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Behavioural instability as an indicator of personality within captive populations of Rothschild Giraffes

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Abstract
The novel concept of behavioural instability has proven suitable for studying the behavior and personality in zoo animals. Individual personality has an impact on how the zoo best perform environmental enrichment, and behavioural diversity of captive populations intended to potentially repopulate wild habitats. This study aims to prove the presence of recognizable personalities in Rothschild giraffes (Giraffa camelopardalis rothschildi), as well as to investigate whether visitor numbers affect the behavioural expressions in this species. Six giraffes (bot young and adults) were filmed in Aalborg Zoo, and the recordings were subsequently analysed. The procured data was then analysed using a series of tests primarily focusing on behavioural reaction norms. The results shows that distinct personalities exist within the groups of Rothschild giraffes. However, the number of visitors exhibited no statistical significance upon the behaviour of the individuals. It can thereby be concluded that specimens of Rothschild giraffes possess unique personality traits which are worth defining in order to ensure behavioural diversity.
Keywords: Giraffa camelopardalis rothschildi, Ethogram, behavioural diversity, behavioural instability, captivity, zoo

Introduction

Zoo administrations and zookeepers are always looking for better ways to optimize animal welfare. Sometimes it can be troublesome to see whether or not the animals are thriving, therefore it's important to measure their welfare in different ways (Miller et al. 2020; Melfi 2009). In the past, in the zoological world, the assumption was that as long as negative behaviours were absent and the five freedoms were fulfilled, the animals were considered to have an acceptable level of welfare (Miller et al. 2020; Melfi 2009). The five freedoms are: 1. Freedom from Hunger and Thirst. 2. Freedom from Discomfort. 3. Freedom from Pain, Injury or Disease. 4. Freedom to Express Normal Behaviour. 5. Freedom from Fear and Distress (Council n.d.). In order to do more than just meet the animal's basic needs, five "Opportunities" have been constructed to make the animals' well-being more probable [Miller et al. 2020]. The opportunities are 1. Opportunity for a thoughtfully presented, well-balanced diet. 2. Opportunity to self-maintain. 3. Opportunity for optimal health. 4. Opportunity to express species-specific behaviour. 5. Opportunity for choice and control (Miller et al. 2020).

Negative and stereotypical behaviours are clear signs of poor well-being. Examples of negative behaviour are self-harm or deviations from "wild type" behaviour [Melfi 2009]. Stereotypical behaviour is defined as many invariant repetitive movements without any actual purpose e.g. tongue play, object licking, mane biting, vacuum chewing, or pacing [Seeber, Ciofolo, and Ganswindt 2012]. Stereotypy appears to be only somewhat affected by external stimuli and will often develop as a response to an insoluble problem (Mason 1991). However, not all stereotypy stems from environmental factors, as some also can be the result of mental instability or brain damage (Mason 1991).

The fact that negative and stereotypical behaviour is not noticeable is not necessarily an indication that the animals are thriving. Whether the implementation of newer methods can measure the welfare of the individuals by looking at the behavioural diversity and instability is being investigated (Gottschalk et al. 2020; Linder et al. 2020; Miller et al. 2020; Pertoldi et al. 2016, 2020a,b).

Behavioural diversity is a recently defined concept being used as a tool in investigating animal welfare. Studies have found that behavioural diversity is often higher when following animal practices thought to increase welfare, including habitat complexity, appropriate social grouping, and animal training [Miller et al. 2020]. Diversity indices, such as Shannon's or Simpson's, which are conservatively used to estimate biodiversity, can also be implemented in order to estimate behavioural diversity. Miller et al. (2020) has collected several studies that show a connection between stereotypical behaviour and behavioural diversity. When the former increases, the latter decreases.

Behavioural instability is an expression of the predictability and variation of behaviours displayed amongst individuals of a population (Pertoldi et al. 2016). Calculating behavioural instability is done by applying the approaches utilised in investigating developmental instability on behavioural data [Pertoldi et al. 2016]. Utilising these methods, the individuals' behavioural reaction norms can be calculated, which are defined as the set of behavioural phenotypes that a single genotype produces in a given set of environments [Linder et al. 2020]. This can be conducted by plotting the medians of each behaviour exhibited by each individual at the different periods of observation and drawing a trend line between them from which a slope can be calculated. Afterwards, the significant differences are determined. This procedure is repeated for the skewness, kurtosis, and standard deviation. Using the results gathered through these methods, aspects of the personality of the individuals can be defined, as the slopes portray the individuals' behavioural reaction norms (Linder et al. 2020; Pertoldi et al. 2016).

Most zoos participate in breeding programs such as EAZA Ex Situ Programmes (EEP) where the goal is to conserve endangered species whilst maintaining a healthy gene pool, ensuring the possibility of re-introduction to the wild. By conserving both genetic and behavioural diversity, one secures better candidates for conservation (Melfi 2009; EAZA n.d.).

The aim of this study was to examine personality differences in Rothschild's giraffes (Giraffa camelopardalis rothschildi), and analyse behavioural instabilities using reaction norms. Additionally, we wish to investigate if changes in visitor numbers entails shift in behavioural patterns.

Methods

Subjects

The behaviour of six G. camelopardalis rothschildi was studied at Aalborg Zoo in Denmark.

The oldest individual, Caroline, 18 years is the mother of Qolile, 1 year and two months. The father Basse, six years, is also father for Dumisani, five months, and Karim, two years.

The mother of Dumisani and Karim is Frida, six years. All individuals were born in Aalborg Zoo, with the exception of Basse who was born at Zoologischer Garten Magdeburg in Germany.

Enclosure

The study was performed at Aalborg Zoo (Aalborg, Denmark). The outdoor enclosure (about 13,000 m2) was built as an artificial savannah in which five different animal species roam throughout the day.

It has a small watering hole, a large tree surrounded by rocks, and another smaller tree from which hay gets hung. Sometimes, a few branches get tied to the tree for additional nutrition and stimulation.

The indoor enclosure (146 m2) was enriched with two hay racks hang from the roof (one inside the smaller pen and one outside). New branches get tied up daily, whenever possible, in each side of the room. In the smaller pen, there's one plastic trough hanging on the bars of the enclosure, in which concentrates get placed. The larger enclosure has six of these plastic troughs. A drinking fountain was placed inside the smaller pen, while another two are placed outside. A single giraf was single housed indoors.

Data collection

Data was collected from the encloser two periods: Control week (CW) from 19 to 22 October 2020 with a low number of visitors and a high visitor week (HVW) from 12 to 15 October 2020 with a higher number of visitors. The Danish autumn holiday week (AHW) spanning from the 12 to 15 October 2020 was utilised for this purpose (Appendix A).

The filming was performed close to 24 hours a day, mostly missing the walking period from the indoor enclosure to the savannah. Three action cameras (Kitvision Venture 4K) were positioned around the enclosure to cover most of the savannah, two on the newly built bridge and one in a nearby tree. The positioning of the cameras is illustrated in the appendix (Appendix B). For the indoor area, the zoo allowed access to their camera, which they use to observe pregnancies, special events like Christmas in Zoo and to see if a sudden change of behaviour was caused by something externally during the night.

Analysis

For the analysis of the different behaviours, a behavioural ethogram was constructed by first using the ethogram contrived by Seeber et al. (2012). After reviewing some of the video material, the ethogram was adapted to better suit the actually observed behaviours and purpose of the study (Table 2.1).

The video material in this study was reviewed by six operators, where everyone was assigned to one of the individuals. To ensure that everyone agreed upon the behaviours of the Rothschild giraffes, the operators were split into three groups of two. In these groups, they reviewed the behaviour of their own and the other's individual for one day. The noted data were then shared and a concordance test (>95%) was performed in order to ensure agreement amongst the operators. When all behaviours, apart from behaviours with a low number of total observations (<10) for each giraffe, correlated above 0.95, each operator could focus on their assigned individual for the rest of the review (Appendix G). The analysis' of the statistics were performed in the software PAST (ver. 4.03, 4 3 2 & 2.17c), www.socscistatistics.com, and Excel (Electronica et al. 2001).

Table 2.1: Behavioural ethogram based on the works of Seeber et al. (2012), with modifications to fit the aims of the investigation

Behaviour	Description
Broom	Any use of the broom including itching, touching, and licking
Eating	The giraffe consumes food in the shape of hay, grass, pellets, and bark.
Follow	The current behaviour of the giraffe is interrupted to follow another giraffe. It is clear which giraffe is following which.
Object licking	There is visible oral activity partaining to an object including mineral supplements.
Resting	The giraffe is laying down, either to relax or to sleep.
Scanning	The giraffe is standing still, moving its eyes and ears. The head is held high and it is attentive.
Sparring	The giraffe is swinging its head softly against another giraffe. The activity stops when a new, clear activity has begun.

Statistical tests

Statistical tests were performed to investigate the legitimacy and distribution of the data.

Cumulative frequency graphs (cml.) were made to monitor if data collection had been sufficient. They were made by using the "integral (running sum)" feature in PAST on the interval-data for each behaviour, and then dividing each with the number row as it is an ongoing average. When the data were processed, it was made into a graph and log(y) was added to reduce the effect of scaling of the variance with the mean (Appendix D) [Pertoldi, Faurby, and Reed 2014].

The pie charts were made to illustrate the time budget of the behaviours performed by the six individuals. The percentage of time allocated to each behaviour was calculated, where the unobserved seconds and "other" behaviours were designated as "not noted" (Appendix 3.1).

The difference between the medians was measured with Mann-Whitney (MWW), which was calculated using the PAST software, in which each behaviour for both weeks was compared (Table H.1).

Behavioural reaction norm graphs were made by calculating the median, kurtosis, skewness and standard deviation for each behaviour and each individual in CW and AHW. For each behaviour, the medians for the individuals and both time periods were plotted, along with a trend line from the median of AHW to the median of CW. Lastly, the slopes of the trend lines were calculated. The same procedure was repeated for kurtosis, skewness and standard deviation (Appendix 3.2).

The median (med) is the middle of the data set. The skewness (skew) describes how uneven a data set is distributed, positive values indicate that the behaviour is performed with few episodes occurring for longer periods, while negative values express that the behaviour is performed for shorter periods with few episodes. The kurtosis (kut) describes the distribution of the behaviour and predictability of the individual, a high value signifies that the behaviour occurs several times with similar time intervals and a low value means the time intervals are distributed throughout the defined time-span. The standard deviation (dev) describes the amount of variation in a data set. A low value expresses that the data tend to be close to the mean of the data set, while a high value illustrates that the data is spread out over a wider range.

Chi-squared ($\chi 2$) tests were performed on the slope of the reaction norms and on the time spent on each behaviour measured in seconds, to indicate whether or not the differences in behavioural reaction norms were significant. Yates corrections were applied to the tests for the reaction norms, to ensure the validity of the tests, as they only had two data-points.

Shannon’s and Simpson’s diversity indices were measured to indicate the diversity and distribution of the behaviours. Chi-squared tests was also applied to determine whether or not there was a significant difference. To calculate these numbers, the total amount of seconds used on each behaviour was put into PAST and the indices were calculated (Appendix J.1).

Histograms that show the distribution and skewness of the gathered numerical data were constructed. The area of each bin indicates the frequency of occurrences (Appendix E).

The boxplots show the median, the minimum and maximum value, and the quartiles of a dataset. The box of a boxplot contains half of the data, which is between the first quartile to the third quartile and is known as the interquartile range (IQR). The "whiskers" of the boxplot depict the rest of the data (Appendix F).

Results

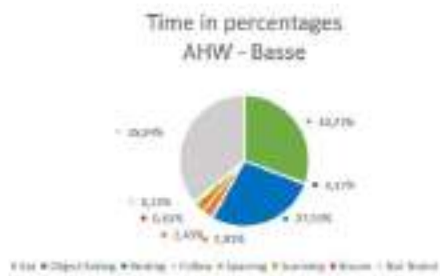
Cumulative graphs

The cumulative graphs indicate that most behaviours have enough data collected as the curves have flattened (Appendix D).

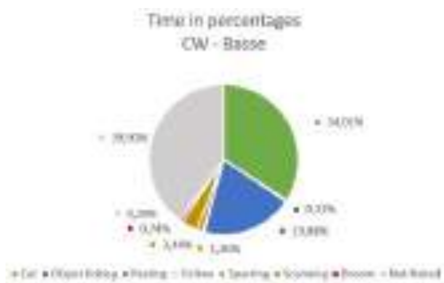
Pie chart

Comparing individual time budgets between weeks

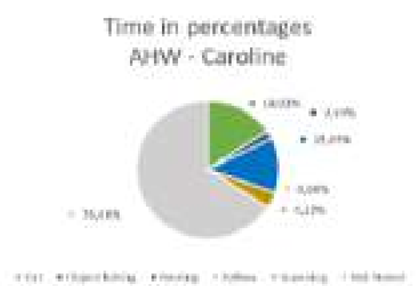
When looking at the time budgets for the individuals, one of the six individuals displays a significant difference ($\chi 2$ $p<0.05$) for the time in percentages in the category "not noted", from AHW to CW (Appendix I.1). No other significant differences in any other behaviour were found, when comparing time budgets between the observation periods (Fig. 1.1-6a-b).



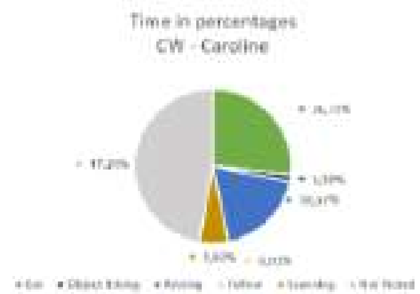
1a



1b



2a

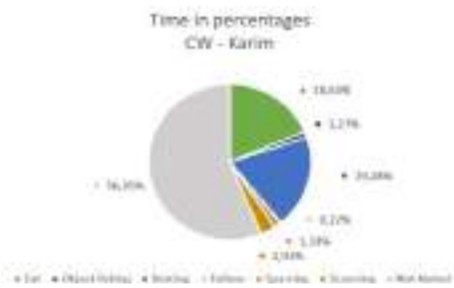


2b

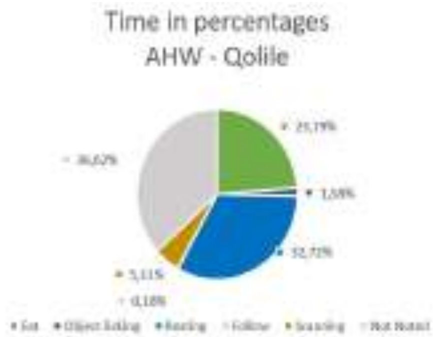
3a

3b

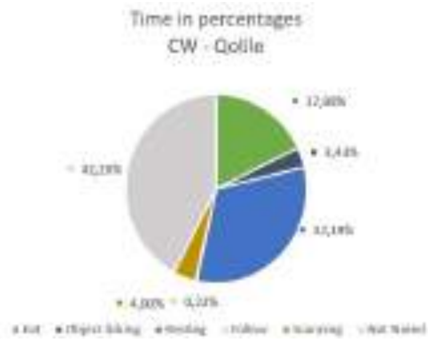
4a



4b

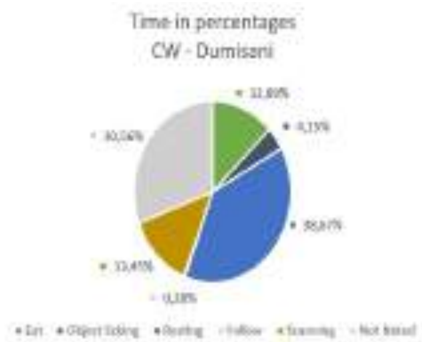


5a



5b

6a



6b

Figure 1.1-6(a-b): Percentages of time spent in seconds for the six individuals 1) Basse. 2) Caroline. 3) Frida. 4) Karim. 5) Qolile. 6) Dumisani for the two weeks a) Autumn holiday week. b) Control week. The colours indicate the different behaviors Green) Eat. Dark blue) Object licking. Blue) Resting. Light pink) Following. Orange) Sparring. Dark yellow) Scanning. Red) Broom.

Comparing individuals' time budgets

Eat The only significant difference ($\chi 2$ $p<0.05$) found was between two individuals in the time budgets of AHW (Appendix I.9). In CW there is significant difference ($\chi 2$ $p<0.05$) between 6 out of 15 chi-squared tests of the time budgets (Appendix I.2).

Object licking No significant difference was found between any individuals for the time budgets during both CW and AHW (Appendix I.3 & I.10).

Resting 6 out of 15 chi-squared tests show a significant difference ($\chi 2$ $p<0.05$) in AHW and only 3 out of 15 show a difference for CW (Appendix I.4 & I.11).

Follow There's no significant difference ($\chi 2$ $p>0.05$) between any individuals for the time budgets during both AHW and CW (Appendix I.5 & I.12).

Sparring No significant difference ($\chi 2$ $p>0.05$) was found in the time budget between the two sparring individuals during both AHW and CW (Appendix I.6 & I.13).

Scanning The time budgets between 4 out of 15 chi-squared tests for AHW show a significant difference ($\chi 2$ $p<0.05$), and only 3 out of 15 during CW for the time budgets (Appendix I.7 & I.14).

Not noted There's significant differences ($\chi 2$ $p<0.05$) in the time budgets between 5 out of 15 chi-squared tests for AHW, and only 2 out of 15 during CW (Appendix I.8 & I.15)

Mann-Whitney

The Mann-Whitney tests show significant differences ($\chi 2$ $p<0.05$) in eating for one individual, object licking for five individuals, scanning for two individuals, and broom for the relevant individual. Resting, follow and sparring show no significant difference ($\chi 2$ $p>0.05$) (Appendix H.1)

Behavioural reaction norms

Eat: One of the individuals is significantly different ($\chi 2$ $p<0.05$) from the others when comparing its median to other individuals (Appendix C.17). The kurtosis and skewness for another individual's eating have a noteworthy fall, and both slopes are significantly different ($\chi 2$ $p<0.05$) from all other individuals' slopes comparing the individual's kurtosis and skewness to the others' (Appendix C.19 & C.20). One of the individual's standard deviations are significantly different ($\chi 2$ $p<0.05$) to the other individual (Appendix C.18 & figure 3.2).

Object licking: There's no significant differences ($\chi 2$ $p>0.05$) between the individuals' medians and standard deviations (Appendix C.9, C.10, C.11 & C.12). One of the individuals' kurtosis and skewness has a noticeable rise from AHW to CW, and are significantly different ($\chi 2$ $p<0.05$) from all individuals, except one other individual (Appendix C.11, C.12 & figure 3.2).

Resting: There's only one significantly different ($\chi 2$ $p<0.05$) median compared to the other individuals (Appendix C.1). 8 out of 15 tests for kurtosis show a significant difference ($\chi 2$ $p<0.05$) (Appendix C.3). Skewness also has 8 out of the 15 tests show a significant difference ($\chi 2$ $p<0.05$) (Appendix C.4). Two of the individuals are significantly different ($\chi 2$ $p<0.05$) from each other for the standard deviations (Appendix C.2 & figure 3.2).

Follow: There's a significant difference ($\chi 2$ $p<0.05$) of the medians in 4 out of 10 tests (Appendix C.5). Only one of the individual's kurtosis is significantly different ($\chi 2$ $p<0.05$) from the others', and for skewness 6 out of 10 tests are significant (Appendix C.7 & C.8). Note that one of the individuals does not have enough observations for the follow behaviour, and therefore does not have chi-squared test (Appendix C.5, C.6, C.7 & C.8). For the standard deviation, only two of the individuals were significant ($\chi 2$ $p<0.05$) compared to the rest of the individuals (Appendix C.6 & figure 3.2).

Sparring: Sparring has not been included in the behavioural reaction norms, as there are only two participants and their medians run parallel.

Scanning: When analyzing the tests, 9 out of 15 are significantly different ($\chi 2$ $p<0.05$) when comparing medians (Appendix C.13). 12 out of 15 tests are significantly different ($\chi 2$ $p<0.05$) when comparing kurtosis (Appendix C.15). When comparing skewness, 11 out of 15 tests are significantly different ($\chi 2$ $p<0.05$) (Appendix C.16). And lastly, 8 out of 15 tests are significantly different ($\chi 2$ $p<0.05$) when comparing standard deviation (Appendix C.14 & figure 3.2).

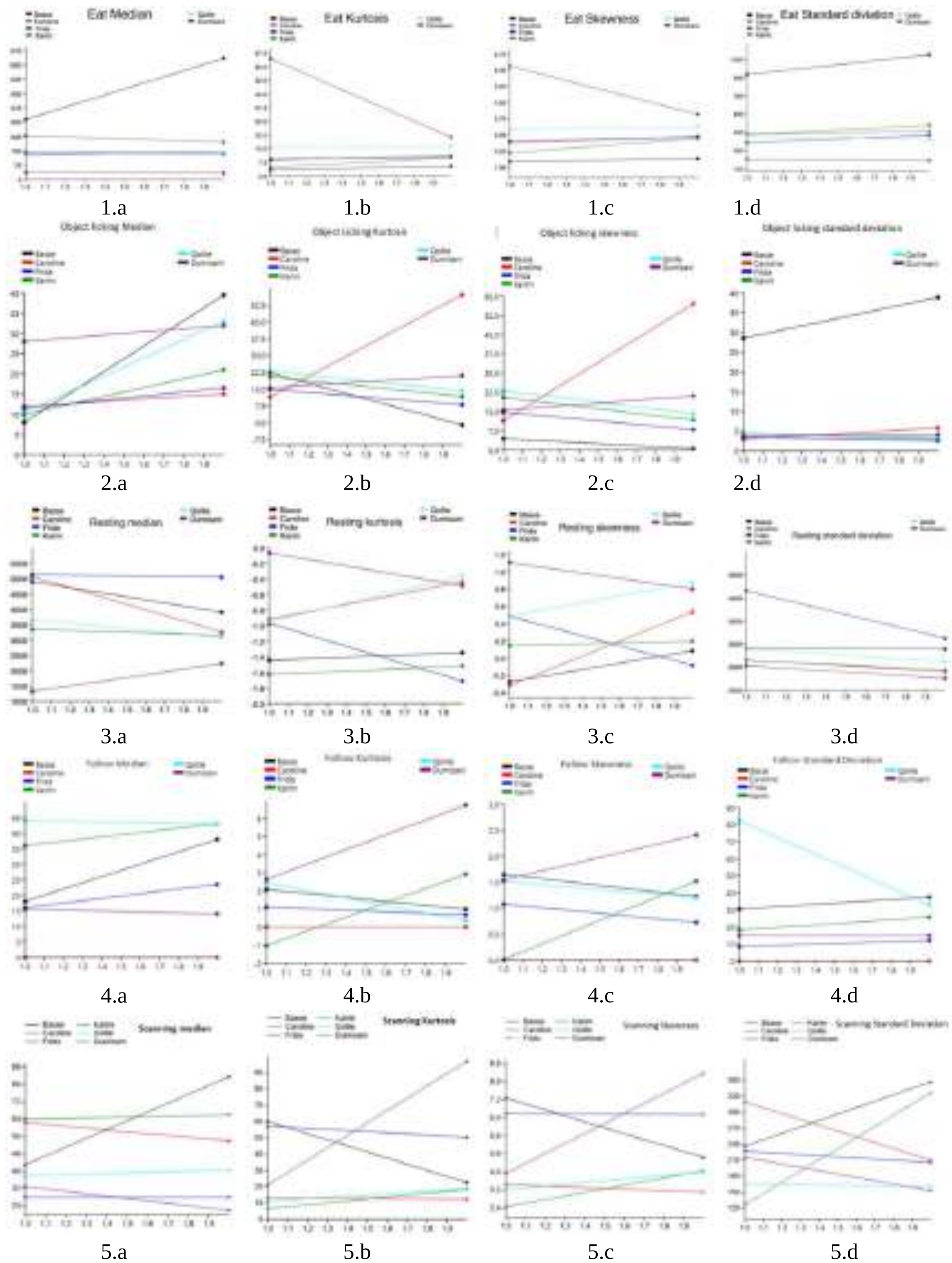


Figure 2.1-5 (a-d): Behavioural reaction norms for the six different types of behavior 1) Eat. 2) Object licking. 3) Resting. 4) Following. 5) Scanning. The different points indicate the average for the a) Median. b) Kurtosis.

c) Skewness. d) Standard deviation from the Autumn holiday and the control week, respectively. The y-axis displays the measured values from each week. The coloured lines correlate to the different individuals Black) Basse, Red) Caroline, Dark blue) Frida. Green) Karim. Light blue) Qolile. Purple) Dumisani.

Shannon's and Simpson's diversity indices

Table 3.1: Shannon's and Simpson's diversity indices for the autumn holiday week and the control week

	Basse	Caroline	Frida	Karim	Qolile	Dumisani
CW Simpson's	0.5654	0.6068	0.6123	0.6165	0.5848	0.6144
CW Shannon's	1.045	1.065	1.045	1.141	1.064	1.147
AHW Simpson's	0.5826	0.6358	0.6129	0.6162	0.5855	0.6354
AHW Shannon's	1.042	1.136	1.033	1.15	1.021	1.148

*G*enerally, all the observed individuals have a quite similar Simpson's and Shannon's index values and they differed little from CW to AHW. As an example, Frida's, Karim's and Qolile's Simpson's index values changed only by a difference of 0.004, 0.003 and 0.007 between CW and AHW. Likewise, Dumisani, Basse and Karim have a change in their Shannon's index values of 0.001, 0.003 and 0.009. Basse has the lowest Simpson's index values of 0.5654 and 0.5826 in both CW and AHW, while Karim has the highest Simpson's index value 0.6165 in CW and Caroline 0.6358 in AHW. Basse and Frida both have the lowest Shannon's index value 1.045 in CW, whereas Qolile has the lowest Shannon's index value 1.021 in AHW. Karim has the highest Shannon's index value 1.147 in CW and Dumisani 1.148 in AHW. Chi-squared tests of the indices showed no significant difference (χ^2 p>0.05) (Table 3.1 & appendix J.1).

Discussion

Individual behavioural differences from AHW to CW

As only one individual exhibits a significant difference (χ^2 p<0.05) for the "not noted" category, no significant correlation between individual behaviour patterns and visitor numbers was found (Appendix I). The significant change in the "not noted" category can be assumed be an individual attempt to distance herself from larger crowds. By placing herself near the gate leading to their indoor enclosure as a response to this, the individual was positioned largely out of sight throughout the video footage [Fernandez et al. 2009]. It should be noted that in the instances where the gate was recorded, individuals were observed standing near it until they were allowed to go inside.

Although not significant (χ^2 p>0.05), a general tendency towards increased object licking throughout CW was observed (Appendix I & figure 3.1). This indicates a lowered level of stimulation during this period. The operators also observed a decrease in the foliage available on the presented branches during CW, which could be causal to the behavioural shift. A study conducted by Fernandez et al. (2008) found that increased levels of tongue manipulation required for feeding reduced the amount of licking behaviour observed, further suggesting a causal relationship between available foliage and object licking.

Restlessness was commonly observed amongst the individuals shortly before being let out onto the savannah. This could be an indicator of stress, as more behaviours that would commonly be categorised as stereotypies, such as pacing and heightened object licking, were observed. This is in concordance with a study conducted on elephants by Andersen et al. (2020) for which an increase in swaying was observed around the keepers schedules.

One of the individuals displayed a significant difference (MWW $p<0.05$) in eating, object licking, scanning and use of the broom (Appendix H.1). The behavioural reaction norms indicate less sporadic activity during CW as compared to AHW (Figure 3.2). It can be speculated that the difference in scanning is a result of the increase in visitors throughout AHW, triggering an antipredatory response as scanning is found to serve a primarily antipredatory function in ungulates by H.Ronald Pulliam (1973) and Elissa Cameron & Johan T. du Toit (2005) (Appendix E.1f & E.2f). A significant increase (MWW $p<0.05$) also occurs for one other individual, however, the period of increased activity occurs during CW as opposed to AHW (Appendix E.5e & E.6e). There is no apparent reason as to why the change in behaviour occurs.

Personality differences between the six individuals

The amount of significant differences for eating changed from CW to AHW (Appendix I.2) as two individuals display contrasting eating patterns, with one spending

more time eating in total, but in shorter intervals, it can be speculated that the significant differences are symptomatic of these alternating patterns (Appendix E.3a, E.4a, E.7a & E.8a).

Statistical significance (χ^2 $p<0.05$) for resting was observed in AHW, which aligns itself well with the total amount of time spent as half of the individuals rested for longer periods during CW (Figure 3.1 & appendix I.11 & I.4). These differences could be the result of individuals interrupting each others rest, such as a calf standing up to follow its mother. This specific example is supported by data as there is no significant difference between cows and calves for resting throughout CW or AHW (Appendix I).

As participation in sparring was limited to two individuals, the time spent, as well as the intervals in which the activity was performed, are identical for the individuals in question, yielding no significant difference (χ^2 $p>0.05$). The activity was performed bull-to-bull, but not all bulls participated in the activity (Appendix I.6 & I.13) [Seeber, Ciofolo, and Ganswindt 2012]. This is likely due to the young age of the last bull, as a study conducted by D. Pratt (1985) found increased levels of the activity amongst younger bulls.

One individual's median for eating, being significantly different (χ^2 $p<0.05$) from all others, can relate to the previous point of distraction triggering the antipredatorial response during AHW due to the higher number of visitors (Appendix C.17) [Pulliam 1973]. Another individual shows a general significant difference (χ^2 $p<0.05$) from the others regarding kurtosis, skewness, and standard deviation (Appendix C.19, C.20 & C.18). In the meantime, the individual's time-frame for eating is predictable, even when presented with more stimuli (Appendix E.6a & E.5a).

One individual was less predictable in the object licking behaviour during AHW than CW, this could be due to heightened stimuli from more visitors (Appendix E.3b & E.4b) [Miller et al. 2020]. This individual is significantly different (χ^2 $p<0.05$) in both kurtosis and standard deviation from all except one other individual, meaning that they may have had a similar change in predictability in the observation period, and therefore have had a similar reaction to the higher number of visitors (Appendix C.10 & C.11).

One individual exhibits a significant difference (χ^2 $p<0.05$) for resting in respects to median, kurtosis and skewness (Appendix C.1, C.3 & C.4). The particular individual was observed to be more easily distracted by its herd during CW as well as displaying a propensity towards interrupting the resting behaviour to initiate behaviours such as eating or object licking. It can be speculated that this is the result of the lower number of visitors during CW or the aforementioned link between foliage density and object licking [Fernandez et al. 2008].

One individual shows significant differences (χ^2 $p<0.05$) in the median and standard deviation when compared to all but one other individual in regards to the "follow" behaviour. The individuals in question are the youngest of the herd, and are therefore still dependant on lactating cows, meaning they are more likely to follow these individuals (Figure 3.2m & 3.2p) [Pratt and Anderson 1979]. It is found by

Daleszczyk (2004) that ungulates use following as a protectional tactic for the calf, denoting that calves are more inclined to follow their mothers, which would be in accordance with the observed behaviour. The second oldest bull would often follow the oldest bull to instigate sparring, which correlates to a study made by D. Pratt et al. (1985), in which they discovered that the smaller bulls often initiate the behaviour [Seeber, Ciofolo, and Ganswindt 2012]. As the oldest individual is less sporadic in CW, it presents the opportunity for longer intervals of following which in turn affect predictability and skewness (Appendix E.9d & E.10d).

Two individuals display a similar change in the median of the scanning behaviour comparative to the rest of the herd from AHW to CW, which is attested by the reaction norms. Both individuals scan for longer periods of time during AHW than CW, suggesting that a higher number of visitors lead to longer periods of scanning (Figure 3.2q & appendix C.13). A second pair of individuals are also significantly different (χ^2 p<0.05) from each other. One individual scans more during AHW than CW and vice versa, this could be due to different reactions to larger crowds (Figure 3.2q). It could be speculated that the individual scanning more during AHW becomes more vigilant as a response to increased visitor numbers, while the other individual lacks the stimuli from AHW in CW and therefore scans more to compensate. Most individuals show a significant difference (χ^2 p<0.05) in kurtosis and skewness, which is speculated to be because of the social structures in which the individuals are both individual entities whilst also being subject to herding behaviour (Figure 3.2r & 3.2s). The standard deviation for two individuals is significantly different (χ^2 p<0.05) from the rest of their herd-mates, except for each other, which could mean they both scan within the same timeframe throughout the day (Appendix C.14). This correlates with sparring, as these two particular individuals are the only ones that spar with each other, and therefore stop the behaviour simultaneously to scan.

As no significant difference (χ^2 p>0.05) for the Shannon's and Simpson's indices were found, even when comparing the indices across all individuals, it expresses that the amount of visitors in the zoo has no affect on the herd as it lacks general behavioural diversity (Appendix J.1).

Possible sources of error

The quality of the recorded video from the outdoors enclosure was dependent upon the weather, as the light from the sun and the shadows from the clouds proved to affect the operators' abilities to observe the behaviours of the individuals correctly. However, this issue was applicable across all days at approximately the same intervals, giving the error consistency and rendering it negligible. The problem of not having all cumulative frequency graphs flatten out is negated by a large number of total observations, granting a high degree of confidence in the data. 691,200 seconds were observed for each individual, resulting in 4,147,200 seconds of total observation. This confidence is further strengthened by drawing comparisons to other articles, such as the following, where the total number of observed seconds is noticeably lower [Linder et al. 2020; Shepherdson et al. 2013; Ross 2006; Myers and Young 2018].

Conclusion

In the study, based on six animals, we found no significant difference between the two weeks with different numbers of visitors. However, significant differences were observed when comparing the individual giraffes for certain behaviours, and behavioural instabilities in regards to AHW, which can be explained by differing reaction norms. Therefore, this study concludes that giraffe possesses a distinct personality, which is an important aspect of reintroduction, as behavioural diversity in a group gives better chances of survival in the wild.

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Author Contributions

All listed authors contributed equally, whilst resources were provided by C.P. and T.H.J. All authors provided critical feedback and contributed to the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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.A Appendix - Visitor numbers

Table A.1: Visitor numbers for the autumn holiday week and the control week respectively

Autumn holiday week			**Control Week**		
Monday	*12-oct*	2472	Monday	*19-oct*	556
Tuesday	*13-oct*	2158	Tuesday	*20-oct*	1525
Wednesday	*14-oct*	1711	Wednesday	*21-oct*	518
Thursday	*15-oct*	351	Thursday	*22-oct*	307

B. Appendix - Placement of Cameras

A picture of the placement of the cameras. The photo used from google maps is old and does not include the bridge Maps n.d.

C. Appendix - chi-squared tests of the slope of the reaction norms

Table C.1: Medians for resting

Med Resting	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$	$p < 0.05$

Table C.2: Standard Deviations for resting

Dev. Resting	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	$p < 0.05$	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table C.3: Kurtosis' for resting

Kut Resting	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	$p < 0.05$	$p < 0.05$	X	X	X
Karim	N.S.	N.S.	$p < 0.05$	X	X
Qolile	N.S.	N.S.	$p < 0.05$	N.S.	X
Dumisani	$p < 0.05$	$p < 0.05$	N.S.	$p < 0.05$	$p < 0.05$

Table C.4: Skewnesses for resting

Skew Resting	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	p <0.05	p <0.05	X	X	X
Karim	N.S.	N.S.	p <0.05	X	X
Qolile	N.S.	N.S.	p <0.05	N.S.	X
Dumisani	p <0.05	p <0.05	N.S.	p <0.05	p <0.05

Table C.5: Medians for follow

Med Follow	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	N.S.	X	X	X	X
Karim	N.S.	X	N.S.	X	X
Qolile	N.S.	X	p <0.05	N.S.	X
Dumisani	p <0.05	X	p <0.05	p <0.05	N.S.

Table C.6: Standard deviations for follow

Dev. Follow	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	N.S.	X	X	X	X
Karim	N.S.	X	N.S.	X	X
Qolile	p <0.05	X	p <0.05	p <0.05	X
Dumisani	p <0.05	X	p <0.05	p <0.05	p <0.05

Table C.7: Kurtosis' for follow

Kur follow	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	N.S.	X	X	X	X
Karim	p <0.05	X	p <0.5	X	X
Qolile	N.S.	X	N.S.	p <0.5	X
Dumisani	p <0.05	X	p <0.05	N.S.	p <0.05

Table C.8: Skewnesses for follow

Skew Follow	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	N.S.	X	X	X	X
Karim	$p < 0.05$	X	$p < 0.05$	X	X
Qolile	N.S.	X	N.S.	$p < 0.05$	X
Dumisani	$p < 0.05$	X	$p < 0.05$	N.S.	$p < 0.05$

Table C.9: Medians for object licking

Med Object licking	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table C.10: Standard deviations for object licking

Dev. Object licking	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table C.11: Kurtosis for object licking

Kut Object licking	Basse	Caroline	Frida	Karim	Qolile
Caroline	$p < 0.05$	X	X	X	X
Frida	N.S.	$p < 0.05$	X	X	X
Karim	N.S.	$p < 0.05$	N.S.	X	X
Qolile	N.S.	$p < 0.05$	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table C.12: Skewness for object licking

Skew Object licking	Basse	Caroline	Frida	Karim	Qolile
Caroline	p <0.05	X	X	X	X
Frida	N.S.	p <0.05	X	X	X
Karim	N.S.	p <0.05	N.S.	X	X
Qolile	N.S.	p <0.05	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table C.13: Medians for scanning

Med Scanning	Basse	Caroline	Frida	Karim	Qolile
Caroline	p <0.05	X	X	X	X
Frida	p <0.05	p <0.05	X	X	X
Karim	N.S.	p <0.05	N.S.	X	X
Qolile	N.S.	p <0.05	N.S.	N.S.	X
Dumisani	p <0.05	N.S.	p <0.05	p <0.05	p <0.05

Table C.14: Standard deviations for scanning

Dev. Scanning	Basse	Caroline	Frida	Karim	Qolile
Caroline	p <0.05	X	X	X	X
Frida	p <0.05	N.S.	X	X	X
Karim	N.S.	p <0.05	p <0.05	X	X
Qolile	p <0.05	N.S.	N.S.	p <0.05	X
Dumisani	p <0.05	N.S.	N.S.	p <0.05	N.S.

Table C.15: Kurtosis for scanning

Kut Scanning	Basse	Caroline	Frida	Karim	Qolile
Caroline	p <0.05	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	p <0.05	p <0.05	p <0.05	X	X
Qolile	p <0.05	p <0.05	p <0.05	N.S.	X
Dumisani	p <0.05	p <0.05	p <0.05	p <0.05	p <0.05

Table C.16: Skewness for scanning

Skew Scanning	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	p <0.05	p <0.05	X	X	X
Karim	p <0.05	p <0.05	p <0.05	X	X
Qolile	p <0.05	p <0.05	p <0.05	N.S.	X
Dumisani	p <0.05	p <0.05	p <0.05	N.S.	N.S.

Table C.17: Medians for eating

Med Eat	Basse	Caroline	Frida	Karim	Qolile
Caroline	p <0.05	X	X	X	X
Frida	p <0.05	N.S.	X	X	X
Karim	p <0.05	p <0.05	p <0.05	X	X
Qolile	p <0.05	N.S.	N.S.	N.S.	X
Dumisani	p <0.05	p <0.05	N.S.	N.S.	p <0.05

Table C.18: Standard deviations for eating

Dev. Eat	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	p <0.05	p <0.05	p <0.05	p <0.05	p <0.05

Table C.19: Kurtosis for eating

Kut Eat	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	p <0.05	p <0.05	p <0.05	p <0.05	p <0.05

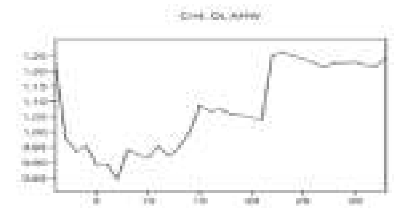
Table C.20: Skewnesses for eating

Skew Eat	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	p <0.05	p <0.05	p <0.05	p <0.05	p <0.05

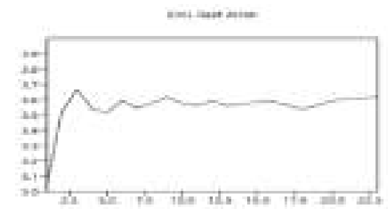
D. Appendix - Cumulative Graphs

D.1 Basse

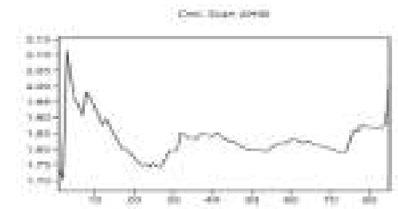
(a) Cumulative graph for eating for Basse in the autumn holiday week



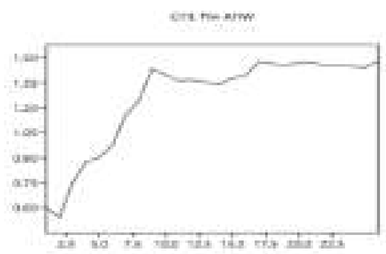
(b) Cumulative graph for object licking for Basse in the autumn holiday week



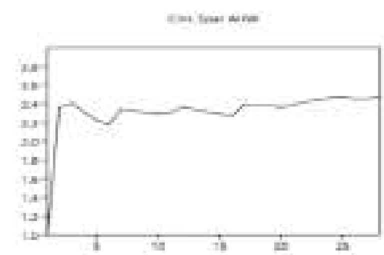
(c) Cumulative graph for resting for Basse in the autumn holiday week



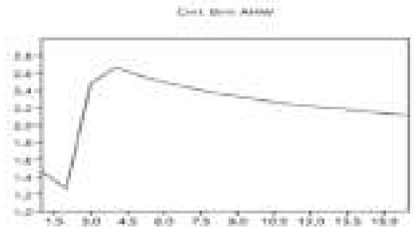
(d) Cumulative graph for scanning for Basse in the autumn holiday week



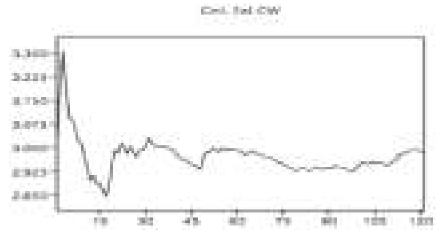
(e) Cumulative graph for follow for Basse in the autumn holiday week



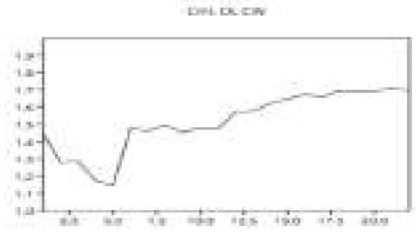
(f) Cumulative graph for sparring for Basse in the autumn holiday week



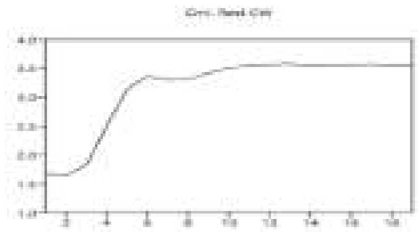
(g) Cumulative graph for the broom for Basse in the autumn holiday week



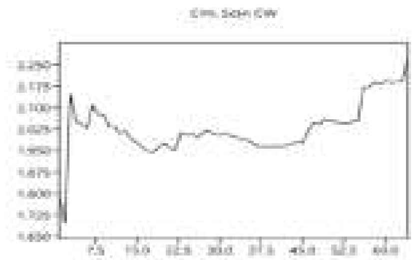
(h) Cumulative graph for eat for Basse in the control week



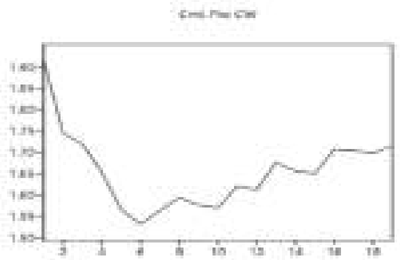
(i) Cumulative graph for object licking for Basse in the control week



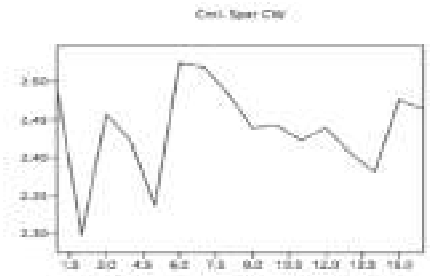
(j) Cumulative graph for resting for Basse in the control week



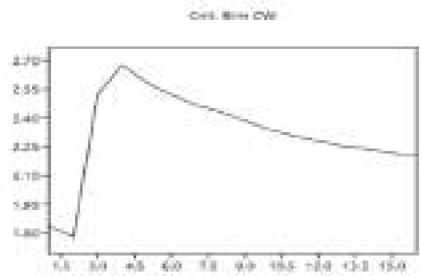
(k) Cumulative graph for scanning for Basse in the control week



(l) Cumulative graph for follow for Basse in the control week

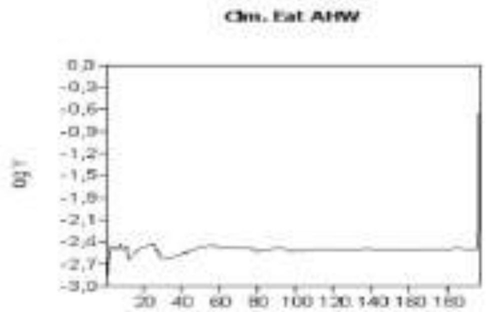


(m) Cumulative graph for sparring for Basse in the control week

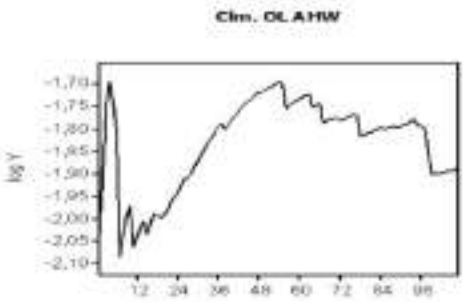


(n) Cumulative graph for the broom for Basse in the control week

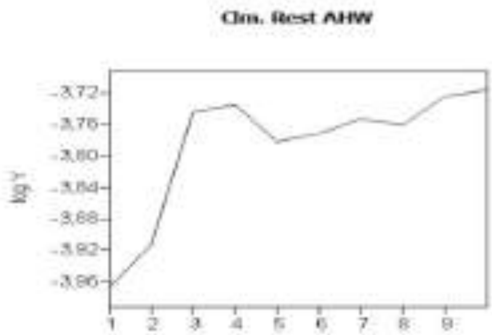
D.2 Caroline



(a) Cumulative graph for eating for Caroline in the autumn holiday week

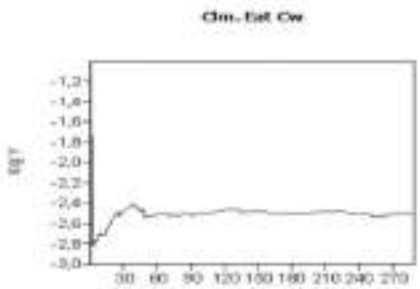


(b) Cumulative graph for object licking for Caroline in the autumn holiday week

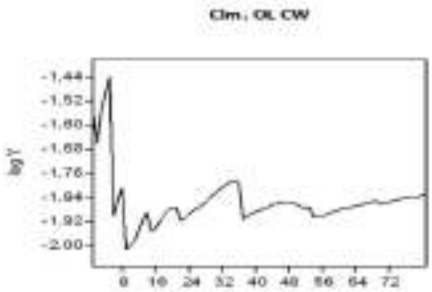


(c) Cumulative graph for resting for Caroline in the autumn holiday week

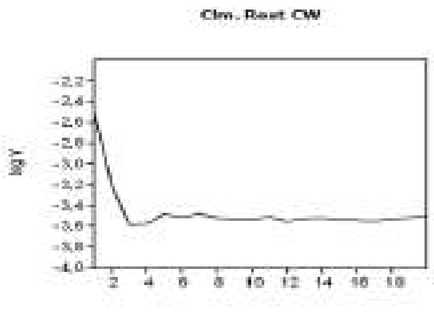
(d) Cumulative graph for scanning for Caroline in the autumn holiday week



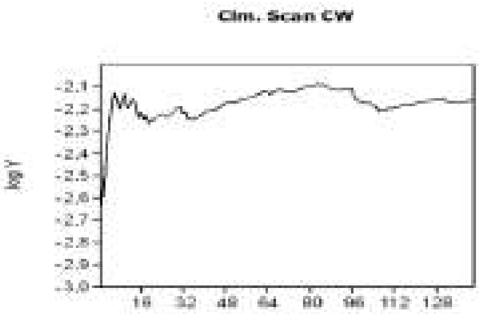
(e) Cumulative graph for eating for Caroline in the control week



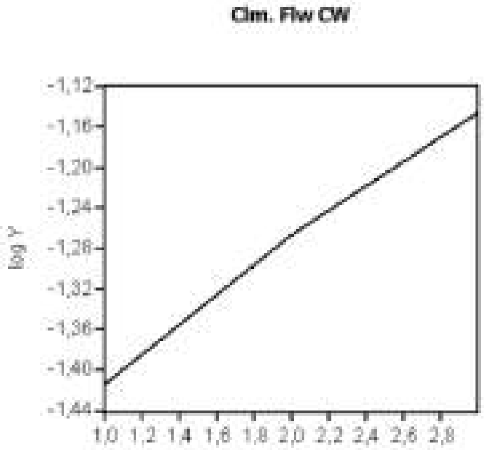
(f) Cumulative graph for object licking for Caroline in the control week



(g) Cumulative graph for resting for Caroline in the control week

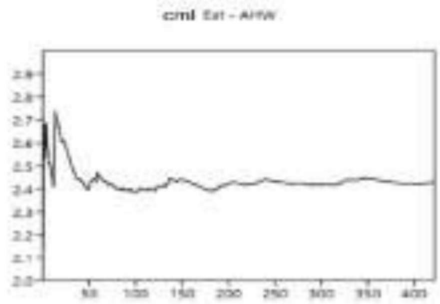


(h) Cumulative graph for scanning for Caroline in the control week

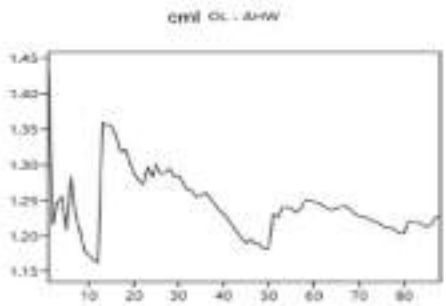


(i) Cumulative graph for follow for Caroline in the control week

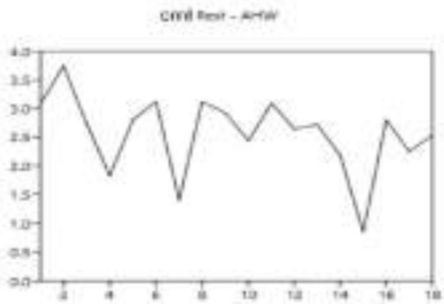
D.3 Frida



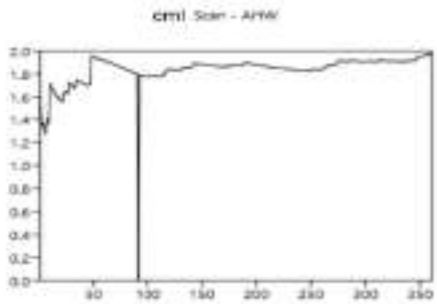
(a) Cumulative graph for eating for Frida in the autumn holiday week



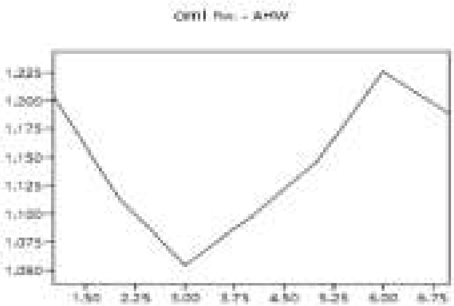
(b) Cumulative graph for object licking for Frida in the autumn holiday week



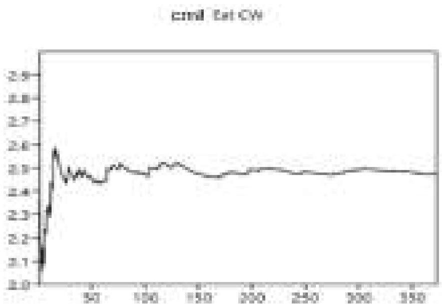
(c) Cumulative graph for resting for Frida in the autumn holiday week



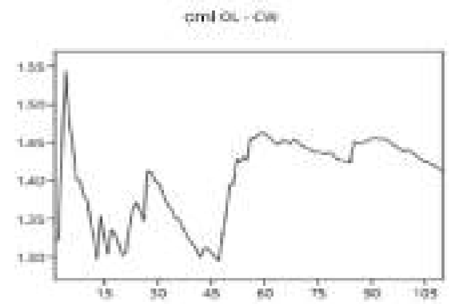
(d) Cumulative graph for scanning for Frida in the autumn holiday week



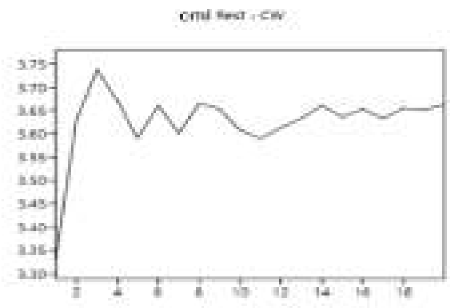
(e) Cumulative graph for follow for Frida in the autumn holiday week



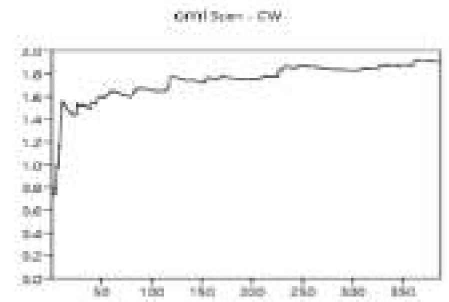
(f) Cumulative graph for eating for Frida in the control week



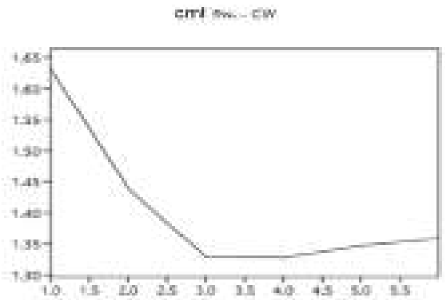
(g) Cumulative graph for object licking for Frida in the control week



(h) Cumulative graph for resting for Frida in the control week

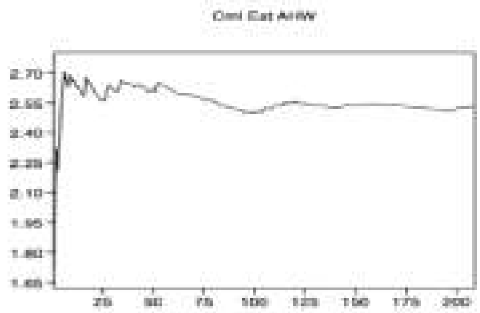


(i) Cumulative graph for scanning for Frida in the control week

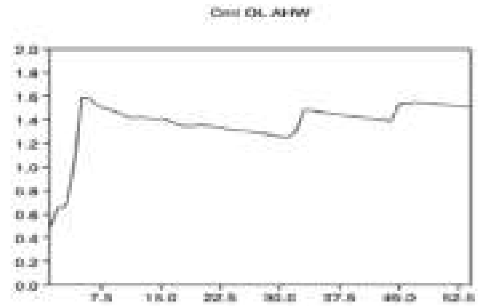


(j) Cumulative graph for follow for Frida in the control week

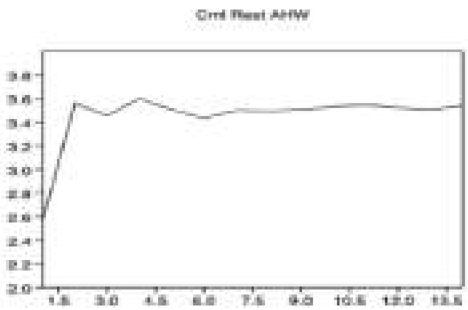
D.4 Karim



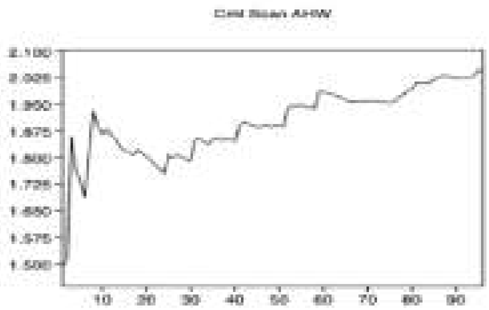
(a) Cumulative graph for eating for Karim in the autumn holiday week



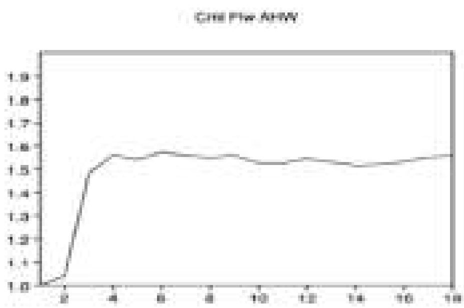
(b) Cumulative graph for object licking for Karim in the autumn holiday week



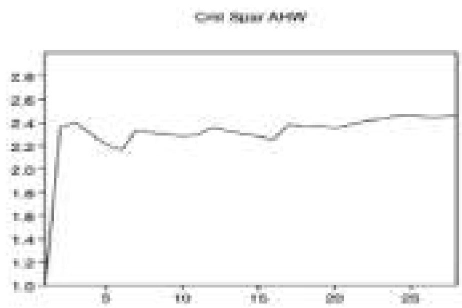
(c) Cumulative graph for resting for Karim in the autumn holiday week



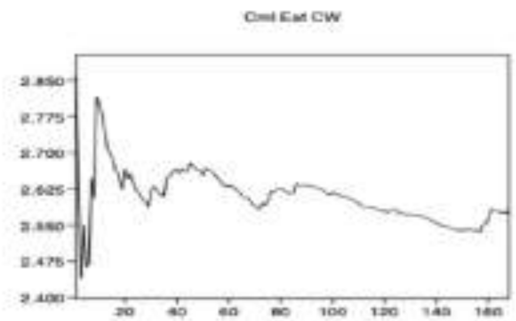
(d) Cumulative graph for scanning for Karim in the autumn holiday week



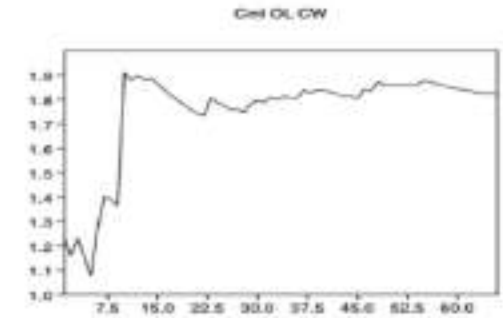
(e) Cumulative graph for follow for Karim in the autumn holiday week



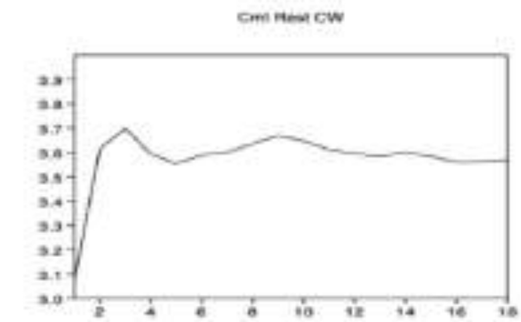
(f) Cumulative graph for sparring for Karim in the autumn holiday week



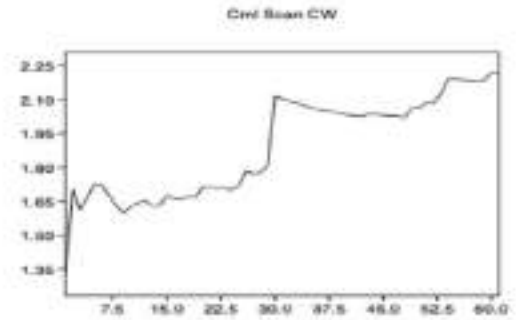
(g) Cumulative graph for eating for Karim in the control week



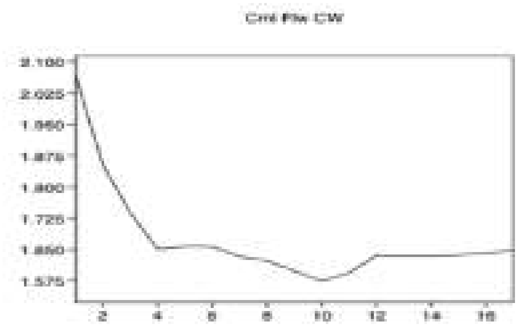
(h) Cumulative graph for object licking for Karim in the control week



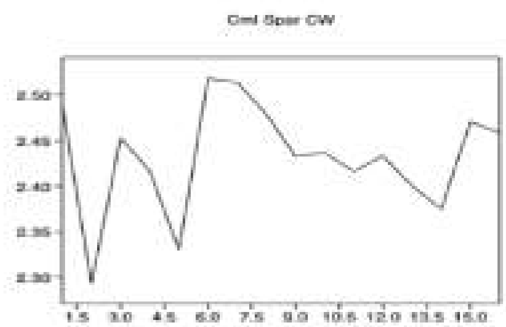
(i) Cumulative graph for resting for Karim in the control week



(j) Cumulative graph for scanning for Karim in the control week

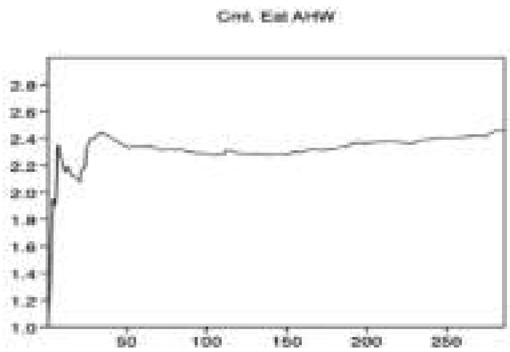


(k) Cumulative graph for follow for Karim in the control week

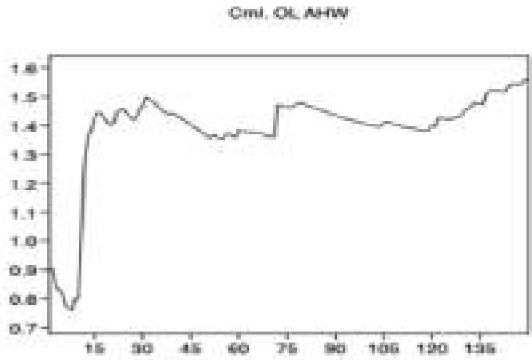


(l) Cumulative graph for sparring for Karim in the control week

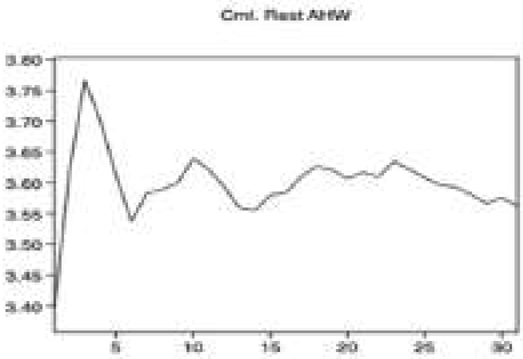
D.5 Qolile



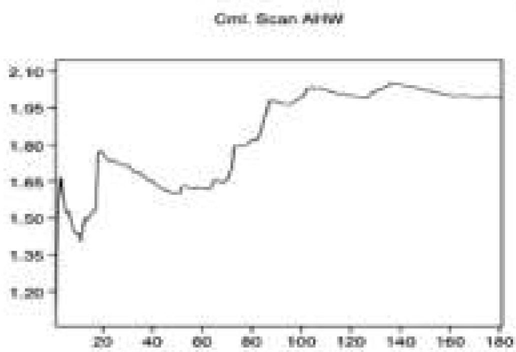
(a) Cumulative graph for eating for Qolile in the autumn holiday week



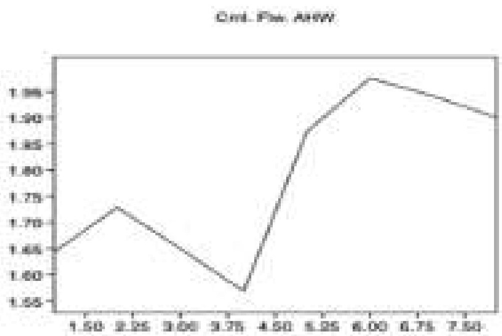
(b) Cumulative graph for object licking for Qolile in the autumn holiday week



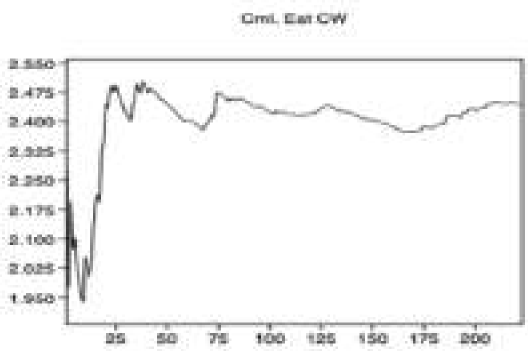
(c) Cumulative graph for resting for Qolile in the autumn holiday week



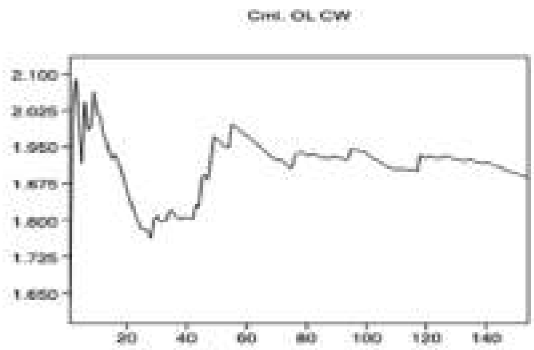
(d) Cumulative graph for scanning for Qolile in the autumn holiday week



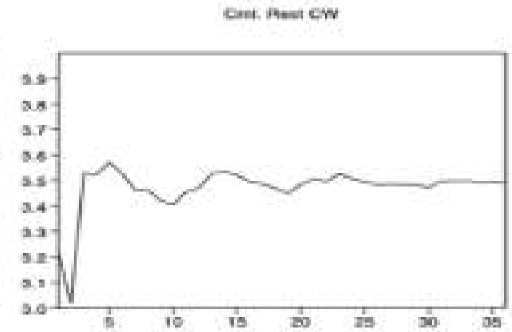
(e) Cumulative graph for follow for Qolile in the autumn holiday week



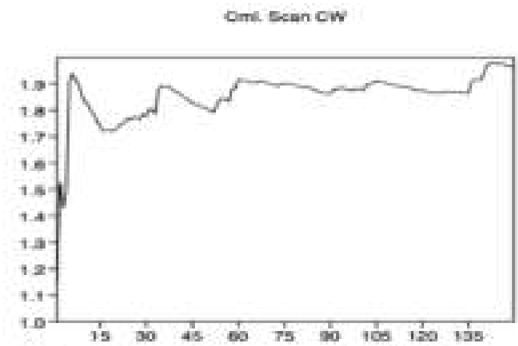
(f) Cumulative graph for eating for Qolile in the control week



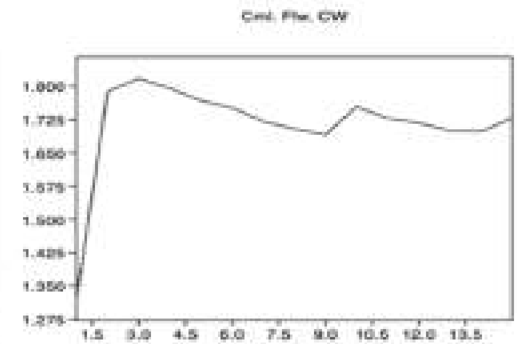
(g) Cumulative graph for object licking for Qolile in the control week



(h) Cumulative graph for resting for Qolile in the control week

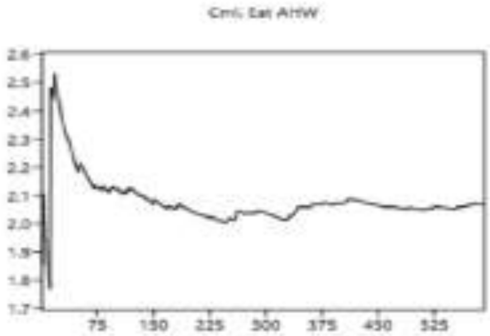


(i) Cumulative graph for scanning for Qolile in the control week

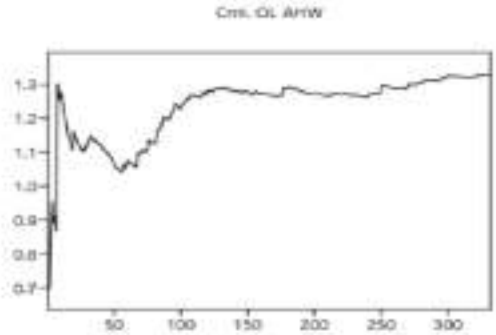


(j) Cumulative graph for follow for Qolile in the control week

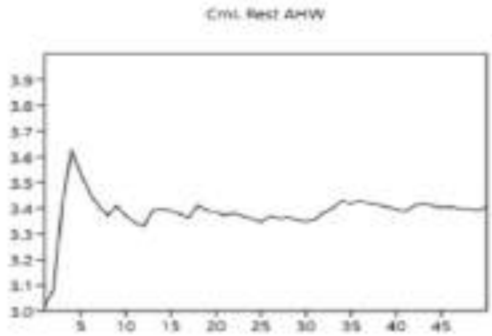
D.6 Dumisani



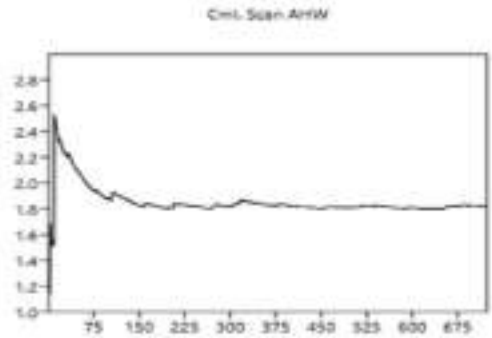
(a) Cumulative graph for eating for Dumisani in the autumn holiday week



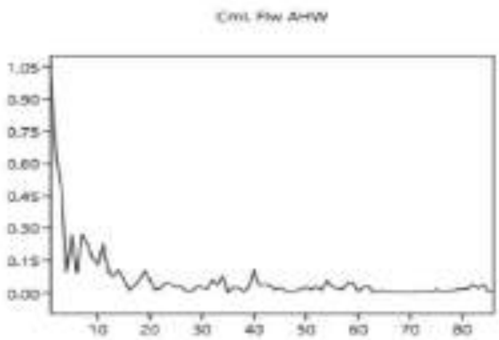
(b) Cumulative graph for object licking for Dumisani in the autumn holiday week



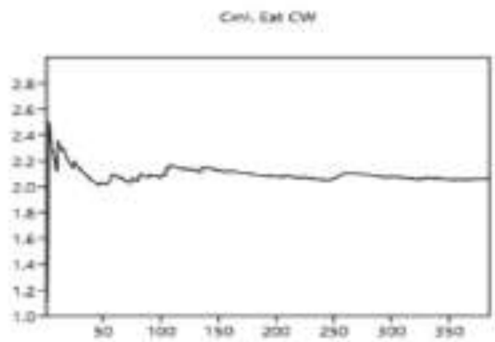
(c) Cumulative graph for resting for Dumisani in the autumn holiday week



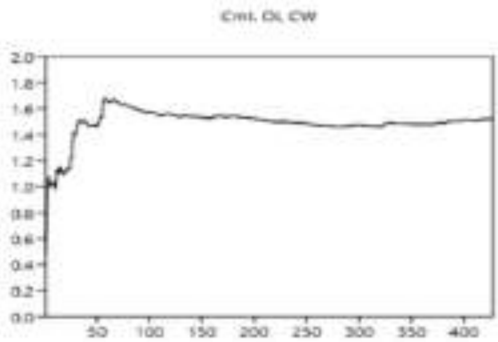
(d) Cumulative graph for scanning for Dumisani in the autumn holiday week



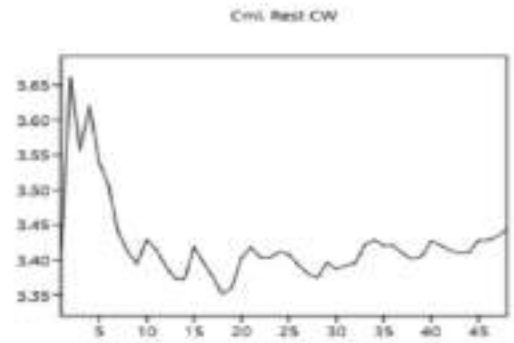
(e) Cumulative graph for follow for Dumisani in the autumn holiday week



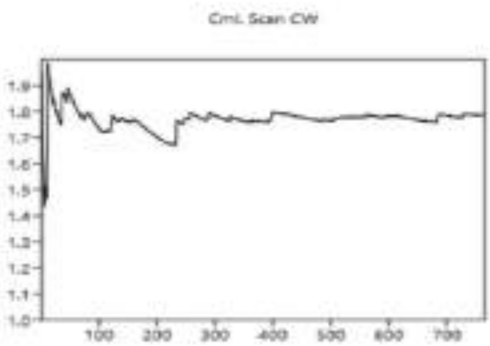
(f) Cumulative graph for eating for Dumisani in the control week



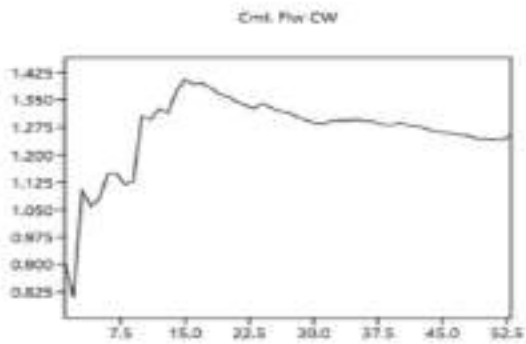
(a) Cumulative graph for object licking for Dumisani in the control week



(b) Cumulative graph for resting for Dumisani in the control week



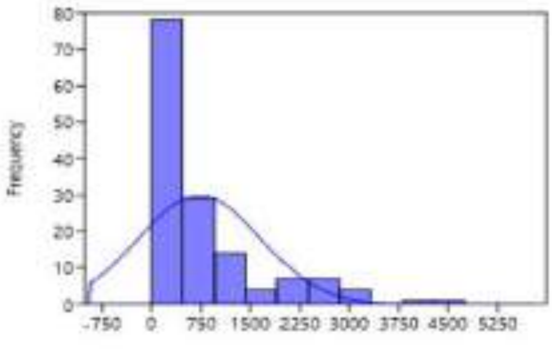
(c) Cumulative graph for scanning for Dumisani in the control week

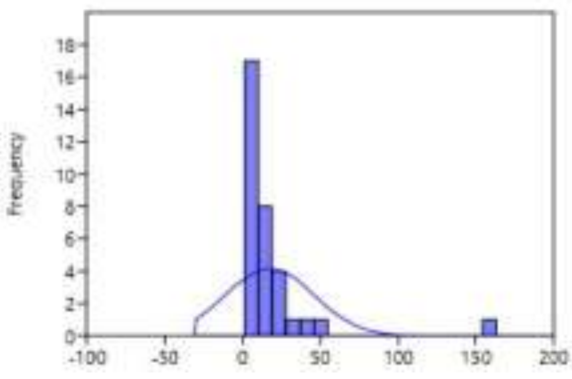


(d) Cumulative graph for follow for Dumisani in the control week

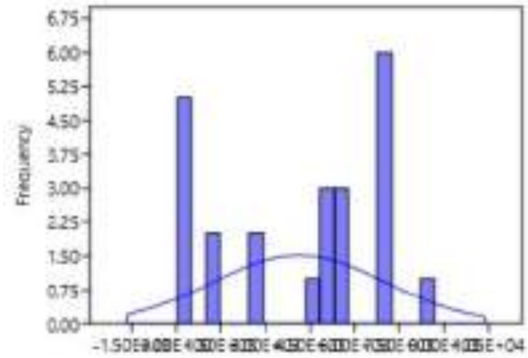
E. Appendix - Histograms

E.1 Basse AHW

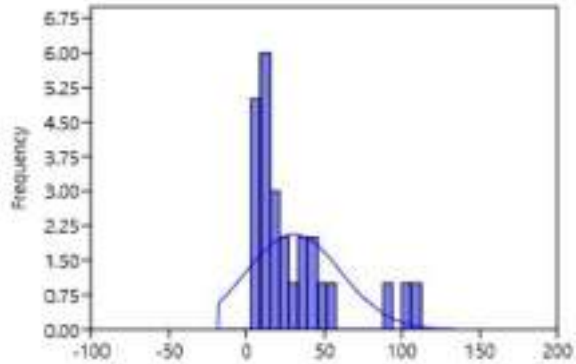




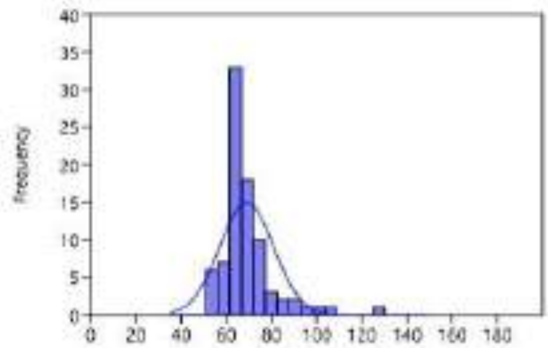
(a) Eating histogram for Basse during the ahw**(b)** Object Licking histogram for Basse during ahw



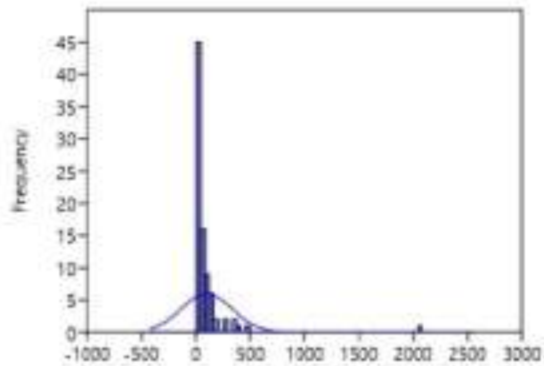
(c) Resting histogram for Basse during ahw



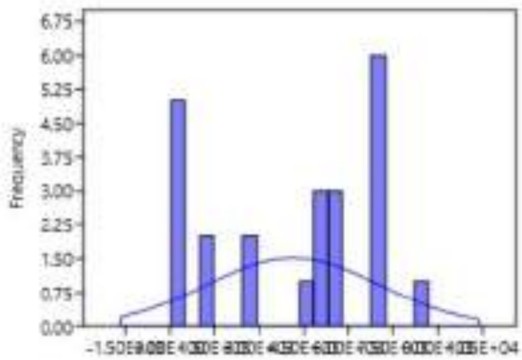
(d) Follow histogram for Basse during ahw



(e) Sparring histogram for Basse during ahw

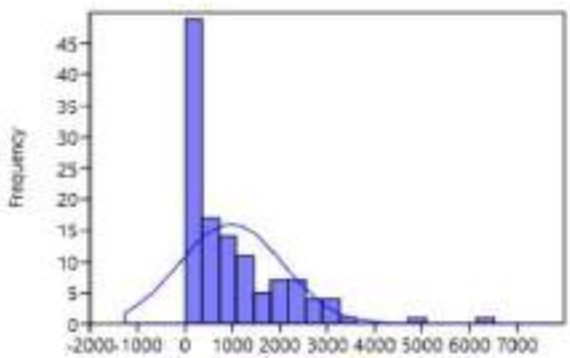


(f) Scanning histogram for Basse during ahw

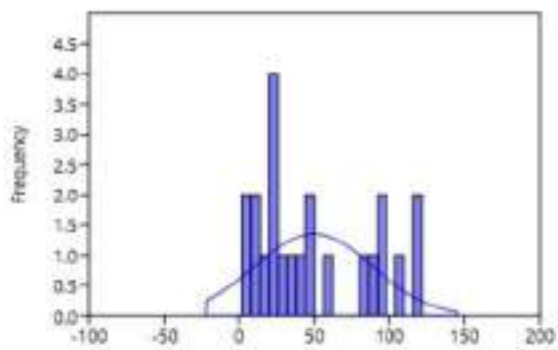


(g) Broom histogram for Basse during ahw

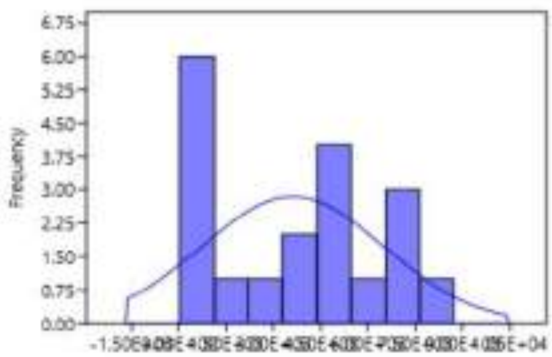
E.2 Basse CW



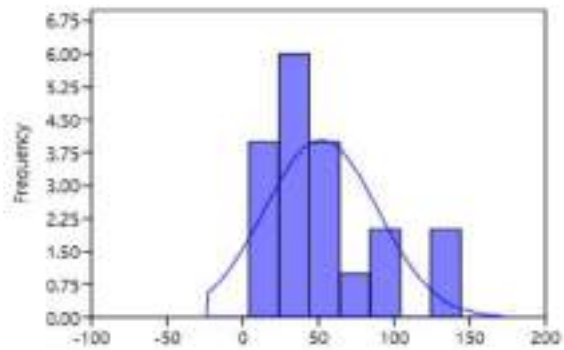
(a) Eating histogram for Basse during the cw



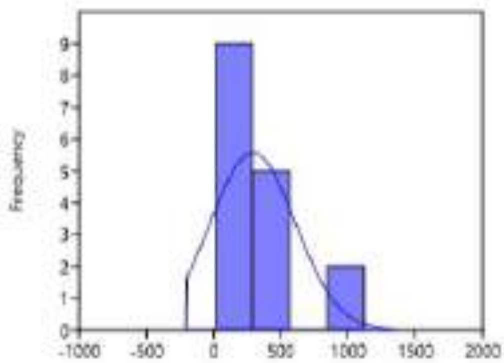
(b) Object Licking histogram for Basse during cw



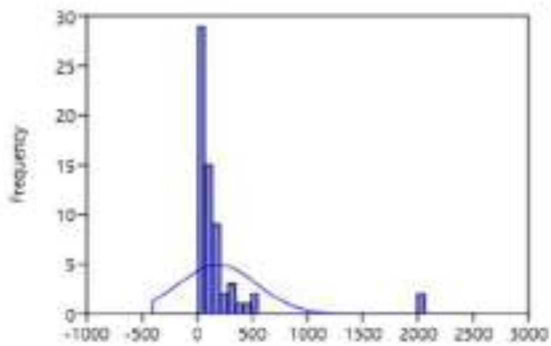
(c) Resting histogram for Basse during cw



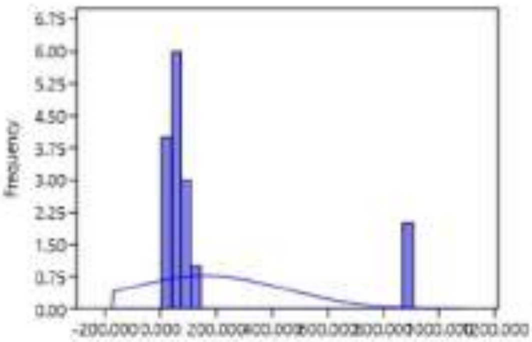
(d) Follow histogram for Basse during cw



(e) Sparring histogram for Basse during cw

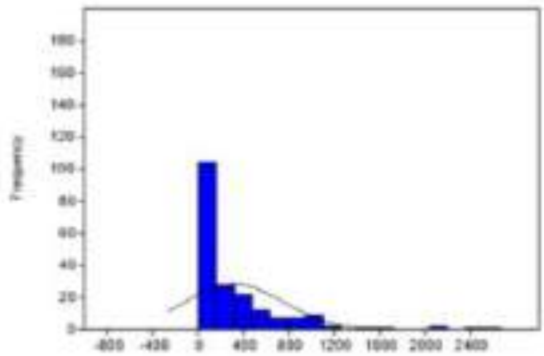


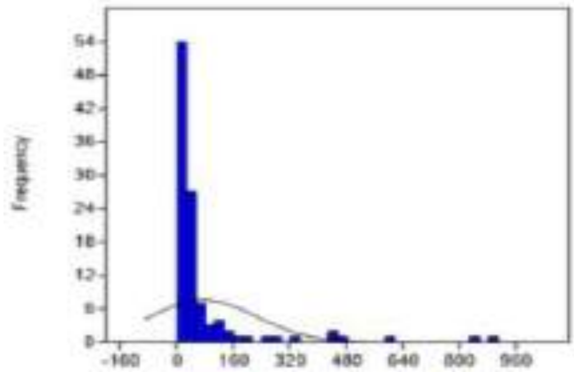
(f) Scanning histogram for Basse during cw



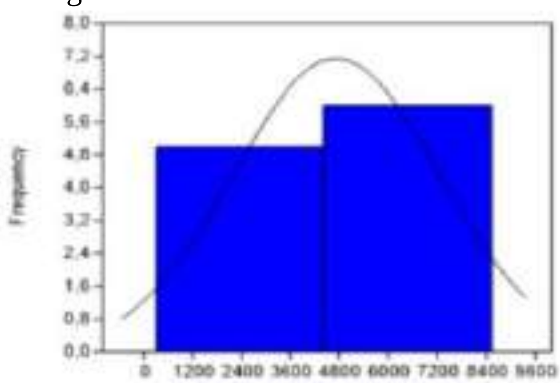
(g) Broom histogram for Basse during cw

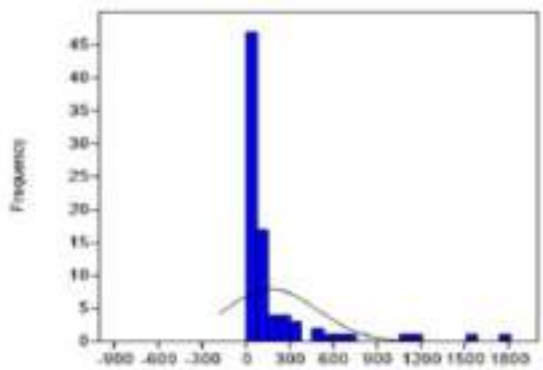
E.3 Caroline AHW





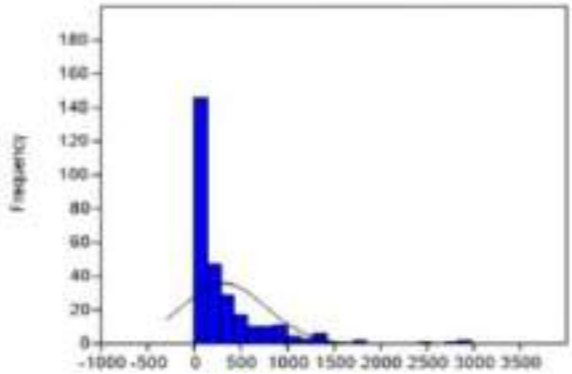
(a) Eating histogram for Caroline during the ahw**(b)** Object Licking histogram for Caroline during ahw

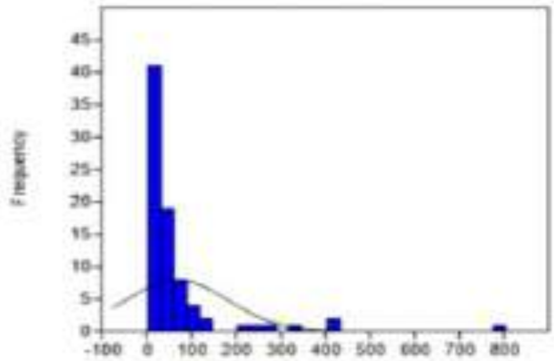




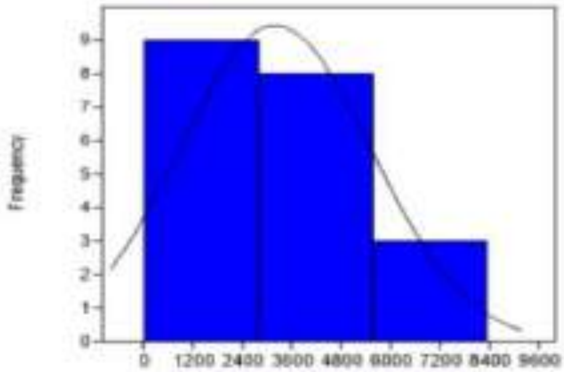
(c) Resting histogram for Caroline during ahw**(d)** Scanning histogram for Caroline during ahw

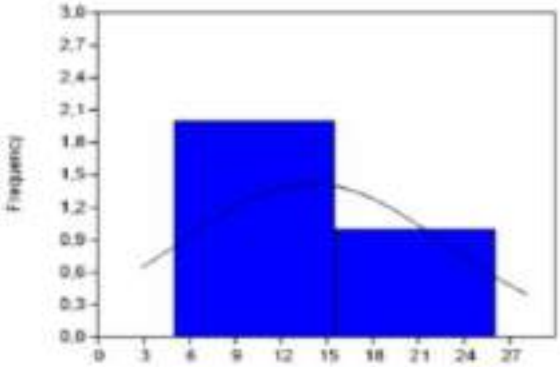
E.4 Caroline CW



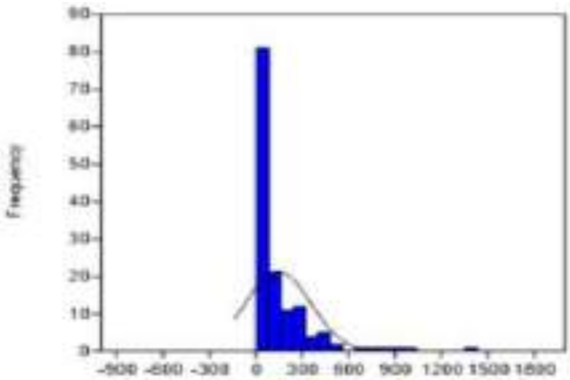


(a) Eating histogram for Caroline during the cw**(b)** Object Licking histogram for Caroline during cw



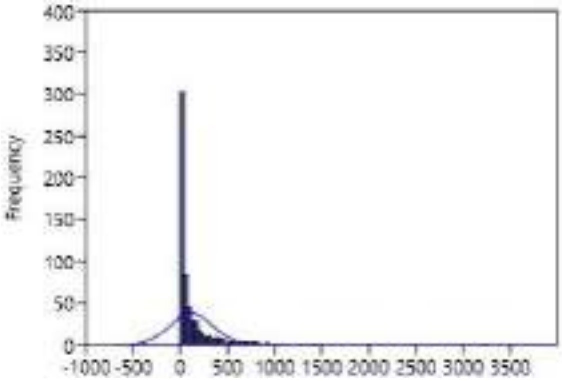


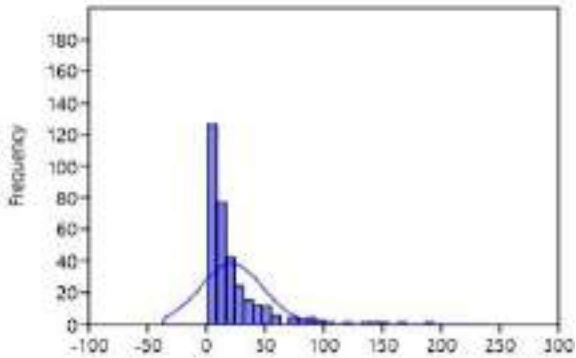
(c) Resting histogram for Caroline during cw**(d)** Following histogram for Caroline during cw



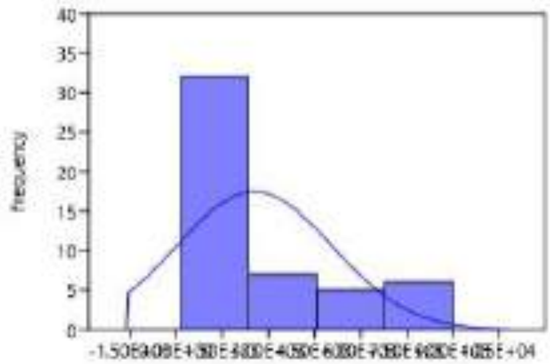
(e) Scanning histogram for Caroline during cw

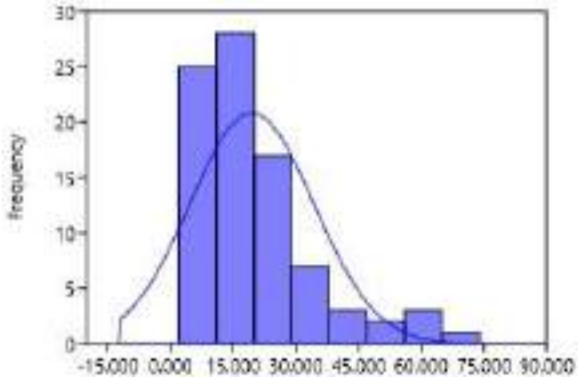
E.5 Dumisani AHW



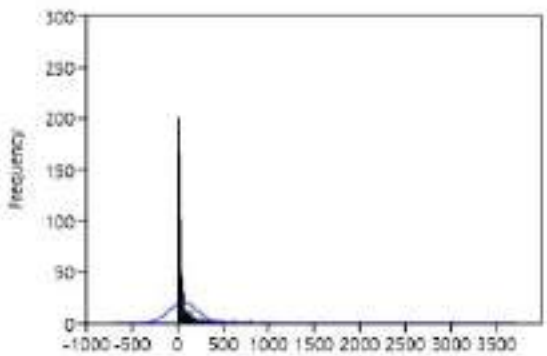


(a) Eating histogram for Dumisani during the ahw**(b)** Object Licking histogram for Dumisani during ahw



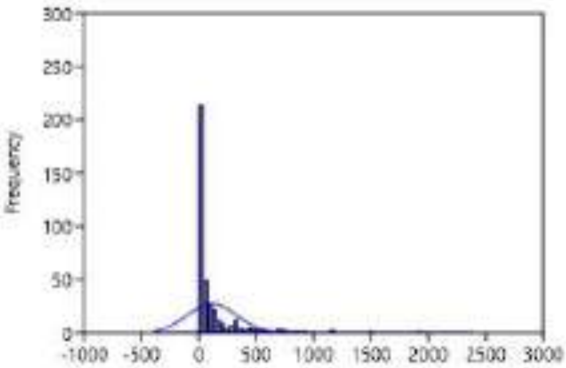


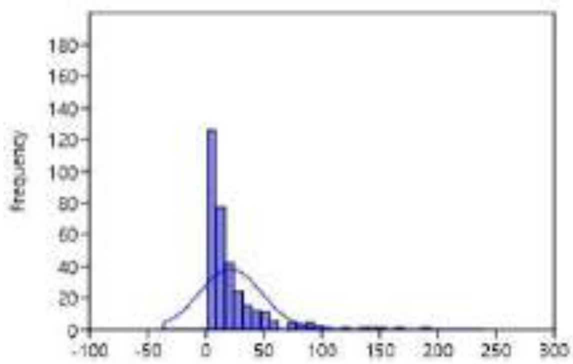
(c) Resting histogram for Dumisani during ahw**(d)** Following histogram for Dumisani during ahw



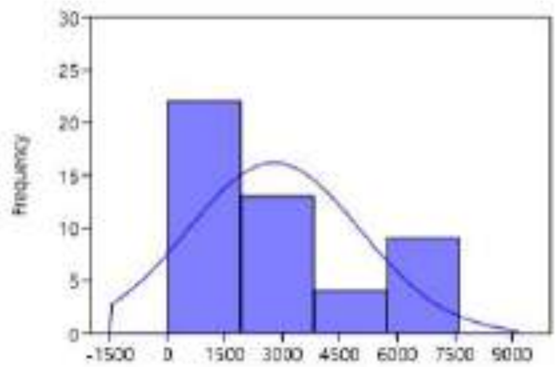
(e) Scanning histogram for Dumisani during ahw

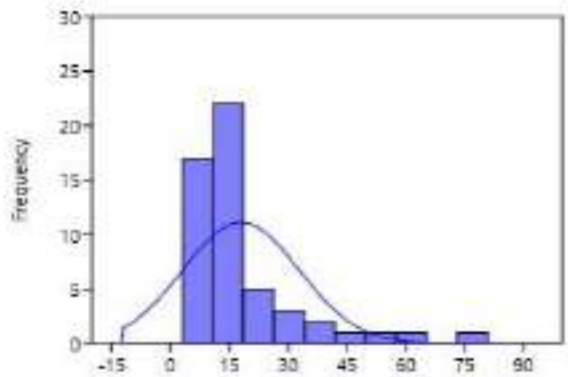
E.6 Dumisani CW



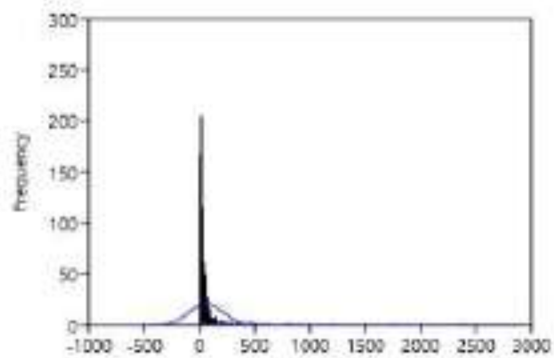


(a) Eating histogram for Dumisani during the cw**(b)** Object Licking histogram for Dumisani during cw



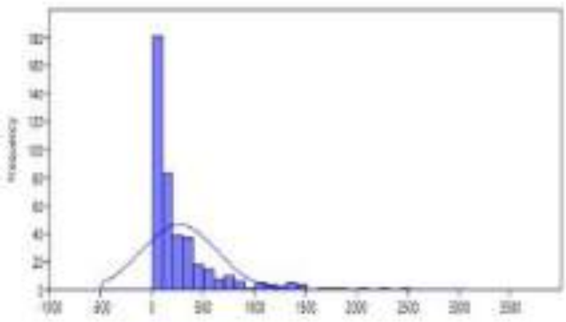


(c) Resting histogram for Dumisani during cw**(d)** Following histogram for Dumisani during cw

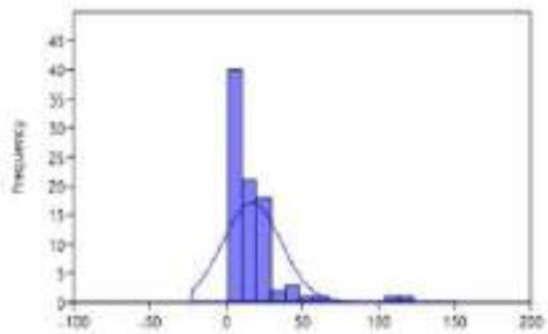


(e) Scanning histogram for Dumisani during cw

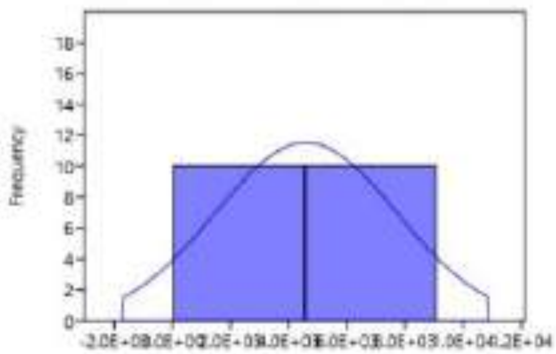
E.7 Frida AHW



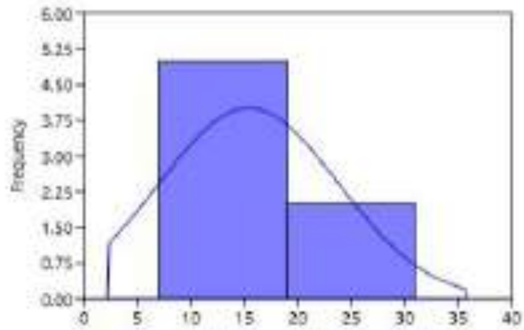
(a) Eating histogram for Frida during the ahw



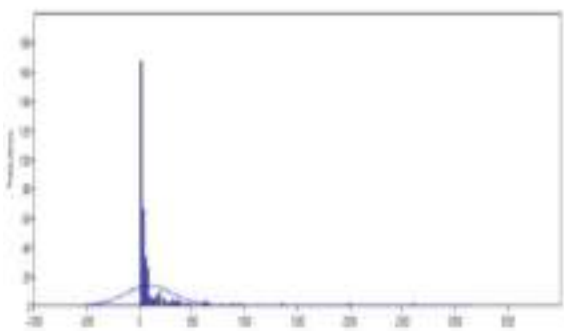
(b) Object Licking histogram for Frida during ahw



(c) Resting histogram for Frida during ahw

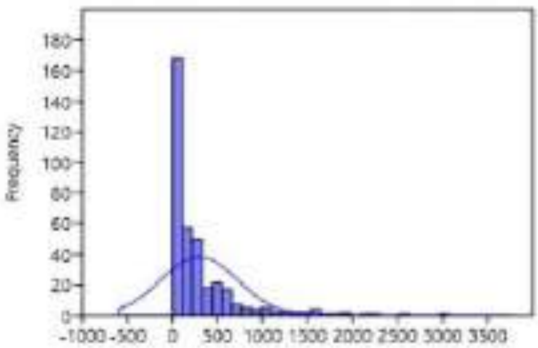


(d) Follow histogram for Frida during ahw

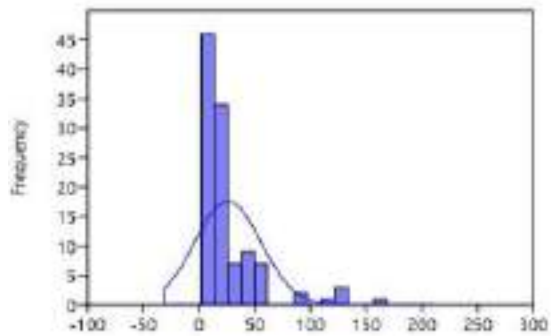


(e) Scanning histogram for Frida during ahw

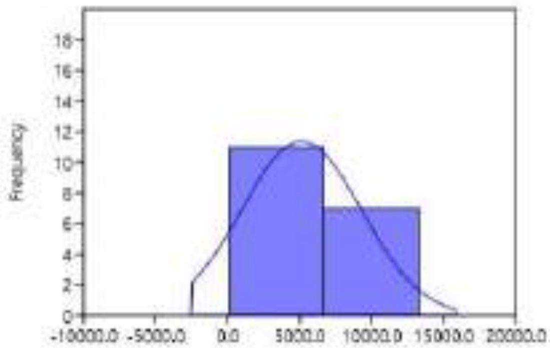
E.8 Frida CW



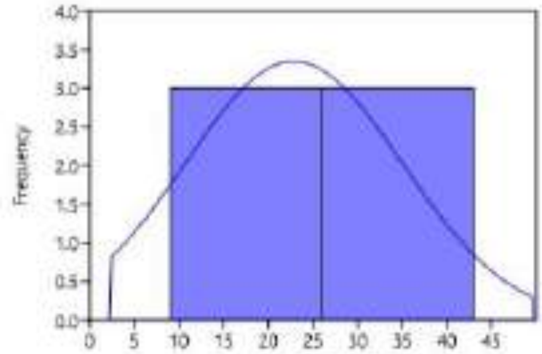
(a) Eating histogram for Frida during the cw



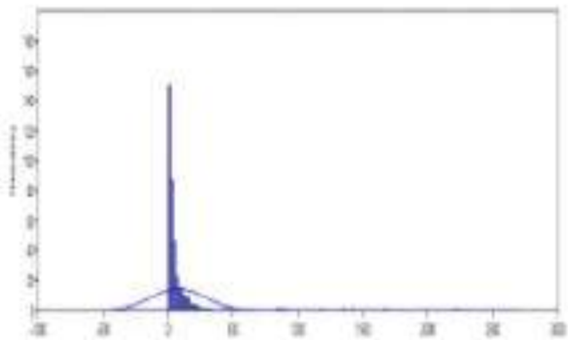
(b) Object Licking histogram for Frida during cw



(c) Resting histogram for Frida during cw

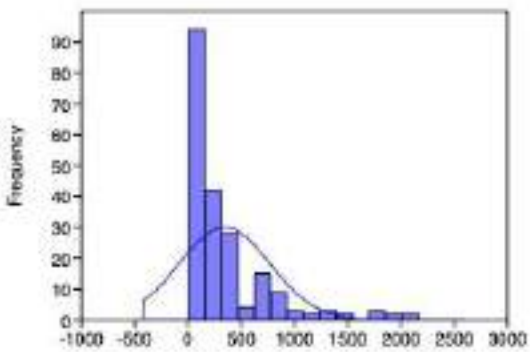


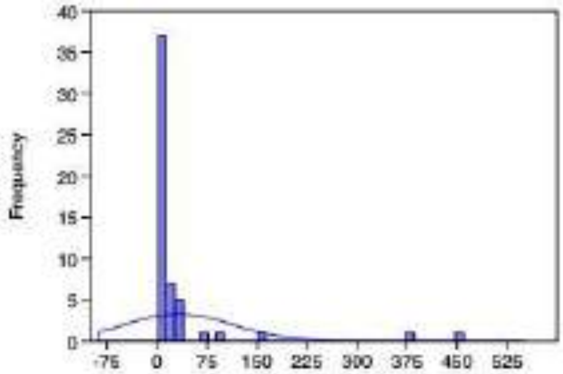
(d) Follow histogram for Frida during cw



(e) Scanning histogram for Frida during cw

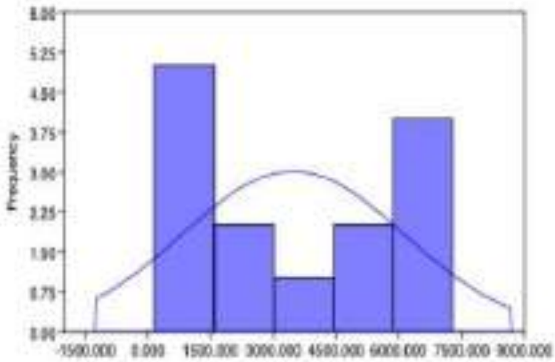
E.9 Karim AHW

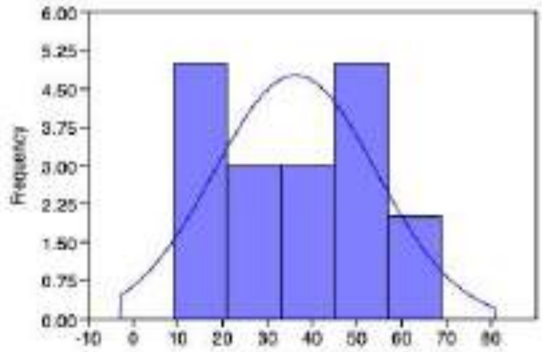




(a) Eating histogram for Karim during the ahw

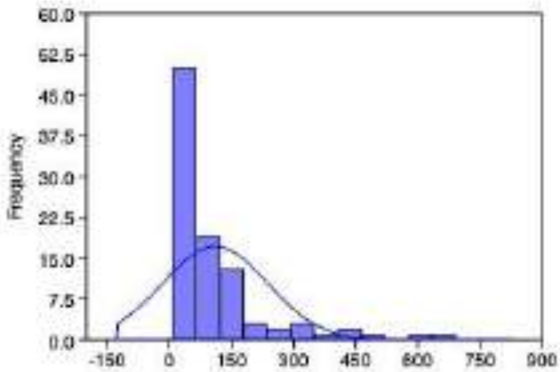
(b) Object Licking histogram for Karim during ahw

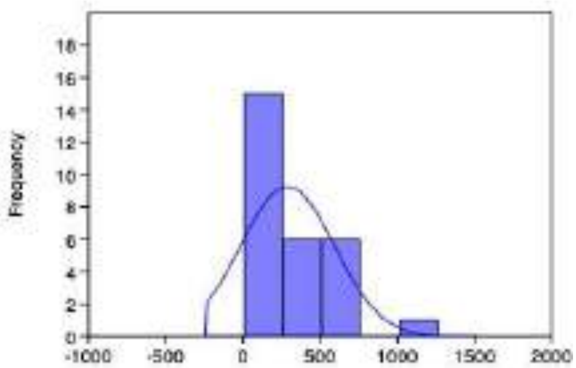




(c) Resting histogram for Karim during ahw

(d) Follow histogram for Karim during ahw

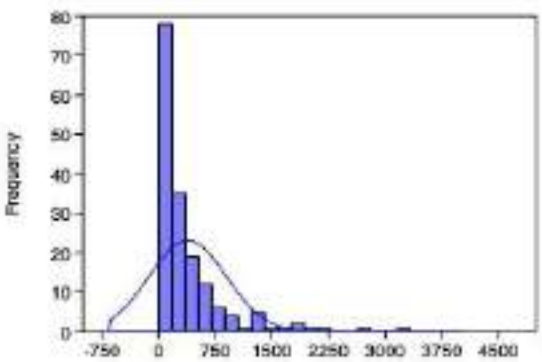




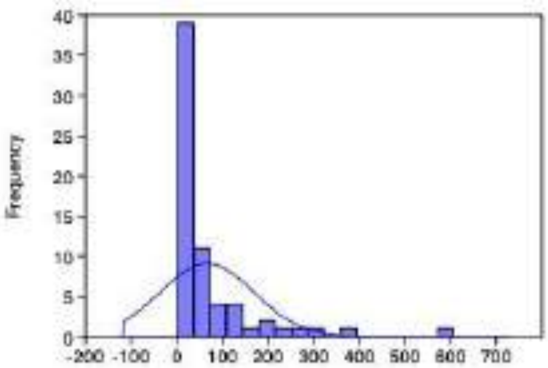
(e) Scanning histogram for Karim during ahw

(f) Sparring histogram for Karim during ahw

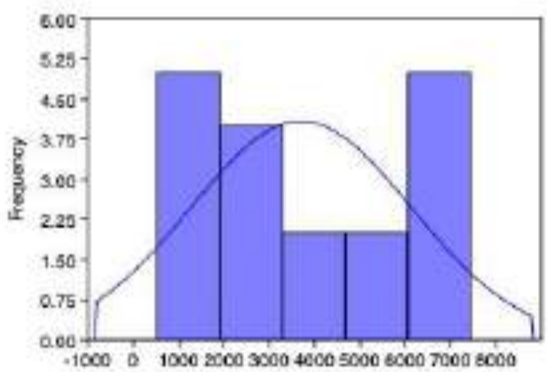
E.10 Karim CW



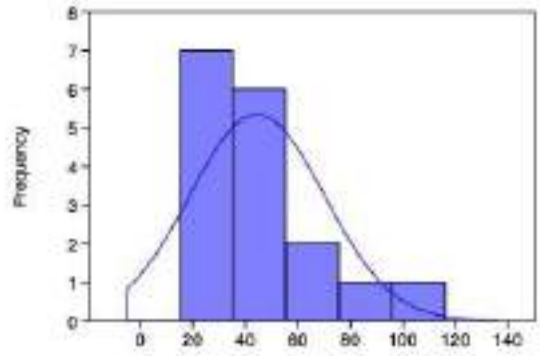
(a) Eating histogram for Karim during the cw



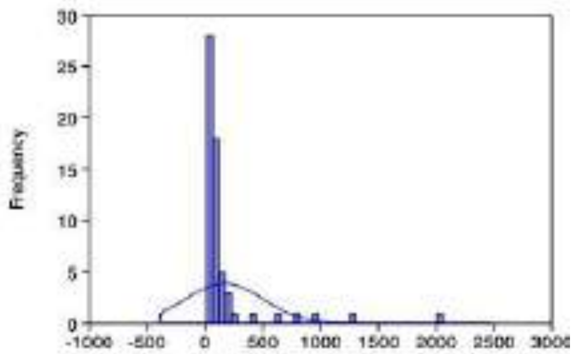
(b) Object Licking histogram for Karim during cw



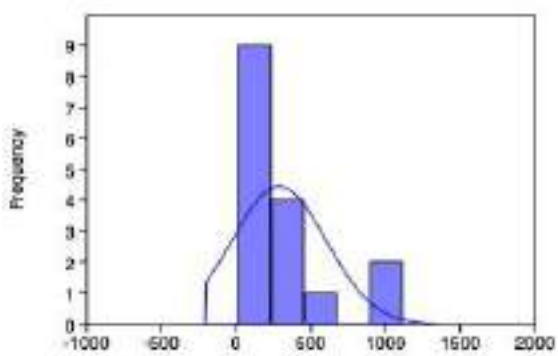
(c) Resting histogram for Karim during cw



(d) Follow histogram for Karim during cw

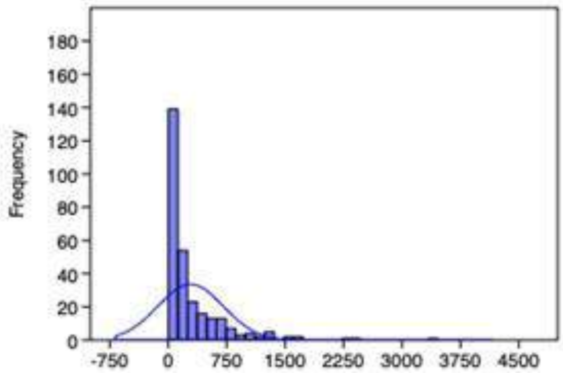


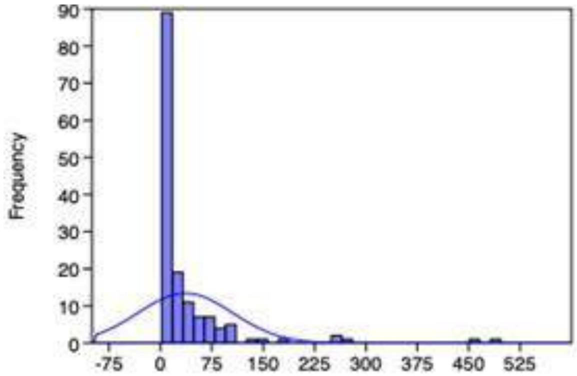
(e) Scanning histogram for Karim during cw



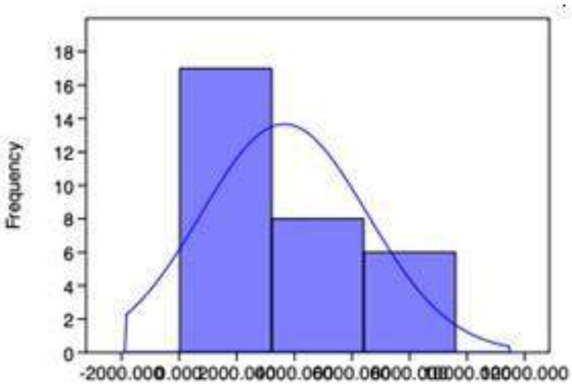
(f) Sparring histogram for Karim during cw

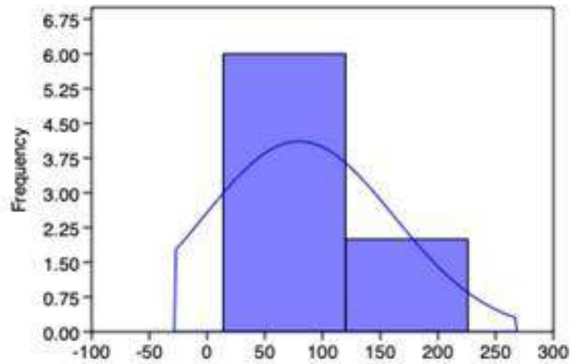
E.11 Qolile AHW



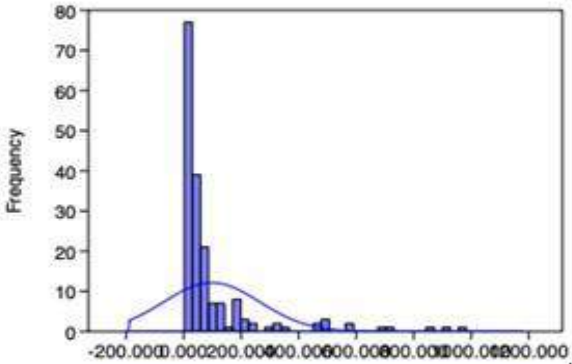


(a) Eating histogram for Qolile during the ahw**(b)** Object Licking histogram for Qolile during ahw



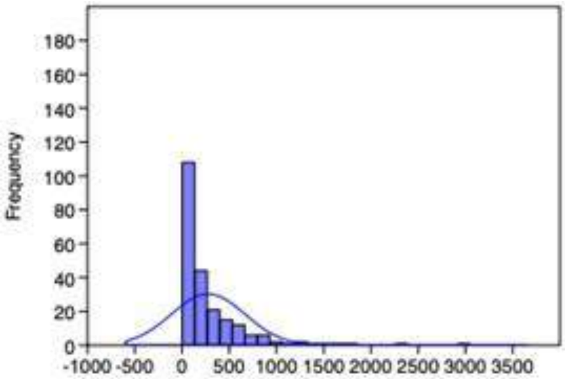


(c) Resting histogram for Qolile during ahw **(d)** Following histogram for Qolile during ahw

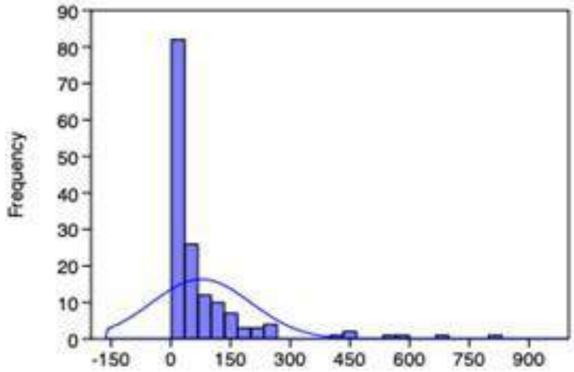


(e) Scanning histogram for Qolile during ahw

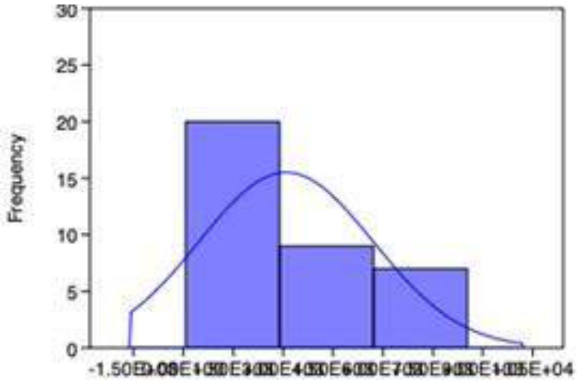
E.12 Qolile CW



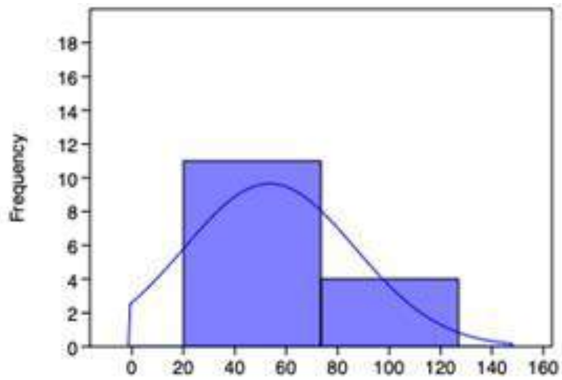
(a) Eating histogram for Qolile during the cw



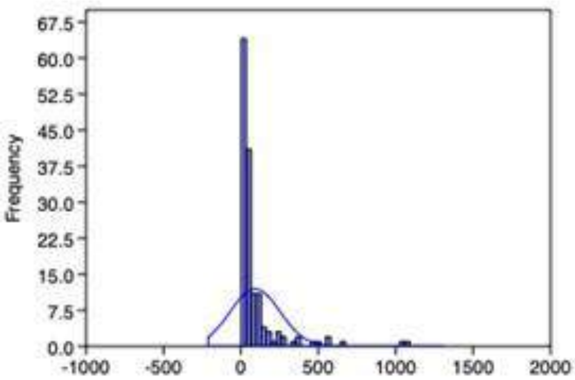
(b) Object Licking histogram for Qolile during cw



(c) Resting histogram for Qolile during cw



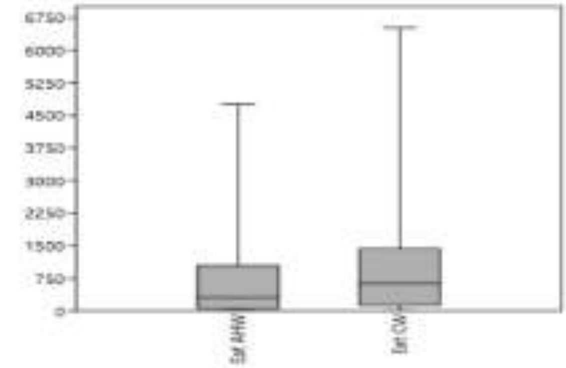
(d) Following histogram for Qolile during cw

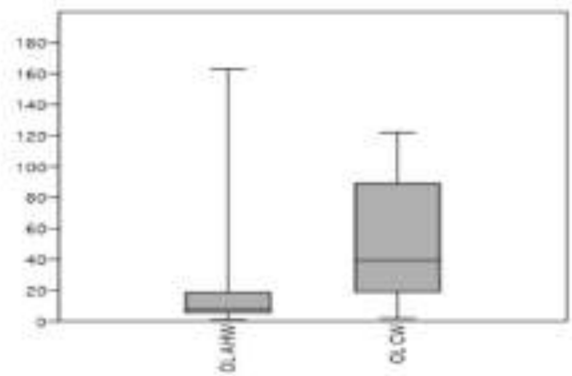


(e) Scanning histogram for Qolile during cw

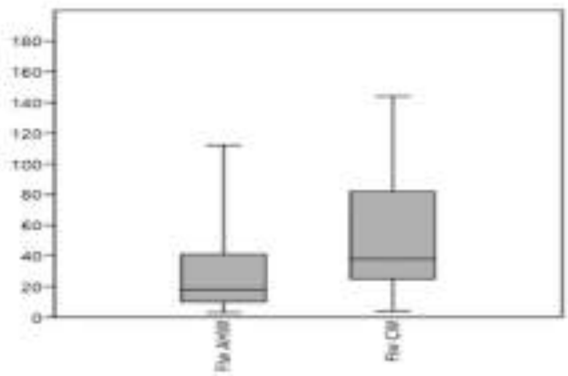
F. Appendix - Boxplot

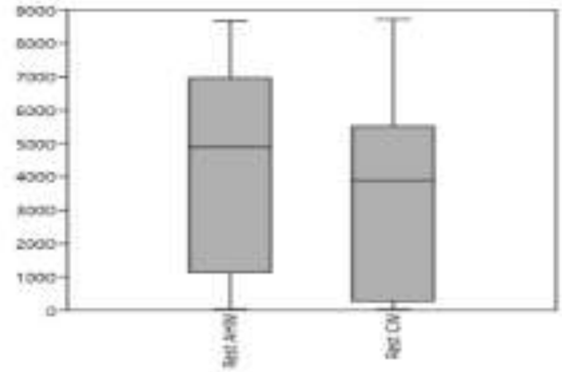
F.1 Basse



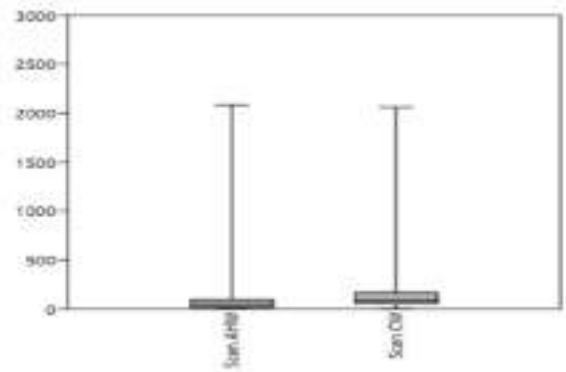


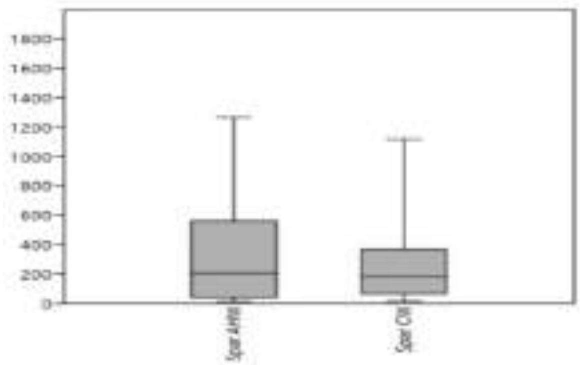
(a) Boxplot for Basse eating during AHW and CW**(b)** Boxplot for Basse object licking during AHW and CW



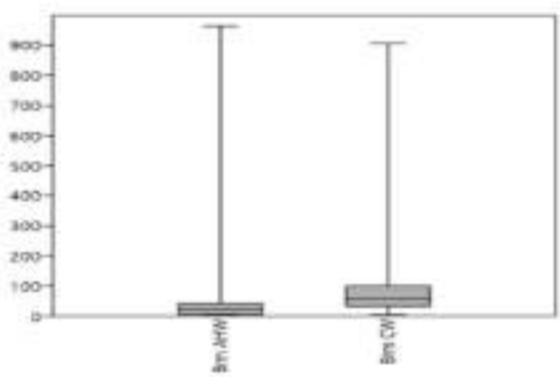


(c) Boxplot for Basse following during AHW and CW**(d)** Boxplot for Basse resting during AHW and CW



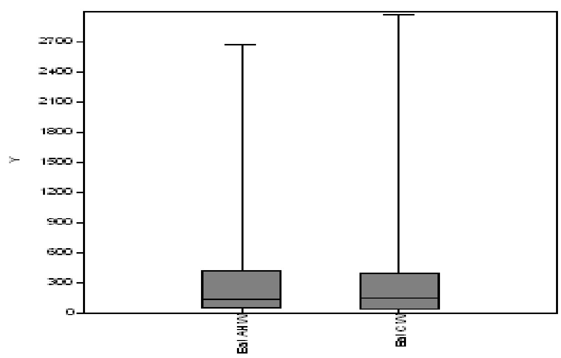


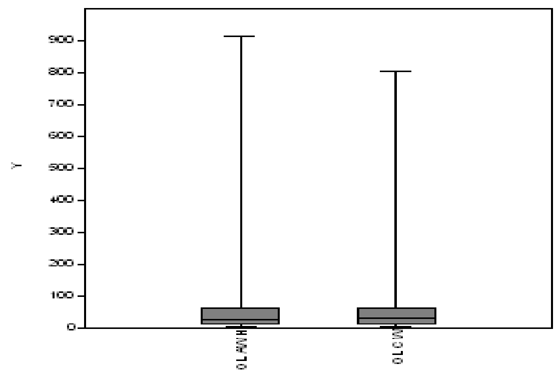
(e) Boxplot for Basse scanning during AHW and CW**(f)** Boxplot for Basse sparring during AHW and CW



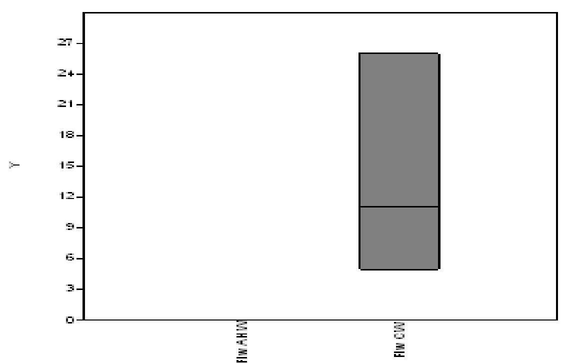
(g) Boxplot for Basse interacting with the broom during AHW and CW

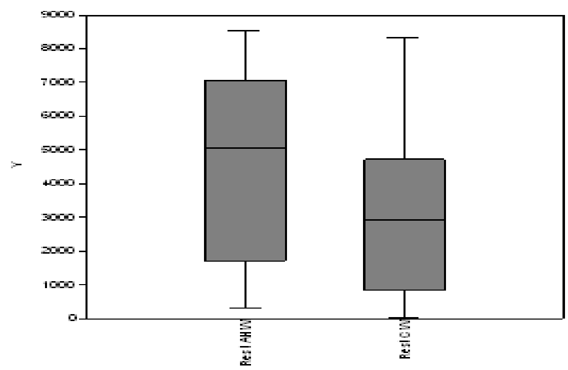
F.2 Caroline





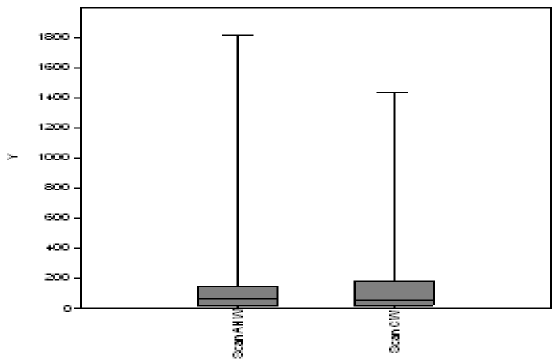
(a) Boxplot for Caroline eating during AHW and CW**(b)** Boxplot for Caroline object licking during AHW and CW





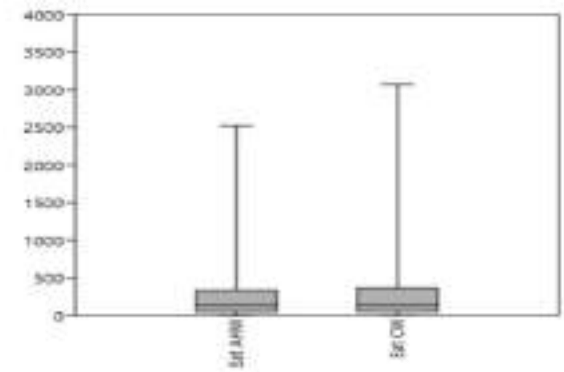
(c) Boxplot for Caroline following during AHW and CW. **(d)** Boxplot for Caroline resting during AHW and CW period

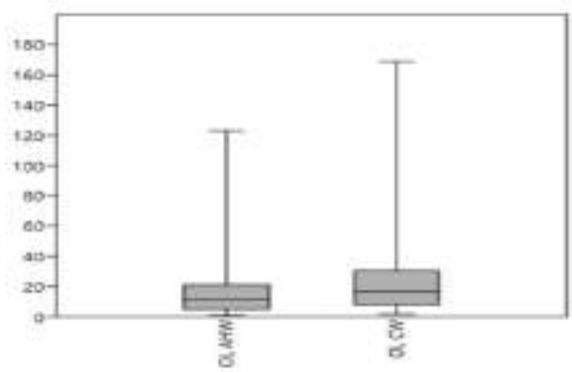
Only three points for CW were noted during the observation



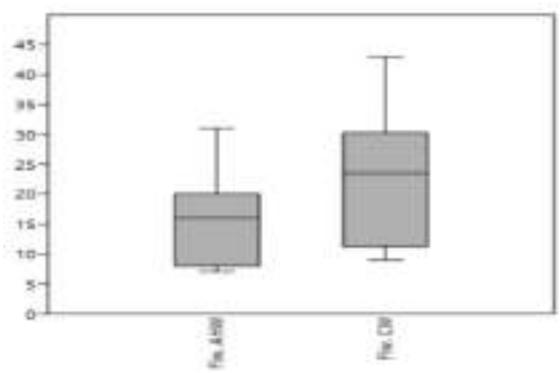
(e) Boxplot for Caroline scanning during AHW and CW

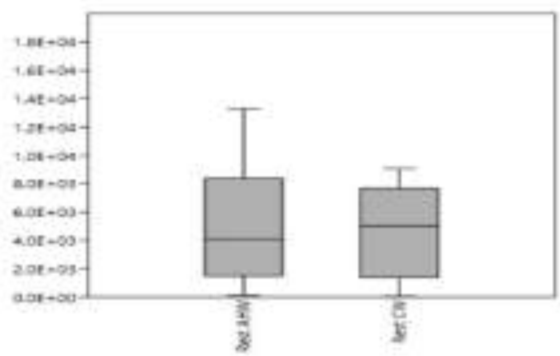
F.3 Frida



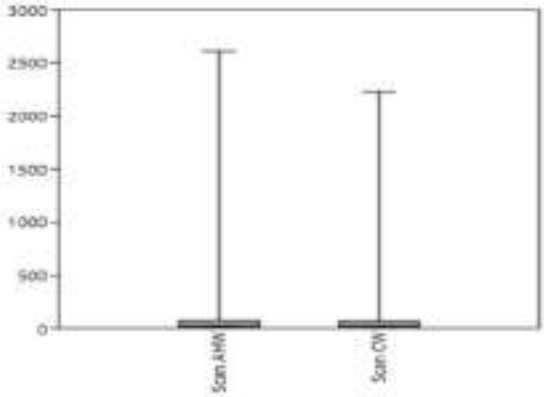


(a) Boxplot for Frida eating during AHW and CW**(b)** Boxplot for Frida object licking during AHW and CW



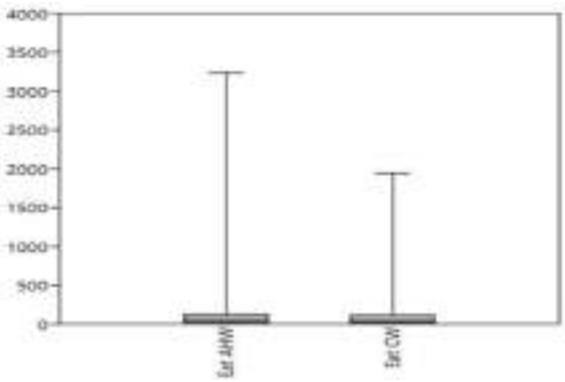


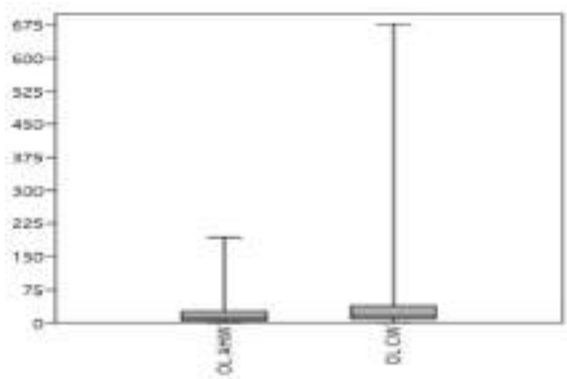
(c) Boxplot for Frida following during AHW and CW**(d)** Boxplot for Frida resting during AHW and CW



(e) Boxplot for Frida scanning during AHW and CW

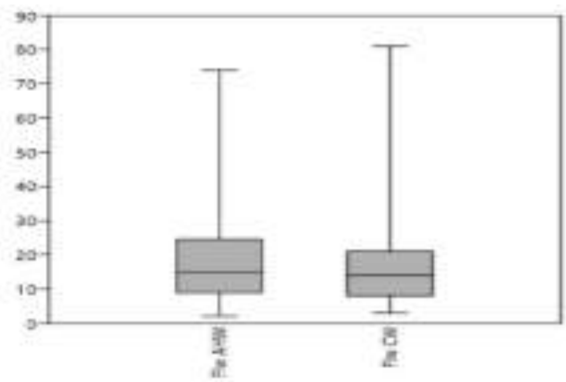
F.4 Dumisani

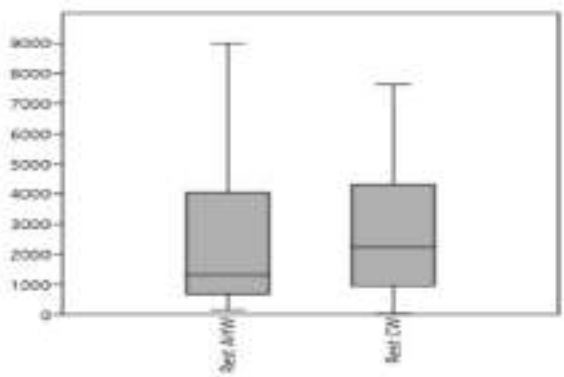




(a) Boxplot for Dumisani eating during AHW and CW

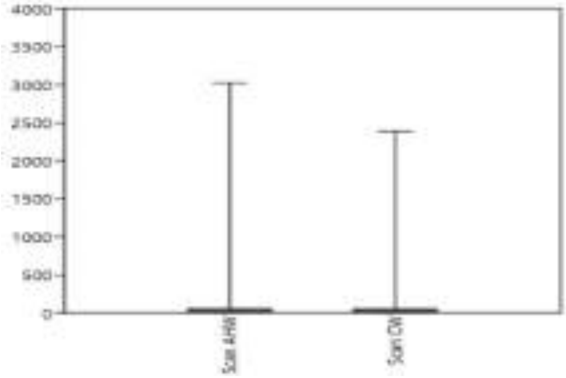
(b) Boxplot for Dumisani object licking during AHW and CW





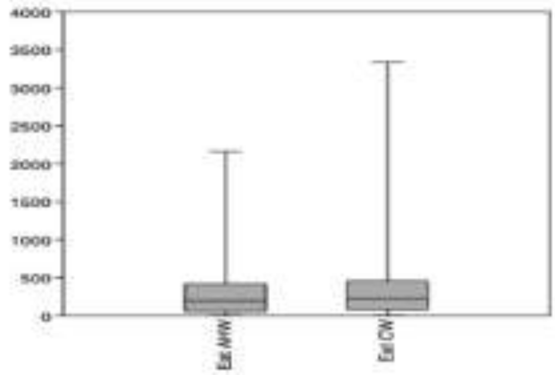
(c) Boxplot for Dumisani following during AHW and CW

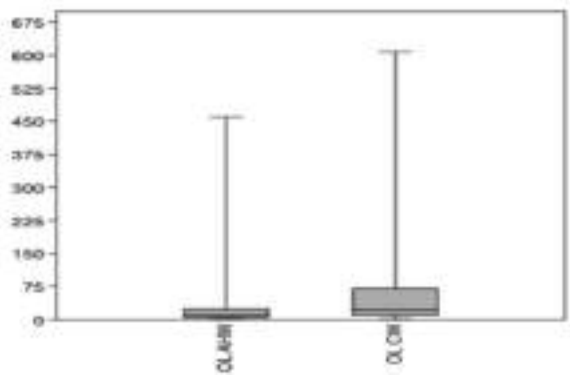
(d) Boxplot for Dumisani resting during AHW and CW



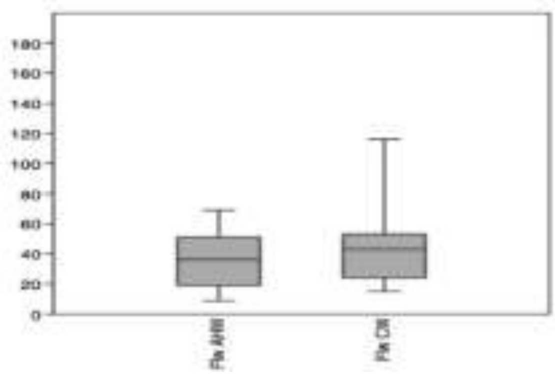
(e) Boxplot for Dumisani scanning during AHW and CW

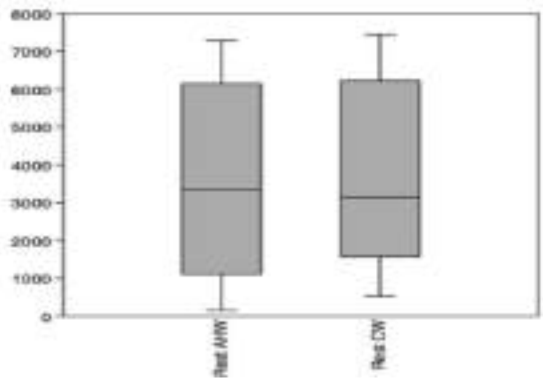
F.5 Karim



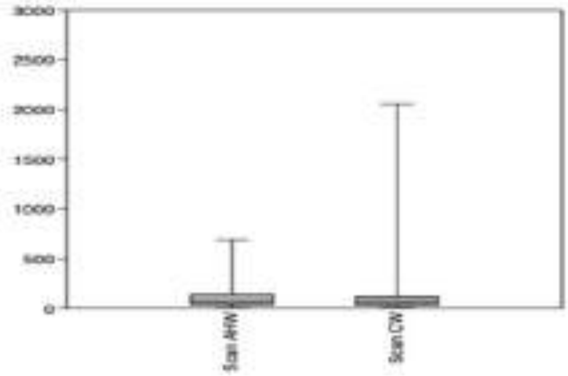


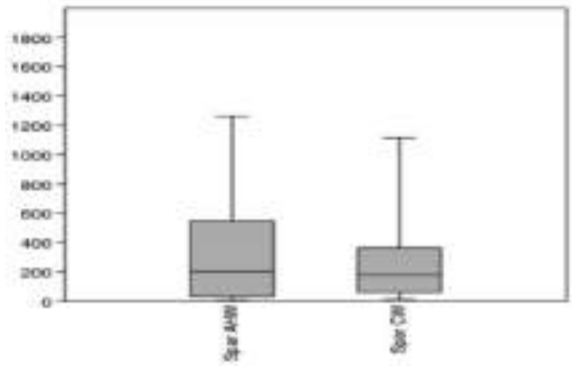
(a) Boxplot for Karim eating during AHW and CW **(b)** Boxplot for Karim object licking during AHW and CW





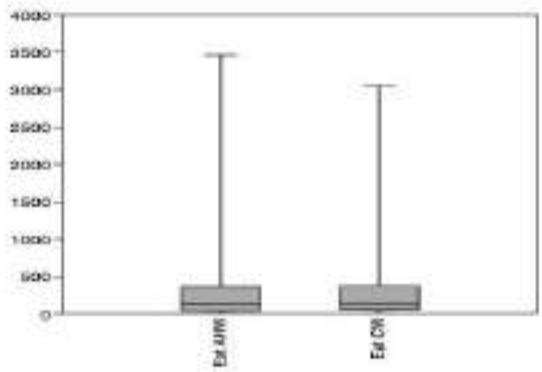
(c) Boxplot for Karim following during AHW and CW**(d)** Boxplot for Karim resting during AHW and CW

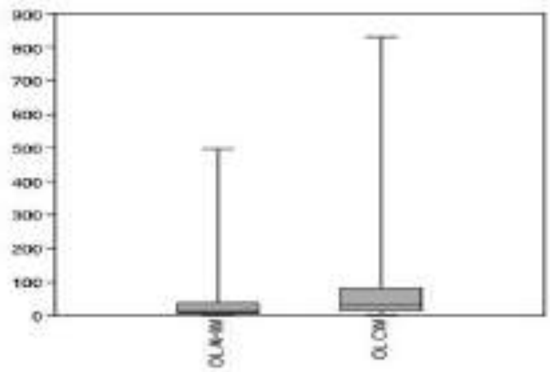




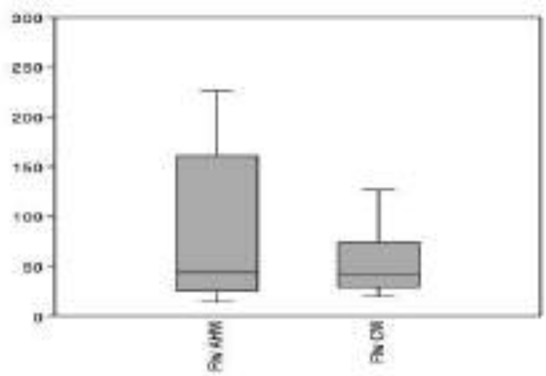
(e) Boxplot for Karim scanning during AHW and CW**(f)** Boxplot for Karim sparring during AHW and CW

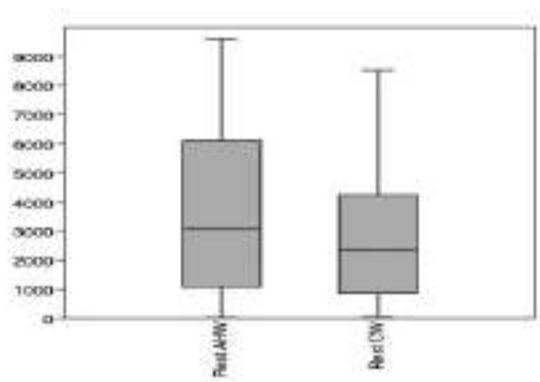
F.6 Qolile



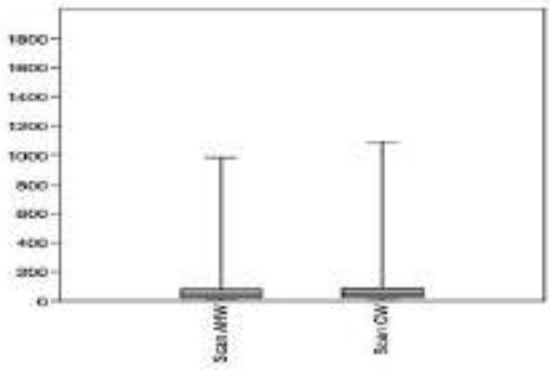


(a) Boxplot for Qolile eating during AHW and CW **(b)** Boxplot for Qolile object licking during AHW and CW





(c) Boxplot for Qolile following during AHW and CW**(d)** Boxplot for Qolile resting during AHW and CW



(e) Boxplot for Qolile scanning during AHW and CW

G. Appendix - Correlation

Correlation values for each individual showing the agreeability of when behaviours were happening of the operators. The N/A indicates that not enough (more than 10) data points were collected

G.1 Basse

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	0.9998	0.99983
Object Licking	N/A	N/A
Resting	0.97672	0.95707
Follow	1	1
Scanning	1	1
Sparring	0.98343	0.98309
Broom	N/A	N/A

G.2 Caroline

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	1	1
Object Licking	1	1
Resting	N/A	N/A
Follow	N/A	N/A
Scanning	N/A	N/A
Sparring	1	1

G.3 Dumisani

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	0.9998	0.99983
Object Licking	N/A	N/A
Resting	0.97672	0.95707
Follow	1	1
Scanning	1	1
Sparring	0.98343	0.98309
Broom	N/A	N/A

G.4 Frida

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	0.9998	0.99983
Object Licking	N/A	N/A
Resting	0.97672	0.95707
Follow	1	1
Scanning	1	1
Sparring	0.98343	0.98309
Broom	N/A	N/A

G.5 Karim

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	1	1
Object Licking	1	1
Resting	N/A	N/A
Follow	N/A	N/A
Scanning	N/A	N/A
Sparring	1	1

G.6 Qolile

Behaviour	Correlation values for startpoint	Correlation values for endpoint
Eat	0.98057	0.9809
Object Licking	0.97955	0.97986
Resting	0.98883	0.9842
Follow	N/A	N/A
Scanning	0.96332	0.96363

H. Appendix - Mann-Whitney

Table H.1: Mann-Whitney p-values for each behaviour for each individual

	Basse	Caroline	Frida	Karim	Qolile	Dumisani
Eat	$p = 0.0087$	$p = 0.5446$	$p = 0.5563$	$p = 0.3408$	$p = 0.6159$	$p = 0.8027$
Obj. lick.	$p = 0.0001$	$p = 0.3612$	$p = 0.0065$	$p = 0.0002$	$p = 0.0001$	$p = 0.0001$
Resting	$p = 0.4856$	$p = 0.1087$	$p = 0.655$	$p = 0.6946$	$p = 0.5209$	$p = 0.2898$
Follow	$p = 0.131$	N/A	$p = 0.223$	$p = 0.5239$	$p = 0.91164$	$p = 0.4564$
Sparring	$p = 0.9161$	X	X	$p = 0.8613$	X	X
Scanning	$p = 0.0002$	$p = 0.8233$	$p = 0.8743$	$p = 0.9337$	$p = 0.622$	$p = 0.001$
Broom	$p = 0.0091$	X	X	X	X	X

I. Appendix - Chi-squared test of the time percentages

Table I.1: chi-squared test of time percentages for one individual between two weeks

	Basse	Caroline	Frida	Karim	Qolile	Dumisani
Eat	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Object licking	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Resting	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Follow	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Sparring	N.S.	X	X	N.S.	X	X
Scanning	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Broom	N.S.	X	X	X	X	X
Not noted	N.S.	$p < 0.05$	N.S.	N.S.	N.S.	N.S.

Table I.2: chi-squared test of time percentages for eating during CW

Eat CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	$p < 0.05$	N.S.	N.S.	X	X
Qolile	$p < 0.05$	N.S.	$p < 0.05$	N.S.	X
Dumisani	$p < 0.05$	$p < 0.05$	$p < 0.05$	N.S.	N.S.

Table I.3: chi-squared test of time percentages for object licking during CW

Object licking CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table I.4: chi-squared test of time percentages for resting during CW

Resting CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	$p < 0.05$	$p < 0.05$	N.S.	$p < 0.05$	N.S.

Table I.5: chi-squared test of time percentages for follow during CW

Follow CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table I.6: chi-squared test of time percentages for sparring during CW

Sparring CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	X	X	X	X	X
Karim	N.S.	X	X	X	X
Qolile	X	X	X	X	X
Dumisani	X	X	X	X	X

Table I.7: chi-squared test of time percentages for scanning during CW

Scanning CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	$p < 0.05$	N.S.	N.S.	$p < 0.05$	$p < 0.05$

Table I.8: chi-squared test of time percentages for not noted during CW

Not noted CW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	$p < 0.05$	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	$p < 0.05$	N.S.

Table I.9: chi-squared test of time percentages for eating during AHW

Eat AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	$p < 0.05$	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table I.10: chi-squared test of time percentages for object licking during AHW

Object licking AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table I.11: chi-squared test of time percentages for resting during AHW

Resting AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	$p < 0.05$	N.S.	$p < 0.05$	X	X
Qolile	N.S.	$p < 0.05$	N.S.	$p < 0.05$	X
Dumisani	N.S.	$p < 0.05$	N.S.	$p < 0.05$	N.S.

Table I.12: chi-squared test of time percentages for follow during AHW

Follow AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	N.S.	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	N.S.	N.S.	N.S.	N.S.	N.S.

Table I.13: chi-squared test of time percentages for sparring during AHW

Sparring AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	X	X	X	X	X
Frida	X	X	X	X	X
Karim	N.S.	X	X	X	X
Qolile	X	X	X	X	X
Dumisani	X	X	X	X	X

Table I.14: chi-squared test of time percentages for scanning during AHW

Scanning AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	N.S.	X	X	X	X
Frida	$p < 0.05$	N.S.	X	X	X
Karim	N.S.	N.S.	N.S.	X	X
Qolile	N.S.	N.S.	N.S.	N.S.	X
Dumisani	$p < 0.05$	$p < 0.05$	N.S.	$p < 0.05$	N.S.

Table I.15: chi-squared test of time percentages for not noted during AHW

Not noted AHW	Basse	Caroline	Frida	Karim	Qolile
Caroline	$p < 0.05$	X	X	X	X
Frida	N.S.	$p < 0.05$	X	X	X
Karim	$p < 0.05$	N.S.	$p < 0.05$	X	X
Qolile	N.S.	$p < 0.05$	N.S.	$p < 0.05$	X
Dumisani	N.S.	$p < 0.05$	N.S.	N.S.	N.S.

J. Appendix - Chi-squared for Simpson's and Shannon's indices

Table J.1: Chi-squared tests for the Simpson's and Shannon's indices

	Basse	Caroline	Frida	Karim	Qolile	Dumisani
CW Simpson's	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CW Shannon's	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
AHW Simpson's	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
AHW Shannon's	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.