



DRUMMING TREES

Diversity of trees used by chimpanzees for stone throwing behaviour, the
Boé-sector, Guinea Bissau

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Abstract: Some chimpanzee populations in West-Africa show a particular behaviour: they return to a specific tree and throw stones at it; often the stones accumulate near and inside the tree. The local population of the Boé sector, Guinea Bissau, called them drumming trees. The behaviour is referred to as ‘chimpanzee accumulative stone throwing’ by Kühl *et al.* 2016. We focus on the trees used by chimpanzees in Boé. Since the behaviour is neither always drumming nor accumulation, we prefer to call the trees used, focal trees. Camera trapping near focal trees and analyses of their surroundings increased our insight into the behavioural phenomenon and the types of trees used. Chimpanzees throw stones to trees of different appearances: hollow, not-hollow, small, big, with or without buttress roots. They use trees like *Ceiba pentandra*, *Cola cordifolia*, *Azelia africana* and *Pterocarpus erinaceus*. The focal trees may occur in the following habitats: savannah edge forests, sacred gallery forests, and ancient dry mountain forests. Our findings suggest that chimpanzees use a higher diversity and density of focal trees in some places than others and some trees are also used more than others. Too few data is available to link chimpanzee behavioural and individual and group characteristics to focal tree, location and purpose.

Key words: focal tree, accumulative stone throwing, chimpanzee, *Pan troglodytes verus*, lithic technology, sacred forests

FRONT PAGE: Different trees in the Boé Sector used by chimpanzees for stone throwing (pictures: Bartelijntje Buys).

NOTE: This report follows my previous report and overlap is common. The author acknowledges Annemarie Goedmakers^{1,2}, Claire Delvaux³, José F.C. Wenceslau¹, Piet Wit², Henk Eshuis¹, Saka Musa Culubali² and many others for their help and support.

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INTRODUCTION

In some populations in West-Africa, chimpanzees (*Pan troglodytes verus*) show a particular behaviour: they often return to the same trees to throw stones at it, which accumulates near the tree trunk, referred to as “chimpanzee accumulative stone throwing” by Kühl *et al.* 2016. This behaviour was first described as drumming on trees by chimpanzees based on observations by the local population of the Boé sector, Guinea Bissau (Chimbo Foundation 2011). The chimpanzees can either ‘hurl’ the stones onto the tree, ‘toss’ the stones into a hollow tree’ cavity and/or between its buttress roots, or ‘bang’ the stones repeatedly while holding the stone into their hands (Kühl *et al.* 2016). Stones (laterite, possibly limonite: a relatively light-weighted, iron-containing mineral) might be as heavy as 3-7 kg and gathered near or inside the trunk (Kühl *et al.* 2016 report even stones of 17 kg). Suggested by bulb formation of tree wound tissue, the trees might be used for many years. Most often, it is adult males that throw stones to the trees, but females and juveniles have also been recorded (Kühl *et al.* 2016; Buys 2016). Accumulative stone throwing often involves a series of behaviours in an almost ritual manner, such as staring at the tree, swaying back and forward, pant-hoot vocalisation (an accelerating and louder becoming *u:hu:-*sound, until a loud scream; Mitani *et al.* 1992), up to and including the throwing of a stone (Kühl *et al.* 2016; Buys 2016).

Researchers are only beginning to investigate the purpose of this stone throwing behaviour: communication, male display and a symbolic function are seen as possible explanations (Kühl *et al.* 2016; Buys 2016). In addition, the likeliness of human stones shrines near trees in e.g., West-African regions (Lentz & Sturm 2001) is remarkable, allowing us, perhaps, to study the origin of ritual places (Bradley 1998; Insoll 2004), such as trees (Laird 2004; Dafni 2007), through a non-human example (also suggested in Kühl *et al.* 2016).

In Boé local people have respect for chimpanzees and will not disturb them, hunt or harm them, based on cultural taboos. They consider chimpanzees as creatures with human-like cultural habits (pers. obs.; but see also Sousa *et al.* 2017, 2018; for other regions in Guinea Bissau). Moreover, in Boé, chimpanzees are partially protected within numerous patches of sacred

forests through habitat taboos. These sacred forests will not be touched by humans because the “ira” (local spirits) live there (Ramachandra 2017).

A site in Boé has been included within the Pan African Programme (PanAf, Max Planck Institute for Evolutionary Anthropology, Leipzig Germany) (Arandjelovic *et al.* 2011) a project which aims to enhance our knowledge of evolutionary and ecological characteristics of chimpanzees all over Africa and to implement this knowledge in future conservation actions (Vaidyanathan 2011). An increase in conservation aimed activities is urgently needed because in many West African regions, habitat for populations of *Pan troglodytes verus* is disappearing at an alarming rate (IUCN Red List 2016).

We describe trees that show traces and/or signs of chimpanzee accumulative stone throwing and refer to them as ‘focal’ trees. We describe the wound tissue of bark caused by the impact of stone throwing, the stone present, and tree species of three locations with different habitats in the Boé sector. We include behavioural observations of chimpanzees throwing stones to those focal trees as observed by camera trapping, and discuss some local beliefs and hypotheses for future research.

MATERIALS AND METHODS

Study Site

The Boé sector is a remote area of ca. 3,000 km² of forest - savannah mosaic in the south-east of Guinea Bissau, West Africa. The rainy season starts in May and ends in October (mean yearly rainfall: 1,600-2,000 mm) (Guilherme 2014; Wit & Reijntjes 1989). Slash-and-burn practices for agriculture and subsequent savannah/forest fires are common. Estimations of chimpanzee populations based on line transects counting carried out for Chimbo Foundation range between 1,000 and 1,500 (A. Goedmakers pers. com.; Nunes van den Hoven 2017), with individual party sizes up to 17 individuals as seen in one camera trapping event (pers. obs.). Chimpanzees live both in the remote parts of the area as in the broad neighbourhood of villages,

often within (sacred) forests (Nunes van den Hoven 2017; Ramachandra 2017). Local people are aware of this behaviour by chimpanzees and often describe this as a common phenomenon that has existed since the time of their ancestors. We even found focal trees of chimpanzees close to a local laundry spot, just outside the village (pers. obs.). We investigated three different habitat types: ancient dry secondary forest (Aicum), savannah edge forest (Quebube), and gallery forest (Tontege) (Figure 1). Old secondary forest is forest with large trees that have been disturbed by humans in the past, without presence of food crops yet oil palm or mango trees can still be present; savannah edge forests are small natural woodland patches surrounded by savannah; and gallery forests are forests with big, tall trees, typically found along brooks and rivers both as a part of a larger forest or isolated within savannah fields (White & Edwards 2000). Aicum is a relatively unpopulated mountain area where the vegetation has an open character; Quebube contains some small agricultural fields on a plateau with dense woodland patches, and in the depression of Tontege human disturbance has been absent for a long time, proven by giant tropical trees (e.g., *Ceiba pentandra* (L.) Gaertn.) which make up the structure of the sacred gallery forest along a rocky river side.



Figure 1. Study sites within the Boé sector in Southeast Guinea Bissau, bordering Guinea. Left: Map from Google Earth, 10 km scale, with main rivers, forests and roads visible, including the central largest village “Béli”. Flags indicate the sites of the focal trees recorded by camera traps. Right: Habitat pictures of different study sites, A: the

ancient secondary dry mountain forest of Aicum; B: the savannah edged forest of Quebube and C: the sacred gallery forest of Tontege. Exact camera location is not given because of protective reasons.

Selection of Trees and Camera Trapping

The main focal trees that are described within this manuscript were selected by previous researchers, to observe chimpanzee behaviour and other animals near the tree (Arandjelovic *et al.* 2011; Kühl *et al.* 2016). New camera trap records are taken from a time period after the study of Kühl *et al.* (2016), with trap camera's installed in December 2014 and removed in July 2015 (by independent researchers from the Foundation Chimbo; Buys 2016). The sensor level was set at "High", the resolution, or video size was 1280 x 720, and video length was 60s (following the PanAf protocol). No continuous data was available due to errors in data transfer, data gathering, camera defects and bush fires in the field, making it impossible to compare different trees and locations adequately.

Other trees described in this manuscript are trees that also might have been used by chimpanzees to throw stones at, accumulative or not, encountered during our fieldwork to investigate the camera trap trees.

Description of Focal Trees and Locations

During our fieldwork (November –December 2015) we identified focal trees (based on Arbonnier 2004, local and former Chimbo/PanAf knowledge¹) that have been used by chimpanzees to (repeatedly) throw stones at, photographed and described them. We described traces and other marks on the outer bark of the tree caused by chimpanzee stone throwing as: (fresh) open wounds, closed healed wounds (overgrown by outer bark), incl. bump formation and large (sometimes rotten) wound spots (Figure 2). The presence of stones, whether or not accumulated, and the relative sound quality of the trees (tested by knocking on it with our knuckles) was also noted down. Within a radius of 30m around each focal tree pictured by a trap camera, we described size and abundance of stones, chimpanzee nests, trails and food

¹ trees were compared to trees within an existing phenology-programme

traces (e.g., termite hills, fruits, edible trees and shrubs), and the presence of other trees which also showed marks of possibly stone throwing events.



Figure 2. Marks of stone throwing on the bark of focal trees. A: open wound with wood sap and resin; B - C: imprint of a recently thrown stone on bark, open wound; D: old throwing spots with removed outer bark; E: closed wound; F-G: bump formation, closed wound; H-I: large wound spots of repeated stone throwing events. Scaling objects in pictures: a human hand, a note book 15cm x 21cm and leaves ca. 12cm x 3,5cm. Trees: Ceiba pentandra (A, D, F, G and I), Spondias mombin (B), Cola cordifolia (C and E) and Pterocarpus erinaceus (H).

RESULTS

Focal Trees and their Environment

Aicum

The trap camera at Aicum was positioned towards a hollow tree of the genus *Combretum* (species unknown) (Figure 3). Inside the tree, there we found a pile of four big stones, while a few more (5 – 10) were spread on the ground around the same tree. Stone throwing marks were present on every side of the tree, and the tree made a loud, hollow sound when knocking on it. Within a radius of 30m around the tree, we did not find any other trees that had marks of stone throwing on the bark, nor did we find chimpanzee nests. However, there was a trail nearby and several trees known to be consumed by chimpanzees (Bogart 2009; Watts *et al.* 2012; van der Meer 2014): *Bombax constatum* (Pellegr. & Vuill.), *Cordyla pinnata* ((Lepr. ex. A. Rich) Milne-Redh.), *Ficus sp.*, *Hexalobus monopetalus* ((A. Rich.) Engl. & Diels), *Lannea acida* (A. Rich.), *Parkia biglobosa* ((Jacq.) R. Br. ex. G. Don), *Pterocarpus erinaceus* (Poir.) and *Saba senegalensis* (A. DC. Pichon).

During our field trip in Aicum, we found only a few traces and tracks of chimpanzees compared to other sites, but heard them screaming nearby. Only two trees (*Cola cordifolia* ((Cav.) R. Br.) and *Parkia biglobosa*), with two resp. three marks, possibly of chimpanzee stone throwing, were present at respectively 68m and 542m distance from the trap camera tree. No accumulation of stones was present at those trees.



Figure 3. The hollow focal tree (*Combretum* sp.) of the ancient dry mountain forest in Aicum, recorded by camera trap. A: front side with main throwing spot and accumulated stones inside the trunk. B: back side of tree. Scaling object: note book 15cm x 21 cm.

Quebube

The first camera trap in Quebube was positioned towards a *Ceiba pentandra* focal tree of ca. 1.50 m width at breast height (Figure 4), in a natural woodland patch, ca. 200m from the savannah border. The camera faced a stone throwing spot, where stones are accumulated and the bark of the tree is harmed. Old-grown bumps together with fresh marks of wounding (incl. Figure 2 G and I) suggested frequent use over a long period of time by chimpanzees for accumulative stone throwing. We found one or two stones within the niches formed by the buttress roots at the other side of the tree. We observed chimpanzee nests only in trees that were standing next to the focal tree. Several types of termite nests (e.g., forest mounds, shelter tubes, arboreal nests and even transported broken parts from mushroom-shaped termite mounds found on the savannah) were present within the 30m radius. We found traces of food consumption including fruit remnants near the foot of the focal tree. Nearby chimpanzee food trees and bushes were present: *Bombax constatum*, *Ceiba pentandra*, *Dialium guineensis* (Willd.), *Landolphia heudelotii* (A. DC.), *Parinari excelsa* (Sabine) and *Saba senegalensis*. The trap camera drumming tree was located near a chimpanzee path.



Figure 4. The *Ceiba pentandra* focal tree of the savannah edge forest in Quebube, recorded by camera trap. A: front side with main throwing spot and accumulated stones. B: detail of stones and bump formation. C: detail of stones: note the (many) small stones on the ground near the trunk, left from the wrist-sized stoned. Scaling object: note book 15cm x 21 cm.

A second camera trap in the woodland of Quebube pictured another focal tree at a distance of approximately two kilometres from the first camera trap. The tree, a *Pterocarpus erinaceus*, was a half-circled hollow tree, shaped by bush fire, standing not far from the savannah edge (ca. 15m) (Figure 5). Dozens of wrist-sized stones lay near the foot of the tree, some smashed into pieces presumably after hitting a flat big rock lying in front of the tree (but see discussion for stone use by chimpanzees). The vegetation in the 30m-radius is similar to the previous camera spot, likewise a chimpanzee trail was near, but here we found only few chimpanzee nests (but not in the adjacent trees) and traces of termites.



Figure 5. The *Pterocarpus erinaceus* focal tree of the savannah edge forest in Quebube, recorded by camera trap. A: habitat picture, focal tree with white note book on the right of S.M. Culubali. B: detail of the focal tree with accumulation of wrist-sized stones, note the flat rock in front. Scaling object: note book 15cm x 21cm.

We found several other trees in the Quebube woodland patch (in a range of ca. 3 km²) which showed evidence that chimpanzees had thrown stones at them, or from which we could assume that they might have been used for stone throwing by chimpanzees. Two other *Ceiba pentandra* focal trees, which stood at 14m and 93m distance from the first trap camera tree, looked similar to one where we placed the camera trap (e.g., by morphology, marks, stone presence and environmental characteristics), except that one was slightly hidden by a few bamboo bushes. We found five other trees (*Pterocarpus erinaceus* and *Cola cordifolia*) with each one to three marks that might have been caused by chimpanzee stone throwing. A remarkable observation was a dead and rotten tree in an open savannah spot, ca. 50m away from the first Quebube trap camera. A chimpanzee trail was still leading towards this tree, even if chimpanzees needed to make a slight detour from the forest edge into this open spot and then back. Stones and old marks suggest that this tree might have been used as a focal tree before, but the tree had become

too rotten to produce much sound. A thin but tall *Spondias mombin* L. tree (Figure 6) captured our attention. The tree produced almost no sound when knocking on it, but the bark showed rotten spots, closed scars, and open wounds with wood sap. Most of the stones present within the 30m radius were located near this tree, although loosely spread and not in piles. In addition, tracks, trails, and signs of chimpanzees were present in the 30m radius around this tree; it was as if the tree was standing in the middle of an open space, with at least seven game trails leading towards it.



Figure 6. A *Spondias mombin* tree in the savannah edge forest in Quebube, possibly used for chimpanzee stone throwing. A: habitat picture, focal tree with white note book on the right of S.M. Culubali. B: detail of tree with example accumulation of stones in the back. Note the typical red imprint of a thrown stone on the bark, large wounding spots and other marks. Scaling object: note book 15cm x 21cm.

Tontege

The focal tree recorded by the trap camera at this site was a *Treculia africana* tree (Figure 7), and produced a loud, hollow sound when knocking on it. A pile of stones lay between buttress roots at the front where most stone throwing marks occurred while marks were present on every site of the tree. The tree stood near a small murmuring brook in the depression of the gallery-forest. Two chimpanzee paths came to this tree (one crossing the small brook) and ca. 5

chimpanzee nests were present in nearby trees but not in those adjacent to the focal tree. Food trees of chimpanzees found were *Azelia africana* Sm., *Landolphia heudelotii*, *Saba senegalensis*, *Cola cordifolia* and *Ceiba pentandra*. Within this 30m radius, we identified at least 13 trees (of a total of 26 trees) with one to three marks on the bark, possibly caused by stone throwing, most of them belonged to the latter chimpanzee food trees. Among the trees with marks, there was a very little and young tree (*Cola cordifolia*) with at the bottom some small stones (100-200g) and marks only close to the ground. When knocking on it, it produced a remarkable and loud sound for such a small tree.



Figure 7. The *Treculia africana* focal tree of the sacred gallery forest of Tontege, recorded by camera trap. A: habitat picture of focal tree, note the large root on the left side of the tree. B: detail of accumulation of stones within the tree' cavity. Scaling object: note book 15cm x 21cm.

Other *Cola cordifolia* trees in Tontege had a few marks on their bark, possibly from chimpanzee stone throwing, and a few stones present near their trunk (although not in piles) (Figure 8). We only found marks and stones near *Cola cordifolia* trees when present near a (chimpanzee) wild tree, whereas a similar *Cola cordifolia* tree some few meters further (for example 5 m) did not show signs of possible chimpanzee stone throwing. Furthermore, we found no *Cola cordifolia*

trees with possible stone throwing marks to which more than one wild trail led, as if those *Cola cordifolia* trees were standing along the path, rather than to be a trail destination.



Figure 8. An example of a *Cola cordifolia* tree of the sacred gallery forest of Tontege, possibly used by chimpanzees for stone throwing. A: habitat picture of the tree. B: detail of the tree trunk with stones and marks: closed wounds but also an orange-red imprint of a possible thrown stone. C. Other typical closed marks on a *C. cordifolia* tree (e.g., left above in picture). Scaling object: note book 15cm x 21cm.

Also specimens of the big and impressive *Ceiba pentandra* trees ('giant kapok' trees) that make up the gallery forests of Tontege, probably are used for accumulative stone throwing by chimpanzees (Figure 9; Chimbo Foundation 2011). Stones were present near the trunk and on/in between the buttress roots (e.g., up to a height of 1m30 high) of the *Ceiba* pictured in Figure 9. The bump formation of trunk tissue shows sizes of over 30cm in diameter. There are marks all around the tree, some recently made (e.g., wood sap present, bump not yet formed, etc.), and far more than compared to those found on the *Cola cordifolia* trees (compare Figure 8 and Figure 9). Interestingly, we found nests of chimpanzees in the trees surrounding the giant *Ceiba pentandra* focal trees, whereas this was not the case for the *Cola cordifolia* trees encountered in Tontege.



Figure 9. An example of a *Ceiba petandra* giant kapok tree of the sacred gallery forest of Tontege, probably used by chimpanzees for stone throwing. A: habitat picture of the tree. B-C: detail of tree trunk with bump formation (sometimes up to 30cm diameter). C. Stones between the buttress roots to a height of ca. 1 m. Scaling object: note book 15cm x 21cm and leaves ca. 12cm x 3,5cm.

Hollow trees encountered in Tontege did also show signs of possible chimpanzee stone throwing, such as the tree pictured in Figure 10 (tree species undetermined). A heap of wrist-sized stones are present under the tree and possible marks of stone throwing are visible on the bark. A rock stands near the tree (see Figure 10).



Figure 10. An example of a hollow tree of the sacred gallery forest of Tontege, possibly used by chimpanzees for stone throwing. A: a heap of wrist side stones is gathered under the tree B: marks of possible stone throwing on the bark on the other side of the tree.

Chimpanzee Behaviour near Focal Trees

Aicum

We did not observe any chimpanzee accumulative stone throwing behaviour during 124 days in the months that the trap camera recorded films: December 2014, April, May, June and the beginning of July 2015. Most of the time, chimpanzees were just passing by. We observed one young female with a disabled hand who inspected the drumming tree for some seconds on the 2th of July (at 11h33). She travelled in the neighbourhood of a group of nine hiking adults (mostly adult males and at least one female in oestrus). She arrived first and climbed in the drumming tree while the others passed (see supplementary video²).

Quebube

The first camera trap recorded for 71 days from end May to end July 2015. On 42 days we observed chimpanzees near the focal tree, of which 11 days showed accumulative stone throwing. 25 times a stone was thrown to a tree: 8 times in the morning (from 7h00 -11h00), 7 times around midday (11h30-14h00) and 8 times in the afternoon (14h05 -17h30), and even

² Supplementary video may be viewed at: <https://www.youtube.com/watch?v=5SHbF1EdqvM&feature=youtu.be>

two times in the middle of the night (around 3h40- 3h50). No observation were made of stone throwing during sunset (17h35-19h00). We identified at least 5 different drumming individuals: 4 males and one juvenile. Accumulative stone throwing often occurred in the typical way described in Kühl *et al.* 2016: the chimpanzee stands on his two hands and two feet in front of the tree, swaying a bit, making soft ‘oohoo-sounds’ (*u:hu:*) which become louder and faster (pant hoot vocalisation). Then the chimpanzee throws one stone to the tree, making loud screams directly after that (Figure 11; see supplementary video³). At the first camera trap, we 7 times observed chimpanzees sitting down for a long time, just before and/or after throwing, in front of the drumming tree – sometimes staring at it, scratching themselves, looking around and even sleeping (see supplementary video in appendix). 4 times more than one stone was touched before picking up one for throwing (see supplementary video³). In 3 cases this typical behaviour stopped before actually a stone was thrown to the tree (e.g., chimpanzees scratching themselves, sitting down or going away, see supplementary video in appendix). In four cases more than one stone was thrown within one footage (60s) or two sequential footages by one or two individuals. An adult male and a juvenile were throwing stones together: first the juvenile then the male, where after they run away (see supplementary video⁴). We observed behaviour possibly related to male display (e.g., shaking with leaves and branches) in which a male chimpanzee is banging to another nearby tree as well (see supplementary video⁵).

³ Supplementary video may be viewed at: <https://www.youtube.com/watch?v=JtEFKZO9cEo&feature=youtu.be>

⁴ Supplementary video may be viewed at: <https://www.youtube.com/watch?v=ujogRdaflJ4>

⁵ Supplementary video may be viewed at: <https://www.youtube.com/watch?v=WMxN9-vpDbg&feature=youtu.be>

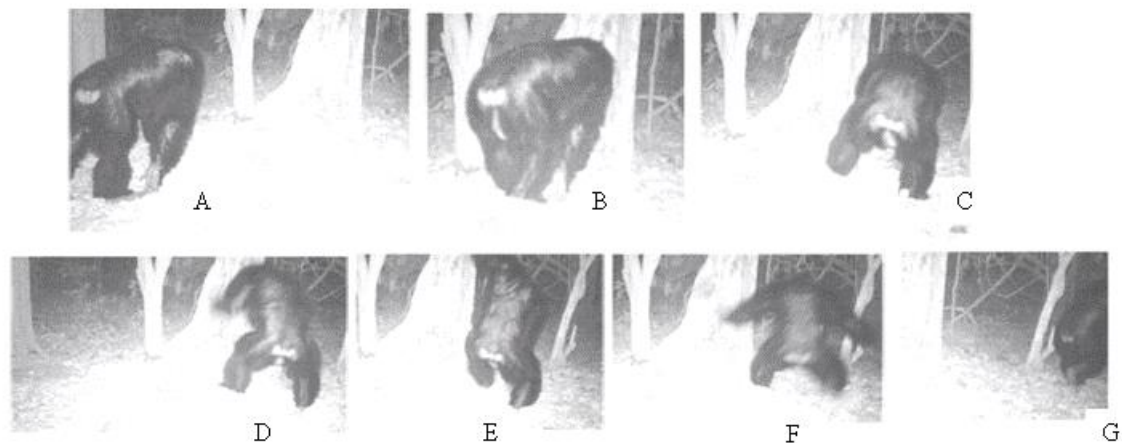


Figure 11. A typical manner of stone throwing behavioural sequences: the chimpanzee stands on his four hands in front of the tree with stone in hand (A), looking at the tree and then swaying a bit sideways (B), making soft oohoo-sounds (*u:hu:*) which becomes louder and faster (pant-hoot vocalisation). Then the chimpanzee gets up (C) throws one stone to the tree (D-F), sometimes banging it, making loud screams directly after. The chimpanzee might run away directly after it (G), or he will stay near the tree, sometimes sitting down in front of it.

A young adult male who came in the night to drum (20 July at 3h40 and at 5h25) stared at the tree, then carefully searched for a stone, drummed while screaming and making a pirouette, hang to the tree (almost ‘hugging’ it), and finally fell asleep in front of it (see supplementary video⁶). In addition, we observed a juvenile playing alone on the tree.

For the second camera trap on another focal tree in Quebube, we only had records from the months December 2014 and April 2015. We observed accumulative stone throwing in 6 records from a total of 17 chimpanzee records in 50 days of recording. Accumulative stone throwing was only recorded in April, and only during the morning (3 times between 6h08 - 6h32; and 3 times between 8h09-8h32). When passing by chimpanzees sometimes pay attention to the tree or only have a fast look at it. Once we observed chimpanzees drumming with his feet on this tree as well (possibly the same juvenile that was recorded playing at the other focal tree in Quebube recorded with camera trap) (see supplementary video in appendix); and an infant jumping off the back of an adult which was passing by) to take a little stone at the foot of the

⁶ Supplementary video may be viewed at: <https://www.youtube.com/watch?v=YG7WUpiTUFY> (time not continuous!)

focal tree to bang it on a tree next to it (see supplementary video⁷).

We observed at least three individuals throwing stones at both focal trees recorded in Quebube by camera trap.

Tontege

We analysed 30 days of sporadic camera trap videos recorded in December 2014, Mars, May, June, July and August 2015. From 12th until 30th December, we observed chimpanzees at nine different days. 17 records showed chimpanzees passing the tree, from which 5 records showed chimpanzee individuals pausing for some seconds in front of the tree looking at it (among them “Witstreep” and a big male, see further). Four times we recorded accumulative stone throwing behaviour (on the 12th at 9h20 and 17h32; on the 13th at 15h44; and on the 18th at 13h37), carried out by an adult female “Hamada” who always sat down on a buttress root of the tree for about a minute, direct after stone throwing (see supplementary video⁸). On the 15th (18h02) we heard on the camera trap a stone throwing event accompanied with pant hoot at another focal tree which was not pictured through the camera. In addition, we observed chimpanzees sniffing near the same spot on a root at 6 different days (the 13th, 16th, 25th, 27th and 30th), among them “Hamada”, “Witstreep”, the big male and an unidentified subadult (see supplementary video⁹, and appendix). On the 26th of May, we made haphazard a similar observation. In March, the 18th, “Witstreep” was observed to fish ants with a small twig at the same root (see supplementary video in appendix). “Witstreep”, a young female with partly white fur, is probably the most recorded near this focal tree throughout our research, although never stone throwing. On the 18th of March she also climbed in the focal tree.

⁷ Supplementary video may be viewed at:

<https://www.youtube.com/watch?v=rBFZXdTcIX4&feature=youtu.be>

⁸ Supplementary video may be viewed at:

<https://www.youtube.com/watch?v=Vm3zzsbCCA4&feature=youtu.be>

⁹ Supplementary video may be viewed at:

<https://www.youtube.com/watch?v=GimzylWZgNM&feature=youtu.be>

From the 24th until the 27th of May, we recorded 21 times chimpanzees passing near the focal tree; 3 times a chimpanzee paused in front of it, looking at it. Five stone throwing events were recorded at two different days (on the 24th at 18h20 and 18h43; on the 26th at 10h41, 11h00 and 15h15) by the same big male (see above). This big male was almost all the time running to the tree, grabbing the three with his hand during or after stone throwing and then running further (see supplementary video in appendix). Hamada was recorded on the 26th at 13h14 to sit on the buttress root for about two minutes without stone throwing (or making any attempt towards it, see supplementary video¹⁰).

At the 18th of June, we observed this big male throwing a stone, closely followed by another unidentified individual (female or subadult). At the 19th of June, an unidentified male came to throw a stone at the three, running away directly after it – probably chased away by this big male who sprang on the tree directly after it, drumming with his feet, again accompanied by this other unidentified individual (see supplementary video¹¹, and in appendix).

In the period 21 July – 28 August 2015, in the middle of the rain season, we recorded 3 times chimpanzees passing by the focal tree, and one time a chimpanzee leaning towards the back of the tree with one hand for several seconds and then going away. Only once a stone throwing event was recorded: in the pouring rain on the 23th of August at 18h07 (see supplementary video¹²). The individual could not be identified.

¹⁰ Supplementary video may be viewed at:

https://www.youtube.com/watch?v=wX_gi95h5oY&feature=youtu.be

¹¹ Supplementary video may be viewed at:

<https://www.youtube.com/watch?v=cjrLC6iR2gI&feature=youtu.be>

¹² Supplementary video may be viewed at:

https://www.youtube.com/watch?v=K_haMUuuU24&feature=youtu.be (1st sec !)

DISCUSSION

We described focal trees in different habitat types: savannah-edged forests, dry mountain forests and (sacred) gallery forests. Trees might be selected for sound quality (e.g., *Cola cordifolia*); for their reaction on stone throwing such as wood splintering (local perspective, Buys 2016); wound generation (e.g., *Ceiba pentandra*), and for their resistance against savannah fires (e.g., *Pterocarpus erinaceus*; pers. obs. the focal tree of Quebube) to survive over a longer time period. Trees may also vary in appearance: with or without buttress roots, hollow or not.¹³ Some trees seemed to have fewer marks and stones present than others and we can assume that they were rather sporadically used in a restricted time period (e.g., only old, closed scars present on a tree). Even in the absence of camera trap evidence, we can assume that the ‘scars’ on those trees are caused by chimpanzee accumulative stone throwing, rather than by any other event. We compared ‘scars’ on different trees, in different habitats, using the focal trees from which we had camera-evidence as a reference. Wound healing of broken branches, parasite infections, machete cuttings, nibbling or peeling of tree bark by animals does not look similar nor was suggested within the context. This was confirmed by the opinion of our local guides on the causes of the scars found. However, clear definitions, descriptions and categories of marks made by chimpanzee stone throwing on trees are still lacking because of the only recent discovering of this phenomenon by western scientists (Chimbo Foundation, 2011; Kühl *et al.* 2016). It will be important to define and categorise focal trees based on more extensive research.

We did not have enough data to compare the different sites in function of chimpanzee behaviour. It is clear that chimpanzees throw stones at different species of focal trees, although the list described here is non-exhaustive. One tree may be used by more than one individual, although a specific individual might have a preference for a specific tree (e.g., the female

¹³ Indigenous people confirm that wooden logs on the ground might be used for stone throwing as well.

“Hamada” who was often recorded near the focal tree of Tontege). Stone throwing individuals were most often adult males, but also females¹⁴ and juveniles were recorded (cf. Kühl *et al.* 2016; Buys 2016), and even an infant was observed banging a little stone on a tree next to a focal tree in Quebube without direct observation that it was imitating an adult behaviour (on the contrary!). Stone throwing behaviour might also be different among individuals, rather than show differences between location or chimpanzee groups (cf. Arcadi *et al.* 1998, 2004; Babiszewska *et al.* 2015 on chimpanzee drumming).

Focal tree abundance, density, and (functional) diversity might be different between habitats; further research is needed since we have not yet enough data to be decisive. In sparsely populated areas, with more wandering chimpanzees (like the mountain area of Aicum) the abundance and use of drumming trees might be much lower than in areas with a higher and more permanent chimpanzee activity (like the sacred gallery forest of Tontege). We did not observe a single stone throwing event on the footage analysed of our camera trap in Aicum, and came across only two other trees in the neighbourhood with few scars. On the contrary, in Tontege, a much more complex and diverse habitat with more permanent and higher chimpanzee activity, we encountered many more focal trees during our field research, and it appeared to us that only some tree species or hollow trees were used to throw stones at.

The complexity of the sacred gallery forest of Tontege with its high diversity and density of impressive focal trees might have developed over a long period of time (i.e. over centuries) of almost no human disturbance because of strong habitat taboos, (Ramachandra 2017). This hypothesis (Buys 2016) is in line with Kühl *et al.* (2019) stating that human disturbance erodes chimpanzee-cultural complexity.

¹⁴ Female chimpanzees in West-Africa (with the Boé region as one of the outermost regions) might have among the strongest bonds within the male phylopatric system, in contrast to East-African populations (Lehmann & Boesch 2008).

The size and therefore the age of focal trees, wounded by stones, is rather impressive (cf. Figure 9), making it likely that the same focal trees are used over generations for stone throwing events. An adult and juvenile were recorded to throw stones together (Figure 12). This hypothesis is supported by that of a stone which was (entirely) overgrown by the bark of a focal tree. Few data are available on the life expectancy of *Ceiba pentandra* trees, but fully grown trees in a rainforest can live for several hundred years – maybe 350 years and more (dr. C. Woodward, president Ceiba Foundation, pers. comm.).

The aging of tree marks caused by stone throwing can be investigated by measuring bump formation growth and speed in the field or by making anatomical studies on transactional wood discs of bump formation (cf. Delvaux *et al.* 2010) in non-active, abandoned or fallen focal trees (Buys, pers. obs. 2017). Such studies should compare different tree species for: i) their ability to survive ‘stone throwing’ events and ii) to recover their bark after wounding over time (year after year, etc).



Figure 12. An adult male chimpanzee (named “Zilverrug”) and a juvenile throwing stones to a focal tree in Quebube, first the juvenile is throwing a stone than the adult, thereafter they run away.

The use of stone tools has been a milestone in human development, and tool use by animals and primates has received much of our attention (Sanz *et al.* 2013). Spontaneous planning for future stone throwing, including stone caching and the manufacturing of objects to use in male

dominance display has been reported in detail by Osvath (2009) of a particular chimpanzee in a zoo, showing such earlier anecdotal observations do not need to be artefacts in experimental research. Interestingly, that chimpanzee took sometimes stones covered with algae from the water moat like the stones we found piled near a possible focal tree near the small stream just outside Béli.

What is the origin of stone throwing? Some hypotheses for accumulative stone throwing are already given by Kühl *et al.* 2016, but based on some interviews with local people, some thoughts might be added (Buys 2016, pers. obs. 2017). Amadal Camará, an indigenous elderly man, referred to stone drumming as the action of a blacksmith, the believed ancestor of the first chimpanzee (Sousa *et al.* 2017). According to him, accumulative stone throwing might occur as a consequence of a random action, a ‘music-making noise’ (cf. Matsusaka 2012; Dufour *et al.* 2015 regarding music-making by hand-drumming chimpanzees); a male display behaviour (although females and juveniles have also been recorded); and especially as a communication tool (cf. Arcadi *et al.* 1998; Arcadi *et al.* 2004, Babiszewska *et al.* 2015 for chimpanzee buttress drumming without using stones). Other locals voiced the possibility that stone throwing is used to chase away dangerous animals (e.g., snakes) or to harvest fruits or other tree food sources¹⁵ and honey (indigenous people follow chimpanzees to find bee nests) whereby stone piles accumulate by accident (as I did indeed once observe through trap cam analysis, although we observed a chimpanzee is bringing a stone to a hollow tree without actually stone throwing). Stone piles and trees may also indicate territorial signs, visual or auditory. Sniffing at the bark of focal trees by chimpanzees was more than once recorded.

The impressive giant focal kapok trees with chimpanzee nests around; the preference for only some particular trees and not similar trees standing near; the staring of chimpanzees at focal

¹⁵ *C. pentandra*, *C. cordifolia*, *P. erinaceus*, *S. mombin*, described here as focal trees are known food trees of chimpanzees)

trees, the same serial sequence of behaviours while throwing stones at trees; and the observation of individuals coming to the focal trees at night – together with the high intelligence of chimpanzees – suggest there might be other reasons for this complex behaviour than until now put forward.

In the small amount of camera trap footage that is so far analysed within this study, we already made a few interesting observations, worthy of the local belief that the first chimpanzee originated from a transformed black smith. We have footage of chimpanzees that hit a rock firmly just before throwing a stone on a focal tree in Quebube (and Capebonde, see appendix). The many broken (fractured, not flaked) stones lay near the trees of Quebube might be a consequence of stones bouncing back from the tree onto the rocks, but could also be the result of the action of chimpanzees. In appendix, the sound of stones rebounding on rocks after hitting a focal tree is recorded, as well as a rhythmical background noise that is undetermined but might be the sound of stone hitting stone. Joost van Schijndel (draft report for Chimbo), writes about accumulation sites of stones in rocky environments, possible caused by the act of chimpanzees. Chimpanzees sometimes seem to choose carefully the stones used for stone throwing. This is illustrated by the supplementary video¹⁶ in which a chimpanzee is touching more than one stone before picking one up for stone throwing. Juveniles are recorded playing with stones near the focal trees or scratching them on other stones while sometimes knocking on the focal trees in Quebube (and in Capebonde, see appendix). At the Capebonde site we recorded a juvenile bringing a stone from elsewhere to the focal tree, as well as a juvenile taking a big stone away from the focal tree – probably to use elsewhere (see supplementary video¹⁷).

Apart from stone throwing events we recorded other behaviours near the tree, such as passing by with or without a particular interest to the trees, sitting on buttress roots or rocks near the

¹⁶ Supplementary video may be viewed at:
<https://www.youtube.com/watch?v=JtEFKZO9cEo&feature=youtu.be>

¹⁷ Supplementary video may be viewed at:
https://www.youtube.com/watch?v=fYJEM_YXJ7w&feature=youtu.be

tree, eating, grooming, playing and climbing into the tree and lianas. In Capebonde a whole party of chimpanzees was often recorded sitting on big rocks in front of the tree (pers. obs., see appendix).

CONCLUSION

This descriptive note aims to encourage further research on accumulative stone throwing of chimpanzees and the trees they use. Marks of stone throwing are visible on the bark of focal trees (e.g., through bump formation, rotten spots), sometimes with accumulation of stones near the trunk. We found stone marks on hollow tree trunks as well as non-hollow trees. Our results suggest that there might be more than one type of focal tree and more than one stone throwing purpose, while both might differ over locations and habitats. Functional (and species) diversity and density of focal trees might be higher in the sacred gallery forests that are protected by local habitat related taboos. Future research is needed to get a better understanding of the different types of focal trees and the relation between the focal tree and the behaviour of chimpanzees. It would be worthwhile to investigate the preference of chimpanzees over generations for one particular focal tree above a similar other tree in the neighbourhood as a crucial element for interpreting this behaviour on a chimpanzee cultural scale.

One hypothesis should not exclude another. Future research should be done with respect to chimpanzees, their habitats, their focal trees, and the customs of the local people. Most studies will include non-invasive camera trap observations, together with audio recordings over a broader temporal and spatial scale than we did now. But, “we have to remember that what we observe is not nature itself, but nature exposed to our method of questioning” as told by Heisenberg (1985).

NOTE:

For more pictures see Buys 2016. For description of behavioural footage at the Capebonde site see appendix 1.1; for all supplementary videos described in this manuscript; see appendix 1.2.

ACKNOWLEDGEMENTS

I would like to thank the Milvus Group, Romania, and especially Szilárd Sugár, to enhance my way of thinking, incl. field research and trap cam analysis. I am also grateful to Saka Mousa Culubali, (excellent field guide) but also to Menno J. Breider; Alfa I. Quita and Djoulde Embalo for her warm welcome in Africa; Simon Braem and Ammie Kalan for quick reading through my internship report. Thanks to Henk Eshuis, Gerco Niezing and José F. C. Wenceslau for setting up the trap cameras and collecting the footages over the different years (with help of Brecht Coppens, Kali Bindia, Marn Manders and Hannah Jacobs), and G. Niezing and L. De Neve for useful comments on the manuscript. And last but not least, to Annemarie Goedmakers and Piet Wit for their efforts to conserve the Boé area both for people and wildlife.

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APPENDIX

1.1 A DRUMMING TREE AT CAPEBONDE

In Capebonde (about 16 km south-east from Béli), we recorded in May 2013 a focal *Ceiba pentandra* tree in the back of picture made by a camera trap (Figure 13) in a study investigating bauxite mining and chimpanzee distribution in the Boé area (Wenceslau 2014)¹⁸. This tree and this location were not investigated as the other sites described here, nevertheless some particularities of this tree are worth noticing here. The tree stands in a sacred gallery forest along a small stream, in the middle of big flat rocks and lianas where we once recorded a party of 17 individuals sitting, playing, eating, grooming and stone throwing (sometimes holding the rocks and lianas, jumping from it) even at night (see supplementary video¹⁹ and in appendix 1.2). Between 1 until 20 May we made 63 chimpanzee records, but only 1 actually accumulative stone throwing event carried out by a strong male and at least 7 related events. We observed different types of sound production: stones thrown on the tree; stone rebounding onto the rocks after hitting the tree (see supplementary video²⁰); stone throwing with and without pant hoot vocalization; stones directly thrown onto the rocks; drumming by feet onto the tree (see supplementary video²¹). Juveniles were also seen to play with stones near the main throwing spot. Once we observed a juvenile (or smaller individual) to be ‘chased away’ from the main throwing spot by a big male. Another juvenile carried a big stone away from the focal tree (see supplementary videos in appendix 1.2). Sometimes we recorded an almost rhythmical sound at the background of the footages but we could not determine it (see videos in appendix 1.2 and

¹⁸ Wenceslau, F.C. J. Bauxite Mining and Chimpanzee Population Distribution, a case study in the Boé sector, Guinea Bissau. 2014. MSc Report submitted for Foundation Chimbo and Van Hall Larenstein University of Applied Sciences, The Netherlands (www.chimbo.org).

¹⁹ Supplementary video may be viewed at: : https://www.youtube.com/watch?v=Jezi6_fho-s&feature=youtu.be

²⁰ Supplementary video may be viewed at: <https://www.youtube.com/watch?v=DTTICMssZ5k&feature=youtu.be>

²¹ Supplementary video may be viewed at: https://www.youtube.com/watch?v=oD_IwKQMUyk&feature=youtu.be

footnotes). It might be of stones against stones/rocks (cfr. Obs. Joost van Schijndel, draft report Chimbo) – stone accumulative sites near rocks.



Figure 13. A focal C. pentandra tree in the sacred gallery forest of Capebonde, picture taken by a Bushnell camera trap 7 May 2013 at 15h36. Big flat rocks are surrounding the tree on which a chimpanzee group may sit and play. For an approximately scale of this figure watch supplementary videos including chimpanzees.

1.2 SUPPLEMENTARY VIDEOS

Aicum

1. Female with disabled hand climbing into a focal tree before a party of chimpanzees passes, afterwards inspecting the tree.

link: <https://www.youtube.com/watch?v=5SHbF1EdqvM&feature=youtu.be>

Quebube 1

1. typical example of accumulative stone throwing

link: <https://www.youtube.com/watch?v=JtEFKZO9cEo&feature=youtu.be>

2. sitting before and/or after accumulative stone throwing

link 1: https://www.youtube.com/watch?v=a_2qiNeX1V0&feature=youtu.be

link 2: <https://www.youtube.com/watch?v=m0mRlaQ2dTs&feature=youtu.be>

3. accumulative stone throwing not finished (out of view?)

link: <https://www.youtube.com/watch?v=3Bvdh4TjW-s&feature=youtu.be>

4. more than one stone touched before accumulative stone throwing

link: <https://www.youtube.com/watch?v=JtEFKZO9cEo&feature=youtu.be>

5. chimpanzee accumulative stone throwing - adult male and juvenile throwing stones together

link: <https://www.youtube.com/watch?v=ujo9RdafLI4>

6. more than one stone thrown in one event – male display?

link: <https://www.youtube.com/watch?v=WMxN9-vpDbg&feature=youtu.be>

7. accumulative stone throwing – big stone

link: <https://www.youtube.com/watch?v=2xs6LIsbRR8&feature=youtu.be>

8. accumulative stone throwing at night – “Krabber”

link 1: https://www.youtube.com/watch?v=tkcNvpIIm_I&feature=youtu.be

link 2: <https://www.youtube.com/watch?v=DxEsHSvPIv8>

and all-in-one link: <https://www.youtube.com/watch?v=YG7WUpiTUFY>

Quebube 2

1. juvenile drumming with feet

link: <https://www.youtube.com/watch?v=tOgvmhZ77A4&feature=youtu.be>

2. infant stone

link: <https://www.youtube.com/watch?v=rbFZXdTcJX4&feature=youtu.be>

Tontege

1. female “Hamada” stone throwing – sitting afterwards

link: <https://www.youtube.com/watch?v=Vm3z2sbCCA4&feature=youtu.be>

2. sniffing near focal tree – male adult

link: <https://www.youtube.com/watch?v=GimzyIWZgNM&feature=youtu.be>

3. Female “Hamada” sitting on a root of the focal tree – and “Witstreep” - sniffing

link: https://www.youtube.com/watch?v=wX_gi95h5oY&feature=youtu.be

5. ant fishing is funny

link: <https://www.youtube.com/watch?v=ArCc-oF3wew&feature=youtu.be>

6. male holding the tree while drumming and running afterwards

link: <https://www.youtube.com/watch?v=VtHQPF3Ggmc&feature=youtu.be>

7. stone throwing while running

link: <https://www.youtube.com/watch?v=OyB-xQSOf0&feature=youtu.be>

8. stone throwing with companion? and chasing away other male

link 1: <https://www.youtube.com/watch?v=CI-vy3XGRg&feature=youtu.be>

link 2: <https://www.youtube.com/watch?v=cjrLC6iR29I&feature=youtu.be>

9. accumulative stone throwing – pouring rain

link: https://www.youtube.com/watch?v=K_haMUuuU24&feature=youtu.be

Capebonde

1. adult male drumming with feet

link: https://www.youtube.com/watch?v=oD_lwKQMUyk&feature=youtu.be

2. accumulative stone throwing with stone rebounding on rocks

link: <https://www.youtube.com/watch?v=DTTICMssZ5k&feature=youtu.be>

3. juvenile chased away

link: <https://www.youtube.com/watch?v=xzKvImQrMJ8&feature=youtu.be>

4. chimpanzee- life near the focal tree

playing : link: <https://www.youtube.com/watch?v=33ieaCoVDII&feature=youtu.be>;

link: <https://www.youtube.com/watch?v=xjBIDGzPSCU&feature=youtu.be>

sitting: link: <https://www.youtube.com/watch?v=RFXg3NdFfvo&feature=youtu.be>

grooming: link: https://www.youtube.com/watch?v=Jezj6_fho-s&feature=youtu.be

night: link: <https://www.youtube.com/watch?v=iWrXx7LqCdg&feature=youtu.be>

5. juvenile bringing stone to main throwing spot focal tree

link: <https://www.youtube.com/watch?v=xjBIDGzPSCU&feature=youtu.be>

6. juvenile carrying away stone from focal tree

link: https://www.youtube.com/watch?v=fYJEM_YXJ7w&feature=youtu.be

7. unknown sound (listen with headphones!)

link: <https://www.youtube.com/watch?v=sFuE4O5hGuY&feature=youtu.be>

and proceeding video <https://www.youtube.com/watch?v=A3rvzafuaGs&feature=youtu.be>