RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Behaviour of Hens in Cages

- a pilot study using video tapes

A report for the Rural Industries Research and Development Corporation

by Clare Rudkin and Geoff D. Stewart

August 2002

RIRDC Publication No 02/…
RIRDC Project No UQ-97A

ISBN 0 642 (…RIRDC to assign)
ISSN 1440-6845

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Publication No. 02/
Project No. UQ-97A

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In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form.

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Published in August 2002
Printed on environmentally friendly paper by Canprint

Foreword

There is a widely held public perception that the welfare of hens in cages is poor. Hens are perceived to be too crowded, and they cannot perform many of their natural behaviours such as scratching and pecking, nesting, dust bathing and perching.

Many alternative systems have been developed to try to address some of these problems. They aim to increase the opportunity for behavioural expression. One alternative is the Edinburgh Modified Cage designed at the Roslin Institute which contains a perch, nest, and a litter box for dust bathing. It is important that behavioural expression in modified cages and in conventional cages is carefully analyzed in order to evaluate the welfare of the hens in the two systems.

As a pilot study, time-lapse videos of two strains of hens in Edinburgh cages and in modern conventional Harrison cages have been viewed and behavioural data collected to assess the relative welfare in the two systems.

This publication describes how the data were collected and how the behavioural results can be interpreted to assess relative welfare. By comparing different sampling techniques, we are able to recommend the most appropriate techniques for obtaining data for specific behaviours. We have also been able to develop ways to reliably identify behaviours in these speeded up photos. We have identified problems in the original experimental set up and have suggested improvements for future studies.

This project was funded from industry revenue which is matched by funds provided by the Federal government.

This report, a new addition to RIRDC'S diverse range of over 800 research publications, forms part of our Egg R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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Simon Hearn
Managing Director
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Acknowledgements

We wish to thank the RIRDC for funding for this work, and the School of Animal Studies, University of Queensland, Gatton for their support.

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Abbreviations

cm - centimetre
h – hour
min – minute
mm – millimetre
s – second

AzH20 – light bodied Aztec hens in conventional Harrison cage 20
T.H19 – heavy bodied Tegel hens in conventional Harrison cage 19
AzEd3 – light bodied Aztec hens in Edinburgh Modified cage 3
AzEd18 – light bodied Aztec hens in Edinburgh Modified cage 18
T.Ed13 – heavy bodied Tegel hens in Edinburgh Modified cage 13
T.Ed5 – heavy bodied Tegel hens in Edinburgh Modified cage 5

Executive Summary

This pilot study aimed to develop ways of collecting and analyzing data from time-lapse videos of the behaviours of hens in different housing systems to assess how cage space is used, and to enable assessment of their relative welfare status.

Many alternative housing systems have been developed in an attempt to provide for a greater repertoire of behaviours than is provided for in the usual conventional cages. One of these modified cage systems is the Edinburgh cage which provides a perch, nest, and litter box.

Time-lapse videos were taken of representative heavy bodied and light bodied Australian strains of layer hens in conventional Harrison cages and in Edinburgh cages (the Edinburgh Modified Cage developed at the Roslin Institute, Appleby and Hughes, 1995). The two dissimilar strains were used because it was thought that birds of different size and temperament would be differently affected by different housing. The heavy bodied strain used was the Tegel, and the light bodied strain was the Aztec. Two Harrison cages were videoed, one with four heavy bodied hens, and the other with four light bodied hens. Four Edinburgh cages were videoed, two each with four heavy bodied hens, and two each with four light bodied hens. The videos took in the whole 16 hour day from lights on to lights off for each cage.

Data were collected by 30s scan sampling over nine or ten half-hour periods over the day. These times included the first and last half hour of the day, and the half hour after feeding. Each hen that laid an egg was observed for two hours before and half an hour after laying. At each scan the position of the hen in the cage and her main activity was recorded. Continuous monitoring was carried out over the same time periods, and time to start and stop the more continuous behaviours, and the number of bouts of the shorter behaviours were recorded. Continuous monitoring over the whole day was also carried out to assess total nest and litter box use.

There was a pronounced effect of the presence of a nest on the pre lay behaviour of the hens in the Edinburgh cages. The nest (or sometimes the litter box) was readily accepted as a laying site, and hens showed an interest (by looking) in the site for some time before laying. Pre lay pacing and aggression were generally much reduced in Edinburgh cages compared with Harrison cages. Before laying in Harrison cages, hens often moved rapidly about the cage and attempted to peck hens in neighbouring cages. The light bodied hens did not sit during this period, but heavy bodied hens alternately sat and paced. Closer to time of lay, hens of either strain in the Harrison cages attempted to creep under their cage mates. Since pre lay behaviour took 10min to 2h, it could be said that the presence of the nest improved welfare for up to two hours, or 12.5% of the day.

The addition of the nest and litter box made Edinburgh cages more spacious than the Harrison cages. Edinburgh cages provided 630 cm^2 per bird in the main part of the cage and an additional 225 cm^2 floor space per bird in the nest box. This added up to 855 cm^2 per bird compared with 700 cm^2 in the Harrison cage. As well as this, the litter box provided even more space. It was thought that this extra space might improve welfare, so we looked at behaviours that might indicate greater comfort for the birds. Amount of movement was estimated since the extra space may be less confining for the birds. Status effects on behaviours, and cage space use by individual hens were measured because more restricted space may inhibit low status hens. The ability to "get away" into nest or litter box may reduce aggression towards low status hens, so aggression rates were measured. The extra space may allow more comfort movements so frequency of comfort movements was measured.

However, the extra space did not seem to affect most of these parameters. There was considerable individual variability, but the hens in the Edinburgh cages did not move about more than those in the Harrison cages. Apart from two bullied hens in two of the Edinburgh cages, the use of different parts of the cage did not seem to be related to social status in either cage type. Moreover, the amount of movement, feeding, standing, sitting, preening and drinking were also unrelated to social status in both

cage types. Aggression was not reduced in Edinburgh cages, and in fact appeared to be greater than in Harrison cages. In two Edinburgh cages, the lowest status hen was chased and pecked by some of their cage mates when in the main part of the cage, and spent a large part of the day taking refuge in the litter box. The incidence of preening, stretching, bilateral wing raise, and feather ruffling was similar in both cage types. Thus the extra space seemed only to exacerbate aggression and could therefore be seen as reducing welfare.

In conventional cages, hens are perceived by the public to be "bored" because they are restricted in the range of behaviours they can perform. Edinburgh cages are said to be "enriched" because they enable nesting, litter pecking, dust bathing, and perching. However, it is necessary to demonstrate that the cages are indeed enriching to the hens by showing that the hens are in fact, less "bored". Boredom is a subjective state presumed to be experienced by animals unable to express desired behaviours. In order to assess this state, one can measure behaviours known to be associated with more restricted housing. Higher rates of food manipulation, standing, sitting, feather pecking and stereotypies are known to occur in more restricted housing than in more open housing. There was considerable individual variability, but overall no differences were evident for feeding, standing, sitting or feather peck rates by birds in either cage type. Stereotypies were encountered in both cage systems. Thus, the extra facilities did not affect behaviours known to be associated with more restricted housing, and judging by this evidence, the subjective state of the hens may not have been greatly affected by the enriched cages.

As stated above, the nest in the Edinburgh cages was readily accepted by most birds as a laying site. However, it was rarely entered by birds at other times of the day, and then only for short periods. Bullied hens sometimes entered it, but did not remain for long periods.

The litter box was used only by three of the 16 hens observed for dust bathing. Of these, one sham dust bathed twice on the perch even though the litter box was unoccupied at the time. Another hen did not enter the litter box at any time, but sham dust bathed on the wire floor at the front even though the litter box was unoccupied at the time. Four hens entered the litter box at times, but did not dust bath in it, three hens did not enter it at any time. Two bullied hens remained in the litter box for long periods. In this position they were unable to access food or water. Two hens laid an egg in the litter box, and one hen was broody and remained in the litter box most of the day. Litter was sometimes pecked but total litter peck bouts were low. The maximum time the litter box was entered other than to use as a refuge or nest was 9% of the day. Thus it could be seen that the litter box improved welfare for some hens for up to 9% of the day.

The perch in Edinburgh cages was used similarly to the middle and back of the Harrison cages. At lights on, most but not all of the hens were sitting on the perch in Edinburgh cages, while hens were usually in the middle or back of the cage in Harrison cages. During the day, most birds sat or preened more often at these sites than at the front of the cage. Hens were on the perch for 40% of the day. In comparison, hens ranging in semi natural conditions are reported to rarely perch during the day. None of the eight light bodied hens, and only two of the eight heavy bodied hens in the Edinburgh cages used the area behind the perch, and one of these only entered this area when bullied. Overall, it seems that the benefits of the perch were not obvious, and it may restrict cage space use.

Overall, time of day did not seem to affect behaviour to any large extent in either cage by either strain. However, some changes in behaviour were evident at the start and end of the day, and at the time the birds were fed. Hens were often more active, preened and stretched more, but fed less during the first half hour of the day than during the next scan. During the last half hour they tended to feed less and sit more than during the previous scan. Topping up the food trough had a pronounced effect on behaviours with more food pecking, drinking, and activity during the subsequent half hour. Feather pecking and aggression were usually reduced or unaffected at this time except in the cages with bullied hens. No other consistent diurnal changes were evident, and no cage or strain differences could be detected.

The only strain differences evident were associated with aggressive and pre lay behaviour. No other behaviours noticeably differed. Both strains used the cage spaces in both cage types similarly, and in the Edinburgh cages, both the light bodied strain and the heavy bodied strain rarely entered the space behind the perch.

This pilot study has enabled assessment of the best methods of data collection from video tapes to obtain the maximum information. Comparison of data obtained by scan sampling with data obtained by continuous measurement showed that scan sampling of the more frequent behaviours gave a reliable estimate of their incidence, while continuous monitoring was necessary to estimate the less frequent behaviours. Diurnal changes in behaviour did not differ between strain and cage type. Therefore it is probably not necessary to collect this sort of data to assess relative welfare. One or two hours of observation of each cage morning and afternoon each day should be sufficient. Time of day affected behaviours at the start and end of the day and after feeding, and around laying time, so these times should be avoided to obtain a typical sample of behaviour. Due to the high individual variability, it is recommended that sufficient replicates of each treatment be obtained. Previous experience has shown that six to eight replicates reveal significant differences for biologically significant effects. It is important to have a good number of replicates since many of the important findings are lack of difference rather than difference.

Future studies would duplicate current strains and practices to make the findings more relevant to modern practices. New methods for marking hens will need to be developed, as problems were encountered with the methods used. Feeding and tending the birds should be confined to a set period of the day as these activities strongly affected behaviour. If birds are able to interact with birds in other cages, then the video picture should include portions of the adjoining cages. The egg tray should also be included so that egg laying can reliably be determined. Status should be determined experimentally because some birds did not interact during the period of videoing. Feather scores should be taken as well as feather peck observations. Foot and keel condition should be measured to add information as to the welfare status of perches. Physical egg production and quality parameters should be recorded and assessed along with the behavioural data for a full assessment of cage type.

These preliminary findings have shown how behavioural data obtained from time-lapse videos can be used to assess relative welfare status. The methods used here can be adapted to all other housing systems. We have identified problems with the original experimental set up and have made suggestions as to how these can be overcome.

Our preliminary assessment of the benefits of the Edinburgh cages is that the nest improved welfare for laying hens for up to 12.5% of the day, and the litter box for up to 9% of the day. The benefits of the perch were less clear. The low use of the nest and litter box and the part of the cage behind the perch suggested that these areas should not be included in per bird cage-space allowance estimates. The extra space provided by the nest and litter box in Edinburgh cages did not appear to affect behaviours that may be associated with amount of space, except for aggression which seemed to be increased. The extra facilities in Edinburgh cages did not affect behaviours known to be affected by restricted housing and may not have been behaviourally enriching for the hens involved.

The parameters measured in this study should complement other studies which measure such parameters as stress hormone levels and fear levels.

This pilot study should be followed up with more studies to allow firm conclusions to be drawn. The preliminary findings of this study have important implications for the poultry industry. We have identified important trends and it is recommended that such studies are performed before expensive changes to housing systems are undertaken.

1. Introduction

Brambell (1965) established a list of the basic freedoms which all farm animals should enjoy. These have become universally recognised as "the five freedoms" which have been described by the UK Farm Animal Welfare Council as:

1. Freedom from thirst, hunger and malnutrition;
2. Appropriate comfort and shelter;
3. Prevention, or rapid diagnosis and treatment, of injury and disease;
4. Freedom to display most normal patterns of behaviour;
5. Freedom from fear.

Conventional cage systems provide adequately for points 1 and 3, but crowding may reduce comfort, and these systems provide little opportunity to express most patterns of behaviour. In conventional cages, hens cannot perch, scratch and peck, dust bathe, nest, or flap their wings. In an attempt to enable a wider repertoire of behaviours, many alternative husbandry systems have been developed and tested (Appleby *et al*, 1992). They include free range systems, strawyards, deep litter, aviaries and percheries, and modified cages. Poor working conditions, difficulty monitoring bird health, dust, and cannibalism can be problems in many of these. Modified enriched cages have been developed to address hens' physical and behavioural problems while retaining such features as small group size and removal from faeces that have made cages successful (Appleby and Hughes, 1990; Tauson, 2000). The Edinburgh Modified Cage is one such cage (Appleby and Hughes, 1995; Tauson, 2000). This cage provides a wide cage area with a perch across its middle from side to side and far enough back so that food cannot be reached from it; and a nest with a litter box above it to one side.

This cage is said to be "enriched" because it provides for a greater repertoire of behaviours. However, it is important that the behavioural expression in alternative systems be carefully analysed and compared with the conventional cage it is designed to replace. The extra facilities may not be adequate to stimulate the required behaviours, and some important behaviours may still be unprovided for. Only by studying the behaviours can it be seen if the modifications are truly enriching for the birds, and the true impact on welfare be assessed. It is necessary to know how the extra space affects behaviours, how, and how much the extra facilities are used, and whether behaviours known to be affected by restricted housing are positively affected. It is important to know the true welfare impact of alternative housing before it is adopted by the industry.

This is a report of a pilot study of the behaviours of laying hens of a light and a heavy bodied Australian strain in modern conventional Harrison cages and in furnished Edinburgh cages. We collected data from time-lapse videos recorded in 1995 of hens in experimental cages from a previous study.

2. Objectives

Many welfare judgements are based on perceptions rather than on hard data. The aim was to show how data could be collected so that the real impact of housing on hens' welfare can be properly assessed. This should add valuable insight into the welfare status of hens in varying housing regimes. By careful observation, we can promote better design, and debug myths. Informed recommendations can be made that will have optimum impact on welfare, and changes that have dubious or minimal benefits will be avoided.

This study aimed to trial methods of data collection from time-lapse videos and develop techniques for a complete study to fully assess the relative welfare status of hens in Harrison cages and in Edinburgh cages. Two dissimilar strains were used as it was expected that hens of different size and temperament may be affected in different ways. Data were collected and subjected to summary analysis to identify trends, and evaluate the sort of information and the best way to collect it to assess relative welfare status.

Firstly, we aimed to measure how much, and how, the extra facilities in the Edinburgh cage were used, and how they affected hens' behaviours such as pre lay restlessness and sham dust bathing.

We aimed to assess of the effect of the more spacious accommodation of Edinburgh cages compared to Harrison cages. In order to achieve this, we compared how much movement there was in each cage type to see if the changed space allowance enabled more movement. Welfare is not just about the flock mean, it is very much about the state of the individual hen within the flock or group. So we also looked at data of individual use of cage parts to see if low status individuals were able to have equal access to all cage parts. Status effects were also evaluated for all behaviour frequencies to see if low status affected ability to perform these behaviours. The ability to "get away" in the modified cages may affect aggression rates, so aggressive rates were measured. Hens are said to be restricted in their comfort movements in close confinement (Dawkins and Hardie, 1989), so the incidence of comfort behaviours was measured in each cage type to see if there was any increase in the modified cages.

Next we aimed to determine whether the extra facilities for behavioural expression were indeed enriching from the hens' point of view. Hens manipulate food, stand, and sit more in more restricted (or barren) housing (Rudkin, 1998). By allowing the expression of a greater repertoire of behaviours, it could be expected that these behaviours would be reduced in the enriched Edinburgh cages compared to the conventional Harrison cages. Restricted housing is also known to be associated with increased rates of abnormal behaviours such as feather pecking and stereotypies. Welfare literature is in general agreement (Hughes and Duncan, 1988; Jensen and Toates, 1993) that a major problem for animals living in captivity is an inability to perform strongly motivated behaviours due to lack of suitable stimuli. This can lead to "frustration" and often to the development of anomalous behaviours. By measuring the incidence of anomalous behaviours it was expected that we could determine how "enriching" the modified cages were.

Because the videos were taken over the whole 16 hour light period, data were sampled over the whole day to test for diurnal effects. Diurnal differences between cage types may indicate welfare differences, but the main benefits expected were to indicate the best times of day to take more extensive observations.

By comparing different sampling techniques, we expected to be able to recommend the most appropriate techniques for obtaining data for specific behaviours. We also intended to develop ways to reliably identify behaviours in these speeded up photos. We aimed to identify problems in the original experimental set up to expedite future studies. By focussing on specific issues for future studies, we should be able to expedite data collection and analysis.

It is expected that the methods and concepts developed in this study can be applied to other housing designs to assess their relative welfare status.

3. Methodology

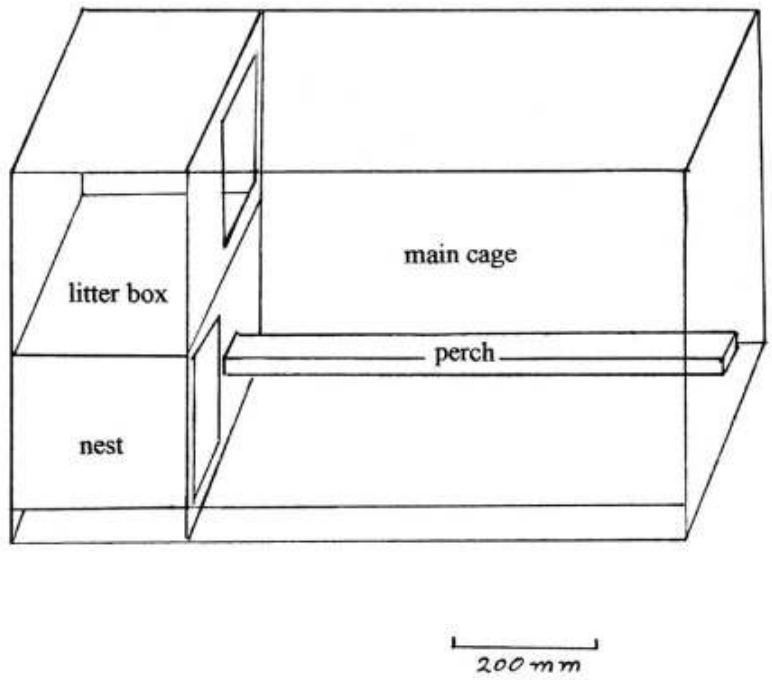
Data on the behaviours of laying hens approximately 30 weeks of age were obtained from time-lapse videos, each taken over the entire light period. Four hens of a heavy black strain (Tegel hens) and four hens of a light white leghorn strain (Aztec hens) in four of 18 experimental Edinburgh cages (modeled on the Edinburgh Modified Cage developed at the Roslin institute, Appleby and Hughes, 1995), and two of eight experimental Harrison cages in a shed at Toowoomba have been observed. Lighting was natural and artificial, with a day length of 16 hours. Birds were fed a standard layer mash, which was topped up with fresh mash each day.

The code used in this report for the strain and cage is: Az – Aztec hens; T. – Tegel hens; Ed – Edinburgh cage; H – Harrison cage; followed by the actual cage number used in the trial. Thus: AzH20, T.H19, AzEd3, AzEd18, T.Ed13, T.Ed5 (see also Abbreviations Section, p x).

The Harrison cages were modern shallow conventional cages measuring 500mm across the front, 560mm deep, 500mm high at the front, and 430mm high at the back. Floor slope was 7°.

The Edinburgh cages were furnished cages containing a perch, a nest at one side of the cage, and a litter box (for dust bathing) above the nest (Fig. 1).

Figure 1. Schematic diagram of the Edinburgh cage. Food trough and egg tray are not shown.



These cages measured 950 mm across the front, with 700 mm feed space and 250mm taken up by nest and litter box, and were 360 mm deep. They were 520mm high at the front, and 470mm at the back, and floor slope was 8°. The nest was 265mm high at the front, and 220mm high at the back. The litter box was 250mm high with a horizontal floor. The softwood perch was 50 mm wide and 25mm thick, and ran across the cage from side to side. It was 185 mm from the front, 125mm from the back, 100mm above the floor and 360 mm from the top. It was far enough from the front to prevent the hens

from feeding from the perch. Feeder space per bird was 125mm in Harrison cages, and 175mm in Edinburgh cages. In Harrison cages, space per bird was 700 cm^2. In Edinburgh cages, space per bird was 630 cm^2 in the main part of the cage and 225 cm^2 in the nest area, making a total floor space area per bird of 855 cm^2 . In addition, the litter box provided 225 cm^2 per bird. The entrance to the nest was 140mm wide and 215 mm high. Its lip across the bottom was 35 mm high with the upper edge rolled over. It was as close to the front as cage construction would allow, and readily entered from the front of the cage. The entrance to the litter box was 150mm wide and 175mm high. It was as close to the back as cage construction would allow and readily entered from the perch. The front wall of the litter box was transparent Perspex to admit light. The nest was lined with artificial "Astro" turf and the litter box was provided with a dry light sandy loam. In order to measure preferred cage space use, the doors to these facilities were open at all times.

Scan data: At each time period, 30s scans were made of each focal bird and its position in the cage and activity at the conclusion of each 30s interval recorded. The behaviours measured by scan sampling included: feeding, head out, drinking, preening, sitting, and standing. Percent of scans when birds engaged in these activities was then calculated.

Continuous monitoring: Each focal bird was consecutively observed over each half-hour period, and all bouts of rare or short duration behaviours were recorded. Time to start and stop of the longer duration behaviours of sitting, feeding and preening were recorded in the first four cages observed (T.Ed5, AzEd3, T.H19, and AzH20). Percent of total time the birds engaged in these activities was then calculated. Subsequently, it was decided that scan data provided sufficient information. Behavioural categories of short behaviours were: drink bouts, bouts of non-aggressive feather pecking, aggressive pecking, comfort movements (stretch, feather ruffle, bilateral partial wing raise), and vertical wing shaking associated with dust bathing.

3.1 Definitions

Feeding – head in trough or head momentarily lifted from the trough.

Head out – standing with head out of front of cage, but not food pecking.

Preening – bird running its beak through its feathers.

Drinking – dabbling with beak at water nipple or tray.

Sitting – bird sitting with keel on substrate. Sitting was clearly visible in Edinburgh cages as they were viewed from the front, but sometimes it was difficult to be sure if a bird was sitting in the Harrison cages as they were viewed from above. Replaying of the tape allowed a change between sitting and standing to be visible, and often a standing individual overlapped a sitting individual. While hens were in the nest in the Edinburgh cage, they presumably primarily sat. However, since this could not be reliably determined, their activity was said to be "nesting". Therefore when birds were in the nest, they were not recorded as sitting.

Standing – if the bird was standing or moving about and not engaged in any of the other categories, it was said to be "standing".

Positions – initially, for the first two cages (T.Ed5 and T.H19) cage positions were simply front, middle or perch, and back except for the laying period. For the laying period, they were initially divided into nine positions, being front right, middle or left; middle right, middle or left; and back right, middle or left. It was found that, since the back of the Edinburgh cage was rarely entered, comparisons of pre lay activity could not be made between the cage types. Also, comparisons could not be made of pre lay activity and activity over the rest of the day. Therefore, the divisions used for subsequent observations were: in the Edinburgh cage, perch left, perch middle, perch right, front left, front middle, front right, back, nest, and litter box. Front was in front of the perch, and back was

behind the perch. Right and left were the observer's right and left. Since hens did not enter the nest or litter box or the area behind the perch a great deal, this effectively divided the cage into six areas. The divisions used in the Harrison cages were front right, front left, middle right, middle left, back right, and back left. This also consisted of six areas so amount of movement in the two cage systems could be approximately compared. The position of the hen was determined by the position of the area between the shoulders when viewed from above, or the position of the feet (for front, perch or back), and the base of the neck at the front (for side of the cage) when viewed from in front. Data for pre lay activity in the first two cages observed were re-collected, but the whole of day scans were not repeated.

Position changes – the number of scans when the focal bird was recorded as being in a different position than the previous scan were counted for each 30 min period. This figure was then divided by the total possible position changes and expressed as a percentage. There were no visible marks on the cage for an accurate assessment, but when hens were in a borderline position, they were said to have stayed in the position initially decided upon until there was a marked change of position. Sometimes if a hen was very active, it would leave and return to the original position between scans. It was then said not to have changed position. Thus there was a tendency to underestimate amount of activity of a very active hen.

Egg laying – egg laying was identified by the appearance of the egg. In the Edinburgh cage, the egg was often visible in the nest through the gap at the bottom of the nest before it rolled out so the precise time of laying could be identified. When the egg was laid in the litter box, the hen was visible and the characteristic lowering of the tail followed by a slight jerk of the body at time of lay was readily identifiable. This jerk was less visible in the photos taken from above the Harrison cages. Unfortunately, the egg tray was not visible in the videos of Harrison cages, so on the side of caution we only recorded an egg as having been laid if it was visible in the cage before rolling out. So even when hens showed typical pre lay and post lay behaviours, they were not recorded as having laid an egg.

Hens that were identified as having laid an egg were scan sampled for the two hours before egg laying, and the following half hour. They were also continuously monitored for this period to identify bouts of behaviours with emphasis on aggressive behaviour. Percent of behaviours measured in half-hour periods over the laying period were graphed along with the half-hour periods over the rest of the day, and percent of behaviours measured in 5 min intervals over the two and a half hour laying period were also estimated and graphed.

Bouts – a *feeding* bout was said to have terminated if more than 10s elapsed before the feeding was resumed. A *preening* bout was said to have terminated if more than 20s had elapsed before preening was resumed. *Sitting* bouts were clearly demarcated. From these data, the percent of time spent at each activity in each 30 min interval was calculated. Average length of bouts was also calculated.

Feather pecking – non-aggressive pecks at companion's feathers. Because of the difficulty of interpretation of pecks in time-lapse videos, no attempt was made to distinguish between light non-damaging pecks at feathers, and stronger more damaging pecks.

Aggressive pecking – aggressive pecks associated with social relationships within the cage. For the purpose of assessing cage and strain differences, only encounters within the cage were counted. For the purposes of assessing pre lay aggression, bouts of aggressive pecks towards neighbours were included.

Feather pecking and aggressive pecking were distinguished in the following ways:
Feather pecking consisted usually of a series of pecks to the companions' feathers, while an aggressive peck consisted of a single or only a few very rapid strikes.
Feather pecks were usually directed at parts other than the top of the head. They could be at the lower neck, ventral parts of the neck, back, base of tail, tip of tail, or abdomen. Aggressive pecks were

usually directed at the top of the head and comb, or sometimes further down the dorsal part of the neck.
Feather pecked individuals did not usually immediately react. Aggressively pecked individuals immediately pulled the head away, often vocalized, and either froze, or moved away.
On the rare occasions where it was difficult to be certain of what type of peck it was, the peck was not recorded.

Comfort movements – these consisted of stretch (the bird stretched a leg and a wing backwards on the same side), ruffle (the bird shook and ruffled its feathers), and bilateral wing raise (the birds did not flap their wings in these cages, but occasionally a bird raised part of both wings close to the body, or extended the tip of the wings).

Other pecks – these included pecking at parts of the cage, pecking a companion's beak or foot, air pecking, or light pecks at the paint on companions' heads.

Dust bathing – each vertical wing shake event was counted. The part of the dust bathing sequence which involves scratching dust through the feathers, looks like a rapid body shake in time-lapse videos. The start and stop of a dust bathing event was difficult to estimate (as was whether a bird was dust bathing at a scan) since birds often sat quietly for periods of variable lengths before starting or resuming dust bathing movements. It was found that counting the number of rapid body shakes was a reliable objective measure of dust bathing. Otherwise, the hens were recorded as sitting.

3.2 Analysis

The volume of data collected for each hen allowed reliable estimates of behaviour frequencies of the hens concerned, and of the behaviours in the cages observed on the day observed. However, the small number of cages available in video form did not allow for statistical analysis for significance.

Summary data were therefore calculated and graphed. Individuals in each cage varied considerably in the frequency of their behaviours, and in the use of cage areas. A very high or very low score by one individual could skew the resulting mean, so means could not be sensibly used to look at behaviour changes over time, or to compare cage frequencies. Moreover, means lost important information about individual behaviours. Most of the data were therefore examined by including individual scores rather than using means.

Summary data showing typical trends are shown in the body of the text of this report, and full summary data are attached to this report as Appendices.

4. Detailed Results

4.1 In brief

There was considerable individual variability in behaviour rates and cage space use. Individual rates are therefore usually presented rather than cage means, and social status is usually indicated so that it can be seen if this variability was associated with hierarchy position.

Hens fed or stood most of the time in both cage types. Most behaviour rates did not appear to be affected by cage type or strain. The abnormal behaviours of feather pecking and stereotypies were encountered in both cage types. Sham dust bathing outside the litter box was seen in Edinburgh cages. There was a trend for the light bodied Aztec hens to be more aggressive than the heavy bodied Tegel hens, and for more aggression in Edinburgh cages than in Harrison cages. In two Edinburgh cages (T.Ed13 and AzEd3) the lowest status hen was severely harassed by some of the cage mates.

The most pronounced difference between cage types was the effect of a site to lay on pre lay behaviour. Hens in Edinburgh cages seemed to readily accept the facilities for laying as they showed interest in the laying site for some time before entering the site. They appeared less "frustrated" because they paced less and were less aggressive before laying than hens in Harrison cages.

In the Edinburgh cages, the nest and litter box were both used as a nest. The litter box was also used as a refuge, occasionally for litter pecking and occasionally for dust bathing. One hen in T.Ed5 was apparently broody in the litter box and remained there most of the day.

The perch in the Edinburgh cages was used for approximately 40% of the time, and was the favoured site for drinking. It was used in a similar way to the back and middle of the Harrison cages. Both were the favoured site for sitting and preening, and most hens were in these positions at lights on. Hens in Edinburgh cages rarely entered the back of the cage behind the perch. The front of the cage was occupied for about 50% of the time in both cage types.

Time of day showed little effect on behaviour rates. No consistent differences between morning and afternoon were shown. However, some changes between behaviour rates during the first half-hour and the next half-hour observation period were evident. There were generally more comfort behaviours (stretching and preening), more activity, and less feeding after lights on than in the subsequent observation period. Topping up the food trough resulted in almost immediate rapid feeding, and more feeding activity over the subsequent half hour. Aggressive interactions at feeding time did not increase except in the cages with bullied hens. Some small changes appeared to occur in the last half hour, with generally less feeding, more sitting, and more feather ruffling.

4.2 Individual differences

Individuals differed greatly in the frequency of behaviours in both cage types, and therefore most of the data are presented for individual hens.

4.3 Social status

All incidents of aggressive pecking seen during observation periods were recorded. From these, tables were constructed and social order determined (Appendix 1; Table 1).

Some of the individual differences seen in this study could be construed as having been due to social status. Therefore, all graphs in this report showing individual means include information as to social status for ease of assessment (Figs. 2a, 2b, 2c, 2d, 4 -11; Appendices 2, 7, 8). Bullied individuals in Edinburgh cages showed a strong effect of status, but there is little evidence of other status effects.

Table 1. Social order from highest to lowest for each group. Figures for each hen in each cage indicate its social status position with 1 indicating the top, and 4 the bottom position.

Group	Hen 1	Hen 2	Hen 3	Hen 4
T.Ed5	3	1	2	?*
T.Ed13	3	1	2	4
AzEd3	4	1	2 or 3**	2 or 3**
AzEd18	4	3	1	2
T.H19	1	?	?	?
AzH20	2	3	4	1

* ? indicates that these birds were not seen to interact and their social position could not be determined.
**Hens 3 and 4 in AzEd3 were not seen to interact.

4.4 Cage space use and use of facilities

4.4.1 Individual use of the cage

In this work, all resources in the Edinburgh cages were available 24 hours a day as a means of establishing "choice usage". Different hens favoured different parts of the cage in both Harrison and Edinburgh cages (Figs. 2a, 2b, 2c, 2d; Appendix 2). For instance, hen 2 in AzH20 was in the back-right of the cage more often than the other hens, and the front-left less often (Fig. 2b). Hen 2 in T.Ed13 was rarely at the front-left of the cage, while hen 3 occupied this position more than any other single part of the cage. Hen 4 in T.Ed5 appeared to be broody in the litter box, and hen 1 in AzEd3 and hen 4 in T.Ed13 were bullied individuals and spent most of the day taking refuge in the litter box (more detail in section 4.7.3). Otherwise, status appeared to have little effect on the positions occupied. There appeared to be some status effect on how often hens were at the front of the cage, with top or second status individuals more often at the front. However, there is no evidence that lowest status hens were less often at the front than higher status hens in either strain or either cage type.

Figure 2a. Percent of scans when each heavy bodied Tegel hen was in each position in the Harrison cage. Hen 1 appeared dominant to hens 3 and 4.

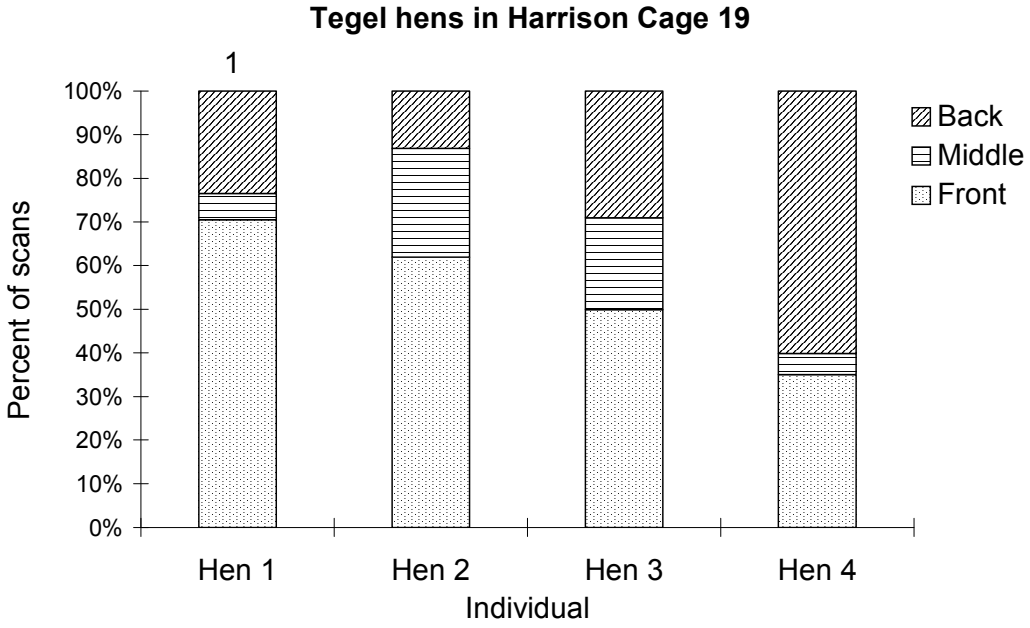


Figure 2b. Percent of scans when each light bodied Aztec hen was in each position in the Harrison cage. Status (from highest to lowest) is shown at the top of the column.

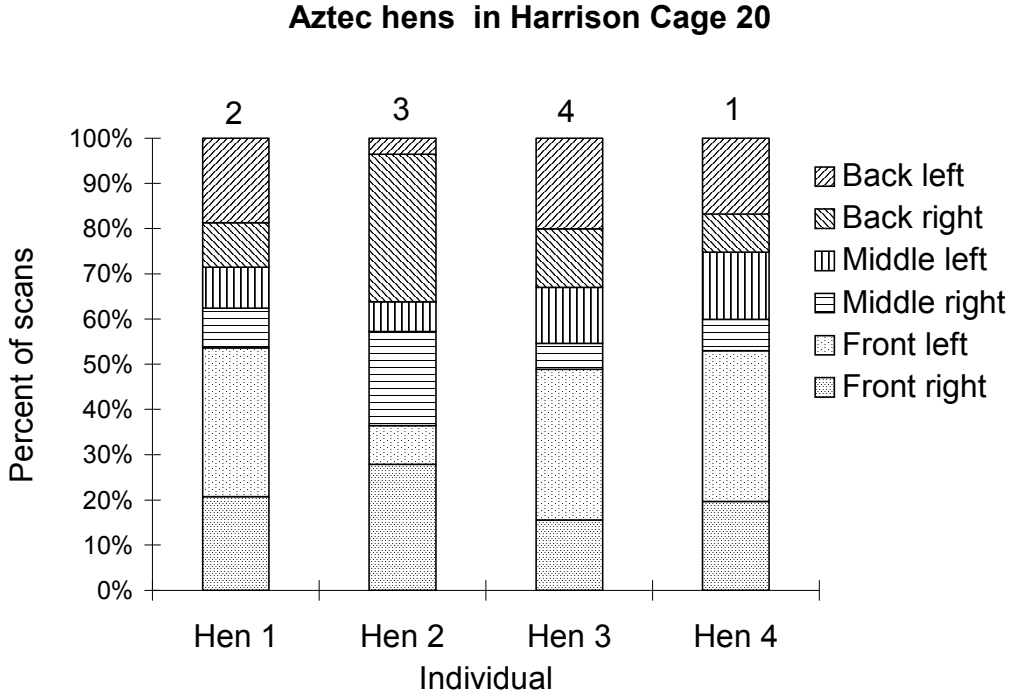


Figure 2c. Percent of scans when each Tegel hen was in each position in Edinburgh cage 13. Status (from highest to lowest) is shown at the top of the column (hen 4 used the litter box as a refuge).

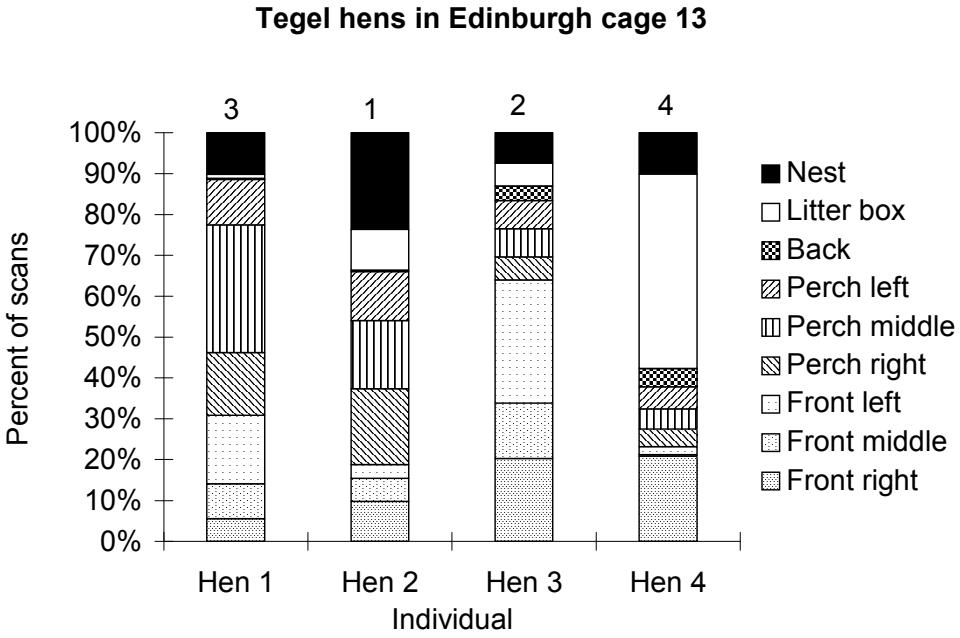
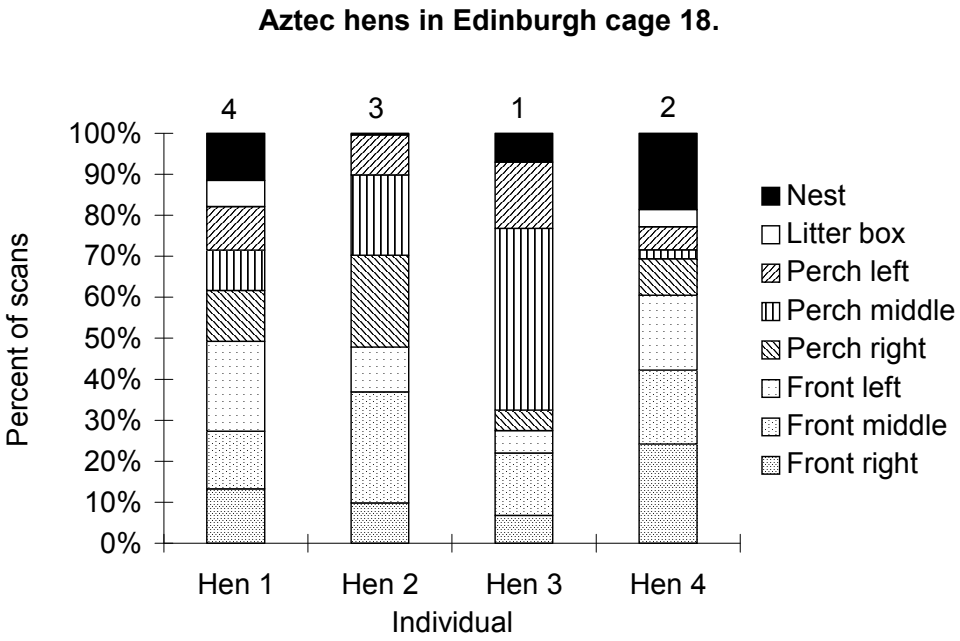


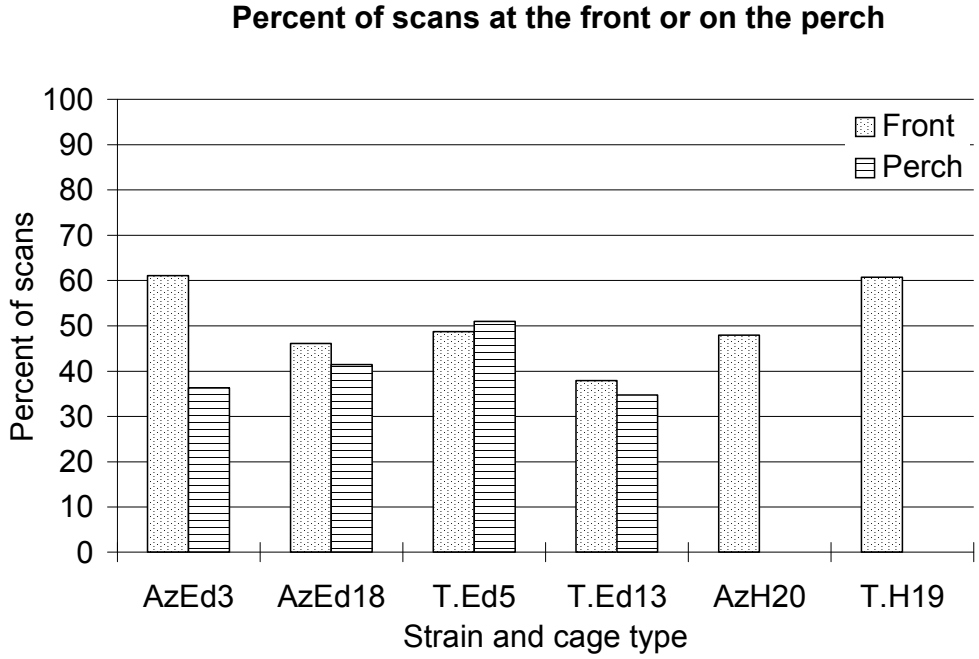
Figure 2d. Percent of scans when each Aztec hen was in each position in Edinburgh cage 18. Status is shown at the top of the column.



4.4.2 Front of the cage

The front of both cage types was occupied on average around 50% of the time, with no trends evident for cage or strain type (Fig. 3).

Figure 3. Mean percent of scans when hens were at the front of the cage or on the perch. Hens that spent a large portion of time in the litter box are not included in calculation of means.



4.4.3 Perch

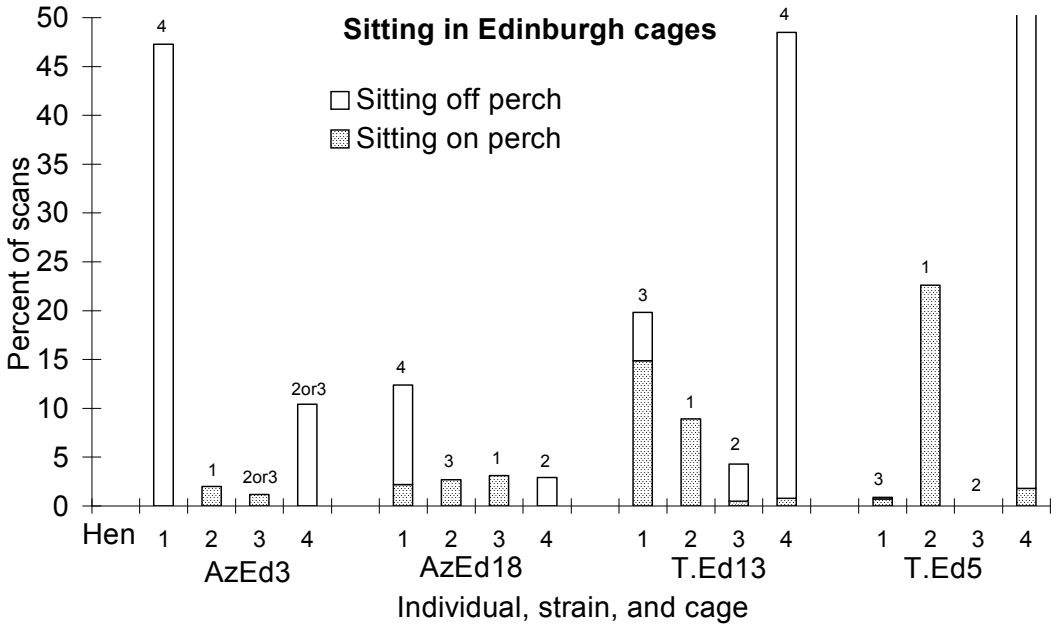
Hens were generally on the perch for approximately 40% of the time (Fig. 3). At lights on, most hens were perching, but at lights off, fewer birds were perching (Table 2).

Table 2. Number of hens in different positions at lights on and lights off.

Strain	Lights on				Lights off			
and cage	Perch	Front	L. Box	Nest	Perch	Front	L. Box	Nest
AzEd3	2	2	-	-	2	2	-	-
AzEd18	4	-	-	-	2	2	-	-
T.Ed13	3	-	1	-	1	1	1	1
T.Ed5	3	-	1	-	2	1	1	-

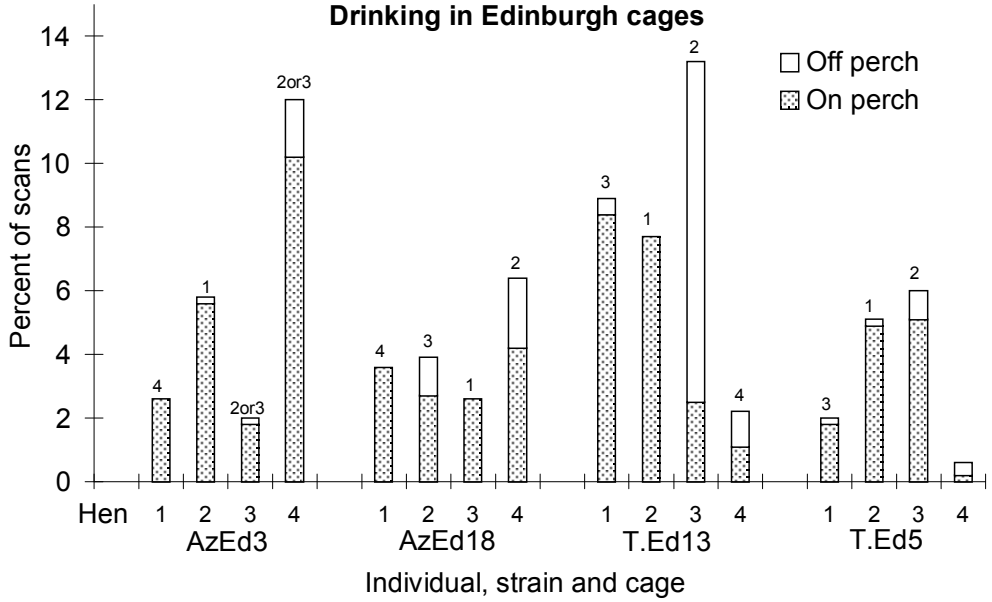
Some birds favoured the perch for sitting (Fig. 4). Exceptions were the broody and the bullied hens that spent most time sitting in the litter box. Also some other hens did not favour the perch: hen 4 in AzEd3 sat only at the front; hen 4 in AzEd18 sat on only one occasion and that was in the litter box; hen 3 in T.Ed13 sat when in the litter box dust bathing and on another occasion at the front. Hen 3 in T.Ed5 did not sit at all during the observation periods.

Figure 4. Percent of scans when individual birds sat, showing percent on the perch and percent off the perch in Edinburgh cages. The figure at the top of the columns indicates social status. Sitting in the nest is not included in the figures.



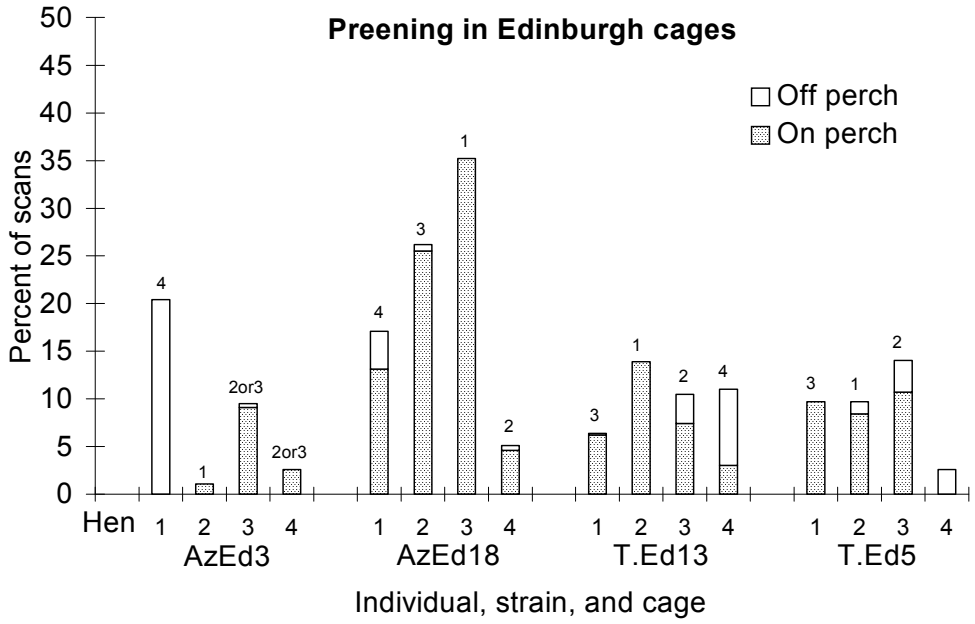
All but hen 3 in T.Ed13 drank primarily from the perch in Edinburgh cages (Fig. 5). This atypical hen showed stereotypic behaviour associated with the left nipple (see Section 4.4.6).

Figure 5. Percent of scans when individual birds drank, showing percent on the perch and percent off the perch in Edinburgh cages. The figure at the top of the columns indicates social status.



Hens also preened primarily on the perch (Fig. 6). The only exceptions were the lowest status hens and the broody hen.

Figure 6. Percent of scans when individual birds preened, showing percent on the perch and percent off the perch in Edinburgh cages. The figure at the top of the columns indicates social status.



4.4.4 Behind the perch

The area behind the perch was rarely occupied. Hen 2 in T.Ed5 was in the back at one scan over the day, and hen 1 stood in the back for 4 or 5 seconds approximately 2 minutes before food was added to the trough. Birds were actively moving about at this time. Two hens in T.Ed13 occasionally entered the back (Fig 2c), one of them when attacked. The Aztec hens in Edinburgh cages did not enter the back when eggs were collected, food trough topped up, or even the time when an individual was removed for re-marking with paint.

4.4.5 Away from the front in Harrison cages

In Harrison cages, hens usually sat in the middle or back of the cage rather than the front. However, this was less pronounced with the Tegel hens (Fig. 7). Preening was predominantly behind the front of the cage in all individuals (Fig. 8). Hens of both breeds were clustered in the middle to back of the Harrison cage at the start of day but at the end of the day, all birds were at any part of the cage.

Figure 7. Percent of scans when individual birds sat, showing percent behind the front of the cage, and percent at the front in the Harrison cages. The figure at the top of the columns indicates social status.

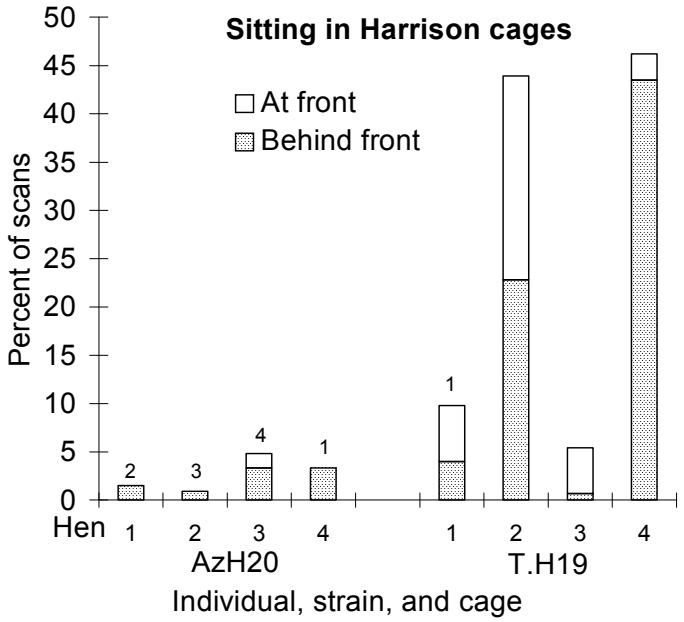
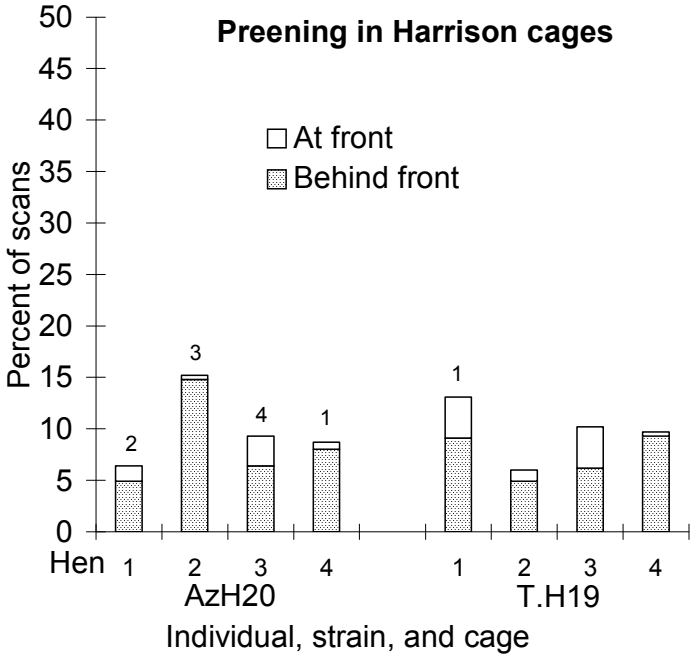


Figure 8. Percent of scans when individual birds preened, showing percent behind the front, and percent at the front in the Harrison cages. The figure at the top of the columns indicates social status.



4.4.6 Water nipple use

Individuals often favoured one nipple over the other in both cage types (Figs. 9 and 10). Two individuals showed stereotyped behaviour associated with high drink rates in Edinburgh cages. Hen 3 in T.Ed13 favoured the left nipple and often drank from the front. She showed a pronounced stereotypy associated with drinking and pecked primarily the left nipple then lowered her head before pecking the nipple again. She also often pecked the nipple, then put her head out over the food, but did not peck the food. Hen 4 in AzEd3 also showed a stereotypy associated with the left nipple. She usually pecked from the perch and repeatedly alternately pecked the nipple then lowered her head or sometimes raised her head and pecked the roof of the cage.

Figure 9. Mean bouts of drinking from each nipple per observation period in the Edinburgh cages. The figure at the top of the columns indicates social status.

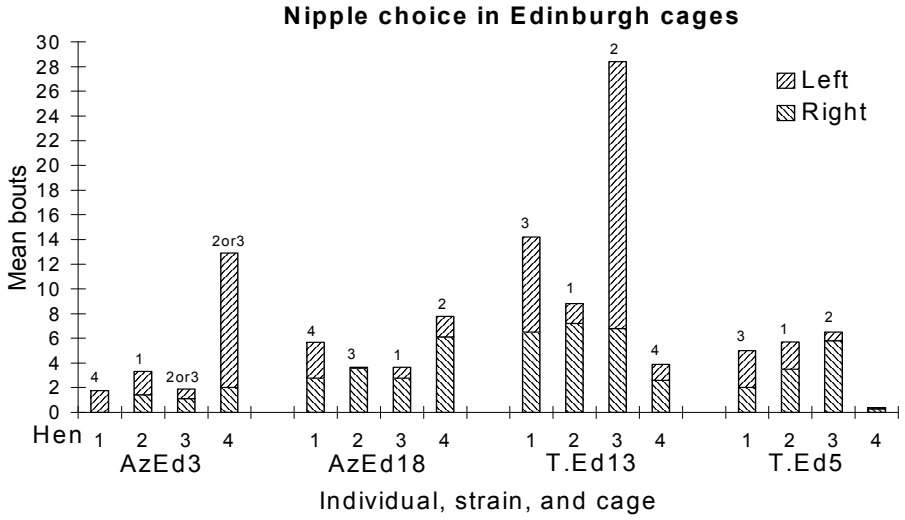
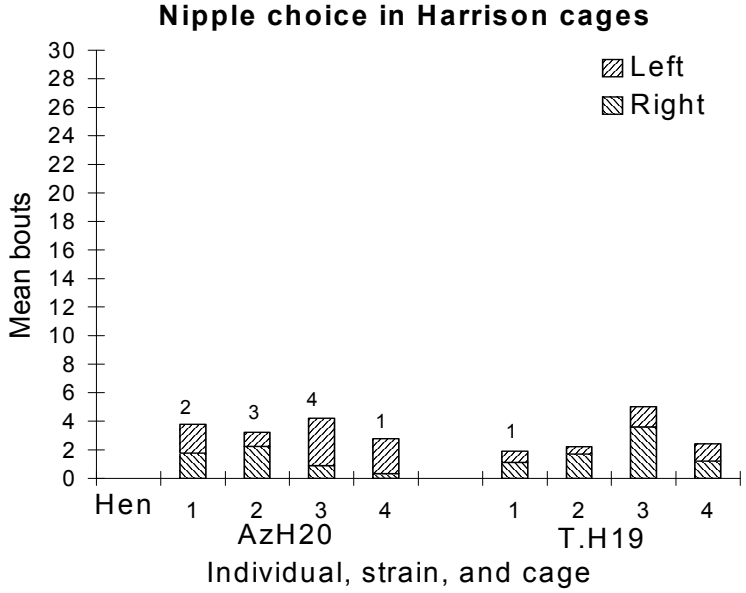


Figure 10. Mean bouts of drinking from each nipple per observation period in the Harrison cages. The figure at the top of the columns indicates social status.



4.4.7 Nest

The nest was used primarily for egg laying and was entered rarely at other times (Fig. 2; Table 3). The median time a hen occupied a nest or litter box to lay an egg was 41 minutes (range 8min 17s to 138min 46s). The median percent of the day any hen occupied the nest was 4.9% (range 0% to 25.7%). Although individual hens occupied the nest for a relatively short proportion of the day, total time occupied usually amounted to a significant proportion of the day (Table 3). Although hen 2 in T.Ed13 occupied the nest considerably more than the other hens, she was not seen to lay an egg. Moreover, she was in the nest at the end of the day. It is suspected that she may have been broody. The occupation of the nest by both this hen and hens laying eggs at around the same time in this cage (T.Ed13) resulted in the nest being occupied by two or more birds for part of the day. (It was occupied by two birds for 51min 11s and by three birds for 21min 06s.)

Table 3. Nest occupation. Total percent of daylight hours when each hen occupied the nest and total percent of day when nest occupied by one or more hens.

Strain and cage	AzEd3	AzEd18	T.Ed13	T.Ed5
Hen 1	8.8	10.3	7.5	0.2
Hen 2	6.8	3.3	25.7	0.1
Hen 3	4.3	4.8	4.2	5.0
Hen 4	2.8	15.1	13.5	0
Total % of day occupied	22.0	32.4	46.7	5.2

4.4.8 Litter box.

The litter box was sometimes used as a nest, for dust bathing, pecking litter, and as a refuge by bullied individuals (Table 4). Occasionally it was occupied by two hens, but its occupation by more than two hens was not seen. A high total occupation reflected its use as a refuge or by a broody hen. A number of observations lead to the conclusion that hen 4 in T.Ed5 was broody. At no time did she show dust bathing behaviour, so it was concluded she was not dust bathing. She sat quietly but alert, and when she left the litter box, she rapidly pecked food for a short time, so it was concluded that she was not sick. When she left the litter box or when another hen entered the litter box, she was not aggressively pecked, so it was concluded that she was not a bullied hen. She also occasionally moved her head over her back in a nest building way after pecking in front of herself, and sometimes performed other nesting movements, so it was concluded that she was probably broody. The median time individual hens occupied the litter box was 2.3% of the day (range 0% to a maximum of 83.2% by the broody hen). The minimum time it was occupied when used for dust bathing at any one time was about 12 minutes, and the maximum was 49 minutes.

Table 4. Litter box occupation. Total percent of daylight hours when each hen occupied the litter box and its prime activity, when two hens occupied the litter box, and total percent of day when litter box occupied by one or more hens.

Strain and cage	AzEd3	AzEd18	T.Ed13	T.Ed5
Hen 1	52.4 (refuge)	2.5 (refuge)	7.6 (d.b.)	2.8 (laying egg)
Hen 2	1.4	0	9.0 (d.b.)	4.5 (laying egg)
Hen 3	0	1.6 (d.b.)*	2.1	0
Hen 4	0.4	1.2	51.5 (refuge)	83.2 (broody)
Two hens	0.5	0.3	4.4	2.8
Total % of day occupied	53.7	5.1	65.8	87.7

* d.b. – dust bathing

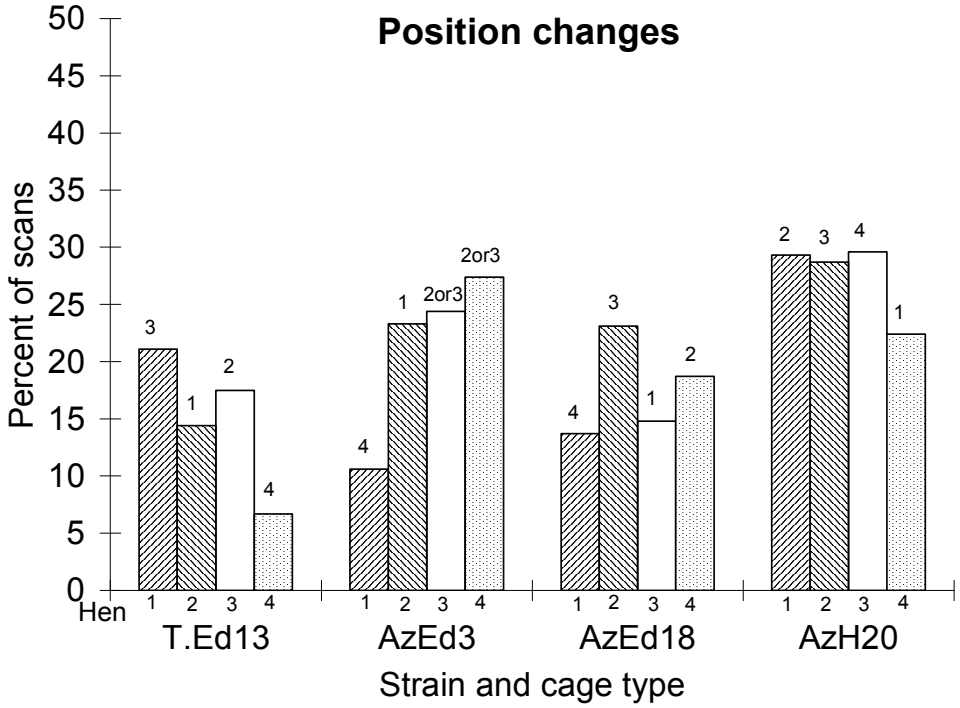
One hen (hen 3 in AzEd18) dust bathed on one occasion in the litter box, then on two occasions later in the day, sham dust bathed on the perch. Another hen in this cage (hen 2) did not on any occasion enter the litter box, but sham dust bathed on the floor at the front of the cage on one occasion. This hen bill raked food in a dust bathing way. At these times, the litter box was empty.

Litter pecking occurred when hens were in the litter box, and sometimes hens outside the litter box pecked the litter (Appendix 8). Sometimes a hen alternately pecked litter and a water nipple.

4.4.9 Activity rates

Amount of activity was estimated as percent of scans when hens changed position. There was at least as much activity in Harrison cages as in Edinburgh cages if not more (Fig. 11). (Note that activity is not shown in T.Ed5 and T.H19 as their positions were measured differently.)

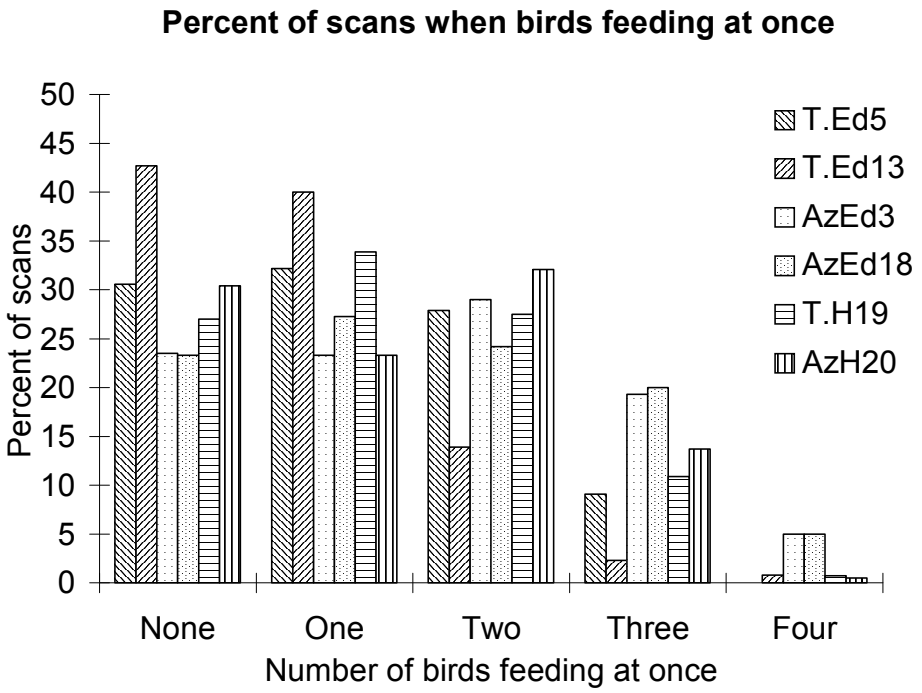
Figure 11. Percent of scans when hens changed position in each cage. The figure at the top of the columns indicates social status.



4.5 Number of hens feeding at once

The number of birds feeding at one time at each scan was measured. All four birds were able to feed at once, and there were 125mm per bird of trough space in Harrison cages, and 175mm in Edinburgh cages – more than the 100mm feed trough space per bird in the current "Code". However, four feeding at once was very rare (Fig. 12), even after topping up the food trough when amount of feeding was high (Appendix 3). Light bodied Aztec hens seemed to have fed alone less often than heavy bodied Tegel hens, and more often two or three fed at once (Fig. 12). Three or four feeding at once was more likely after feeding (Appendix 3). Light bodied Aztec hens in Edinburgh cages fed four at a time after feeding more often than heavy bodied Tegel hens, and more often than hens of both strains in Harrison cages.

Figure 12. Percent of scans when different numbers of birds were feeding at once in the different cages.



4.6 Egg laying behaviour

In total, the laying behaviour of 15 hens has been observed. In Edinburgh cages, they consisted of a total of six heavy bodied Tegel hens and six light bodied Aztec hens. In Harrison cages, they were two heavy bodied Tegel hens, and three light bodied Aztec hens. Hen 2 in T.H19 showed distinct pre lay behaviour, but time of lay could not be detected, and no egg was visible so she is not included.

Hens in Edinburgh cages paid most attention to the chosen nest site (litter box or nest) soon after they stopped feeding and started moving about. None of the hens in Edinburgh cages that were observed laid an egg on the floor although floor laying is known to have occurred on other days. Hens of both strains in Harrison cages typically paced the side of the cage or pushed their head through a back corner of the cage before laying. They often pecked at hens in neighbouring cages. Closer to laying, they usually attempted to push themselves under cage companions.

Individuals varied in the length of time from first sign of egg laying behaviour to egg laying (Table 5). In Harrison cages it varied from 10 minutes to 68 minutes, and in Edinburgh cages, from 25 minutes, to 159 minutes.

Table 5. Length of time in minutes from first sign of pre lay behaviour to time of egg laying.

Strain and cage	T.H19	AzH20	AzEd3	AzEd18	T.Ed13	T.Ed5
Hen 1	68	-	101	78	34	88
Hen 2	-	65	-	56	-	84
Hen 3	31	10	63	51	59	-
Hen 4	-	15	-	159	52	25

4.6.1 Position changes

There was a marked increase in activity before laying an egg in Harrison cages, particularly pronounced among light bodied Aztec hens (Figs. 13, 14, 15, 16; Table 6; Appendix 4). The 30 minute activity peaks in Tegel hens were around 40%, and in Aztec hens around 50%. The five minute scans showed that bouts of intense activity were sporadic, and became more intense closer to time of lay. The Tegel hens in the Harrison cages moved about less than the Aztec hens before laying, and sat more. In this case, bouts of sitting alternated with bouts of activity. The maximum 5 minute activity peaks were about the same in both strains, being 70% to 90% (Table 6).

There was also some increase in activity before entering the nesting site in Edinburgh cages, and after leaving the nest. However, the 30 minute activity peaks reached only about 8% to 20% when the nest was unoccupied. Bouts of activity did not become more intense closer to the time the nest was entered. Their maximum 5 minute activity peaks were usually below 50%. Tegel hens 1, 3 and 4 in Edinburgh cage 13 did, however, show higher increases in activity before entering the nest. When hens 1 and 3 entered the nest, it was already occupied by two other hens. Hen 4 was a bullied hen who spent most of the day in the litter box. Hen 3 in AzEd3 also showed high activity rates although the nest was unoccupied.

Table 6. Maximum peak of activity expressed as percent of scans when each hen changed position over periods of 30 min and of 5 minutes over 2 hours prior to egg laying.

Hen	Cage	30 min peak %	5 min peak %
2	AzH20	50	90
3	AzH20	48	70
4	AzH20	48	70
1	T.H19	38	71
3	T.H19	40	82
1	AzEd18	12	30
2	AzEd18	20	40
3	AzEd18	8	20
4	AzEd18	18	50
1	AzEd3	10	51
3	AzEd3	35	82
1	T.Ed13	30	60
3	T.Ed13	35	83
4	T.Ed13	33	72
1	T.Ed5	NA	50
2	T.Ed5	NA	50
3	T.Ed5	NA	40

4.6.2 Preening
The incidence of preening noticeably increased before laying by many hens in both cage systems (Figs. 13, 14, 15, 16; Appendix 4). This was more pronounced in the Edinburgh cages.

4.6.3 Feeding
Feeding typically stopped or reduced for a variable length of time before egg laying. Almost immediately after laying the egg in the Harrison cages, and after leaving the nest in the Edinburgh cages, hens typically fed with rapid pecks (Figs. 13, 14, 15, 16; Appendix 4). Hens in Edinburgh cages usually left the nest very soon after laying.

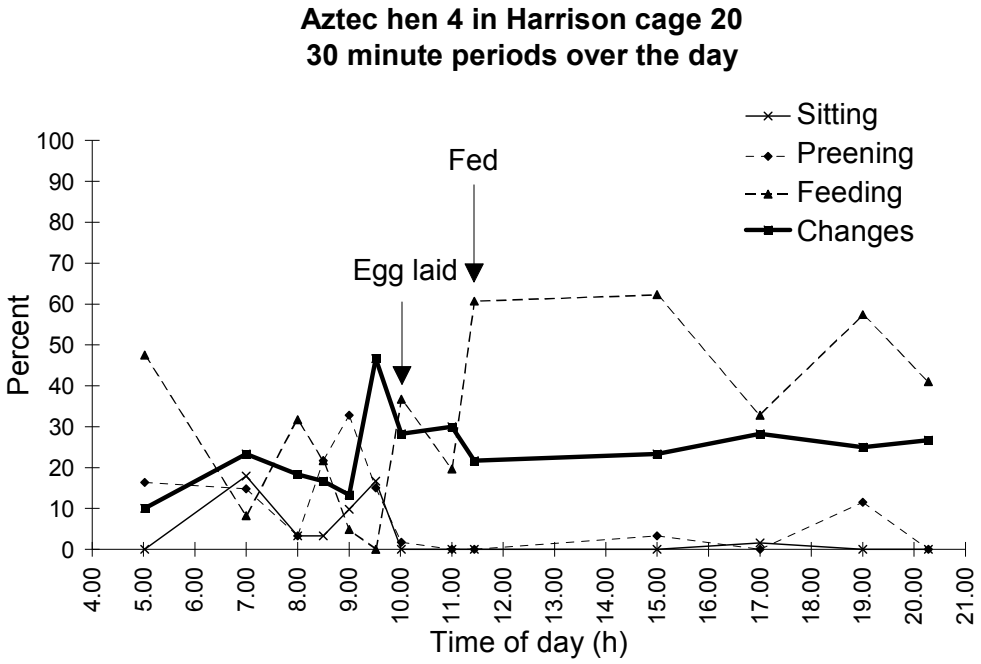
4.6.4 Sitting
Hens in Edinburgh cages often sat or stood outside the chosen nest site before entering the nest (Figs. 13,14,15, 16; Appendix 4). In Harrison cages, there was a marked increase in sitting by the two heavy bodied Tegel hens prior to laying, but not by the light bodied Aztec hens.

4.6.5 Aggression
In Harrison cages, there was a marked increase in aggressive interactions, mostly directed at hens in neighbouring cages. (Hen 1 in T.Ed19 did not have neighbours on the day she was observed.) There was no noticeable increase in aggression prior to laying in Edinburgh cages (Fig. 17; Appendix 5).

4.6.6 Vent pecking
One occurrence of vent pecking was seen. Tegel hen 3 in T.H19 was vent pecked when she started laying her egg. After each series of pecks, she vocalized and moved position. The vent pecking ceased after the egg was laid.

Figure 13. Laying behaviour by a light bodied Aztec hen in a Harrison cage. A. Mean percent of scans of each behaviour each 30 minutes over the day. The time periods given are at the start of each half-hour scan. B. Mean percent of scans of each behaviour each 5 minutes over 2 hours prior to laying, and half an hour after laying. The time periods given are at the end of each 5 minute period.

A.



B.

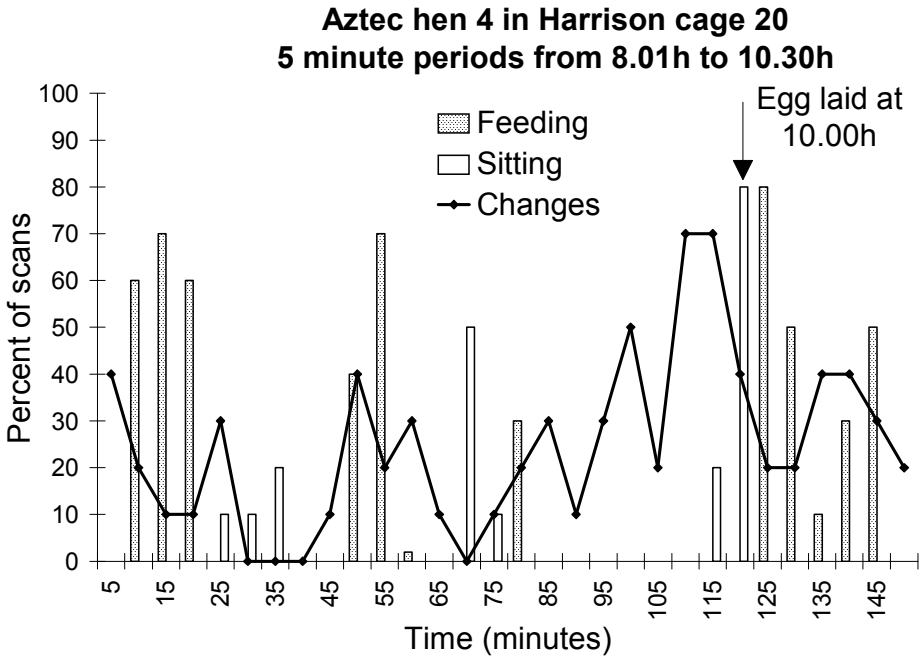
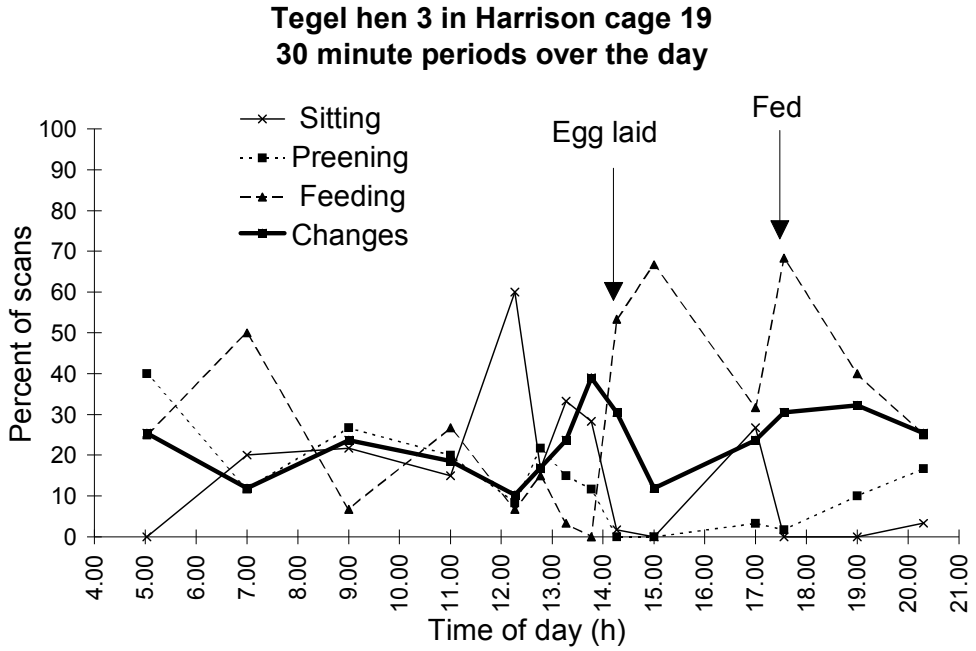


Figure 14. Laying behaviour by a heavy bodied Tegel hen in a Harrison cage. A. Mean percent of scans of each behaviour each 30 minutes over the day. The time periods given are at the start of each half-hour scan. B. Mean percent of scans of each behaviour each 5 minutes over 2 hours prior to laying, and half an hour after laying. The time periods given are at the end of each 5 minute period.

A.



B.

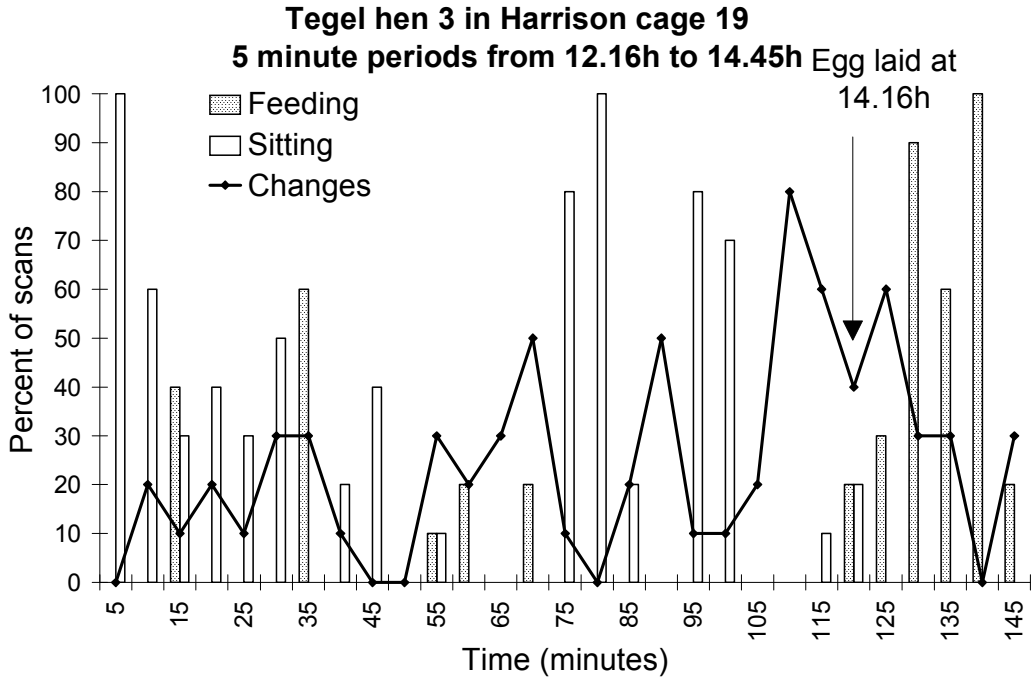
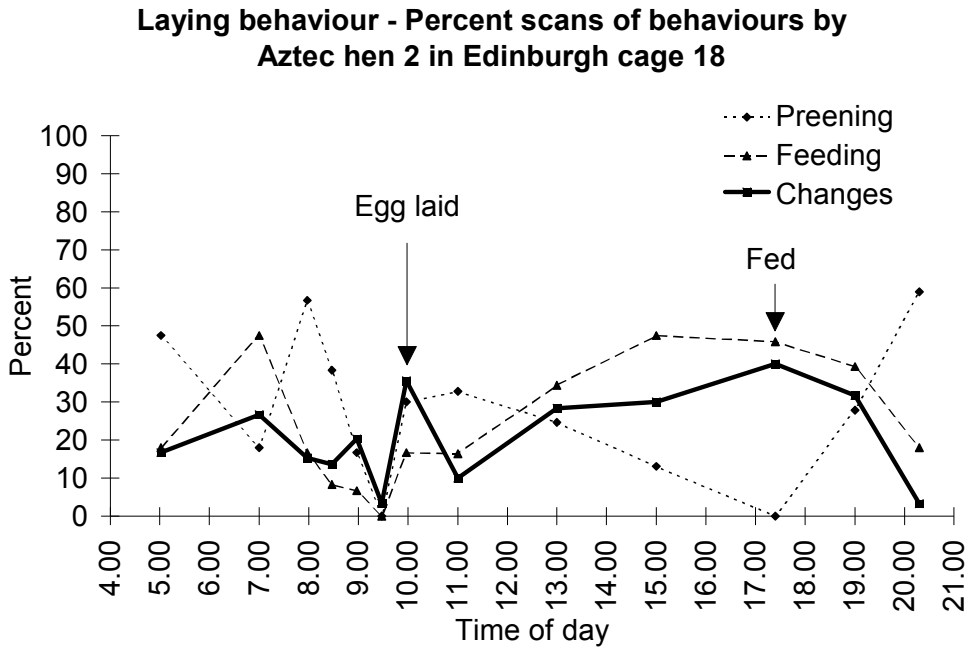


Figure 15. Laying behaviour by a light bodied Aztec hen in an Edinburgh cage. A. Mean percent of scans of each behaviour each 30 minutes over the day. The time periods given are at the start of each half-hour scan. B. Mean percent of scans of each behaviour each 5 minutes over 2 hours prior to laying, and half an hour after laying. The time periods given are at the end of each 5 minute period.

A.



B.

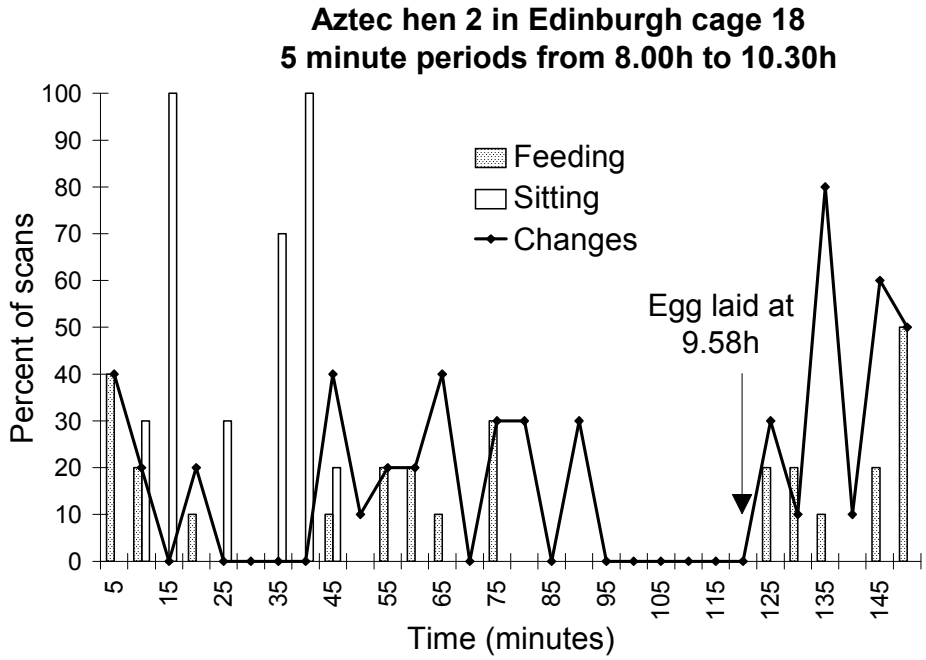
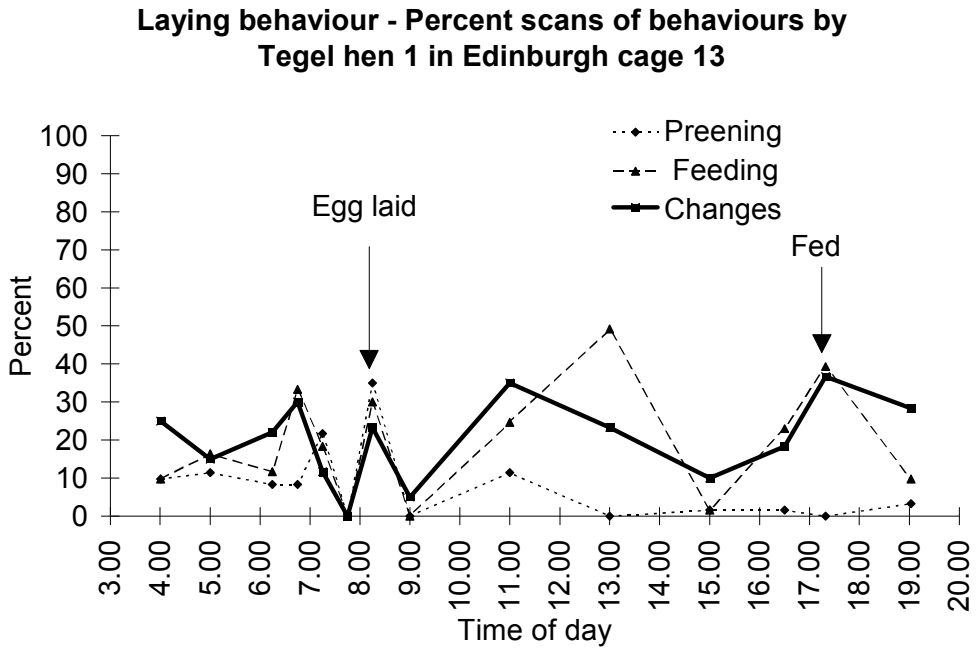


Figure 16. Laying behaviour by a heavy bodied Tegel hen in an Edinburgh cage. A. Mean percent of scans of each behaviour each 30 minutes over the day. The time periods given are at the start of each half-hour scan. B. Mean percent of scans of each behaviour each 5 minutes over 2 hours prior to laying, and half an hour after laying. The time periods given are at the end of each 5 minute period.

A.



B.

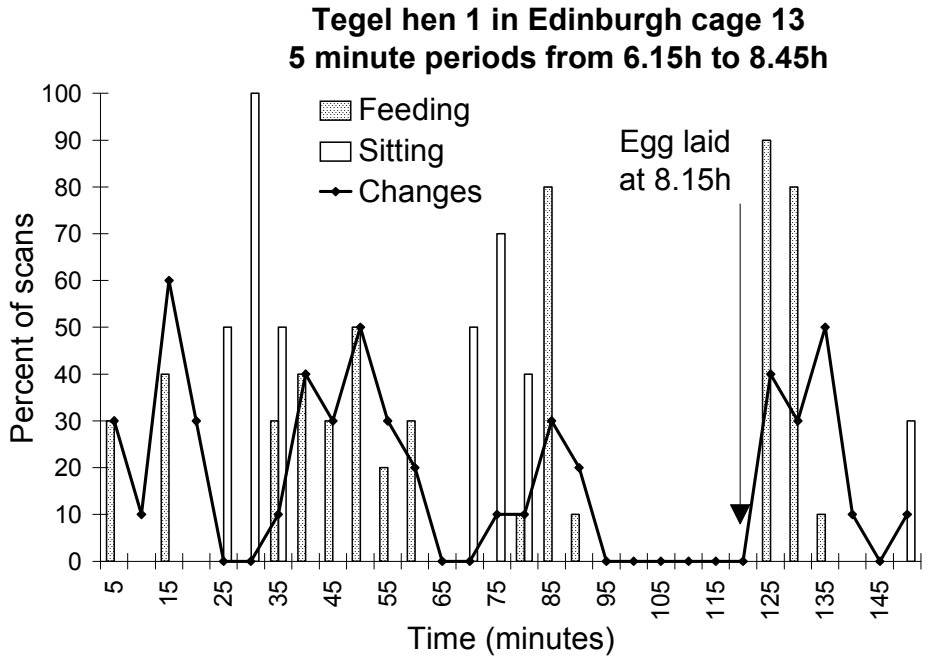
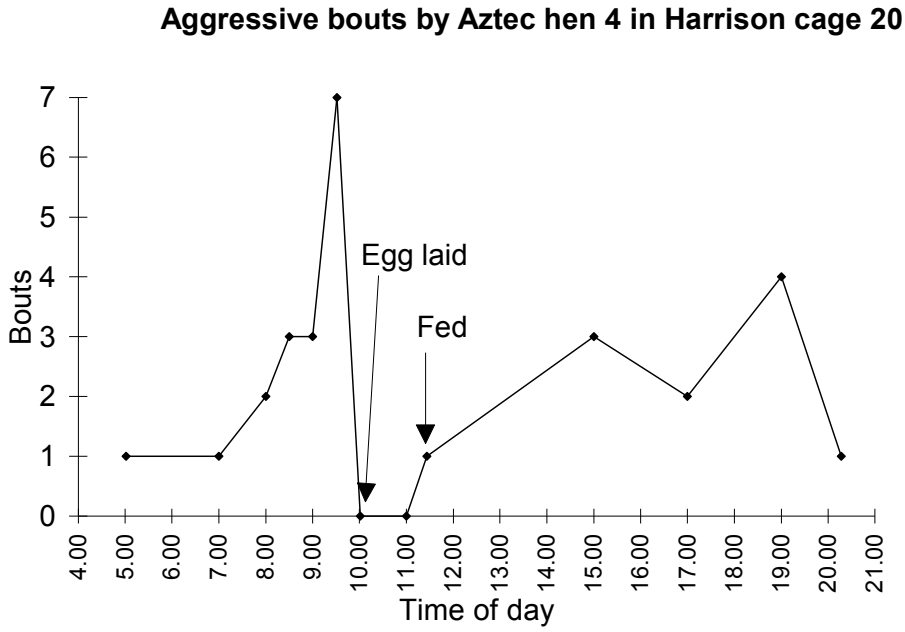
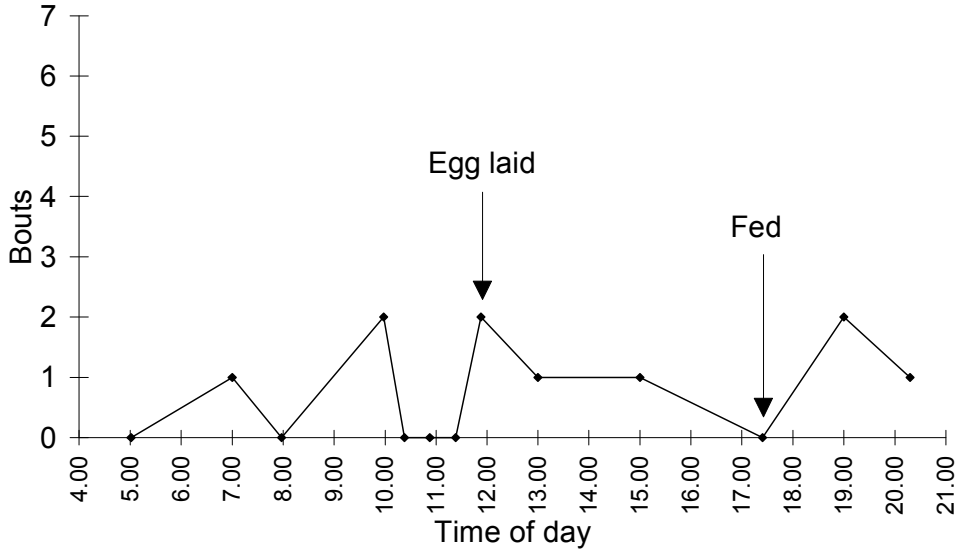


Figure 17. Aggressive behaviour in relation to laying by A. a light bodied Aztec hen in a Harrison cage, and B. a light bodied Aztec hen in an Edinburgh cage.

A.



B.

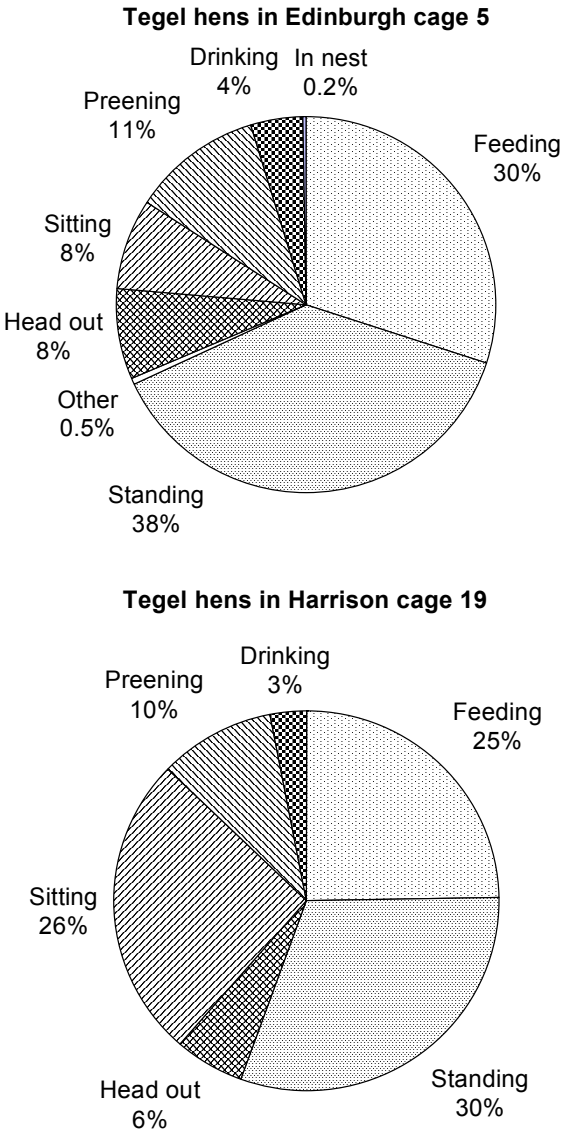


4.7 Behaviour rates

4.7.1 Cage means

Time budgets of hens were similar in both cage types and both strains (Fig. 18; Appendix 6). More than 50 percent of activities in cages consisted of feeding and standing which usually occurred in about equal proportions. Percent of scans performing the passive behaviours of standing, standing with head out of the front of the cage, and sitting, together occupied more than half the day. Preening, drinking and time in the nest was comparatively low.

Figure 18. Mean behaviour rates by heavy bodied Tegel hens in Edinburgh cage 5 and Harrison cage 19. The data from the broody hen were excluded from estimation of means.



4.7.2 Individual behaviour rates

As mentioned above, there was considerable variability between individuals (Appendix 7). When looking at individual rates, no trends between strains or cage type were evident in amount of sitting, standing, standing with head out the front of the cage, feeding, drinking, or preening. Note that heavy bodied Tegel hen 4 in T.Ed5 was broody and spent most of the day in the litter box, and that Tegel hen 4 in T.Ed13, and light bodied Aztec hen 1 in AzEd3 were bullied individuals and spent a large part of the day sitting in the litter box. They therefore showed high sit rates, low stand rates, and low feed and drink rates. Many hens showed an inverse relationship between sit rates and stand rates (Appendix 7). The high drink rates recorded for Tegel hen 3 in T.Ed13 and Aztec hen 4 in AzEd3 were due to the stereotypic behaviours associated with the water nipple (Section 4.4.6).

4.7.3 Behaviour bouts

Comfort behaviours (other than preening) and pecking bouts (other than food pecking) were comparatively rare. Both mean bouts per observation period by individuals, and mean bouts in each cage are shown in Appendix 8. Stretching, partial bilateral wing raise, and feather ruffle occurred about as much in both strains in both types of cage. Dust bath shakes were recorded in three of the Edinburgh cages, but not in the Harrison cages during observation periods.

No trends for strain or cage effect are evident for feather pecking. The tables in Appendix 1 show the number of feather peck interactions recorded. It is noteworthy that these do not necessarily reflect aggressive interactions. One of the heavy bodied Tegel hens in the Harrison cage performed the stereotypic behaviour of air pecking. Stereotypies associated with water nipple pecking were seen in two Edinburgh cages (Section 4.4.6).

"Other pecks" included pecking paint on the heads of cage mates, pecking beaks or feet of cage mates, cage pecks, and air pecks. Some of these pecks can be considered to be abnormal. No trends were evident for strain or cage type. The heavy bodied Tegel hens in the Harrison cage pecked at the paint on each others' heads. Hens in other cages rarely pecked at the paint. These pecks were clearly not aggressive in nature as they were repetitive and did not result in avoidance by the pecked hen.

Aggression seemed to be higher in Edinburgh cages than in Harrison cages, particularly by the Aztec hens. The aggression rate by heavy bodied Tegel hens in the Harrison cage was so low that only the position of the most dominant individual could be inferred. The lowest status hens in three of the Edinburgh cages were strongly harassed. Hen 1 in AzEd18 sometimes took shelter in the litter box or nest, but she did not stay in these places for long periods. After she left the shelter, she tended to be pecked more than usual. She was pecked primarily by hen 4 (Appendix 1). Hen 1 in AzEd3 and hen 4 in T.Ed13 sheltered for most of the day in the litter box. Hen 4 also sometimes crouched in the back of the cage. She was pecked by hens 1 and 2, but not by hen 3 (Appendix 1). Hen 1 in AzEd3 was pecked only by hens 3 and 4. Hen 2 was sometimes jostled when hens 3 and 4 were attacking hen 1, but she did not join in the fray. When hen 1 left the litter box she was immediately attacked. She then moved rapidly to the right front corner and crouched with her head under the feed trough. Her head had been painted brown. At 16.00h, she was removed from the litter box by a carer, and returned shortly afterwards with her head painted white. After this, only hen 3 continued to attack her. After her return, she pecked food for a while, then drank for about 5 minutes. After being fed, she fed for 15 minutes, without interruption. She was in the left corner, and hen 2 was between her and hen 3. By the end of the trial, this hen died.

4.8 Diurnal changes

By sampling half-hour periods over the whole day it was possible to determine if there were any consistent diurnal changes. Mostly, consistent diurnal changes were not evident with activities as likely in the morning, midday, or afternoon (Appendices 9 to 15). Distinct changes were evident after the food trough was topped up or the food stirred, and changes between the first half-hour observation period, and the next one, one or two hours later were shown by most hens. There was also a tendency

for some behaviours of many hens to change during the last half hour before lights off compared to the previous observation period. No differences between strain or cage type could be detected.

During the first half hour, most hens were more active, but fed less than during the next observation period. They also preened and stretched more. There tended to be less feeding during the last half hour, and more sitting. There also seemed to be more feather ruffling at this time, but not more stretching.

After feeding, most hens immediately started pecking food, and food pecking was usually at the highest rate for the day during the subsequent half hour. The percent of scans when three or four birds were feeding at once increased. During this half hour, they tended to drink more, were more active, sat less, and preened less. Other comfort behaviours appeared unaffected. Feather pecking and aggression were usually reduced or unaffected except in the cages with bullied hens (hen 4 in T.Ed13 and hen 1 in AzEd3). In these cases, aggression increased as the bullied hens left the litter box.

When viewing Appendices 9 to 15, some unusually high or low rates of behaviours by some individuals can be seen. Explanations for some of these observations are given here. The bullied hens (hen 4 in T.Ed13, hen 1 in AzEd3) and the broody hen (hen 4 in T.Ed5) showed low feed rates over the day, low drink rates, high sit rates, and in the case of hen 1 in AzEd3, high preen rates. Hen 1 in AzEd18 was also often bullied, and she often sheltered in the litter box or nest, but not for long periods as in the case of the other bullied hens. Low feed rates were recorded for hens in T.Ed5 from 9.00h to 13.00h, in AzEd3 at 13.00h to 15.00h and in T.H19 over the middle part of the day (Appendix 9). During these periods, the birds were showing signs of heat stress. Other causes of low scores for feeding were use of the litter box by hen 1 in T.Ed13 at 15.00h, and laying or pre laying behaviour by hens 1 and 2 in AzEd18 at 19.00h. High sit rates were often recorded during these observation periods. During the 11.00h observation period AzH20 hens vocalized and moved rapidly about the cage for about 10 minutes of the observation period. Apparently someone was in the shed and they were fed soon afterwards. The presence of a person in the shed can be inferred by the behaviour of the hens. Long "friendly" calls by large numbers of hens can be heard on the tape, and the hens under observation move rapidly about the cage.

The high activity rate shown by hen 2 in AzH20 at 9.00h was due to pre lay pacing. Stereotypic behaviour associated with pecking the water nipple caused high drink scores for hen 3 in T.Ed13 and hen 4 in AzEd3 during some observation periods. Hen 4 in AzEd3 sometimes alternately pecked the water nipple then food. If water was regurgitated into the food, the food was rapidly pecked. This type of behaviour has often been observed by one of us during observations of hens in cages.

Some high scores for feather pecking were recorded when hens pecked the water nipple (Appendix 15), then the back of a hen under the nipple. Some of these pecks may have been at water droplets on the hen below. Many of the feather pecks in T.Ed13 were these types of pecks. At 15.00h, hen 1 appeared to peck at water on a back, but further pecks looked more like typical feather pecks. The very high feather peck score in AzEd3 at 15.00h was all due to pecks by hen 4 – eight of the pecks were typical feather pecks to various parts of the body, and five of them were apparently at water on a back. The high scores for aggression in T.Ed13 and AzEd3 were, as previously mentioned, at times when the bullied hens left their shelter.

4.9 Scan data and continuous monitoring data

Appendix 16 shows the data for percent of scans compared with percent of time that the behaviours of sitting, feeding, and preening were recorded. It can be seen that these data were very similar, both in absolute values and comparative values.

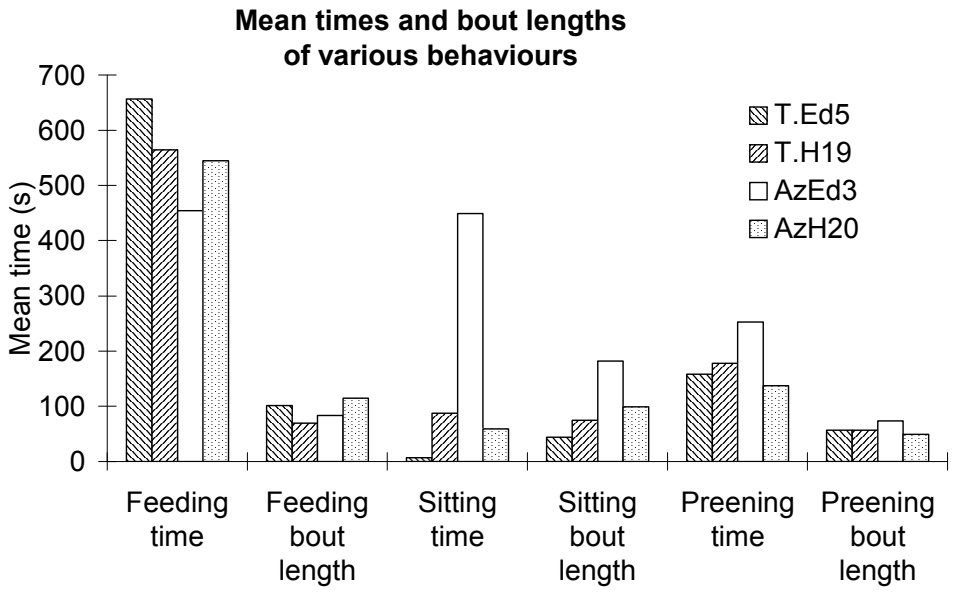
Appendix 17 compares the data for drinking gathered by the two methods. Comparatively, they were similar but details differ considerably. This was probably because hens that drank with longer bouts were more likely to score higher for scan data but lower for bout data and vice versa.

4.10 Bout lengths

The mean length of time feeding, sitting, and preening was compared with the mean bout length of these activities using the continuous data collected from the first four cages observed. Differences between the cages by the two measures were comparable; groups with higher mean times also had longer bout lengths and those with lower mean times had shorter bout lengths (Fig. 19).

It is interesting to note that mean feeding bouts were much shorter than mean feeding times, while sitting bouts were about the same length of time.

Figure 19. Mean times and bout lengths for feeding, sitting, and preening.



5. Discussion of Results

The aim of this study was to develop methods for assessing the relative behavioural welfare status of hens in different housing systems. In pursuit of this aim, data were gathered over nine or ten half-hour periods over one whole day in each cage. There are sufficient data to give a reliable assessment of the behaviours of the hens observed, but there are insufficient replicates available to allow for statistical analysis of cage or strain effects. Analysis is therefore descriptive. We have been able to identify trends and these are discussed to show how these data can be interpreted to assess welfare.

This study has shown the best methods for collecting specific data. We have also determined how to recognise behaviours in these speeded up photos; and definitions and how to recognise the behaviours have been given in the Methods section. Ideas for improvements to the experimental procedure are given, and recommendations made for fuller studies to confirm the trends seen in this study.

5.1 Use of facilities in Edinburgh cages

5.1.1 Nest

Briefly, it seemed that the nest reduced pre lay frustration, particularly if not already occupied by a laying hen. Therefore, the hens' welfare in Edinburgh cages was improved for a maximum of approximately two hours of pre lay behaviour (or 12.5% of the day). The nest was only entered for short periods by bullied hens, so it did not improve welfare by providing a refuge.

In detail, the nest or litter box was used readily for laying, and the hens showed an interest in the place where they eventually laid before entry, and persisted in using this place even if it was already occupied, and the alternative site was unoccupied. Pre lay restlessness was usually reduced. However, when the nest was already occupied as in T.Ed13, activity rates were higher than when it was unoccupied. This observation might indicate that more than one nest box should be provided in each cage. The 5 minute activity peaks usually became higher the closer to laying time in Harrison cages. Activity could not be reliably recorded within the Edinburgh cage's nest box because it necessarily had opaque walls (to create a dark place to lay). However, when hens were moving about in the nest box, the feet became visible through the egg gap. Hens occupying the nest box to lay an egg appeared generally quiet. Hens in Harrison cages sometimes rapidly moved the head as well as moved about, while this was not seen by hens in the Edinburgh cages. These observations indicate that there was probably less pre lay agitation before laying in the presence of a nest even when the nest was occupied.

Likewise, aggression increased before laying in Harrison cages, but this was less evident in Edinburgh cages. At this time, aggression in Harrison cages was almost entirely directed towards hens in neighbouring cages rather than cage mates. The fact that hens in Edinburgh cages did not increase aggressive behaviour before laying could have been because they were unable to interact with neighbours. However, they were, in general, more aggressive towards their cage mates than the hens in Harrison cages, and might have been expected to become more aggressive towards cage mates during pre lay in the absence of neighbours. This did not occur.

There was a strain effect in the Harrison cages, with the heavy bodied Tegel hens sitting more than the light bodied Aztec hens before laying, and their 30 minute activity peaks being somewhat lower. However, their 5 minute activity peaks were comparable, so it seems that basically the Tegel hens were as frustrated by the lack of a nest as the Aztec hens. The Tegel hens' lower score for the 30 minute observation period would have been because they tended to alternate restlessness with sitting. The fact that sitting by Aztec hens in Harrison cages was virtually absent before laying, and time sitting by the Tegel hens in Harrison cages was not comparable to the time spent in the nest in Edinburgh cages shows that other aspects of their laying behaviour were disrupted.

The typical increase in preening and decrease in feeding before laying was seen in both cage types, and hens in both typically fed immediately after lay. Free range hens also have been reported to feed after laying (Rudkin, 1998). It would seem therefore, that some normal laying behaviours could be carried out in both cage types.

Another welfare concern seen in the Harrison cage was the vent pecking that occurred in one of the cages. It is usually said that vent pecking occurs after laying while the vent is still everted, but in this case, it occurred during lay, and not afterwards. The provision of a nest may make the vent less visible to cage mates and less likely to be pecked.

5.1.2 Litter box

Considering all factors, the benefits of the litter box for welfare were not clear.

Dust bathing was occasionally observed in the litter box. Only three hens ever dust bathed in the litter box. One hen was broody in the litter box. Seven other hens sometimes entered the litter box at times, but did not use it for dust bathing. Three hens did not enter it at all. The maximum amount of time the litter box was occupied by any one hen (other than as a refuge or for brooding) was nine per cent of day light hours. Therefore the litter box can be seen as improving welfare for hens for up to nine per cent of the day. However, since so few hens dust bathed, and sham dust bathing still occurred outside the litter box, the litter box may not have provided a very strong stimulus for dust bathing. This may have been a problem with the litter provided. Litter boxes were well used in studies such as Appleby *et al* (1993) and Appleby and Hughes (1995). These authors used fine dry sand whereas we used light sandy loam. It is well known that hens dust bathe more readily in some substrates than in others. However, some other factor may have been responsible.

The use of the litter box for laying can be viewed as improving welfare for the hens, but not for the producer. Dirty and broken eggs, and a broody sitting on the eggs would all be a problem to the producer. It may also encourage broodiness. However, exclusion from the litter box during the morning as recommended by Appleby and Hughes (1995) may help control these problems.

The use of the litter box as a refuge by bullied hens may be seen as improving welfare for these hens. However, these hens were unable to access food or water from this site, and they could well have been underfed. One of the hens that used the litter box as a refuge later died. The limited access to feed and water could have been a factor contributing to this death. Also the long periods away from the other hens may have increased aggression when they eventually left the sanctuary. The bullied hen in AzEd18 only occupied the litter box for relatively short periods, but each time after leaving it, she was pecked more often than usual.

The litter was sometimes pecked, but this was at a low rate, compared to floor housed hens, and probably did not improve welfare to any degree by allowing foraging behaviour.

Dust bathing movements were only recorded in the Edinburgh cages and not in the Harrison cages. The presence of litter is known to encourage dust bathing movements even if it cannot be pecked (Petherick *et al*, 1993). Therefore, not only the dust bathing in the litter boxes, but also the sham dust bathing seen in an Edinburgh cage could have been at least in part promoted by the presence of litter. This could therefore be seen as improving welfare by promoting the intrinsic behaviour of dust bathing.

5.1.3 Perch

As in the case of the litter box, the benefits of a perch to the behavioural welfare of hens were not clear.

It seemed that the perch was equivalent to the middle and back of the cage in Harrison cages. The hens used the perch in a similar way to the middle and back of the cage in Harrison cages with more preening and sitting occurring there. Hens in Harrison cages tended to cluster in the middle of the

cage at night (as shown by positions at lights on), while in Edinburgh cages many hens sat on the perch. However, usually not all the hens were on the perch at night. The perch was occupied for about 40 percent of the time during the day, and the middle and back of the Harrison cages for about 50 percent of the time. The fact that the hens sat for such a large amount of time on the perch could have been simply because that was the most convenient place to occupy, to be away from the front. Out of the four Edinburgh cages observed, only one group of hens used the back of the cage behind the perch. This group was the larger Tegel hens. Therefore, the presence of the perch may have restricted usable cage space.

One advantage of the perch was that it was the preferred site for reaching the water nipples. This allowed hens to drink without getting in the way of feeding hens. However, it may have exacerbated feather pecking as some hens appeared to peck water droplets off the back of hens that were standing under the water. This appeared to lead to more damaging pecking.

The perch was only 360mm below the top of the cage (less than the 400mm required by the Code of Practice) and it was observed that it restricted the ability of the hens to stand fully upright. The fact that the perch was used for a large proportion of the day, indicates that it is important that sufficient standing space be given above the perch. Laying hens rarely sit, and the free ranging laying hens that one of us has observed did not perch during the day (Rudkin, 1998). This adds weight to the idea that the high use of the perch may not indicate that it is a benefit to the birds. The main benefit of perches that has been demonstrated in the past is the improvement in bone strength (Appleby and Hughes, 1990). However, increased bone strength due to different housing has been shown not to decrease the incidence of old breakages (Whitehead, 2002).

5.2 Effects of cage shape and space allowance

The longer shallower shape of the Edinburgh cage compared with the Harrison cage may have provided easier movement about the cage, particularly from front to away from front. The fact that most hens used the nest and litter box for only a short part of the day in the Edinburgh cages made the main part of the cage the primary living area. Therefore, the space per bird was effectively less than that in Harrison cages. However, in three of the four Edinburgh cages observed, one hen spent a large part of the day in the litter box, so in these cases, space per hen for the other three hens in the main part of the cage was often more than for the hens in the Harrison cages. This changed shape and extra space could be expected to alter many behaviours. However, as is shown below, space related behaviours apart from aggression did not show any consistent differences.

5.2.1 Activity rates

Activity rates were determined to assess how cage design affected activity in the Harrison cages compared with the Edinburgh cages, whether low social status restricted activity, and whether status may have more effect in one cage type than the other. However, it appeared that neither cage type nor social status affected activity. As would be expected, the bullied hens in the Edinburgh cages did not move about as much as other hens, but the lowest status hen in AzEd18 moved about as much as the top status hen. There was at least as much, if not more activity by the light bodied Aztec hens in the Harrison cage as by hens of either strain in the Edinburgh cages. Therefore, neither cage type appears to have restricted movement about the cage. The slightly higher score in the Harrison cage could have been because the movement of one hen was more likely to affect the position of another hen. Since top status hens seemed to move about somewhat less than lower status hens, perhaps greater comfort for the birds was represented by less movement rather than more movement. Repetition of this study with different numbers of birds per cage could resolve this question.

5.2.2 Cage space use by individuals

The use of cage space by individual hens was looked at particularly because it was thought that lower status hens would be more restricted in their use of cage space than higher status hens. If this was more often in one cage type than the other, then comparison of their welfare status could be made. This does not seem to have been the case. Apart from the bullied hens that remained for a large part of the day in the litter box, it seems that all hens tended to be found more often in some parts of the cage

than in other parts, and that these were different for different hens but did not appear to be related to status. Also many hens drank more often from one nipple than the other although the preferred nipple differed for different birds. The top or second status hens seemed to be at the front of the cage rather more than the third status hens. Lowest status hens did not seem to be affected however. Otherwise, no consistent status effect could be seen, and space restriction does not seem to have been a problem as regards cage space use in either cage type.

5.2.3 Status effects on other behaviours

More restricted space allowance may have limited some lower status hens' activities. Many behaviours by the two extremely bullied hens that spent most of the time in the litter box, were certainly reduced. This extreme bullying may have been in part because of the method of marking (see Section 4.7.3 and 5.2.7). Other lower status hens in these two cages, and low status hens in other cages appeared to perform all behaviours at similar rates to other hens in their cage in both cage types and by both strains. Thus, in general, status did not appear to restrict behaviours in either cage type.

5.2.4 Feeder space

The feeder space of 125mm per hen in Harrison cages, and 175mm per hen in Edinburgh cages was more than the recommended minimum of 100mm per hen in both cases. However, feeding of more than two at a time was not very common. Also the smaller light bodied Aztec hens were more likely to have more than two hens feeding at once compared to the larger heavy bodied Tegel hens, and Aztec hens in Edinburgh cages fed more often together than those in Harrison cages. Therefore the smaller body size appeared to facilitate more hens feeding at once. However, the heavy bodied Tegel hens in the Edinburgh cages fed less often together than the Tegel hens in the Harrison cages even though they had more space. Aggression was much higher in the Edinburgh cages, and in T.Ed5, one hen stayed nearly all day in the litter box, so most of the time only three hens were in the main part of the cage. It seems that social factors as well as feeder space were influencing how many birds were feeding at once. In another video study one of us observed the behaviour of hens in the older style deep conventional cages where two birds were housed per cage with 300mm of feeder space (unpublished observation). In some cages, one hen spent most of the time feeding at the front, and the other hen only fed when this hen moved to the back of the cage. In other cages, both hens fed comfortably together. Therefore, there may be a lot of variability between the behaviours of different groups of hens, depending on social relationships in the particular cage.

5.2.5 Space allowance in Edinburgh cages

The results of cage space use in this study leads into a consideration of how space in Edinburgh cages should be allotted for each bird. The fact that the back of the cage was rarely used indicates that this area should not be included as space per bird allowance. Moving the perch forward would mean that hens would remain on the perch to feed. Therefore, the back of the cage should either be widened, or the area behind the perch not be regarded as standing room. A build-up of manure had been seen in the cages occupied by Tegel hens and not by Aztec hens, so it had been thought that the smaller bodied Aztec hens were using the back, and not the larger bodied Tegel hens. However, the one group that occasionally entered the back was Tegel hens. Therefore, it seems that another explanation needs to be sought. Possibly the droppings of the Aztec hens were smaller and fell through the wire at the bottom of the cage more readily. Since the back of the cage is so rarely used for standing, the problem of manure build up could be solved by widening the mesh on the floor behind the perch. Another problem recognised was that the perch was too close to the top of the cage for the comfort of the birds. Cage specifications will need to be at least 40mm higher than that used in these studies.

When calculating space allowance to determine the number of birds each cage can house, it is probably not desirable to include either nest space or litter box space in the calculations. The nest was rarely entered except to lay an egg (or by a broody), and the litter box was used primarily by bullied hens. If the litter box were included in space allowance, low status hens are very likely to be forced to stay for a disproportionate amount of time in this place. Since they cannot access food or water there, this should not be seen as desirable from a health and welfare point of view.

5.2.6 Comfort behaviours

More comfort behaviours such as preening, stretching, feather ruffling, and wing movements may have been expected in the Edinburgh cages than in the Harrison cages. Wing flaps never occurred in either cage type. This was expected as it has been established that hens need a minimum of 860 cm^2 to wing flap (Dawkins and Hardie, 1989). Space per bird in both cage types was below this figure (in the main part of the Edinburgh cages it was 625 cm^2 and in the Harrison cages it was 700 cm^2). Preening, stretching, feather ruffling, and bilateral partial wing raise occurred at about the same rate in both cage types and both strains, and there was no evidence that the different cage spaces and shape of the cages affected these behaviours.

5.2.7 Aggression

Aggression seemed to differ between cage type and strain with more aggression being seen in Edinburgh cages, and light bodied Aztec hens being more aggressive than heavy bodied Tegel hens (Appendix 8). Note that hens' heads were not painted in the Edinburgh cages T.Ed5 and AzEd18. When unpainted birds in Edinburgh cages are compared, it can be seen that the heavy bodied Tegel hens had fewer aggressive interactions than the light bodied Aztec hens, and likewise when painted birds are compared. In Harrison cages, the heavy bodied Tegel hens had fewer aggressive interactions than the light bodied Aztec hens. Both groups of hens in Harrison cages were painted and comparison with painted hens in Edinburgh cages of the same strain shows higher aggressive rates in the Edinburgh cages. Therefore, taking account of paint as well as strain and cage type, it seems that Aztec hens were more aggressive than Tegel hens, and more aggression occurred in Edinburgh cages than within Harrison cages. Therefore the ability to "get away" in Edinburgh cages did not reduce aggression. One possible explanation is that by removing itself from the other hens for a period of time, the bullied hen was more prone to attack when it again encountered the other hens. If further studies confirm this trend, Edinburgh cages can be seen as reducing welfare by this criterion.

5.3 Behaviour rates and their relevance to welfare

Edinburgh cages are said to be "enriched" because their extra facilities provide stimuli for the performance of a greater repertoire of behaviours than in conventional cages. A common perception by the general public is that hens are "bored" in conventional cages. Therefore, to demonstrate that a modified housing system is an improvement on another housing system, one should be able to demonstrate that the hens are, in fact, less bored. In other words, the "*enriched"* cages should be shown to be behaviourally "*enriching"* for the birds.

It is known that hens on litter and free range hens feed less, stand less, sit less, and show less abnormal behaviours such as feather pecking and stereotypies than caged hens (Appleby *et al*, 1992; Keeling, 1994). If the Edinburgh cages were enriching as compared to Harrison cages, one may have expected to see some reduction in feeding, standing, and sitting rates, and less feather pecking and stereotypies in the Edinburgh cages. However, no consistent differences between cage type or strain could be seen for any of these behaviours. Not only did they feed, sit, stand, and stand with head out as much, feather pecking was at about the same rate in both cage types. Air pecking was seen in one Harrison cage, and stereotypic behaviour directed at water nipples was seen in two of the Edinburgh cages. Excess drinking and regurgitation into the food may also be a behaviour associated with unenriched conditions, and this was seen in the Edinburgh cages but not in the Harrison cages.

Therefore, according to these measures, these data suggest that the Edinburgh cages were not enriching as far as the hens were concerned. The opportunity to perform a greater repertoire of behaviours did not alter behaviours known to be associated with more restricted or "barren" housing. The time from first sign of pre laying behaviour to egg laying, was for a median of 3% of the daylight hours in Harrison cages, and 6% in Edinburgh cages. The maximum percent of the day that hens were showing laying behaviour was 12.5%. The median time any hen used the litter box was 2.3% of the day, and its maximum was 9%. Therefore, considered together they were affecting behaviours for around 10% of the day for most of the birds, leaving 90% of the day when the extra facilities were not increasing the performance of extra behaviours. Therefore, the Edinburgh cages we used may be interpreted as having not improved welfare for the greater part of the day. Litter was sometimes

pecked when birds were not in the litter box and may be seen as enriching, but it did not appear to be sufficient to affect the behaviours that indicated enrichment. The litter box was used rather less than in other studies, so its greater use may have improved welfare rather more in these other studies. Therefore, the stimuli in our Edinburgh cages may have been insufficient to stimulate optimum rates of the extra behaviours. Another explanation could be that the stimuli were insufficient to promote some other important behaviours such as foraging (Blokhuis and van der Haar, 1992).

5.4 Diurnal changes

The videos extended over the whole daylight hours and gave a good opportunity to look for diurnal changes. They allowed assessment of the effect of laying and of feeding on activity rates and behaviour rates. The effect of laying has already been examined in the section above on laying behaviour. Topping up the food trough (or even stirring it as happened in one case) had a pronounced effect on a number of behaviours. The birds pecked food more, moved about more, and sat less. Aggression and feather pecking were either reduced or unaffected. It was interesting to note that feeding rate tended to be higher than usual during the observation period preceding the after-feeding observation period. This may have been coincidental, but the birds may have been showing anticipation.

The fact that topping up food troughs did not usually exacerbate aggression or feather pecking indicated that this method of feeding did not compromise welfare. In fact, it may be concluded from some of these observations that feeding the birds, or stirring the food improves welfare for a while subsequently. The hens behaved as though they "enjoyed" feeding time, with much anticipatory movement while people were tending the birds in the shed, and rapid feeding after topping up. It appeared that feeding time alleviated "boredom". If this was the case, "boredom" was as great in Edinburgh cages as in Harrison cages. Perhaps if the food is regularly stirred or topped up over the day, aggression and feather pecking may be reduced. However, a study by one of us indicated that stimulation may have the opposite effect by increasing arousal and thereby exacerbating feather pecking and cannibalism (Rudkin, 1998).

Other diurnal effects were less pronounced. The slightly lower feeding rate after lights on and before lights off indicated that hunger may not be an important factor in determining feeding in cages. It may have been expected that after the period of darkness, the birds would be hungry and feed more. Also, that before lights off, they may "top up" to carry them through the period of darkness. Van Rooijen (1991) has suggested that the food manipulation in cages is more to do with carrying out an intrinsic motivation to perform the actions of foraging or exploration rather than feeding. These observations, as well as the observation that hens feed immediately after topping up are consistent with this view.

No consistent morning/afternoon differences were noticeable. It is usually found that more feeding occurs in the morning, and more feather pecking in the afternoon (Preston, 1987; Kjaer, 2000). However, this was not seen in these videos. Perhaps this was simply a factor of insufficient replicates, or perhaps afternoon feeding disrupted this trend.

There was no theoretical expectation of differences between cage and strain types in diurnal changes and no differences were seen. Therefore, examination of diurnal effects probably does little to inform the relative welfare status of the two cage systems. This is discussed in more detail below.

5.5 Future studies

5.5.1 Current videos

More data can be obtained from the videos we already have. Only one day has been analysed, so observation of more days in each cage would give information on daily variability. The laying behaviour of all hens in each cage has not yet been observed. Examination of more tapes may allow studying the laying behaviour of the other hens. Some of the hens sometimes laid on the floor. It is unknown why hens do this. If it was because the nest was already occupied, or if the hen did not

perceive the nest or litter box as a suitable place to lay, it may be accompanied by increased movement indicating frustration. Or, if the floor was for some reason the preferred place of lay, it presumably would not be accompanied by extra movement. It would also be useful to repeat the scanning observations on the first two cages observed, using the six cage divisions as for the later cages observed.

Production data, including where the eggs were laid, have been collected in this study, and for a full assessment of cage type, the production parameters will have to be considered. Housing that has relatively small welfare benefits would be more advisable if production effects were either neutral, or improved.

5.5.2 New studies

Using the experience gained in the present study, we are able to recommend techniques to be followed in a new complete study.

We would recommend using time-lapse videoing as used in this study. An important advantage of analysing video data over direct observation was that the behaviours of all birds could be viewed over the same time period. In this way, interactions of the birds could be assessed. Obtaining data from a whole day's videoing was a very time consuming activity. However, it was shown that diurnal changes did not shed much light on welfare, so it would not be necessary to view the whole tape to look for behavioural differences. Previous experience indicates that data from one or two hours of morning and afternoon observations for three to six days would be sufficient. Diurnal observations indicate that these observations should be taken away from laying and feeding times or early morning or late afternoon in order to measure typical behaviours. Viewing the whole tape to assess nest and litter box use and detecting egg laying can be done quite rapidly. This study has developed good methods of objectively assessing pre lay behaviour. Both the whole day's half-hour observation periods, and the two hour's viewing subdivided into five minute periods yielded useful data. It would probably only be necessary to watch one event of laying by each hen in the study, so the technique developed should not be too time consuming.

Scans were an ideal method of assessing the frequency of behaviours of longer duration, with continuous monitoring only necessary for measuring infrequent behaviours of shorter duration. The technique used in this study was simple and easily done, and gave a good estimate of the proportion of the day spent in the more common activities. It was sometimes found that when hens were extremely active, they often moved away from and returned to the same place they had been at in the previous scan. This caused some underestimation of activity rates, but when birds appeared restless, scores were still greatly increased over the usual scores.

Wood-Gush (1959) found that 22s intervals gave greater accuracy for measurement of behaviour rates than 66s although he felt that 66s was adequate for some types of investigation. We felt that the 30s intervals were adequate when backed up with continuous monitoring for the less frequent behaviours of short duration. Any shorter time period in time-lapse videos would necessitate stopping the video at each scan, which would be very time consuming. Therefore, in order to take shorter intervals, it would be necessary to use modern mechanical techniques. So, either one should stay with the 30s scans, or use good equipment to help take observations. Taping at normal speed would also be an option, but more than one tape would be necessary to take in a whole day's observations – necessary to do to assess full usage of cage facilities.

It was found necessary to watch each focal hen separately for scanning, and then again for continuous monitoring. At the outset, it had been thought that at each 30s scan all hens' positions and activities could be recorded. It was found, however, that this necessitated stopping the tape at each point, and identifying each hen over again. It was quicker and easier to follow each hen separately for the 30 minutes. The procedure of noting the position and behaviour, and watching the timer on the tape meant that less frequent behaviours of short duration were missed, so each hen had to be watched again to record these behaviours.

Continuous monitoring allowed estimation of mean bout lengths of the longer behaviours. However, it was found that mean bout lengths were associated with mean total times. At the start of the study it had been thought that bout lengths could reflect "restlessness" with shorter bouts in cages where the animals appeared more restless. This did not seem to be the case. Since this method of data collecting and analysis was time consuming and seemed to add little new information, it was not pursued.

The strains used in this study were chosen as being representative of a light and a heavy bodied strain. However, to make these studies more relevant to modern practices, future studies would use strains in current use. Also, stocking density and cage design would meet the current Code of Practice in line with commercial operations.

It would also be of interest to use different numbers of hens in each cage to see how social factors influence behaviours. For instance, it would be interesting to see how much movement there is in a cage occupied by a single hen. This would give some idea of how much a hen would voluntarily move about. It would also show whether hens still favour different parts of the cage and water nipples. Carrying out trials with different numbers of hens would also show how space restriction affects behaviours, and suggest ideal group sizes.

Future studies would use sufficient replicates to enable statistical analysis. It would be important to have a good number of replicates since many of the important findings are lack of difference rather than difference. Previous experience in other studies has shown that eight replicates revealed statistically significant differences for biologically important differences. Several days' observations would be taken of each cage to take account of day to day variability.

A method of identifying the hens that does not involve marking with paint or using leg bands needs to be developed. The head is an important area for individual recognition, and painting the head sometimes caused severe aggression. Also, the paint pecking by the Tegel hens in the Harrison cage may possibly have affected aggression and feather peck rates. Leg tags were difficult to see in the Edinburgh cages and impossible to see in the Harrison cages. Many hens were readily identifiable by the shape of the comb but this was not always the case. Preferably we should investigate the availability of wing tags as used in a number of studies such as that by Appleby *et al* (1989).

Although social status did not appear to affect behaviours in either cage type, it is still possible that it would in some cages, or other cage types or under different housing practices such as different densities. Therefore, social status is important to know in order to assess the welfare effects of housing on each individual hen. It involved much careful observation to determine from the videos, and then some hens did not interact or interactions were so rare that the social status could not be certainly assessed. It would be preferable to determine their relationships directly before taking videos. This could be done after allowing sufficient time after caging for social relationships to stabilize, then design a procedure such as placing the hens in an arena with restricted feeding space to encourage social interactions.

Since the information is there, and easily obtained, feather scores and keel and foot condition should be estimated at the end of the trial. Feather scores would add weight to the feather peck data. Also, feather pecks differ in the amount of force used, and greater force could reflect a stronger tendency to feather peck even though number of peck bouts are similar. Foot and keel condition would add valuable information about the benefits of the perch. Also, perch use at night could be more reliably assessed by direct observations after lights out with a hand held torch as done by Duncan *et al* (1992).

The method of assessing cage position was rather ad hoc although the large number of observations would have removed any inconsistencies. However, marking the cage into the 6 parts would enable more objective estimates. Small movements backwards and forwards across a line would have to be discounted though to keep measurements realistic.

People entering the shed during videoing caused strong behavioural changes in the birds. It would be desirable that the birds be tended at a fixed time of day, and observations aimed at assessing usual activities be taken away from this time.

Hens in the Harrison cages should have neighbours so that their interactions are as similar as possible to hens under commercial conditions. Ideally these neighbours would not be observed so as to reduce any correlation effects. The hens in this study either had neighbours of a different strain or no neighbours. It would be important that the neighbours always be of the same strain. Some of the inter-cage aggression could have been due to the neighbours being a different strain.

At least some observations of hens in Edinburgh cages should be taken when the door to the litter box is closed in the morning, since this would be the usual practice in a commercial situation.

It would be preferable to take videos at different times of the year for assessment of the range of behaviours associated with climate change and the different microclimates in different cage types.

Photography of cages where hens can interact with birds in neighbouring cages should include part of the neighbouring cages to assess between cage interactions. The egg tray of Harrison cages should be included for more easy assessment of when an egg was laid. It would also be useful if a method could be developed to see into the nest in the Edinburgh cages. Perhaps another camera with infra red capabilities?

As well as measuring amount of pre lay movement, heart rate measures would be useful for assessing amount of stress. It is known that more "placid" strains show longer heart rate elevations in reaction to a visual stressor than more "flighty" strains (Duncan and Filshie, 1979, cited by Ödberg, 1987). The apparent differences between the heavier bodied Tegel hens and the lighter bodied Aztec hens may not be reflected by heart rates.

The preliminary data collected in this study have shown how behavioural data can be used to assess comparative welfare. The data collected suggested that the presence of a nest improved the welfare of hens over the pre lay period, which can be up to two hours. The benefits of a litter box and a perch were less clear, and the perch appeared to prevent use of the back of the cage. The extra space provided by the nest and litter box, and the different shape of the Edinburgh cages compared to Harrison cages also did not appear to have any beneficial effect. The fact that aggression seemed to be exacerbated in Edinburgh cages could be seen as being harmful to welfare. There was no behavioural evidence that the Edinburgh cages were "enriching" in the sense that they alleviated "boredom" by giving the hens "something to do". Yet perceived "boredom" of hens in cages is probably the chief concern of the public. It is therefore essential that a more extensive study be undertaken before any firm recommendations be made whether or not to use Edinburgh cages in preference to conventional cages.

This study has developed useful techniques for assessing behavioural welfare and has been able to suggest improvements in experimental set up. This information can be used to expedite other more extensive studies.

6. Implications

Over time the welfare lobby is having gradually more influence on Government decisions. Public perceptions of the welfare problems of farmed poultry are generally based on emotion rather than on information. If responses are based on these perceptions rather than on any real welfare problems, the industry could be put to great expense for very little change in the welfare status of the birds in their care. This may be beneficial for improved public relations, but little benefit to the hens or the farmer. Studies such as this could save the industry from a great deal of unnecessary expense. The exact potential saving to the industry cannot be assessed in this report.

The physical welfare of hens is basically at its optimum in modern cage systems. The public concerns are mostly about whether the hens are "happy". To assess this subjective state, it is necessary to take behavioural measurements. The parameters that may be measured and interpreted to assess the behavioural welfare of the hens are shown in this report. Such studies should complement other more physiologically based studies such as stress hormone levels, and fear measurements.

7. Recommendations

The preliminary data obtained in this study have very important implications to the poultry industry. It is recommended that these studies be repeated with sufficient replicates to interpret the data reliably. Future studies should make use of the experience gained in the present study. It has been shown how the data collection can be fast tracked to get the optimum information. Details of how these studies could be carried out are in the body of the text in the Discussion of Results, section 5.5. These are outlined below.

- It is recommended that data from all day time-lapse videos should be collected for 1-2h morning and afternoon from approximately six to eight replicates per treatment, for approximately three to six days. Thirty second scan techniques of focal hens should be used to assess frequency of behaviours of long duration, and continuous monitoring for the frequency of rarer behaviours of shorter duration. Tapes should be viewed over at least one whole day per cage for nest and dust bath use, and to measure pre lay behaviour.

- Photography of hens in conventional cages should take in part of surrounding cages and the egg tray. Neighbouring cages should be populated with hens of the same age and strain but not observed.

- Methods of identification that do not involve painting the birds will need to be developed. The availability of wing tags such as mentioned in literature from the European Union should be investigated.

- The assessment of behaviour should be determined using current strains and the latest Code of Practice to keep relevance to the commercial industry.

- Hens should be separately assessed by experimental means for social status in each cage.

- Feathering, foot, and keel conditions should be separately assessed.

- As was done in this study (but not reported), physical egg production and quality parameters should be recorded and assessed along with the behavioural data.

We already have time-lapse videos of hens in cages with egg baffles, and of hens in combined cages. Egg baffles may change effective space for the birds. In order to conform to the new Code of Practice, cages may be combined in an attempt to house the maximum number of birds permissible. These videos would give valuable information as to the impact of these modifications on the hens. Since they already exist, it is recommended that observations of the behaviours of hens in these videos be undertaken.

Appendices

Appendix 1. Pecking interactions between hens showing total number of peck bouts by each individual and when individual was pecked observed during the half-hour observation periods.

Appendix 1A. Aggressive Encounters

Tegel hens in Edinburgh cage 5

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	1	6	0	**7**
2	0	-	1?	0	**1**
3	0	5	-	0	**5**
4	0			-	**0**
Total	**0**	**6**	**7**	**0**	

Tegel hens in Edinburgh cage 13

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	1	1	0	**2**
2	0	-	0	0	**0**
3	0	3	-	0	**3**
4	10	7	0	-	**17**
Total	**10**	**11**	**1**	**0**	

Aztec hens in Edinburgh cage 3

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	0	24	17	**41**
2	0	-	0	1	**1**
3	0	3	-	0	**3**
4	0	0	0	-	**0**
Total	**0**	**3**	**24**	**18**	

Aztec hens in Edinburgh cage 18

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	2	1	22	**25**
2	0	-	9	2	**11**
3	0	0	-	0	**0**
4	0	1	2	-	**3**
Total	**0**	**3**	**12**	**24**	

Appendix 1A. Aggressive Encounters (continued)

Tegel hens in Harrison cage 19

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	0	0	0	**0**
2	0	-	0	0	**0**
3	1	0	-	0	**1**
4	2	0	0	-	**2**
Total	**3**	**0**	**0**	**0**	

Aztec hens in Harrison cage 20

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	0	0	8	**8**
2	1	-	0	2	**2**
3	6	1	-	9	**16**
4	0	0	0	-	**0**
Total	**7**	**1**	**0**	**19**	

Appendix 1B. Feather Peck Bouts

Tegel hens in Edinburgh cage 5

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	6	14	4	**24**
2	2	-	0	0	**2**
3	0	4	-	0	**4**
4	1	0	2	-	**3**
Total	**3**	**10**	**16**	**4**	

Tegel hens in Edinburgh cage 13

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	0	3	0	**3**
2	0	-	0	0	**0**
3	8	3	-	2	**13**
4	10	12	2	-	**24**
Total	**18**	**15**	**5**	**2**	

Aztec hens in Edinburgh cage 3

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-		1	8	**9**
2		-	2	8	**10**
3	1	1	-	9	**11**
4		4	1	-	**5**
Total	**1**	**5**	**4**	**25**	

Aztec hens in Edinburgh cage 18

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	0	8	3	2	**13**
2	1	0	0	1	**2**
3	1	2	0	0	**3**
4	2	3	4	0	**9**
Total	**4**	**13**	**7**	**3**	

Appendix 1B. Feather Peck Bouts (continued)

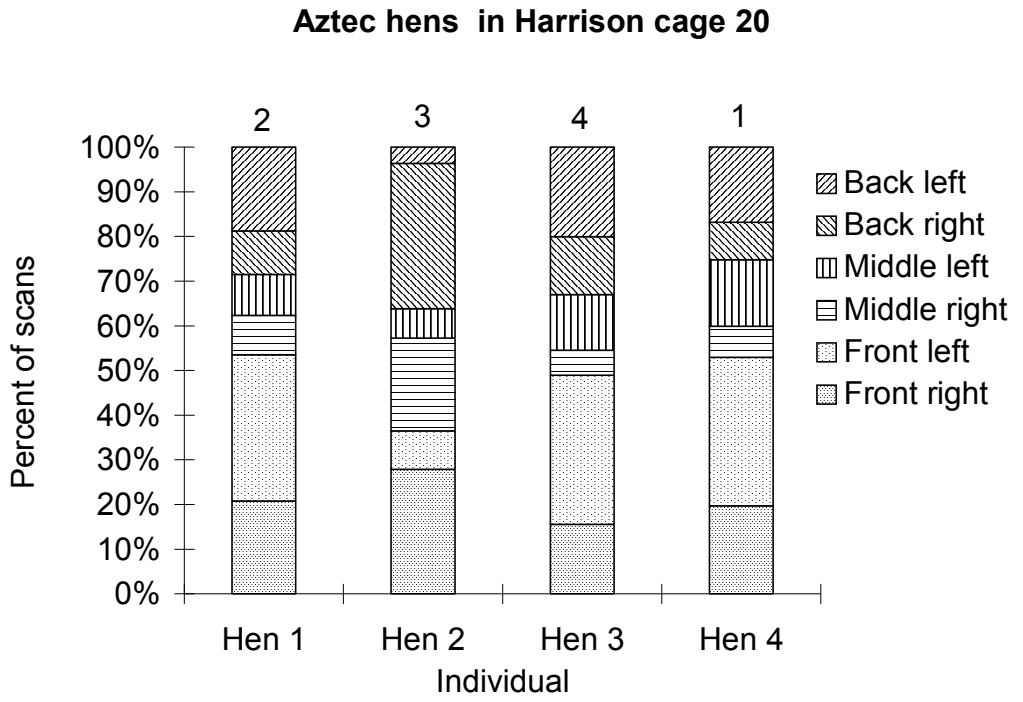
Tegel hens in Harrison cage 19

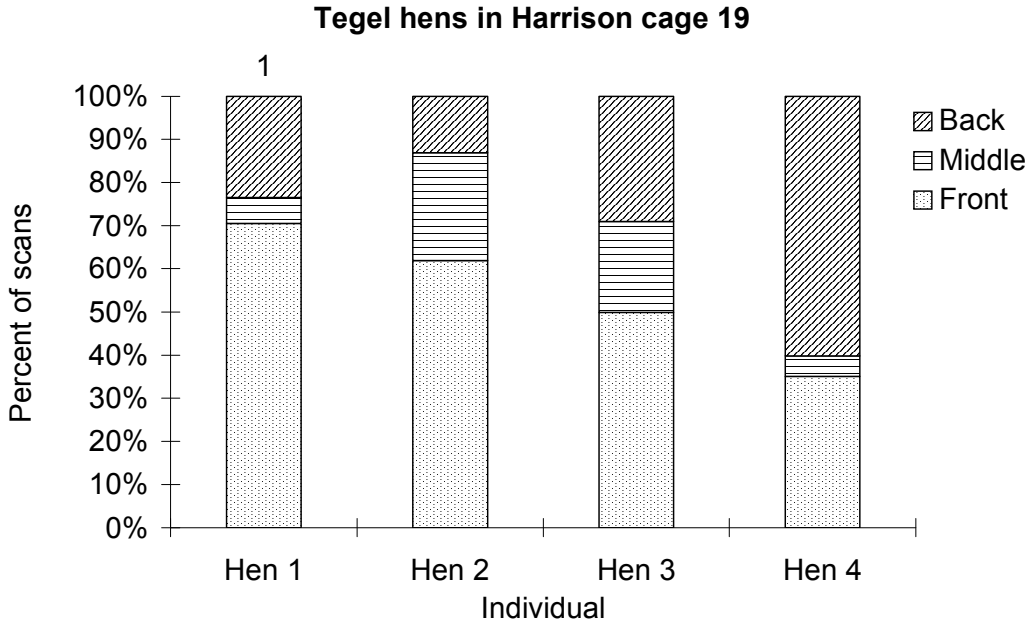
	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	2	5	2	**9**
2	15	-	9	3	**27**
3	3	0	-	0	**3**
4	17	0	5	-	**22**
Total	**35**	**2**	**19**	**5**	

Aztec hens in Harrison cage 20

	PECKERS				
PECKEES	**1**	**2**	**3**	**4**	**Total**
1	-	0	0	3	**3**
2	0	-	3	2	**5**
3	5	0	-	6	**11**
4	1	0	3	-	**4**
Total	**6**	**0**	**6**	**11**	

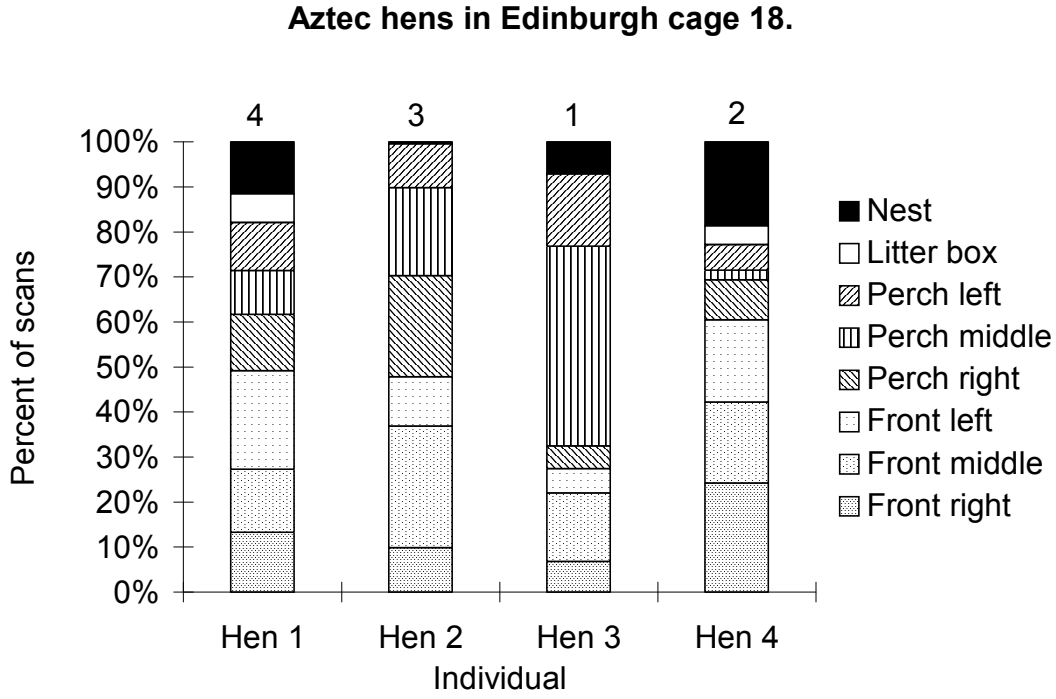
Appendix 2. Percent of scans individual hens were in different positions. The number at the top of the column indicates social status.

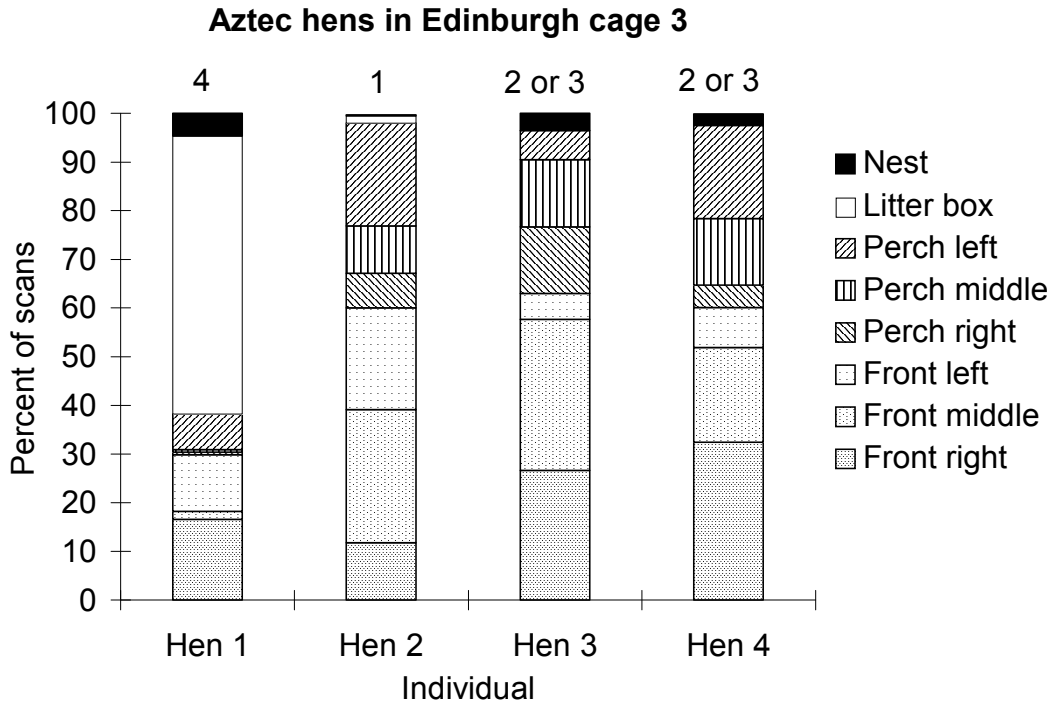




(Above: this cage was the first Harrison cage observed and was only divided into 3 parts.)

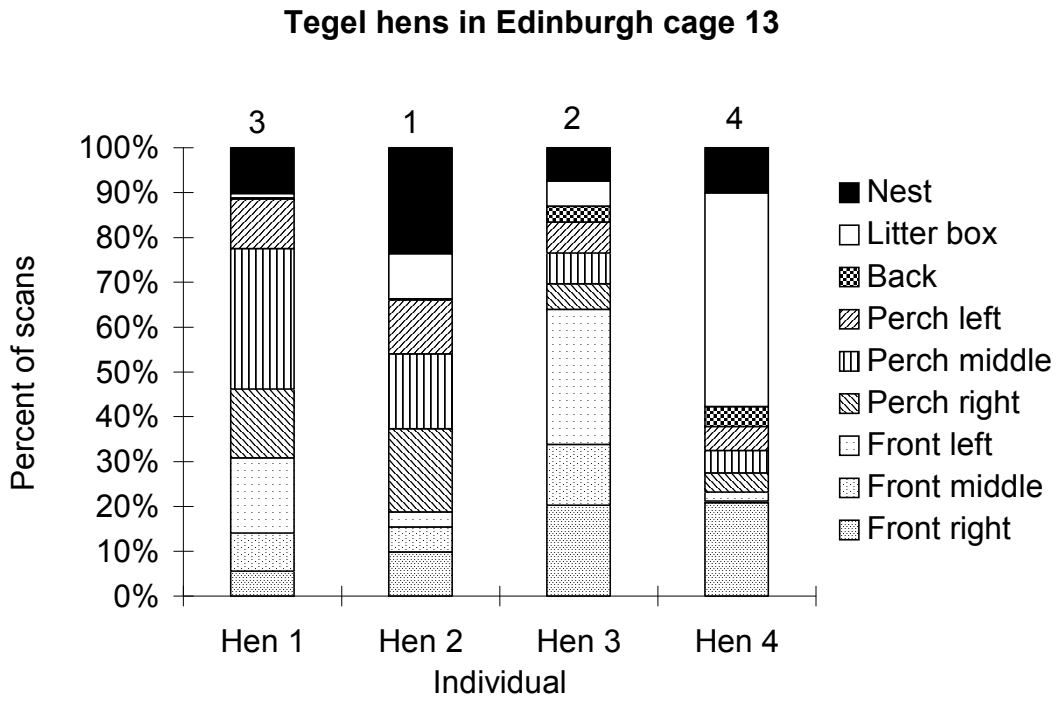
Appendix 2. Percent scans in different positions (continued)



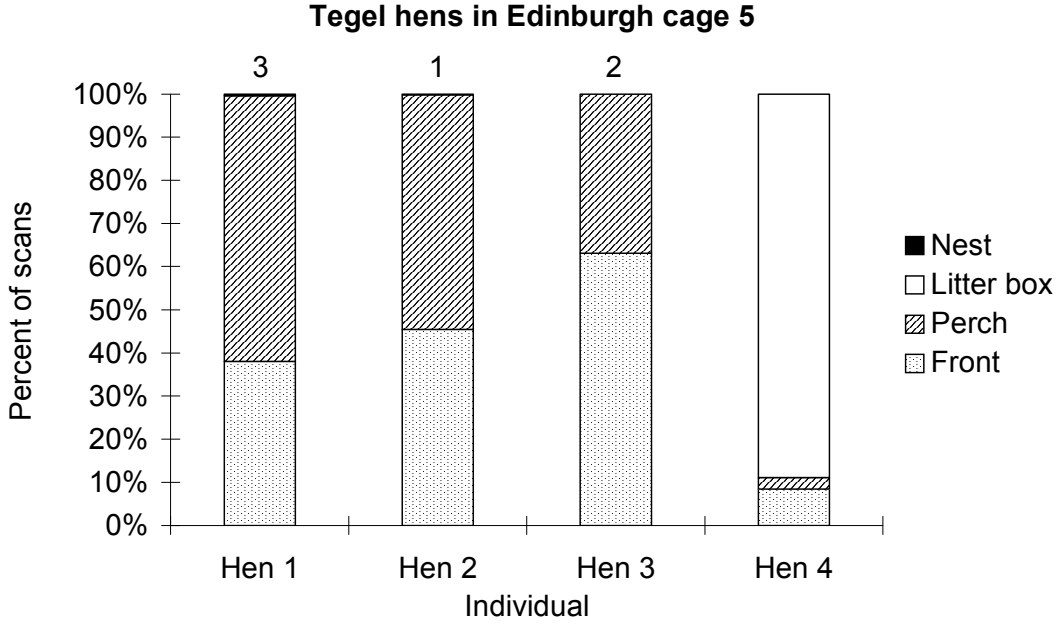


(Above: hen 1 used the litter box as a refuge.)

Appendix 2. Percent scans in different positions (continued)

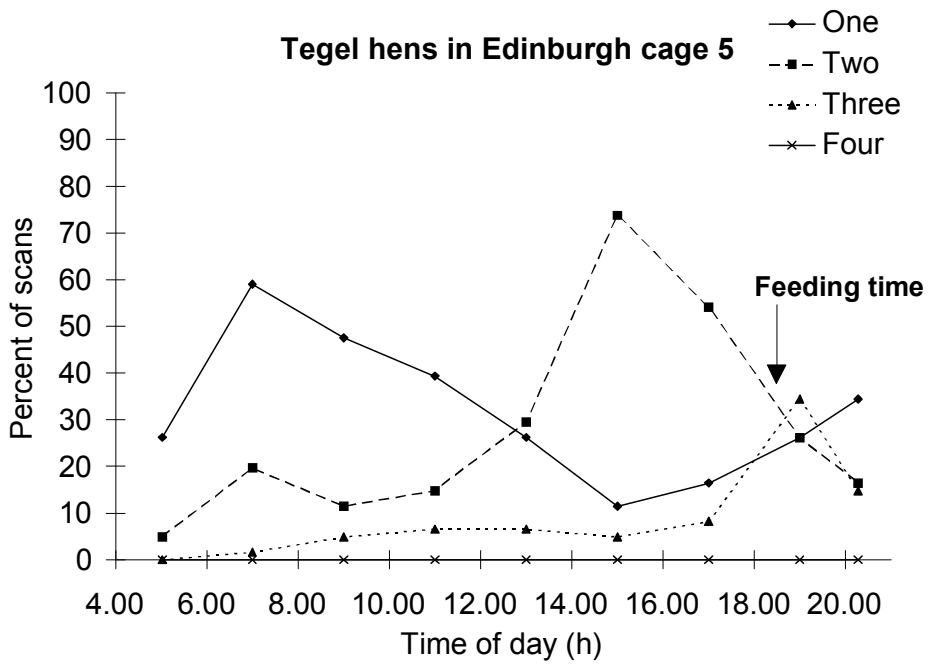


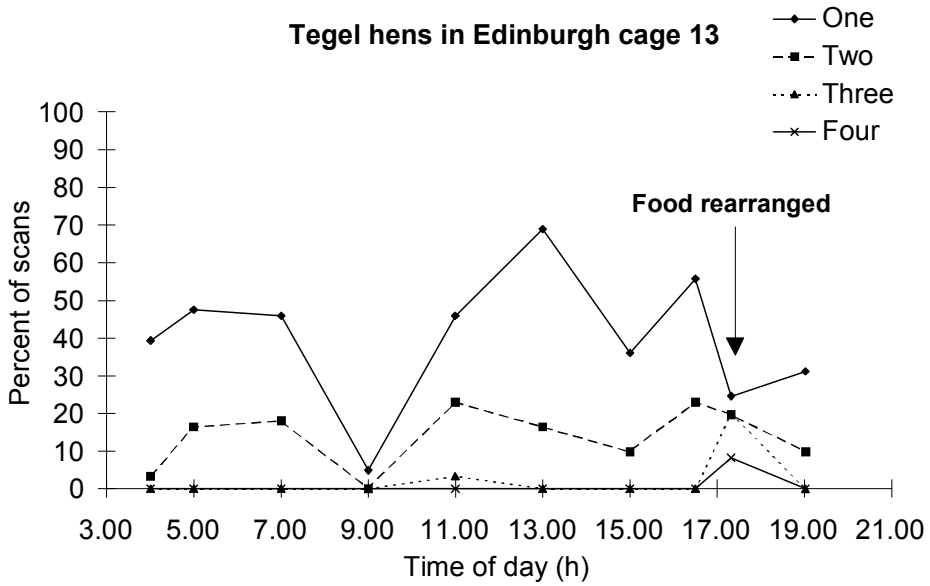
(Above: hen 4 used the litter box as a refuge.)



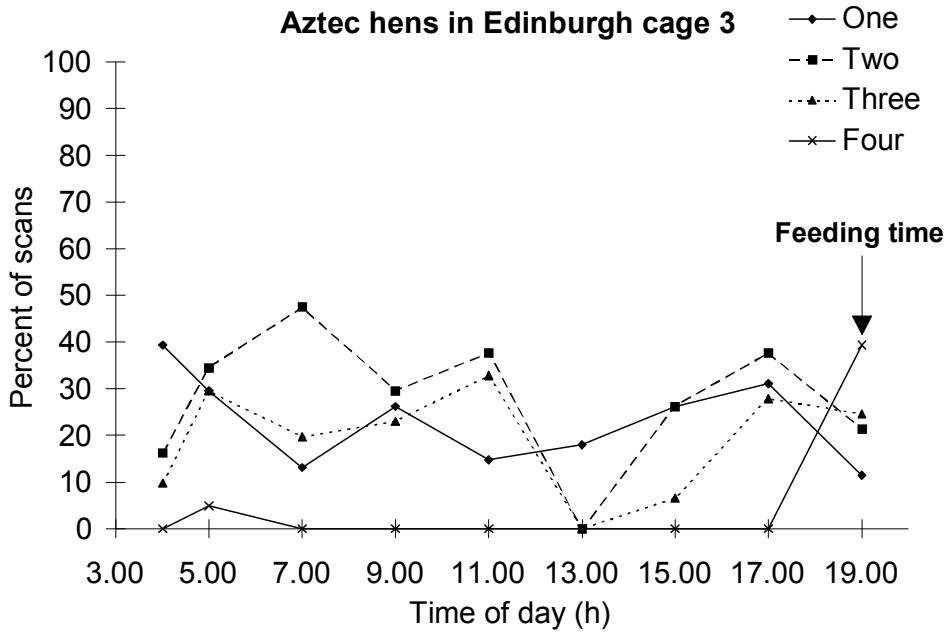
(Above: hen 4 appeared to be broody in the litter box. This was the first Edinburgh cage observed and only divided into 4 parts.)

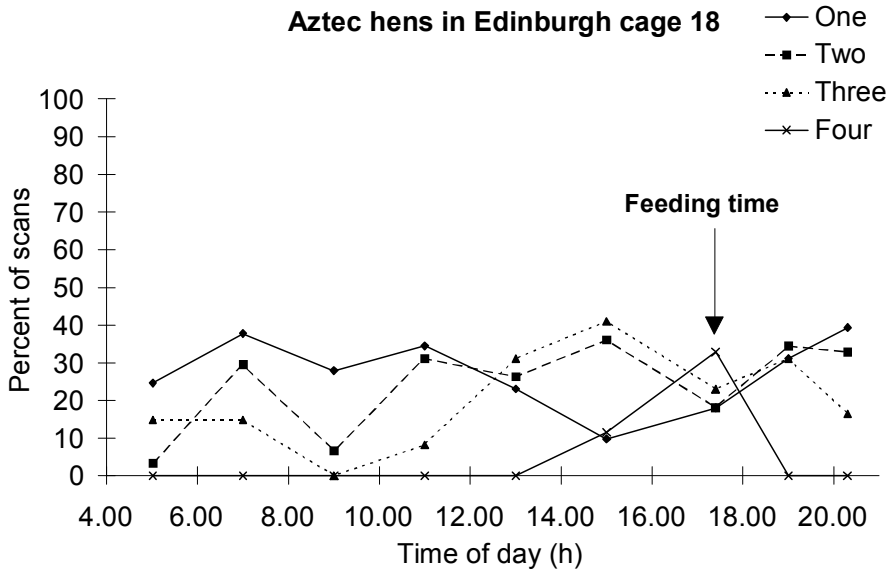
Appendix 3. Percent of scans when one, two, three of four hens feeding at once over the day.



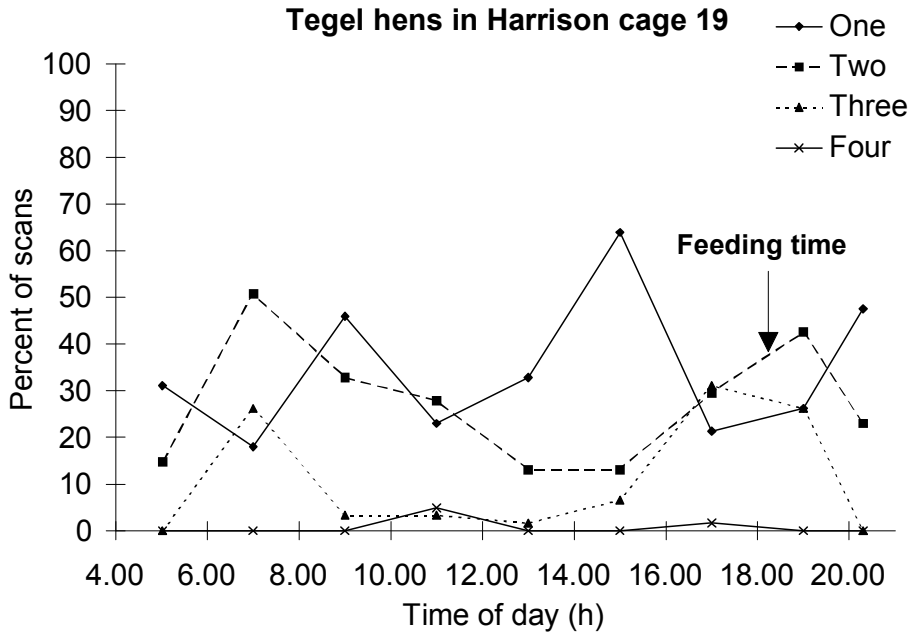


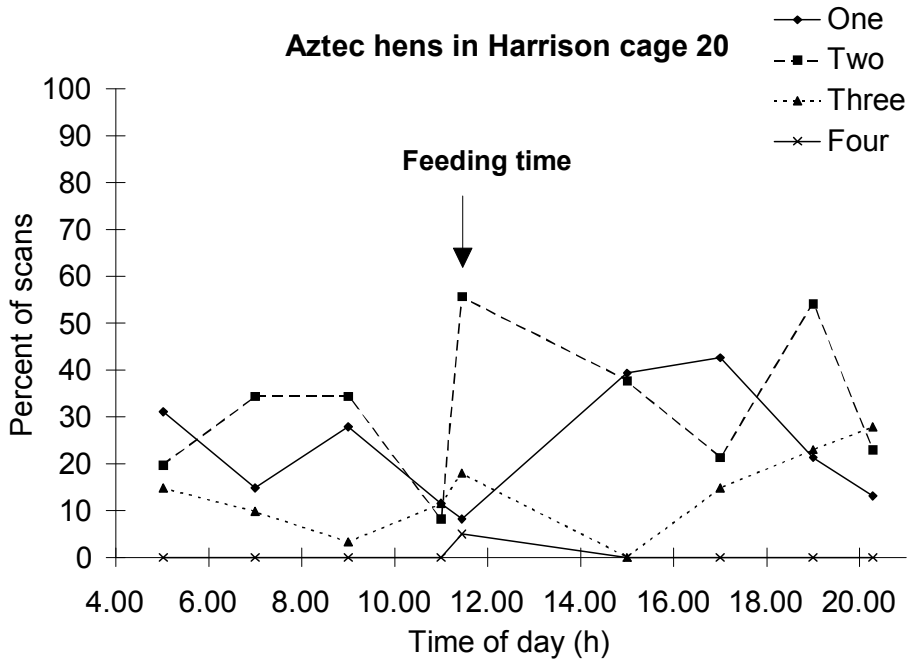
Appendix 3. Number feeding at once (continued)



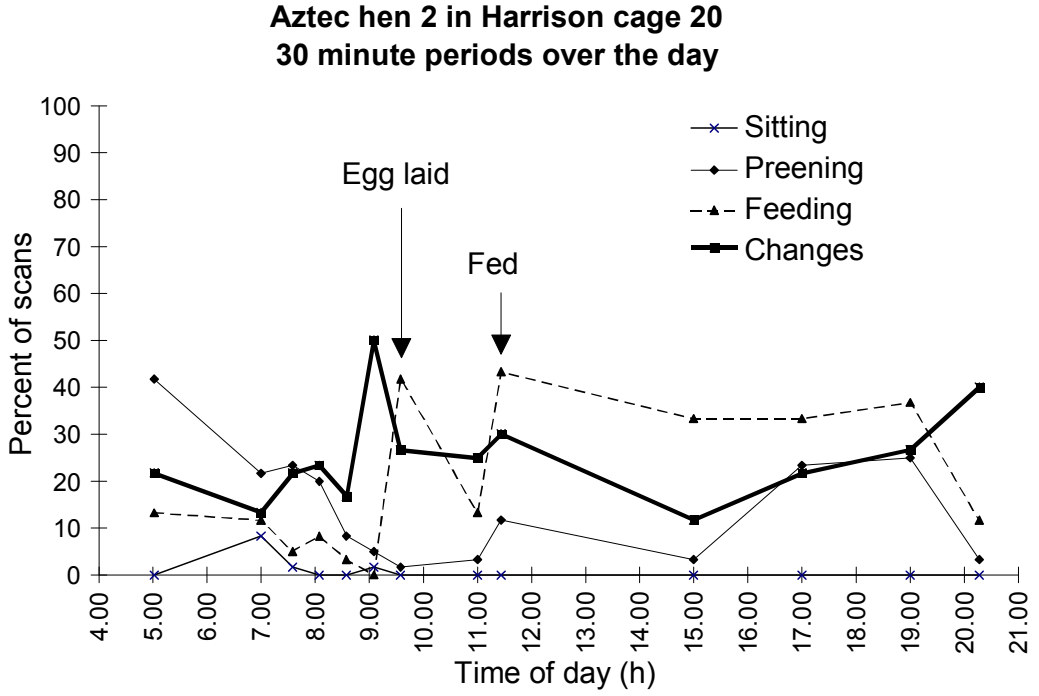


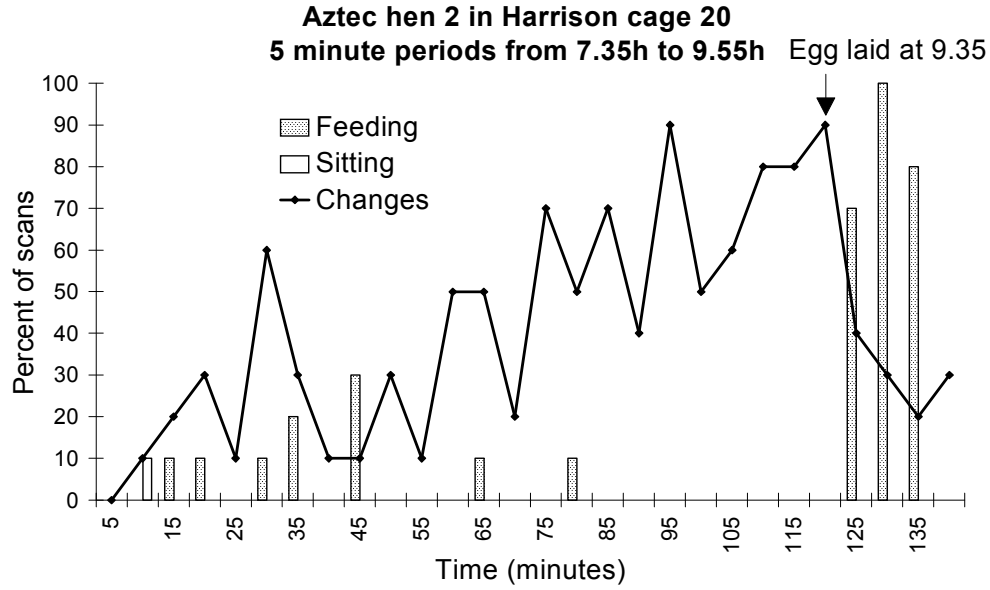
Appendix 3. Number feeding at once (continued)





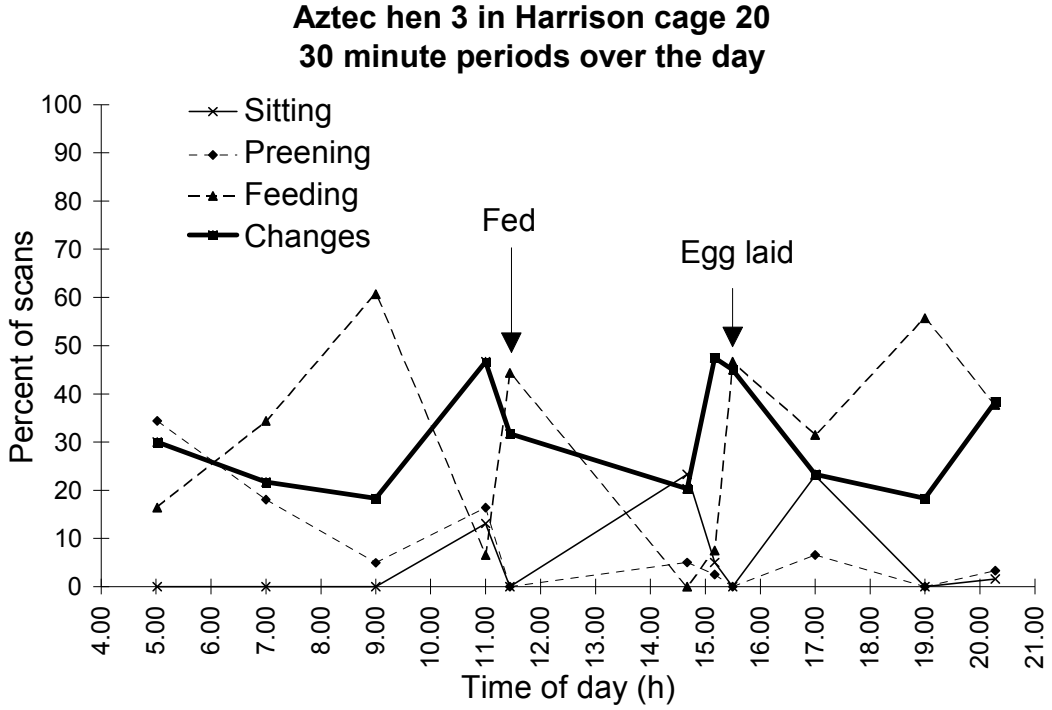
Appendix 4. Laying behaviour. Percent of 30s scans of various behaviours in relation to egg laying in 30 minute periods over the whole day, or in 5 minute periods for approximately 2 hours before, and 0.5 hours after laying. Time of laying was at the start of the 30 minute period or at the end of the 5 minute period.

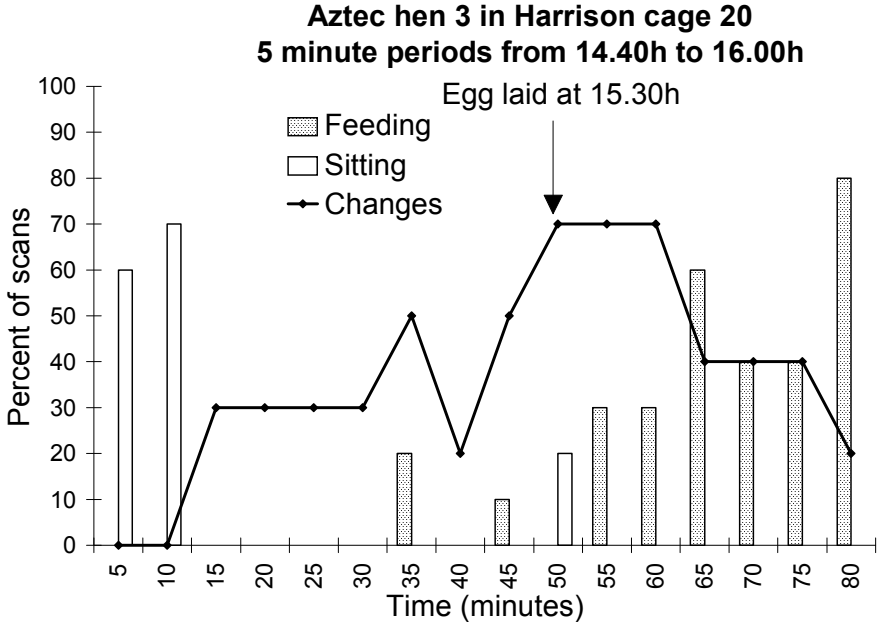




About 65 minutes before laying, this hen showed rapid head movements. Following this, she did not sit, and often momentarily made preening movements. For a short time before laying, she crept under others, then crouched and laid her egg. Immediately following, she fed.

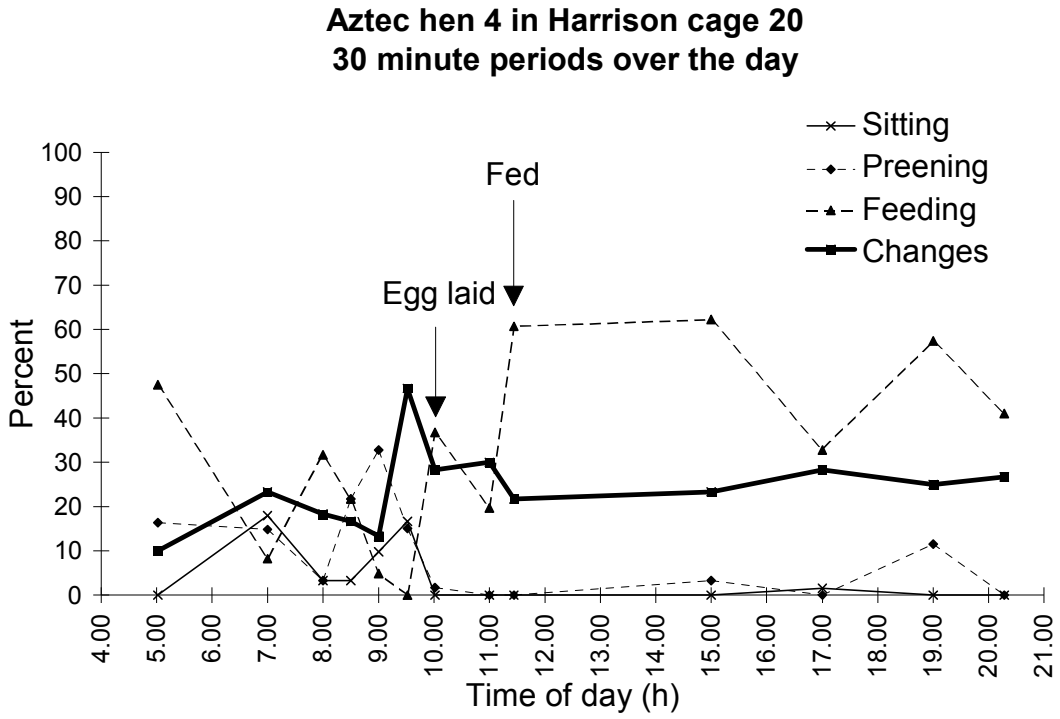
Appendix 4. Laying behaviour (continued)

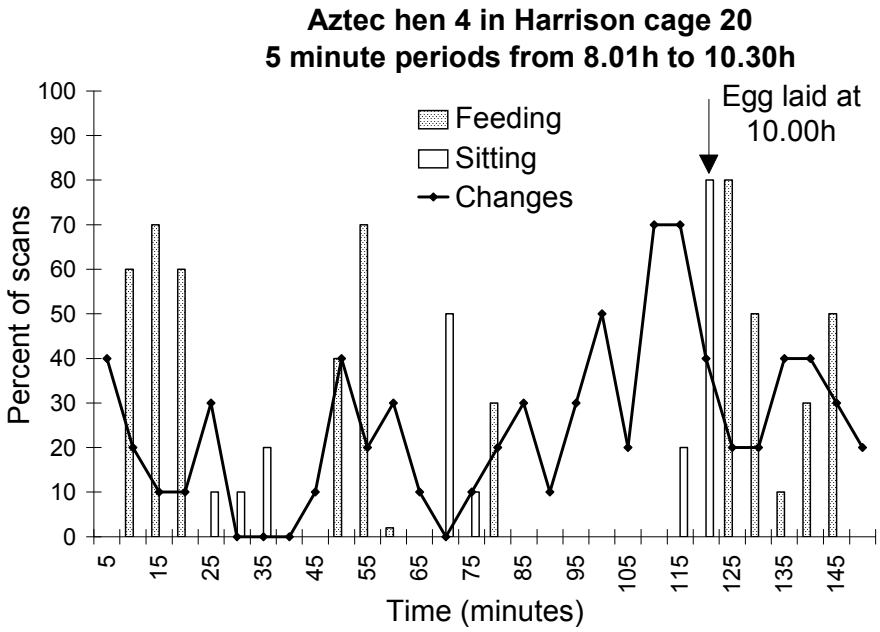




Pre lay restlessness was obvious for 10 minutes before laying. Prior to this, this hen had been putting her head through the back corner and pecking at neighbours. Restlessness continued for about 10 minutes after laying.

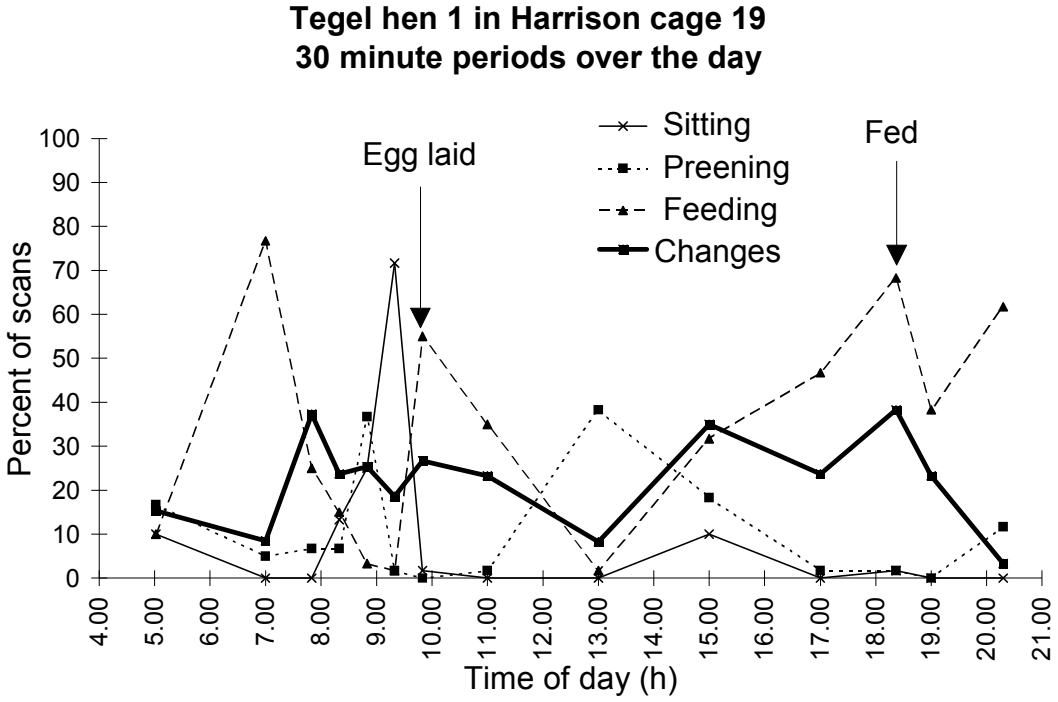
Appendix 4. Laying behaviour (continued)

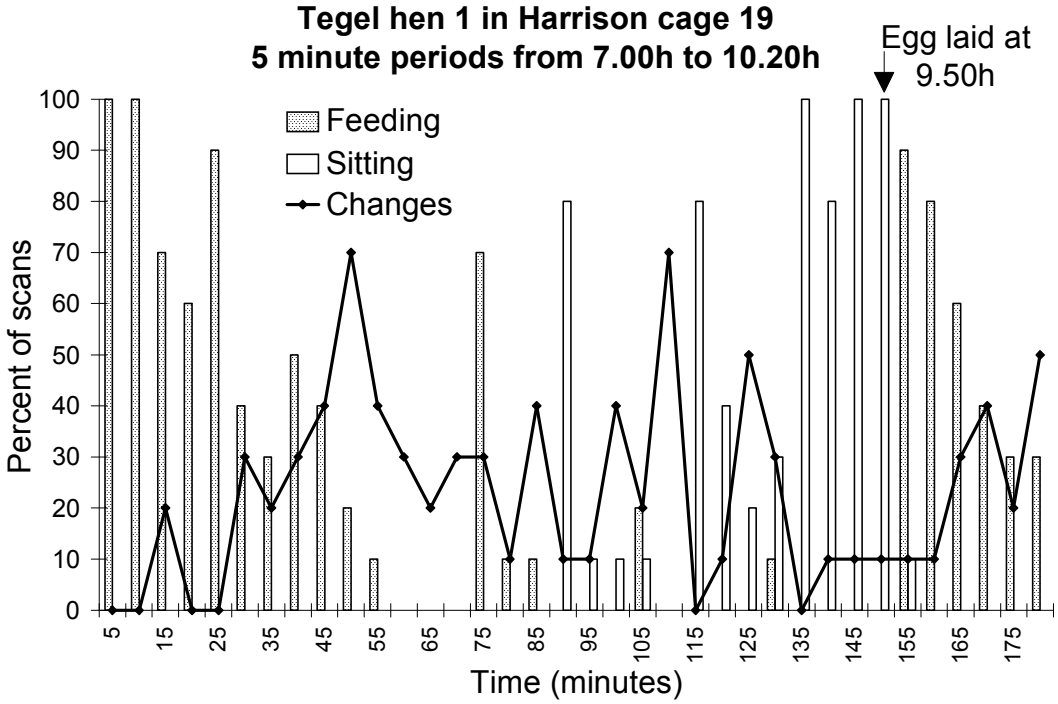




Pre lay restlessness obvious 15 minutes before laying. At 9.51h (115 minutes), this hen started creeping under cage mates and sitting.

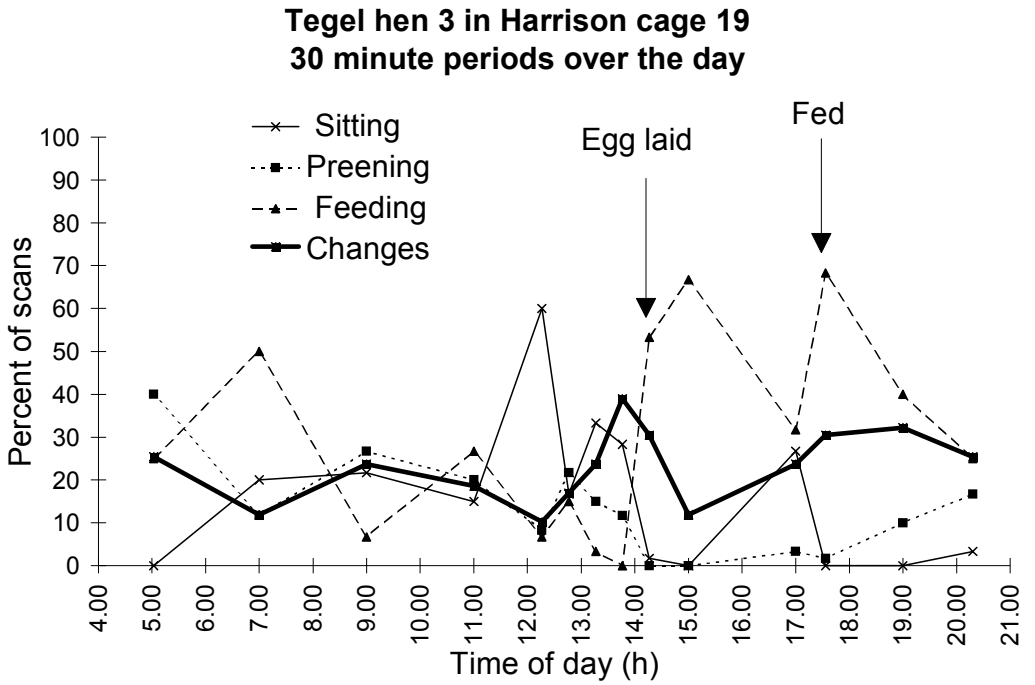
Appendix 4. Laying behaviour (continued)

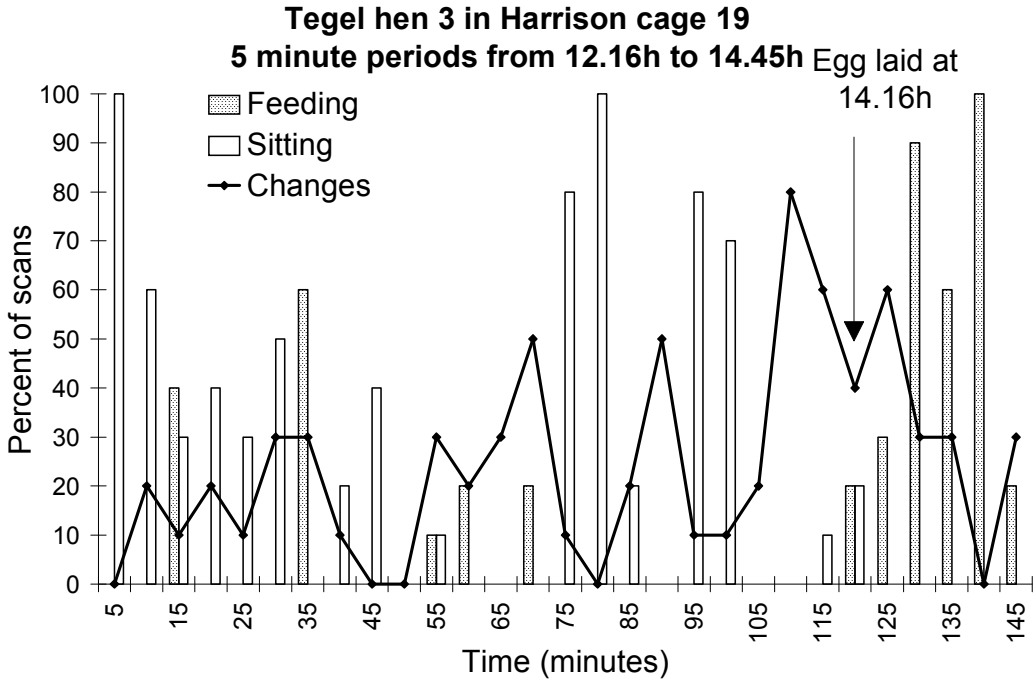




Before laying, sitting alternated with restlessness. The first sign of pre lay behaviour was at 13.08 (50 minutes). From about 9.25h (130 minutes) this hen started sitting under cage mates. Finally, she sat between 2 cage mates at the front for about 60s, stood for 28s, a slight jerk of the body, then immediately fed.

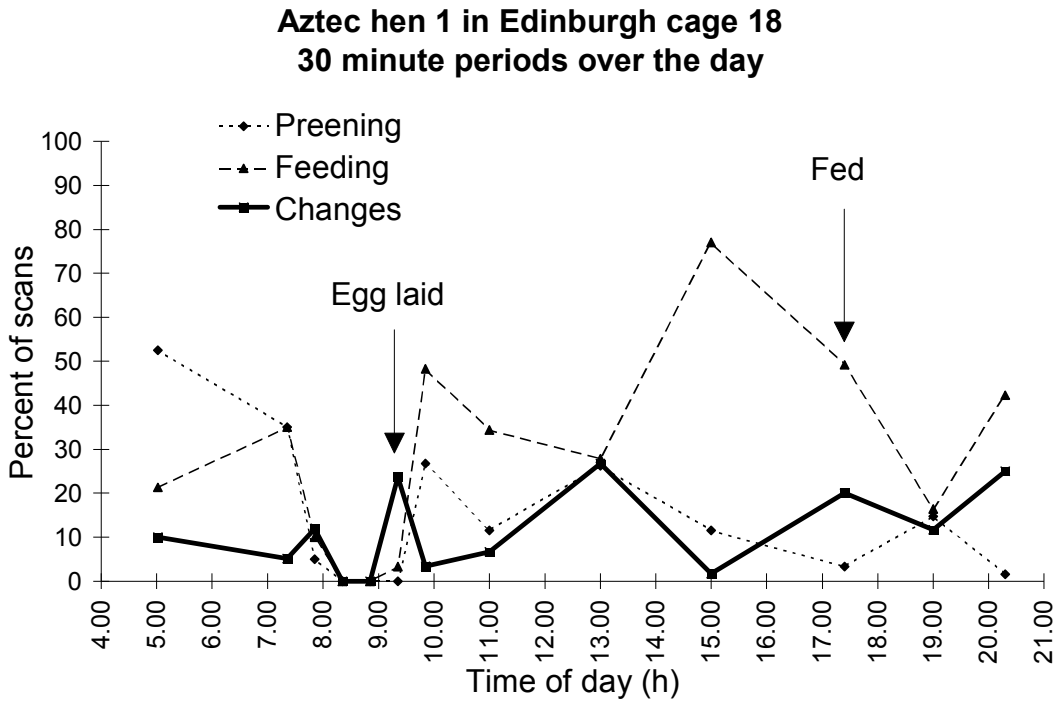
Appendix 4. Laying behaviour (continued)

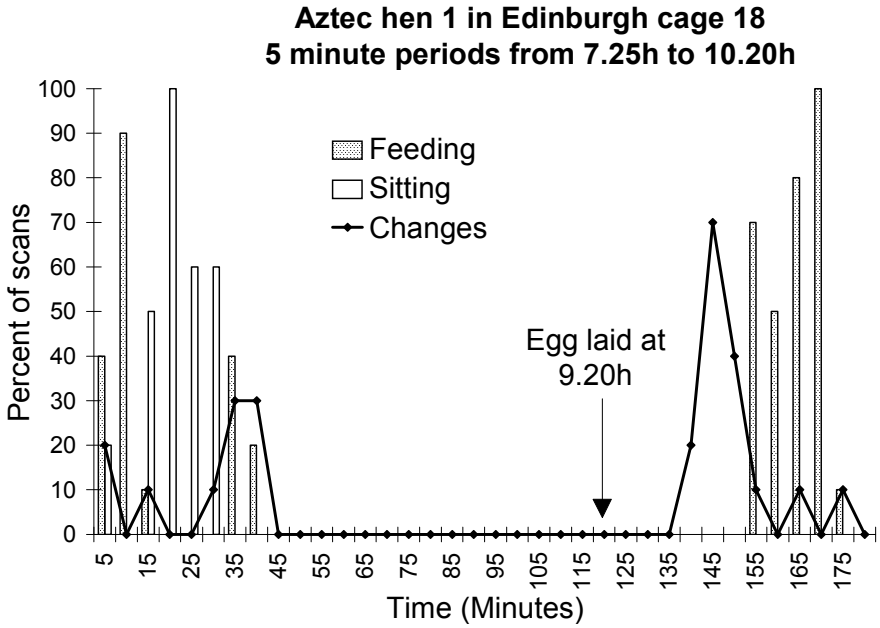




First rapid head movements noted at 13.45h (90 minutes). Most pacing and rapid head movements were between 14.00h and 14.14h (105-115 minutes). From 14.15h to 14.16h this hen apparently squatted to lay an egg and was pecked on the vent by hen 1. After each peck, she vocalised and after each series of pecks, she moved position.

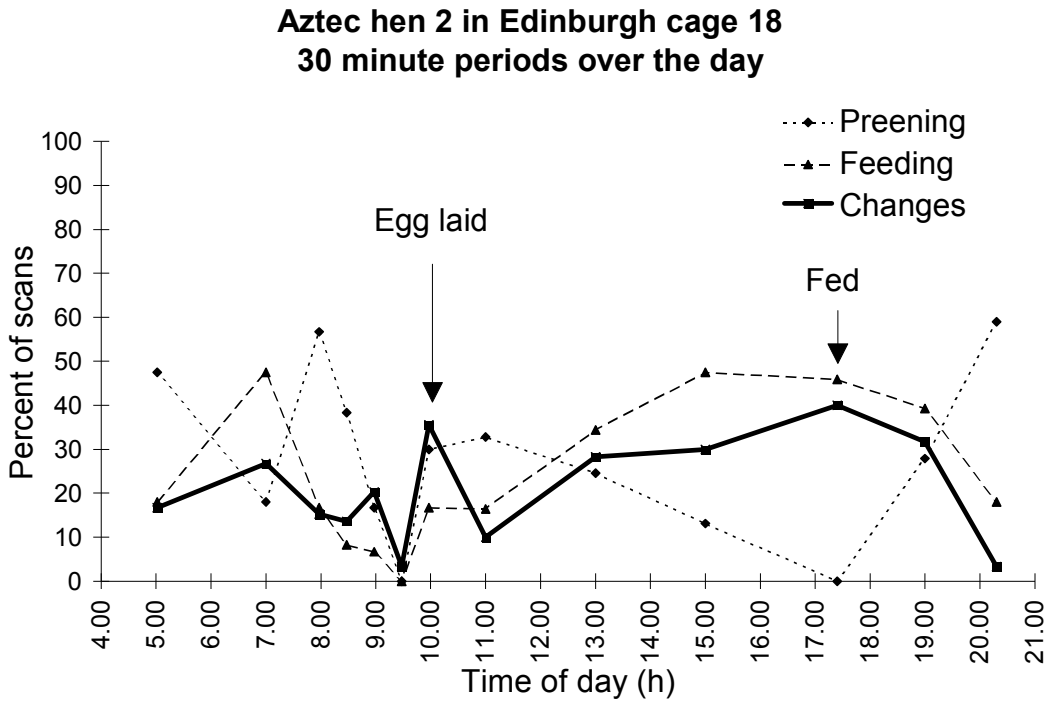
Appendix 4. Laying behaviour (continued)

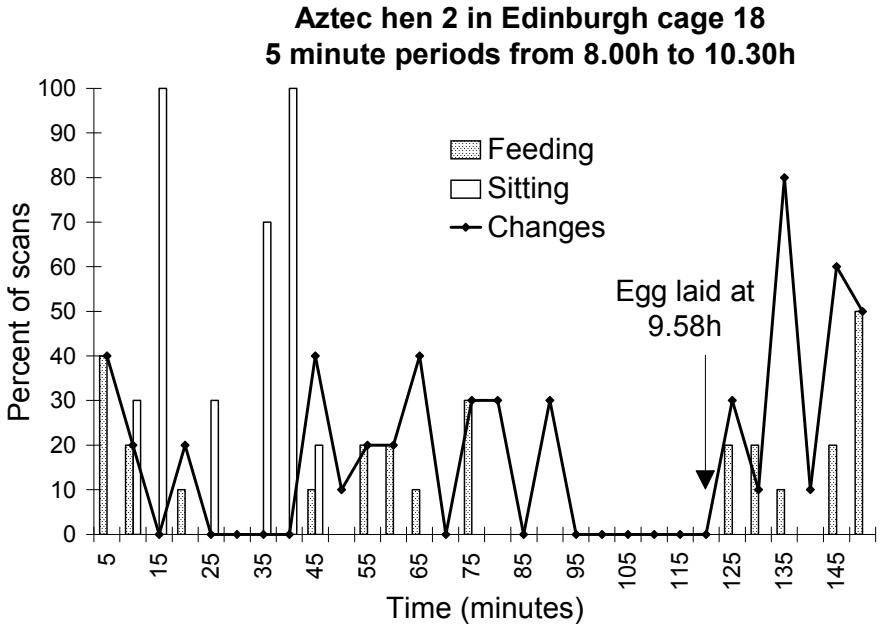




This hen entered the nest at 8.04h and left it at 9.38h. At the time she entered the nest, no other hens were in it. Hen 2 entered the nest at 9.29h and was still there when hen 1 left the nest. This hen was lowest status and was pecked and chased by hen 4 before she commenced feeding after laying.

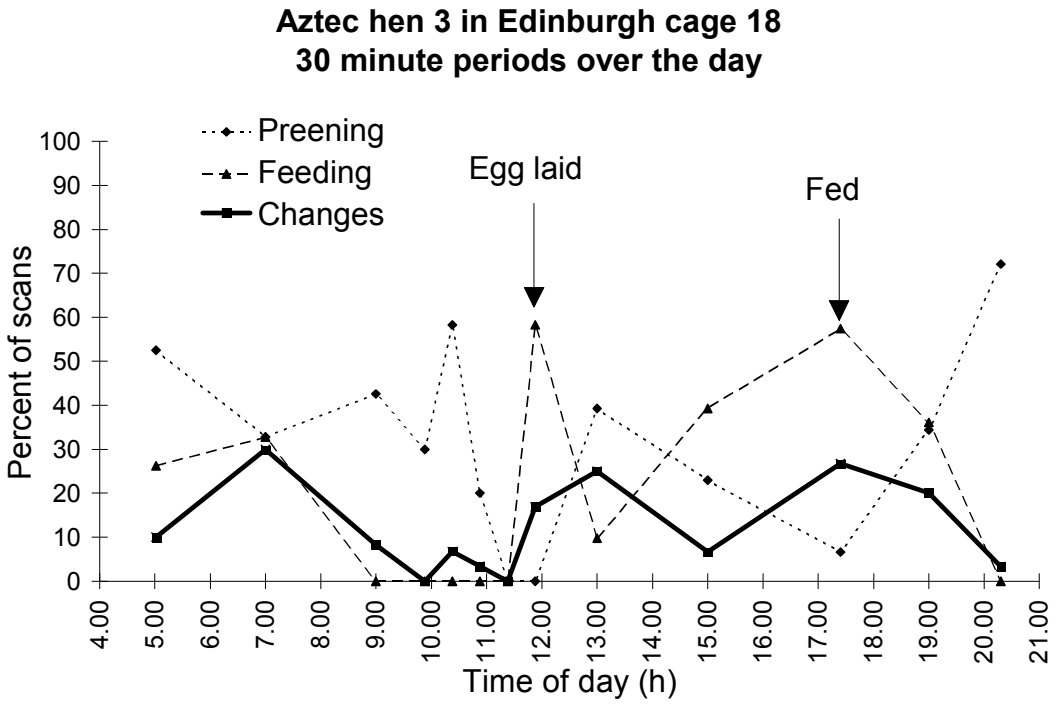
Appendix 4. Laying behaviour (continued)

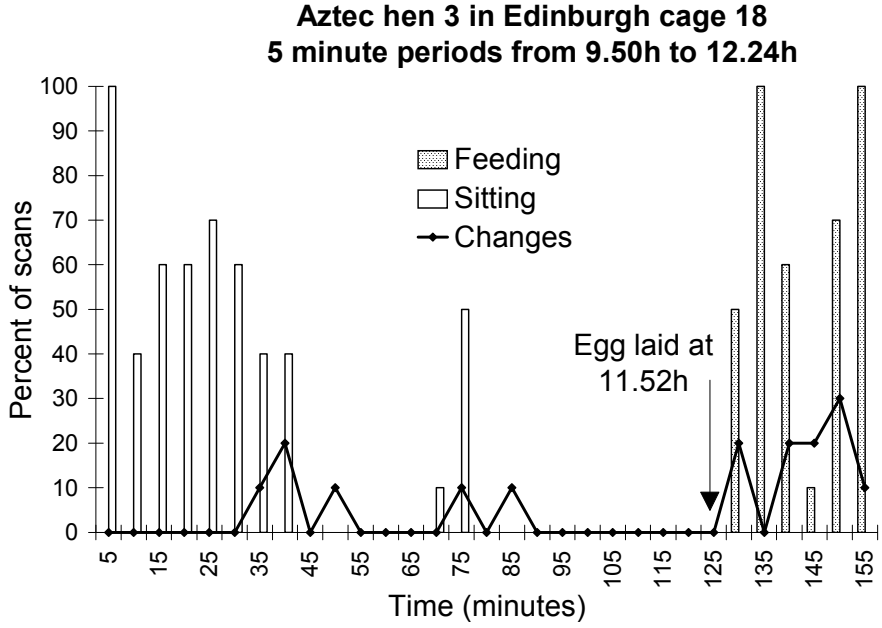




Nest entered at 9.29h while hen 1 was still in there. Some aggressive pecking from hen 3 after leaving the nest.

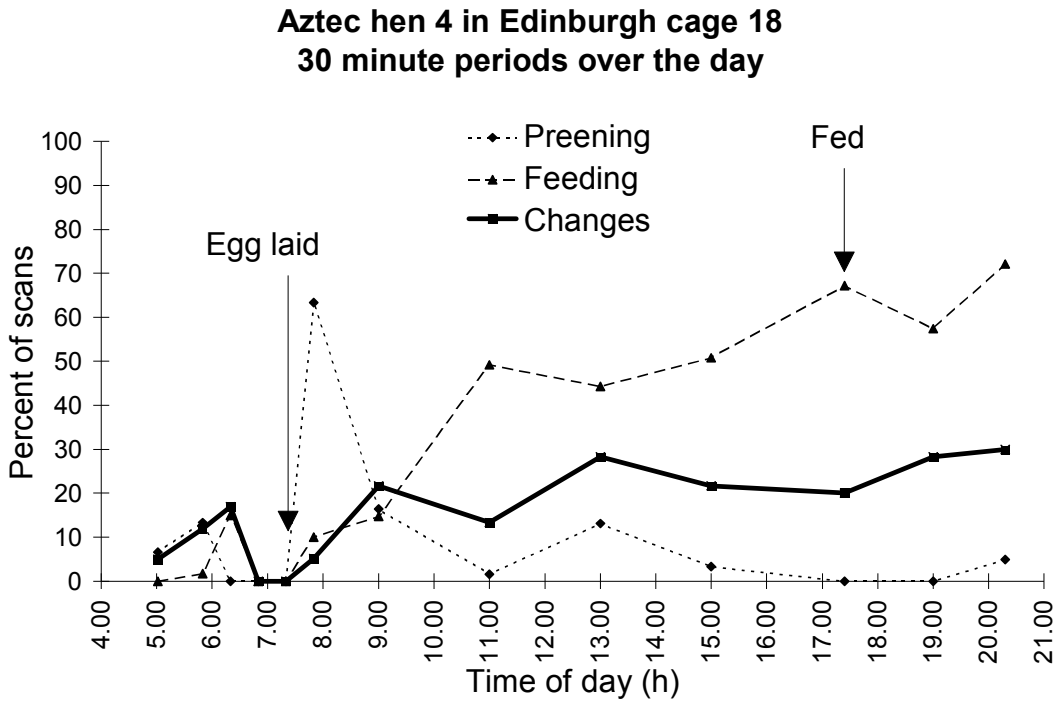
Appendix 4. Laying behaviour (continued)

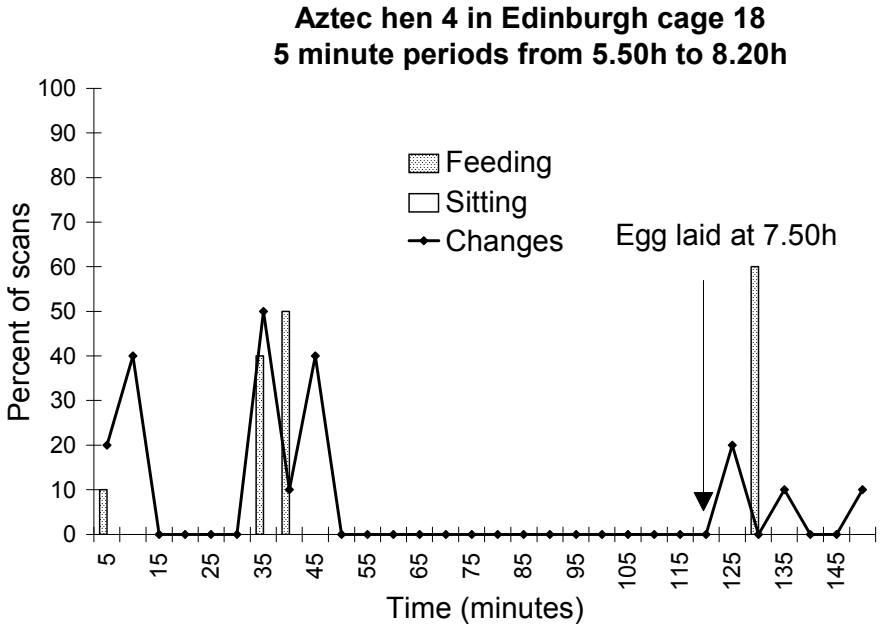




Hen 3 stood or sat in the middle of the perch or on the perch close to the nest for some time before entering the nest. She entered it at 11.12h (no other hen had been in the nest). While in the nest, she frequently pulled an egg into the nest from the egg tray with her beak. She left the nest at 11.57h.

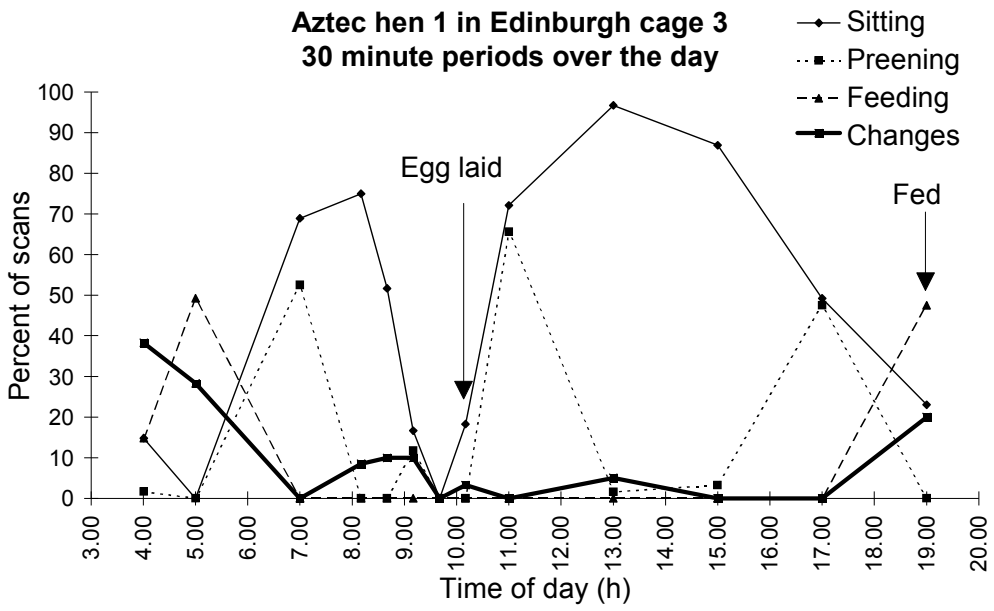
Appendix 4. Laying behaviour (continued)

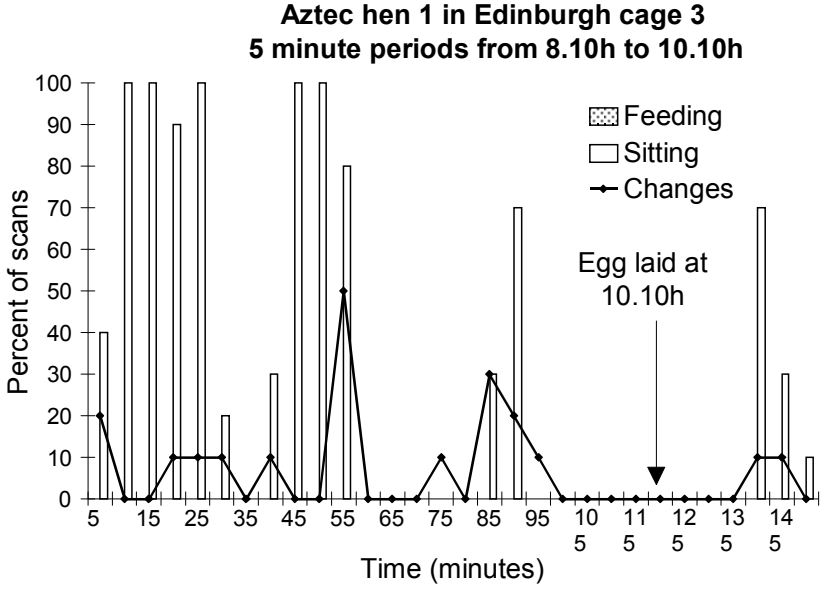




This hen was in the nest from 5.11h to 5.45h, again from 5.57h to 6.21h, then from 6.33h to 7.53h. After laying the egg, she pulled the egg back into the nest twice before she left the nest.

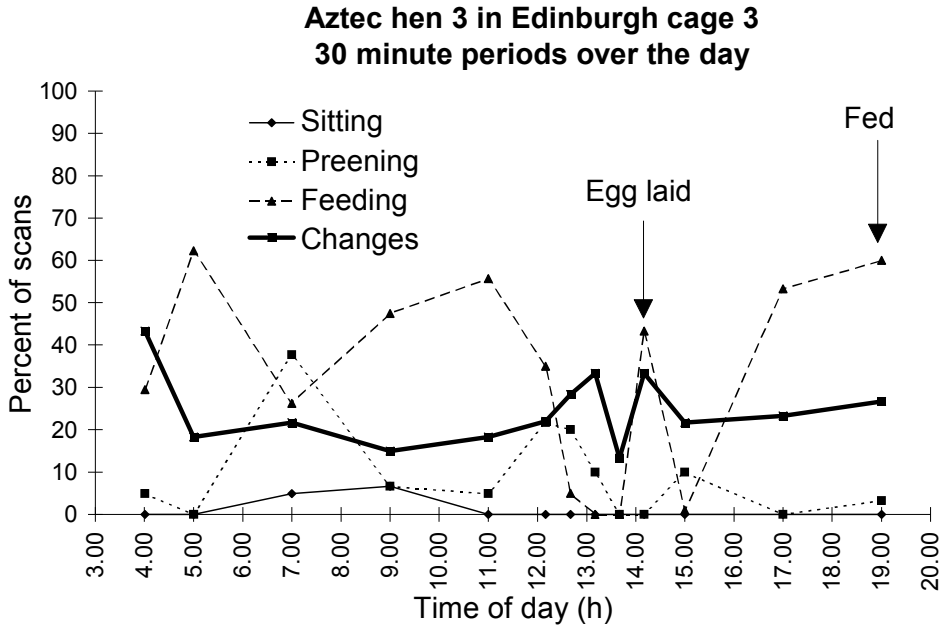
Appendix 4. Laying behaviour (continued)

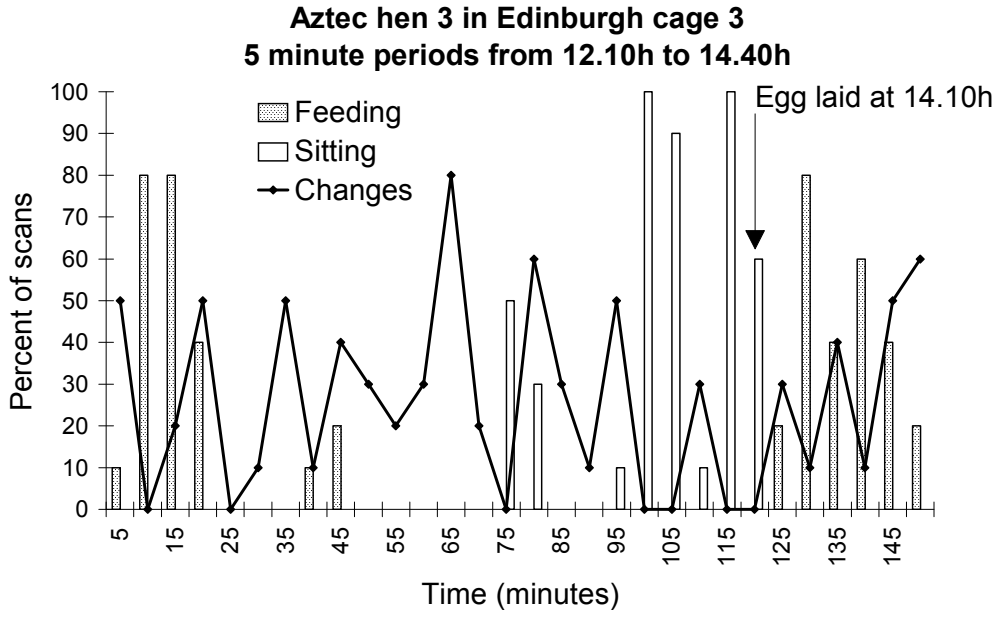




This hen was pecked by hens 3 and 4. She was in the litter box for most of the day, and when out she often crouched with head under the feed trough. She left the litter box at 7.47h, was attacked, entered the nest 7 times for a few seconds to about 2 minutes, avoiding pecks. From 8.13h to 8.29h (5 to 25 minutes) she crouched at the front right corner, got in the nest for 12 minutes, then out again for 18 minutes, most of the time in the corner again, then in the litter box for 17 minutes, then in the nest again at 9.21h (75 minutes), out again at 9.33h, in at 9.40h where she remained for 16 minutes after laying the egg. After leaving the nest, she crouched in the corner for 10 minutes, then returned to the litter box. The main significance of these observations is that this hen went to considerable trouble to lay her egg in the nest rather than in the safer site of the litter box. Over this entire period, no other hen entered the litter box.

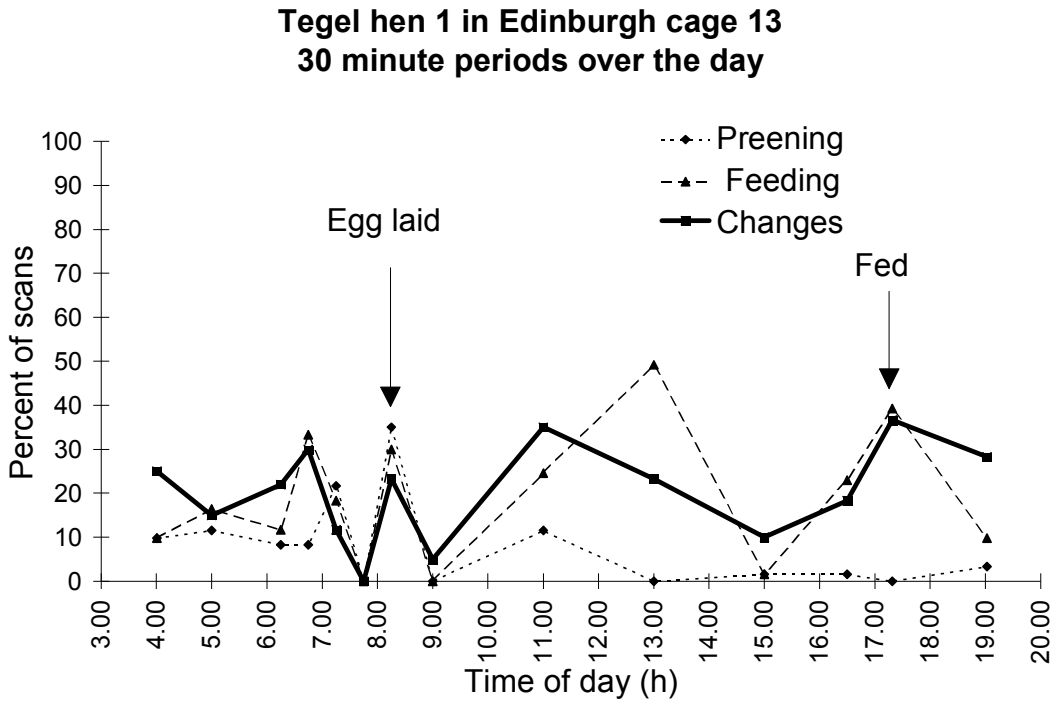
Appendix 4. Laying behaviour (continued)

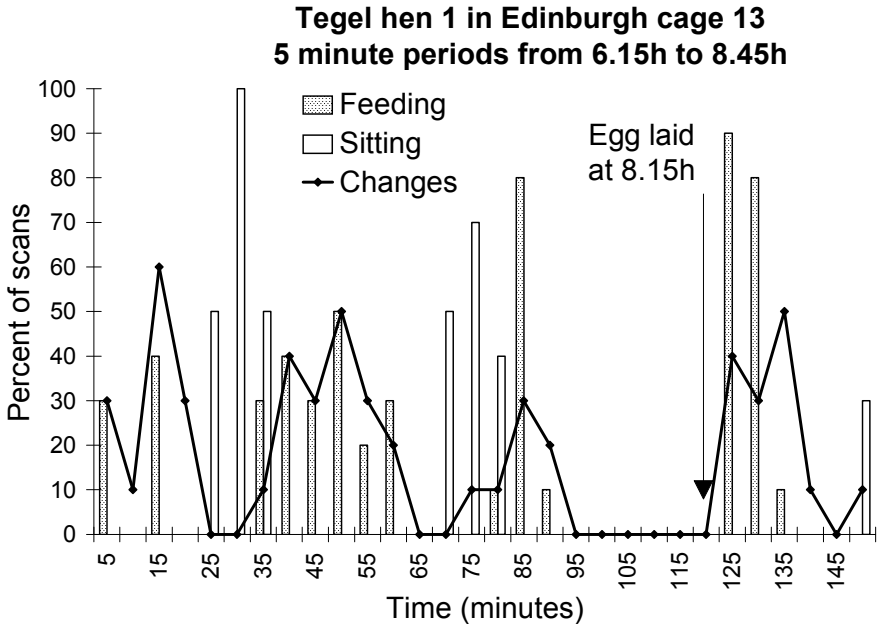




This hen also laid in the nest. She first entered the nest at 13.07h (60 minutes) but stayed for only a few minutes, then got out and moved about a lot. She entered and left the nest 4 times with much movement between. She finally entered the nest at 13.58h (110 minutes), laid her egg 12 minutes later. She laid her egg at 14.10h (120 minutes) then left the nest 1.5 minutes later, cackled and fed. The nest was not occupied by another hen over this period. Also, the litter box was empty at the last time she entered the nest, so the continual leaving of the nest was not because the litter box was the preferred site.

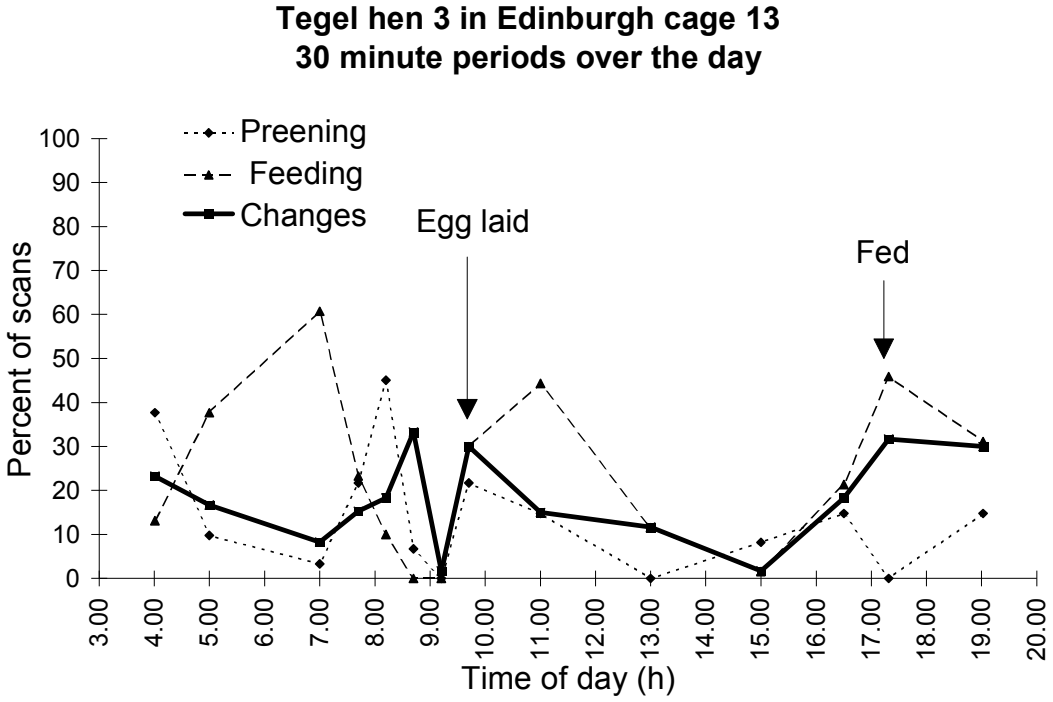
Appendix 4. Laying behaviour (continued)

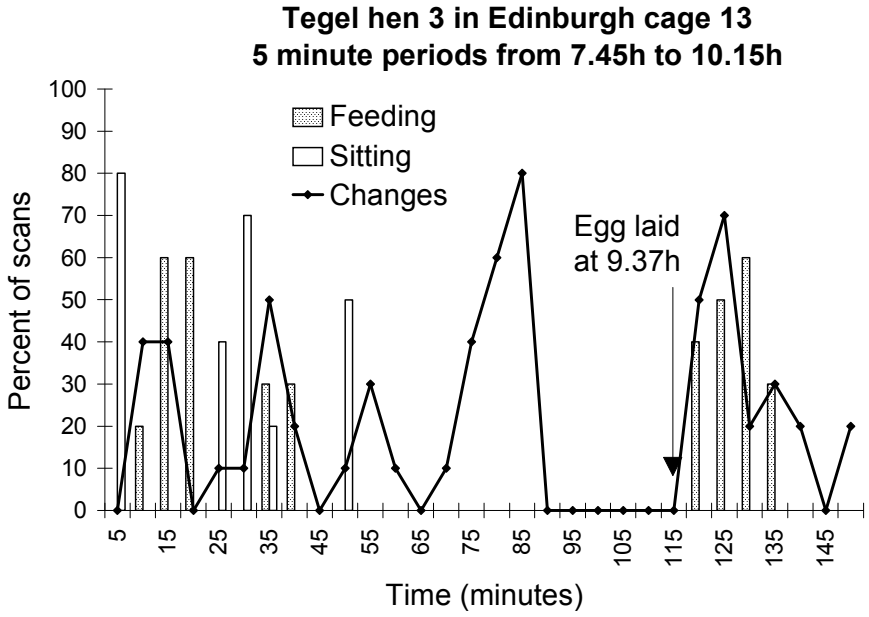




This hen was in the nest from 4.58h to 5.00h, for 1 minute from 6.17h, and from 6.30h. Sitting before laying was primarily on the middle of the perch. When she entered the nest to lay at 7.45h, it was already occupied by hen 2, but hen 2 left the nest a few minutes later at 7.47h. The nest was then solely occupied by hen 1. She left the nest 19s after laying the egg. (Hen 2 occupied the nest for long periods but did not apparently lay an egg – she may have been broody.)

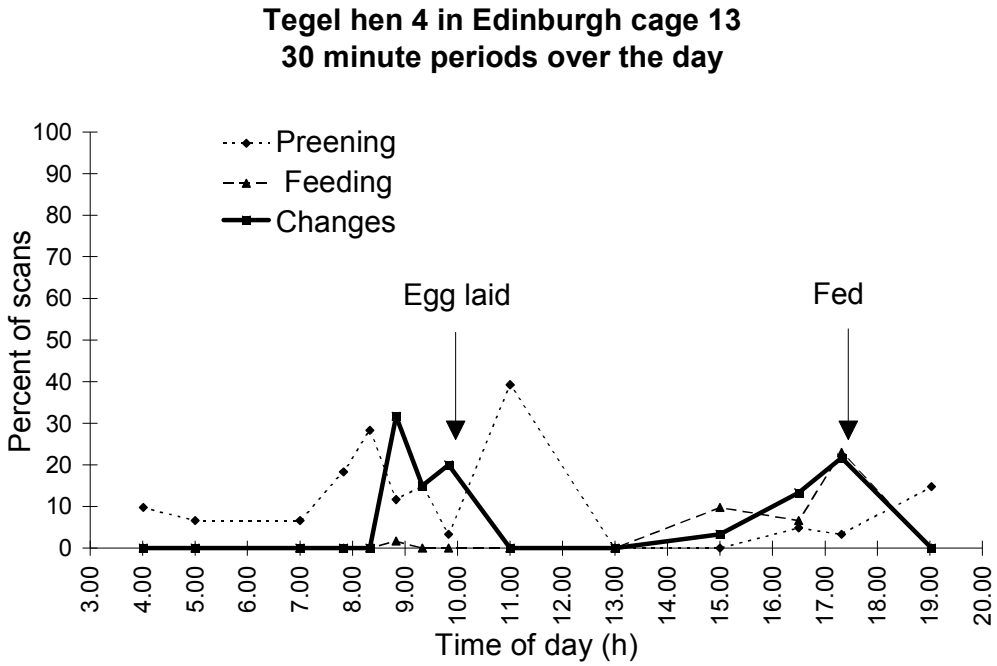
Appendix 4. Laying behaviour (continued)

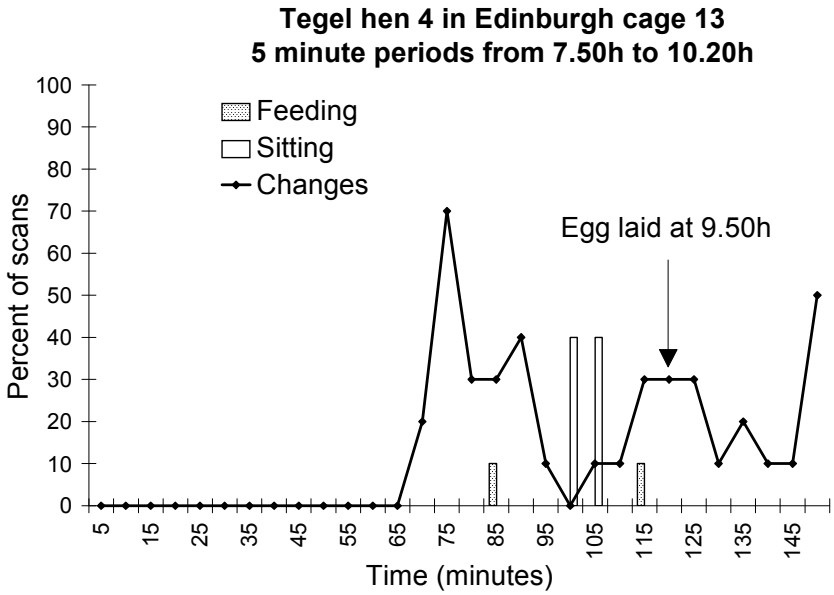




This hen entered the nest at 8.51h for 18s, then entered it again at 8.52h and left it again at 8.57h. Over this period it was continually occupied by hen 2. Hen 1 then entered the nest and hen 3 moved about the cage, put her head in the nest, entered the nest for about a minute, left it, moved about, then entered the nest at 9.09h. So when she entered the nest to lay her egg, it was already occupied by 2 hens. Meanwhile, the litter box was unoccupied. Hen 1 left the nest at 9.29h, so by the time hen 3 laid her egg, it was only occupied by one other hen.

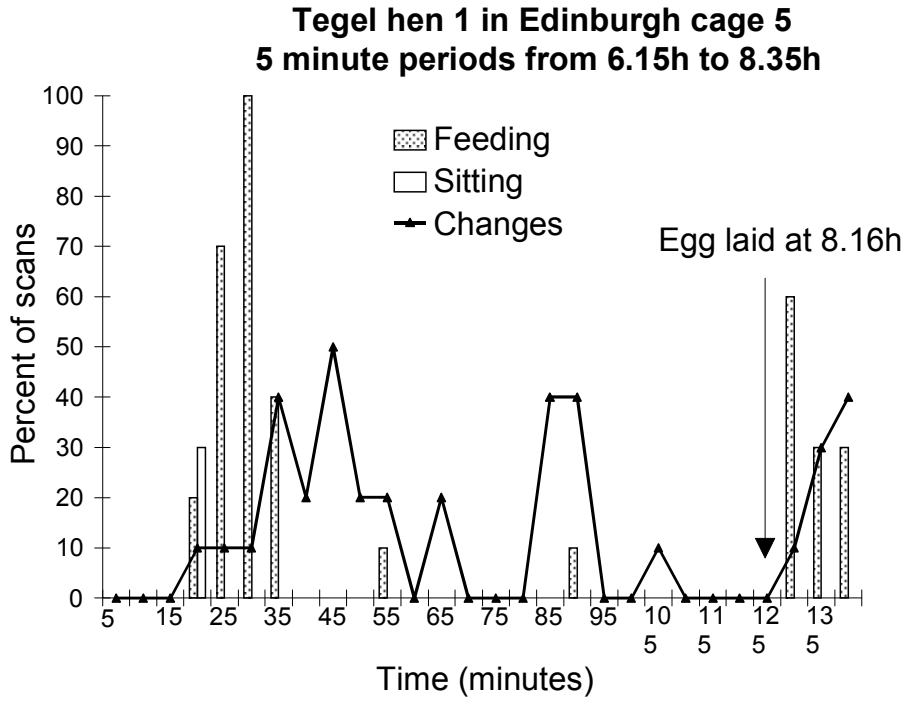
Appendix 4. Laying behaviour (continued)





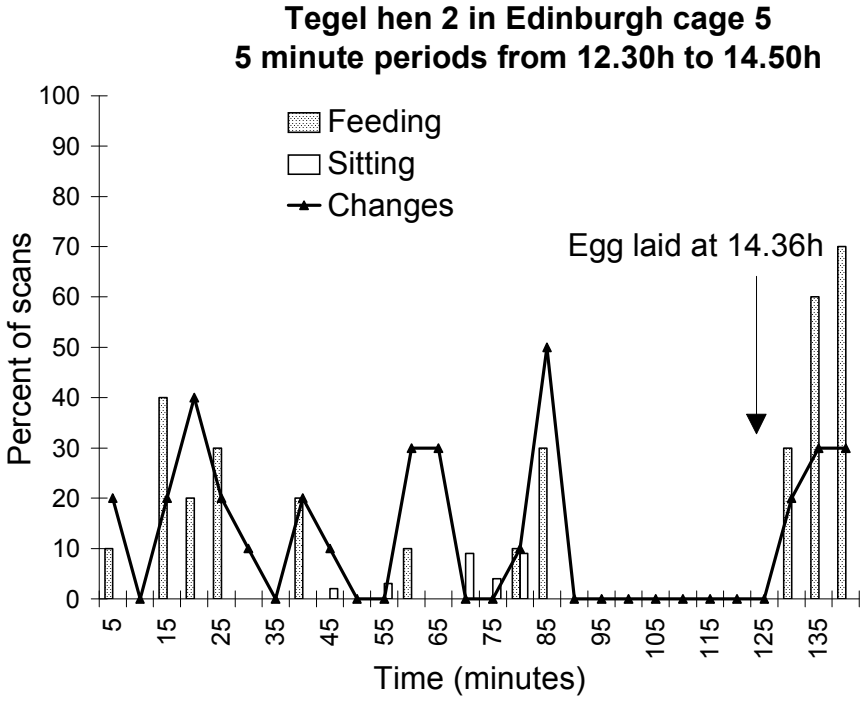
This hen's behaviour was abnormal since she occupied the litter box for most of the day. She was chased and pecked by hens 1 and 2 when she was in the cage proper. She left the litter box at 8.58h when hens 1 and 2 were in the nest. Then from 9.08h, three hens were in the nest. At 9.29h, hen 1 left the nest, then at 9.41h, hen 3 left the nest. Hen 4 entered the nest still occupied by hen 2 at 9.44h, left it again at 9.47h, entered it again 6s later, then left it at 9.53h, 3m after laying the egg. After leaving the nest, she was bullied and chased by hen 1. Therefore the high percent of position changes before laying appeared to be because she was unable to enter her preferred place of lay, and afterwards to escape bullying.
(All the eggs laid on this day in this cage were pecked and pushed off the egg tray or broken and eaten)

Appendix 4. Laying behaviour (continued)



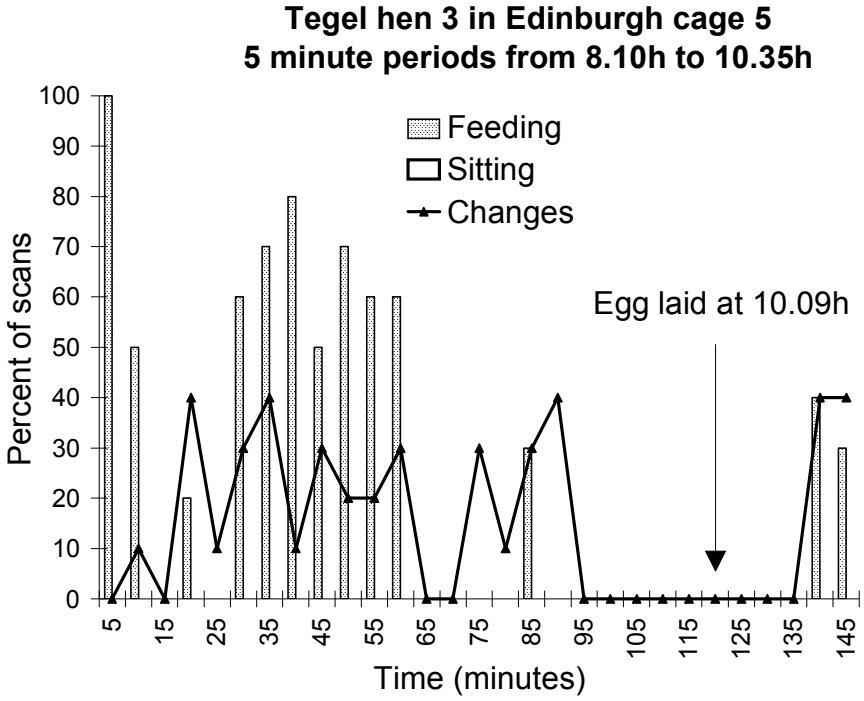
Hen 4 (the broody) was in the litter box. Hen 1 stood for a long time outside the litter box looking in. She got in the nest 3 times but only stayed there for 2 consecutive scans (approx. 1 min). There was an obvious change in behaviour at 6.48h (35 minutes) with more moving about and the first look in the litter box. Entered the litter box at 7.43h and stayed behind hen 4 the whole time. Could see the tip of her tail projecting from the litter box. Assessed time of lay by the movement of the tail which slowly lowered, then abruptly raised. Immediately afterwards, could see her head moving about until she got out at 8.21 when she immediately fed.

Appendix 4. Laying behaviour (continued)



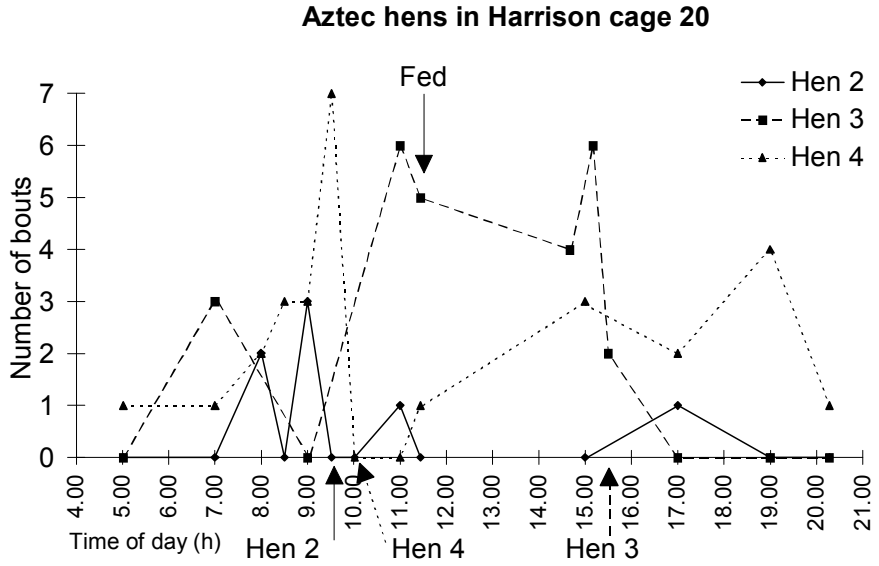
Hen 4 was out of the litter box over the whole of this period so there was no competition for the litter box. Put head in nest and litter box a few times before getting in the litter box at 13.54h. Behaviour in the litter box was clearly laying. Rotated frequently, scratched while sitting using alternate legs (different that dustbathing scratches), pecked around at litter, and occasionally tossed head over back. Just before egg laid, stood and remained very still – then a slight jerk of the body. She got out almost immediately after laying the egg at 14.36 and almost immediately fed. Hens 1 & 2 clearly preferred the dust box for laying the egg, since they showed little investigation of the nest, and even when litter box already occupied, hen 1 used it in preference to the nest. (Positions in the cage were measured differently over the whole day, so whole day's activities not shown.)

Appendix 4. Laying behaviour (continued)

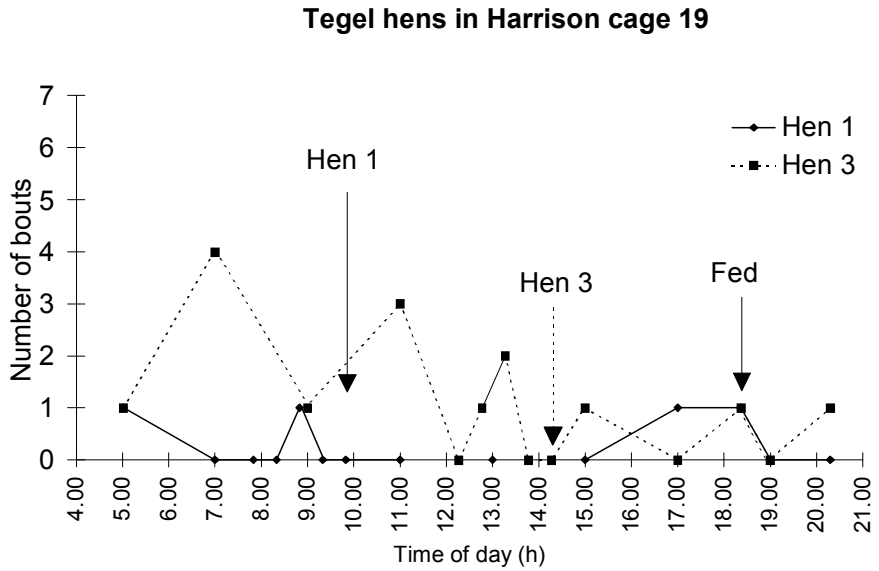


Hen 3 did not sit over this period. She was the only individual to use the nest. She first put her head in the nest at 9.34h (85 minutes), put her head in the litter box twice, then got in the nest at 9.39h. She left the nest at 10.27 when she immediately fed.

Appendix 5. Number of aggressive bouts per half-hour period over the day by hens that laid an egg. Arrows indicate when hen laid the egg.

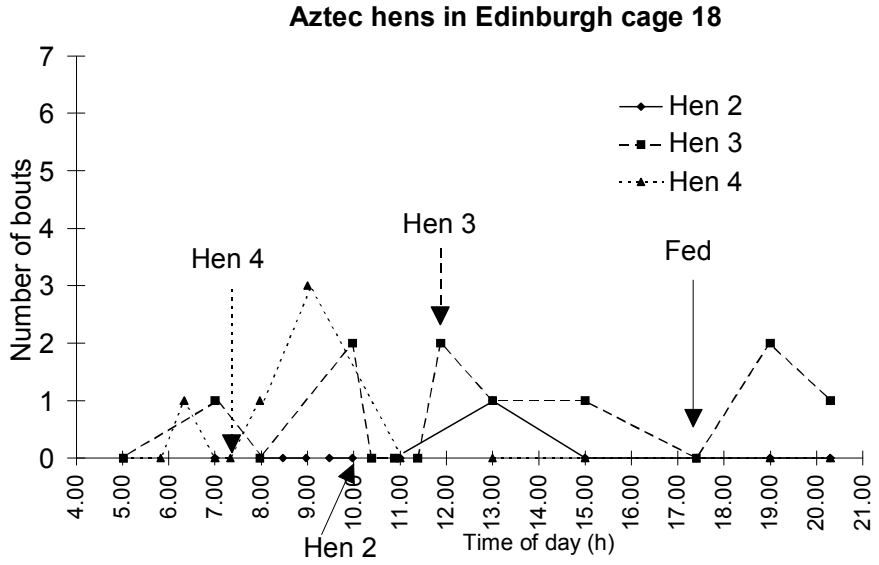


Before hen 2 showed pre laying behaviour as evidenced by rapid head movements, she directed aggressive behaviour towards hens in the neighbouring cage on the right. Before laying, hen 3 directed aggression at hens on both sides and through back corners of the cage. She remained aggressive and restless for about 10 minutes after laying. Hen 4 directed most aggression towards neighbours before laying, but all aggression after laying was directed at cage mates.

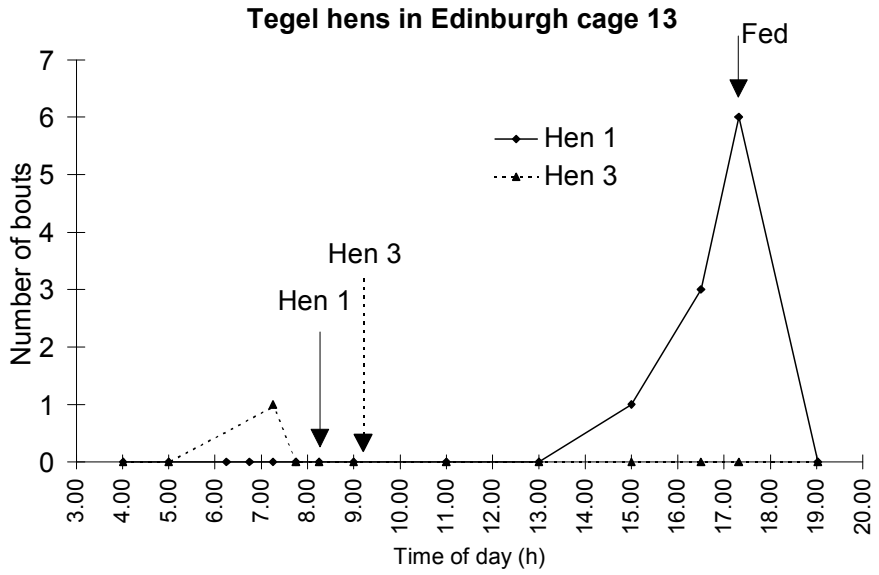


Hen 3 was observed on a tape taken 4 weeks after the tape used for Hen 1's behaviour. On the earlier tape, there were no neighbours. Hen 3 directed the major part of her aggression to the neighbours.

Appendix 5. Aggression in relation to laying (continued)

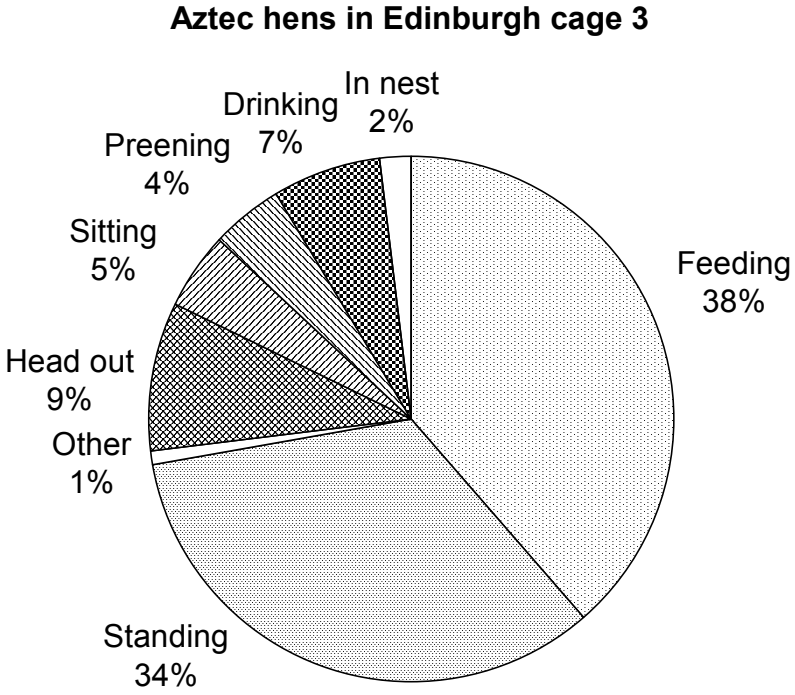


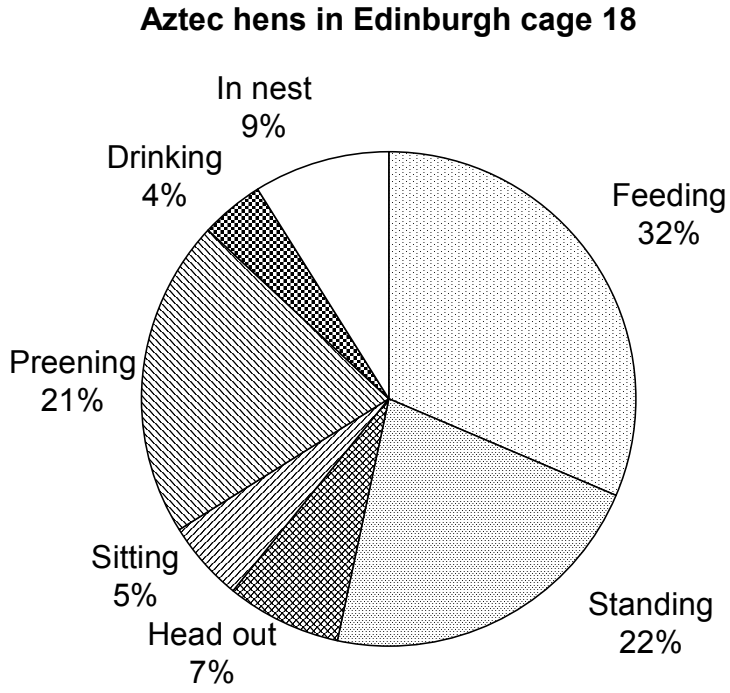
Most aggression was directed towards Hen 1 by Hens 3 and 4. Hen 1 was the lowest status bird but she remained for the greater part of the day in the main part of the cage. Because hen 1 showed no aggression, she is not shown on the graph.



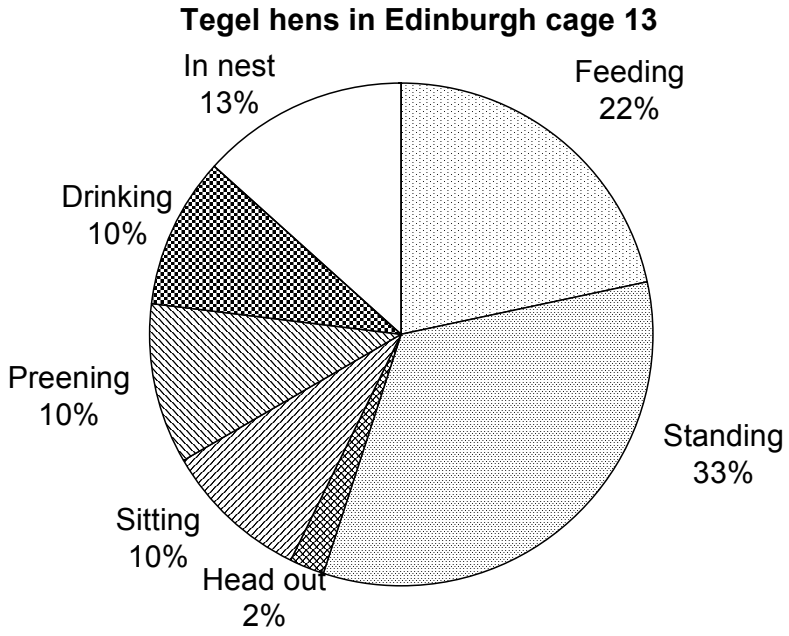
Hen 4 was the lowest status bird. She was in the litter box from lights on to 8.58am. Although Hen 1 had already laid her egg, she was in the nest at this time. She was pecked when she left the litter box in the afternoon.

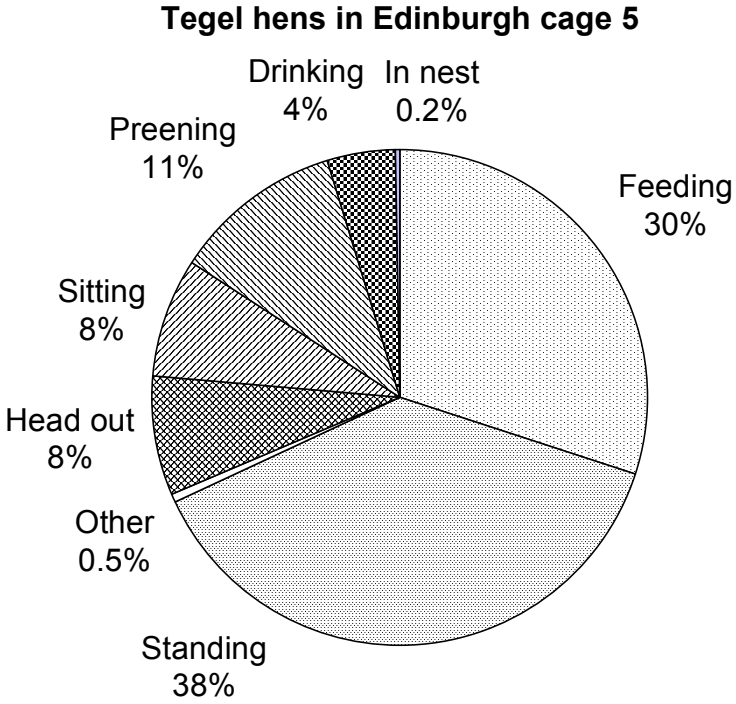
Appendix 6. Mean percent of scans at different activities. Data do not include the bullied or broody hens (hen 1 in AzEd3, hen 4 in T.Ed13, and hen 4 in T.Ed5).



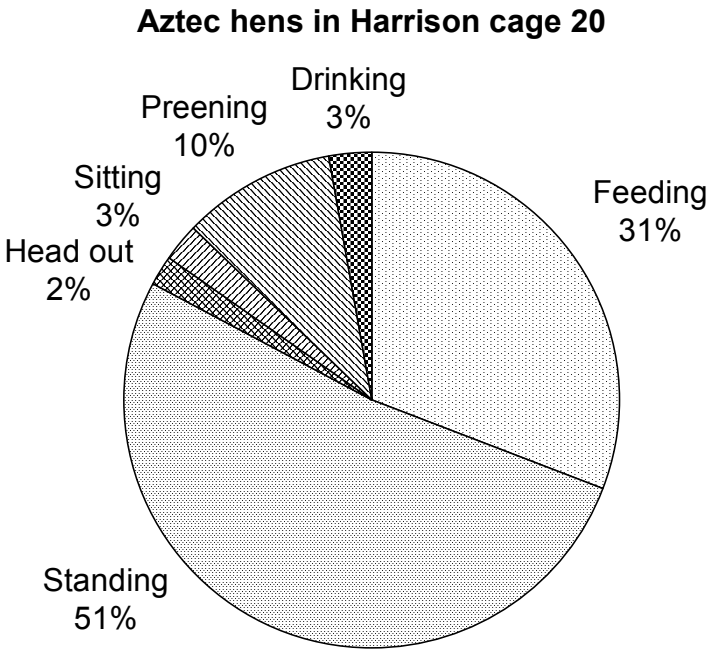


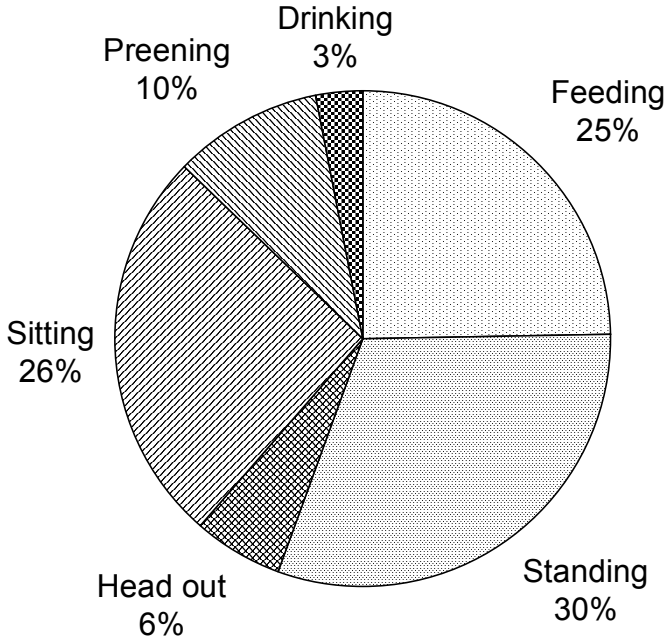
Appendix 6. Percent of scans at different activities (continued)



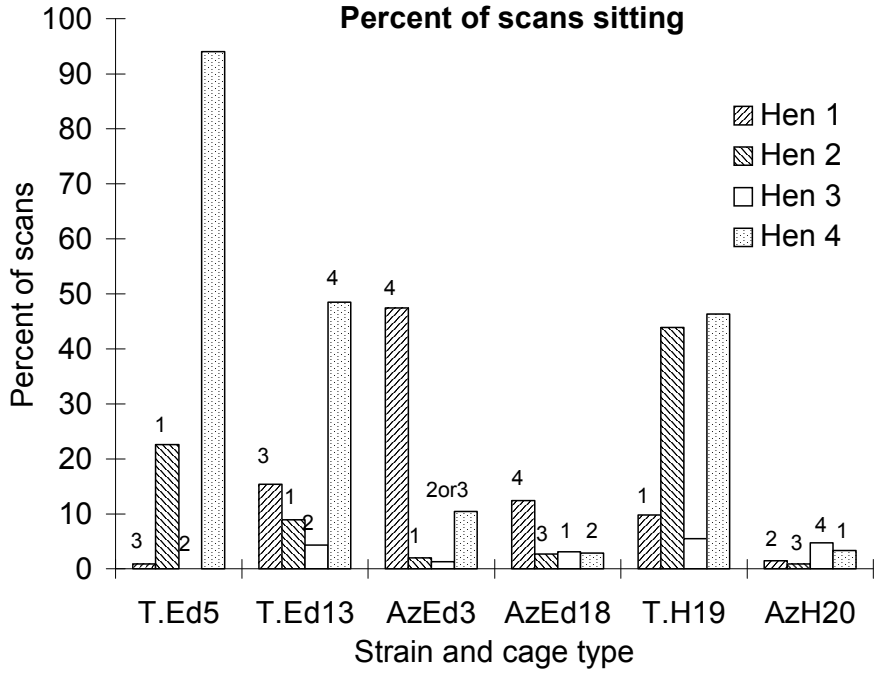


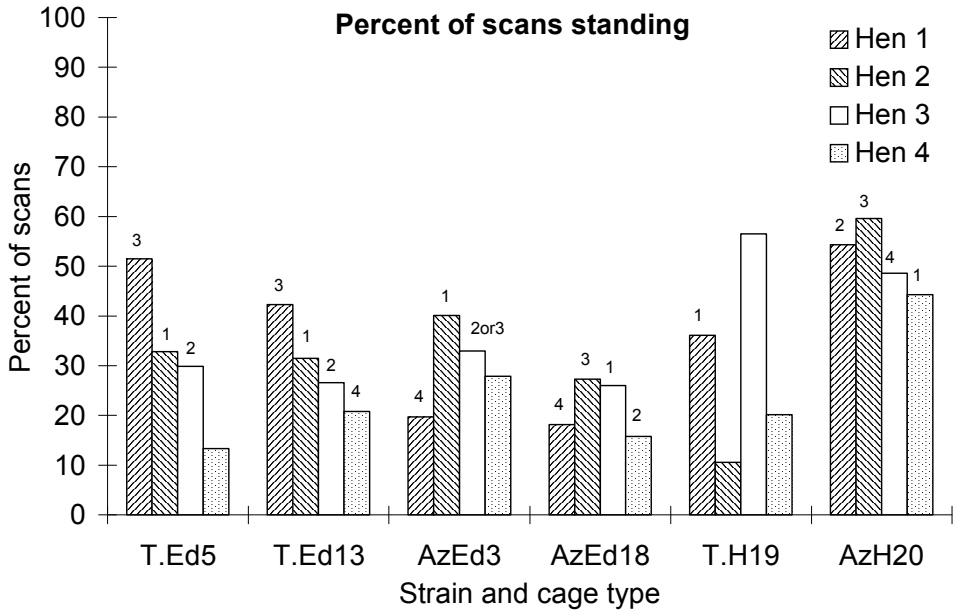
Appendix 6. Percent of scans at different activities (continued)



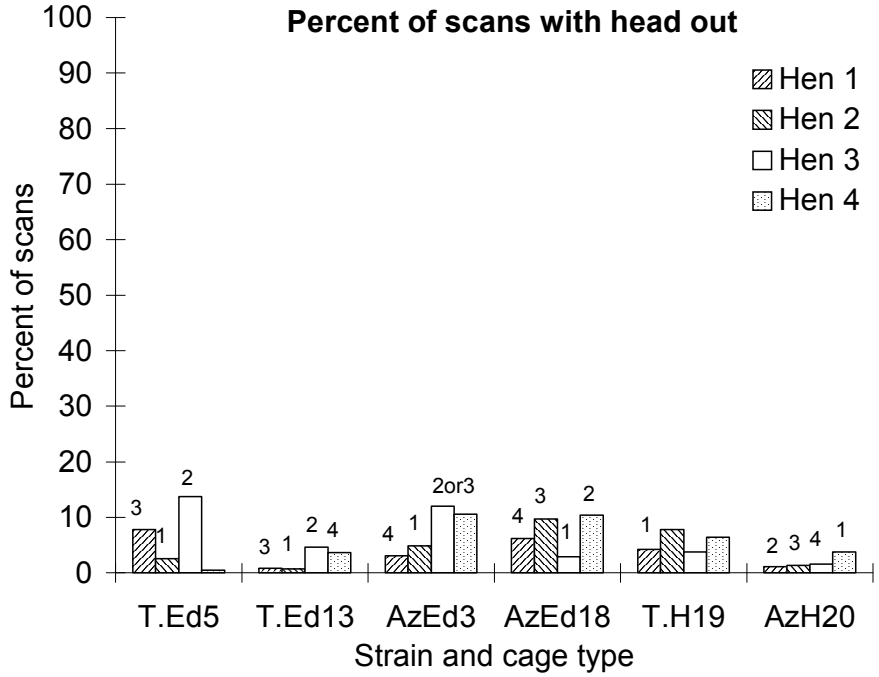


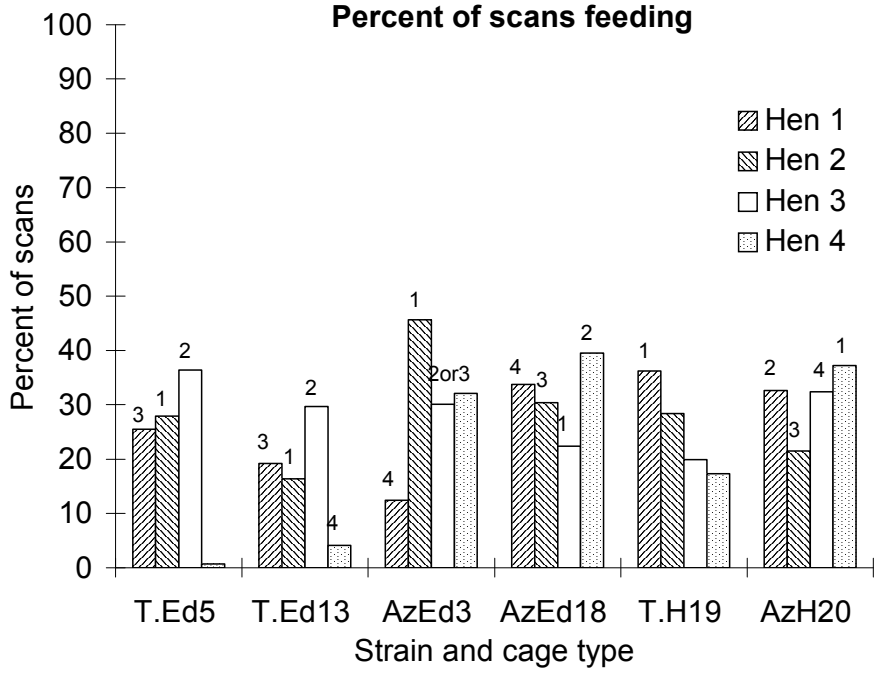
Appendix 7. Percent of scans individuals were recorded as doing different behaviours in each cage. The figure at the top of the column indicates social status.



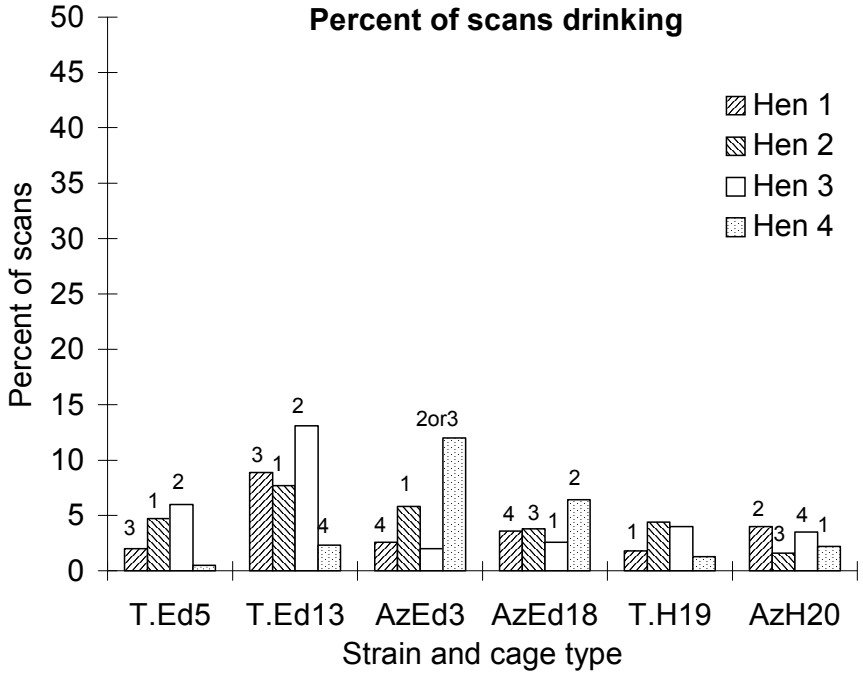


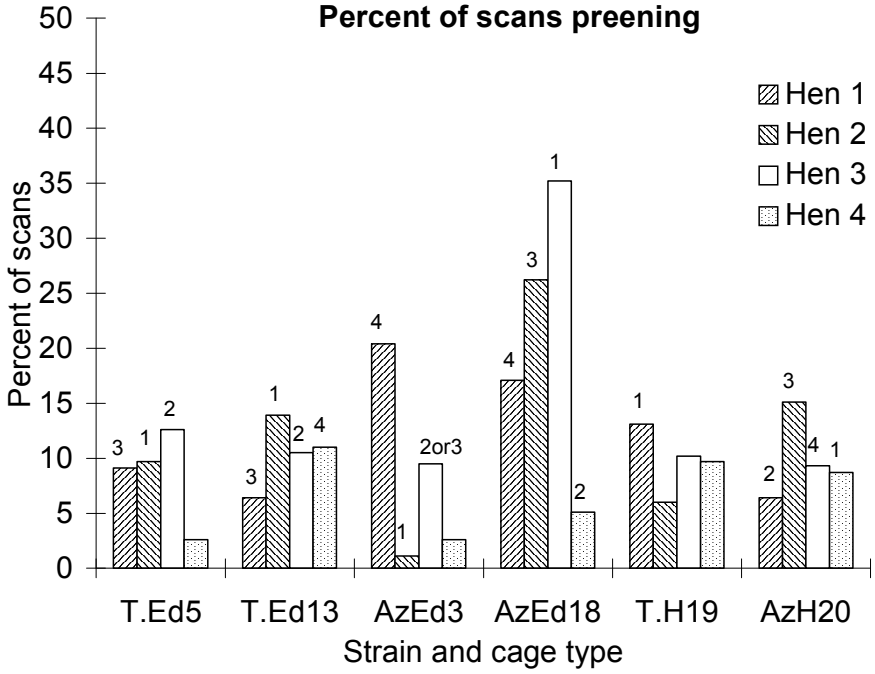
Appendix 7. Percent of scans at different behaviours in each cage (continued)



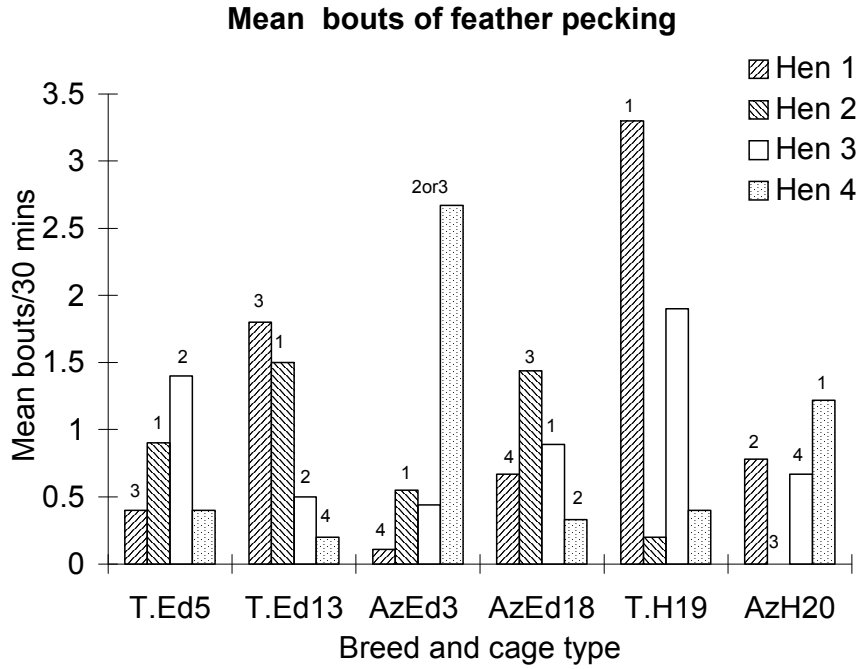


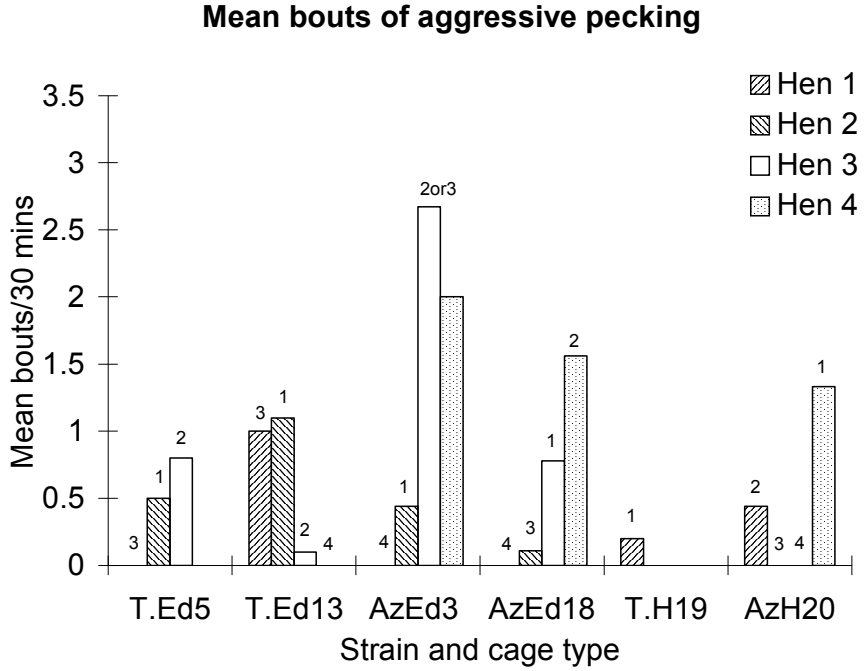
Appendix 7. Percent of scans at different behaviours in each cage (continued)



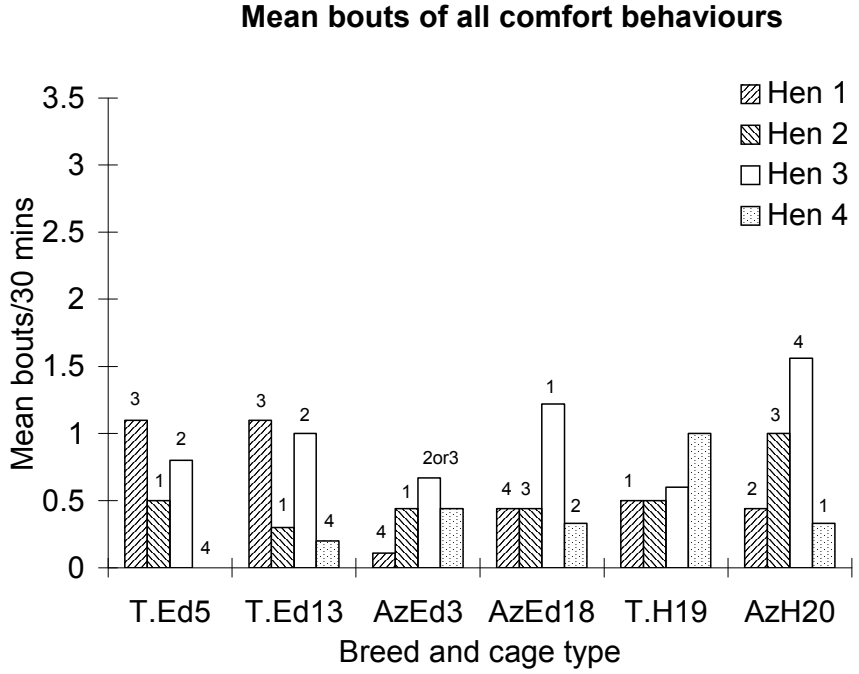


Appendix 8. Mean bouts of behaviours. Mean feather pecks and aggressive pecks by each hen recorded at each observation period in each cage.

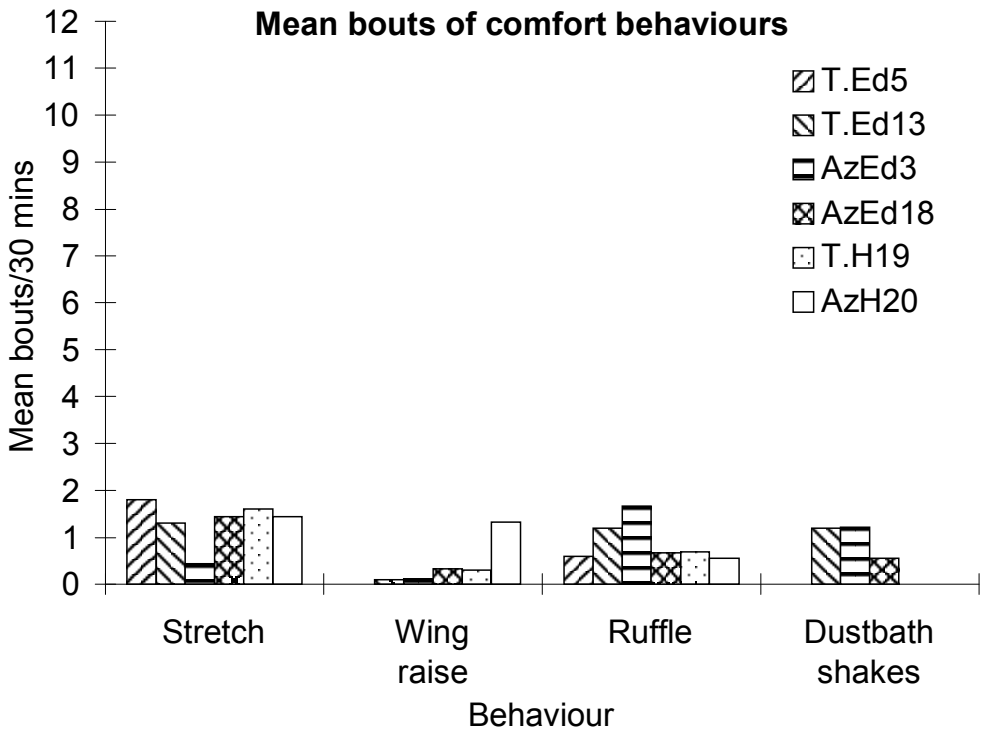


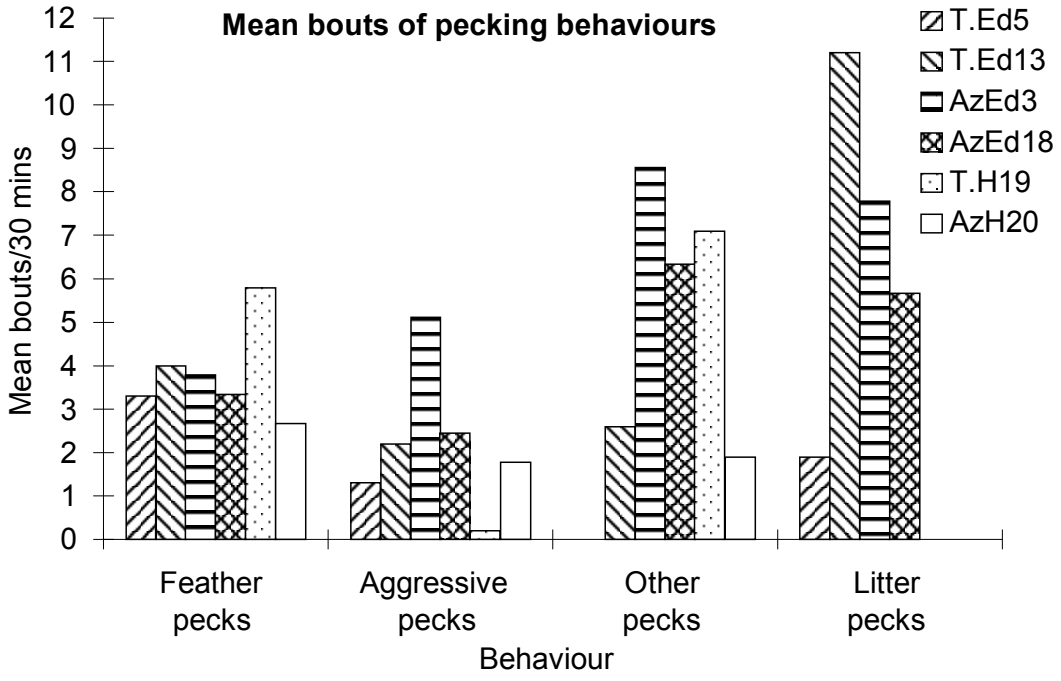


Appendix 8. Mean bouts of behaviours (continued)

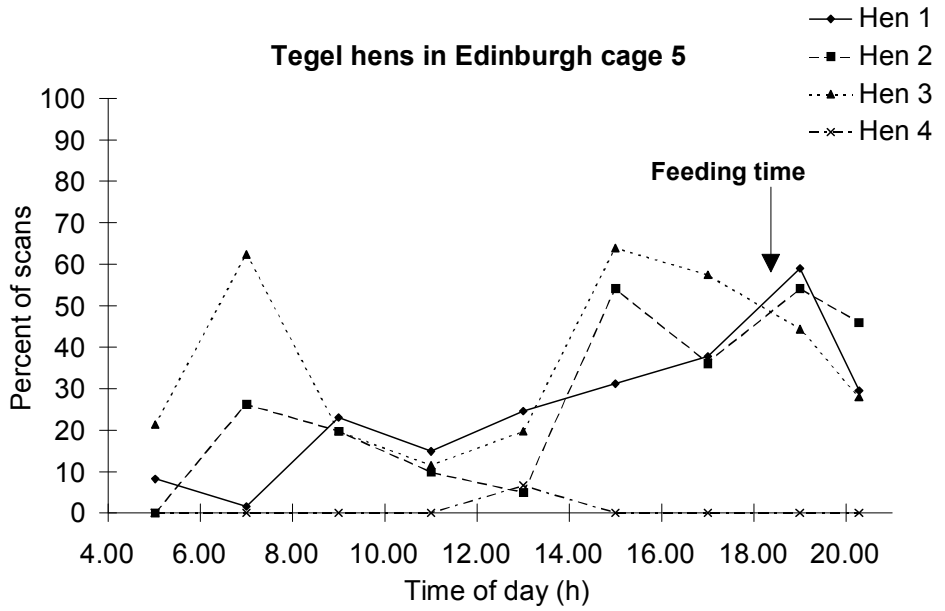


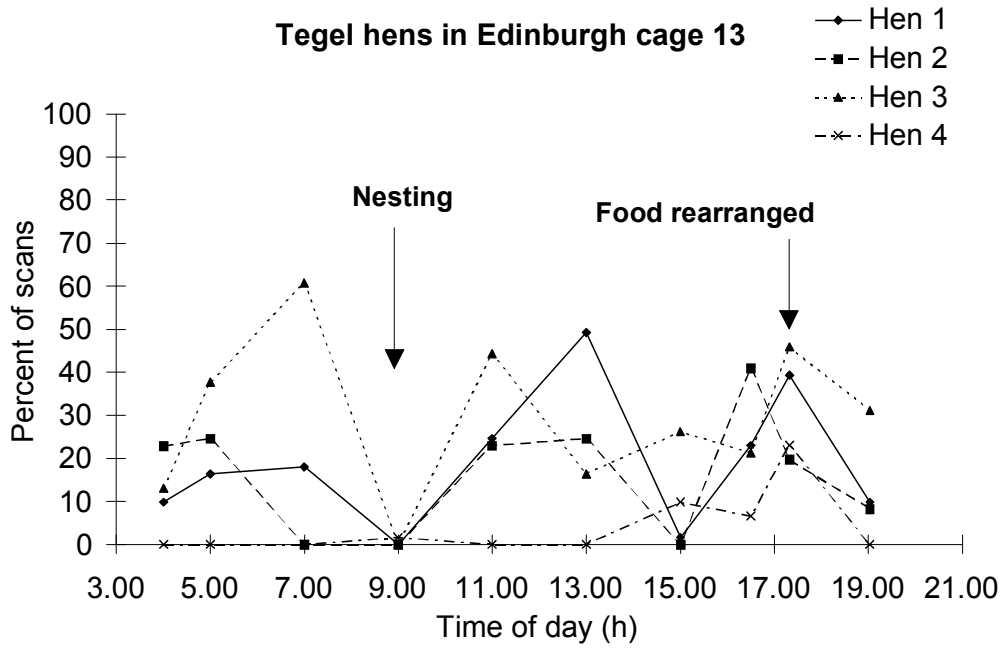
Appendix 8. Mean bouts of behaviours (continued)



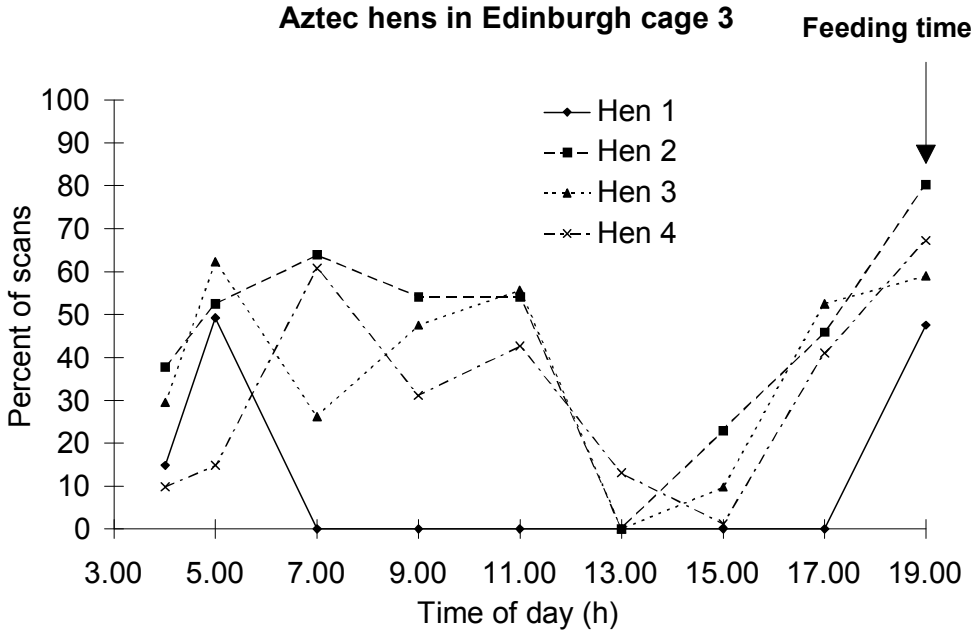


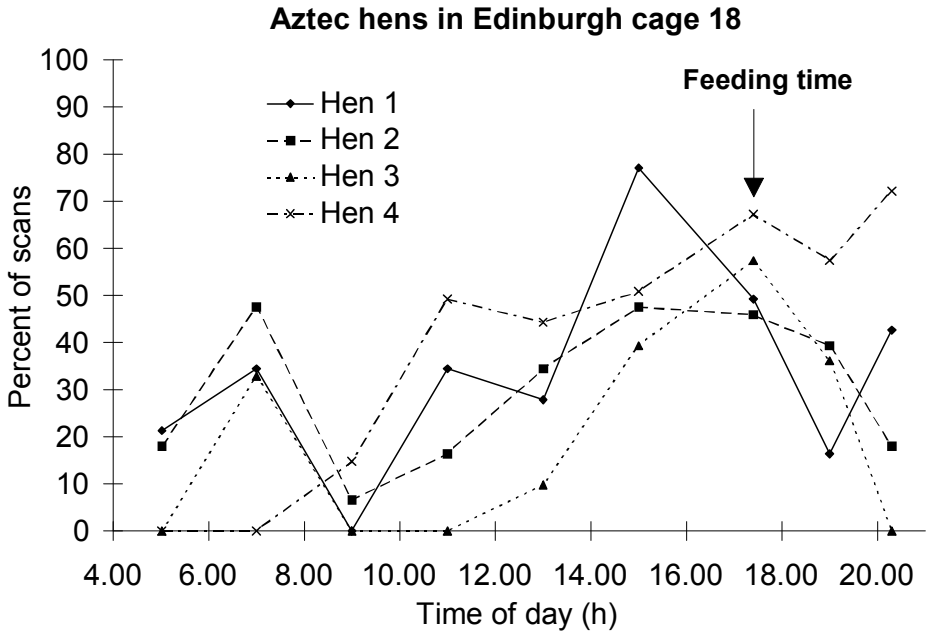
Appendix 9. Percent of scans when individual hens were feeding at each half-hour observation period in each cage.



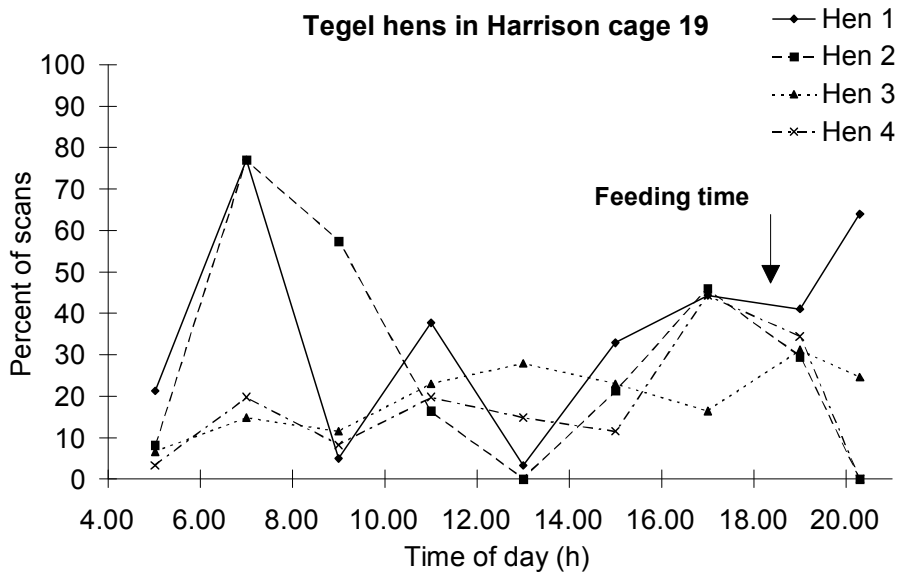


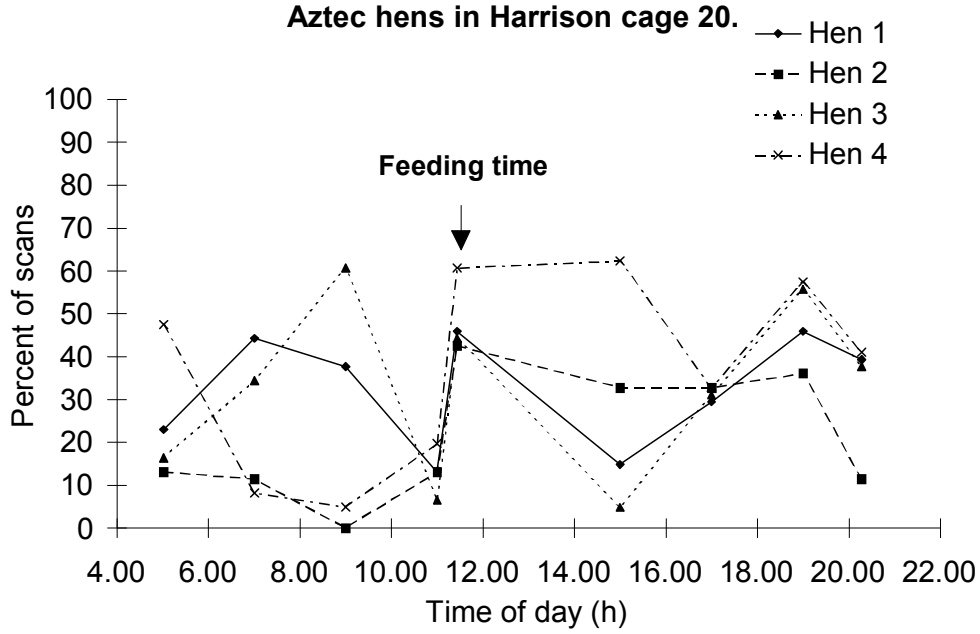
Appendix 9. Feeding over the day (continued)



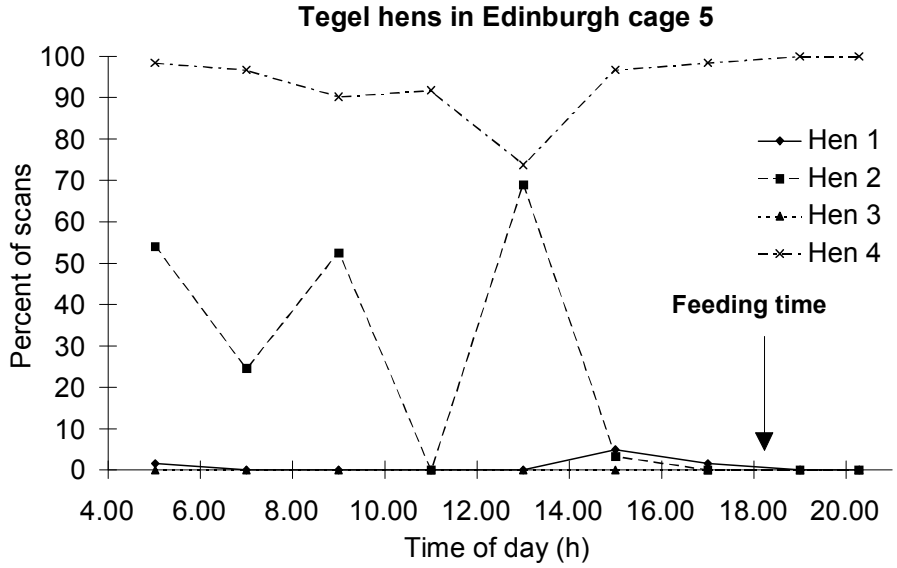


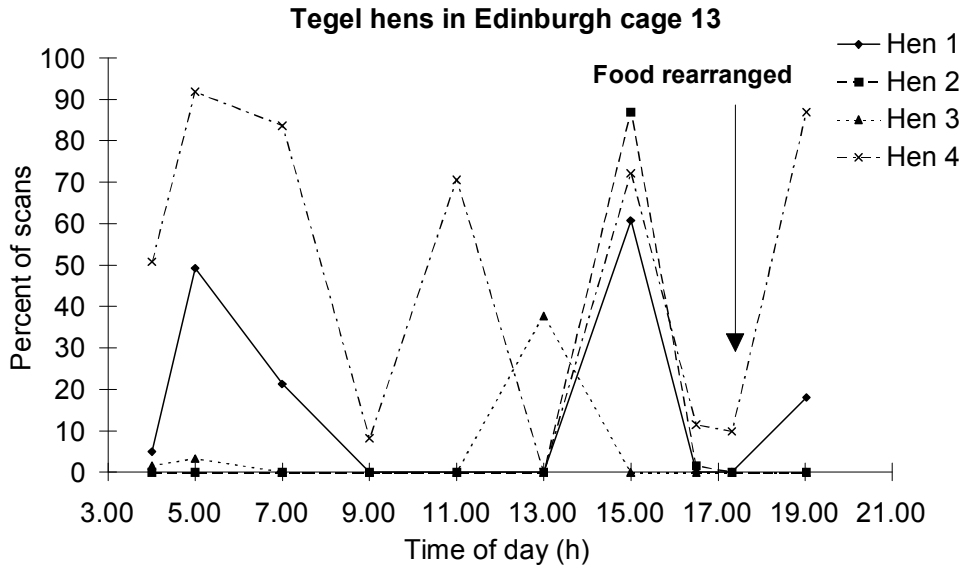
Appendix 9. Feeding over the day (continued)



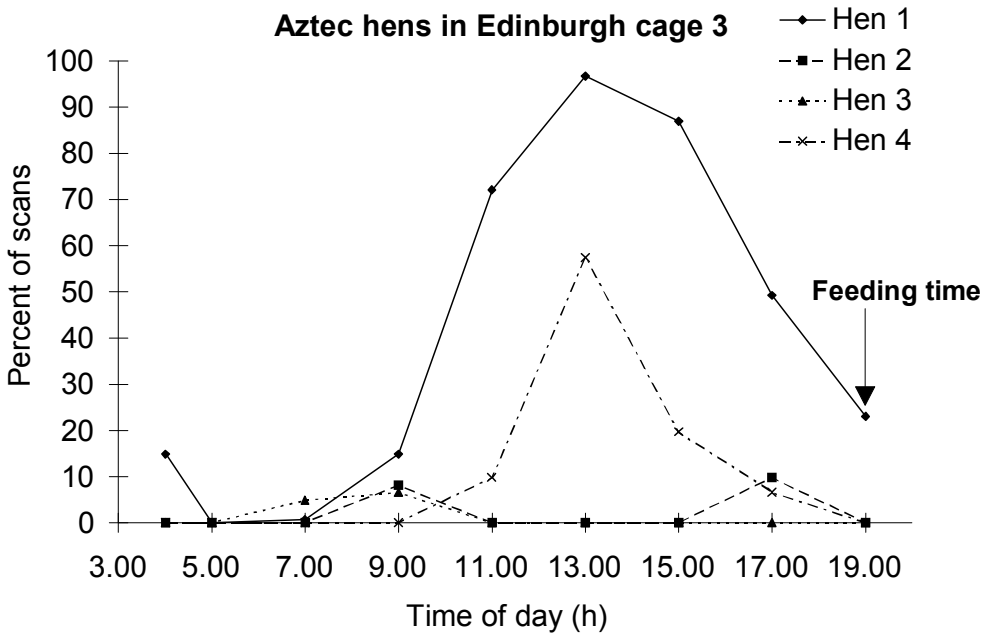


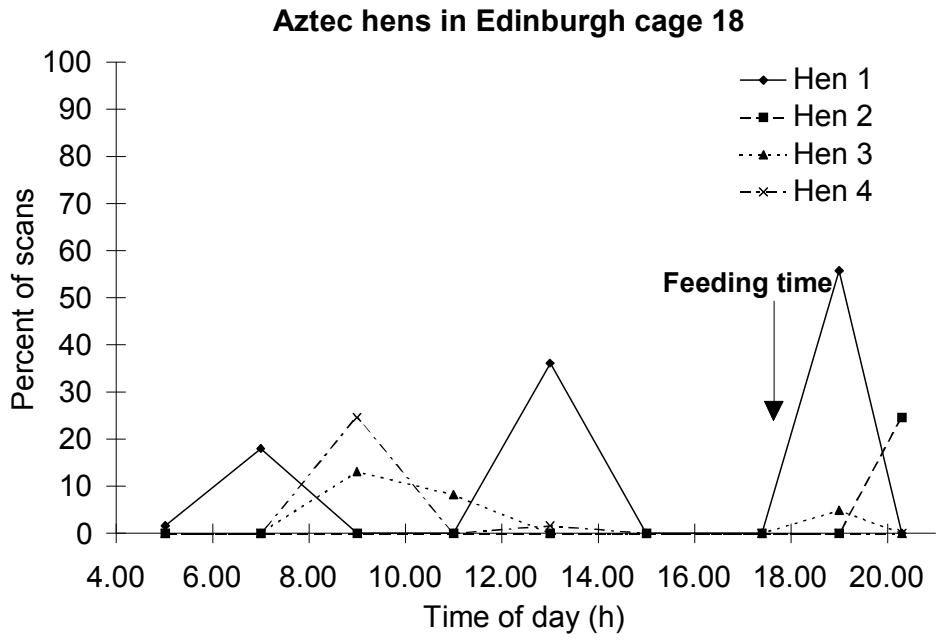
Appendix 10. Percent of scans when individual hens were sitting at each half-hour observation period in each cage.



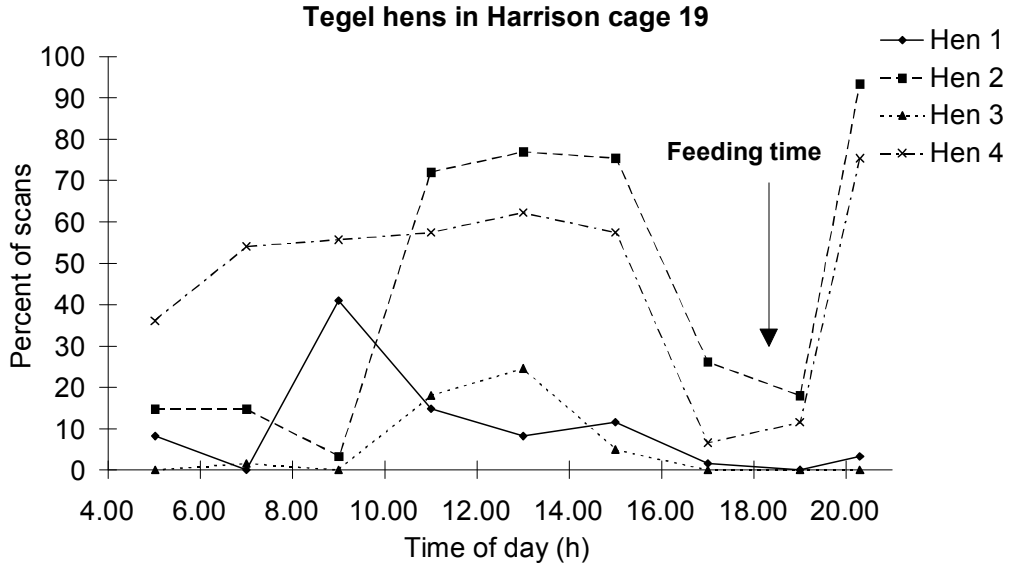


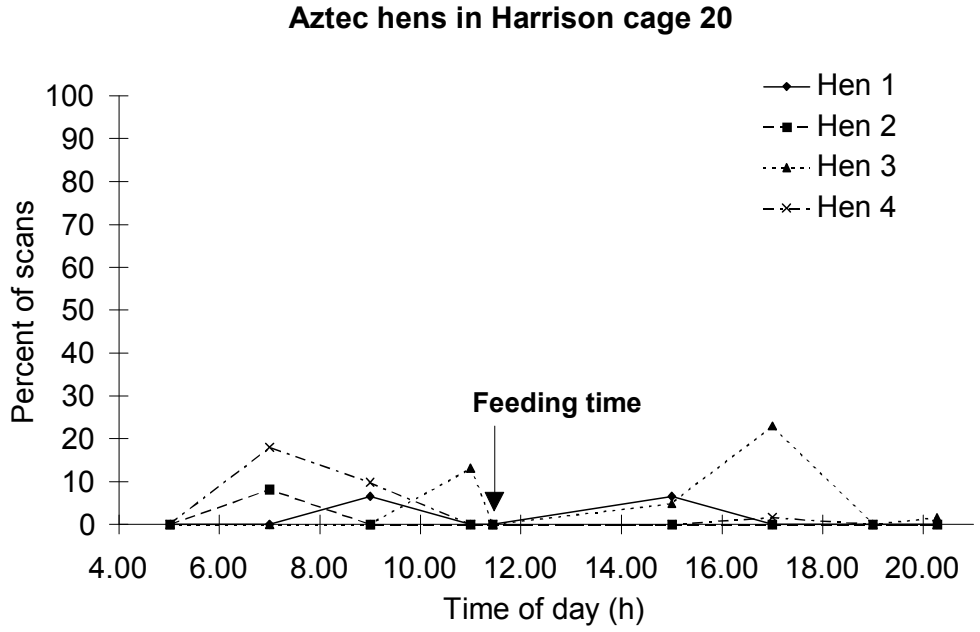
Appendix 10. Sitting over the day (continued)



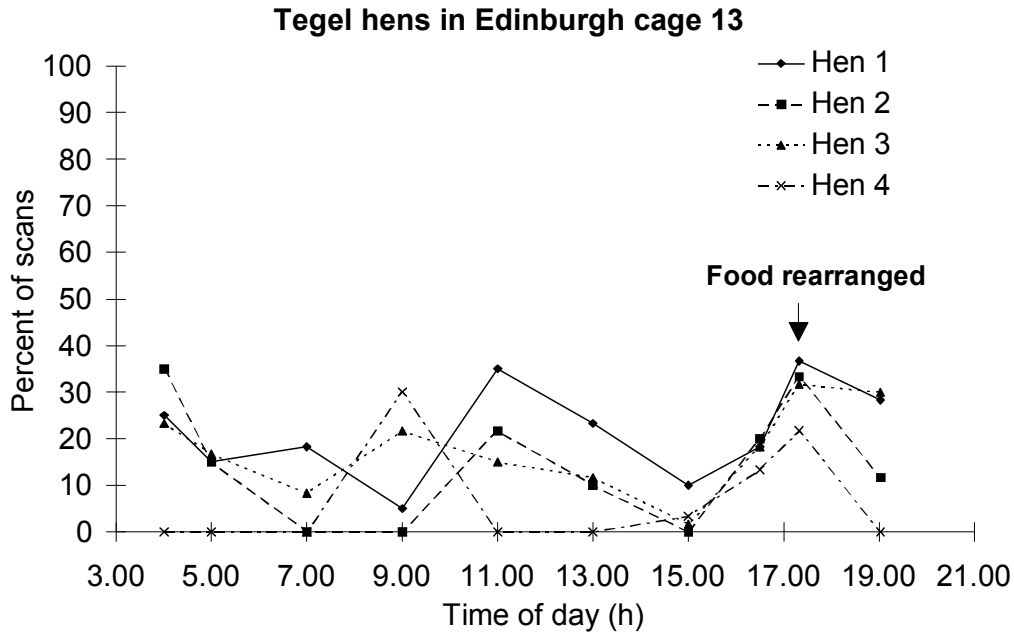


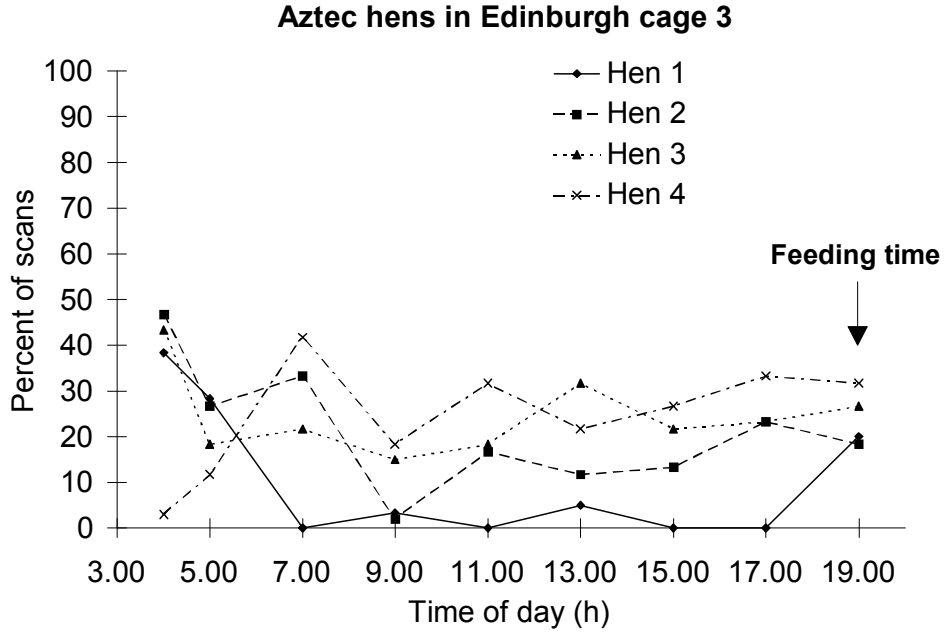
Appendix 10. Sitting over the day (continued)



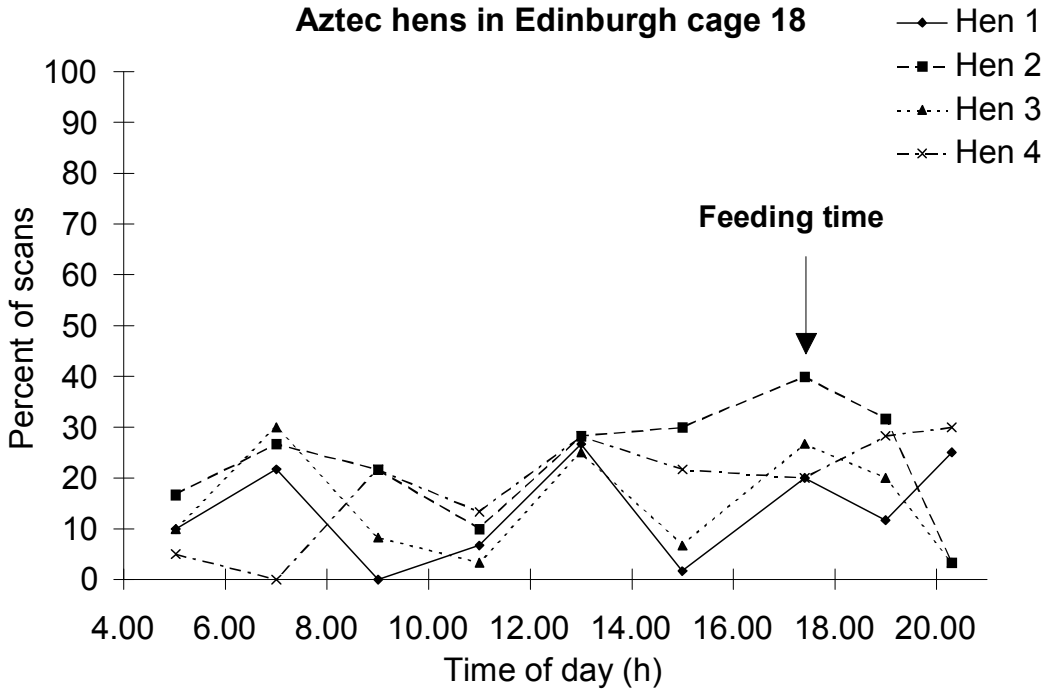


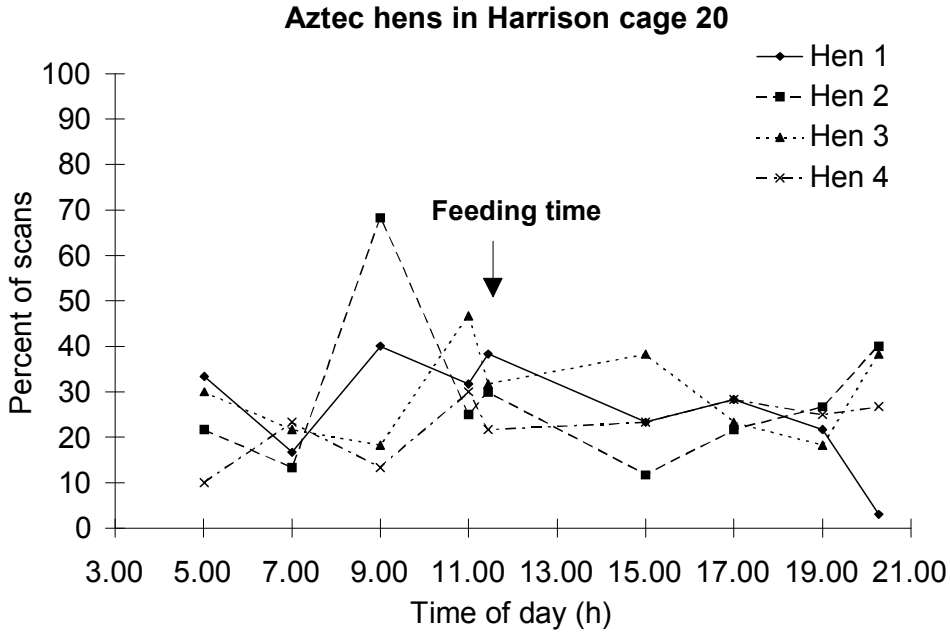
Appendix 11. Activity rates as measured by percent of scans when individual hens changed position during each half-hour observation period in each cage.



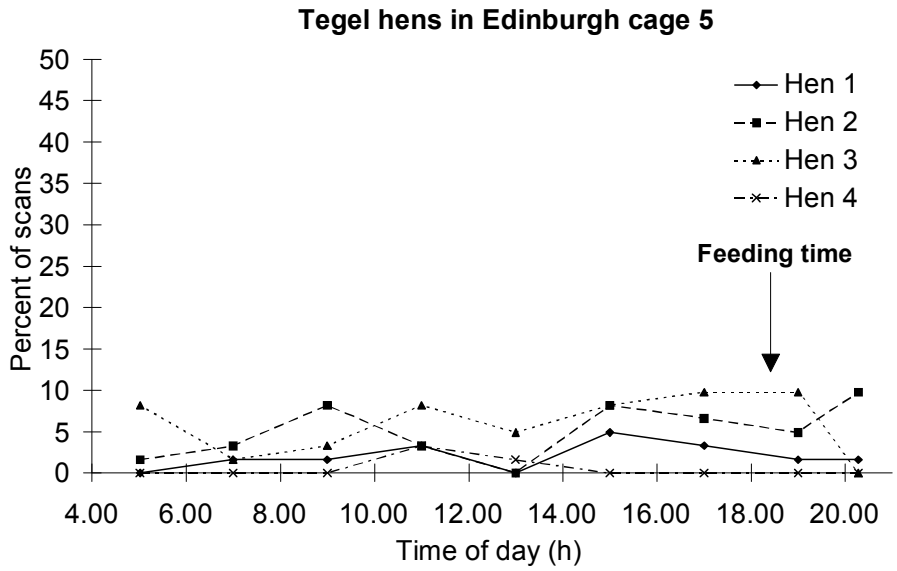


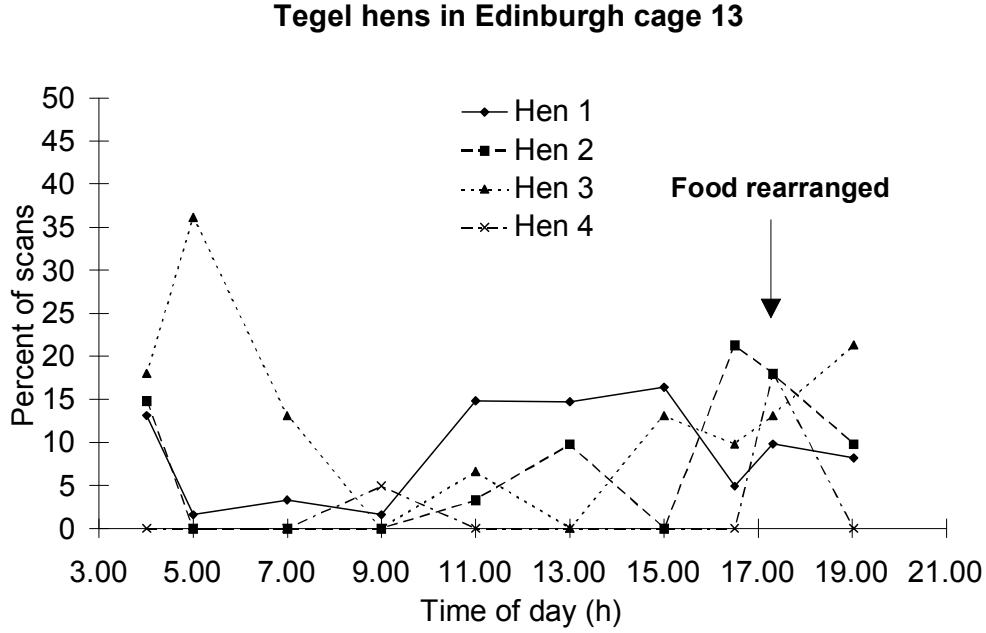
Appendix 11. Position changes over the day (continued)



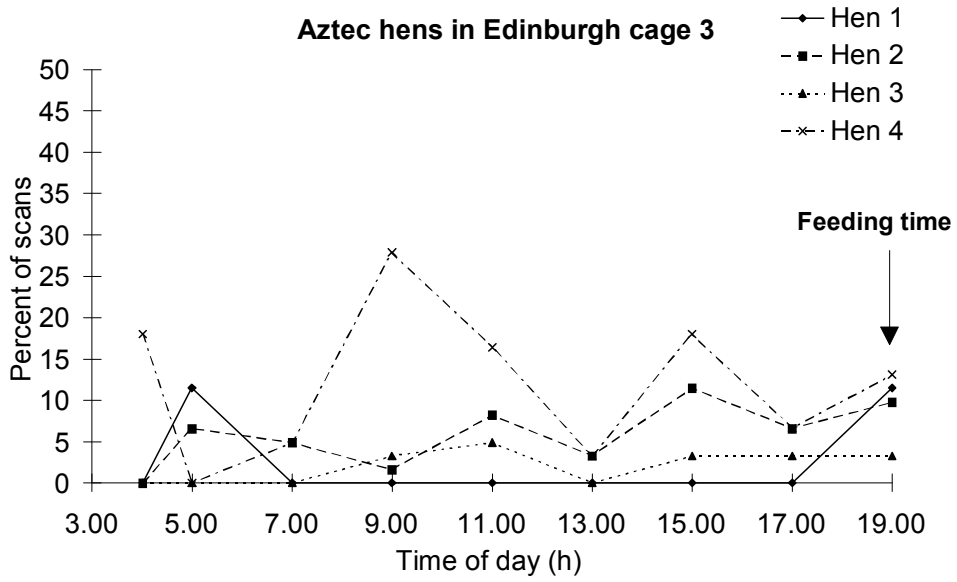


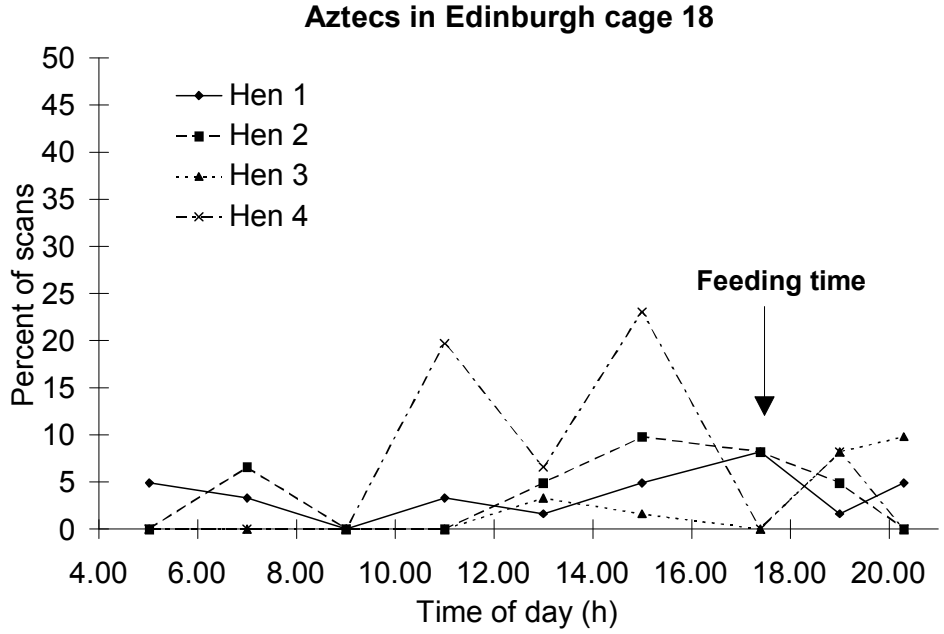
Appendix 12. Percent of scans when individual hens were drinking at each half-hour observation period in each cage.



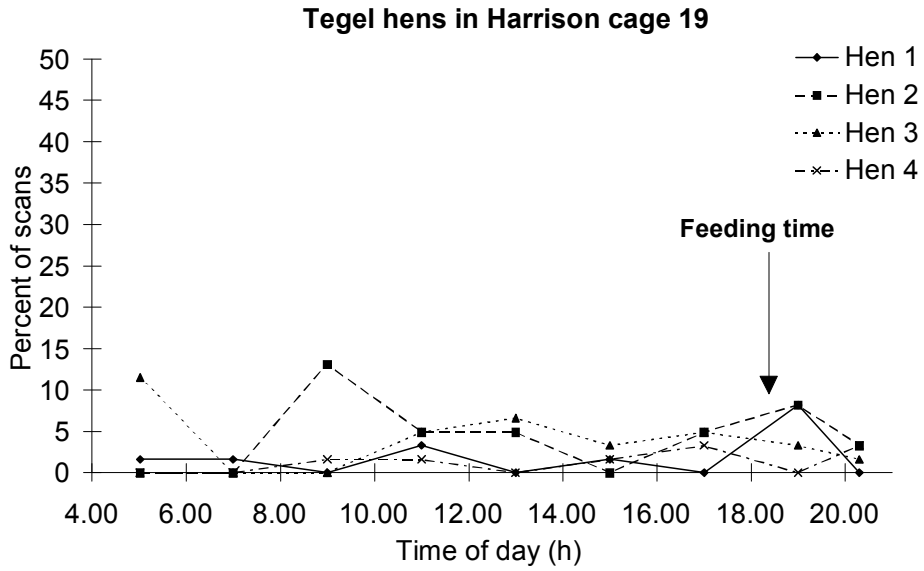


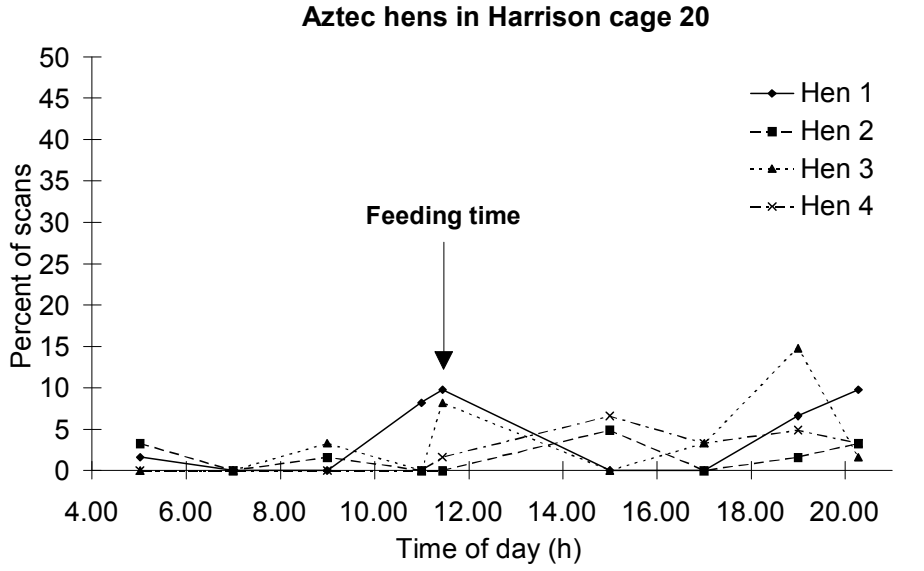
Appendix 12. Drinking over the day (continued)



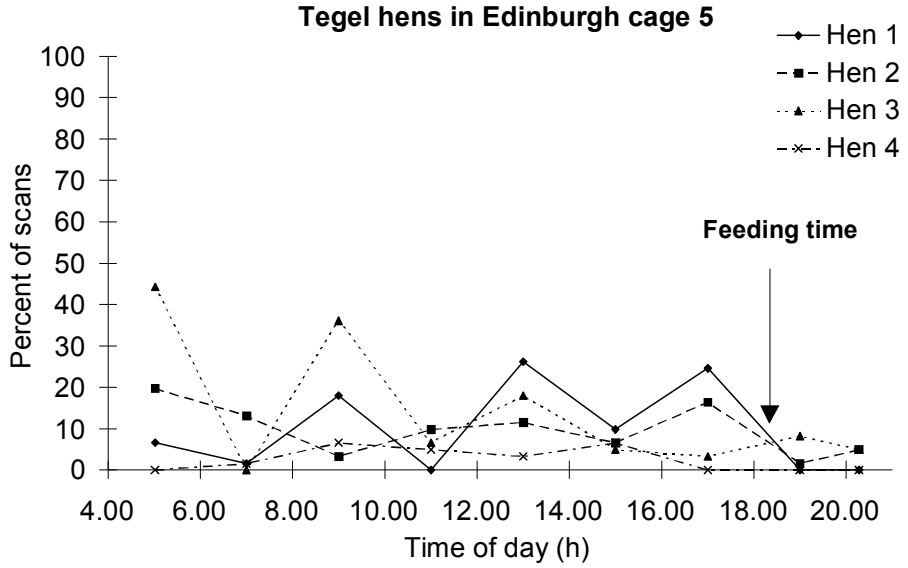


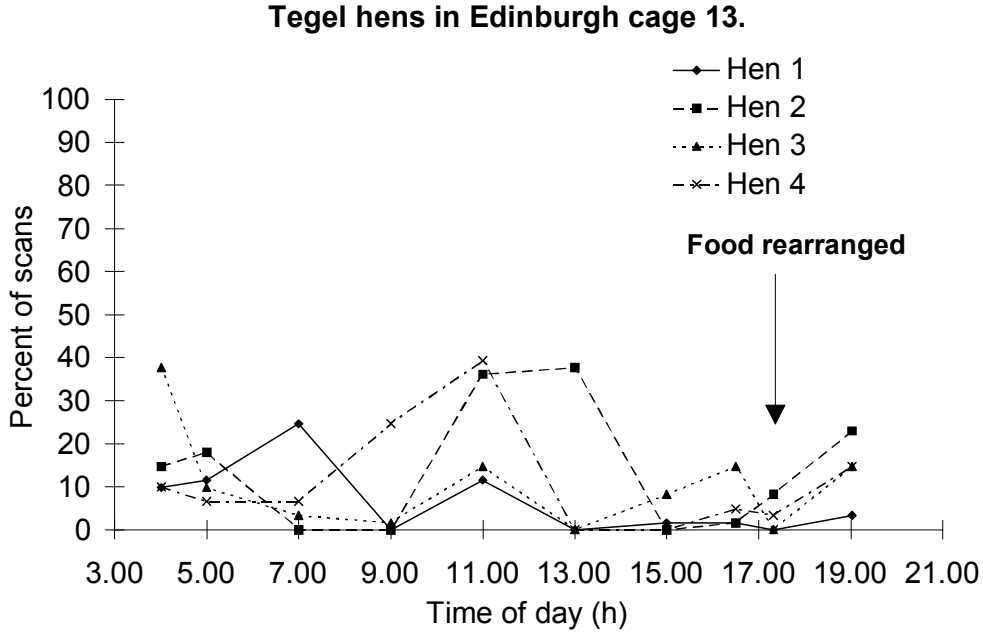
Appendix 12. Drinking over the day (continued)



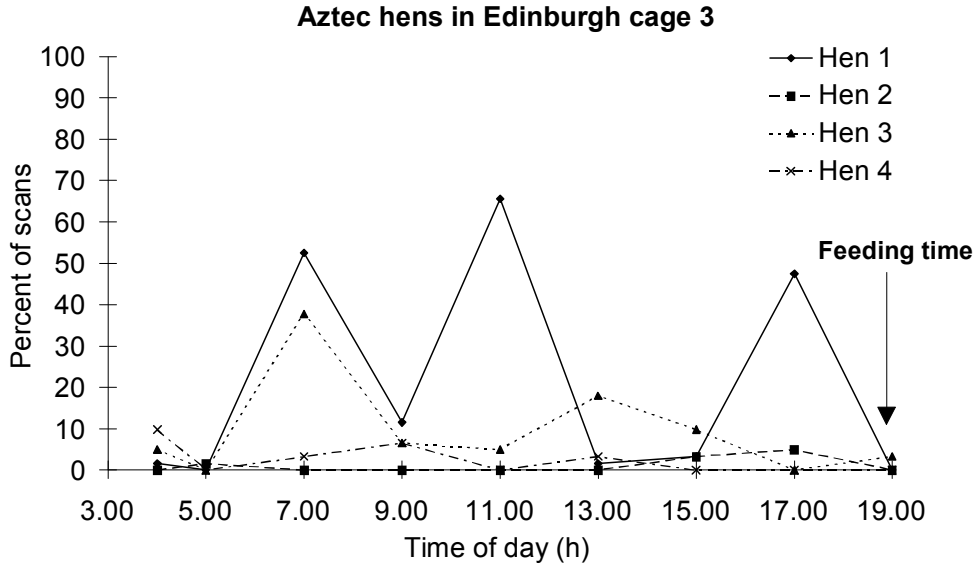


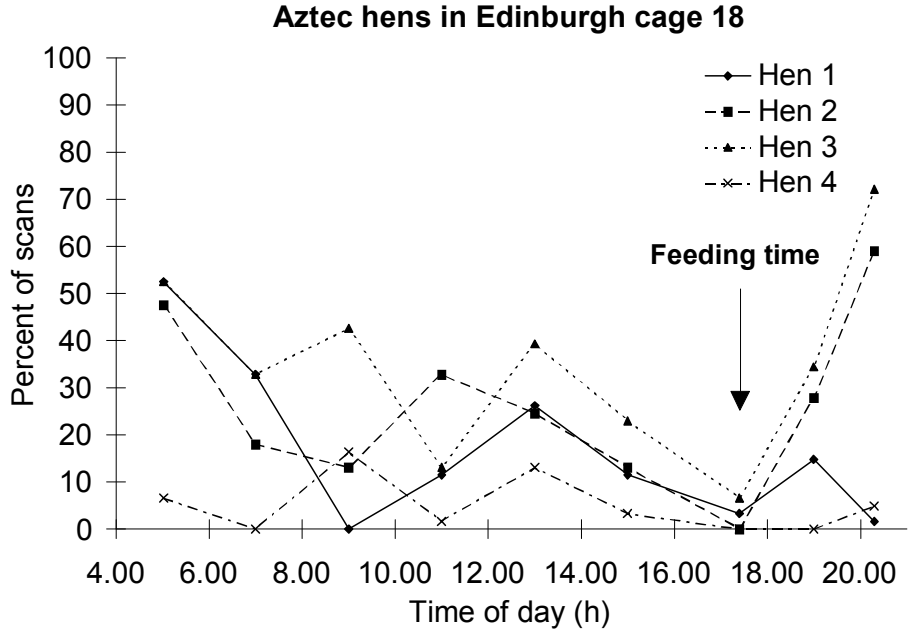
Appendix 13. Percent of scans when individual hens were preening at each half-hour observation period in each cage.



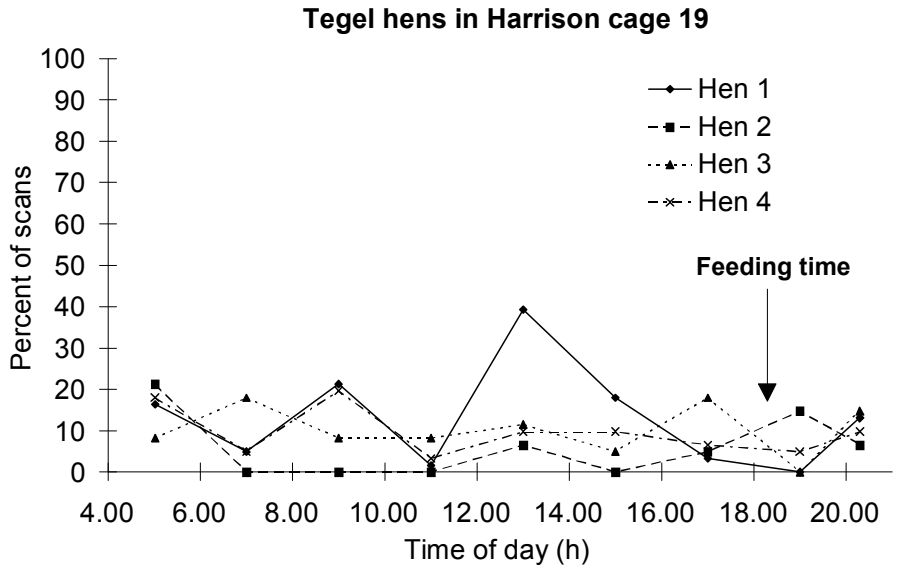


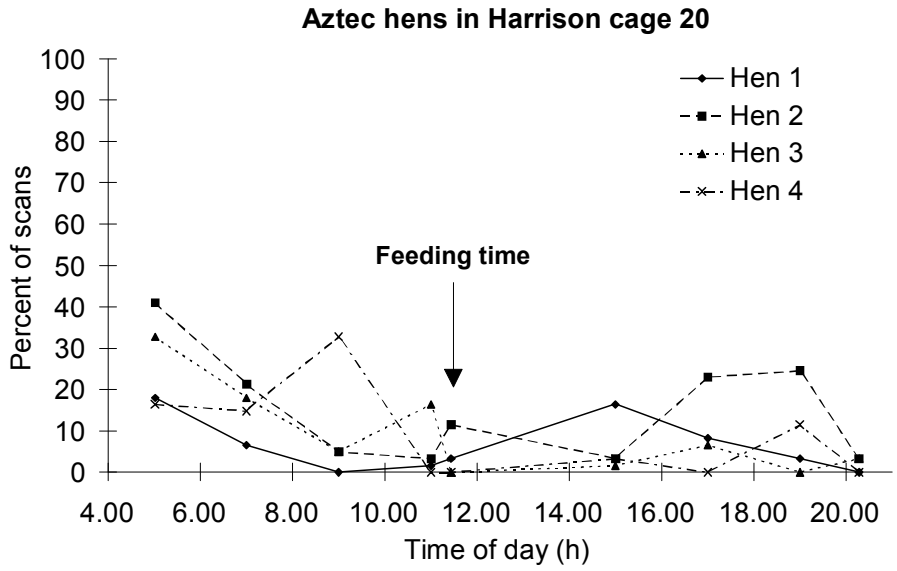
Appendix 13. Preening over the day (continued)



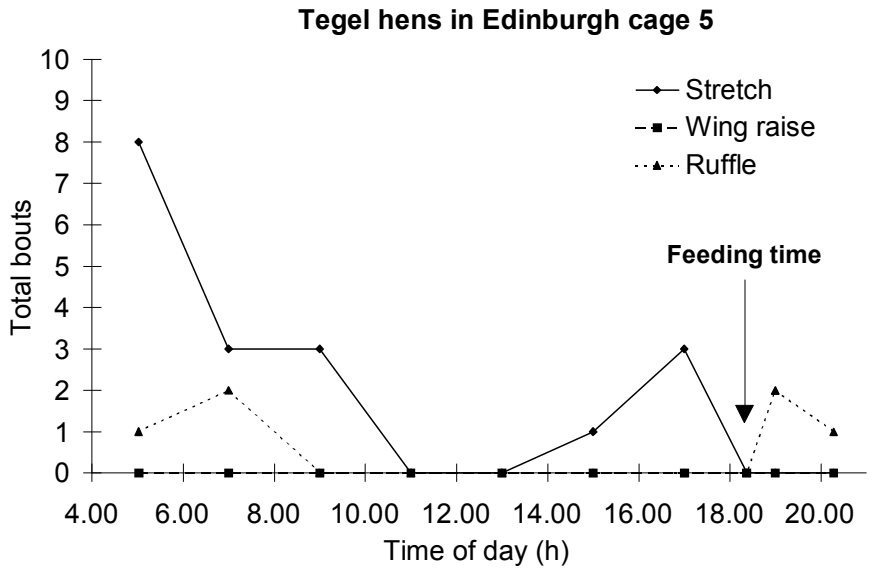


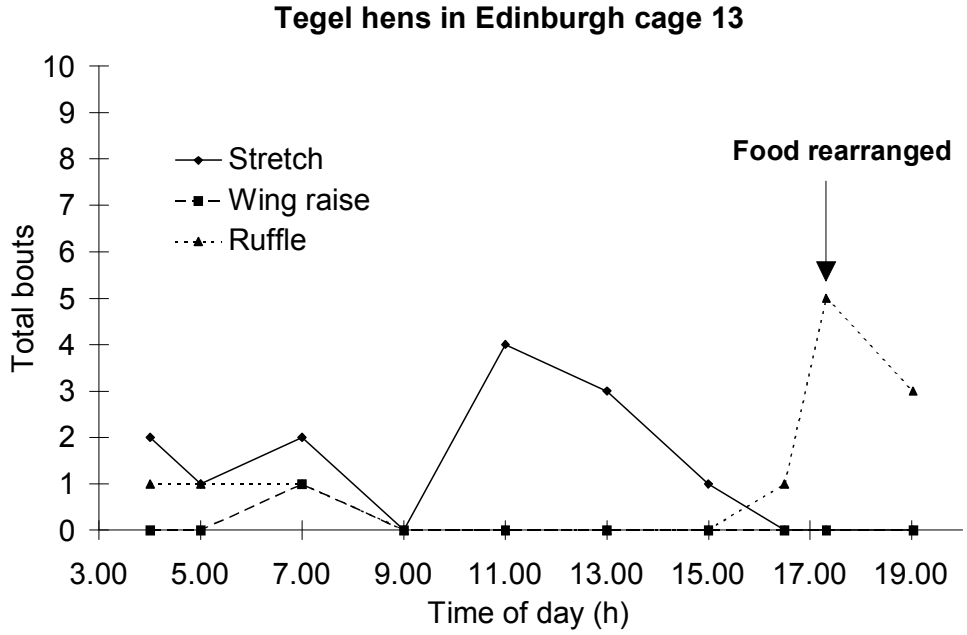
Appendix 13. Preening over the day (continued)



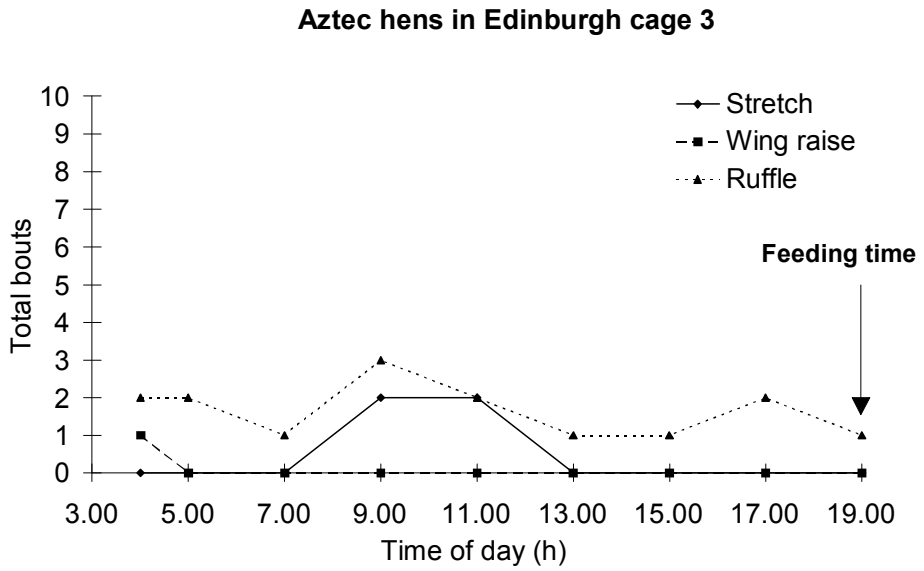


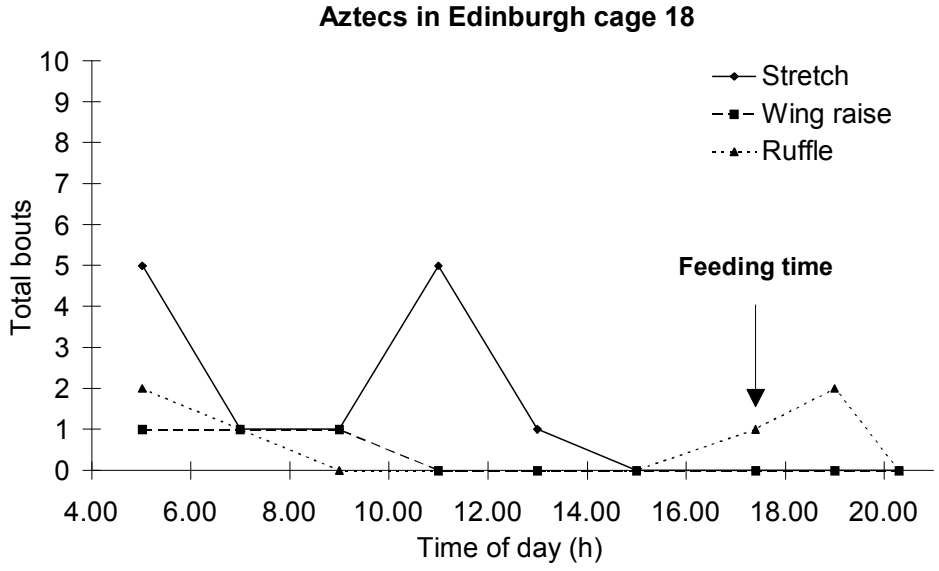
Appendix 14. Total bouts of the comfort behaviours of stretching, partial wing raise, and feather ruffle observed at each half-hour observation period over the day in each cage.



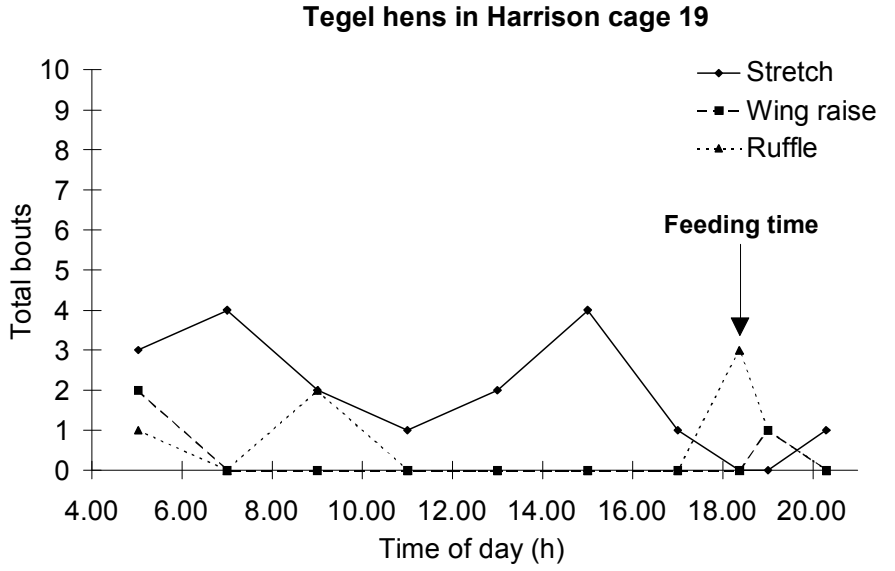


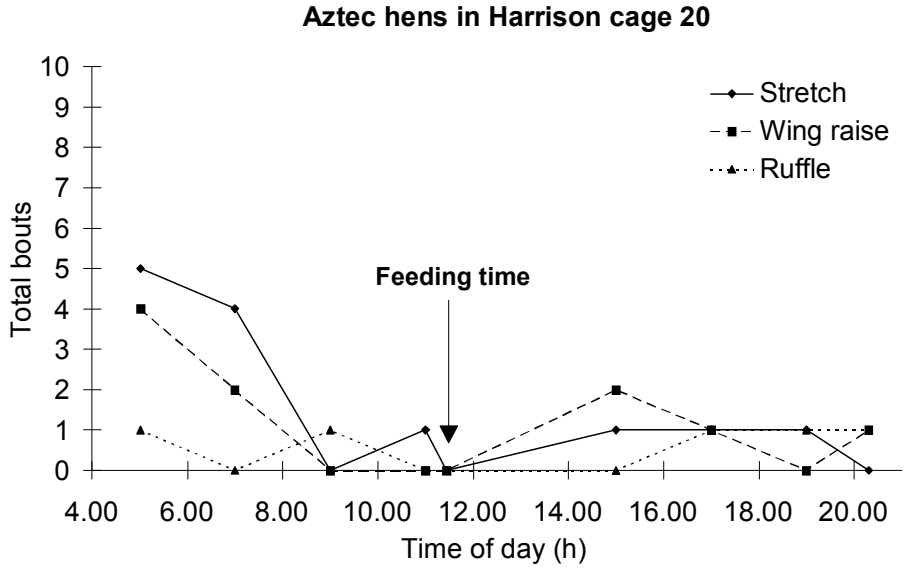
Appendix 14. Comfort behaviours over the day (continued)



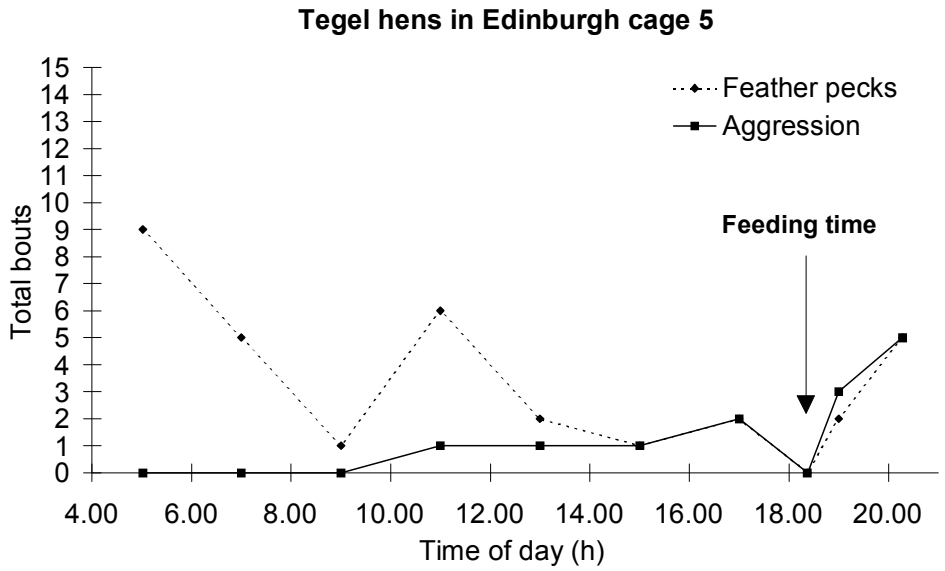


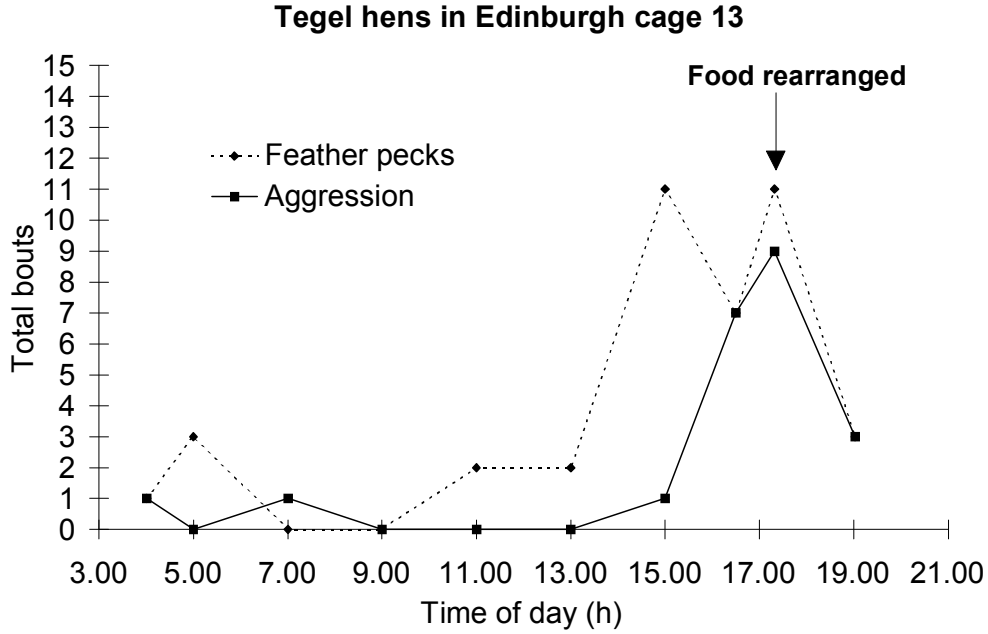
Appendix 14. Comfort behaviours over the day (continued)



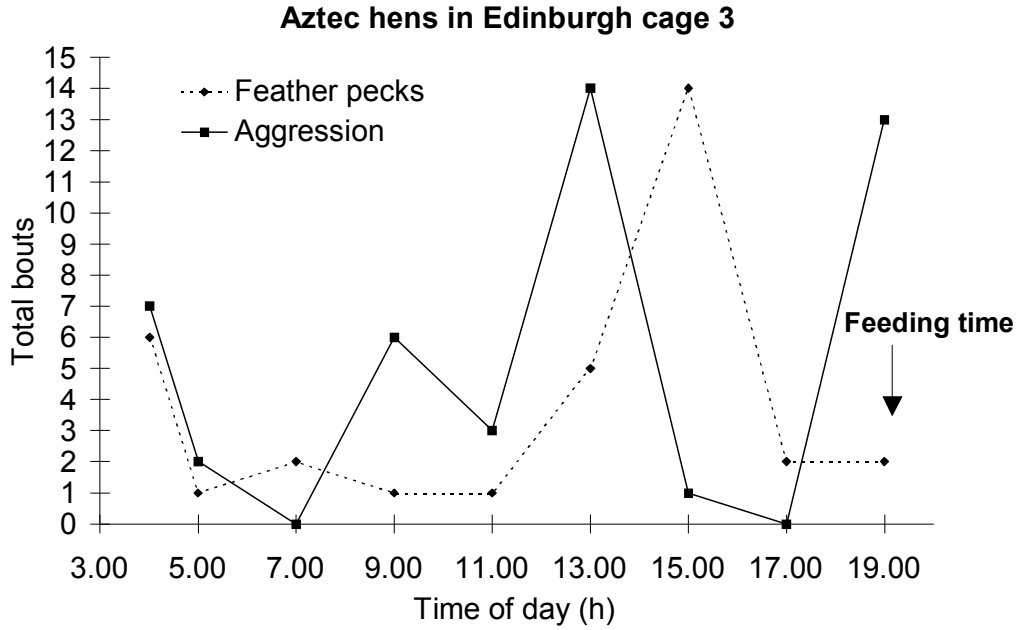


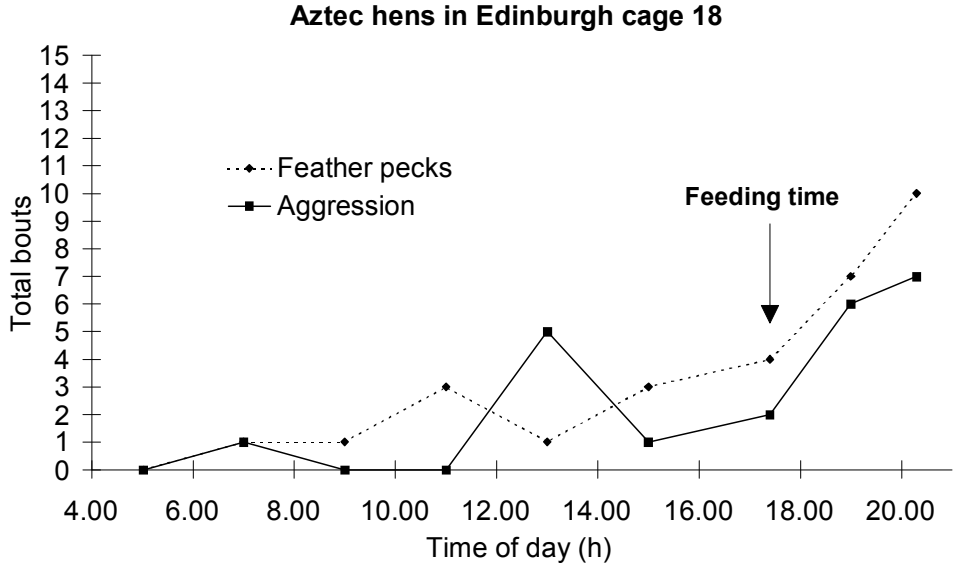
Appendix 15. Total bouts of feather pecks and aggressive pecks observed at each half-hour observation period over the day in each cage.



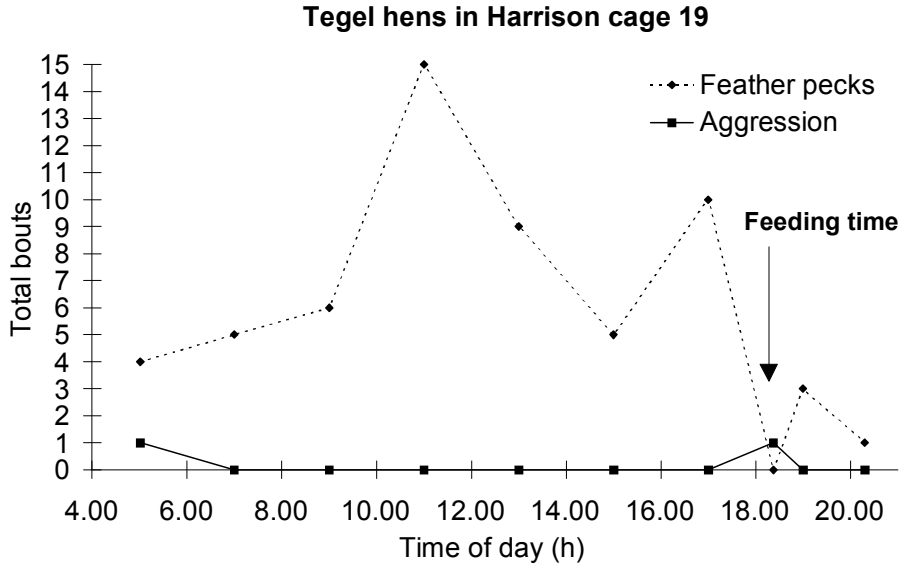


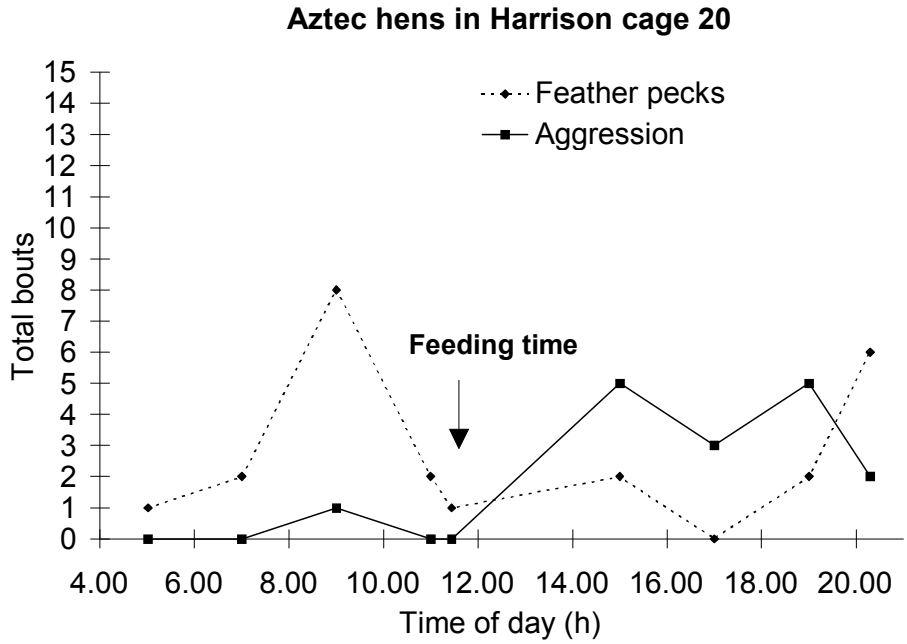
Appendix 15. Aggressive and feather peck bouts over the day (continued)



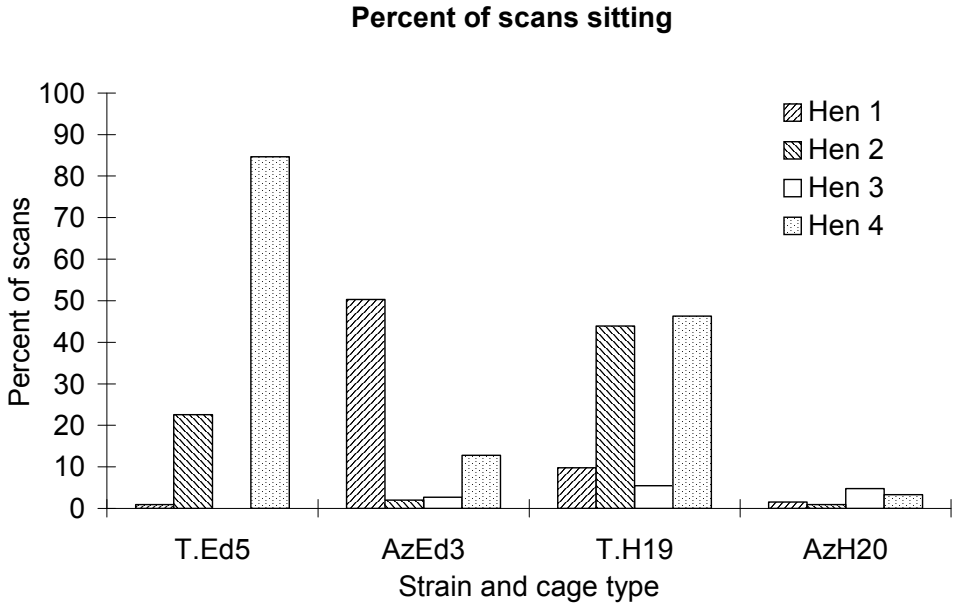


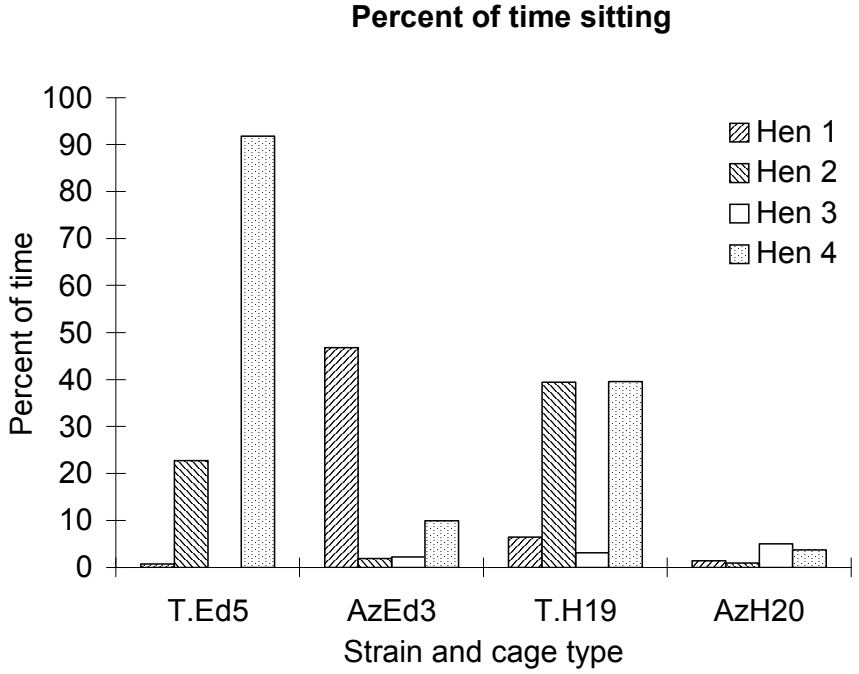
Appendix 15. Aggressive and feather peck bouts over the day (continued)



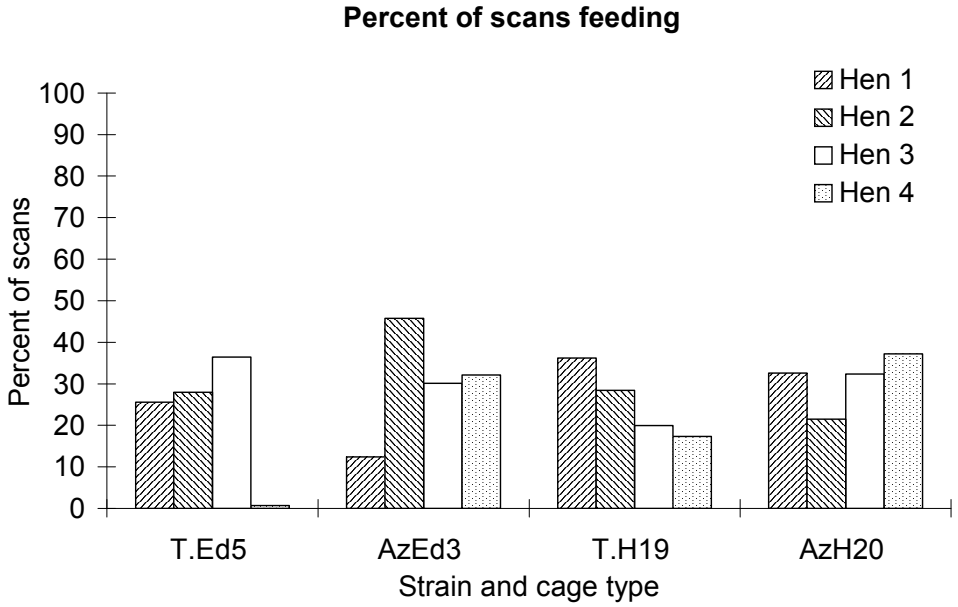


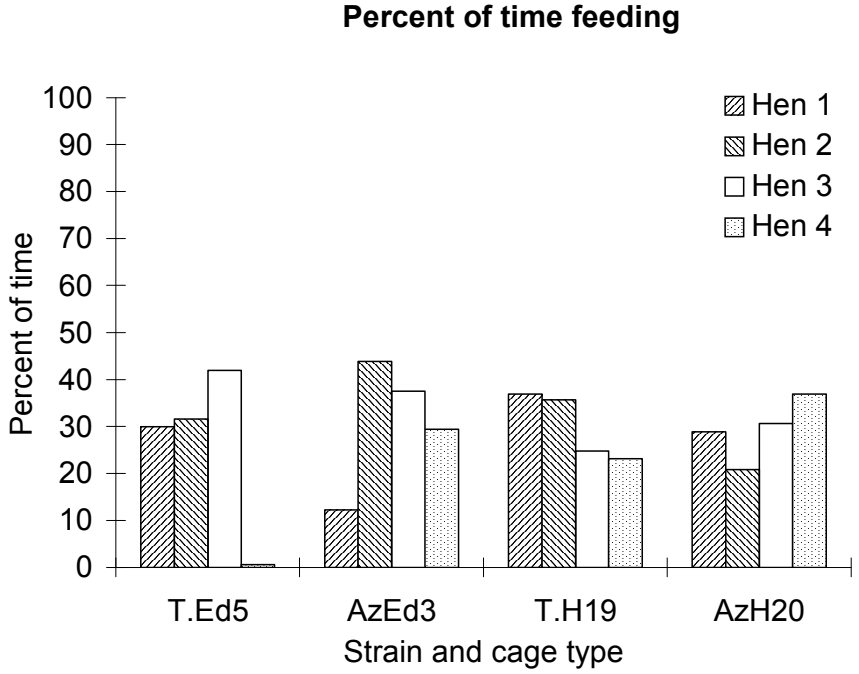
Appendix 16. Comparison of scanned data (top) with timed data (bottom) for continuous behaviours.



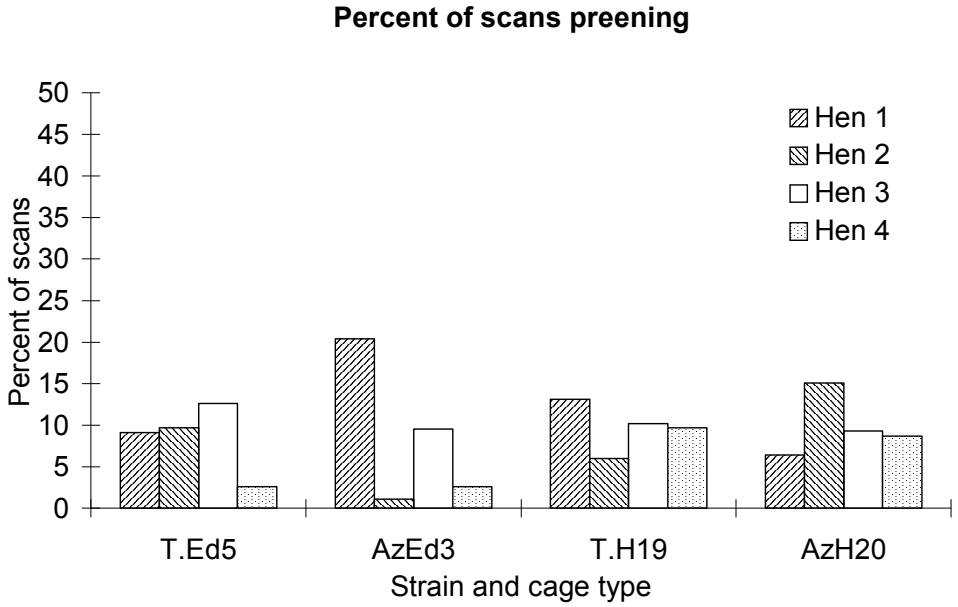


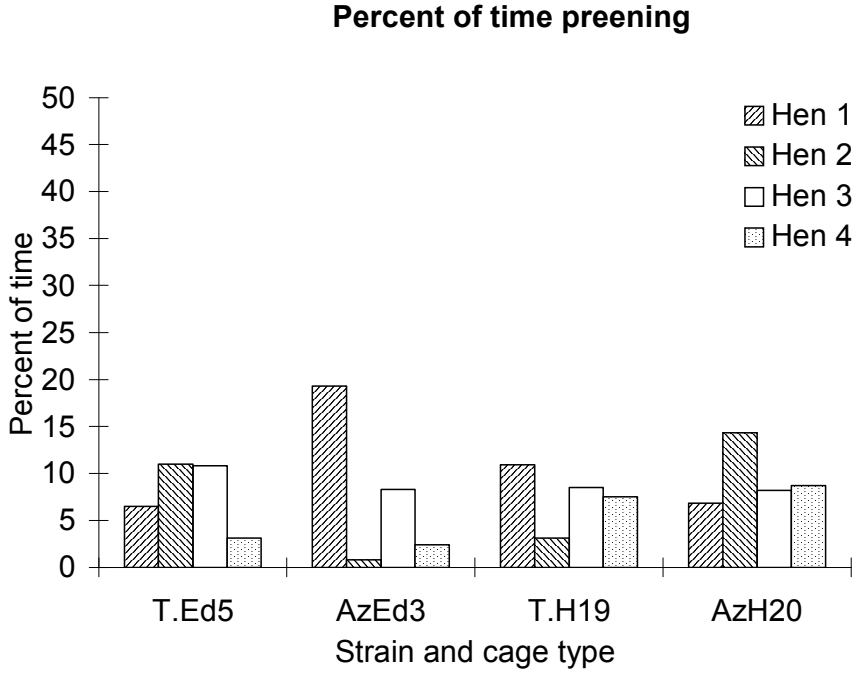
Appendix 16. Comparison of scanned with timed data (continued)



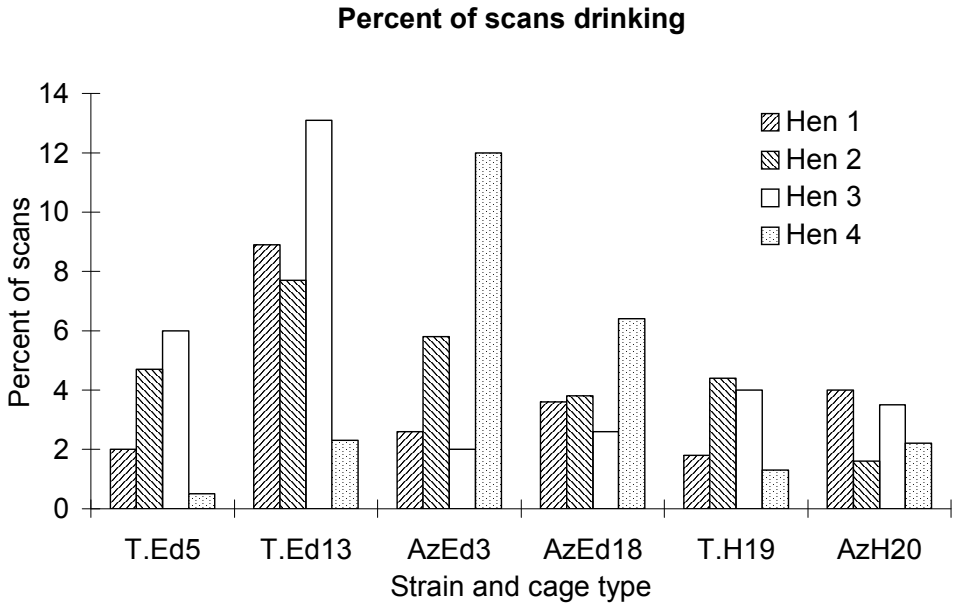


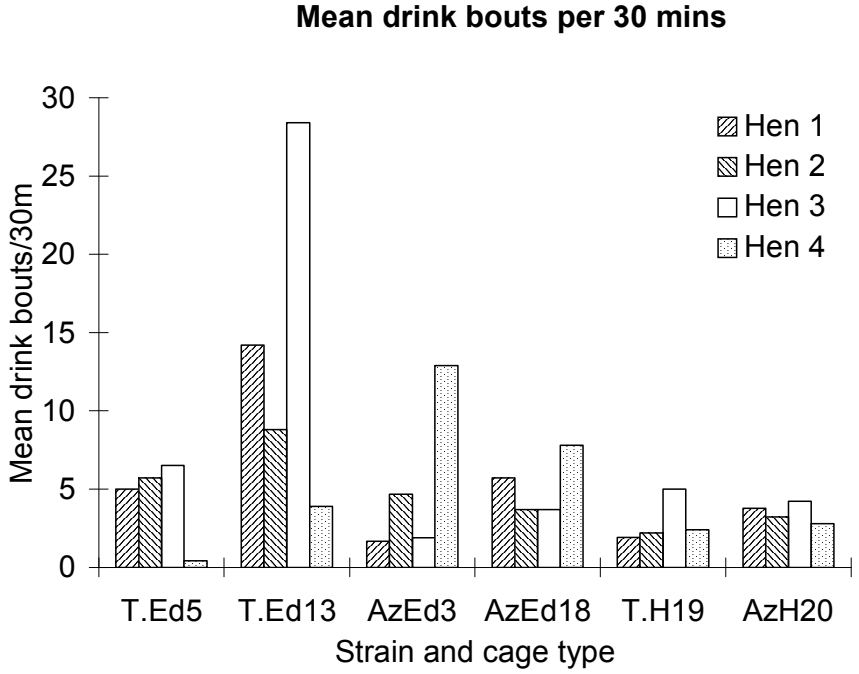
Appendix 16. Comparison of scanned with timed data (continued)





Appendix 17. Comparison of percent of scans drinking (top) with mean drink bouts per 30 minutes (bottom).





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