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Contexts of Positional Behavior in Captive *Cebuella pygmaea*

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Introduction

Feeding is a critical factor that influences an organism's survival and ability to eventually reproduce, and this includes all sexually reproducing organisms including humans. How an organism moves to acquire food is a significant aspect of feeding behavior. Paul Garber (1992) examined the behavioral and morphological adaptations of feeding and ecology within the family *Callitrichidae*. Claw like nails represent the basal morphological adaptation from which four large-branch feeding patterns are characterized and expressed (Garber 1992). These are the four representative large-branch foraging patterns: seasonal gum/sap consumption and occasional trunk foraging, bark dwelling insect consumption and the use of vertical trunks as scanning platforms, manipulative foraging and bark stripping, and lastly, tree-gouging and year-round exudativory. *Cebuella pygmaea* is characterized by tree gouging and year round exudativory. The available research has developed a clear relationship between the positional behavior of *Cebuella pygmaea* and year round exudativory (Kinzey et al. 1975; Coimbra-Filho, Mittermeier 1976: 1978; Moynihan 1976; Ramirez et al. 1978; Garber 1992; Youlatos 1999; Youlatos In Press).

Vertical clinging and leaping were once considered as a single complex, but the earliest field observations (Kinzey et al. 1975) revealed that *Cebuella* had a highly advanced, claw clinging postural adaptation that is separate from the vertical leaping adaptation. This astute observation has since been recognized and understood through subsequent research projects that deal specifically with the positional behavioral repertoire of the *Callitrichidae* (Garber 1992), *Saguinus midas midas* (Youlatos 1995), and *Cebuella* (Youlatos 1999). Much of this previous research has been aimed at the

various contexts within which positional behaviors occur such as: the relationship of support size and support orientation to postural and locomotor choices (Kinzey et al. 1975), year round tree gouging and the elicitation of exudates and gums (Garber 1992), and exudativory and traveling (Youlatos 1999; Youlatos In Press).

The aims of this study are to understand whether or not the relationship between feeding, foraging, traveling, and positional behavior are similarly expressed in captivity as compared to the wild, and whether or not there is a relationship between positional behavior and the contexts of agonistic behavior and vocalizations.

Materials and Methods

The data was collected at the St. Louis Zoo, on a small group of two individual pygmy marmosets. Ricky is an 8-year-old male, and Polly is an 11-year-old female. They were housed with two other species, which included five *Pithecia pithecia* (three females and two males) and two *Leontopithecus chrysomelas*. Data collection occurred from May to September 2005 at the St. Louis Zoo.

The enclosure itself was separated vertically by an elevated rock shelf into a bottom portion that was tall enough for an average human and a larger top portion. Due to the small size of *Cebuella*, Polly and Ricky could hide from view when they were on top of the flat rock shelf. Polly and Ricky also had the opportunity to leave the display area of the enclosure. During times where enrichment items were present, such as the tire swing or the burlap hammock, Polly and Ricky had the opportunity to leave the observer's field of vision by walking inside the tire or crawling under the fabric of the hammock.

For this study, data on positional behavior was collected using two minute, focal animal sampling. Youlatos (1999) collected data on these positional behaviors: quadrupedal walking and bounding, vertical leaping, quadrupedal standing and cantilever, and scansorial/vertical clinging. All of the data collected by Youlatos (1999) was analyzed in context with support size and where the individual was located during specific positional behavioral contexts such as: traveling, foraging, and feeding (“claws up” versus “claws down”). For this current study, positional behaviors were differentiated from locomotor behaviors.

In order to understand positional behavior in additional contexts, additional categories were utilized, including: hind limb dominated claw clinging and branching. Scansorial was separated from vertical clinging.

1. Activity:

All of the following descriptions are collected and described according to Bergeson (1996) with the exception of the description of vocalizations.

- a. **Allogroom**: The focal animal was grooming another animal (*Ibid*: 51).
Autogroom: The focal animal was grooming itself (*Ibid*: 51).
- b. **Feed**: The focal animal was holding or processing a food item (*Ibid*: 51).
- c. **Forage**: The focal animal was actively searching for food (*Ibid*: 51).
- d. **Rest**: The focal animal had stopped for an extended period of time (*Ibid*: 51).
- e. **Social Interaction**: The focal animal was interacting with another animal exclusive of grooming or copulating (*Ibid*: 52).

- f. **Travel**: The focal animal moved throughout space without feeding or foraging; the sole function of travel was spatial displacement (*Ibid*: 52)

2. **Substrate Size:**

Garber and Leigh's (*Ibid*. 18) descriptions of substrate size will be utilized in the current study, and they are as the following – small (less than or equal to 5 cm.), medium (6-10 cm.), and large (greater than 10 cm.).

3. **Substrate Angle**

Substrate orientation is described and is collected following Garber and Leigh's (2001: 18) descriptions – horizontal (0° - 15°), oblique (16° - 74°), vertical (75° - 90°), or terminal (masses of thin flexible supports).

4. **Postural Behaviors:**

Postural behaviors were recognized as any event in which the focal animal refrained from traveling activities. The following categories of postural behaviors were modified from Fleagle and Mittermeier (1980): grasp; Bergeson (1996): lay, orthograde lay back, quadrupedal stand, and sit; and Garber and Leigh (2001): cling. Here are the researcher's descriptions of the above categories of postural behaviors.

- a. **Grasp**: A postural behavior in which the hands or feet are clutched around the substrate; not to be confused with claw clinging – the fingers are fully wrapped around the substrate.

- b. **Lay**: “Reclined on a relatively horizontal support with the body weight borne by the back, side or stomach (Bergeson: 1996: 53)”
- c. **Orthograde Lay Back**: “The animal [is] orthograde and leaning back on a vertical or highly oblique branch; its arms [are] flexed, wrapped around the branch, and under tension, and its legs [are] under compression (Ibid: 1996: 53)
- d. **Quadrupedal Stand**: “Posture on three or four limbs, typically on a relatively horizontal branch or branches. Trunk was pronograde, and all limbs [are] under compression (Ibid: 1996: 53).”
- e. **Sit**: “Posture in which the weight was supported by the ischia...legs were flexed, and arms supported little or no weight (Ibid: 1996: 53).”
- f. **Cling**: Posture in which claws are embedded into the bark and the body is supported in any surface of the substrate (Garber and Leigh: 2001; 19).
- g. **Hind limb**: a type of posture in which the hind limb claws are used to support the weight of the individual; this is utilized when reaching across relatively short, discontinuous gaps.

5. Locomotor Behaviors:

Here are the following categories of locomotor behaviors that were modified from the literature: Fleagle and Mittermeier (1980): climb, and Garber and Leigh (2001): quadrupedal walking, quadrupedal running, bounding, scansorial, and leap. Here are the descriptions of the researcher’s categories used in this study:

- a. **Climb**: A locomotor behavior in which the focal animal utilizes both hands and feet to propel the body upwards against gravity.
- b. **Quadrupedal Walking**: “Slow pronograde movement using a diagonal-sequence/diagonal couplet- gait” (Garber and Leigh: 2001; 19).
- c. **Quadrupedal Running**: “A rapid form of diagonal-sequence/diagonal-couplet pronograde travel that does not include an in air phase stride” (Ibid: 19).
- d. **Bounding**: “High speed, hind limb dominated, asymmetrical pronograde travel” (Ibid: 19).
- e. **Scansorial**: “A form of positional behavior in which *Saguinus* and *Callimico* embed their claw-like nails directly into the arboreal support” (Ibid: 19). It must also be noted that the researcher will add that *Cebuella* utilizes this locomotor behavior with pronograde movement and the body pressed close to the support. This has been seen when *Cebuella* stalks insect prey.
- f. **Leap**: “A form of salutatory locomotion characterized by a relatively long in air phase of stride which is used to cross between discontinuous supports” (Ibid: 19).

6. **Vocalization:**

Vocalizations of *Cebuella pygmaea* were recorded in a captive setting that was enclosed behind a glass wall, so the data collection of vocalizations were defined as events in which the mouth is opened with the exception of any event in which the mouth

was closed or any of the following events – allogrooming, autogrooming, feeding, or tonguing. Vocalization is recorded as Yes / No.

7. Agonistic Behavior:

An agonistic behavior is an aggressive behavior directed at an inter-/intra- specific other, usually at the expense of the recipient. Some examples include: taking food from another individual, biting, usurping space, and genital displays. For this study, these agonistic behaviors were examined. The following categories were integrated into the data collection procedure:

- a. **Assertion:** agent directs behavior towards another.
- b. **Submission:** recipient receives directed agonistic behavior and does nothing.
- c. **Retaliation:** recipient receives directed agonistic behavior and does something.
- d. **Avoidance:** recipient tries to leave the presence of the agent.
- e. **Trailing:** agent follows the recipient.
- f. **Attack:** bite, push, nip, or scratch.

8. Analysis:

From these data, time budgets were constructed. These will be compared with the positional behavior of wild *Cebuella pygmaea* (Youlatos 1999; Youlatos In Press), *Callimico goeldii*, *Saguinus labiatus*, and *Saguinus fuscicollis* (Garber and Leigh 2001). The vocalization data will be compared with the vocalizations of wild *Cebuella pygmaea* (De la Torre and Snowdon 2000; 2002).

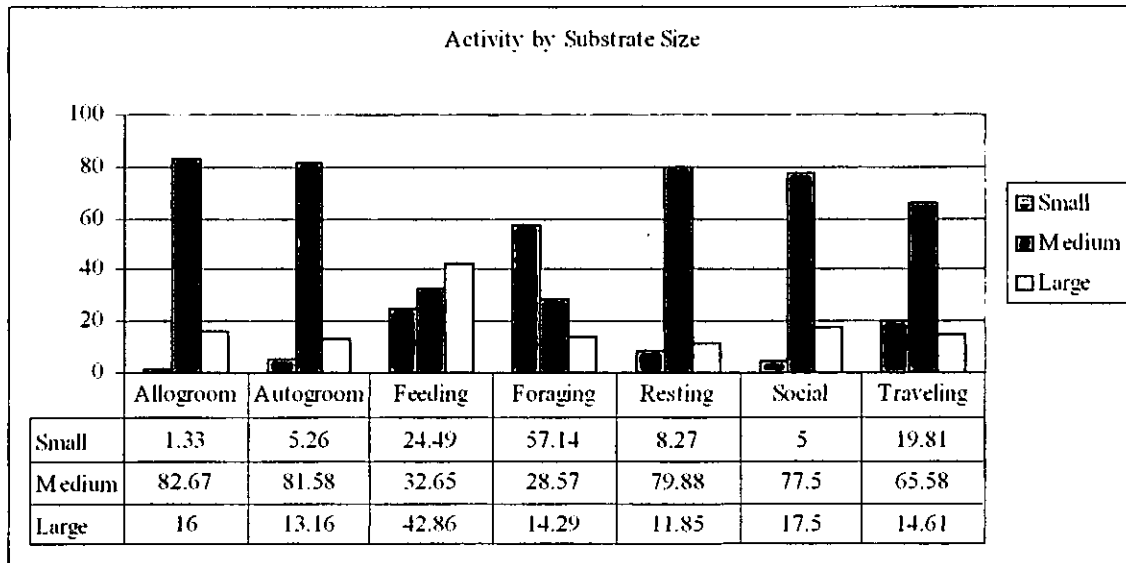
Results

Budget of Activity

The rank order of activity was organized according to both individual frequencies and frequencies of both individuals combined together. When combined together, the rank order of activities was as follows – resting (76.78%), traveling (10.22%), autogrooming (5.03%), feeding (3.24%), allogrooming (2.48%), social (1.32%), and foraging (0.92%).

When combined based on individual differences, the rank order of activity for Polly was as follows – resting (73.65%), traveling (12.01%), autogrooming (5.76%), feeding (4.08%), social (1.80%), allogrooming (1.56%), and foraging (1.14%). The rank order of activity for Ricky was as follows – resting (80.62%), traveling (8.03%), autogrooming (4.13%), allogrooming (3.61%), feeding (2.21%), social (0.74%), and foraging (0.66%).

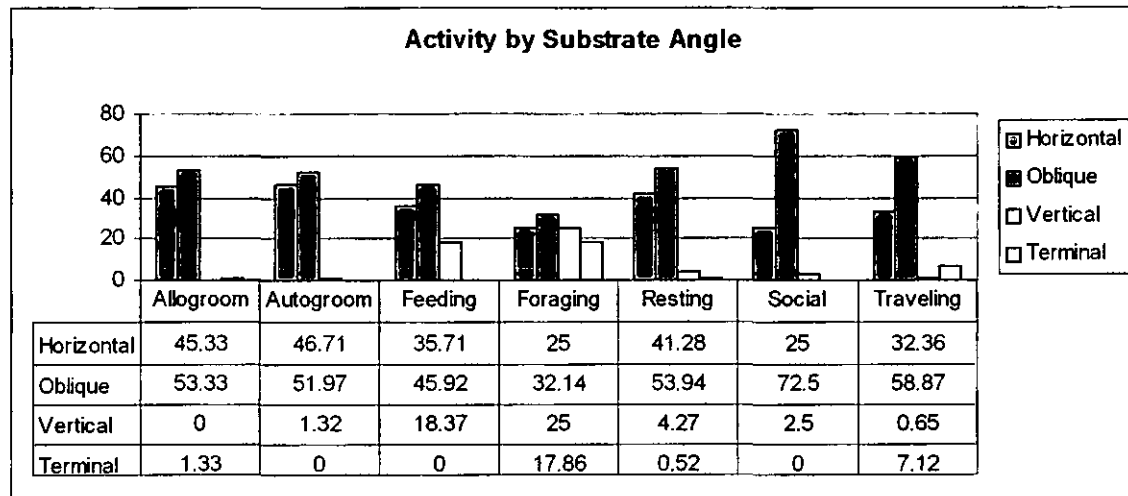
Activity and Substrate Size



The analysis of activity compared against substrate size revealed a preference for medium substrates – allogroom (82.67%), autogroom (81.58%), resting (79.88%), social

(77.50%), and travel (65.58%). Feeding (42.86%) occurred the most on large substrates, while foraging (57.14%) occurred the most on small substrates.

Activity Compared to Substrate Angle

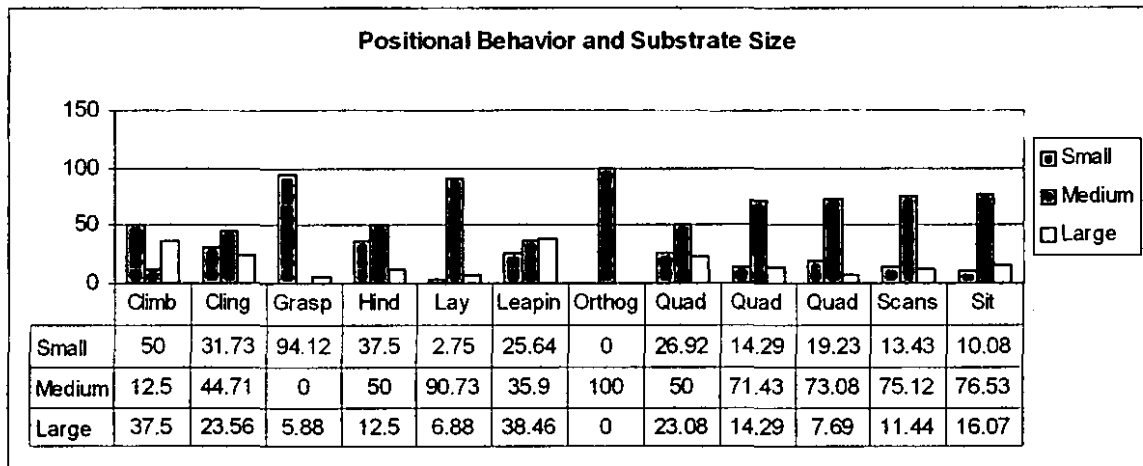


The analysis of activity compared against substrate size illustrated the primary and secondary preference for oblique then horizontal substrates: feeding (oblique = 45.92%; horizontal = 35.71%), resting (oblique = 53.94%; horizontal = 41.28%), social (oblique = 72.5%; horizontal = 25%), allogroom (oblique = 53.33%; horizontal = 45.33%), autogroom (oblique = 51.79%; horizontal = 46.71%), and traveling (oblique = 59.87%; horizontal = 32.36%). Foraging showed a primary preference for oblique substrates (32.14%) and a secondary preference for both horizontal and terminal substrates (25%).

Positional Behavior and Substrate Size

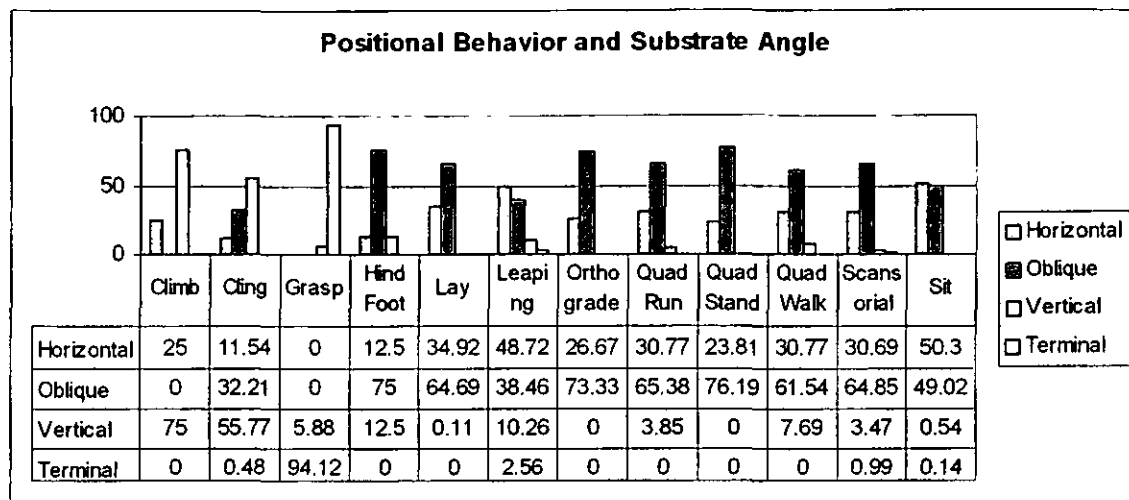
When comparing positional behavior in occurrence with substrate size, the analysis revealed a preference for positional behaviors on medium substrates – cling (44.71%),

hind foot cling (50%), lay (90.37%), orthograde lay (100%), quadrupedal run (50%), quadrupedal stand (71.43%), quadrupedal walk (73.08%), scansorial (75.12%), and sit (75.15%). Climb (50%), grasp (94.12%), and leap (38.46%) occurred most frequently on small substrates. There were no records of any positional behavior occurring the most on large substrates.



Positional Behavior Compared to Substrate Angles

When comparing positional behavior against substrate angles, the data revealed a preference for oblique substrates – hind foot cling (75%), lay (64.97%), orthograde lay (73.33%), quadrupedal run (65.38%), quadrupedal stand (76.19%), quadrupedal walk (61.54%), and scansorial (64.85%). Climb (75%) and cling (55.77%) occurred the most on vertical substrates; leap (48.72%) and sit (50.30%) occurred the most on horizontal substrates. Grasp (94.12%) was the only positional category that occurred the most on terminal substrates.



Vocalization

An analysis of vocalizations compared between Polly and Ricky showed that while vocalizations were extremely rare, Polly (1.27%) vocalized more frequently than Ricky (0.25%). The analysis of vocalizations compared to total time spent alone, together and out of sight was not validated by the Chi-Square analysis ($P=0.2812$). Vocalizations analyzed by positional types did not reveal significant results either ($P=0.8926$). When compared to positional behavior, vocalizations were not significant ($P=0.4547$). The analysis of vocalizations to activity did show any significance ($P=0.1897$).

Agonistic Behavior

These analyses did not reveal any significant relationships - agonistic behavior compared to animal ($P=0.1915$), agonistic behavior compared to positional behavior ($P=0.2559$), vocalization compared to agonistic behavior ($P=0.1318$), and agonistic behavior compared to alone, together and out of sight time ($P=0.1604$). On the other hand, agonistic behavior compared to activity did not show a significant relationship

($P=0.0255$). Assertion was only recorded once during foraging and once during social. Avoidance was recorded six times, and resting was recorded four times during travel. The “none” category is the most significant statistic within this analysis. A lack of agonistic behavior represented 99.60% of the total time.

Discussion

Activity Budget

Both Polly and Ricky showed high frequencies of resting, but Ricky showed higher frequencies of resting when compared to Polly. Ricky showed second rank traveling and third rank allogrooming; Polly showed second rank traveling and third rank feeding. This relationship showed that Ricky spent more of his time resting and allogrooming, while Polly spent her third rank activity feeding. This might be a sex-biased difference in allogrooming and feeding, but these conclusions cannot be addressed until the sample size has exceeded at least two pairs.

Both Polly and Ricky showed foraging as the least accounted activity. From the available literature, foraging and feeding should account for more of the budget, but since feeding requires absolutely no preparation time in captive display, there should be an expected decrease in foraging and the procurement of food items.

Youlatos (1999) reported that the evolutionary adaptations of *Cebuella pygmaea* may be the result of the ecological and dietary selective forces of exudativory, and his data indicated higher frequencies of feeding and foraging activities in wild *Cebuella pygmaea*. In contrast, captive *Cebuella pygmaea* showed very low frequencies of feeding and foraging activities with an inordinate amount of resting, plus autogrooming as the second

rank order activity. There is direct relationship between the increased frequencies of resting and the reduced frequencies of all other activities due to the absence of the need to procure and maintain active feeding sites.

The evidence from this study indicated the centrality of exudativory and large vertical substrates in determining the higher frequencies of feeding and foraging activities in wild studies. The differences in substrate size and orientation between wild and captive studies showed that in captive studies, *Cebuella pygmaea* utilize fewer large vertical substrates because there are fewer total possible large vertical substrates within the enclosure. With less time needed and devoted to feeding and foraging, *Cebuella pygmaea* engaged in a large frequency of resting activities.

Substrate Size

Garber and Leigh (2001) gave a detailed report on the mixed-species troops of *Callimico goeldii*, *Saguinus labiatus*, and *Saguinus fuscicollis*, and they reported that *C. goeldii* and *S. fuscicollis* showed a higher frequency of medium substrate usage, while *S. labiatus* showed a higher frequency of large substrate usage. When comparing travel as the factor and substrate size and as the response, the results for *Cebuella pygmaea* showed medium substrates occupying 65.58% and large substrates occupying 14.61% of the total counts (N=3022). The preference for medium substrates compared with *Callimico goeldii* – the species showing the largest frequency of medium substrate use, and the low occurrence of large substrates compared with *Saguinus fuscicollis* – the species showing the smallest frequency of large substrates usage.

Garber and Leigh (2001) showed the differences between these three mixed-species with regard to small branches and terminal supports; *S. fuscicollis* showed higher frequencies of small branch usage than *Callimico goeldii*. When comparing travel as a factor and substrate size as the response, the results showed small substrates occupying 19.81% of the time and terminal branches occupying 7.12% of the time. This data is comparable to the data of *S. labiatus*, *S. fuscicollis*, and *Callimico goeldii* in that all three of the species along with *Cebuella pygmaea* display small substrate sizes in higher frequencies than terminal substrates. *S. fuscicollis* and *S. labiatus* show higher frequencies compared to *Cebuella pygmaea*, while *C. pygmaea* and *C. goeldii* have more similar frequencies with regard to small substrate usage.

With regard to support size preference, Youlatos (In Press) showed that *Cebuella* prefers large supports and used supports less than 2cm significantly less than large supports. When analyzing the distribution of support size, the results showed a preference of supports that are 6-10 cm (76.54%). Supports less than 2 cm were not calculated due to differences in substrate size categories, but the preference of supports less than 5 cm occupied 10.06% of the total counts. When comparing the total percentages of Youlatos (In Press) and the data of this current study, wild *Cebuella pygmaea* preferred substrates that were less than 2cm, but the data of this study showed that captive *C. pygmaea* preferred substrates that were 5 – 10 cm.

Youlatos (1999) gave the support size preference within a traveling context, and the records showed over half of all occurrences of traveling happened on substrates that were less than 5cm. When comparing substrate activity as a factor and substrate size as a response, 19.81% of all traveling instances were on supports less than 5cm while 65.58%

of travel occurred on medium substrates. The low occurrence of traveling on small substrates as compared to wild *Cebuella* is due to the lower occurrence of liana substrates in captivity as compared to the high occurrence of lianas in the liana forest where they live.

Youlatos (1999) combined his quadrupedal walk and bound into one category, and he demonstrated that these locomotor behaviors occurred mostly on supports less than 5cm. When comparing positional behavior by substrate size, the data showed quadrupedal walk occurring mostly on medium substrates, but quadrupedal walk only accounted for 0.87% of the total positional data. Travel on small substrates only occurred 19.23% of the total percentage, and this significantly differed from Youlatos (1999) in that quadrupedal walking occurred mostly on substrates less than 5cm. This is also related to the habitat differences between a liana forest and a captive display room.

Youlatos (1999) gave an account of scansorial locomotion occurring mostly on substrates larger than 10cm. For this study, scansorial locomotion occurred more frequently on medium supports (75.12%, scansorial sample $n = 201$). The high prevalence of scansorial locomotion in the wild is due to the habitat utilization and dietary specialization of *Cebuella pygmaea*, but in captivity, there was not a central large vertical substrate and a high prevalence of large substrates that were of horizontal orientation.

Substrate Angle

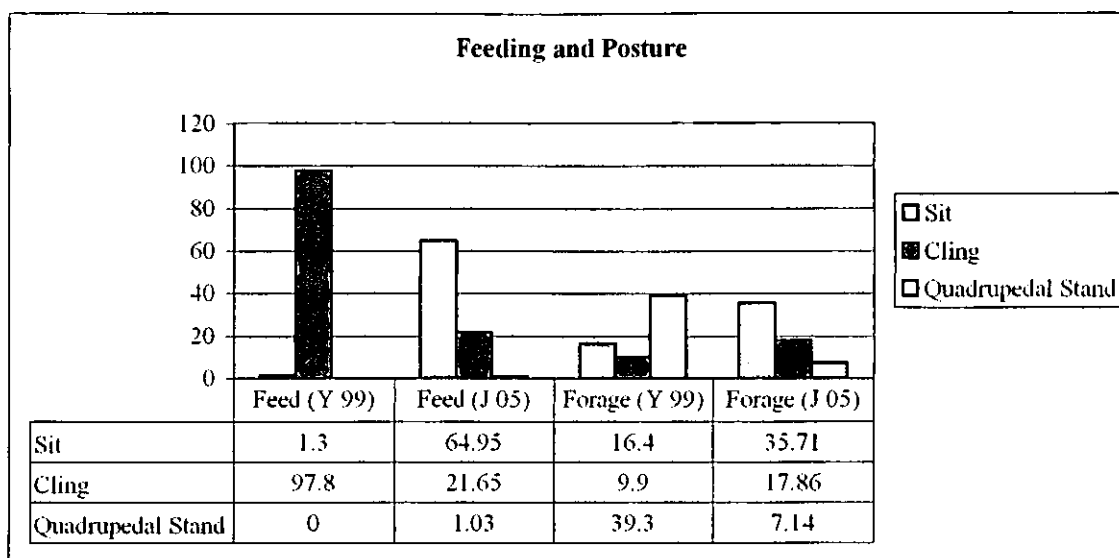
Youlatos (1999) showed that *Cebuella* utilized oblique and vertical supports in a good portion of the total sample. For this study, oblique supports (54.02%) represented more

than half of all substrate angles with vertical supports representing only (4.8%). This data shared similarities with oblique supports reported in Youlatos (1999), but this data showed a difference between the frequencies for oblique and vertical supports with horizontal supports in this captive study representing 40.32% of the total frequency of substrate angles.

Youlatos (1999) recorded travel occurring mostly on vertical supports and least for oblique supports. Foraging samples showed traveling occurring mostly on horizontal supports and least on vertical supports. Feeding samples showed the dominance in vertical supports in feeding behaviors. For this study, travel occurred 32.36% on horizontal substrates, 59.87% on oblique substrates, and 7.2% on vertical supports. Foraging occurred so rarely that it was not a significant count ($n = 28$). During feeding, 18.37% occurred on vertical substrates, 45.92% occurred on oblique substrates, and 35.71% on horizontal substrates.

Garber and Leigh (2001) gave accounts of take-off and landing substrate orientation for *Callimico goeldii* and *Saguinus labiatus*, and they showed that *S. labiatus* used oblique substrates and terminal branches as take-off and landing platforms. When analyzing positional behavior as the factor and substrate angle as the response, the results show leaping from vertical platforms occurred 10.26% of the time with 38.6% of takeoff positions occurred on oblique substrates. There was no data collected on the landing platforms of these leaps, but the substrate orientation from which leaping occurred was recorded. When these figures of take-off platforms are compared to *Callimico*, *Cebuella* showed significantly less leaping behavior overall; when compared to *S. labiatus*, *Cebuella* showed a similarity in frequencies of the oblique take-off position.

Positional Behavior – Feeding



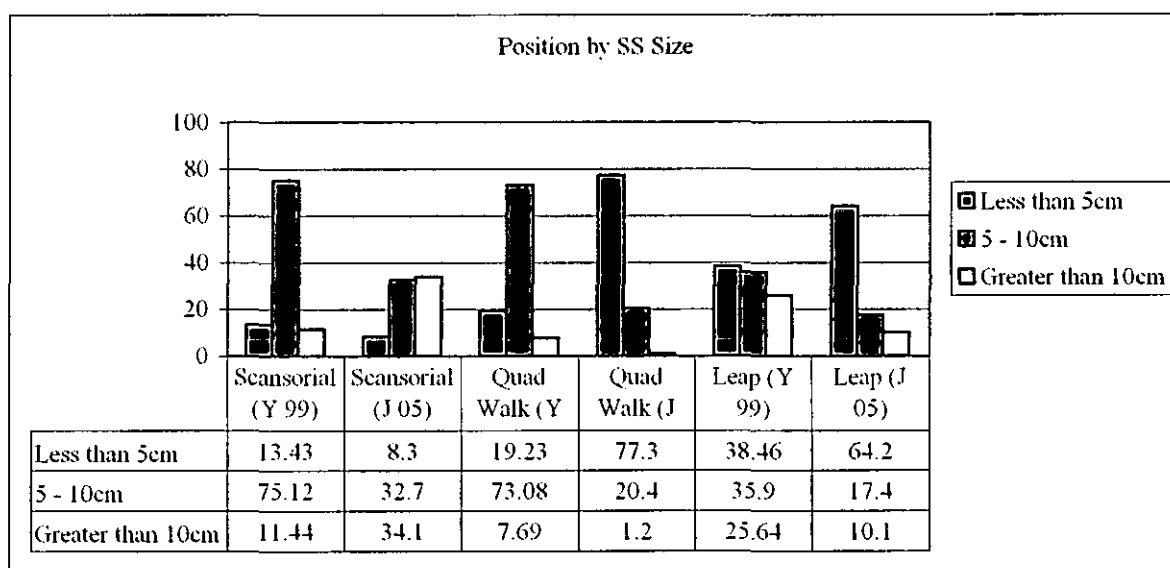
Youlatos (1999; In Press) and Garber (1992) reported that claw clinging and claw climbing are the dominant postural and locomotor behaviors associated with exudativory. The results from this study indicated reduced frequencies of claw clinging within a feeding context, and showed sitting as the dominant feeding and foraging posture. Again, this evidence is almost certainly related to the scarcity of large vertical supports suitable for claw clinging in the captive enclosure. This evidence further supports the importance of large vertical substrates within wild studies.

Positional Behavior – General

When comparing the data of this study with that of Youlatos (1999), he reported a majority of scansorial activity occurring on 5 – 10cm substrates, while the data of this study reported scansorial locomotion distributed mostly between 5 – 10cm and greater than 10cm. Youlatos (1999) also reported a majority of quadrupedal walking on substrates 5 – 10cm, while the data of this study reported quadrupedal walking mostly on

substrates less than 5cm. Youlatos reported a quite even distribution of leaping substrates, while the data of this study reported a majority of leaping on substrates less than 5cm.

Climb and grasp occurred mostly on small substrates while cling, hind foot cling, lay, orthograde lay back, quadrupedal run, quadrupedal stand and sit all occurred on medium substrates. This evidence suggested a preference for medium substrates under the condition that large vertical substrates and lianas are lacking in captivity. There were counts of grasping, and this occurred mostly on freshly placed bamboo rods.



Vocalizations

Polly and Ricky only displayed 22 counts of vocalization for the entire study period (N = 4749). What were the possible factors that led to a decreased probability of vocalizations? Research conducted by S. de la Torre et al. (2000) suggested wild pygmy marmosets that live in environments where eco-tourism are prevalent experienced low human impacts and vocalized more than those communities that experienced high human impact: "Groups subjected to high human impact emitted trills less frequently (*mean proportion of scans with trill* = 0.36 +/- 0.003) than groups with low human impact

(mean proportion of scans with trills = 0.53 +/- 0.001)" (S. de la Torre et al., 2000: 159).

S. de la Torre et al. (2000) is useful because it gives evidence of the effects of eco-tourism on native fauna, and this study is important here because this provides a wild study that is comparable to a captive situation.

For this study, Polly and Ricky had a probability of 0.0081 of vocalizing. This was an extremely low probability, and if interpreted in context with S. de la Torre et al. (2000), it was reasonable to attribute the low frequency of vocalization as a result of captive display. If this is true, then we should see a higher frequency of vocalizations within the off display portion of the enclosure or when the zoo is closed. (These were situations that could not be examined for this study) The conditions of captive display present Polly and Ricky with a condition that resembles an extremely high human eco-tourist impacted community in that Polly and Ricky are on display from 9 AM to 7 PM daily during the summer and 9 AM to 5 PM during the rest of the year.

The small size of the enclosure might be another possible factor for the low occurrence of vocalizations. Research by Torre and Snowden (2002) suggested that the Trill call, which is used primarily as a contact call to another individual that is not in close proximity, is only used when in the wild – "The distance between the calling animal and a nearest observed receiver was less than 5m in 52% of the Trills (N=360 Trills), between 6 and 10m in 43% of the Trills, and between 11 and 15m in only 5% of the Trills" (Ibid. 853). Based on this data, the low occurrence of vocalizations may result from a lowered need to identify another individual within such small space. The research of Torre and Snowden (2002) showed that normal vocal range of the Trill call did not exceed fifteen meters, and this established the Trill call as a close range call.

Evidence presented by Snowdon and Elowson (1999) suggested that wild pygmy marmosets utilized the Trill call as intra-group communication, and they concluded that “To be able to call in sequence or to be able to recognize which individuals are in proximity during foraging, a pygmy marmoset must be able to recognize the trills of each of their own group members” (Ibid. 609). Polly and Ricky’s captive setting presented a social situation in which there were not enough individuals to engage in a sequence of vocalizations, and the proximity of individuals during foraging was rather close. The frequency of vocalizations in this study might be attributed to the lack of inter-group interaction and the frequency with which the two marmosets were already in close contact.

Agonistic Behavior

There are no other comparable studies to interpret and analyze this study’s data on agonistic behaviors. The agonistic categories proved ineffective in recording agonistic encounters and required more specific categories. Genital displays, urination, tail flickering, clawing, and vocalizations might prove to be useful categories to record agonistic behaviors in future studies.

Conclusions

- 1) Unusually high frequencies of resting suggest a diminished need to maintain active feeding sites within captivity.
- 2) Without large vertical supports to feed from, captive *Cebuella pygmaea* utilize more sitting postures rather than clinging postures when feeding.

- 3) *Cebuella pygmaea* is more similar to *Callimico goeldii* than *Saguinus labiatus* and *Saguinus fuscicollis* in substrate preferences.
- 4) The conditions of captive display parallels the effects of eco-tourist impact areas in wild studies, and this is reflected in the extremely low frequencies of vocalizations.
- 5) Agonistic behaviors require more specific categories to adequately record agonistic events.

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