This photo was taken in June, 2013, in Three Mile Bush behind Karanambu Lodge.

Figure 12. Mole Crickets and other cricket species start emerging from their underground nests from March into the primary rainy season. This photo was taken in April, 2014, at Karanambu Lodge.

Figure 13. Young Acoushi Ant queen digging her new nest at Karanambu Lodge in May, 2013, after swarming the previous day.

Figure 14. Nailhead Termites swarming from an arboreal nest in a Cashew tree in St. Ignatius Village in late-May, 2020, after a heavy overnight rainfall.

Figure 15. Cassava Horn-Worm caterpillars swarming and feeding on a small cassava farm at Karanambu Lodge during May, 2015.

Figure 16. An Orchid Bee visiting Glory Bush (*Tibouchina aspera*) flowers during their nesting season in June, 2015, at Karanambu Lodge. They make their nests in holes in trees or house walls.

Figure 17. Gray Cracker Butterfly emerging from its cocoon during their June season (June, 2015) at Karanambu Lodge.

Figure 18. Gulf Fritillary Butterfly newly emerged from its cocoon during its season at Karanambu Lodge in June, 2016.

Figure 19. Edible Giant Silk Moth caterpillars in a bush island at Karanambu in June, 2013.

Figure 20. A Dragonfly from one of the large swarms observed in the authors garden in Lethem, June, 2020. It had landed on a young Jasmine tree.

Figure 21. Sulphur Butterflies at Maruranau Village on their second annual migration traveling south to north in September, 2011. Their first migration traveling north to south was in May, 2011.

Birds

Another very important aspect of indigenous calendars concerns birds, which like mammals, reptiles, amphibians, and insects can sometimes be utilized as a food source. They are further used as regular seasonal and environmental indicators, e.g. Grey-necked Wood-rail, White-collared Swift, Black Nun Bird, and the parrot family (*Psittacidae*), which call rain (Forte 1996; Henfrey 2002; CI 2002; David et al. 2006; Gomes et al. 2012; M. Allicock pers. comm.; C. Pereira pers. comm.; K. Edwards pers. comm.). Some birds were also viewed as having medicinal properties, e.g. Crested Oropendola, Painted Parakeet, Black Nun Bird, Smooth-billed Ani; as well as being used as binas, charms, omens or spirit mediums, e.g. Carib Grackle, Swallow-tailed Kite, Squirrel Cuckoo, and Laughing Falcon (Forte 1996; Forte and Melville 1997; Henfrey 2002; J. Francisco pers. comm.; C. Pereira pers. comm.).

Certain birds are associated with particular animals or insects such as Toco Toucans and Pavonine Cuckoos with White-lipped Peccaries (Henfrey 2002; L. O'connell pers. comm.), Black-capped Donocobius with Anacondas (K. Edward pers. comm.), and the Ant Birds and Ant Shrikes (several species of both), along with several other bird species who follow Army Ants (*Eciton sp*.) during feeding frenzy's for escaping insects (K. Mandook pers. comm.; M. Roberts pers. comm.). It should be noted here that in recent years, the Makushi assisted by both local and foreign researchers, have also been investigating birds as biological indicators for the health of the North Rupununi Wetlands (Mistry et al. 2004, 2008). See Table 4 and Figures 22-30 below for some of the birds utilized in the indigenous calendars of the Rupununi as biological indicators.

Table 4. Biological Indicators: Birds

Indigenous Name(s)	Scientific Name	English Name	Indicator	Description
Koyowa (Makushi); Oi (Wapishana)	*Crotophaga major*	Greater Ani	The beginning of the primary rainy season.	The Greater Ani's migrate up river from the Essequibo River to the Rupununi at the beginning of the primary rainy season. They then stay in the Rupununi until October when they begin migrating back down river to the Essequibo River (D. McTurk pers. comm.; A. Holland pers. comm.).
Wanore (Makushi); Washanao (Wapishana); Anra, Sipatîpîn (Makushi); Waakara (Wapishana); Anîwa (Makushi); Waaro (Wapishana); Kuwaku (Makushi); Warauka (Makushi)	*Ardea cocoa; Ardea alba; Egretta thula; Bulbulcus ibis; Cochlearius cochlearius; Nycticorax nycticorax*	Wading Birds:- Cocoi Heron; Great Egret; Snowy Egret; Cattle Egret; Boat-Billed Night Heron; Black-Crowned Night Heron	The primary rainy season.	In May the wading birds begin making their nests in certain ox-bow lakes in the big rivers, e.g. Crane Pond on the Rupununi River. By June they start to lay, while in July the eggs begin to hatch. By mid-August the chicks become large enough to fly away and leave the nests which are then abandoned. The abandoned nests will then be utilized by the Anhingas and Neo-tropical Cormorants who do not construct nests (D. McTurk pers. comm.; A. Holland pers. comm.; M. Mandook pers. comm.).
Maiwa (Makushi); Bai (Wapishana); Kamîya, Sapuru (Makushi); Bididi (Wapishana); Rapon, Wawinkuwa (Makushi); Anarau (Wapishana)	*Cairina moschata; Dendrocygna viduata; Dendrocygna autumnalis*	Ducks (several species):- Muscovy Duck; White-Faced Whistling Duck; Black-Bellied Whistling Duck	The primary rainy season.	The duck season from May to July when ducks start hatching in the lakes and swamps (R. Merriman pers. comm.).
Tanuwaka (Makushi)	*Pandorion haliactus*	Osprey, Fish Eagle, River Hawk	The primary rainy season.	Ospreys migrate back to their home countries to breed during the primary rainy season. They usually begin to return to Guyana by September. Ospreys only come to Guyana to feed and do not nest here (A. Holland pers. comm.). However, in recent years some Ospreys are being observed to stay during the rainy season. Thus, it is now believed that some may be staying here year round and nesting, possibly due to climate change or other factors.

Katama, Pauwi (Makushi), Pawish (Wapishana); Pauwitîmî (Makushi), Pawish, Pawish Waokim (Wapishana)	*Crax alector erythrognatha; Mitu tomentosa*	Black Curassow, Smooth-billed Curassow, Powis; Crestless Curassow, Lesser Razorbill, Powis	The primary rainy season	The Powis bird has its season when it is mating and laying for 1-2 weeks in June. During this time they call often and can easily been observed during the early morning after sunrise, and in the afternoon before sunset (G. Pereira pers. obs.). It should be noted that the Black Curassow will also start to call at midnight when the Powis stars (Crux or Southern Cross constellation – known as the spirit of the savannah) reach their zenith in June. An event which totally amazed the Prussian explorer Richard Schomburgk when he encountered it in the Rupununi after being informed by his Makushi guides (Schomburgk 1923). Also of note is the fact that the Southern Cross constellation is further linked to both the vernal and autumn equinoxes, and the summer solstice (G. Pereira pers. obs.).
Sakai'ka (Makushi); Sara'oo (Wapishana)	*Megaceryle torquata*	Ringed Kingfisher	The middle of the primary rainy season/ beginning of the intermediate dry season.	In July the Ringed Kingfishers start flying over land and calling loudly. This signifies the beginning of their season when they start looking for a place to nest in hollow trees or exposed river banks (D. McTurk pers. comm.). It should be noted that they are often seen in large numbers nesting in holes along the Rupununi River bank until the end of the intermediate rainy season (G. Pereira pers. obs.).
Koka (Makushi); Kabishko, Kabichako (Wapishana); Kino, Turupiya (Makushi); ?; Ske-ske (Makushi); Kadipi (Wapishana); Kupî (Makushi); Wiirom (Wapishana)	*Cacicus cela; Jacana jacana; Busarellus nigricollis*	Birds (several species):- Yellow-Rumped Caciques; Crested Oropendulas; Wattled Jacana; Black-collared Hawks etc.	The end of the primary rainy season.	Several bird species hatch their eggs in July/August towards the end of the primary rainy season when food is abundant and the water level is dropping.
Pîrekî (Makushi); Odoo (Wapishana); Kuyawi, Keawi (Makushi); Yarim (Wapishana)	*Phalacrocrax brasilianus; Anhinga anhinga*	Neotropic Cormorant, Duckla; Anhinga	The beginning of the intermediate dry season.	In August when the wading birds abandon their nests the Neotropic Cormorants and Anhinga's reoccupy the nests to start laying (D. McTurk pers. comm.; A. Holland pers. comm.; K. Mandook pers. comm.).

Tukui-yunkon (Makushi)	*Agamia agamia*	Agami Heron	The beginning of the intermediate dry season.	In August when the water level starts to drop very fast and the river banks start to show the Agami Herons begin to nest and lay in the ox-bow lakes (D. McTurk pers. comm.; A. Holland pers. comm.; K. Mandook pers. comm.).
Tîwî Tîwî (Makushi), ?; ?, Waiyaka (Wapishana); Matiwittwi (Makushi), ?	*Hoploxypterus cayanus; Trigasolitaria, Actitis macularia*	Ground Birds:- Pied Plover; Solitary Sandpiper, Spotted Sandpiper	The beginning of the intermediate dry season.	In August when the water level starts to drop very fast and the river banks and sandbanks begin to be uncovered the 'Ground Birds' like Pied Plovers, Solitary Sandpipers, Spotted Sandpipers etc begin to return. This heralds the start of the 'Ground and Swamp Bird Season' as they very soon begin to mate, make nests, lay their eggs and hatch by December (Gomes et al. 2012).
	Philohydor lector; Myiozetetes cayanensis	Lesser Kiskadee; Rusty-Margined Flycatcher etc	The beginning of the intermediate dry season.	In August the Lesser Kiskadees, Rusty-Margined Flycatchers and other Flycatchers begin to return with the start of the dry weather (K. Mandook pers. comm.; G. Pereira pers. obs.).
Warima (Makushi); Kiizu (Wapishana); Kurawu, Kuraurî, (Makushi) ?	*Ramphastos vitellinus, Ramphastos tucanus etc*	Toucans (several species):- Channel-Billed Toucan, White-Throated Toucan etc	The beginning of the intermediate dry season.	The small Toucan season in August when they migrate out of the forest and the mountains into the savannah. According to a Wapishana story the Toucans are sent out of the forest to let people know that the Crabs will soon arrive (L. O'Connell pers. comm.; M. Pablo pers. comm.).
Siki (Makushi); Daakari, Daakar (Wapishana)	*Colinus cristatus*	Crested Bobwhite, Quail	The beginning of the intermediate dry season.	The Quail season from August to October when they start to call and fly in the savannah, and make croaking noises as a sign the dry season is here (David et al. 2006; M. Pablo pers. comm.).
Tararamu (Makushi); Tararam (Wapishana)	*Jabiru mycteria*	Jabirú Stork	The beginning of the intermediate dry season.	The Jabirú Storks return to the savannah from Brazil in September and start to either repair their old nests or construct new nests. As soon as the nests are finished the storks begin to lay their eggs (M. Roberts pers. comm.; V. Roberts pers. comm.).
Tararamu (Makushi); Tararam (Wapishana)	*Jabiru mycteria*	Jabirú Stork	The beginning of the intermediate rainy season.	In November the Jabirú Stork eggs start to hatch (M. Roberts pers. comm.; V. Roberts pers. comm.).

Tararamu (Makushi); Tararam (Wapishana); Wakîroyan (Makushi); Waioozu (Wapishana); Anra, Sipatîpîn (Makushi); Waakara (Wapishana); Wanore (Makushi); Washanao (Wapishana); ?	*Jabiru mycteria, Mycteria Americana, Ardea alba, Ardea cocoa, Egretta thula*	Jabirú Stork, American Woodstork, Great Egret, Cocoi Heron, Snowy Egret	The end of the intermediate rainy season/ beginning of the primary dry season.	The large wading birds like Jabirú Storks, American Woodstorks, and Great Egrets begin congregating in large numbers along the rivers and in large lakes in January. In February and March they are joined by Cocoi Herons and Snowy Egrets to feed on the fishes in the rapidly drying rivers and ponds. Large flocks of wading birds at a drying pond are used as an indicator of where to find fish (K. Mandook pers. comm.; R. Merriman pers. comm.; C. Mandook pers. comm.).
Kino, Turupiya (Makushi)	*Psarocolius decumanus*	Crested Oropendulas (Weaver Birds)	The ending of the primary dry season.	In March the Crested Oropendulas make their large hanging nests in tall trees then begin their laying season (M. Roberts pers. comm.).
Kariwana yukon (Makushi); Kuruku, Maratu (Wapishana)	*Gallus domesticus*	Domestic Chicken	The ending of the primary dry season.	In March/April the Domestic Chicken will start continuous or frequent preening, as well as frequent sand bathing as a sign that the rains will soon start (C. Pereira pers. comm.).
Koka (Makushi); Kabishko, Kabichako (Wapishana)	*Cacicus cela*	Yellow-Rumped Cacique (Weaver Birds)	The ending of the primary dry season.	In April the Yellow-Rumped Caciques make their hanging nests in trees with nearby wasp nests for protection prior to their laying season (K. Mandook pers. comm.; V. Roberts pers. comm.).
Kawanuru (Makushi); Kawanaru, Kaonari (Wapishana)	*Rupicola rupicola*	Guianan Cock-of-the-Rock	The ending of the primary dry season.	In April the Guianan Cock-of-the-Rock make their nests then start laying their eggs (Gomes et al. 2012).
Tararamu (Makushi); Tararam (Wapishana); Wakîroyan (Makushi); Waioozu (Wapishana)	*Jabiru mycteria, Mycteria Americana,*	Jabirú Stork; American Woodstork	The beginning of the primary rainy season.	In May with the coming of the first rains of the primary rainy season and the raising of the rivers the Jabirú Storks and American Woodstorks feed for the last time before migrating to Brazil (D. McTurk pers. comm.; G. Pereira pers. obs.).

Figure 22. Left photo shows Great Egrets nesting in Crane Pond, Rupununi River, in May, 2010. Figure 23. Right photo shows Great Egrets nesting with their young at Crane Pond in July, 2015.

Figure 24. An Agami Heron emerging in late-July, 2015, in the Simonie River.

Figure 25. A Greater Ani along the Rupununi River in late-September, 2013. In October they begin their northward migration back to the Essequibo River.

Figure 26. Jabirú Storks nesting and laying in October, 2014, in a blossoming Angeline tree at Karnambu Lodge near the road to Maricuba Lake.

Figure 27. Jabirú Stork with young in December, 2015 (Hatched November, 2015), near Karanambu Lodge.

Figure 28. Large wading birds gathering and feeding in the drying Honey Pond 1 in February, 2015, at Karanambu Lodge.

Figure 29. Crested Oropendolas nesting in March, 2013, in River Burst ox-bow lake on the Rupununi River near Karanambu Lodge.

Figure 30. Yellow-Rumped Caciques nesting in April, 2015, along the Rupununi River. Not shown in the photograph is a large wasp nest to the left of the nests.

Reptiles and Amphibians

Reptiles and amphibians also feature a lot in the indigenous calendars of the Rupununi. Frogs and toads are generally used as seasonal indicators, usually for the prediction of rain (Gomes et al. 2012), although the Makushi, in particular, used to eat several species of frogs years ago (Forte 1996; Forte and Melville 1997). Frogs were further used as binas or charms (Forte 1996). Of note here is that the Patamona people of the north Pakaraima Mountains and the Makushi of the south Pakaraimas eat a large species of frog (referred to as "Mountain Chicken" - "Chinau" in Patamona, "Puupu" in Makushi), which features a lot in local indigenous calendars (Forte and Melville 1997; CI 2002).

For their part reptiles are used by the Makushi and Wapishana in the Rupununi as both seasonal indicators and as an additional food source (Im Thurn 1883; Farabee 1918; Forte 1996; Henfrey 2002; David et al. 2006; M. Francisco pers. comm.; Caiman House Project). Therefore important parts of their life cycles such as when they nest, lay eggs, and hatch are usually indicated in these calendars (CI 2002; David et al. 2006; Gomes et al. 2012). For some of the reptiles and amphibians that feature in the indigenous calendars of the Rupununi see Table 5 and Figures 31-38 below.

Table 5: Biological Indicators: Reptiles and Amphibians

Indigenous Name(s)	Scientific Name	English Name	Indicator	Description
Murupî (Makushi); Tururup (Wapishana)	*Phrynohyas venulosa*	Marbled Tree Frog, Common Tree Frog	The end of the primary dry season.	Marbled Tree Frogs (Carib Rain Frog – Kobono-aru (Roth 1924)) sometimes reside in human habitations where they live in the roof tops. They begin calling in March/April when they are said to be 'calling the rain.' After this they start to slowly make their way down the roof each week (while calling regularly) to reach the bottom of the roof as the primary rainy season begins in May (S. de Caires pers. comm.; G. Pereira pers. obs.).
Ware (Makushi)	*Hypsiboans boans (Hyla boans)*	Giant Gladiator Frog, Gladiator Tree Frog, Rusty Tree Frog	The end of the primary dry season.	Giant Gladiator Frogs sometimes reside in human habitations where they live in the lower part of the roof. They begin calling in March/April when they are said to be 'calling the rain.' After this they start to slowly make their way up the roof each week (while calling regularly) to finally reach the top of the roof as the primary rainy season begins in May (K. Butler pers. comm.; P. Allicock pers. comm.).
Peretuku (Makushi); Tororaba (Wapishana)	*Rhinella marina (Bufo marinus)*	Cane Toad, Marine Toad, Crapau	The end of the primary dry season.	Cane Toads start to come out of semi-hibernation from March to April and begin calling as the sky gets progressively more cloudy and rain showers are beginning. They are said to be "calling the rain" (E. Raphael pers. comm.).
Kui (Makushi); Poipoi (Wapishana)	*Leptodactylus fuscus*	Whistling Frog, Fuscous Foam Frog	The beginning of the primary rainy season	Whistling Frogs are one of the first frogs to appear with the early rains of the primary rainy season in April/May. Their foam nests on pools of water are a common sight (C. Pereira pers. comm.).

A'ruwaimî, Koyoti (Makushi); Atoru (Wapishana)	*Paleosuchus palpebrosus, Paleosuchus trigonatus*	Cuvier's Dwarf Caiman, Schneider's Dwarf Caiman	The end of the primary rainy season.	In August both species of Dwarf Caiman (Cuvier's Dwarf Caiman and Schneider's Dwarf Caiman) make their nests and lay their eggs (Gomes et al. 2012).
Wayamîka (Makushi); Sowan (Wapishana)	*Iguana iguana*	Green Iguana, Common Iguana	The end of the primary rainy season.	Green Iguana season from August to September when they dig their nesting holes in sandbanks, river banks, gravel hills, bush islands etc, before laying their eggs. Iguana eggs are eaten by many people (R. Merriman pers. comm.).
Akare (Makushi); Barakad (Wapishana)	*Caiman crocodilus*	Spectacled Caiman, Common Caiman	September	Spectacled Caiman season when they make their nests and lay eggs on the banks of rivers and lakes. Spectacled Caiman eggs are eaten by some people, as well as Foxes, and Golden Tegu Lizards (M. Francisco pers. comm.).
Wayamuri (Makushi); Wurada (Wapishana)	*Geochelone carbonaria*	Red-footed Tortoise	September	Red-footed Tortoise season when they lay their eggs in bush islands and on savannah hills. Tortoise eggs are eaten by many people (David et al. 2006; D. Melville pers. comm.).
Kuratu (Makushi); Kanawada (Wapishana)	*Melanosuchus niger*	Black Caiman	October	Black Caiman start to make their nests on banks of rivers and lakes (Caiman House Project).
Kuratu (Makushi); Kanawada (Wapishana)	*Melanosuchus niger*	Black Caiman	October	Black Caiman start to show themselves on sandbanks. The Makushi believe that this is a sign of the upcoming Christmas and cashew rains of the intermediate rainy season (K. Mandook pers. comm.).
Kuratu (Makushi); Kanawada (Wapishana)	*Melanosuchus niger*	Black Caiman	November	Early in November the Black Caiman start to lay their eggs in the completed nests (Caiman House Project).
Wayamîka (Makushi); Sowan (Wapishana)	*Iguana iguana*	Green Iguana, Common Iguana	January/ February	Green Iguana eggs start to hatch.
Wayamuri (Makushi); Wurada (Wapishana)	*Geochelone carbonaria*	Red-footed Tortoise	January/ February	Red-footed Tortoise eggs hatching.
Kuratu (Makushi); Kanawada (Wapishana)	*Melanosuchus niger*	Black Caiman	January	Black Caiman eggs hatching.

Tarekaya (Makushi); Arawish (Wapishana)	*Podocnemis unifilis*	Yellow-Spotted Sidenecked River Turtle	February	The main laying season of the Yellow-spotted River Turtles is February. They lay their eggs in the exposed sandbanks. However, it should be noted that if the 'Turtle Rains' (final rain of the intermediate rainy season) fall hard enough the water level can rise high enough to cover the turtle nests destroying the eggs. The turtle eggs are eaten by many people, as well as Foxes, Golden Tegu Lizards, Raccoons, wild cats etc. It should further be noted that sometimes Yellow-spotted River Turtles start to lay their eggs in January (Caiman House Project; A. Holland pers. comm.).
Warara (Makushi); Matad (Wapishana)	*Podocnemis expansa*	Giant South American River Turtle, Arrau River Turtle; Tartaruga (Portuguese)	February	The main laying season of the Giant River Turtle is February. They lay their eggs in the exposed sandbanks, however, it should be noted that if the 'Turtle Rains' fall heavy enough the water level can rise high enough to cover the turtle nests destroying the eggs. The turtle eggs are eaten by many people, as well as animals (Caiman House Project).
Warara (Makushi); Matad (Wapishana)	*Podocnemis expansa*	Giant South American River Turtle, Arrau River Turtle; Tartaruga (Portuguese)	The end of the primary dry season.	Giant River Turtle eggs hatching in April just before the primary rainy season.
Tarekaya (Makushi); Arawish (Wapishana)	*Podocnemis unifilis*	Yellow-Spotted Sidenecked River Turtle	The end of the primary dry season.	Yellow-spotted River Turtle eggs hatching at the end of the primary dry season/ beginning of the primary rainy season from April to May.

Figure 31. Marbled Tree Frog calling for rain in May, 2012, at Karanambu Lodge. In early-April these frogs were living near the top of a large thatch-roofed building. By early-May they had made their way slowly down to the bottom of the roof in time for the first rains to start falling.

Figure 32. A Whistling Frog that came out in late-April, 2014, during the April showers in Lethem.

Figure 33. A Cane Toad 'calling for rain' in May, 2013, at Karanambu Lodge.

Figure 34. Whistling Frog eggs in a small water pool in Lethem in mid-June, 2020, shortly after heavy overnight rainfall.

Figure 35. Green Iguana digging its nest into a laterite hill at Karanambu Lodge in September, 2012.

Figure 36. Black Caiman nest at Mobai Lake at Karanambu in October, 2012.

Figure 37. Yellow-Spotted River Turtle laying her eggs along the Rupununi River near River Burst Lake in February, 2013. Photograph by Oswin Ambrose.

Figure 38. Turtle nest on a sandbank on the Rupununi River near Karanambu Lodge that was disturbed by wild animals (Foxes and Golden Tegu Lizards) in January, 2014. The turtles laid their eggs early that year.

Plants

Indigenous peoples are well known for their knowledge of plants which play an important part in their culture and way of life. Thus, local people are well versed in when plants blossom, when they fruit and any uses of that particular plant (Roth 1924). Of interest here is that Gumilla (1791) stated that "the Orinocco indian distinguish each month by the fruits that matured in it, every month of the year having its particular kind." Similarly in the Rupununi phenological occurrences such as the flowering of plants and the ripening of fruit are used in local indigenous calendars. For their part the plant families of the Rupununi are well known to Western science from several explorers and researchers who have passed through this area since the early-19th century. Some of the more notable of these are: Robert Schomburgk (1835-1844), Richard Schomburgk (1840-44), J.G. Meyers (1936), A.C. Smith (1939), N. Guppy (1958) and R.J.A. Goodland (1966). Collections of plant specimens have also been conducted by the Utrecht Herbarium as part of the "Flora of the Guianas Project" (Delprete 2007), and the Smithsonian Institution, "Biological Diversity of the Guiana Shield Program" (BDG) (Funk et al. 2017).

The savannah biome is mainly composed of fire climax vegetation and consists of grasses (*Trachypogon spicatus* – Savannah grass), sedges (*Bulbostylis sp.* – Caribbean hairsedge or Terrawad; *Scleria sp.* – Razor grass), and shrubs and treelets (*Curatella americana* – Sandpaper tree*, Byrsonima crassifolia* – Mirichi*, Antonia ovata* - Inyak, *Himatanthus articulates* – Sucuba or Cow wood*,* and *Lippia origanoides* – Fine-leaf thyme or Wild thyme among others) most of which are resistant to the effects of fire and the frequent burning of the savannah. As such most of these plants need to be burned before they can flower and propagate (Myers 1936; Eden 1964; Goodland 1964). Like many other savannah regions, fire is the critical and most recurrent element noticeable during the dry seasons. Originally all fires were of natural origin and most savannah plants developed a natural fire-resistance (pyrophytes), which in most cases actually means they need to be burned before they can flower and seed. Close examination of savannah tree species shows that they have thick or cocky bark, and thick, rubbery or xerophytic leaves, all evidence of fire-resistance (Myers 1936; Goodland 1966). The importance of fire to savannah environments was noted by indigenous peoples who have adapted themselves with their extensive use of fire. Thus, the dynamics of fire has played a very important role in the culture of indigenous people living in the Rupununi for centuries with the result that fires are now mainly of human origin due to indigenous fire management practices. The reasons given for this large scale burning of the savannah are several and include: to promote the growth of fresh grasses for cattle, to keep vegetation around dwellings low so as to discourage snakes, clearing around dwellings to discourage mosquitoes and other pests, clearing around dwellings to prevent out of control fires from burning down houses, to improve access to fishing grounds, to improve access to hunting grounds and as a tool for chasing game, to improve access to palm leaves (ité, kokerite), to clear farm land, and camp fires left unattended amongst others (Hills 1973; Forte 1996; David et al. 2006; Rodríguez et al. 2011; Gomes et al. 2012). Thus, fire management as a part of Amerindian culture is another important component in indigenous calendars (Forte 1996; David et al. 2006; Rodriguez et al. 2011; Gomes et al. 2012) See Table 6 and Figures 39-60 for some of the plants used as biological indicators in the Rupununi.

Table 6: Biological Indicators: Plants

Local Name(s)	Scientific Name	English Name	Indicator	Description
Ranoi (Makushi); Konawadranup (Wapishana)	*Tabebuia serratifolia*	Yellow Poui, Hakia, Savannah Greenheart	The primary dry season.	Yellow Poui blossoming mainly from March to May. This tree may start to blossom in February and is known to blossom conspicuously in the mountains (Roth 1924; K. Mandook pers. comm.).

Maripa (Makushi); Pokorid (Wapishana)	*Attalea maripa*	Kokerite palm, American Oil Palm	The primary dry season/ primary rainy season	The Kokerite Palm blossoms and fruits mainly from March to August, sometimes fruiting in November. The fruit are eaten by people, animals and birds. The decaying seeds sometimes have a beetle larvae (Kiyo Kiyo - Makushi) living inside them which is edible and also used as fish bait (Forte 1996; E. Raphael pers. comm.).
Kankuron, Koramii (Wapishana)			The ending of the primary dry season.	White forest flowers which indicates the end of the primary dry season/ start of the primary rainy season (Gomes et al. 2012).
Puruye' (Makushi); Iziari (Wapishana)	*Manilkara bidentata*	Bulletwood, Balata Tree	The primary rainy season.	Bulletwood trees blossoming mainly from May to August (Polak 1992).
Waiye (Macushi); Dyuwuza (Wapishana)	*Mauritia flexuosa*	Ité Palm	The primary rainy season.	Ité Palms blossoming from May to September. Children sometimes eat the tips of the blossoms (O. Raphael pers. comm.).
Maipaye' (Makushi); Dyakara (Wapishana)	*Inga alba*	Maporokon, Whitee Tree, Inga	The primary rainy season.	Whitee Trees blossom from May to September. Brown Capuchin Monkeys have their season during the fruiting of this tree from October to March (Henfrey 2002).
	Cladophora sp.; Spirogyra sp.	Filamentous Algae	The primary rainy season.	From May to September in small to large rivers, as well as savannah ponds and swamps Filamentous Algae develops and spreads over wide areas. As soon as the water level begins to drop and the savannah ponds and swamps start to dry out the algae disappears (B. Waldrop pers. comm.; G. Pereira pers. obs.).
Toroye' (Makushi)	*Mora excelsa*	Mora, Nato	The middle of the primary rainy season.	The Mora Tree fruits from June to July (sometimes also from October to November) (Polak 1992). Long ago the seeds were grated, mixed with cassava meal and used as a hard time food when the cassava crop failed (Henfrey 2002).
	Mora gonggrijpii	Morabukea	The middle of the primary rainy season.	The Morabukea Tree fruits from June to July (sometimes also from October to November) (Polak 1992).
Manuzu (Wapishana)	*Inga sp.*	Water Whitee, Water Inga	The primary rainy season.	The Water Inga fruits from May to July during the annual flood pulse which helps to disperse the seeds. The fruit are eaten by people, birds and fish (G. Pereira pers. obs.).
Dizuri (Wapishana)	*Amaryllis sp.*	Amaryllis, Belladonna Lily	The primary rainy season.	Amaryllis flowers blossom from May to August with the main rains. Some savannah areas can become covered with these lilies (D. McTurk pers. comm.).

Pokaab (Propeller Flower) (Wapishana)	Iridaceae Family:- *Alophia drummondii, Cipura paludosa etc*	Propeller Flower (Iris); Iris	The primary rainy season.	The small picturesque ground flowers of the Iris (*Iridaceae*) Family blossom from May to October (L. O'Connell pers. comm.).
	Macrolobium acaciifolium	Arapari	The primary rainy season.	The Arapari Tree blossoms and fruits from June to October during the high water pulse which helps to disperse the seeds. The blossoms from the Arapari Tree also help to feed the Sulphur butterflies during their return migration from South to North (G. Pereira pers. obs.).
Aro-dawu-u (Deer backbone) (Wapishana)	*Acanthocereus tetragonus*	Night Blooming Cereus	The primary rainy season.	The white flower Night Blooming Cereus cactus blooms and fruits from June to September. The fruit is edible. The blossoms are pollinated by The Nectar Feeding Common Long-tongued Bat – (*Glossophaga soricina*) and Moths (G. Pereira pers. obs.).
Miyuke (Makushi); Saonoro (Wapishana)	*Genipa americana*	Genipap, Marmalade Box	The primary rainy season.	The white flower Genipap Tree blossoms from June to September. It fruits for most of the year. The fruits are eaten by people, animals, birds and fish.
Annai, Moroyansi (Makushi)		Fish Corn	The primary rainy season.	During the main flood pulse from June to September the riverine tree known as 'Fish Corn' fruits. The small yellow fruit are eaten by fish and birds (Forte 1996; A. Holland pers. comm.).
Wiwizub (Wapishana)			The primary rainy season.	The Wiwizub blossoms with red flowers indicating the middle of the primary rainy season (Gomes et al. 2012).
Wana' (Makushi); Pinidi (Wapishana) (Generic words for grass)	*Trachypogon spicatus*	Savannah Grass	August	Savannah Grass grows long stalks and seeds pods in August. The time of the 'long savannah grass' according to local people (R. Merriman pers. comm.).
Wacocowak (Wapishana)	*Hymenolobium petraeum*	Angeline, Sherry-Ann Rock, Amazon Tree	The intermediate dry season.	The Angeline Tree blossoms with its distinctive violet to pink blossoms from September to November every 2-3 years. Jabirú Storks often nest in Angeline trees because they are one of the tallest trees in the savannah (A. Holland pers. comm.; G. Pereira pers. obs.).

Aiyaye' (Makushi); Inyak (Wapishana)	*Antonia ovata*	Inyak, Savannah Christmas Tree	September to December.	The Inyak Tree mainly blossoms from September to December (Polak 1992). This tree is used as a fish poison (piscicide) and as a Christmas Tree (Forte 1996; E. Raphael pers. comm.).
Kupaiye' (Makushi), Deokunud (Wapishana)	*Vochysia sp. (3 sub-species)*	Iteballi, Hill Iteballi	September to December.	The Iteballi Trees blossom from September to December; fruiting from October to December (Roth 1924; R. Merriman pers. comm.).
Yoroiye (Makushi); Toboichi (Wapishana)	*Anacardium occidentale*	Cashew; Caju, Cajueiro (Brazil)	The end of the intermediate dry season/ the intermediate rainy season.	The Cashew Tree blossoms from October to November towards the end of the intermediate dry season, and fruit from December to February during the intermediate rainy season (E. Raphael pers. comm.; O. Raphael pers. comm.).
Mankro (Makushi); Mangoro, Mãgoroo (Wapishana)	*Mangifera indica*	Mango; Manga (Brazil)	The end of the intermediate dry season/ the intermediate rainy season.	The Mango Tree blossoms from October to December (the end of the intermediate dry season/ beginning of the intermediate rainy season). Mango trees then fruit from December to March during the intermediate rainy season, and sometimes into the primary rainy season. This tree species is not native to the Americas but native to southeast Asia (Omawale 1973).
Kuratkiye', uratkiye (Makushi); Imiaru, Iminaru (Wapishana)	*Curatella americana*	Sandpaper tree, Sandbox tree, Caimbé (Brazil)	The intermediate rainy season.	The Caimbé Tree blossoms from October to January mainly during the intermediate rainy season. This tree is known to make nice honey and to be strong spiritually (M. Foo pers. comm.; D. Melville pers. comm.).
Maka (Makushi); Warad (Wapishana)	*Psidium striatulum*	Water Guava	The intermediate rainy season.	The Water Guava blossoms and fruits from October to January mainly during the intermediate rainy season. The sour fruit are eaten by people, birds and fish (Forte 1996).
	Triplaris weigeltiana	Long John, Long jack, Christmas Candle, Ant Tree	The intermediate rainy season.	The Long John Trees blossoms from October to January (hence the name Christmas Candle), mainly during the intermediate rainy season every 2-3 years (A. Holland pers. comm.). This tree also has the *Pseudomyrmex triplarinus* ant living on it to help protect it from herbivores and invaders, hence the other name Ant Tree.
Pimiyaye' (Makushi); Matchi (Wapishana)	*Bowdichia virgilioides*	Paricarana, Ironwood	The intermediate rainy season.	The Paricarana Tree blossoms and fruits from October to January, and blossoms from May to September during the primary rainy season.

Dizuri (Wapishana)	*Amaryllis sp.*	Amaryllis, Belladonna Lily	The intermediate rainy season.	Amaryllis flowers blossom from November to January with the rains of the intermediate rainy season. Some areas the savannah, e.g. casweiro, can become covered with these white lilies (G. Pereira pers. obs.).
Awara (Makushi); Wazi (Wapishana)	*Astrocaryum vulgare*	Awara, Awarra	The intermediate rainy season.	The Awara Palm fruits from November to January (Forte 1996).
Kun, Kung (Small variety), Kuwarmu, Kuwarama (Makushi); Mapizii (Small variety), Ochoro (Wapishana)	*Oenoccarpus baccaba (2 sub -species)*	Lu Palm, Turu Palm	The intermediate rainy season.	The Turu/Lu (small variety) Palm fruits from November to March, while the Turu/Lu (big variety) Palm fruits from February to April (Forte 1996; C. Pereira pers. comm.).
Kuwai, Waiye (Macushi); Dyuwuza (Wapishana)	*Mauritia flexuosa*	Ité Palm	December to June.	Ité Palms fruiting mainly from December to June.
Apoye' (Makushi)	*Senna multijuga*	False sicklepod, Leafy Cassia, November Shower	The Turtle Rains in January and early February.	When False Sicklepod blossoms in January the Makushi believe the "Turtle Rains" (last rains of the intermediate rainy season) are about to fall (Forte 1996).
Shuwu (Wapishana)			The intermediate rainy season.	The Shuwu Tree Blossoms in January indicating the intermediate rainy season (Gomes et al. 2012).
Manuzu (Wapishana)	*Inga sp.*	Water Whitee, Water Inga	January to March.	The Water Inga blossoms from January to March; blossoms and fruiting June to July. Birds, fish and people feed off the fruit (K. Mandook pers. comm.; G. Pereira pers. obs.).
Mobe (Makushi); Zoop (Wapishana	*Spondias mombin*	Plum, Hog Plum, Yellow Mombin, Mombin Plum, Tropical Plum	The primary dry season.	Tropical Plum blossoms from February to May; fruiting April to October. Plums are eaten by people, animals, birds and tortoise. Hunters often hunt for Tapir using plum fruit as bait (Forte 1996; A. Holland pers. comm.).
Puruye' (Makushi); Iziari (Wapishana)	*Manilkara bidentata*	Bulletwood, Balata Tree	The primary dry season.	Bulletwood trees fruiting from February to April (Polak 1992). The fruit are popular with people, birds and animals (A. Pablo pers. comm.).

Moye' (Makushi)	*Jacaranda obtusifolia*	Jacaranda, Worm Tree, Bad Luck Tree, Sand Trysil	The end of the primary dry season.	The Jacaranda Tree with its light-purple blossoms is blooming and fruiting from March to May. It should be noted that the Warau people of north-west Guyana consider the blossoms of the Jacaranda tree to be unlucky, hence the name 'Bad Luck Tree' (van Andel 2000).

Figure 39. Yellow Poui trees beginning to blossom in the south Pakaraima Mountains in February, 2017.

Figure 40. A Kokerite Palm blossoming and fruiting in April, 2014, at Karanambu Lodge landing.

Figure 41. Water Inga trees blossoming and fruiting in May, 2012, along the Rupununi River near Karanambu Lodge.

Figure 42. The Arapari Tree blossoming in July, 2015, in an ox-bow lake Near Karanambu Lodge.

Figure 43. Sulphur Butterflies feeding on Arapari tree blossoms at Karanambu Landing in September, 2014, during their second annual migration from south to north.

Figure 44. Amaryllis Lilies flowering in early May, 2020, in Yupukari Village shortly after the start of the primary rainy season. Photograph by Monique Ambrose.

Figure 45. One of the Irises (*Cipura paludosa*) blossoming in May, 2012, at Karanambu Lodge.

Figure 46. A Plum tree fruiting in June, 2020, in Lethem. Of note is that a recent invasive bird species, the Saffron Finch, has been observed nesting in this tree.

Figure 47. The Propeller Flower, one of the Irises, blossoming in July, 2020, at Lethem.

Figure 48. The Night-Blooming Cereus cactus blossoming in July, 2015, at Karanambu Lodge.

Figure 49. The Genipap tree blossoming in the savannah in July, 2014, at Karanambu Lodge.

Figure 50. "Fish Corn" fruiting in July, 2011, at Karanambu Landing on the Rupununi River. This is an important fish food during the primary rainy season.

Figure 51. An Angeline tree blossoming in October, 2014, near Karanambu Lodge along the road to Maricuba Lake.

Figure 52. The Inyak tree blossoming in the savannah in October, 2015, at Karanambu Lodge

Figure 53. Iteballi Tree blossoming in November, 2012, in a bush island near Karanambu Lodge.

Figure 54. Cashew trees blossoming and fruiting in December, 2015, at Karanambu Lodge.

Figure 55. Mango trees throwing new leaves in September, 2012, prior to blossoming from October to December, 2012, at Karanambu Lodge.

Figure 56. Sandpaper Trees blossoming in the savannah in October, 2013, near Karanambu Lodge.

Figure 57. The Water Guava blossoming and fruiting in December, 2013, at Karanambu Landing on the Rupununi River.

Figure 58. A Long John tree blossoming in November, 2012, along the Rupununi River near the mouth of the Simonie River.

Figure 59. A Paricarana tree blossoming and fruiting in November, 2016, at Yupukari Village.

Figure 60. Jacaranda tree blossoming in February, 2016, along the Rupununi River.

Concluding Remarks

This study looked at some of the existing indigenous ethno-meteorology knowledge among the Kapon Makushi and Arawakan Wapishana peoples of the Rupununi. Like many indigenous peoples who have limited access to modern meteorological information, persons continue to rely on local avenues of weather information and knowledge although this appears to be lessening in recent years with the passing away of the elders, and traditional information not being transmitted to the younger generation. Indigenous seasonal forecasters use a diverse range of indicators ranging from plant phenology; animal, insect, reptile, amphibian and bird seasons and behavior; movements of constellations, main stars, the moon; the winds, and the amount of sunshine to predict seasonal rains, short-term rains, dry weather and dry seasons (Barrington Brown 1876; Im Thurm 1883; Farabee 1918; Schomburgk 1923; Roth 1924; Guppy 1958; Forte 1996; Forte and Melville 1997; CI 2002; David et al. 2006; Gomes et al. 2012).

The Makushi and Wapishana "calendars" are largely an annual cycle of events in their stellar and biophysical landscapes, along with its cultural, social and economic implications, for the Makushi and Wapishana peoples. It must be emphasized that the timing of events is not actually tied to the European calendar system of 12 months but is a matter of chance when it coincides with this system. As with most people around the world the European calendar is used purely as a known and reliable reference point. In many cases over the years I was able to identify and correlate in the field, and while speaking to local informants, Makushi and Wapishana TEK knowledge and names of indicators or resources to corresponding knowledge and names in Western biological and ecological science. I was further able to add details found through searches of anthropological, scientific, natural history and other literature (Barrington Brown 1876; Im Thurm 1883; Farabee 1918; Schomburgk 1923; Roth 1924; Myers 1936; Guppy 1958; Eden 1964; Goodland 1966; Eden 1973; Forte 1996; Henfrey 2002).

As would have been noticed this paper did not deal much with astronomical or sky phenomenon which is a huge topic on its own, and which the author feels would best be dealt with separately. How-

ever, briefly mentioned were beliefs in the lunar phases, as well as the most important constellation to indigenous peoples in Guyana and the circum-Roraima region which consists of: the "Seven Stars" (Pleiades) ("Wiinao" in Wapishana, "Tîmîkan" in Makushi); the "Tapir's Jaw Bone" (Taurus constellation) ("Kodoiawa'u" in Wapishana, "Waira Mata Ye'pî in Makushi); and the "One Foot Man" (Orion constellation) ("Ba'okuz" in Wapishana, "Ipe'pîn" in Makushi). This large constellation is of importance for indicating the end of the primary dry season/beginning of the primary rainy season, as well as the beginning of the intermediate rainy season, and forms part of an important myth cycle (Roth 1924; Forte 1996; Gomes et al. 2012). This myth concerns a former shaman, the "One Foot Man," who chooses to go up into the sky upon his death at the hand of his wife after she cuts off one of his legs (Butt-Colson and Armellada 2001). For her part the wife is killed by her brother-in-law who uses a "Tapir's Jaw Bone" in some versions of the story (L. O'Connell pers. comm.). It should be noted that celestial phenomenon, such as constellations and the moon, were very important for calculating the seasons and important calendrical events such as the equinoxes and solstices, and were regularly used by indigenous people along with associated biological and environmental indicators (Roth 1924; Hastings et al. 2018). An example of this which was also mentioned above is the Southern Cross or Crux constellation (Pawish in both Makushi and Wapishana) which is linked to the season of the Powis birds (*Crax alector erythrognatha* and *Mitu tomentosa*), and as a directional indicator for the south (Schomburgh 1923).

Climate change is now being discussed in the Rupununi at many forums and is presently a recognized issue, although opinions on its current and potential impacts are varied (FAO and CI 2014; PAC 2015). What is now beginning to be recognized is that temperatures have started to rise in the Rupununi and worldwide in recent years, and that there are predicted to be higher temperature rises (from 2° to 3°), as well as more frequent and severe droughts by the end of the century in Latin America, which includes Guyana and the Rupununi (IPCC 2007). As such many people in the Western scientific community, as well as others, are starting to examine new (to them) areas such as TEK to assist with better local, national and global level ecosystem management and understanding, social and environmental impact assessments, as well as climate change research. As it is becoming more evident that climate change is increasing environmental stress from a range of threats, e.g. changed fire regimes, increased temperatures, increased development and farming etc, and is highlighting the need to address the sustainability of current land use, economic development and socio-economic disparities (Green et al. 2009; FAO and CI 2014).

Although this paper mentions many of the different climatic indicators used by indigenous peoples of the Rupununi it must be remembered that it did not, and could not, touch on everything. For example there is a species of grass (?) which if it blossoms early this is reportedly an indicator of upcoming drought to the Makushi (A. Edwards pers. comm.; R. Roberts pers. comm.). This is also the case when certain birds, frogs and insects start swarming or calling to indicate rain or drought (Forte 1996; Melville 2004; David et al. 2006; Gomes et al. 2012), while fish are known to start biting baited hooks from September when the water level has dropped enough (S. Moses pers. comm.). There are also many forest trees which flower and/or fruit during the end of the primary dry season and into the primary rainy season like Locust (*Hymenaea courbaril*) (Natu – Wapishana, Mîireye' - Makushi)(Forte 1996; C. Pereira pers. comm.) (Figure 61), as well as other fruiting trees such as poo (Wapishana) and bow-wow (Wapishana) which fruit during the primary rainy season (R. O'Connell pers. comm.; C. Pereira pers. comm.). Also of note is the fact that indigenous people eat mollusks such as a large species of apple snail (?)(Owuur - Wapishana) which is mainly available during and after the primary rainy season when both the forest and savannah are flooded (M. Pablo pers. comm.; C. Pereira pers. Comm, Figure 62).

Figure 61. Locust tree fruiting in July, 2017, at Maruranau Village in the south savannahs.

Figure 62. Large Apple Snails at Maruranau Village in March, 2018, when the water level was still deep enough in a pond after a good intermediate rainy season.

Other areas not touched on include prediction of short term rains using wind direction, the sudden change in air temperature and/or "smelling" the approaching rain (E. Raphael pers. comm.; K. Peter pers. comm.). Also the lowering of the air temperature that tells you that rain is coming in the distance to fall several hours later (K. Peter pers. comm.) Of note here is an interesting experience the author had several years ago when I was working with a local indigenous NGO, the Rupununi Weavers Society (RWS). While on a cotton trading trip to the south Rupununi savannahs during the intermediate rainy season in 1999 we were camped in the savannah, along with members of a British adventure/scientific charity "Operation Raleigh." While breaking camp one morning a large rain storm was observed passing parallel to us to the east so everyone ignored it while taking their time packing up. Suddenly the wind changed direction to the south blowing directly towards us. We saw the storm change direction and head our way while the temperature dropped significantly, and we could "smell" the rain. All of the RWS members, mainly Makushi's with a few Wapishana's along with myself and the Technical Advisor, burst into frenzied activity to pack away our things, and load and cover the tractor trailer. However, all of the Operation Raleigh members, with their supposed "jungle" training, just stood around looking at us as if we were crazy! I then realized that they did not understand what was happening and that the heavy rain would be upon us within the next 5 minutes. So I stopped what I was doing, pointed to the approaching rain and calmly explained that they had better start to break camp immediately due to the very large storm fast approaching us. This had the desired effect of getting them to break camp before the storm hit us five minutes later.

Yet another interesting area not mentioned includes land navigation/direction finding and TEK. Here we find interesting facts like moss grows on the southwest side of trees or opposite to the prevailing NE wind which prevents moss from forming (K. Butler pers. comm.). This is similar to moss growing on the north side of trees in the northern hemisphere, the north side of trees being cooler and damp. The author has also come across hunters navigating according to the direction clouds are moving, and/or the prevailing NE dry season wind direction (A. Ambrose pers. comm.). Lastly there is the fact that although Guyana experiences the overhead sun throughout the year (due to being located within the Tropic of Cancer) there is still a slight difference in the length of the day from January to December. This difference amounts to approximately half an hour between June and December, and is fully recognized by indigenous people who are able to tell the time by looking at the hourly position of the sun (C. Baretto pers. comm.; E. Raphael pers. comm.). Thus, it is also possible to tell what time of year it is due to the length of the day, as well as by how far the sun moves along both the eastern and western horizons during sunrise and sunset (K. Peter pers. comm.; C. Pereira pers. comm.). As such there is still much work to be done with recording the many different long-term and short-term climatic, and seasonal indicators, as well as directional and other indicators of the Makushi and Wapishana by their use of plants, animals, fish, birds, insects, invertebrates, celestial and weather phenomenon.

As noted before the knowledge holders are mainly the elders (and/or adults over 50 years). The younger generation especially of Makushi and Wapishana were often found to be most unlikely to know anything much about ethno-meteorology and TEK in general, with only a very few exceptions. My experiences over the years has shown me that the main causes of this appear to be: (i) the lack of communication between the young and the elders; (ii) the passing away of many knowledgeable elders; (iii) exposure of the younger generation to Western schooling, modern society and religious influences; and iv) the perception by the younger generation that TEK is "old fashioned," "behind the times", or "not relevant" in today's modern society (and in extreme cases is an anachronism that is best forgotten due to it being embarrassing, primitive thinking or the work of the devil). Thus, similar to other areas in Guyana, as well as around the world, it has become generally noticeable that interest in TEK by young people has declined in recent years (Forte and Melville 1997; CI 2002; O'Conner and Prober 2010; Hastings et al. 2018). Very noticeable to me during my research was the difficulty I experienced with getting the indigenous names of many plants, insects, amphibians and birds. As many elders or older villagers did not seem to know much about these names, and even some village leaders admitted that it was getting more difficult to find elders with this knowledge due to the information not being passed onto the younger generation (R. Roberts pers. comm.; M. Pugsley pers. comm.).

As they are still generally subsistence farmers many indigenous people acknowledge the need for accurate weather forecasts and would welcome the Ministry of Agriculture disseminating regular weather information if possible (FAO and CI 2014). However, until this is achieved people will still be relying on indigenous and local weather forecasting which has been passed on from generation to generation. Similar to other areas of the world there is a pressing need for further research into ethno-meteorology and other branches of TEK in Guyana to investigate any shared traits and/or differences with Western Science, and to see how they can all be combined for the benefit of natural resource, protected areas, and wetlands management, as well as climate change research.

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Appendix 1

Weather reports for Lethem, Region #9, Southwest Guyana for 27 April to 06 May, 2020. These readings were taken by the author.

Month	Date	Rain Gauge	Temp.	Hum.		General Weather Report	Remarks
April	27	0	27.8°C	73		50% cloud, cloud is 3000ft, vis. 14 miles.	
	28	0	27.6°C	72		80% cloud, cloud is 4000ft with some higher thinner cloud, vis. 14 miles.	
	29	0	27.5°C	68		70% cloud, cloud is 3000ft with some higher thinner cloud, vis. 14 miles.	
	30	0	28.4°C	72		30% cloud, cloud is 4000ft, vis. 14 miles.	First Quarter Moon.
May	1	0	27.5°C	80		80% cloud, cloud is 2500ft with some higher cloud, vis. 14 miles.	Rain from 8:45pm onwards.
	2	18mm	25.7°C	91		100% cloud, cloud is 4000ft, vis. 9 miles, very hazy.	A light rain last night.
	3	2mm	27.3°C	86		85% cloud, cloud is 3000ft with higher cloud, vis. 14 miles, hazy.	Rain during the day.

	4	16mm	26.1°C	91		80% cloud, cloud is 3000ft with higher cloud, vis. 14 miles, hazy.	Rain from 10pm onwards.
	5	32mm	25.6°C	94		100% cloud, cloud is 4000ft with higher and lower cloud, vis. 7 miles (mountains barely visible), very hazy.	
	6	4mm	26.1°C	96		100% cloud, cloud is 2500ft, vis. 6 miles, very hazy.	Rain during the night.

The above table shows an example of the indigenous belief in the way they feel that the moon affects rainfall by the position of the lunar 'horns.' When the 'horns' were pointing upwards on the 27th April the moon was believed to be holding in all of the water (rain). But when the moon and its 'horns' were pointing downwards on 2nd May it was believed that it released all of the water (rain).

References

Abbott, M. (Ed.)
2009 Makushi Dictionary, Prototype Tri-lingual Dictionary, Makushi-English-Portuguese. Makushi Research Unit of the North Rupununi District Development Board.

Agrawal, A.
2002 Indigenous Knowledge and the Politics of Classification. *International Social Science Journal* 54: 287-297.
2003 Sustainable Governance of Common-Pool Resources: Context, Methods and Politics. *Annual Review of Anthropology* 32: 243-262.

Agriconsultants
1993 Preparatory Study for the Creation of a Protected Area in the Kanuku Mountains Region of Guyana. European Development Fund, Rome, Italy.

Aveni, A.F.
1989 *Empires of time: Calendars, Clocks, and Cultures*. Basic Books, New York, USA.

Baldwin, R.
1946 *The Rupununi Record*. The Barbados Advocate Company, Barbados.

Barrington Brown, C.
1876 *Canoe and Camp Life in British Guiana*, With Map and Illustrations. Edward Stanford, London.

Bayley, P.B.
1995 Understanding Large River-floodplain Ecosystems. *Bioscienc*e 45(3): 153-158.

Bennett, E. M., and M. Zurek

2006 Integration Epistemologies Through Scenarios. Pages 275-293 in W. Reid, F. Berkes, T. Wilbanks, and D. Capistrano (eds.) . *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Environmental Assessments.* Island Press, Washington, D.C., U.S.A.

Beckerman, S.

1987 Swidden Agriculture in Amazonia and the Amazon Rim. *In Comparative Farming Systems*, B.L. Turner and S.B. Brush (eds.) New York: Guilford Press.

Berkes, F.

2012 *Sacred Ecology: Traditional Ecological Knowledge and Resource Management. 3rd Edition* Routledge, New York.

Berkes, F., W. V. Reid, T. J. Wilbanks, and D. Capistrano

2006 Conclusions. Bridging Scales and Knowldege Systems. Pages 315-331 W. Reid, F. Berkes, T. Wilbanks, and D. Capistrano (eds.). *Bridging Scales and Epistemologies: Linking Local Knowledge and Global Science in Environmental Assessments*. Island Press, Washington D.C., U.S.A.

Borrini-Feyerabend, G., A. Kothari, and G. Oviedo

2004 Indigenous and Local Communities and Protected Areas: Towards Equity and Enhanced Conservation. IUCN, Gland, Switzerland, and Cambridge, UK.

Bourne, G.R and C.M Bourne (eds.)

2010 The CEIBA Reader, An Introduction to the People, Ecosystems, Plants, Animals & Cuisine of the CEIBA Biological Center, Madewini, Guyana Yerfdog Publishing, St. Louis, Missouri.

Brett, W.H.

1868 *The Indian Tribes of Guiana; Their Condition and Habits.* London (Second Edition).

Bridges, J.

1985 Rupununi Mission: the Story of Cuthbert Cary-Elwes SJ, Among the Indians of Guiana 1909-1923. London: Jesuit Missions.

Butt-Colson, A. and C. de Armellada

2001 The Pleaides, Hydes and Orion (Tamõkan) in the Conceptual and Ritual System of Kapon and Pemon Groups in the Guiana Highlands. *Archaeology and Anthropology* 13: 8-46.

Casimirri, G.

2003 Problems with Integrating Traditional Ecological Knowledge into Contemporary Resource Management. Pages 199-200 in *Proceedings of the XII World Forestry Congress: Area A – Forests for People* (Quebec City, 2003). CD-ROM. Food and Agricultural Organization, Quebec City, anada.

Cerda, H., Martinez, R., Briceno, N., Pizzoferrato, L., Manzi, P., Tommaseo Ponzetta, M., Marin, O. and M.G. Paoletti
2000 Palm worm (Insecta: Coleoptera: Curculionidae: *Rhynchophorus palmarum*) Traditional Food in Amazonas, Venezuela: Nutritional Composition, Small Scale Production and Tourist Palatability. *Ecology of Food and Nutrition Volume* 40: 13-32.

Clarke, P.A.
1998 Re-generating Alaska: Alternative Knowledge Applications in the Greatland. USDA Forest Service, Alaska Region. Paper Presented at the Conference Bridging Traditional Ecological Knowledge and Ecosystem Science, Northern Arizona University, Flagstaff, Arizona.
2007 *Aboriginal People and Their Plants.* Rosenberg Publishing, Dural Delivery Centre, New South Wales, Australia.
2009 Australian Aboriginal Ethno-meteorology and Seasonal Calendars. *History and Anthropology* 20(2):79-106.

Cochran, F.V., Brunsell, N.A., Cabalzar, A., van der Veld, P.J., Azevedo, E., Alves Azevedo, R., Araújo Pedrosa, R. and L.J. Winegar
2016 Indigenous Ecological Calendars Define Scales for Climate Change and Sustainability Assessments. *Sustainability Science* 11: 69-89. Springer, Japan.

Coimbra Jr., C. E. A.
1984 Estudios de Ecologia Humana Entre os Surui do Parque Indigena Aripuana, Rondonia.1. O Uso de Larvas de Coleopteros (Bruchidae e Curculionidae) na Alimentacao. Rev. Brasil*. Zool.* 2: 35-47.

Colchester, M.
1994 Salvaging Nature: Indigenous Peoples, Protected Areas and Biodiversity Conservation. *Ecological Applications* 11: 584-600.

Conklin, H.C.
1957 An Ethnoecological Approach to Shifting Agriculture, *Transactions of the New York Academy of Sciences* 17: 133-142.

Conservation International (CI)
2002 The Kanuku Mountains Protected Area Process, The Community Resource Evaluation Master Report, May to December 2002. Conservation International, Georgetown, Guyana.

Daniel, J.R.K. and B.A. Hons
1984 *Geomorphology of Guyana. Occasional Paper No.* 6. Department of Geography, University of Guyana, Georgetown, Guyana.

David, B., Isaacs, P., Johnny, A., Johnson, L., Pugsley, M., Ramacindo, C., Winter, G., and Y. Winter
2006 Wa Wiizii – Wa Kaduzu: Customary Use of Biological Resources and Related Traditional Practices Within Wapichan Territory in Guyana United Kingdom: Forest Peoples Programme.

De Souza, L.S., Armbruster, J.W., and D.C. Werneke
2012 The Influence of the Rupununi Portal on Distribution of Freshwater Fish in the Rupununi District, Guyana. *Cybium* 36(1): 31-43.

De Foliart, G. R.
1999 Insects as Food: Why the Western Attitude is Important. Annual *Review of Entomology* 44: 21-50.

Delprete, P.G. (Ed.)
2017 Flora of the Guianas, *Newsletter* No.19, Special Workshop Issue, Cayenne Cedex, French Guiana, France.

De Walt, B.R.
1994 Using Indigenous Knowledge to Improve Agriculture and Natural Resource Management. *Human Organization* 53(2): 123-131.

Dove, M.
1983 Theories of Swidden Agriculture and the Political Economy of Ignorance, *Agroforestry Systems* 1(3): 85-99.

Drew, J.A. and A.P. Henne
2006 Conservation Biology and Traditional Ecological Knowledge: Integrating Academic Disciplines for Better Conservation Practice. *Ecology and Society* 11 (Article 34)

Dufour, D.
1987 Insects as Food: A Case Study From the Northwest Amazon. *American Anthropologist* 89: 383-396.

Dufour, D.L.
1990 Use of Tropical Rainforests by Native Amazonians. *Bioscience* 40:652-659.

Eden, M.J.
1964 The Savanna Ecosystem—Northern Rupununi, British Guiana. *McGill University Savanna Research Service* 1:1-216.
1973 The Savanna Environment, Guyana, 1. Some aspects of weathering and landforms 11. Savanna vegetation in the northern Rupununi, McGill University.

Elkin, A.P.
1964 *The Australian Aborigines. How to Understand Them*, 4th edition, Angus and Robertson, Sidney, Australia.

Ens, E.J., Pert, P., Clarke, P.A., Budden, M., Clubb, L., Doran, B., Douras, C., Gaikwad, J., Gott, B., Leonard, S., Locke, J., Packer, J., Turpin, G., and S. Wason
2014 Indigenous Biocultural Knowledge in Ecosystem Science and Management: Review and Insight From Australia. *Biological Conservation.* Elsevier Ltd. Environmental Protection Agency (EPA)
2009 Kanuku Mountains Protected Area, Five Year Management Plan 2009-2013, Final Draft. Environmental Protection Agency, Guyana.

Evans, C. and B.J. Meggers
1960 *Archaeological Investigations in British Guiana,* Bureau of AmericanEthnology, Bulletin 197, Washington DC, Smithsonian Institute.

Food and Agricultural Organization (FAO) and Conservation International (CI)
2014 The State of Food and Agriculture in the Rupununi, Guyana, Imperatives for Sustainable Livlihoods and Development. Food and Agricultural Organization/Conservation International, Georgetown, Guyana. Final Report.

Farabee, W.C.
1918 'The Central Arawaks'. *University of Pennysylvania Museum, Anthropological Publications* Volume 9.

Fernandes, D.
2005 "More Eyes Watching……", Community-Based Management of the Arapaima (*Arapaima gigas*) in Central Guyana. Iwokrama Centre for Rainforest Conservation and Development.

Folke, C.
2004 Traditional Knowledge in Social-Ecological Systems. *Ecology and Society* 9(3): 7.

Folke, C., J. Colding, and F. Berkes
2003 Synthesis: Building Resilience and Adaptive Capacity in Social-Ecological Systems. Pages 352-387 in F. Berkes, J. Colding, and C. Folke (eds.). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge University Press, UK.

Forte, J. (Ed.)
1996 Makuspe Komanto Iseru, Sustaining Makushi Way of Life. Makushi Research Unit, North Rupununi District Development Board.

Forte, J. and I. Melville (Eds.)
1997 *Amerindian Testimonies*. Business Print, Georgetown, Guyana.

Funk, V., Hollowell, T., Berry, P., Kelloff, C., and S. N. Alexander
2007 Smithsonian Institution, Contributions from the United States National Herbarium, Vol.55:1-584, Checklist of the Plants of the Guiana Shield, (VENEZUELA: Amazonas, Bolivar, Delta Amacuro; GUYANA, SURINAME, FRENCH GUIANA), Department of Botany, National Museum of Natural History, Washington DC.

Gadgil, M., F. Berkes, and C. Folke
1993 Indigenous Knowledge for Biodiversity Conservation. *Ambio* 22:151-156.

Gibbs A.K. & C.N. Barron
1993 The Geology of the Guiana Shield, *Oxford Monograph on Geology and Geophysics*, No. 23. ISBN 0-19-507350-9

Goldstein, M.
2002 *The Complete Idiot's Guide to Weather.* Alpha Books, Penguin Group Inc., USA.

Gomes, P. and H. Wilson (Project Leaders)
2012 Baokopa'o wa di'itinpan wadaun nii nao ati, Thinking Together for Those Coming Behind, An Outline Plan for the Care of Wapichan Territory in Guyana. South-Central and South Rupununi Districts Toshaos Councils, Region #9, Guyana.

Goodland, R.
1964 The Phytosociological Study of the Northern Rupununi Savanna, British Guiana. Thesis, McGill University, Montreal, Quebec.

Goodland, R.J.A.
1966 On the Savannah Vegetation of Calabozo, Venezuela and Rupununi,

British Guiana. McGill University, Montreal, Canada.

Green, J., Jackson, S. and J. Morrison
2009 Risks from Climate Change to Indigenous Communities in the Tropical North of Australia. Department of Climate Change and Energy Efficiency: Canberra.

Gumilla, J.
1791 *Historia Natural, Civil y Geografica de Las Naciones Situadas en Las Rivieras del Rio Orinoco*, 2 Volumes. Barcelona.

Guppy, N.
1958 *Waiwai, Through the Forests of the Amazon*, 1st Edition. John Murray.

Hallett, T.M., Kinahan, A.A., McGregor, R., Baggallay, T., Babb, T., Barnabus, H., Wilson, A., Li, F.M., Boorie, W.W., and Bankovich, B.A
2019 Low-Intensity Hunting on Game Species in and Around the Kanuku Mountains Protected Area, Guyana. *Frontiers in Ecology and Evolution* 7:412. doi: 10.3389/fevo.2019.00412.

Hamilton, S.K., Sippel, S.J. and J.M. Melack
2002 Comparison of inundation Patterns Amongst Major South American Floodplains. *Journal of Geophysical Research* 107(D20): 8038.

Harrison, A.D.
2007 *When Languages Die. The Extinction of the World's Languages and Erosion of Human Knowledge.* Oxford University Press, Oxford, UK.

Hastings, R.D., Daggers, L.B. and A.A.M. Stoll
2018 Ethno-Meteorology in Upper Mazaruni: Uncovering Indigenous Knowledge of the Kapon Akawaio People*. Archaeology and Anthropology* 22: 25-45.

Hemming, S., Rigney, G., Wallis, L., Trevorrow, T., Rigney, M., and G. Trevorrow
2007 Caring for Ngarrindjeri Country: Collaborative Research, Community Development and Social Justice. *Indigenous Law Bulletin* 6: 6-8.

Hemming, S., Rigney, G., and S. Berg
2010 Researching on Ngarrindjeri Ruwe/Ruwar: Methodologies for Positive Transformation. *Australian Aborigine Studies* 2: 92-106.

Henfrey, T.B.
2002 Ethnoecology, Resource Use, Conservation and Development in A Wapishana Community in the South Rupununi, Guyana Ph.D. thesis, University of Kent.

Hennessy, K., B. Fitzharris, B. C. Bates, N. Harvey, S. M. Howden, L. Hughes, J. Salinger, and R. Warrick
2007 Australia and New Zealand. Pages 507-540 *in* M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson (eds.). Climate Change 2007: *Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

Hill, R., A. Baird, D. Buchanan, C. Denman, P. Fischer, K. Gibson, J. Johnson, A. Kerry, G. Kulka, E. Madsen, A. Olbar, L. Olbar, J. Pierce, J. Schuan, E. Shipton, H. Shipton, J. Smith, R. Sykes, E. Walker, W. Walker, P.

Wallace, B. Yerry, D. Yougie, D. Ball, E. Barney, R. Buchanan, R. Buchanan, H. Denman, R. Fischer, R. Gibson, L. Talbot, E. Tayley, N. Tayley, D. Walker, K. Walker, M. Wallace, and L. Yougie
2004 *Yalanji Warranga Kaban: Yalanji People of the Rainforest Fire Management Book*. Little Ramsay Press, Cairns, Australia.

Hills, T.L.
1973 The Savannah Biome: A Case study of Human Impact on Biotic Communities, Pp. 354-373 in *Savannah Research Series* 19, Manners and Mikesell (eds.), McGill University.

Holling, C. S., L. H. Gunderson, and D. Ludwig
2002 In Quest of a Theory of Adaptive Change. Pages 3-24 in L. H. Gunderson and C. S. Holling (eds.). Panarchy*: Understanding Transformations in Human and Natural Systems.* Island Press, Washington D.C., USA.

Houde, N.
2007 The Six Faces of Traditional Ecological Knowledge: Challenges and Opportunities for Canadian Co-Management Arrangements. *Ecology and Society* 12(2): 34.

Hydromet Office
2014 Lethem, Region #9, Guyana. ICSU
2002 International Council for Science (ICSU) *Series on Science for Sustainable Development* No.4: Science, Traditional Knowledge and Sustainable Development, ICSU and UNESCO.

Intergovernmental Panel on Climate Change (IPCC)

2007 Climate Change 2007: Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Im Thurn, E.F.
1883 *Among the Indians of Guiana: Being Sketches Chiefly Anthropologic From the Interior of British* Guiana. London.

Johnson, J.T. and B. Murton
200 Re/placing Native Science: Indigenous Voices in Contemporary Constructions of Nature. *Geographical Research 45* no.2:121–129.

Junk, W.J., Soares, M.G.M., and U. Saint-Paul
1997 *The Central Amazon Floodplain: Ecology of a Pulsing System.* Ecological Studies 126, pp. 385–408, Springer, Berlin.

Katz, S. H., and W. W. Weaver
200 *Encyclopedia of Food and Culture*, New York: Schribner.

Kricher, J.
2011 *Tropical Ecology,* Princeton University Press. Princeton and Oxford.

Loxton, R.F, Rutherford, G.K., Speetor, J., and T.A. Jones
1958 *British Guiana : the Rupununi Savannahs, Soil and Land-Use Surveys, No. 2,* Imperial College of Tropical Agriculture, Trinidad.

Lowe-McConnell, R.H.
1964 The Fishes of the Rupununi Savanna District of British Guiana, South

America. *Journal of the Linnean Society (Zoology*) 45, 304: 103-144.
1987 Ecological Studies in Tropical Fish Communities. Cambridge University Press.

Mazzocchi, F.
2008 Analyzing Knowledge as Part of a Cultural Framework: The Case of Traditional Ecological Knowledge. *Environmental Journal* 36(2):39–57.

McConnell, R.B., Williams, E., Cannon, R.T. and Snelling, N.J.
1964 A New Interpretation of the Geology of British Guiana. *Nature* 204: 115-118.

Melville, C.
200 *Wapichan-English Dictionary*. Clays Ltd, St. Ives PLC, UK.

Mistry, J., Simpson, M., Berardi, A. and Y. Sandy
2004 Exploring the Links Between Natural Resource Use and Biophysical Status in the Waterways of the North Rupununi, Guyana. *Journal of Environmental Management* 24: 117-131.

Mistry, J., Berardi, A. and M. Simpson
2008 Birds as Indicators of Wetland Status and Change in the North Rupununi. *Biodiversity Conservation* 17: 2383-2409.

Moran, E.F.
1991 Human Adaptive Strategies in Amazonian Blackwater Ecosystems. *American Anthropologist* 93:361–382.

Myers, J.G.
1936 Savannah and Forest Vegetation of the Interior Guiana Plateau. *Journal of Ecology* 24:162-184.

Nadasdy, P.
1999 The Politics of Tek: Power and the ‘‘Integration’’ of Know*Arctic Anthropology* 36(1/2):1–18.

Natural Resources Canada (NRC)
1996-1997 State of Canada's Forests Report. Chapter Three: Traditional Ecological Knowledge . http://nrcan.gc.ca/cfs/proj/ppiab/sof/sof96/toc.shtml

Nicholls, C.
2006 Yilpinji: Love, Art and Ceremony. Craftsman House, Fishermans Bend, Australia.

O’Connor, M.H. and S.M. Prober
2010 A Calendar of Ngadju Seasonal Knowledge. A report to the Ngadju Community and Working Group. CSIRO Sustainable Ecosystems, Floreat, Western Australia.

Omawale
1973 Guyana’s Edible Plants. University of Guyana.

Onore, G.
1997 A Brief Note on Edible Insects in Ecuador. *Ecological Food and Nutrition* 36: 275-285.

Ozanne, C., Cabral, C., and P. Shaw
2014 Variation in Indigenous Forest Use in Central Guyana. *PL0S ONE* 9(7): e102952. doi:10.1371/journal. pone.0102952

Paoletti, M.G., Dufour, D.L., Cerda, H., Torres, F., Pizzoferrato, L. and D. Pimentel
2000 The Importance of Leaf- and Litter-feeding Invertebrates as Sources of Animal Protein for the Amazonian Amerindians. *Proceedings of the Royal Society B: Biological Sciences* 267: 2247-2252.

Parmesan, C.
2006 Ecological and Evolutionary Responses to Recent Climate Change, *Annual Review of Ecology, Evolution, and Systematics* 37(1): 637–669.

Pereira, G.
2019 Cassava as an Important Part of Wapishana Culture in South-Western Guyana. *Archaeology and Anthropology* 23: 4-46.

Polak, A.M.
1992 Major Timber Trees of Guyana, A Field Guide, Series 2. The Tropenbos Foundation.

Posey, D. A.
1978 Ethnoentomological Survey of Amerind Groups in Lowland Latin America. *The Florida Entomologist* 61 (4): 225-229.

Prober, S.M., O'Connor, M.H., and F.J. Walsh
2011 Australian Aboriginal Peoples' Seasonal Knowledge: A Potential Basis for Shared Understanding in Environmental Management. *Ecology and Society* 16(2): 12.

Protected Areas Commission (PAC)
2015 Kanuku Mountains Protected Area, Management Plan 2015-2019. Protected Areas Commission, Guyana.

Raynond, C.M. Fazey, I., Reed, M.S., Stringer, F.C., Robinson, G.M., and A.C. Evely
2010 Integrating Local and Scientific Knowledge for Environmental Management. *Journal of Environmental Management* 91, 1766-1777.

Rodríguez, I., Albert, P., La Rose, C., and C.J. Sharpe
2011 A Study of the Use of Fire by Amerindian Communities in South Rupununi, Guyana, With Recommendations for Sustainable Land Management. Study Prepared for South Central and South Rupununi District Toshaos Councils.

Roth, W.E.
1922 Translation by Walter Roth of Richard Schomburgk, *Travels in British Guiana (1840-44),* Vol.1. J.J Weber, Leipzig, 1848. Reprint Edition.

1924 An Introductory study of the arts, crafts and customs of the Guiana Indians. *30th Annual Report, Bureau of American Ethnology (1908-1909*), Smithsonian Institution Washington Government Printing Office, USA.

Ruddle, K.
1973 The Human Use of Insects: Examples From the Yukpa. *Biotropica* 5: 94-101.

Schomburgk, R.H.
1923 *Travels in British Guiana 1840-1844,* Volume 2 Translated by Walter Roth, Georgetown, British Guiana.

SIL Language and Culture Archives
2000 *Scholar's Dictionary and Grammar of the Wapishana language, Wapishana Language Project*. SIL International.

Simpson, J.
1997 Perceptions of Meteorology in Some Aboriginal languages. Pages 20-28 *in* E. K. Webb, Editor. *Windows on Meteorology: Australian Perspective*. CSIRO Publishing, Melbourne, Australia.

Smith, A.C.
1939 Plant Collecting in British Guiana*. Journal of the New York Botanical Gardens* 40: 10-21 and 35-39.

Smith, L.T.
1999 *Decolonizing Methodologies: Research and Indigenous Peoples.* University of Otago Press: Dunedin, New Zealand.

Sobel, A.H.
2012 Tropical Weather. Nature Education Knowledge 3(12):2 Columbia University, New York, USA.

Turner, H.E.
1972 The Rupununi Development Company Limited, The Early History. Edited by Terence McCann, Autoprint, Guyana.

Usher, P. J.
2000 Traditional Ecological Knowledge in Environmental Assessment and Management. *Arctic* 53(2):183-193.

van Andel, T.
2000 Non-Timber Forest Products of the North-West District of Guyana, Part 2, Tropenbos-Guyana programme.

Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig
2004 Resilience, Adaptability and Transformability in Social-ecological Systems. *Ecology and Society* 9(2): 5.

Zent, S.
1992 Historical and Ethnographic Ecology of the Upper Cuao River Votiha: Clues for an Interpretation of Native Guianese Social Organization. PhD dissertation, Columbia University, NY, USA.