A Field Observation on Color Selection by New World Sympatric Primates, *Pithecia pithecia* and *Alouatta seniculus*

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ABSTRACT. This work characterizes differences in selection of *Talisia retusa* fruits by two sympatric Neotropical primates, *Pithecia pithecia* (white-faced sakis) and *Alouatta seniculus* (red howlers). Color appears to be the criterion by which fruits were selected. Greenish fruits were mainly eaten by *Pithecia*, while yellowish fruits by *Alouatta*. The characteristics of these primates in relation to seed predation and seed dispersal are discussed in the context of the *Talisia retusa* fruit color spectrum. Furthermore, a possible differential acquisition of chemical components, like tannins, is hypothetically treated considering the variation in fruit color.

Key Words: *Talisia retusa*; Fruit choice; Seed predator/seed disperser; Lago Guri; Venezuela.

INTRODUCTION

Color vision is thought to be important in the discrimination of fruits chosen by primates. As JACOBS (1997: 69) points out, "with the appropriate color vision a fruit might be rendered more discriminable from leafy surrounding if it were any of several colors." Thus, color gives information about fruit ripeness that, combined with fruit morphology (e.g. protection of a hard husk, fruit weight and size: JANSON, 1983; GAUTIER-HION et al., 1985; KINZEY & NORCONK, 1990), are variables used for its choice. Another poorly studied selection criterion is fruit scent.

This work has as its objective to characterize systematically the color of fruits chosen by sympatric primates, *Pithecia pithecia* (white-faced sakis) and *Alouatta seniculus* (red howlers) and to determine if this could be a decisive approach in studying fruit selection by these primates. For primates of the Old World, the color criterion has been considered by GAUTIER-HION et al. (1985) and SOURD and GAUTIER-HION (1986). For the New World primates, the color criterion was considered by SNODDERLY (1978, 1979), JANSON (1983), TERBORGH (1983), SABATIER (1983, cited in GAUTIER-HION et al., 1985), and GUILLOTIN et al. (1994). TERBORGH (1983) and GUILLOTIN et al. (1994) characterized the color of fruits eaten by sympatric monkeys, finding a selection between yellow and orange. On the other hand, SNODDERLY (1978, 1979) dedicated a work exclusively to consider the fruit color choice of a wild neotropical primate, *Callicebus torquatus*, concluding this primate feed primary on green/unripe fruits. I examined the feeding activities of a red howler and a white-faced saki when selecting *Talisia retusa* (Sapindaceae) fruits. Individual fruit color change from green (unripe) to yellow (ripe).

STUDY AREA AND METHODS

The study area is an island of approximately 12 ha located in the Lago Guri, Caroní River

(7°45' N, 62° 52' W), Venezuela. The vegetation of the island is a lowland dry primary forest (AYMARD et al., 1997). It presents two climatic seasons, rainy between May and September and dry between October and April. The fieldwork was carried out in July and August 1999, coinciding with the year's rain peak and the fruiting of great quantity of plants, among them with the one that concerns us, *Talisia retusa*. A study group each of *Pithecia pithecia* (Pitheciinae) and *Alouatta seniculus* (Atelinae) have been habituated to human observers in behavioral and ecological studies.

The sample consisted of 60 exocarps of *Talisia retusa* eaten by an individual of *Pithecia pithecia* and an *Alouatta seniculus*, these were the only two members of their groups who were feeding on the same tree. This tree genus produces "ovoid to globose, one seeded, not deshiscent" fruits (GENTRY, 1996: 767). In Venezuela, it is named "cotoperi" (AYMARD, pers. comm.) and is similar in appearance to a fruit commonly found in Venezuelan markets, called "mamón," *Melicoccus bijugatus* (Sapindaceae). It is interesting to point out that in Colombia, *Talisia* is known as "mamón de mico" – monkey's melicoccus – (GENTRY, 1996: 767).

The selection of *Talisia retusa* fruits was based on two factors. First, the fruit is consumed by both primates, which allowed to carry out this comparative work and second, the external surface (exocarp) of the fruit is sufficiently large (ca 2 to 2.5 cm in mean diameter), with a smooth surface that made it possible to accurately determine the color. Other fruits eaten at the same time of the year were not suitable for color comparison. For example, *Actinostemon schomburgkii* (Euphorbiaceae) and *Chiococa alba* (Rubiaceae) fruits were consumed only by *Pithecia pithecia*. These are small fruit and were consumed entirely. *Connarus venezolanus* (Connaraceae) fruits, also ingested by *Pithecia*, changed in color from green to red when ripe.

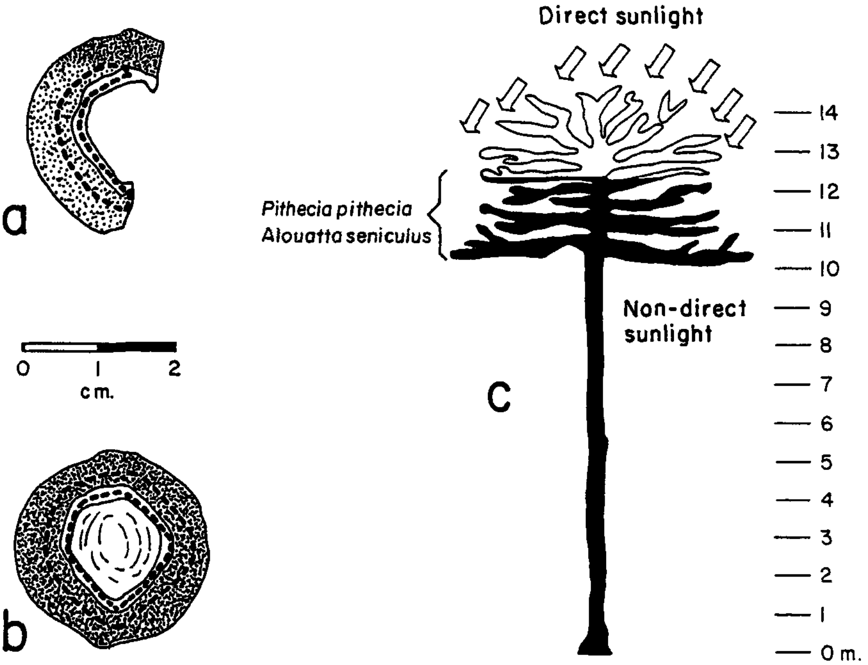

Fig. 1. **a**: *Talisia retusa* fruit unit bitten and seed eaten: predated or ingested; **b**: *Talisia retusa* fruit unit bitten but seed not eaten (The coarse segmented-line indicated the color measure area on the exocarp); **c**: sketch graphic of the lighting situation of the *Talisia retusa* tree, when the fruits were taken by the sympatric Neotropical primates.

This fruit was not used in the study because the capsules were sometimes opened, seeds removed, and left hanging on the tree.

The fruit sample consisted of exocarp remains. The *Pithecia* sample was the remains of the feeding activity of an adult male who consumed 30 fruits units, eating the seed flesh, while bitting the seed. The *Alouatta* sample consisted of 30 exocarps dropped by an adult female, after the seed was swallowed, in this case the amount of exocarps gathered was the same as in the previous primate to have an equal sample size. The fruits were gathered as they fell from the tree. The color measurement was made *in situ* by the author and assisted by a botanist, and right after the exocarp remains were taken to avoid any color change with time. The Munsell® Color Charts for Plant Tissues for botanical and forest purpose was applied to perceive and register accurately the fruit color in the field. This color chart is "a scientific concept for describing and analyzing color in terms of three attributes called Hue, Value, and Chroma" (MUNSELL®, w/d). The part of the exocarps remains in which the color was determined, belongs to the surface around the fruit bitten area, which could reasonably represent the fruit color perceived by the primates when the seed was eaten: predated or ingested (Fig. 1a). In the few cases that the fruit was bitten and the seed not eaten, the color was uniform in the whole fruit (Fig. 1b).

According to the suggestion given by JACOBS (1997: 70), the state of environmental light at the moment of consumption was considered. There were only two moments during the field session when the primates fed on the same *Talisia retusa* tree. The *Pithecia* male ate the fruits at 06:20 in conditions of low light. Two days later, the *Alouatta* female carried out the ingestion at 15:32. Even though it was in the afternoon, the lighting conditions were similar. In both cases, the feeding area was not in direct sunlight and the fruit eaten by the primates were at the same height – between 10 and 12 m – above the ground (Fig. 1c). A similar energy spectrum could have been reflected by the fruits. Therefore, the conditions in the field were good since the fruits eaten came from the same tree under similar illumination conditions. Both subjects[1] were adults and sufficient number of samples (exocarps) were obtained for statistical analysis.

Apart from color, another non-tactile selection criterion is the fruit odor which in some cases could be related with color. In our case, the primates were not observed to smell the fruits. The only case known by the author in which the odor apparently was a selection criteria is the case of the direct *Pithecia* nose-fruit smelling behavior on fruits of *Capparis muco* (Capparidaceae). Fruits of this species have a highly fragrant odor when ripe (RIVEROS, pers. comm.), even though there is no change in color when the fruit ripens.

RESULTS

The *Alouatta seniculus* individual selected mainly the yellower fruits (80% yellows against 20% greens) and the *Pithecia pithecia* individual selected mainly the greener fruits (77% greens against 23% yellows). It is interesting to note that the green fruits bitten, but the seed not eaten by *Alouatta seniculus* (Fig. 2) matched the preferential color spectrum of those mostly by

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[1] *Alouatta seniculus* is a trichromatic primate (REGAN et al., 1998). Another Pitheciinae, *Callicebus moloch* males are dichromatics (JACOBS & NEITZ, 1987). Probably, a similar visual discrimination capacity exist among *Pithecia pithecia* males. This consideration, is strictly *a priori* and hypothetical, and need specific studies to test the color vision of this Pitheciinae. It is important to point out that "For identification tasks the dichromatic's eye is almost as good as a trichromat's, but the trichromat has an advantage for detecting fruits against a background of leaves." (OSORIO & VOROBYEV, 1996: 593).

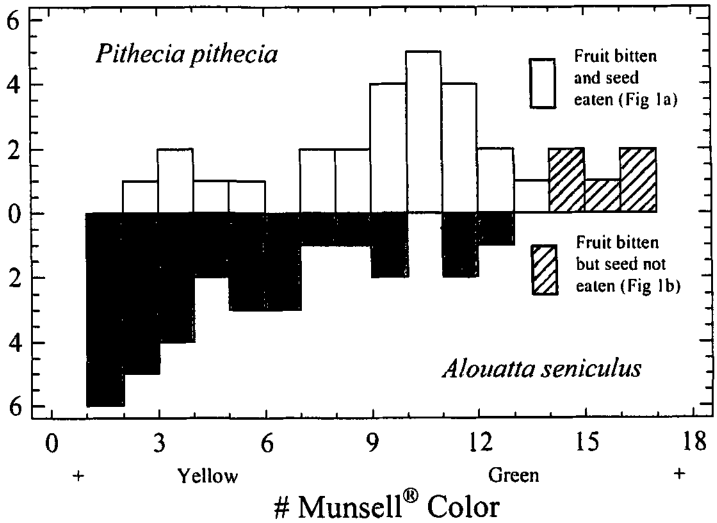

Fig. 2. Histogram representing the differential fruit color choice by *Pithecia pithecia* and *Alouatta seniculus*. The Munsell® Color Code are, as follow, (1) Strong yellow, 2.5Y7/10; (2) Strong yellow, 2.5Y8/10; (3) Strong yellow, 5Y7/10; (4) Strong yellow, 5Y8/10; (5) Moderate yellow, 5Y7/8; (6) Yellow, 2.5Y8/8; (7) Yellow, 5Y8/8; (8) Moderate greenish-yellow, 2.5GY7/6; (9) Moderate greenish-yellow, 2.5GY7/8; (10) Strong greenish-yellow, 2.5GY7/10; (11) Dark greenish-yellow, 2.5GY6/6; (12) Dark/deep greenish-yellow, 2.5GY6/8; (13) Moderate yellow-green, 5GY6/6; (14) Moderate yellow-green, 5GY5/6; (15) Strong yellow-green, 5GY5/8; (16) Moderate olive green, 5GY4/6.

Pithecia pithecia. The very green fruits, and therefore very unripe, were bitten but the seed not eaten by the *Pithecia* individual (Fig. 2).

Besides the graphic differences shown on Figure 2 to quantitatively compare the two samples three statistical tests were carried out. So at a 95% confidence level significant differences are shown on the means (*t*-test, *p*-value 5.10^{-7}), medians (Mann Whitney-Wilcoxon-W test, *p*-value 6.10^{-6}), and the two distributions (Kolmogorov-Smirnov test, *p*-value 1.10^{-5}).

Both yellow and green fruits were available at the time the two individuals were feeding; no data on the relative abundance of both types of fruits on the tree is avaliable. This observation discounts the possibility that *Alouatta* consumed yellow, mature fruits before they could be consumed by *Pithecia*. Thus, the *Pithecia* male had the opportunity to choose yellow, mature fruits, but took mainly the green, unripe fruits.

Besides that only one individual of red howler and white-faced saki were observed, it is possible to tentatively suggest that these primates largely choosed *Talisia retusa* fruits on the basis of color. This could be a constant among the other members of their groups, but it is opened the possibility that could exist difference among individuals. As in a work conducted by KINZEY and NORCONK (1990) based on *Ateles* (Atelinae) and *Chiropotes* (Pitheciidae), another fruit criterion was studied, hardness, and can be inferred that no apparent selectivity difference existed among group members.

DISCUSSION

These preliminary results seem to reinforce the idea that *Alouatta seniculus* is primarily a forager of ripe fruit (CROCKET & EISENBERG, 1987; GAULIN & GAULIN, 1982) and soft pulp (for *Alouatta palliata*: MILTON, 1980), that in our case were the yellow fruits. Our findings also support previous evidence that *Pithecia pithecia* is a forager of unripe, green fruits (KINZEY, 1997). Observations suggest that there is no direct competition for specific fruit units between *Alouatta seniculus* and *Pithecia pithecia* even when feeding on fruits from the same tree.

SNODDERLY (1978, 1979) suggested that most of the fruits chosen by another Pitheciinae, *Callicebus torquatus*, were mainly immature and green. The seeds eaten by *Callicebus* were soft, just like *Pithecia pithecia*, also a seed predator. In this study as in SNODDERLY's (1978, 1979), the color seemed to be the primary fruit selection criterion, because it appears to be the first feature perceived by the primate. This observation is consistent with the relation between seed that of other authors that the Pitheciinae are specialized in unripe fruits – normally green ones, when those have this color spectrum – with hard pericarps and soft seeds (KINZEY, 1992, 1997; NORCONK et al., 1998), a feature that matches with the green color, or a trend to green, pointed out by SNODDERLY (1979). On the contrary, *Alouatta seniculus* mainly consumes yellow-orange fruits (GUILLOTIN et al., 1994) that are mature and soft and have seeds harder and more difficult to digest. Howlers ingest the entire fruit including the seed, obtaining the nutritional requirements from the fruit flesh, excreting the non-digestible hard seed, serving as a seed disperser. Therefore, the relation between seed predator/seed disperser seemed to be correlated directly with the relation greener fruit/yellowish fruit, respectively, in the case of fruit with this chromatic spectrum, like those of *Talisia retusa*.

Hypothetically, an association could exist among the green/yellow color and unripe/ripe relation – and the astringency (GOLDSTEIN & SWAIN, 1963; LASKA, 1999; SIMMEN et al., 1999) –, with fruits chemicals compounds like tannins, which are determinants of the fruits pigmentation (for discussion see CHICHESTER & MCFEETERS, 1971; GOLDSTEIN & SWAIN, 1963; and specially WILLSON & WHELAN, 1990: 791). There are no data on the tannins concentration of *Talisia retusa* fruits, but probably it could be like other Neotropical woody plants with differences in tannins concentration between the fruit flesh and the seed during the fruit maturation periods, externally reflected in *Talisia retusa*, with the color spectrum from green to yellow. This hypothesis on fruit color-tannin concentration relationship could support the independent evidence that Pitheciinae in general, and *Pithecia pithecia* particularly, avoid seeds with extreme high concentration of tannins, tolerating moderated seed tannins levels (KINZEY & NORCONK, 1993). The green/yellow color selection, as in our case, could probably be linked with a differential acquisition of some of these chemical components by *Pithecia pithecia* (KINZEY & NORCONK, 1993; NORCONK et al., 1998) and *Alouatta seniculus* respectively.

Finally, we hope that this report can stimulate new field studies looking towards new approaches for the understanding of color as a criterion for food selection among primates.

Acknowledgments. To the members of the Departamento de Estudios Básicos of EDELCA-Guri, and particularly to LUIS BALBAS for their cooperation. To TERRENCE GLEASON, BRIAN GRAFTON, JASON BRUSH, and GERARDO AYMARD for their comments and support in the field, and MAILÉN RIVEROS for her advice. To ENID A. ALLEN, MUNSELL® Visual Products Specialist for the assistance, and CARLOS QUINTERO for the final draft of the Figure 1. And especially to MARILYN NORCONK for her confidence, support and constructive comments on the manuscript. Thanks to the three anonymous reviewers for their stimulating and constructive suggestions. This work was funded by a National Science Foundation Grant SBR 98-07516 to M. NORCONK.

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—— Received: *June 4, 2000*; Accepted: *February 5, 2002*

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