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The Influence of Bedding Depth on Behaviour in Golden Hamsters (*Mesocricetus auratus*)

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1 Einleitung und Zielsetzung

Goldhamster sind als Heimtiere sehr beliebt und werden ebenfalls oft als Labortiere gehalten (Gattermann et al. 2001). Die Zahl der in Schweizer Haushalten lebenden Goldhamster ist nicht bekannt, aber die Verkäufe in den Heim- und Zootiergeschäften zeigen, dass Goldhamster, und Hamster im Allgemeinen, in den letzten Jahren immer beliebter geworden sind (Qualipet, pers. Auskunft). Im Allgemeinen werden Goldhamster als anspruchslose Tiere angesehen, vermutlich weil man glaubt, ein solch kleines Tier brauche nur wenig Platz, um sich wohl zu fühlen. Wegen der vermeintlichen Anspruchslosigkeit und wegen seines niedlichen Aussehens wurde er sehr beliebt als Heimtier.

Da trotz gelegentlicher Publikationen über die Haltung der Goldhamster (z.B. Kuhnen, 2002, Vonlanthen, 2003) wenig über ihre Bedürfnisse bekannt ist, zielt unsere Studie auf die Heimtierhaltung des Goldhamsters. In den Haushalten sind viele Käfige nur wenig grösser als die Boxen in den Laboratorien (ungefähr 2500 anstelle 1800 cm^2, eigene Beobachtung) und die Einstreu, die den Hamstern gegeben wird, reicht kaum aus, um sich darin zu vergraben (<5 cm). Normalerweise sind in jedem Käfig ein Häuschen oder anderer Unterschlupf und ein Laufrad vorhanden.

Über den Goldhamster, wie er in der freien Natur lebt, weiss man, dass sein natürliches Habitat die Getreide- und Gemüsefelder hauptsächlich in der Hochebene von Aleppo (Syrien) sind. Ausgewachsene Goldhamster leben einzeln in Gangsystemen in der Erde, die nächste Distanz von einem bewohnten Bau zum nächsten beträgt 118m (Gattermann, 2001). Die Schlafkammer liegt in einer durchschnittlichen Tiefe von einem halben Meter unter der Oberfläche (Gattermann, 2001). Wenn wir das mit der Haltung der meisten Goldhamster in Haushalten vergleichen, fällt die grosse Diskrepanz auf: kommerzielle Käfige (abgesehen von ebenfalls erhältlichen Terrarien) sind ohnehin so konstruiert, dass es einem Besitzer nicht möglich ist, mehr als 10 cm Einstreu anzubieten. Die tatsächlich eingestreute Menge ist meist geringer, obwohl es erwiesen ist, dass Kleinnager eine starke Motivation zu graben haben (Sherwin, 2004). Auch Hamster, die als Heimtiere gehalten werden, graben in die Tiefe (Dieterlen 1958). In Versuchen hatte Lochbrunner (1956) gezeigt, dass Hamster aggressiv werden und zu essen aufhören, wenn ihnen Nestmaterial und Einstreu verwehrt wird.

Graben und Nestbau scheinen beim Goldhamster sehr wichtige Verhaltensweisen zu sein (Dieterlen, 1956, Kuhnen, 2002). Sherwin (1996) beschreibt, dass Nistmaterial, zumindest bei Mäusen, eine ähnliche Wichtigkeit wie Futter und Wasser aufweist, allerdings wurde die Einstreutiefe nicht untersucht.

Das Schweizer Tierschutzgesetz verbietet die Bewegungseinschränkung eines Tieres, wenn dies mit Schmerzen, Leiden oder Schäden einhergeht. Zuweilen ist es jedoch sehr schwierig, wirklich bewerten zu können, wann ein Tier leidet. Zur Beurteilung des Wohlbefindens und der artgerechten Haltung wird oft das Augenmerk auf Stereotypien gerichtet. Im Allgemeinen wird eine Haltung für gut befunden, wenn das Individuum sein natürliches Verhalten zeigen kann; auftretende Stereotypien werden dagegen als Anzeichen eines geringen Wohlbefindens gewertet (Mason, 1991, und entsprechende Referenzen). Jedoch sind nicht alle natürlichen Verhalten in der Heimtier- rsp. Labortierhaltung wünschenswert, z.B. Aggressivität gegenüber dem Menschen (Galef, 1999).

Als Stereotypie wird bei Kleinnagern unter kleiner, restriktiver Käfighaltung oft Gitternagen gezeigt (u.a. Würbel, 1997, Würbel et al., 1998, Nevison et al., 1999 bei Mäusen; Waiblinger & König, 1999 bei Gerbils). Stereotypien, definiert als sich wiederholende Verhaltensmuster ohne offensichtliches Ziel oder Funktion, werden bei freilebenden gesunden Tieren nicht beobachtet, dagegen oft, wenn die Haltungsbedingungen für ein Tier nicht optimal erscheinen (Mason 1991). Nun sind aber Stereotypien und schlechtes Wohlbefinden nicht einfach gleichzusetzen, wie Mason & Latham (2004) betonen, sondern sollten eher als Anzeichen verwendet werden, dass etwas an einer Haltungsbedingung nicht stimmen könnte, wenn sie auftauchen.

Minimale Platzansprüche als einziges Kriterium für die Eignung einer Unterbringung sind kaum ausreichend, die Umgebung sollte auch dazu stimulieren, natürliches Verhalten auszuleben (Mason, 1991). Die Interaktion mit der Umgebung ist einer der Schlüsselfaktoren in der angereicherten Tierhaltung (Manosevitz & Pryor, 1975).

Mehrere Studien zeigten auf, dass Anreicherung in der Haltung, hier speziell bei Nagern, das Wohlbefinden erheblich steigern kann (Würbel, 2001, Würbel et al., 1998, van Loo, 2002, Pietropaolo, 2004; alle bei Mäusen). Stereotypien können verhindert werden oder verschwinden, wenn man entsprechende Ersatzmittel anbietet (Mason, 1991). Wiedenmayer

(1997) zeigt zum Beispiel, dass bei Gerbils stereotypes Graben aufhörte, sobald man ihnen Baue und Schlafkammern anbot.

Der Schweizer Tierschutz empfiehlt in seinem Merkblatt „Hamster - Goldhamster und Zwerghamster - ein Leitfaden für die tiergerechte Haltung“ eine minimale Einstreutiefe von 30 cm, damit die Hamster ihr Grabebedürfnis ausleben können. Dies war für uns der Anlass, den Einfluss der Einstreutiefe auf das Verhalten und Wohlbefinden von Goldhamstern zu untersuchen.

Im Hauptteil dieser Dissertation stehen drei verschiedene Publikationen, wobei die erste das eigentliche Forschungsthema behandelt.

In der ersten Publikation „The influence of bedding depth on behaviour in golden hamsters (*Mesocricetus auratus*)” liegt das Schwergewicht auf der Untersuchung, welchen Einfluss verschiedene Tiefen von Einstreu aus Holzspänen auf das Verhalten bei Goldhamstern aufweist. Verglichen wurden die drei Einstreutiefen von 10 cm, 40 cm und 80 cm, die mit Hilfe von Videoaufnahmen nach ihrer Tiergerechtheit bewertet wurden. Insgesamt wurden 45 Tiere beobachtet, 15 Hamster pro Gruppe, wobei aus Platzgründen immer je fünf Tiere pro Gruppe gehalten wurden. Unter weitgehend gleichwertigen Bedingungen wurden die Versuche 3x durchgeführt. Der Lichtzyklus im Versuchsraum war auf 12 Stunden Dunkelheit und 12 Stunden Helligkeit reguliert. Für die 40 und 80 cm Gruppe wurde ein Einsatz aus Plexiglas verwendet, bestehend aus zwei Teilen, zwischen denen die Einstreu bis zum unteren Rand des Käfiggitter aufgefüllt wurde (s. Paper und Abb. 5).

Es wurde darauf geachtet, ob die Tiere in tieferer Einstreu geringere Anzeichen von Stress und weniger Verhaltungsstörungen (Stereotypien) zeigten. Ausserdem beobachteten wir, ob Goldhamster graben und sich Gänge wie in ihrer natürlichen Heimat anlegen, wenn sie die Gelegenheit dazu bekommen. Zusätzlich zu etwaigem chronischem Stress durch unzweckmässige Käfige sind Goldhamster als Heimtiere auch zeitweise akutem Stress ausgesetzt; sei es durch Kinder, die den Hamster tagsüber wecken, um mit ihm zu spielen, sei es durch Lärm (Musik), Käfigreinigung, u.s.w. Diese Faktoren imitierten wir in einer Stressbehandlung: Wecken der Hamster während des Tages, Lärm (laute Musik), in die Hand nehmen, eingeengte Platzverhältnisse und Sicht auf und Geruch von einem fremden Hamster. Um den möglichen Stress zu erhöhen, führten wir diese Störungen während zweier Tage in der Hellperiode (Ruheperiode der Hamster) durch.

Die zweite Publikation „Shifts in circadian rhythms in golden hamsters (*Mesocricetus auratus*) housed in deep bedding" befasst sich mit den gefundenen Daten des Laufradrhythmus. Normalerweise stellen sich Goldhamster unter Licht-Dunkel-Bedingungen auf einen Tagesrhythmus von ca. 24 Stunden ein. Die Hamster in den tiefen (80 cm) Käfigen und die Hälfte der Tiere in den 40 cm-Käfigen zeigten jedoch einen für diese Bedingungen ungewöhnlichen Rhythmus, indem sie täglich später aus den Behausungen kamen.

Eine allgemeine Problemstellung wird in der dritten Publikation, „How can we tell hamsters are stressed by measuring their cortisol levels?", diskutiert. Es geht darin um Schwierigkeiten, einen chronischen Stresszustand mit Hilfe von Hormonen wie Cortisol, Corticosteron und ACTH zu messen und die gefundenen Resultate zu interpretieren.

2 Zusammenfassung und Schlussfolgerung

Wie erwartet haben sämtliche Tiere der Gruppen mit tiefer Einstreu (sowohl 40 als auch 80 cm) die Möglichkeit, sich Gänge und eine Schlafkammer anzulegen, vom ersten Tag an wahrgenommen. Durch die Plexiglaswände waren die Gänge oft sehr schön zu sehen. Das Gitternagen, als typische Stereotypie bei Nagern, wurde unter diesen Haltungsbedingungen weniger (40 cm Gruppe) oder gar nicht (80 cm Gruppe) gezeigt. Daraus folgerten wir, dass tiefe Einstreu tatsächlich das Wohlbefinden von Goldhamstern verbessert. Dass Hamster, die sich Gänge anlegten, insgesamt auch weniger im Laufrad liefen, lässt ebenfalls auf eine bessere Haltung schliessen, wenn man Laufen im Rad als „potenzielles Suchtmittel“ ansieht. Das Bedürfnis, sich im Laufrad zu bewegen, scheint kleiner zu sein.

Aufgrund der im Verhaltensversuch gefundenen Daten scheint es sinnvoll, Goldhamstern unbedingt Käfige mit tiefer Einstreu anzubieten. Genaue Masszahlen anzugeben ist allerdings schwierig, da wir nur die drei verschiedenen Grössen 10 cm, 40 cm und 80 cm untersucht haben. Der Schweizer Tierschutz empfiehlt mindestens 30 cm. Wenn man Käfige zwischen einem halben und einem Meter Tiefe anbieten könnte, wäre das vermutlich insofern ideal, als die Bauten der wilden Goldhamster in etwa in diese Tiefe gebaut sind und diese Grössenordnung auch in unserem Projekt ausgenutzt wurde. Man muss sich allerdings im Klaren sein, dass unter diesen Bedingungen der Hamster eher ein Wild- als ein Haustier ist. Denn die Hamster in genügend tiefer Einstreu schienen sich länger im Bau aufzuhalten als die Hamster, die in den Häuschen wohnten, sie waren weniger oft zu sehen.

Insbesondere die Hamster in den 80 cm Behausungen waren weniger an den Menschen gewöhnt. Das kann ein Problem in der Haltung darstellen. Beim Herausnehmen der Tiere, zur Kontrolle oder Stressapplikation zum Beispiel, waren Bissverletzungen der Experimentatorin recht häufig, vor allem während des ersten Durchganges. Im Privathaushalt kann sich das Verhältnis zum Menschen jedoch anders entwickeln als im Versuchsraum, wo die Hamster kaum mit den Betreuungspersonen in Berührung kamen.

Aufgrund der Sektionsbefunde und berechneten Kondition kann davon ausgegangen werden, dass die Tiere in den 80 cm tiefen Käfigen mehr Fettanteil aufwiesen. Hält man einen Hamster während seiner gesamten Lebensdauer unter diesen Bedingungen, können die Tiere verfetten, was zu gesundheitlichen Problemen führen kann. Ein weiteres Problem der tiefen

Käfige ergibt sich aus der Beobachtung, dass diese Hamster ihren zirkadianen Rhythmus verschoben haben und täglich später herausgekommen sind. Ob dies dem Wohlbefinden des Tieres abträglich ist oder nicht, ist bisher noch ungeklärt.

In der Gruppe von 40 cm Einstreutiefe waren sowohl Käfige als auch Hamster einfacher zu handhaben. Es zeigte sich im Vergleich zu den niedrigsten Käfigen eine Verbesserung der Haltung. Das zu vermeidende Gitternagen wurde jedoch in diesen Käfigen im Versuch immer noch von einem Fünftel der Tiere gezeigt.

Obwohl Hamster eine Rückzugsmöglicheit brauchen, ist es möglich, auch in genügend hoher Einstreu (40 cm, persönliche Beobachtung) ein recht zahmes Tier zu halten. Man braucht einfach etwas mehr Geduld dazu als in einem kleineren Käfig, wo der Hamster sozusagen ständig verfügbar ist.

Will man dem Hamster tiefe Einstreu anbieten, benötigt man eines der im Handel erhältlichen Terrarien, oder man wandelt einen bestehenden Käfig selbst um, wie zum Beispiel durch einen künstlichen Einsatz, den der Hamster nicht zernagen kann, wie in diesem Projekt.

Im weiteren wäre es gut zu wissen, wie wichtig das Graben für Goldhamster ist, also ob es ein echtes Bedürfnis ist und wie viel sie dafür arbeiten würden, um eine Grabmöglichkeit zu erlangen (behavioural demand studies, Sherwin, 2004, und entsprechende Referenzen).

Zusätzlich zu den Resultaten aus den Verhaltensbeobachtungen kann eine Messung von Hormondaten als Mass für chronischen Stress angewendet hilfreich sein. Diese sollten allerdings nicht allein interpretiert, sondern im Kontext mit weiteren gefundenen Daten eines Projektes getroffen werden. In diesem Projekt war kein Einfluss der unterschiedlichen Haltungsbedingungen auf chronische Stressprozesse auszumachen.

Den Einfluss von zusätzlichen Aspekten haben wir in diesem Projekt nicht untersucht. Im Allgemeinen wird jedoch von Verhaltensforschern (z.B. Manosevitz & Pryor, 1975, Mason, 1991) empfohlen, die Umgebung für das Tier möglichst abwechslungsreich und stimulierend zu gestalten.

3 The Influence of Bedding Depth on Behaviour in Golden Hamsters (*Mesocricetus auratus*)

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The Influence of Bedding Depth on Behaviour in Golden Hamsters (*Mesocricetus auratus*)

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Abstract

Although golden hamsters are popular as pets and widely used as laboratory animals, little is known about their welfare requirements and behavioural needs. Most hamsters are provided with only little material to dig, although digging was found to be important in captive rodents. In this study, the influence of different bedding depths and an acute stressor on the behaviour and welfare of golden hamsters was analysed. Forty-five male golden hamsters were assigned to three experimental groups with 80 cm, 40 cm or 10 cm deep wood shavings and kept singly in cages with a running wheel. Light regimen was artificial with a 12 h light – 12 h dark cycle. The running wheel activity was recorded continuously, video recordings were made four times during 13 weeks to evaluate behaviour. A series of stressors (waking, handling, noise, restraint, and confrontation with an unfamiliar hamster, respectively) was applied for two consecutive days for each animal. Burrows, if constructed, were mapped when the hamsters were taken out of their cages. Hamsters in 80 cm deep bedding were never observed gnawing stereotypically at the cage bars. Frequency and duration of wire-gnawing differed significantly between the treatment groups, with significantly more wire-gnawing in hamsters kept only with 10 cm deep bedding. Hamsters in 10 cm bedding cages ran significantly more in their running wheels than hamsters in the other two groups. All hamsters in 40 cm and 80 cm bedding constructed their own burrows which they occupied, the artificial shelters provided by the experimenters were only used by these animals as an occasional cover when on the surface. If we consider stereotypic wire-gnawing to be an indication of reduced welfare, cages with at least 40 cm of bedding seem to enhance the welfare of golden hamsters. Stressor application showed no significant immediate influence on behaviour, besides slightly increased running wheel activity during and shortly after stressor application. In this study, we could show that golden hamsters, provided with the opportunity to dig, did perform this and developed significantly fewer stereotypies than hamsters under standard housing with shallow bedding. Therefore, deep bedding, which is appropriate for burrowing, can be recommended for golden hamsters.

Keywords: bedding depth, golden hamster, stereotypy, wire-gnawing, running wheel

Introduction

Golden hamsters are very popular as pets, but are also used as laboratory animals (Gattermann, 2000, Gattermann et al., 2001), although there are no reliable figures available as to the numbers of hamsters as pets. They are considered as convenient pets, probably due to the general opinion that, as small animals, they do not need much space. The aim of this study was to examine housing improvements of hamsters kept as pets in private homes, rather than laboratory hamster housing.

Wild golden hamsters live solitary in subsoil burrow systems. The smallest distance between inhabited ones was found to be 118 m (Gattermann, 2000, Gattermann et al., 2001). The sleeping chambers were situated 0.5 m on average below the surface (Gattermann et al., 2001). In comparison, most cages only allow the hamsters to dig to a depth of 10 cm at most.

In mice, digging was found to be of similar importance as food and water, and they were highly motivated to perform this behaviour (Sherwin et al., 2004). The influence of different bedding depths was not investigated. Digging into the soil is also performed by captive hamsters (Dieterlen, 1958). If nesting material and bedding are missing, hamsters become aggressive and stop eating (Lochbrunner, 1956). Kuhnen (2002) recommended sufficient bedding for laboratory hamsters to allow them digging and building a nest. The Swiss Animal Protection SAP (Schweizer Tierschutz STS) discourages owners the use of pre-fabricated artificial burrow systems (plastic tubes such as Habitrail) because of their poor ventilation and the restriction of performing natural digging behaviour (STS Leaflet). They recommend a minimum bedding depth of 30 cm. Therefore, we wanted to test the influence of bedding depth on the behaviour and welfare of golden hamsters.

In general, pet hamster cages are often only slightly bigger than laboratory cages (about 2500 cm^2 instead of 1800 cm^2, personal observation), provided with a thin layer of bedding (about 5 cm). Additionally, a shelter and a running wheel are usually provided. Although cage size is considered to be an important welfare factor for animals (e.g. Sherwin & Nicol, 1997), an enclosure should also be adequately structured to stimulate the performance of natural behaviours (Mason, 1991) and enable varying interactions with the environment (Manosevitz & Pryor, 1975). Several studies have shown that environmental enrichment improves well-being in small rodents (e.g. Würbel, 2001, Würbel et al., 1998, van Loo et al., 2002, Pietropaolo et al., 2004; in mice).

Because stereotypies and compromised welfare are not always correlated (Mason & Latham 2004), they cannot be taken as the only evidence of suffering, rather as indicators of sub-optimal housing conditions. Stereotypies might be an expression of frustration and poor welfare in captive animals (Mason, 1991, Garner et al., 2003), fear, restraint and lack of stimulation. There might be a coping response which can help animals to deal with the sub-optimal circumstances (Mason, 1991). Stereotypies which developed because of frustration can be reduced by providing substitutes (Mason, 1991). For instance, stereotypic digging in gerbils can be prevented by the substitution of artificial burrows and sleeping chambers (Wiedenmayer, 1997).

Stereotypies - behaviours without an obvious goal or function - do not occur in free-living healthy animals and are usually taken as a sign of poor welfare (Mason, 1991 and references therein). Clubb & Mason (2003) reported that it is often the species with the largest natural home-range that are most susceptible to performing stereotypies as an expression of reduced well-being in captivity. However, Galef (1999) considers that not all natural behaviours are desired in laboratories and homes, as aggressive animals for example cannot be easily housed or handled.

Assessing animal welfare can be difficult. Anthropomorphic interpretations should be avoided (Wynne, 2004), therefore objective measurements are needed (Mason & Mendl, 1993, Galef, 1999). In particular, wire-gnawing as a common stereotypy in small rodents is often used to assess housing conditions for these species (Würbel & Stauffacher, 1997, Würbel et al., 1996, 1998, Nevison et al., 1999; all in mice, Waiblinger & König, 1999; in gerbils). It will also be used in this study to assess well-being in hamsters.

Besides the influence of bedding depth, we intended to study the influence of acute stressor arousal on the behaviour. Hamsters kept as pet animals are often disturbed during their resting time by children, noise, movements of the cage, cage-cleaning etc. Stress stimuli were chosen to mimic everyday household stressors: a) arousal when sleeping, b) noise (loud music), c) handling, d) restraint, and e) sight and odour of an unfamiliar conspecific. To increase the impact of these stressors, they were applied during the light phase (Gattermann & Weinandy, 1996/97), i.e. the usual sleeping time of golden hamsters.

In general, we wanted to test if golden hamsters dig if provided with deep bedding and if this influences their general behaviour positively, suggesting that golden hamsters should be provided with deep bedding in their cages.

Three bedding depth in comparison (from left: 10 cm, 80 cm, 40 cm)

Methods

Animals and cage design

Forty-five male golden hamsters (progeny of Crl: LVG (SYR) from Charles River, Germany), weaned between day 25 and 31, were half-randomly assigned to three experimental groups: deep bedding (b_{deep} = 80 cm), medium bedding (b_{medium} = 40 cm) and low bedding (b_{low} = 10 cm), matched for litter and body weight. The hamsters were kept singly in wire cages with plastic bottoms (95 cm x 45 cm x 57 cm including the wire top).

Bedding consisting of wood shavings (Allspan®) mixed with straw and hay was provided. The cages were distributed evenly across the room. Four cages were situated on a table, the fifth on the ground. The cages with the deeper bedding (40cm, 80 cm) were equipped with an insert of Perspex to obtain the different depths. This insert consisted of an outer element onto which the cage lid was adjusted and a smaller inner element, which was closed on the top (**Fig. 1**).

Figure 1: Experimental cage with an insert of Perspex in order to provide deep beddings (40 and 80 cm): insert containing an outer and a smaller inner element with a space of 10 cm between them. The space between the two elements was filled up to the cage lid with wood shavings.

A space of 10 cm on all four sides between the outer and closed inner element was thus available for the hamsters to dig. The depth of the bedding on the top of the inner element was 5 cm. The outer element was covered with black paper to provide darkness in case the hamsters would build burrows, but to still allow for mapping of the burrow structures when removed. A bottomless shelter (20 x 14 x 14 cm), which was made of ply wood and had an entrance of 5 cm in diameter on one side, was provided at the bedding surface. Additionally, a cardboard tube, a hazel branch, a sand bath, paper towels as nesting material, a feeding bowl, a water bottle and a running wheel (Ø 30 cm, width 10 cm) were provided. The running surface of the wheels was made of a perforated metal plate with holes of 5 mm in diameter to prevent leg injuries during running.

The light regimen was artificial with a 12 h light – 12 h dark cycle. Dusk began at 1 p.m. (CEST), then the light decreased from 280 Lux within half an hour to 5 Lux max.

The room temperature was between 21 and 23 °C, except in the last few days of series 1 when the temperature went up to 26 °C. Relative humidity varied from 30 to 55 %; the lowest values were found at temperatures ~21 °C.

Twice a week the hamsters were provided with grain feed (Witte Molen); fresh fruit or vegetables (mainly apples, carrots etc.) were provided daily. Cat food as a protein source and mineral supplementation (Marienfelde Vitakalk®) was administered once a week. Water was offered ad lib. in bottles.

Cages were cleaned each month by replacing exclusively the soiled bedding around the hamsters' nesting chambers and shelters. Due to lack of space, three series were conducted on 15 animals each, 5 subjects per bedding group. Each series lasted from week 0 (weaning) until week 13 (euthanasia). After each series the cages were emptied, cleaned and re-equipped, then their positions swapped to prevent cage x location effects.

Measurements

After weaning, at the age of 25-31 days, the hamsters were weighed and placed singly into their experimental cages. Additional weighings took place after four weeks, during stressor application (week 7 or 8, depending on the stressor group) and before euthanasia (week 13).

Running wheel activity was recorded continuously by The Chronobiology Kit (Standford Systems). Transmission was controlled regularly. Data were analysed from day 27 onwards, since in the first series the recording device did not work properly before that day. For running wheel data, the periods before and after stressor application were analysed separately (before = day 27 until day before stressor application; after = day after stressor application until the end of the project). The days around stressor application were also analysed (the 2 days of stressor application compared with the 2 days before and the 2 days after stressor application).

Behaviour was recorded by video four times: in week 3, one week before stressor application (week 6 or 7), on the second day of stressor application (week 7 or 8) and in week 12 (**Fig. 2**).

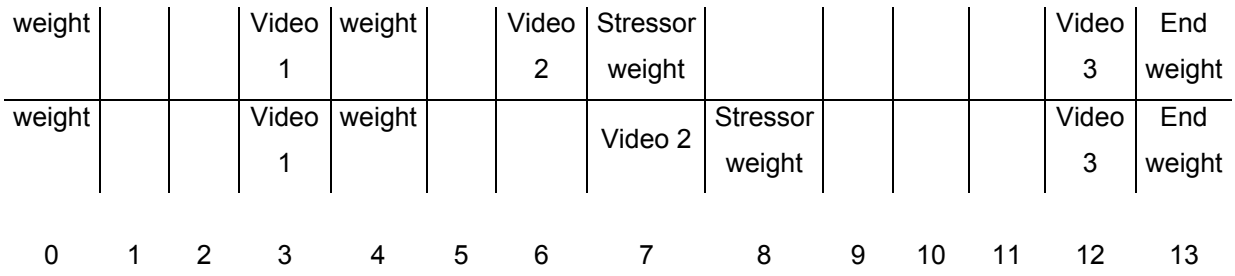

Figure 2: Date of stress and videos. The hamsters were assigned to two stressor groups, the first group was applied with stressor in week 7, the second in week 8. The time schedule of the first group is written above the line, the one of the second group beneath it. The numbers on the lowest line give the weeks of the project: week 0 = week 4 of age.

The hamsters were videotaped in the dark using infrared sensitive cameras (Ikegami ICD-47E) and recorded on video (Panasonic Model AG-6730). The animals were taped twice for each recording day, each recording lasting 3 h: the first recording starting half an hour after dusk, during the hamsters' main activity time (Gattermann 1980, 1984), the second recording starting 3 h after the end of the first one, because some hamsters were not visible any earlier.

From the total time when the hamsters were visible, 10 x 3-minute sections were extracted for analyses to gain an overview of their behaviour. For hamsters that were visible less than half an hour analyses were nevertheless made for 30 minutes, but their behaviour was labelled "depth/invisible" rsp. "shelter/invisible" (in low cages) when they could not be seen. The behaviour of hamsters that showed up in both recordings was analysed for 5 x 3-minute-sections of each of the two recordings. Behavioural analyses were made using the Observer® Version 5.1 (Noldus Information Technology, Wageningen, The Netherlands). The total duration of the behaviours and the rate in % of total duration in each video was analysed. Since some hamsters did not show up in some video recordings at all, the number of analysed recordings was smaller for certain videos than the total number. Behaviours and their description are shown in **Table 1a + b**.

Table 1a: The catalogue of behaviour that was used for analyses in the Observer® was separated for "location" and "behaviours". Certain behavioural patterns were merged into one (e.g. hoarding and eating as occupation with food, body rearing and sniffing as head rearing). Classification was made according to Dieterlen (1959) and Richards (1966).

Term	**Description**
moving	horizontal locomotion: moving, walking, running, creeping
resting	standing still, freezing movement (> 1 sec), sitting, lying, break during wheel-running; without head rearing
head rearing	head raised, looking around, sniffing, also erected on hind legs
wheel-running	movements in the running wheel
climbing	vertical locomotion: clinging to or climbing on the grid, hind legs lifted off the floor, on top of or behind the running wheel
grooming/scratching	scratching and grooming movements
stretching	back stretched, forelegs forward, hind legs backward, with or without yawning (common stretching of hind or forelegs or alternating right or left hind or foreleg individually)
gnawing	gnawing at wood, carton, bedding/nesting material
wire-gnawing	gnawing at wire bars or drinking bottle without drinking (min.3 sec)
occupation with food	Eating, sniffing and gnawing at food, filling cheek pouches, treating food with paws
drinking	drinking from the water bottle without stereotypic gnawing
digging	scraping with forepaws, ejecting material with hind legs; pushing bedding material aside
not visible	action cannot be recognized, hamster is in the shelter, carton tube or burrow

Table 1b: Catalogue of locations

Term	Description
shelter/carton tube	at least one pair of limbs in the shelter / in the carton tube
running wheel	in the running wheel
cage lid	Clinging to, climbing at the wire, forelegs on the wire with or without hind legs on the floor, on top of or behind the running wheel
sand bath	at least one pair of limbs in the sand bath or on its rim
feeding bowl	at least one pair of limbs in or on the feeding bowl
anywhere (else)	somewhere in the rest of the cage, also peering out of the burrow entrance
depth	hidden in the bedding / burrow
on top of the shelter	at least hind legs on top of the shelter

Maps of burrow entrances and burrow tunnels were drawn when the hamsters were taken out of their cages in order to be controlled, weighed or stressed.

In week 13, all hamsters were anaesthetised by inhalated isoflurane (5%) before decapitation and the body length was measured. Hamsters were between 113 to 119 days of age at euthanasia. Blood samples (roughly 5 ml each) were collected at the time of decapitation for analysis of the blood levels of corticosterone, cortisol, ACTH and testosterone. Samples were centrifuged immediately after collection and stored at –80 °C until being sent to Alomed Laboratory for analyses (corticosterone: commercial RIA for rats (Fa. DPC); cortisol: in-house RIA (3H) from the Endocrinological Institute Tierärztliche Hochschule Hannover; ACTH: chemoluminescence-immunometric assay for ACTH in human plasma from Nichols Institute Diagnostics; testosterone: luminescence-immunologic assay (LIA) for human testosterone from Bayer Diagnostics).

Several organs were isolated and weighed: heart, liver, spleen, kidneys, adrenal glands, testes and epididymal glands. Stomachs were checked for ulcers. The body condition was calculated as final body weight / (body length)^3 .

Stressor application

Stressor application was conducted on two consecutive days on each hamster using different, assumedly stressful stimuli with the aim to investigate immediate effects on running wheel activity and behaviour. Hamsters were divided into two stressor groups, the stressor application for the first group took place in week 7, for the second group in week 8. Two neighbouring hamsters were applied with stressors simultaneously (**Fig. 2**).

Stressor on day 1: the hamster was aroused from sleep four hours before lights-off but left in the cage. Forty-five minutes later the hamster was disturbed again and set into an opaque plastic bucket. At intervals of 15 minutes the hamster was handled three times, additionally, the other hamster allocated to application of stressors on the same day was presented to the hamster in the bucket during one of these handlings (held in the handler's hand and moved towards the other hamster for one minute to provoke a reaction). The third time, the hamster was weighed and returned to the home cage.

Stressors on day 2: the hamster was aroused from sleep four hours before lights-off, then the cage was pushed across the room for 2 minutes. After the cage was put back in its place, the experimenter knocked ten times against the Perspex (low cages: plastic) walls of the cage. Half an hour later the hamster was disturbed again. A radio was placed into the inner empty part of the Perspex equipment in the 40 and 80 cm cages, loud radio music was switched on for 5 minutes and the top was closed. After removal of the radio, the handler again knocked 10 times against the cage walls. A handful of bedding of a hamster which did not belong to the experiment was scattered around the feeding bowl. It was removed again the next day. The stressor treatment for hamsters in low cages was similar, but instead of pulling the cage across the room and radio exposition in the cage, hamsters were put into a box, carried around, weighed, exposed to 5 minutes of radio transmission and then put back.

Hydrocephalus

In some of the hamsters, hydrocephalus internus was detected (Gebhardt-Henrich, 2004, Edwards et al., in preparation). The hamsters of series 2 and 3 were examined for hydrocephalus post-mortem and its occurrence was initially included as a factor in all analyses. Since the occurrence of hydrocephalus did not significantly influence wheel-running activity and behaviour, it was excluded in the final analyses. In series 2, one animal had to be euthanized due to health problems. Subsequently, all data of this hamster were excluded from the analyses.

All statistical analyses were carried out using NCSS® . Data and residuals were checked for normality of distribution. If necessary, logarithmic transformations or non-parametric tests were used. All comparisons were post-hoc (Tukey-Kramer Test) and the post-hoc critical value is provided.

Results

Behaviour

Wire-gnawing (**Fig. 3**), including gnawing at the water bottle, which was only observed once, was never observed in hamsters of group b_{deep}. There was a significant difference in the frequency and total duration of wire-gnawing in relation to bedding depth. The proportion of animals performing wire-gnawing increased with decreasing bedding depth (**Tab. 2**). In group b_{medium} the maximum rate of wire-gnawing was observed after stressor application. The hamsters in group b_{low} exhibited their maximum stereotypic wire-gnawing in video 2, before it decreased with age.

Figure 3: Wire-gnawing

Table 2: Frequency and duration of wire-gnawing. Frequency: Fisher's Exact Test: n=44, P=0.0059. Difference in total duration: Kruskal Wallis: χ^2=9.598483, DF=2, P=0.0082.

Bedding depth	Wire-gnawing	No wire-gnawing	Total duration (s)	Number of animals
Deep	0	15	0	15
Medium	3	11	327.32	14
Low	7	8	1773.48	15
Total number	10	34	2100.8	44

Gnawing at objects other than the cage lid was rarely observed, and there was no difference in bedding depths. Wire-gnawing and gnawing at other objects were not correlated.

Daily wheel rotations were performed significantly more in the hamsters in b_{low} than the hamsters in the other two groups, both in the periods before and after stressor application (**Fig. 4a**). Although the animals in b_{deep} ran the least, this group did not differ significantly from b_{medium}. This was also true for the days around stress (**Fig. 4b**). The hamsters in group b_{deep} used their running wheels more excessively after stressor application than before (paired t-test: T = -3.028, P = 0.005). When the days around the stressor application were compared individually, significantly fewer rotations were recorded on the day before stressor application compared to stressor application on day 1 in group b_{deep} (Wilcoxon signed rank test: Z = -2.257, P = 0.012).

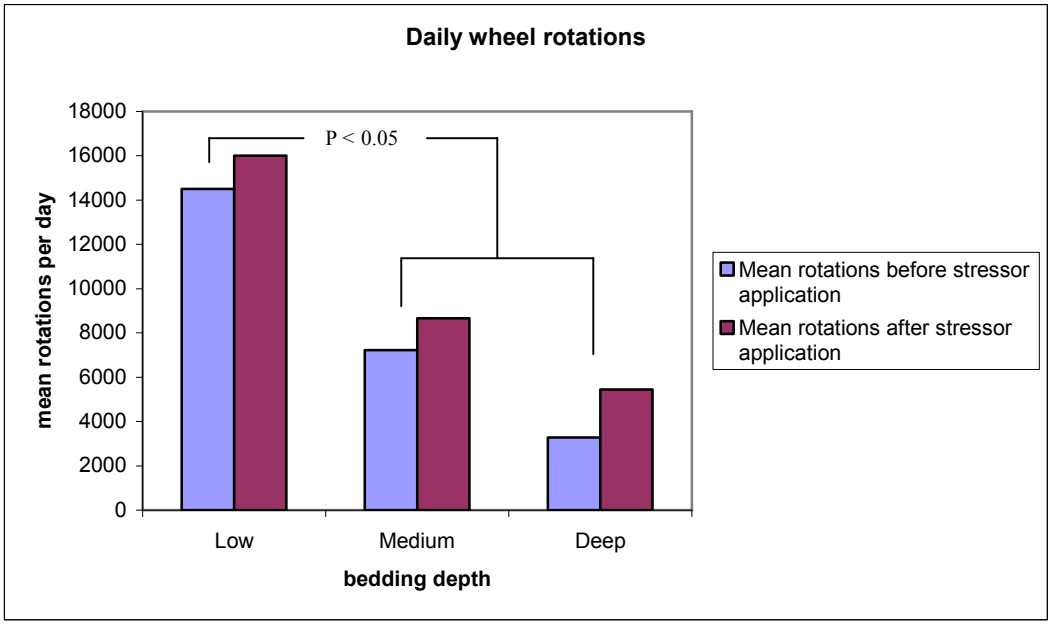

Figure 4a: The hamsters in the 10 cm bedding cages used their running wheels much more than the hamsters from b_{deep} and b_{medium}. Before stressor application: Analysis of variance: F= 16.95, P<0.005; after stressor application: Analysis of Variance: F= 17.12, P<0.005, post hoc critical value = 4.723. The hamsters in the treatment group b_{deep} used their running wheels more intensely after stressor application than before (paired t-test: T=-3.028, P<0.005).

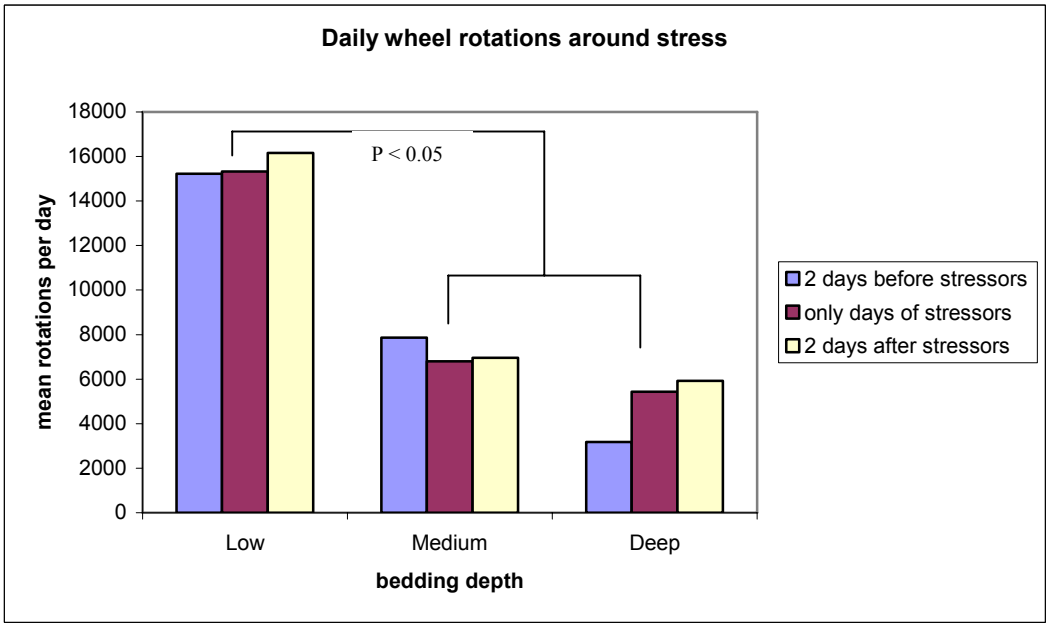

Figure 4b: The hamsters in b_{low} ran significantly more in the wheels compared with the individuals of the other two groups (post hoc critical value = 4.361) on the two days before stress application (Analysis of Variance: F=14.77, P<0.001), on the two days when stressors were applied (Analysis of Variance: F=11.82, P<0.001) as well as on the two days after stressor application (Analysis of Variance: F=12.46, P<0.001).

The running wheel activity increased steadily in all treatment groups up to a maximum around day 37 after the onset of running wheel data registration (age of hamsters at this point was about 90 days) (**Fig. 5**). When the first hamsters were applied with stressors, the slope became distinctively steeper in all bedding groups. The stressor application of the last hamsters was on day 31.

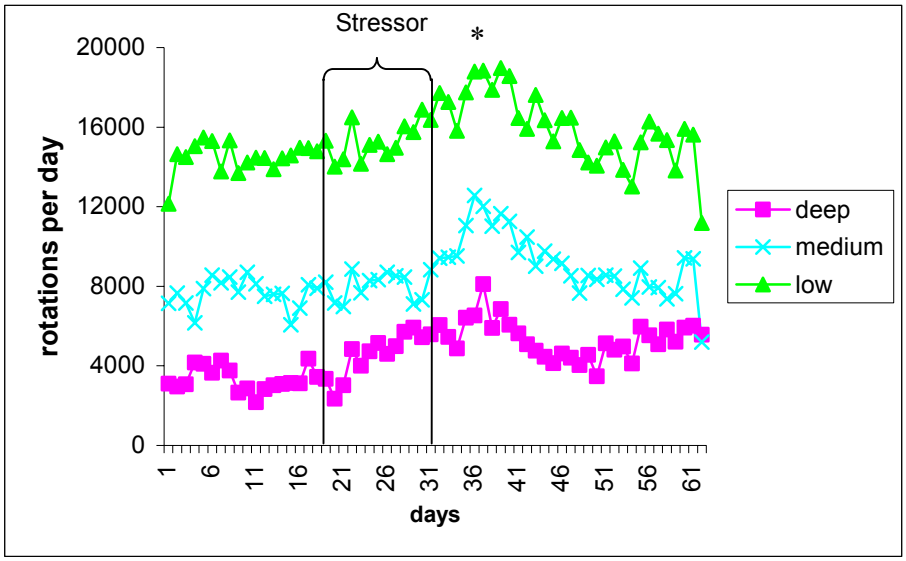

Figure 5: Daily running wheel activity. Day 1 = first day of data analysis, i.e. day 27 after start of the experiment. Stressors were applied during the period between the two vertical lines, beginning on day 19 after start of analysis until day 31. The maximum was reached approximately on day 37 (*).

Wheel-running was negatively correlated with time spent in the depth (Spearman rank: r = -0.628, P <0.005), at the feeding bowl (r = -0.335, P = 0.028), anywhere in the cage (r = -0.5, P = 0.001), head rearing (r = -0.543, P <0.005) and occupation with food (r = -0.408, P = 0.007). The wheel parameters in the video observations (wheel-running and time spent in the running wheel) correlated significantly with the simultaneously electronically recorded data collected by the Chronobiology Kit (**Tab. 3**).

Table 3: Correlation between wheel-running in video observations and electronically recorded data (Spearman correlations). Upper value: regression coefficient (r); lower value: probability level (P).

Observational data	**Electronic data**	
	Daily rotations before stress	Daily rotations after stress
Running wheel (Location)	0.613 0.00001	0.533 0.0002
Wheel-running (Behaviour)	0.665 0.000001	0.582 0.00004

The average running distance was 4.11 km/day in group b_{deep}, 7.06 km/day in group b_{medium} and 13.72 km/day in group b_{low}. The overall average was 8.3 km/day.

Only some hamsters climbed, and their number decreased with increasing age. The hamsters in group b_{deep} climbed the least in all videos. Climbing was weakly correlated with wire-gnawing ($r = 0.298$, $P = 0.05$). The hamsters in deep bedding cages spent less time clinging to the cage lid than the hamsters in the other groups (**Tab. 4**).

The resting phases (resting, invisible) increased over time and declined after stressor application, both in group b_{deep} and group b_{medium}. In group b_{low}, changes in the resting phases were not observed.

Table 4: Total duration in all videos analysed by Kruskal Wallis Tests: SE – standard error of the mean, NS = P > 0.05, N = 44: P = probability level; χ^2 and P values are mentioned only if significant.

	DEEP (80 cm)		**MEDIUM (40 cm)**		**LOW (10 cm)**		**X^2**	**P<0.05**
	mean	**SE**	**mean**	**SE**	**mean**	**SE**		
shelter / carton tube	296.28	133.80	259.42	93.87	338.26	117.62	-	-
running wheel	2093.77	418.51	2829.80	314.79	3222.59	235.12	-	-
cage lid	47.94	29.30	202.30	84.75	258.96	104.35	10.842	0.004
sandbath	104.42	31.65	112.28	29.64	148.69	46.33	-	-
feeding bowl	716.23	137.37	441.74	55.08	406.85	39.87	-	-
anywhere (else)	1201.08	235.74	840.36	173.79	823.89	90.35	-	-
depth	730.23	202.45	368.8	182.513	5.03	3.82	12.574	0.002
shelter (on top)	3.61	3.61	36.43	27.80	1.28	1.28	5.834	0.054
moving	164.81	21.81	188.24	19.39	180.60	19.53	-	-
resting	385.29	101.10	423.90	57.38	361.43	29.15	-	-
head rearing	876.03	164.12	598.33	93.01	543.39	85.53	-	-
wheel-running	1682.09	358.20	2248.43	259.75	2705.22	218.24	3.28	0.048
climbing	25.17	17.86	64.58	29.79	89.74	31.91	-	-
grooming	559.78	95.69	625.36	106.42	674.09	96.03	-	-
stretching	0	0	1.01	0.46	2.55	1.10	8.112	0.017
gnawing	8.36	5.58	4.29	2.50	1.33	0.60	-	-
stereotypical (wire) gnawing	0	0	5.71	3.91	99.94	74.46	9.599	0.008
occupation with food	540.95	107.84	389.29	44.43	366.500	40.01	-	-
drinking	13.27	10.40	5.86	5.34	0.33	0.33	-	-
digging	1.90	1.14	0.86	0.86	1.67	1.14	-	-
not visible	933.74	202.23	530.99	170.79	161.61	52.97	7.593	0.022

Burrows

All hamsters in groups b_{medium} and b_{deep} constructed their own burrows which they occupied (**Fig. 6**). Comparable to the natural burrows in Syria (Gattermann et al., 2001), the ones our hamsters constructed consisted of at least one vertical entrance tube of about 10 – 20 cm length, from which one or two tunnels branched off. When the hamsters were inside their burrows, the entrance tube was closed by a plug of bedding. In cages with 40 cm deep bedding, all sleeping chambers were situated right at the bottom of the cage. Sleeping chambers in the deepest cages were built in a depth of about 50 cm, similar to average natural conditions (Gattermann et al., 2001) or also at the bottom of the cage. At least some tunnels reached the bottom in every cage. A separated urination chamber for deposition of urine and faeces was not detectable. In most cases, burrow and entrance layout remained rather constant over the weeks. The entrances were often inside the wooden shelter.

The hamsters in group b_{deep} spent significantly more time in the bedding than the hamsters in group b_{low} (**Table 4**; $P < 0.05$, post hoc critical value = 3.439).

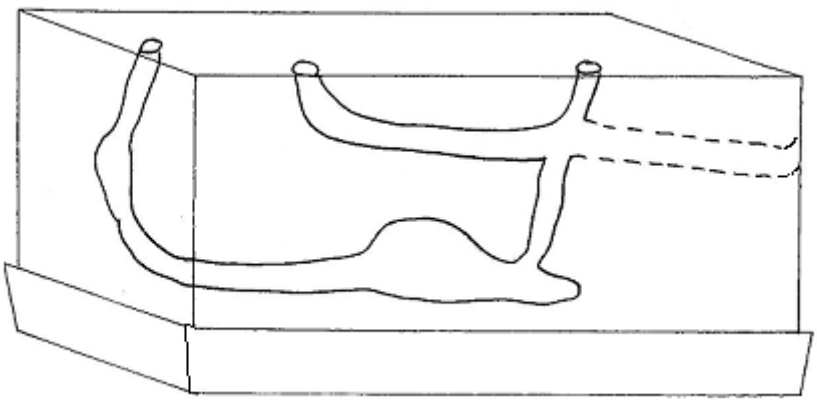

Figure 6: Typical burrow as it was found in this experiment, this example coming from a hamster in medium bedding (40 cm).

Body weight, organs and hormones

The final body weight of the hamsters in group b_{deep} was significantly higher compared with the hamsters in group b_{low} (Kruskal Wallis: $x^2 = 6.513$, $P = 0.039$, post hoc critical value = 3.439). Body weight after weaning differed significantly between the series (Kruskal Wallis: $x^2 = 16.172$, $P = 0.0003$), probably due to differing litter sizes among the series. Litter size was correlated with weight after weaning ($r = 0.571$, $P = 0.0001$). A negative correlation was found between final body weight and daily wheel rotations ($r = -0.54$, $P = 0.0002$; wheel rotations after stressor application); i.e. animals that used the wheel less often were heavier.

The relative heart weights were bigger in the hamsters in b_{low} (Kruskal Wallis: $x^2 = 8.287$, $P = 0.016$). The relative heart weight of one hamster of group b_{medium} was excluded since it was two times bigger than the average. The relative liver weights were lower in b_{deep} compared with the other groups, the relative kidney weights were higher in low bedding cages and the relative testicular weights were significantly different in all three treatment groups with deep < low < medium. There was no significant correlation between the relative testes weights and testosterone levels.

Positive correlations were found between daily wheel rotations and the relative weights of heart ($r = 0.591$, $P < 0.001$), spleen ($r = 0.311$, $P = 0.042$), kidney ($r = 0.452$, $P = 0.002$), adrenal glands ($r = 0.37$, $P = 0.015$) and testes ($r = 0.453$, $P = 0.002$; all values compared with running wheel activity after stressor application).

No significant differences could be found between the different bedding groups for the spleen, adrenal and epididymal glands, plasma cortisol, corticosterone, ACTH and testosterone levels.

The body condition, as a measurement for body weight in relation to body size, was found to be significantly higher in the animals kept in deep (80 cm) compared with those housed in low (10 cm) bedding cages (**Fig. 7**). Some hamsters of group b_{deep} had more body fat compared with hamsters of the other two groups (personal observation during dissections). There was a negative correlation of body condition with daily wheel rotations ($r = -0.458$, $P = 0.002$; wheel rotations after stressor application).

No stomach ulcers were detected.

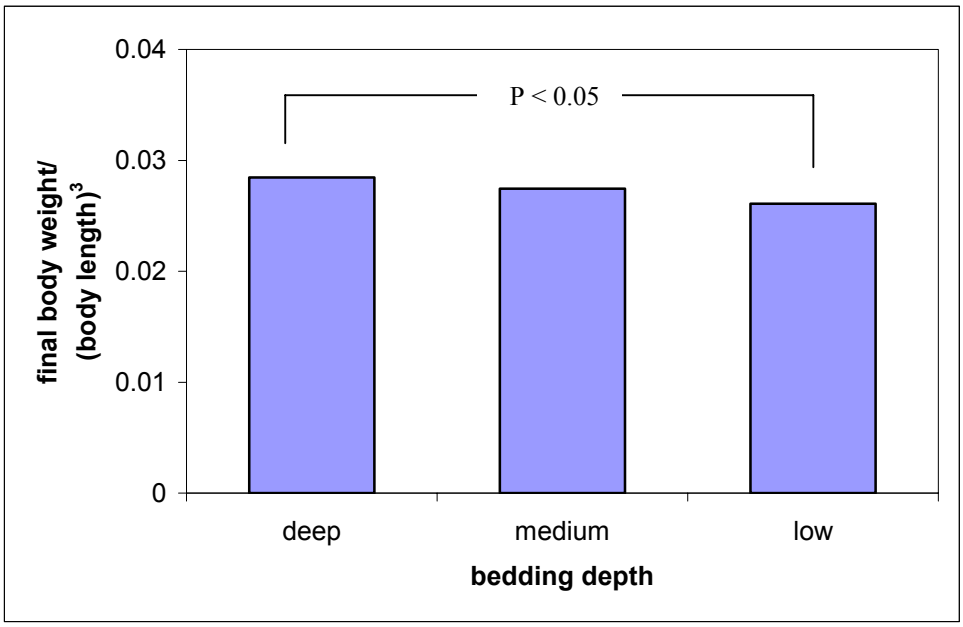

Figure 7: The body condition was significantly higher in the animals in cages with 80 cm bedding depth compared with the animals in 10 cm bedding depth (Analysis of Variance: F=3.25, P=0.049, post hoc critical value=3.439).

Discussion

Behaviour

In cages with low bedding, 7 out of 15 hamsters, n about 50% of the subjects, were observed gnawing stereotypically at the cage bars. Wire-gnawing was directed almost exclusively at the corners of the cage. As described in mice by Waiblinger & König (1999) a preferred location could generally not be detected and some hamsters changed corners for wire-gnawing during the same recording. The hamsters that were provided with at least 40 cm of bedding material suitable for constructing burrows showed significantly less wire-gnawing than the hamsters with only 10 cm of bedding. Wire-gnawing was not observed at all in group b_{deep} and only in three animals in b_{medium}. One hamster of the latter group began to gnaw on the bars after unsuccessfully trying to run in the wheel when it was inadvertently jammed after stressor application. Thus, in this case, the increase in wire-gnawing in the video after stressor application might be due to the blocked wheel. In general, in case wire-gnawing is considered to be an indication of reduced welfare, cages with at least 40 cm of bedding seem to improve the welfare in hamsters.

The hamsters often reared and looked outside the wire lid. Some put their noses through the bars, sniffing, without biting into the bars. Wire-gnawing seems to derive from this explorative behaviour (Würbel et al., 1996; in mice).

Stereotypical wire-gnawing has been interpreted as escape behaviour (e.g. Würbel & Stauffacher, 1997). In our facility, a few hamsters succeeded to reach the plastic part of the cage while gnawing and managed to chew through it. In these cases, wire-gnawing achieved its (supposed) purpose.

Gnawing performed on wood, food, cardboard etc. seemed to differ from wire-gnawing in its underlying motivation, since it did not correlate with wire-gnawing at all. It is not clear why gnawing decreased in group b_{deep} and b_{medium}. Gnawing was possibly related to exploratory behaviour (Nevison, 1999, Würbel et al., 1996) which decreased over time.

Running wheel activities by video observations and by electronic data recording correlated well. Hence our video observations were a valid method to record behaviour of the hamsters. Although running wheel activity does not necessarily represent general activity (de Visser, 2005), it served as an indicator for the time during which the hamsters were visible. In group

b_{low}, running wheels were used significantly more than in the cages in which the hamsters were able to dig deeper. The time spent in the depth was negatively correlated with wheel-running. Digging and constructing burrows might leave less time to perform wheel-running activity. Mean daily running distances, if averaged over all bedding depths, were similar to those reported in the literature (Sherwin 1998).

The running wheel activity increased steadily in all bedding groups from the onset of stressor application (at weeks 6 and 7 of experiment) until day 37 after the onset of electronic wheel data registration. Thus, stress might have had a stimulating influence on the wheel-running activity of all hamsters, yet changes might have been too gradual to be detected statistically, except for the hamsters in group b_{deep}. More precise conclusions could only be drawn in comparison to a control group without stressor application. In particular if wheel-running is interpreted as an escape or migratory behaviour (Mather, 1981), the hamsters might have been more motivated to escape after stressor application, as their cages were considered to be less safe.

The hamsters in b_{deep} might have perceived the stressors as more severe than the hamsters in the other two groups. The latter might have been more used to disturbances, since they lived nearer to the surface and outside stimulation, and thus have been more accustomed to everyday stressors. As an alternative, running wheel activity might have increased with time because the hamsters got accustomed to the cage and thus spent less time exploring. In the deep bedding group the hamsters might have taken longer to explore, because the cage was bigger and gave more stimulation and therefore running wheel activity increased as a substitution for exploratory behaviour (Mather, 1981) later on in this group, when stressors were applied. The change after stress was seen most pronounced in the actogram of one hamster from group b_{deep} (**Fig. 8**), where no regular running wheel rhythm was discernable before stress.

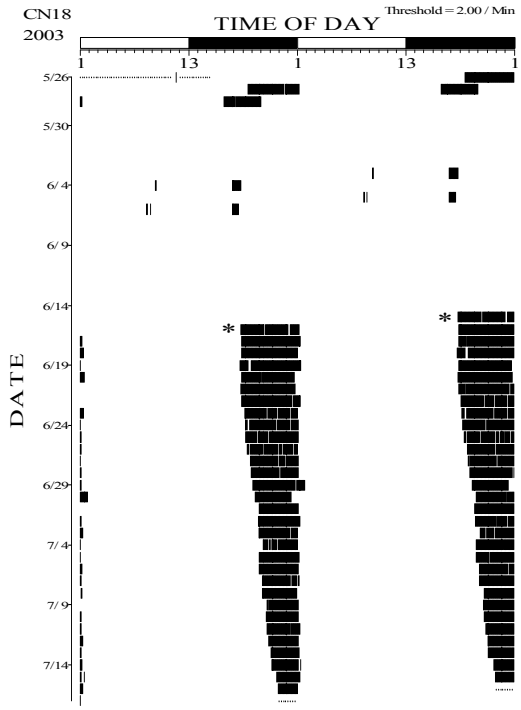

Figure 8: In the actogram of animal nr 524 running activity became regular after stressor application, denoted by an asterisk (*). Function of the wheel was confirmed.
Each horizontal line in this plot corresponds to a day. A double plot (data of two succeeding days given in one horizontal line) was chosen for a better outline of the rhythm course. Light and dark phases are given by light and dark bars on top of the actogram.

The increase in wheel-running activity is in contrast to Gebhardt-Henrich et al. (2005), who described a decrease in activity with increasing age. But in this project, the hamsters were observed during a period of time, when they were still rather active, whereas in their study, the hamsters lived longer.

Climbing and rearing seem to be behavioural elements of exploration (Würbel & Stauffacher, 1997, Würbel et al., 1996). Climbing decreased with age, probably due to less exploratory behaviour or because the hamsters became less active.

The hamsters in b_{deep} seemed to spend more time occupied with food in percentage of the observed time. For all hamsters, time spent at the feeding bowl and in occupation with food was negatively correlated with duration of wheel-running. The hamsters always hoarded food from the bowl immediately before disappearing into their burrows or shelters. In group b_{deep}, the hamsters spent very little time outside their burrows. Some of them only came up to

collect food for hoarding. The animals in the other groups had longer activity bouts on the surface and the percentage of food hoarding was therefore smaller.

The duration of resting and not being visible decreased after stressor application, both in group b_{deep} and in group $b_{medium.}$ This indicates the arousing potential of stressors which increase sympathetic metabolism, causing hamsters to be more active. The hamsters in group b_{low} were always more active outside their nests. However, we do not know whether this is due to a generally higher stress level of these animals. At any rate, the size of adrenal glands of b_{low} animals did not differ from adrenal size in animals of the other two groups.

Burrowing

In this study, we were able to demonstrate that golden hamsters which have the opportunity to dig will perform this behaviour and construct burrows similar to those found in Syria, their natural habitat. All hamsters provided with 80 cm or 40 cm deep bedding constructed their own burrows. They did this despite the fact that the lack of predators and need for climate buffering might not be present in our laboratory. The wooden shelter was only used as an occasional cover for the entrance, probably because after placing the hamsters into their cages they hid in the shelters and began to dig their burrows from there.

It was not easy to exactly follow the tunnels and thus we did not collect any more detailed data on burrow construction and development over time.

Body weight, organs and hormones

No significant differences were found in relative or absolute adrenal weights between the bedding groups. Even low bedding cages were probably big enough and sufficiently enriched that hamsters were not stressed, or else all bedding depths were perceived as similarly stressful. Methodological problems might have covered significant treatment effects on plasma levels of cortisol, corticosterone, ACTH, and the ratio of cortisol/corticosterone (Gebhardt-Henrich et al., in prep.).

Higher relative testes weights in b_{medium} might indicate higher fertility, although there was neither a significant difference in testosterone levels nor a significant correlation between testosterone levels and testes weights.

The hamsters with a low running wheel activity were heavier. It was the animals in b_{deep} that were heaviest and ran the least. Interpreted along with body condition values as well as observations during sections, it seemed that they had more body fat compared with the hamsters that lived in lower bedding and that exhibited a higher running wheel activity. This was possibly due to less wheel-running, or less movement in general. Rats that were housed in spacious cages weighed less compared to conspecifics housed in smaller cages, because of a higher state of activity (Spangenberg et al., 2005). Gattermann (2004) found that golden hamsters were heavier if they had access to a running wheel, body composition did not change, though.

In the hamsters with high wheel-running activity, the organs except for liver and epididymal glands were heavier compared with the organs of the individuals that did not use their wheels as much. These results confirm previous observations (Gattermann, 2004).

Practical implications

A general recommendation for bedding depth in golden hamsters cannot easily be given. Medium cages were much easier to clean and the hamsters in those cages were easier to handle than in cages with a bedding depth of 80 cm. It is possible to keep tame hamsters in a cage with 40 cm deep bedding (personal observation). Yet, wire-gnawing still occurred in cages of this size. In our study, there was space to dig available only in a width of 10 cm between the inner and outer Perspex walls. The results might differ for cages without an inner element, but then burrow structures cannot be observed.

On the other hand, hamsters that live in burrows might become more stressed by handling, i.e. catching, and they might perhaps be more intimidated by the outside environment due to their more secluded and protected way of living. Further, they run the risk of becoming too fat. Additionally, several hamsters in the groups b_{deep} and b_{medium} showed phase shifts in daily wheel-running activity. The importance of this result for the welfare of the affected hamsters is unknown. Details will be discussed elsewhere (Hauzenberger et al., in preparation).

Other enrichment items were not examined in this study, but might be important as well to allow hamsters to perform as many behaviours of their natural behavioural repertoire as possible.

Conclusions

Although the provision of deep bedding cannot be the final answer for optimal husbandry of pet golden hamsters, animals provided with enough bedding material in order to construct burrows developed significantly fewer stereotypies, if at all, than commonly held ones. Therefore, deep bedding can be recommended for pet owners (**Fig. 9**).

Figure 9: Cage with 40 cm deep bedding in a household

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4 Phase delays in circadian rhythms in golden hamsters *(M. auratus)* housed in deep bedding

This manuscript will be modified and submitted to a chronobiological journal

Phase delays in circadian rhythms in golden hamsters *(Mesocricetus auratus)* housed in deep bedding

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Abstract

The influence of three different bedding depths (10 cm, 40 cm, 80 cm) on the circadian rhythm of golden hamsters was studied. Forty-five animals (15 per group) were kept singly. To obtain the depths of 40 and 80 cm of bedding, the cages for the two deeper beddings were equipped with an insert of Perspex onto which the cage lid was adjusted. The light-dark cycle was 12:12 h. Wheel-running activity was continuously recorded. After a familiarization of four weeks, the running wheel data of the hamsters held in low bedding (10 cm) showed a constant circadian pattern. The hamsters in the two deeper beddings showed significant phase delays, whereas few individuals of the medium sized group ran in constant patterns similar to those in the low bedding cages. Mean phase delays were significantly different for the three different bedding depths. They might have occurred because the difference in light intensity between light and dark conditions was not big enough for hamsters that were able to live in burrows, thus their rhythms ran free. Due to fewer disturbances by experimenters in the room their rhythm did not entrain, unlike the hamsters in low bedding cages that were more exposed to light and disturbances. Thus, we conclude that bedding depth has an influence on the circadian rhythm of golden hamsters. We do not know if this influence has a positive or negative impact on the welfare of the hamsters that were provided with bedding that allowed them to construct burrows.

Keywords: bedding depth, golden hamster, phase delay, running wheel

Introduction

The aim of this study was to find out whether there was a difference in the circadian rhythm of golden hamsters in different bedding depths. In chronobiology, hamsters are frequently used because they show a very stable circadian rhythm (Gattermann, 1984, Mrosovsky, 1989, Weinert et al., 2001). As a nocturnal rodent, repeated light pulses, which are naturally represented by dusk and dawn, regulate their rhythms (Johnson, 1999, Johnson et al., 2003). To adjust to seasonal changes, the rhythm exhibits phase delays to follow dusk (Johnson et al., 2003). Under laboratory conditions with constant light-dark (L:D) cycles it is not necessary to shift the rhythms. Free running rhythms occur in constant light conditions (DD or LL) without a photic zeitgeber (Johnson et al., 2003). Pratt & Goldman (1985) reported that the mean τ (free-running period) of burrow housed hamsters was longer than that of hamsters housed in cages with running wheels. Thus, the ability to hide can have an influence on the circadian rhythm. Shelters are recommended for laboratory hamsters (Kuhnen, 2002). However, in the wild, golden hamsters live in burrow systems in the soil (Gattermann et al., 2001). Thus we wanted to study if a seminatural housing of golden hamsters, i.e. providing enough bedding to dig, had an influence on their circadian rhythm.

Figure 1: Experimental cage with an insert of Perspex in order to provide deep beddings (40 and 80 cm): insert containing an outer and a smaller inner element with a space of 10 cm between them. The space between the two elements was filled up to the cage lid with wood shavings.

Animals and Methods

Forty-five male golden hamsters (progeny of Crl: LVG (SYR) from Charles River, Germany), weaned between day 25 and 31, were half-randomly assigned to three experimental groups, i.e. deep bedding (b_{deep}) = 80 cm of bedding depth, medium bedding (b_{medium}) = 40 cm and low bedding (b_{low}) = 10 cm of bedding depth, matched for litter and body weight. The hamsters were kept singly in wire cages with plastic bottoms (95 x 45 x 57 cm including the wire top). Bedding consisting of wood shavings (Allspan®) mixed with straw and hay was provided. The cages were distributed evenly across the room. Four cages were situated on a table, the fifth on the ground. The cages with the deeper bedding (40 cm, 80 cm) were equipped with an insert of Perspex to obtain the different depths. This insert consisted of an outer element onto which the cage lid was adjusted and a smaller inner element which was closed on the top (**Fig. 1**). A space of 10 cm on all four sides between the outer and closed inner element was thus was available for the hamsters to dig. The outer element was covered with black paper to provide darkness in case the hamsters built burrows. A wooden shelter, a carton tube, a hazel branch, a sand bath, paper towels as nesting material, a feeding bowl, a water bottle and a running wheel (Ø 30 cm, 10 cm width) were provided.

Light regimen was artificial with a L:D cycle of 12:12 h. Dusk began at 1 p.m. (CEST), when the light decreased from 280 Lux within half an hour to max. 5 Lux. For light intensity on the level of the cages see **tab. 1**. The room temperature was normally between 21 and 23 °C, except in the last few days of series 1 when the temperature went up to 26 °C. Relative humidity varied from 30-55%; the lowest values were found with temperatures ~21 °C.

Table 1: Light regimen. Light intensity below the lamp in the middle of the room during light phase = 280 Lux, during dark phase = 5 Lux

Light intensity	dark phase	light phase
level of shelters in group 80 cm (80 cm above ground)	0.5 – 2 Lx	70-85 Lx
level of shelters in group 40 cm (40 cm above ground)	0.5 – 2 Lx	50-85 Lx
level of shelters in group 10 cm (above tables – 75 cm above ground)	0.5 – 1 Lx	50 Lx
level of shelters in group 10 cm (below tables - 0 cm above ground)	0.5 Lx	40 Lx

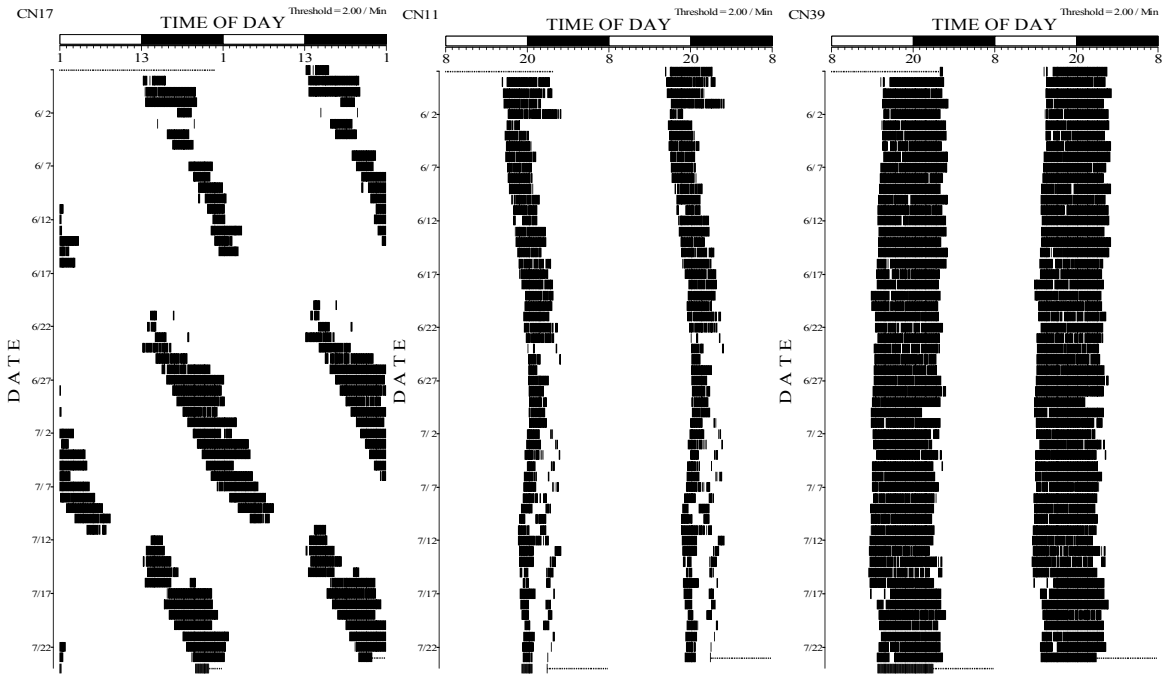
The hamsters were provided with grain feed twice a week (Witte Molen). Fresh fruit or vegetables (mainly apples, carrots etc.) were provided daily. Cat food as a protein source and mineral supplementation (Marienfelde Vitakalk®) was administered once a week. Water was offered ad lib. in bottles.

Due to the lack of space, three series were conducted with 15 animals each, 5 individuals per bedding group. After each series, the cages were emptied, cleaned and re-equipped, then their positions swapped to prevent cage x location effects.

Wheel-running activity was continuously recorded (i.e. 24 h/day) using The Chronobiology Kit (Standford Systems). The difference in minutes between the onset times of each day and the next were measured. Only data from day 27 onwards were analysed, since the recording device did not work properly before that day in the first series. Two periods of data collection were analysed separately, since a stressor application was used for another experiment about behaviour in golden hamsters (Hauzenberger et al., in prep.). Data of the two days when those stressors were applied were thus not taken into account. Period 1 lasted from day 27 until the day before stressor application, period 2 from the day after stressor application until the end of the project.

Results

After a familiarization of four weeks, the running wheel data of the hamsters in group b_{low} showed a constant circadian pattern as it is normally seen in chronobiological data. On the contrary, in group b_{deep} the onset of activity time was later each day (**Fig. 2**). The differences between two consecutive days were positive, i.e. the phase was delayed. Half of the individuals of the medium sized group (8 animals) ran in constant patterns similar to the hamsters in low bedding cages, the other half (7 animals) exhibited phase delays as seen in cages of 80 cm of bedding depth. These periods looked as though they were free running and longer in the hamsters from the deep bedding group.



actogram b_{deep} (animal #521) actogram b_{medium} (animal #513) actogram b_{low} (animal #525)

Figure 2: Actograms of hamsters of the three beding groups, each. Each horizontal line corresponds to a day, black bars reflect rotations of the running wheel. Light and dark phases are denoted by light and dark bars on top of the actogram.

During both periods the means of daily phase delays were significantly larger in the group b_{deep} than in the groups b_{medium} and b_{low} (**Fig. 3, Tab. 2**). In the period before the stressor application shifts for the hamsters in low bedding cages were significantly smaller than afterwards (paired t-test: T-Value = -2.388; P = 0.016).

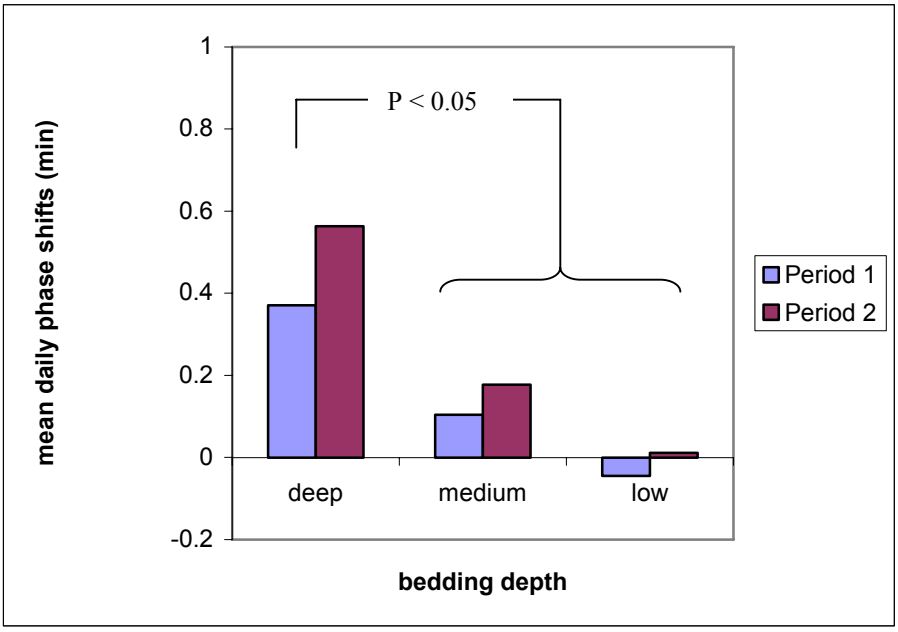


Figure 3: In period 1 and period 2 the hamsters in b_{deep} showed significantly larger phase delays than the hamsters in b_{medium} and b_{low} . P<0.05, post hoc critical value = 3.439.

Table 2: Phase shifts before and after stress including means and standard errors; n=44, df=2

Phase shift	Deep		Medium		Low		X^2	p<0.05
	mean	SE	mean	SE	mean	SE		
before stress	0.371	0.097	0.105	0.08	-0.045	0.024	11.411	0.003
after stress	0.564	0.132	0.177	0.069	0.012	0.014	11.906	0.003

Periods of the hamsters in deep bedding cages were longer than group b_{low} ($x^2 = 6.278$, P = 0.043; post hoc critical value = 3.449). The free running periods τ were correlated with the phase delays (r = 0.683, P <0.05).

In deep and medium bedding the hamsters ran significantly less in the running wheel than the animals in low (10 cm) bedding cages (Hauzenberger et al., in prep.). The phase shifts and number of wheel rotations were significantly negatively correlated (**Fig. 4**).

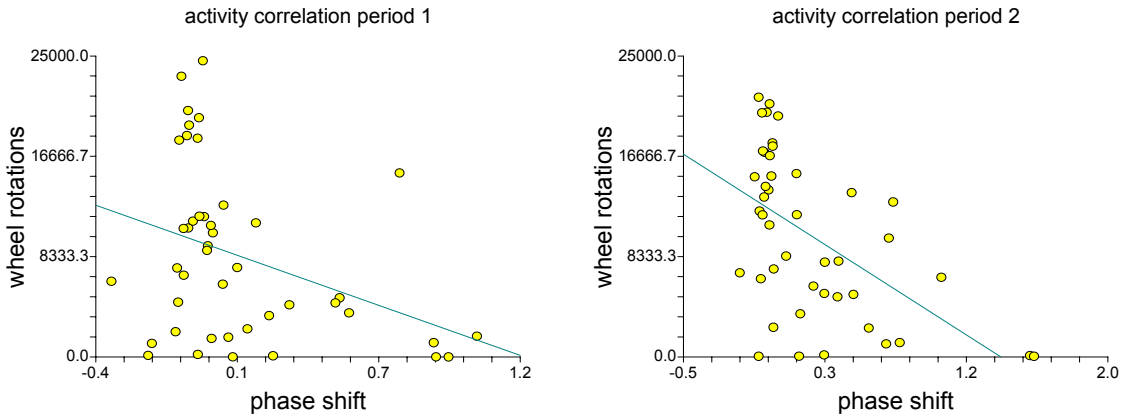


Figure 4: Phase shifts as a function of wheel-running activity. Spearman Correlation: before stress: r=-0.308, P=0.02, after stress: r=-0.513, P=0.0004.

Discussion

In this experiment, the hamsters held in deep bedding cages developed significant longer periods compared with the hamsters in low bedding cages and phase delays were larger in their circadian rhythm compared with the groups b_{medium} and b_{low}. Their circadian rhythm resembled a free running rhythm, similar to the one found in constant light or constant dark conditions, if there was an identifiable rhythm at all.

These results were unexpected. Under light-dark-conditions (LD), as it was the case in this study, a constant circadian rhythm of ~24 h is normally found (e.g. Gattermann, 1984, Mrosovsky, 1989, Weinert et al., 2001). Under artificial L:D conditions, activity coincides with lights-off, not with local time (Gattermann, 1984). This was confirmed in our results (**Fig. 2**).

Each hamster with a delayed rhythm developed its own free running rhythm, the animals therefore did not synchronise. The existence of a „social entrainment" has been rejected in golden hamsters and gerbils (Gattermann & Weinandy, 1997, Klaus et al., 2000). Human-derived activity influenced hamsters, though (Gattermann & Weinandy, 1997).

Every organism has its own internal circadian rhythm, the free running period (FRP), that can be entrained by an external stimulus to adjust to the rhythm of the external environment. This free running period is about 24 h in most species, including the golden hamster (DeCoursey, 1986, Johnson et al., 2003). After Aschoff's rule, the free running period τ depends on light intensity. In nocturnal species, like the golden hamster, τ lengthens when light intensity increases (Aschoff, 1981, Johnson et al., 2003). The period τ is usually >24 h under constant light conditions (Aschoff, 1981). The rhythms in the hamsters with phase delays averaged 24 h 20 min., thus similar to the results described in literature (Gattermann, 1984) for constant light conditions. These results, a mean free running rhythm >24h in the two deeper bedding groups, lead to the assumption that these hamsters might experience light conditions as constantly light. During the dark phase it was not perfectly dark in the room (max. 5 Lux). Thus the dark phase might have been too bright for the hamsters in deep bedding cages in comparison to their burrows.

The rhythm of the nocturnal golden hamster is regulated by repeated light pulses, naturally represented by dusk and dawn (Johnson 1999, Johnson et al., 2003). Delays in a phase mainly

develop when a light stimulus occurs during the early subjective night (Johnson, 1999, Weinert et al., 2001), particularly around the beginning of activity, i.e. after lights-off (DeCoursey 1964; in Aschoff et al., 1973, Mead et al., 1992). Under light-dark conditions, the influence of light is smaller in the subjective day, i.e. the usual resting phase for golden hamsters (Mistlberger et al., 2003), than in subjective night (Johnson 1999, Johnson et al., 2003). The extent of a phase shift depends on the intensity and duration of the stimulus (Johnson, 1999). There was some light shining into the room for a few seconds when the experimenters entered or left the room after lights-off. But only hamsters with a constant rhythm of 24 h were seen outside the burrows at that time. The intensity of light reaching the cages was considered to be too small to act as an influencing stimulus.

The fact that 7 hamsters did not stop running in their wheels at lights-on suggests that the difference in light intensity between the dark and the light phase might have been not sufficient. On the other hand, 14 hamsters ran until lights-on and then stopped running. Nevertheless, their rhythms shifted. Obviously, the difference in light was noticed by these hamsters, yet it might not have been strong enough to entrain their rhythms to a period approximating 24h.

Light-sampling behaviour as described by DeCoursey (1986) in the Flying Squirrel (*Glaucomys volans*), could not be ascertained. Pratt & Goldman (1985) mentioned hamsters emerging from their burrows during daytime. In our study, the hamsters were observed standing still at the entrance and peering outside for minutes. However, this was always at the beginning of their individual activity time and they never returned to their sleeping chambers.

Although the circadian activity is primarily influenced by light stimuli (Pratt & Goldman, 1985), other cues can act as entraining stimuli in absence of a photic zeitgeber. These include temperature, humidity, and behavioural stimuli like noise, feeding and cage cleaning (Mrosovsky, 1989, Gattermann & Weinandy, 1997, Johnson, 1999). However, Gattermann (1980) concluded that the golden hamster is rather insensitive for changes in a pace maker by disturbances like handling. This should therefore not lead to serious changes in activity patterns and biorhythm. Besides, as the hamsters of all groups were simultaneously kept and treated in the same room, these factors cannot explain the differences between the groups.

The running wheels might have influenced the circadian clock (Maywood et al., 1999). The hamsters that exhibited the longest periods in our experiment were those that ran the least. Weisgerber et al. (1997) described longer free-running periods in hamsters that run less compared to hamsters with a higher running wheel activity. She suggested the existence of a feedback mechanism which depended on activity. Mice were also found to sleep more if locomotor activity was lower (Welsh et al., 1988). Larger shifts were also found together with less wheel-running activity (Mrosovsky, 1996). The cause and effect of wheel-running and the length of free-running periods is up to debate.

We could not observe the hamsters in their burrows, so we do not know when they woke up compared to their onset of wheel-running activity. Aschoff (1981) stated the theory of "partial entrainment": daily rhythm is a multioscillatory system, where parts of it might run free, while others remain entrained.

Conclusion

The difference in rhythms between the groups cannot be explained. The opportunity to dig and hide in the burrows for the treatment groups b_{deep} and b_{medium} may lead to differences in their daily routine. Behavioural differences point in this direction (Hauzenberger et al., in preparation).

Hamsters in shallow cages might have been more exposed to light during their resting period. Further, they were disturbed by handlers in the room which was sufficient together with light to entrain to a 24 h -rhythm. The hamsters that showed a delay, on the contrary, might not have been able to discriminate between light and dark, because the difference in light intensity between lights-on and lights-off that reached the cages was not strong enough. In addition, these hamsters were less disturbed in their burrows. Thus their rhythms ran free.

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5 Can we tell hamsters are stressed by measuring their cortisol levels?

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Can we tell hamsters are stressed by measuring their cortisol levels?

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Abstract

The serum levels of corticosterone, cortisol, and ACTH were measured in male and female golden hamsters under different housing conditions. In males, the duration of handling until blood was taken (4.6 min. on average) significantly influenced the concentrations of corticosterone, cortisol, and the ratio of cortisol/corticosterone. Handling times for females were only 2.3 min. on average and no time effects were found. However, significant effects of series were detected in both sexes. No significant differences in the hormone levels were found due to housing treatments. Values of these hormones in the literature reveal large variation in this species. Due to the sensitivity of hormonal measurements to (sometimes unknown and unavoidable) environmental factors interpretations of the stress levels of golden hamsters based on these hormones must be made with caution.

Keywords: cortisol, corticosterone, ACTH, stress, golden hamster

Introduction

Concentrations of glucocorticoids are commonly used to infer the stress condition in various species (see review by Buchanan, 2000). Unfortunately, poor repeatabilities of the measured values and contradictory results of several studies have raised controversies about the value and applicability of the measurements of these hormones (Rushen, 1991; Sandoe and Simonsen, 1992; Mason and Mendl, 1993). Several problems probably contribute to the difficulties of interpreting hormonal measurements in regard to stress and these have been sufficiently discussed elsewhere (Rushen, 1991; Buchanan and Goldsmith, 2004). In this note we want to report experimental influences on hormonal measurements in golden hamsters in reference to published results on these species and to discuss the difficulties of measuring the stress condition in male and female golden hamsters.

Methods

Animals and husbandry

Forty-five male and sixty female golden hamsters (progeny of Crl: LVG (SYR) from Charles River, Germany) were used in two experiments. In the experiment with male hamsters, animals were assigned to three groups, differing in bedding depth (b_{deep} = 80 cm, b_{medium} = 40 cm and b_{low} = 10 cm of bedding). In the experiment with female hamsters, animals were kept in four different cage sizes (1,800 cm^2 , 2,500 cm^2, 5,000cm^2, 10,000 cm^2). Due to space limitations the experiments were performed at three different times. Additional hamsters for the validation of the ACTH test were kept in cages of 5,000 cm^2. Food and water were offered ad lib. Lighting was artificial with 12h light 12 h dark. Temperatures were between 20 and 26º C. After weaning at around 4 weeks of age, the hamsters were placed into the experimental groups and kept singly for 13 weeks. More details of the experiments are given in Fischer et al. (in preperation) and Hauzenberger et al. (in preperation). Thirteen weeks after weaning hamsters were decapitated after isoflurane-anaesthesia (5%). The duration of catching the hamster out of its cage, the duration of anaesthesia, and the total time from first disturbance to decapitation (= total duration of blood sampling) were recorded. The trunk blood was used for analyses of corticosterone, cortisol, and ACTH. Hamsters of each series and each sex were euthanized on two consecutive days.

An additional ACTH-challenge test was done with 12 adult female golden hamsters for further validation of the cortisol and corticosterone levels. The animals were kept in 5,000 m^2 cages with 10 cm of bedding. After an i.p. injection of ACTH (Synacthen® 60 µg/100 g body mass) the anaesthesia and decapitation was done in ascending time intervals. Blood was collected in EDTA-vials.

The experiments were approved by the Cantonal Office of Agriculture and Nature to adhere to the Swiss legislation of housing, anaesthesia and euthanization of laboratory animals.

Hormonal analyses

After collection blood was centrifuged and the serum was stored in -80º C until it was shipped to the laboratory on dry ice.

The following analyses were done at the Institute of Endocrinology of the Tierärztliche Hochschule Hannover (1,2) and the Alomed Laboratory in Radolfzell (3) in Germany :

1. Corticosterone was assayed with the commercial RIA for rats (DPC). Intra-assay variability was 4.3 %, inter-assay variability was 5.8 %.
2. Cortisol was assayed with in-house RIA (3H) , the precision was 1.0 ng/ml. The antibody used was Anti-Cortisol-3-(CMO-)BSA Antiserum (rabbit), for cross-reactions see Klein et al. (1989). Intra-assay variability was 9.2 %, inter-assay variability was 10.9 %.
3. ACTH was assayed with a chemoluminescence-immunometric assay (Nichols Institute Diagnostics), which was validated for dogs (Schwedes and Müller, 2000). The analytical sensitivity was 2 pg/ml. Intra-assay variability was 7.2 %, inter-assay variability was 8 %.

Statistics

Analyses were done using NCSS® and SAS®. Data and residuals were checked for normality and transformed if necessary, or non-parametric tests were used (see text). All correlation coefficients are Spearman's (r_s). The influences of the duration of handling the hamsters before euthanasia were analysed by stepwise regressions. Post-hoc multiple comparisons were done using the Tukey-Cramer method (NCSS®).

Results

Males had generally higher values of the measured hormones (**Tab. 1**). None of the treatment effects (cage size or depth of bedding) influenced the concentration of glucocorticoids although significant differences in behavior and relative weights of organs were detected (Fischer et al., in preperation, Hauzenberger et al., in preperation).

Table 1: Hormonal measurements of male and female golden hamsters. The means are given with the standard deviations in parantheses.

Hormone	**Males n = 44**	**Females n = 57**
corticosterone [ng/ml]	32.228 (±18.129)	7.338 (±4.583)
cortisol [ng/ml]	18.340 (±28.141)	8.329 (±6.544)
cortisol/corticosterone	0.511 (±0.515)	1.531 (±1.698)
ACTH [pg/ml]	39.512 (±36.514)	12.714 (±13.520)

Corticosterone

In males, which were held in three different depths of bedding, corticosterone levels differed significantly between series (Kruskal Wallis: $x^2 = 9.411$, P = 0.009). Nine out of 45 values were above a level of 50 ng/ml. All but one high value derived from series 1. Corticosterone was significantly correlated with the duration of catching ($r_s = 0.314$, P = 0.040), duration of anaesthesia ($r_s = 0.367$, P = 0.016) and total duration until blood samples were taken ($r_s = 0.382$, P = 0.012). In a stepwise regression log-transformed corticosterone levels were significantly correlated with the duration of anaesthesia (partial $r^2 = 0.14$, F = 7.10, P = 0.01).

Similarly in females in different sized cages, series differed significantly (GLM-ANOVA: F = 5.92, N = 56, P = 0.005). The level of corticosterone was positively correlated with the series (Spearman rank correlation coefficient (r_s) = 0.397, N = 56, P = 0.002). On day 1 of blood sampling values were higher than on day 2 (GLM-ANOVA: F = 4.52, N = 57, P = 0.039).

Cortisol

In males, cortisol levels were approximately normally distributed (around 18 ng/ml) with the exception of eleven deviating values above a level of 20 ng/ml (**Tab. 1**). One value was even 8 fold above the mean value. All but two high values derived from series 1, 10 out of 15 hamsters of series 1 had levels above 20 ng/ml. Cortisol levels were significantly higher in series 1 than in series 2 and 3 (Kruskal WallisTest: $x^2 = 25.614$, $P < 0.005$). Cortisol levels were significantly correlated with the weight of the epididimal glands ($r_s = 0.317$, $P = 0.043$). In a stepwise regression log-transformed cortisol levels correlated significantly with the duration of catching (partial $r^2 = 0.41$, $F = 28.52$, $P < 0.0001$) (**Fig. 1**).

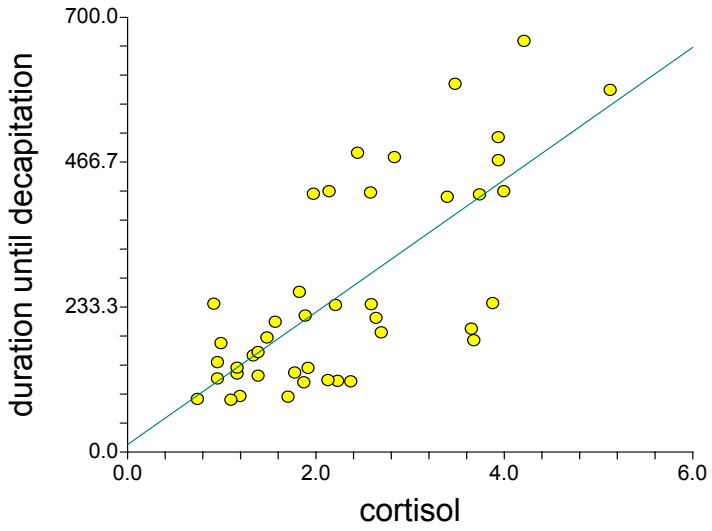

Figure 1: The concentration of cortisol correlated with the total duration between arousal and decapitation (shown for males)

In females, there were 14 very high values which were distributed over all three series. No reasons for the outliers could be found. To fulfill the assumption of normality data were log transformed. Cortisol values tended to be higher on day 1 compared with day 2 (GLM-ANOVA: $F = 3.23$, $N = 56$, $P = 0.079$). On day 1 cortisol was negatively correlated with the order of sampling ($r_s = -0.456$, $N = 28$, $P = 0.015$) (**Fig. 2**).

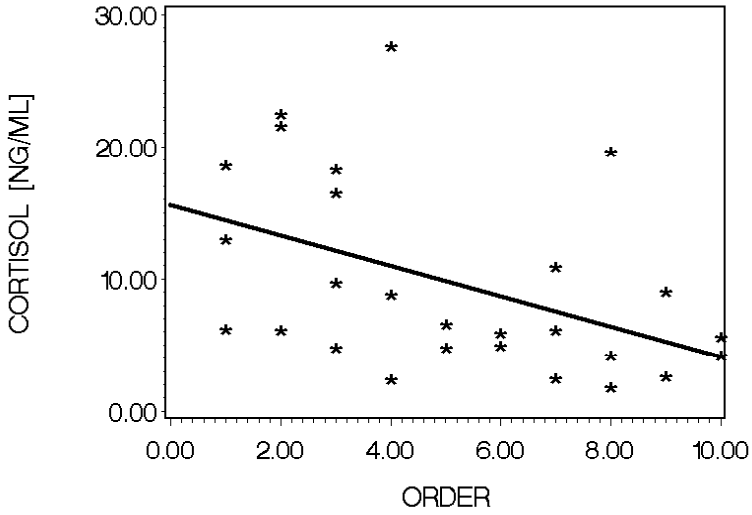

Figure 2: The concentration of cortisol in females was negatively correlated with the order of sampling on day 1.

Cortisol/corticosterone ratio

In males, the cortisol/corticosterone ratio was significantly correlated with the total duration until blood samples were taken (partial r^2 = 0.42, F = 29.97, P <0.0001) (all data log-transformed) (**Fig. 3**).

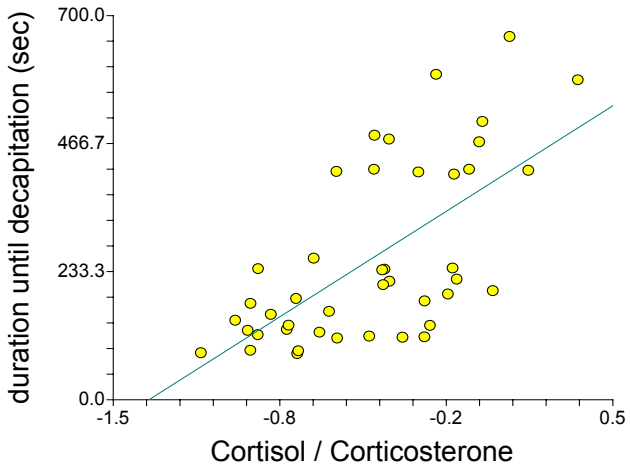

Fig. 3. In males the ratio of cortisol/corticosterone was correlated with the total duration of blood sampling.

In females the cortisol/corticosterone ratio was negatively correlated with the series (r_s = -0.303, N = 54, P = 0.026).

ACTH

Levels of ACTH were significantly higher in male hamsters from cages with 80 cm deep bedding compared with male hamsters in low cages (Kruskal Wallis: $x^2 = 11.319$, $P < 0.005$, post hoc critical value = 4.723). There were no significant differences among series.

In female hamsters, ACTH (log-transformed) was negatively correlated with the duration of anaesthesia (partial $r^2 = 0.13$, $F = 5.96$, $P = 0.019$). Thirteen values of females were too small for measurement (< 2pg/ml, 10 of them in series 3).

Sampling effects

In the first series it took longer to catch the male hamsters out of their cages than in the following series (Kruskal-Wallis: $x^2 = 25.409$, $P < 0.005$, post hoc critical value = 4.723). Anaesthesia was also significantly longer in series 1 (Kruskal-Wallis: $x^2 = 31.050$, $P < 0.005$, post hoc critical value = 4.723), as was total duration of blood sampling (Kruskal-Wallis: $x^2 = 28.282$, $P < 0.005$, post hoc critical value = 4.731). Most time was needed to catch hamsters in deep bedding cages of 80 cm (Kruskal Wallis: $x^2 = 5.757$, $P = 0.05$).

The duration of catching and the duration of anaesthesia were significantly correlated ($r_s = 0.674$, $P < 0.005$).

In females there were no significant differences among series of the duration of catching, anaesthesia, or total duration of blood sampling (all P values > 0.4). There was a trend that the duration of anaesthesia and total duration of blood sampling were higher on day 1 than on day 2 although just not significant (Kruskal-Wallis Test for total duration of blood sampling: $x^2 = 3.552$, $P = 0.06$). As expected, it took significantly more time to catch hamsters out of the largest cage than out of the smaller cages (GLM-ANOVA: $F = 9.00$, $N = 56$, $P = 0.00007$, post hoc critical value = 4.634, $P < 0.01$) (**Fig. 4**). This resulted in a higher total duration of blood sampling in the largest cages (Kruskal Wallis Test: $x^2 = 10.068$, $N = 56$, $P = 0.018$) compared with the other cage sizes (post hoc critical value = 4.895, $P < 0.05$).

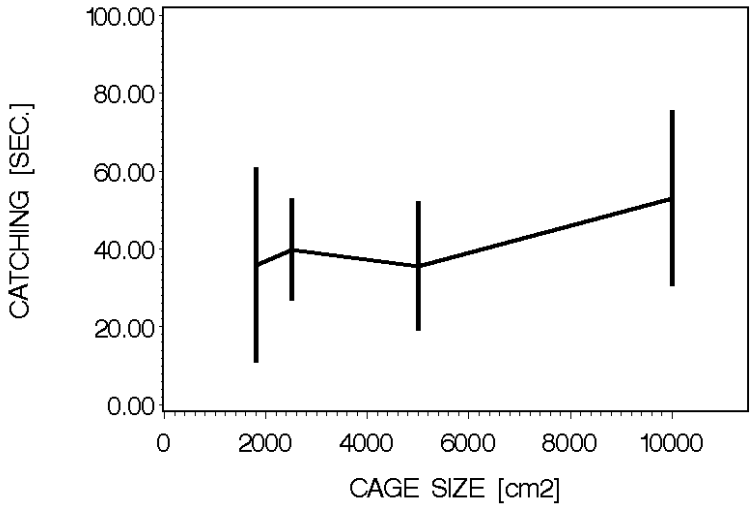

Figure 4: Duration of catching in 4 cage sizes

It took more than twice as long to catch the male hamsters out of their cages than the female hamsters (**Tab. 2**).

Table 2: Durations [min.] of catching, anaesthesia, and the total time male and female hamsters. Standard deviations are given in parantheses. NS – not significant

Variable	**Male**	**Female**	χ^2	**P-Value**
catching	2.1 (1.46)	0.68 (0.20)	37.90	< 0.0001
anaesthesia	2.4 (2.75)	1.6 (0.56)	1.49	NS
total duration	4.6 (3.69)	2.3 (0.65)	15.24	< 0.0001

ACTH-Challenge Test

In the ACTH-challenge test there was an elevation of cortisol 3 minutes after the injection of ACTH with a maximum value of 100 ng/ml 20 minutes after injection. Corticosterone values peaked 1 hour after the injection with a maximum of 53 ng/ml (**Fig. 5**).

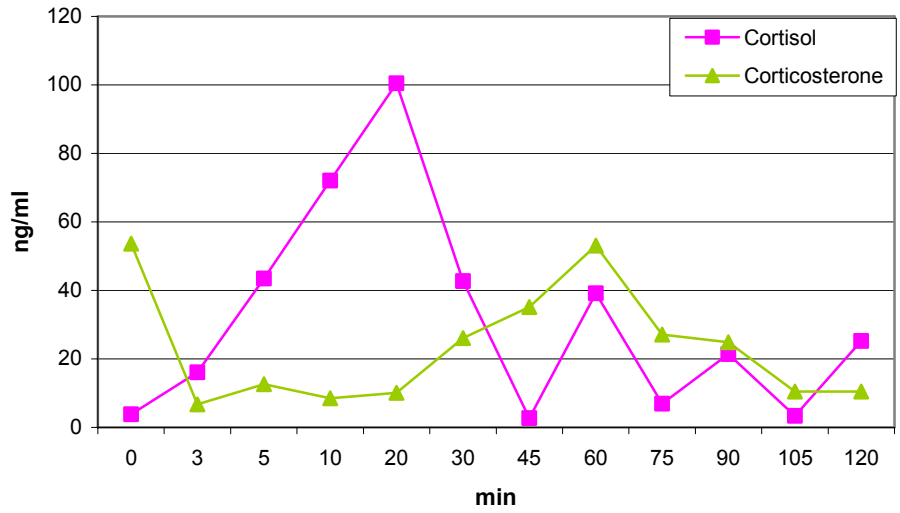

Figure 6: ACTH challenge experiment, for details see text

Discussion

Various concentrations of cortisol in golden hamsters under different (stress) situations have been published (**Tab. 3**). Possible causes of the differences in the hormonal reaction to stress have been directly investigated, namely age, different stressors ((Wommack and Delville, 2003; Taravosh-Lahn and Delville, 2004), duration (Ottenweller et al. 1985), time of day (Albers et al. 1985), and experience (Weinberg and Wong, 1986). Different methods could explain the discrepant values. However, it is not clear why the studies of Wommack and Delville (2003) and Taravosh-Lahn and Delville (2004) obtained such different values under the same stress with the same hormonal analyses. Unknown influences varying with time might be very important and the factor age might be confounded with the factor time. Different aged individuals should be tested and their blood taken at the same time to attribute effects clearly to the age. Our cortisol concentrations in males could indicate that they were acutely stressed at the time of blood sampling. This is supported by the result that corticosterone, cortisol, cortisol/corticosterone ratio and ACTH mainly depended on how much time was spent from first disturbance of the hamsters until blood samples could be taken after euthanasia. It shows the sensitivity of the pituitary-adrenal axis (PAA). Cortisol was already elevated after three minutes of the injection of ACTH. Probably in some cases blood samples where taken at a point when hormone levels had already begun to increase. On average, blood samples in males were taken about 4 minutes after the first disturbance. Since the duration of catching the hamsters depended on the treatments (bedding depth or cage size) we cannot draw any conclusions concerning the state of stress in the hamsters in relation to their treatments. The decrease of ACTH with time can be explained by the negative feedback of cortisol: increasing cortisol levels suppress the release of ACTH in the pituitary gland.

ACTH seemed to increase with increasing duration of sampling, although not significantly. It is the first hormone that is released in a stress situation and increases within a few seconds until a negative feedback of the glucocorticoids starts. Because of the immediate reaction it is not possible to draw any conclusions about the stress level. In series 4 we measured 13 values below 2 pg/ml. The reason for such small values could be the fast decomposition of ACTH due to the negative feedback, which does not explain why it occurred so frequently in series 3.

Table 3: Concentrations of cortisol [ng/ml] (STD) in golden hamsters under control conditions and various stress treatments

year	control	stress	sex	kind of stress	author	method
2004	1.3	2.6	both	conspecific intruder, clean cage, day 27	Taravosh-Lahn and Delville, 2004	EIA
2004	2 – 2.5	1.5 – 2.1	both	conspecific intruder, clean cage, day 41	Taravosh-Lahn and Delville, 2004	EIA
2003	4.5	10	male	conspecific intruder, day 28	Wommack and Delville, 2003	EIA
2003	4.5	14	male	clean cage, day 28	Wommack and Delville, 2003	EIA
2003	6	14	male	conspecific intruder, day 42	Wommack and Delville, 2003	EIA
2003	6	5	male	clean cage, day 42	Wommack and Delville, 2003	EIA
2003	12.7 (4.47)	20.56 (6.01)	male	weasel odor	Zhang, Cao, Gao, Yang, Sun, Zhang, and Wang, 2003	RIA
2001	38	65 - 70	male	conspecific intruder	Jasnow, Drazen, Huhman, Nelson, and Demas, 2001	RIA
1998	1.8	3.7	male	cage size	Kuhnen and Werner, 1998	?
1986	8	26 - 38	male	new cage	Weinberg and Wong, 1986	RIA
1986	9.6	18	female	new cage	Weinberg and Wong, 1986	RIA
1985	2.5 - 18				Albers, Yogev, Todd, and Goldman, 1985	RIA
1985	4	60	male	supine restraint	Ottenweller, Tapp, Burke, and Natelson, 1985	RIA
1972	5.9 (1.5)	6.1 (1.5)	male	conspecific intruder	Brain, 1972	Protein Binding assay
1972	12.8 (2.6)	11.9 (1.9)	female	conspecific intruder	Brain, 1972	Protein Binding assay
1970	4.5 (0.4)	62.4 (0.74)	male	ether stress	Gaskin and Kitay, 1970	Protein Binding assay
1970	3.8 (0.9)	24.7 (5.1)	female	ether stress	Gaskin and Kitay, 1970	Protein Binding assay

Our data show that sampling blood for measuring chronical stress must be taken quickly, at least within 2.5 minutes, before levels rise due to the acute stress of sampling. This might be difficult because the (Swiss) Animal Welfare Legislation forbids decapitation without previous anaesthesia. For more accurate values hamsters could be administered with a catheter, yet it is very difficult in this species and causes stress itself. There is no solution for cages with deep bedding, for the time until hamsters are caught out of their cages can take just as long as the PAA system needs to react to acute stress.

Fecal samples have their advantage in being non-invasive, a critical drawback is that it gives only average hormone levels over a, sometimes unknown, period and this method is sometimes not validated (Buchanan and Goldsmith, 2004). During the ACTH-challenge test no increase in suspected metabolites of cortisol was found in the feces (unpublished data).

Blood samples were taken on two following days. Although the duration of anaesthesia and total duration of sampling did not differ significantly among days of sampling, there was a tendency of higher values of total duration of sampling on day 1. Corticosterone levels on day 2 were lower than on day 1. It is likely that hamsters were disturbed from sampling on the previous day, while sleeping in the bedding, but because of a habit effect PAA-reaction was lower on the second day which resulted in lower corticosteroid values. So it might be better to perform blood sampling within one day. However, further complications arise due to the dependence of the PAA on chronobiology. When treatments affect the circadian rhythms as was found (Hauzenberger et al., in preparation), it would be impossible to relate certain hormone levels to circadian times.

Other complications could arise from a shorter duration of catching due to the training of the handler. It means that hamsters that were caught later were caught faster. Although it seems to have had no general influence in our analyses, we cannot exclude an effect, since on day 1 hamsters that were caught later had a lower cortisol level. This could be due to the time of day, or due to a difference in duration of anaesthesia and total duration of blood sampling.

The correlation between the duration of catching and the anaesthesia was probably due to the level of experience. Furthermore, the equipment for anaesthesia was not not working properly in the first series which might have contributed to the effect of series. Since the experiments were done year-round, an effect of the season cannot be excluded.

Conclusion

Since the stress response of the PAA is very sensitive to many unwanted and uncontrollable factors the results have to be interpreted with caution.

Physiological measures of animal welfare can only serve as an additional brickstone to accompany parameters such as behaviour. No parameter can be interpreted by itself, but always in the context of additional findings.

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6 Anhang

6.1 Referenzliste der Gesamtdissertation

6.2 Materialliste und Tiere

- 6.2.1 Versuchsraum
- 6.2.2 Aufbau der Käfige
- 6.2.3 Tiere

6.3 zusätzliche Tabellen

6.4 zusätzliche Grafiken

6.5 Abbildungen

6.6 Danksagungen

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6.2 Materialliste und Tiere

6.2.1 Versuchsraum

Die Fläche des Versuchsraums betrug 46,04m^2. Da er für zwei Hamsterprojekte gleichzeitig benutzt wurde, teilten ihn Trennwände in zwei Hälften. Der für dieses Projekt zur Verfügung stehende Raum betrug 23 m^2.

Damit das künstliche Lichtsystem (Dämmerungssteuerung RDW Beleuchtungstechnik, Bern) angewandt werden konnte, wurden die Fenster (120x65cm) zur Verdunkelung mit Baufolie abgedeckt (1500/3000 200µ; Gobag Gummi Oberleitner AG), so dass von aussen kein Licht mehr hinein drang.

Je zwei der Käfige der niedrigsten Einstreugruppe standen auf einem von zwei Holztischen (Masse: 150x70x75 cm), die in der entgegengesetzten Ecke des Raumes platziert waren, der fünfte Käfig dieser Gruppe stand unter dem Tisch gleich neben dem Eingang. Die restlichen Käfige wurden durchmischt im Raum verteilt. Die 80cm-Käfige wurden auf eine Spanplatte (950 x 570 x 22 mm) mit Rollen gestellt, damit sie, wenn nötig, bewegt werden konnten, z.B. zum Aufstellen für die Videoaufnahmen. An jeder Ecke war eine Rolle mit 4,8 cm Durchmessern (Befestigungsplättchen 38 x 38 mm) mit je vier flachköpfigen Spanplattenschrauben angebracht (Material aus Coop Bau+Hobby).

Temperatur: die Raumtemperatur betrug zwischen 21 und 23 °C. In den letzten Tagen (ab Mitte Juli 2003) des ersten Durchganges stieg die Temperatur auf 26°C. Ab dem zweiten Durchgang stand eine Klimaanlage zur Verfügung. Die relative Luftfeuchtigkeit lag zwischen 30 und 55%; die tiefsten Werte traten bei einer Temperatur von ~21 °C auf.

Während der Dämmerung nahm das Licht innerhalb einer halben Stunde auf max. 5 Lux auf Höhe der Käfige ab. Der Licht-Dunkel-Zyklus betrug 12:12h. Die Helligkeiten auf Höhe der Käfige lassen sich aus **Tabelle (1)** im Paper „Phase delays in circadian rhythms in golden hamsters *(Mesocricetus auratus)* housed in deep bedding“ entnehmen.

6.2.2 Aufbau der Käfige

Die Tiere wurden einzeln in standardisierten Käfigen gehalten, wie sie in unserer Zucht verwendet werden (Modell ‘Massa’®, 95x45x57cm). Für die Käfige mit 40 rsp. 80 cm Einstreu wurde ein Einsatz aus Plexiglas von Hand gefertigt. Er bestand aus einem äusseren Teil mit der entsprechenden Höhe, der auf den Rand der Plastikwanne gestellt wurde, und einem kleineren, inneren Teil, oben mit einem Plexiglasdeckel abgeschlossen, der in der Mitte des äusseren stand. So konnte jeder Hamster rundherum in einer Breite von 10 cm und in die entsprechende Tiefe graben. Das Gitteroberteil wurde auf dem äusseren Teil des Einsatzes mit Klammern befestigt.

Um die Käfige mit den Plexiglaseinsätzen herum wurde schwarzes Zeichenpapier (Kollbrunner, Bern) gehängt, damit die Hamster in ihren Bauen nicht durch Licht gestört wurden. Das Papier wurde an selbstklebende Klettverschlüsse (TESA) angebracht, damit man es abnehmen konnte, um das Grabverhalten des Hamsters durch das Plexiglas hindurch kontrollieren zu können. Die Masse betrugen 95 x 70 cm für die Längswand und 57 x 7 cm für die Breitwand der 80-cm-Käfige, 90 x 30 cm, rsp. 57 x 30 cm. für die 40-cm-Käfige.

Eingestreut waren alle Käfige mit Holzspänen (“Allspan”®, Landw. Genossenschaft), etwas Langstroh und Heu (entstaubt; beide Pferdeklinik, Tierspital Bern). Als Unterschlupf diente ein Häuschen aus Sperrholz mit den Massen 20x14x14 cm. Gegen unten war es offen, auf einer Seite befand sich ein runder Eingang mit dem Durchmesser 5cm.

Weitere Einrichtungsgegenstände waren eine Kartonröhre von handelsüblichem Haushaltspapier, einen Ast von Hasel oder ungespritzen Obstbäumen zum Benagen, ein Sandbad (Ø 17 x 2.5cm; Migros-Genossenschaft) mit Spezial-Badesand (Eric Schweizer Samen AG, Thun), eine Futterschale (Ø 11 x 2.5 cm; Migros-Genossenschaft), eine Wasserflasche („mouse“ drinking bottle; Classic Pet), Haushaltspapier (Hopi Clas) und ein Laufrad an der Innenseite eines jeden Käfiggitters mit dem Durchmesser 30 cm und einer Breite von 10 cm. Die Lauffläche bestand aus einem Lochblech mit einem Lochdurchmesser von 5 mm. Diese Art Fläche wurde gewählt, um Pfotenverletzungen aufgrund des Laufradlaufens vorzubeugen. Es sind die selben Räder wie sie im Projekt Vonlanthen verwendet wurden (Vonlanthen, 2003). Angefertigt waren sie vom Technischen Dienst des Tierspitals Bern. Sie waren mit einem Computer verbunden, der mittels eines Spezialprogramms (The Chronobiology Kit) die Laufradaktivität aufzeichnete.

Als Nahrungsgrundlage diente Körnerfutter für Nagetiere aus dem Handel (Witte Molen), welches zweimal pro Woche gegeben wurde. Zusätzlich erhielten die Hamster täglich frisches Obst, meistens Äpfel und Karotten, aber auch Birnen, Salat, Fenchel etc. Einmal pro Woche wurde proteinhaltiges Katzentrockenfutter gegeben (Croc Menu Selina, Migros-Genossenschafts-Bund, Zürich), da Hamster auch mit tierischem Eiweiss gefüttert werden sollen (Merkblatt STS). Mineralfutter zur Vorbeugung von Mangelerscheinungen wurde zusammen mit dem Proteinfutter gefüttert (Marienfelde Vitakalk®, Marienfelde GmbH, Roth b. Nürnberg). Liegengebliebenes Frischfutter wurde täglich, Körnerfutter bei Wiederauffüllen entfernt. Trinkwasser stand ad libitum zur Verfügung.

Nach einer Behandlung wie Gewichtsmessung und Stressapplikation erhielt jeder Hamster einen Joghurtdrop (Vitobel, Natura Saaten GmbH, DE).

Jeder Käfig wurde mit einer Nummer angeschrieben und eine Tierkarte angebracht mit der Kennzeichnung der Tiere und dem Vermerk von wichtigen Daten (wiederholte Gewichtsmessungen, Stress etc). Einmal im Monat wurde die verschmutzte Einstreu erneuert (lediglich wo nötig, d.h. ums Häuschen und die Schlafkammern herum). Nach jedem Durchgang wurden die Käfige vollständig geleert, gereinigt und desinfiziert. Die Häuschen, Sandbäder, Futterschalen, Trinkfläschchen und das Laufrad wurden gesäubert, Küchenpapier, Äste und Kartonröhren ersetzt. Vor der Wiederbelegung wurden die Plexiglaseinsätze, die Gitter, Türchen und Kartons auf ihren Zustand geprüft, wo nötig geflickt und angebracht. Die Laufräder und Anschlüsse wurden ebenfalls auf ihre Funktion überprüft. Für einen neuen Durchgang wurden die Käfige neu durchmischt im Raum aufgestellt.

6.2.3 Tiere

Die 45 Hamster aus dem Projekt wurden nach Würfen getrennt in fünf Gruppen pro Durchgang eingeteilt. Da im zweiten Durchgang zu wenig Würfe vorhanden waren, nahmen wir aus drei Würfen je 4 Tiere, wobei von jedem Wurf je ein Hamster zufällig der fünften Gruppe zugeteilt wurde. Im letzten Durchgang stammten die Projekttiere von sechs verschiedenen Würfen, eine Gruppe bestand aus einem Hamster des einen und zwei eines anderen Wurfes. Die Tiere wurden gewogen und in Gewichtsklassen (leicht, mittel, schwer) eingeteilt. Aus jeder Gruppe wurde ein Tier in ein Käfig aus je einer Einstreugruppe gesetzt. Es wurde darauf geachtet, dass die Gewichtsklassen gleichmässig auf die einzelnen Einstreutiefen aufgeteilt wurden. So war jede Wurfgruppe in jeder Einstreutiefe nur einmal vertreten.

s. Tabellen 4. a-c im Anhang

6.3 zusätzliche Tabellen

Tabelle 1: Projektablauf

Stressgruppe 1	Projektwoche	Stressgruppe 2
Einsetzen, Gewichtkontrolle	WOCHE 0	Einsetzen, Gewichtkontrolle
	WOCHE 1	
Video 1	WOCHE 2	Video 1
	WOCHE 3	
Kontrolle der Hamster und Gewicht	WOCHE 4	Kontrolle der Hamster und Gewicht
Kontrolle Hamster + Gewicht, Durchg. 3	WOCHE 5	Kontrolle Hamster + Gewicht, Durchg. 3
Video 2	WOCHE 6	
Stressfaktor & Stressvideo	WOCHE 7	Video 2
	WOCHE 8	Stressfaktor & Stressvideo
	WOCHE 9	
	WOCHE 10	
	WOCHE 11	
Video 3	WOCHE 12	Video 3
Euthanasie und Sektion	WOCHE 13	Euthanasie und Sektion

Für den Stressfaktor wurden die Hamster in zwei Gruppen eingeteilt, die erste Gruppe wurde in Woche 7 gestresst, die zweite in Woche 8.

Tabelle 2: Datum der Videoaufnahmen und Alter in Tagen

Tier Nr	Datum Video 1	Alter (Tage)	Datum Video 2	Alter (Tage)	Datum Stressvideo	Alter (Tage)	Datum Video 3	Alter (Tage)
511	22. Mai 03	49	12. Juni 03	70	19. Juni 03	77	24. Juli 03	112
512	21. Mai 03	48	11. Juni 03	69	18. Juni 03	76	23. Juli 03	111
513	20. Mai 03	47	10. Juni 03	68	17. Juni 03	75	22. Juli 03	110
514	22. Mai 03	50	19. Juni 03	78	26. Juni 03	85	24. Juli 03	113
515	22. Mai 03	50	12. Juni 03	71	19. Juni 03	78	24. Juli 03	113
516	21. Mai 03	49	18. Juni 03	77	25. Juni 03	84	23. Juli 03	112
517	20. Mai 03	48	17. Juni 03	76	24. Juni 03	83	22. Juli 03	111
518	23. Mai 03	51	13. Juni 03	72	20. Juni 03	79	25. Juli 03	114
519	22. Mai 03	50	19. Juni 03	78	26. Juni 03	85	24. Juli 03	113
520	21. Mai 03	48	11. Juni 03	69	18. Juni 03	76	23. Juli 03	111
521	21. Mai 03	48	18. Juni 03	78	25. Juni 03	85	23. Juli 03	111
522	23. Mai 03	50	20. Juni 03	80	27. Juni 03	87	25. Juli 03	113
523	20. Mai 03	48	17. Juni 03	76	24. Juni 03	83	22. Juli 03	112
524	20. Mai 03	48	10. Juni 03	69	17. Juni 03	86	22. Juli 03	112
525	23. Mai 03	51	13. Juni 03	71	20. Juni 03	78	25. Juli 03	115
680	2. September 03	47	25. September 03	68	1. Oktober 03	75	5. November 03	109
681	3. September 03	48	2. Oktober 03	75	9. Oktober 03	82	6. November 03	110
682	4. September 03	49	23. September 03	66	30. September 03	73	4.November 03	111
683	3. September 03	50	26. September 03	71	2. Oktober 03	78	6. November 03	112
684	3. September 03	50	2. Oktober 03	77	9. Oktober 03	84	6. November 03	112
685	2. September 03	49	1. Oktober 03	76	8. Oktober 03	83	5. November 03	113
686	2. September 03	48	25. September 03	67	1. Oktober 03	74	5. November 03	108
687	3. September 03	49	26. September 03	68	2. Oktober 03	75	6. November 03	109
688	5. September 03	51	3. Oktober 03	75	10. Oktober 03	82	7. November 03	110
689	5. September 03	51	27. September 03	68	3. Oktober 03	75	7. November 03	110
698	4. September 03	50	30.September 03	72	7.Oktober 03	79	4.November 03	107
699	4. September 03	50	23. September 03	65	30.September 03	72	4.November 03	107
700	5. September 03	51	3. Oktober 03	75	10. Oktober 03	82	7. November 03	110
701	2. September 03	48	1. Oktober 03	73	8. Oktober 03	80	5. November 03	108
725	12. Februar 04	52	4. März 04	73	11. März 04	80	15. April 04	115
726	13. Februar 04	53	12. März 04	81	19. März 04	88	16. April 04	116
730	11. Februar 04	49	10. März 04	77	17. März 04	84	14. April 04	112

731	12. Februar 04	50	11. März 04	78	18. März 04	85	15. April 04	113
732	13. Februar 04	51	5. März 04	72	12. März 04	79	16. April 04	114
736	10. Februar 04	47	3. März 04	69	9. März 04	75	13. April 04	110
737	12. Februar 04	48	4. März 04	69	11. März 04	76	15. April 04	111
738	10. Februar 04	46	3. März 04	68	9. März 04	74	13. April 04	109
739	11. Februar 04	47	3. März 04	68	10. März 04	75	14. April 04	110
749	12. Februar 04	48	11. März 04	76	18. März 04	83	15. April 04	111
750	10. Februar 04	46	9. März 04	74	16. März 04	81	13. April 04	109
751	13. Februar 04	49	5. März 04	70	12. März 04	77	16. April 04	112
758	10. Februar 04	46	9. März 04	73	16. März 04	80	13. April 04	108
759	11. Februar 04	47	10. März 04	74	17. März 04	81	14. April 04	109
760	11. Februar 04	47	3. März 04	67	10. März 04	74	14. April 04	109

Tabelle 3: Datum und Alter der Hamster bei Projektbeginn (Einsetzen) und bei der Euthanasie

Tier Nr.	Geburt	Einsetzen	Alter (Tage) bei Einsetzen	Todesdatum	Alter (Tage) bei Euthanasie	Einstreutiefe
511	03. Apr 03	29. Apr 03	26	29. Jul 03	117	niedrig
512	03. Apr 03	29. Apr 03	26	30. Jul 03	118	tief
513	03. Apr 03	29. Apr 03	26	30. Jul 03	118	mittel
514	02. Apr 03	29. Apr 03	27	29. Jul 03	118	tief
515	02. Apr 03	29. Apr 03	27	30. Jul 03	119	niedrig
516	02. Apr 03	29. Apr 03	27	29. Jul 03	118	mittel
517	02. Apr 03	29. Apr 03	27	29. Jul 03	118	tief
518	02. Apr 03	29. Apr 03	27	29. Jul 03	118	niedrig
519	02. Apr 03	29. Apr 03	27	30. Jul 03	119	mittel
520	03. Apr 03	29. Apr 03	26	29. Jul 03	117	mittel
521	03. Apr 03	29. Apr 03	26	29. Jul 03	117	tief
522	03. Apr 03	29. Apr 03	26	30. Jul 03	118	niedrig
523	02. Apr 03	29. Apr 03	27	30. Jul 03	119	mittel
524	02. Apr 03	29. Apr 03	27	30. Jul 03	119	tief
525	02. Apr 03	29. Apr 03	27	30. Jul 03	119	niedrig
680	19. Jul 03	14. Aug 03	26	10. Nov 03	114	tief
681	19. Jul 03	14. Aug 03	26	11. Nov 03	115	niedrig
682	19. Jul 03	14. Aug 03	26	10. Nov 03	114	tief
683	17. Jul 03	14. Aug 03	28	10. Nov 03	116	mittel
684	17. Jul 03	14. Aug 03	28	10. Nov 03	116	niedrig
685	17. Jul 03	14. Aug 03	28	11. Nov 03	117	tief
686	20. Jul 03	14. Aug 03	25	11. Nov 03	114	mittel
687	20. Jul 03	14. Aug 03	25	10. Nov 03	113	tief
688	20. Jul 03	14. Aug 03	25	10. Nov 03	113	niedrig
689	20. Jul 03	14. Aug 03	25	11. Nov 03	114	niedrig
698	20. Jul 03	14. Aug 03	25	11. Nov 03	114	tief
699	20. Jul 03	14. Aug 03	25	10. Nov 03	113	mittel
700	20. Jul 03	14. Aug 03	25	11. Nov 03	114	niedrig
701	20. Jul 03	14. Aug 03	25	10. Nov 03	113	mittel
725	22. Dez 03	22. Jan 04	31	20. Apr 04	119	mittel
726	22. Dez 03	22. Jan 04	31	20. Apr 04	119	niedrig
730	24. Dez 03	22. Jan 04	29	19. Apr 04	116	tief
731	24. Dez 03	22. Jan 04	29	20. Apr 04	117	mittel
732	24. Dez 03	22. Jan 04	29	19. Apr 04	116	niedrig
736	25. Dez 03	22. Jan 04	28	19. Apr 04	115	tief
737	26. Dez 03	22. Jan 04	27	20. Apr 04	115	tief
738	26. Dez 03	22. Jan 04	27	19. Apr 04	114	mittel
739	26. Dez 03	22. Jan 04	27	19. Apr 04	114	niedrig
749	26. Dez 03	22. Jan 04	27	20. Apr 04	115	tief
750	26. Dez 03	22. Jan 04	27	20. Apr 04	115	mittel
751	26. Dez 03	22. Jan 04	27	19. Apr 04	114	niedrig
758	27. Dez 03	22. Jan 04	26	19. Apr 04	113	tief
759	27. Dez 03	22. Jan 04	26	19. Apr 04	113	mittel

Tabelle 4. a-c: Wurfnummern der Hamster und Aufteilung auf die Käfiggruppen

1. Durchgang	**Einstreutiefe der Käfige**					
Wurf Nr. (Paarung ♀x♂)	**Tief** (80 cm)		**Mittel** (40 cm)		**Niedrig** (10 cm)	
	Gewicht	**KäfigNr.** *Tier Nr.*	Gewicht	**KäfigNr.** *Tier Nr.*	Gewicht	**KäfigNr.** *Tier Nr.*
89 (506x489)	Leicht 29,3 g	**31** *512*	Mittel 31,47 g	**11** *513*	Schwer 36,22 g	**6** *511*
86 (499x489)	Schwer 47,24 g	**33** *514*	Mittel 36,3 g	**22** *516*	Leicht 33,48 g	**50** *515*
85 (502x490)	Mittel 27,43 g	**19** *517*	Schwer 30,76 g	**37** *519*	Leicht 25,24 g	**1** *518*
87 (500x487)	Mittel 37,7 g	**17** *521*	Leicht 35,9 g	**35** *520*	Schwer 39,1 g	**36** *522*
88 (497x488)	Leicht 35,77 g	**18** *524*	Schwer 42,7 g	**24** *523*	Mittel 36,45 g	**39** *525*

2. Durchgang	**Einstreutiefe der Käfige**					
Wurf Nr. (Paarung ♀x♂)	**Tief** (80 cm)		**Mittel** (40 cm)		**Niedrig** (10 cm)	
	Klasse Gewicht	**KäfigNr.** *Tier Nr.*	Klasse Gewicht	**KäfigNr.** *Tier Nr.*	Klasse Gewicht	**KäfigNr.** *Tier Nr.*
105 (503x487)	Schwer 60.65 g	**33** *685*	Mittel 56.33 g	**11** *683*	Leicht 50.19g	**36** *684*
106 (505x491)	Schwer 58.81 g	**31** *680*	Leicht 36.63 g	**22** *679*	Mittel 58.06 g	**1** *681*
107 (499x490)	Mittel 41.5 g	**19** *687*	Schwer 43.90 g	**37** *686*	Leicht 39.13 g	**39** *688*
108 (497x489)	Leicht 34.91 g	**18** *698*	Mittel 46.56 g	**24** *699*	Schwer 48.15 g	**6** *700*
106/7/8	Mittel 43.07 g	**17** *682*	Leicht 37.61 g	**35** *701*	Schwer 49.96 g	**50** *689*

3. Durchgang	**Einstreutiefe der Käfige**					
Wurf Nr. (Paarung ♀x♂)	**Tief** (80 cm)		**Mittel** (40 cm)		**Niedrig** (10 cm)	
	Klasse Gewicht	**Käfig Nr.** *Tier Nr.*	Klasse Gewicht	**KäfigNr.** *Tier Nr.*	Klasse Gewicht	**KäfigNr.** *Tier Nr.*
118 / 116	Leicht 64,53g	**31** *736*	Mittel 85,10g	**22** *725*	Schwer 91,71g	**1** *726*
120 (715x490)	Schwer 43,18g	**19** *749*	Leicht 36,95g	**37** *750*	Mittel 43,04g	**50** *751*
119 (717x489)	Mittel 36,58g	**33** *737*	Leicht 32,07g	**24** *738*	Schwer 36,88g	**6** *739*
117 (713x490)	Mittel 47,56g	**17** *730*	Schwer 49,59g	**35** *731*	Leicht 47,45g	**36** *732*
121 (712x490)	Schwer 39,78g	**18** *758*	Mittel 36,68g	**11** *759*	Leicht 33,29g	**39** *760*

118 = 625x711; **116** = 633x710

Tabelle 5: Stressprotokoll

Tag		Einstreu 40 cm und 80 cm	Einstreu 10 cm
Tag 1			
		Graben von Hand, bis sicht-, hör- oder spürbare Bewegung (Hamster ist wach)	dito
	45 Minuten später	Hamster in Eimer mit Tuch gesetzt	dito
	3x im Abstand von 15 Minuten	Hamster in die Hand nehmen	dito
	Nach dem 3. Mal	Wägen Hamster wird zurückgesetzt Kotsammlung	dito
Tag 2			
		Wecken des Hamster (s. oben)	dito
		Käfig wird durch den Raum und wieder zurück geschoben (ca. 2 Min.)	-
		Klopfen an die Aussenwände des Käfigs	-
	45 Minuten später	Hamster durch Graben mit der Hand gestört	Hamster in eine Kiste gesetzt, herumgetragen, gewogen
		Radio im inneren Teil des Einsatzes mit geschlossenem Deckel, Radio für 5 Minuten laufen gelassen	5 Minuten Exposition Radio
		Erneutes Graben und Klopfen an die Käfigwände	dito, aber 45 Minuten später
		Einstreu eines fremden Hamsters um Futterschale gelegt (am nächsten Tag entfernt)	dito

Tabelle 6: Reihenfolge der Stressapplikation

Tier Nr.	Einstreutiefe	Datum	Tier Nr.	Einstreutiefe	Datum
513	mittel	16./17. Juni 2003	**736**	tief	8./9. März 2004
524	tief	16./17. Juni 2003	**738**	mittel	8./9. März 2004
512	tief	17./18. Juni 1003	**760**	niedrig	9./10. März 2004
520	mittel	17./18. Juni 1003	**739**	niedrig	9./10. März 2004
511	niedrig	18./19. Juni 2003	**725**	mittel	10./11. März 2004
515	niedrig	18./19. Juni 2003	**737**	tief	10./11. März 2004
518	niedrig	19./20. Juni 2003	**732**	niedrig	11./12. März 2004
525	niedrig	19./20. Juni 2003	**751**	niedrig	11./12. März 2004
517	tief	23./24. Juni 2003	**750**	mittel	15./16. März 2004
523	mittel	23./24. Juni 2003	**758**	tief	15./16. März 2004
516	mittel	24./25. Juni 2003	**730**	tief	16./17. März 2004
521	tief	24./25. Juni 2003	**759**	mittel	16./17. März 2004
514	tief	25./26. Juni 2003	**731**	mittel	17./18. März 2004
519	mittel	25./26. Juni 2003	**749**	tief	17./18. März 2004
522	niedrig	26./27. Juni 2003	**726**	niedrig	18./19. März 2004
682	tief	29./30. Oktober 2003			
699	mittel	29./30. Oktober 2003			
680	tief	30. September / 1. Oktober 2003			
686	mittel	30. September / 1. Oktober 2003			
683	mittel	1./2. Oktober 2003			
687	tief	1./2. Oktober 2003			
689	niedrig	2./3. Oktober 2003			
679	mittel	6./7. Oktober 2003			
698	tief	6./7. Oktober 2003			
685	tief	7./8. Oktober 2003			
701	mittel	7./8. Oktober 2003			
681	niedrig	8./9. Oktober 2003			
684	niedrig	8./9. Oktober 2003			
688	niedrig	9./10. Oktober 2003			
700	niedrig	9./10. Oktober 2003			

Tabelle 7. a Gesamtdauer der Verhaltensweisen in Video 1

Kruskal Wallis Tests, SE – standard error of the mean, NS = P > 0.05, N = 44

	DEEP (80 cm)		MEDIUM (40 cm)		LOW (10 cm)		χ^2	P <0.05
	mean	SE	mean	SE	mean	SE		
shelter / carton tube	173.66	127.737	86.851	63.128	205.809	91.691	-	-
running wheel	471.626	175.388	797.52	187.103	1018.32	178.632	6.031	0.049
cage lid	40.017	30.669	129.594	72.330	129.22	45.497	-	-
sandbath	75.557	30.880	67.134	18.717	44.269	11.452	-	-
feeding bowl	289.543	101.948	85.466	23.589	131.189	29.262	-	-
anywhere (else)	507.043	119.561	348.709	86.104	264.454	72.717	-	-
depth	212.417	97.563	123.929	88.201	5.39143	4.085	-	-
shelter (on top)	3.87143	3.871	5.143	3.031	0	0	-	-
moving	76.626	14.536	75.269	9.574	92.189	14.046	-	-
resting	80.689	13.480	153.58	40.043	134.886	16.058	-	-
head rearing	420.38	76.288	233.311	61.548	233.28	68.910	-	-
wheel-running	407.677	155.510	617.774	169.344	833.817	150.279	-	-
climbing	22.606	19.103	27.669	15.044	56.269	23.853	-	-
grooming	232.417	50.590	259.354	64.375	185.457	48.478	-	-
stretching	0	0	0.42	0.226	0.143	0.143	-	-
gnawing	6.954	5.184	1.214	0.866	0.569	0.441	-	-
stereotypical (wire) gnawing	0	0	3.143	3.143	25.797	22.153	-	-
occupation with food	181.969	47.250	85.994	23.571	135.623	34.767	-	-
drinking	9.714	7.112	5.357	5.357	0	0	-	-
digging	0.537	0.343	0.857	0.857	0.931	0.931	-	-
not visible	333.166	125.879	179.403	90.335	98.974	38.005	-	-

P = probability level; χ^2 und P -Werte nur angegeben, wenn signifikant

Tabelle 7. b Gesamtdauer der Verhaltensweisen in Video 2

Kruskal Wallis Tests, SE – standard error of the mean, NS = P > 0.05, N = 44

	DEEP (80 cm)		MEDIUM (40 cm)		LOW (10 cm)		χ^2	P <0.05
	mean	SE	mean	SE	mean	SE		
shelter / carton tube	88.8	54.917	71.191	46.421	74.232	30.424	-	-
running wheel	626.053	189.840	1042.61	173.642	1211.29	101.894	3.75 (F)	0.032
cage lid	10.392	8.815	34.034	14.595	119.629	91.006	7.8	0.020
sandbath	20.947	11.789	19.329	7.722	47.891	23.211	-	-
feeding bowl	257.392	65.858	164.569	40.773	138.973	22.68	-	-
anywhere (else)	400.147	115.222	296.772	74.429	208.12	43.223	-	-
depth	347.64	124.474	135.779	78.575	0	0	11.128	0.004
shelter (on top)	0	0	23.308	23.308	0	0	-	
moving	51.179	10.182	55.425	15.771	51.723	7.446	-	-
resting	194.971	83.786	137.911	32.322	100.956	14.097	-	-
head rearing	256.925	59.699	160.815	40.828	157.02	27.543	-	-
wheel-running	471.963	150.581	852.637	161.526	1014.75	95.426	4.31 (F)	0.020
climbing	4.072	3.319	24.132	14.117	23.843	13.792	-	-
grooming	119.12	41.382	209.668	55.0	200.04	47.023	-	-
stretching	0	0	0	0	0.957	0.751	-	-
gnawing	1.867	1.028	3.308	2.649	0.2	0.2	-	-
stereotypical (wire) gnawing	0	0	0	0	75.733	73.34	-	-
occupation with food	228.821	57.038	149.363	35.436	114.944	19.168	-	-
drinking	4.2	3.793	0	0	0.333	0.333	-	-
digging	1.2	0.952	0	0	0	0	-	-
not visible	416.453	132.578	192.025	85.083	44.421	22.373	-	-

P = probability level; χ^2 und P -Werte nur angegeben, wenn signifikant

Tabelle 7. c Gesamtdauer der Verhaltensweisen im Stressvideo

Kruskal Wallis Tests, SE – standard error of the mean, NS = P > 0.05, N = 44

	DEEP (80 cm)		MEDIUM (40 cm)		LOW (10 cm)		χ^2	P <0.05
	mean	**SE**	**mean**	**SE**	**mean**	**SE**		
shelter / carton tube	118.467	67.715	38.443	15.169	90.485	30.214	-	-
running wheel	832.92	192.549	1158.08	151.697	1223.85	120.035	-	-
cage lid	24.429	16.566	70.492	38.367	90.344	51.743	-	-
sandbath	69.483	34.028	49.963	18.152	51.093	15.593	-	-
feeding bowl	273.848	70.079	102.935	35.978	168.58	43.765	-	-
anywhere (else)	359.123	81.535	344.311	101.313	160.293	28.745	-	-
depth	77.725	31.617	28.046	20.952	0	0	12.94	0.002
shelter (on top)	6.667	6.667	0	0	13.6	13.6	-	-
moving	76.581	11.124	65.674	11.503	62.856	11.007	-	-
resting	147.637	34.671	133.689	27.063	145.26	13.772	-	-
head rearing	265.219	73.558	152.991	53.356	178.018	52.361	-	-
wheel-running	646.291	164.585	955.139	127.978	1005.24	105.725	-	-
climbing	17.365	16.392	16.462	10.468	28.723	19.624	-	-
grooming	235.888	48.144	304.102	46.964	176.421	25.624	-	-
stretching	0	0	0.212	0.212	0.363	0.196	-	-
gnawing	0	0	1	0.698	0.347	0.347	-	-
stereotypical (wire) gnawing	0	0	18.923	18.923	18.267	18.267	-	-
occupation with food	242.808	62.452	83.859	29.1	141.135	39.787	-	-
drinking	0	0	0	0	0	0	-	-
digging	1.067	1.067	0	0	0.187	0.133	-	-
not visible	153.272	52.206	52.372	20.266	39.965	14.443	-	-

P = probability level; χ^2 und P -Werte nur angegeben, wenn signifikant

Tabelle 7. d Gesamtdauer der Verhaltensweisen in Video 3

Kruskal Wallis Tests, SE – standard error of the mean, NS = P > 0.05, N = 44

	DEEP (80 cm)		MEDIUM (40 cm)		LOW (10 cm)		χ^2	P <0.05
	mean	**SE**	**mean**	**SE**	**mean**	**SE**		
shelter / carton tube	45.4	26.189	106.463	58.388	71.939	38.628	-	-
running wheel	1027.53	189.767	1064.14	157.601	1060.88	122.490	-	-
cage lid	0.2	0.2	41.1	26.786	18.731	12.1	6.152	0.046
sandbath	12.957	5.49	27.2	8.585	59.485	21.625	-	-
feeding bowl	188.595	64.78	203.46	43.08	145.437	36.234	-	-
anywhere (else)	327.696	102.066	216.077	63.395	368.947	73.163	-	-
depth	184.333	92.043	118.791	82.349	0	0	7.035	0.03
shelter (on top)	0	0	9.643	6.999	1.283	1.283	-	-
moving	42.112	9.91	61.503	12.055	42.837	6.66	-	-
resting	115.005	21.591	142.263	28.762	134.576	26.977	-	-
head rearing	226.752	69.769	215.694	55.048	168.645	33.626	-	-
wheel-running	829.624	164.464	838.926	132.805	912.248	111.951	-	-
climbing	0	0	14.5	10.961	13.379	11.961	-	-
grooming	223.733	59.893	171.311	37.654	300.96	66.978	-	-
stretching	0	0	0.589	0.446	1.461	0.698	-	-
gnawing	0	0	0	0	0.6	0.476	-	-
stereotypical (wire) gnawing	0	0	2.571	2.571	0.133	0.133	-	-
occupation with food	142.288	43.773	164.597	30.344	124.973	32.565	-	-
drinking	0	0	0.5	0.5	0	0	-	-
digging	0.2	0.2	0	0	0.8	0.8	-	-
not visible	206.333	108.450	173.277	84	24.816	11.38	-	-

P = probability level; χ^2 und P -Werte nur angegeben, wenn signifikant

Tabelle 8: Prozentanteile der einzelnen Verhaltensweisen in den Videoaufnahmen

Video 1

	DEEP	LOW	MEDIUM
occupation with food	10.26%	7.54%	5.23%
stereotypic gnawing	0.00%	1.43%	0.19%
digging	0.03%	0.05%	0.05%
climbing	1.28%	3.13%	1.68%
moving	4.32%	5.13%	4.58%
wheel-running	23.00%	46.38%	37.59%
gnawing	0.39%	0.03%	0.07%
not visible	18.79%	5.50%	10.92%
grooming	13.11%	10.32%	15.78%
resting	4.55%	7.50%	9.35%
head rearing	23.71%	12.97%	14.20%
stretching	0.00%	0.01%	0.03%
drinking	0.55%	0.00%	0.33%

Video 2

	DEEP	LOW	MEDIUM
occupation with food	13.07%	6.44%	8.37%
stereotypic gnawing	0.00%	4.24%	0.00%
digging	0.07%	0.00%	0.00%
climbing	0.23%	1.34%	1.35%
moving	2.92%	2.90%	3.10%
wheel-running	26.96%	56.85%	47.76%
gnawing	0.11%	0.01%	0.19%
not visible	23.79%	2.49%	10.76%
grooming	6.80%	11.21%	11.74%
resting	11.14%	5.66%	7.72%
head rearing	14.67%	8.80%	9.01%
stretching	0.00%	0.05%	0.00%
drinking	0.24%	0.02%	0.00%

Video stress

	DEEP	LOW	MEDIUM
occupation with food	13.59%	4.70%	7.85%
stereotypic gnawing	0.00%	1.06%	1.02%
digging	0.06%	0.00%	0.01%
climbing	0.97%	0.92%	1.60%
moving	4.29%	3.68%	3.50%
wheel-running	36.18%	53.53%	55.95%
gnawing	0.00%	0.06%	0.02%
not visible	8.58%	2.93%	2.22%
grooming	13.21%	17.04%	9.82%
resting	8.27%	7.49%	8.08%
head rearing	14.85%	8.57%	9.91%
stretching	0.00%	0.01%	0.02%
drinking	0.00%	0.00%	0.00%

Video 3

	DEEP	LOW	MEDIUM
occupation with food	7.97%	7.24%	9.22%
stereotypic gnawing	0.00%	0.01%	0.14%
digging	0.01%	0.05%	0.00%
climbing	0.00%	0.78%	0.81%
moving	2.36%	2.48%	3.44%
wheel-running	46.45%	52.87%	46.98%
gnawing	0.00%	0.03%	0.00%
not visible	11.55%	1.44%	9.70%
grooming	12.53%	17.44%	9.59%
resting	6.44%	7.80%	7.97%
head rearing	12.70%	9.77%	12.08%
stretching	0.00%	0.08%	0.03%
drinking	0.00%	0.00%	0.03%

Tabelle 9: Korrelationen der Verhaltensweisen

a)

	shelter		running wheel		cage lid		sandbath		feeding bowl		anywhere	
	r	P	r	P	r	P	r	P	r	P	r	P
anywhere	-	-	-0.556	0.0001	-	-	-	-	-	-	-	-
depth	-	-	-0.604	0.00002	-0.299	0.052	-	-	0.407	0.007	0.349	0.022
on top of the shelter	-	-	-	-	0.366	0.016	0.255	0.099	-	-	-	-
moving	0.316	0.039	-	-	-	-	0.430	0.004	-	-	0.385	0.011
resting	-	-	0.293	0.056	0.355	0.019	-	-	-	-	-	-
head rearing	0.406	0.007	-0.571	0.00006	-	-	-	-	0.402	0.006	0.627	0.00001
wheel-running	-	-	0.953	0.0000	-	-	-	-	-0.336	0.028	-0.50	0.001
climbing	-	-	-	-	0.862	0.0000	-	-	-	-	-	-
grooming	-	-	-	-	0.369	0.015	-	-	-	-	-	-
stretching	-	-	-	-	0.459	0.002	-	-	-	-	-	-
gnawing	0.307	0.045	-	-	-	-	-	-	0.260	0.092	-	-
wire-gnawing	0.304	0.047	-	-	0.469	0.002	-	-	-	-	-	-
feeding behaviour	-	-	-0.345	0.024	-	-	-	-	0.932	0.0000	0.315	0.040
digging	0.308	0.044	-	-	-	-	-	-	-	-	-	-
not visible	0.368	0.015	-0.633	0.00001	-	-	-	-	0.316	0.040	0.328	0.032

b)

	climbing		grooming		stretching		gnawing		wire gnawing		occupation with food		digging	
	r	P	r	P	r	P	r	P	r	P	r	P	r	P
depth	-	-	-	-	-	-	-	-	-	-	0.42	0.005	-	-
on top of the shelter	0.39	0.009	-	-	-	-	-	-	-	-	-	-	-	-
resting	0.36	0.016	-	-	-	-	-	-	-	-	-	-	-	-
head rearing	-	-	-	-	-	-	0.39	0.009	-	-	0.48	0.001	-	-
wheel-running	-	-	-	-	-	-	-	-	-	-	-0.41	0.007	-	-
climbing	-	-	0.29	0.055	0.37	0.016	-	-	0.29	0.052	-	-	-	-
grooming	0.29	0.055	-	-	-	-	-	-	-	-	-	-	-	-
stretching	0.37	0.016	-	-	-	-	-	-	-	-	-	-	-	-
gnawing	-	-	-	-	-	-	-	-	-	-	-	-	0.33	0.028
wire-gnawing	0.29	0.052	-	-	-	-	-	-	-	-	-	-	-	-

c)

	depth		moving		head rearing		wheel-running		climbing		feeding behaviour	
	r	P	r	P	r	P	r	P	r	P	r	P
not visible	0.760	0.0000	0.414	0.006	0.446	0.003	-0.587	0.00004	-0.295	0.054	0.346	0.023

r = Regressionskoeffizient; P = probability level; Werte nur angegeben, wenn signifikant

Tabelle 10: Tägliche Laufradumdrehungen: Mittelwerte und Standardfehler

One way ANOVA, SE – standard error of the mean, NS = P > 0.05, N = 44

	Tief		**Mittel**		**Niedrig**		**F**	**p<0.05**
	MW	**SE**	**MW**	**SE**	**MW**	**SE**		
vor dem Stress	2977.858	945.458	6438.37	1115.68	13174.59	1801.251	16.95	0.000004
nach dem Stress	5447.96	1254.666	8671.941	1645.797	16010.4	1038.799	17.12	0.000004
2 Tage davor	3181.248	1174.384	7865.743	1955.538	15221.76	1613.838	14.77	0.00002
nur Stresstage	5435.856	1538.744	6794.177	1675.914	15324.29	1505.171	11.82	0.0001
2 Tage danach	5920.08	1696.5	6964.406	1751.365	16161.55	1367.278	12.46	0.0001

Tabelle 11: Korrelationen der Organe mit der Laufradaktivität

	TÄGLICHE UMDREHUNGEN VOR STRESS		TÄGLICHE UMDREHUNGEN NACH STRESS	
Körpergewicht Ende	-0.410	0.006	-0.540	0.0002
Länge Ende	-	-	-	-
Kondition	-0.359	0.018	-0.458	0.002
Herz relativ	0.460	0.002	0.591	0.00003
Leber relativ	-	-	-	-
Milz relativ	0.378	0.013	0.311	0.042
Niere relativ	0.359	0.018	0.452	0.002
Nebenniere relativ	-	-	0.370	0.015
Hoden relativ	0.360	0.018	0.453	0.002
NH relativ	-	-	-	-

oberer Wert in der Zelle: Regressionskoeffizient (r); unterer Wert: probability level (P)
r und P -Werte nur angegeben, wenn signifikant

Tabelle 12: Körpermasse, Hormonlevel, relative Organgewichte und Euthanasiedaten

One way ANOVA und Kruskal Wallis Tests, SE – standard error of the mean, NS = P > 0.05, N = 44

	TIEF		**MITTEL**		**NIEDRIG**		**F / χ^2**	**p<0.05**
	MW	**SE**	**MW**	**SE**	**MW**	**SE**	**-**	
Absetzgewicht	43.201	2.839	42.994	3.787	44.563	4.003	-	-
Endgewicht	135.019	3.793	125.688	4.383	121.389	3.117	6.513	0.039
Körperlänge	16.807	0.01	16.593	0.144	16.693	0.11	-	-
Kondition	0.029	7.831 E-04	0.028	6.848 E-04	0.206	5.231 E-04	3.25	0.049
Herz (rel.)	3.569	0.119	3.441	0.288	4.054	0.084	8.287	0.016
Leber (rel.)	41.382	0.809	43.836	0.711	43.794	0.761	3.42	0.042
Milz (rel.)	0.616	0.028	0.651	0.039	0.646	0.064	-	-
Nieren (rel.)	3.001	0.085	3.095	0.074	3.344	0.065	5.67	0.007
Nebennieren (rel.)	0.104	0.006	0.111	0.007	0.112	0.005	-	-
Hoden (rel.)	11.455	0.426	12.737	0.291	12.387	0.363	3.25	0.049
Nebenhoden (rel.)	2.34	0.085	2.27	0.215	2.353	0.219	-	-
Corticosteron	36.607	4.375	32.493	6. 273	29.127	3.595	-	-
Cortisol	30.66	11.194	16.25	4.364	11.233	3.641	-	-
Cortisol/Corticost.	0.655	0.151	0.595	0.17	0.336	0.058	-	-
Testosteron	24.667	5.249	29.571	5.13	17.933	2.829	-	-
ACTH	63.333	12.052	31.857	4.982	21.467	5.848	11.327	0.004
Dauer Einfangen (s)	164.519	18.807	112.303	21.858	114.331	26.479	5.758	0.056
Dauer Narkose (s)	152	29.78	180	70.602	124	22.271	-	-
Gesamtdauer	316.519	44.443	292.303	84.982	238.331	45.169	-	-

P = probability level; χ^2 und P -Werte nur angegeben, wenn signifikant

Tabelle 13: Korrelationen der Organe und Hormone

	KOERPER-GEWICHT (ENDE)		LÄENGE (ENDE)		KONDITION		HERZ		LEBER		MILZ	
Körpergewicht Ende	-	-	0.542	0.0002	0.721	0.0000	-0.277	0.072	-	-	-	-
Körperlänge Ende	-	-	-	-	-0.138	0.377	-	-	-	-	0.480	0.001
Kondition	-	-	-	-	-	-	-	-	-	-	-0.378	0.013
Leber	-	-	-	-	-	-	-	-	-	-	0.306	0.046
Niere	-0.332	0.030	-	-	-0.383	0.011	0.357	0.019	0.436	0.003	-	-
Nebenniere	-	-	-	-	-	-	0.329	0.031	0.433	0.004	-	-
Hoden relativ	-0.369	0.015	-	-	-	-	-	-	-	-	-	-
Nebenhoden relativ	-	-	-0.384	0.011	-	-	-	-	-	-	-	-
Cortison	-	-	-	-	-0.358	0.019	-	-	-	-	0.324	0.034
Cortison / Corticosteron	-	-	0.300	0.050	-0.349	0.022	-	-	-	-	0.331	0.030
ACTH	0.297	0.054	-	-	0.402	0.008	-0.293	0.057	-	-	-	-

	NIERE		NNIEREN		HODEN		NHODEN		CORTICO-STERON		CORTISON	
Nebenniere	0.418	0.005	-	-	-	-	-	-	-	-	-	-
Hoden	-	-	0.443	0.003	-	-	-	-	-	-	-	-
Nebenhoden	-	-	0.406	0.007	0.517	0.0004	-	-	-	-	-	-
Cortisol	-	-	-	-	-	-	-0.327	0.032	0.597	0.0000	-	-
Cortison / Corticosteron	-	-	-	-	-	-	-0.294	0.056	-	-	0.887	0.0000
ACTH	-0.399	0.008	-	-	-	-	-	-	-	-	-	-

oberer Wert in der Zelle: Regressionskoeffizient (r); unterer Wert: probability level (P)
r und P -Werte nur angegeben, wenn signifikant

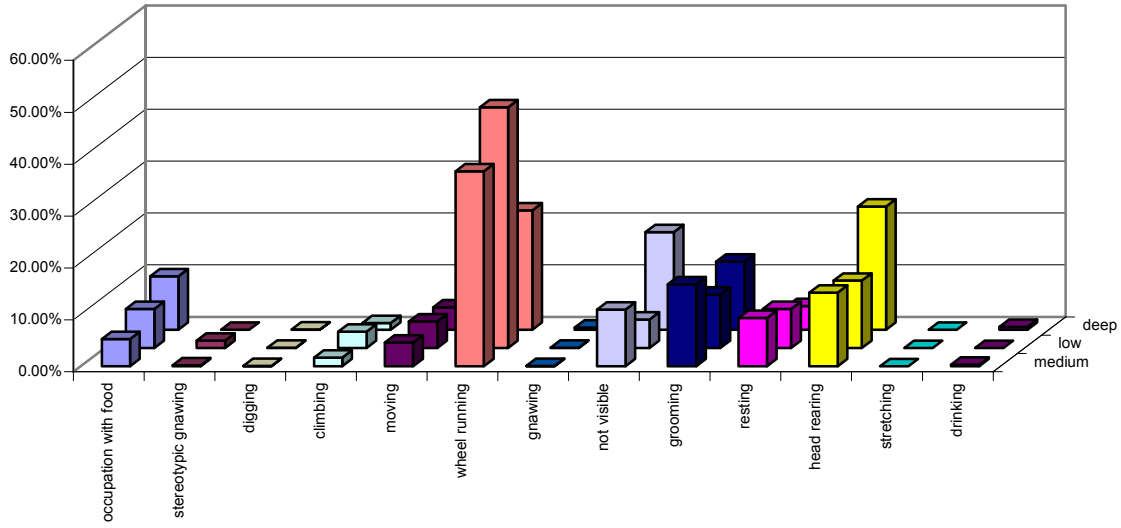
Tabelle 14: Korrelationen der Hormone mit Zeit für Einfangen, Narkose und Gesamtstörung

	EINFANGEN (SEC)		NARKOSE (SEC)		GESAMT-DAUER (SEC)	
Corticosteron	0.314	0.040	0.366	0.016	0.481	0.001
Cortison	0.643	0.000003	0.605	0.00002	0.686	0.000001
Cortisol/ Corticosteron	0.610	0.00001	0.572	0.0001	0.620	0.00001
Testosteron	-		-		-	
ACTH	-		-		-	

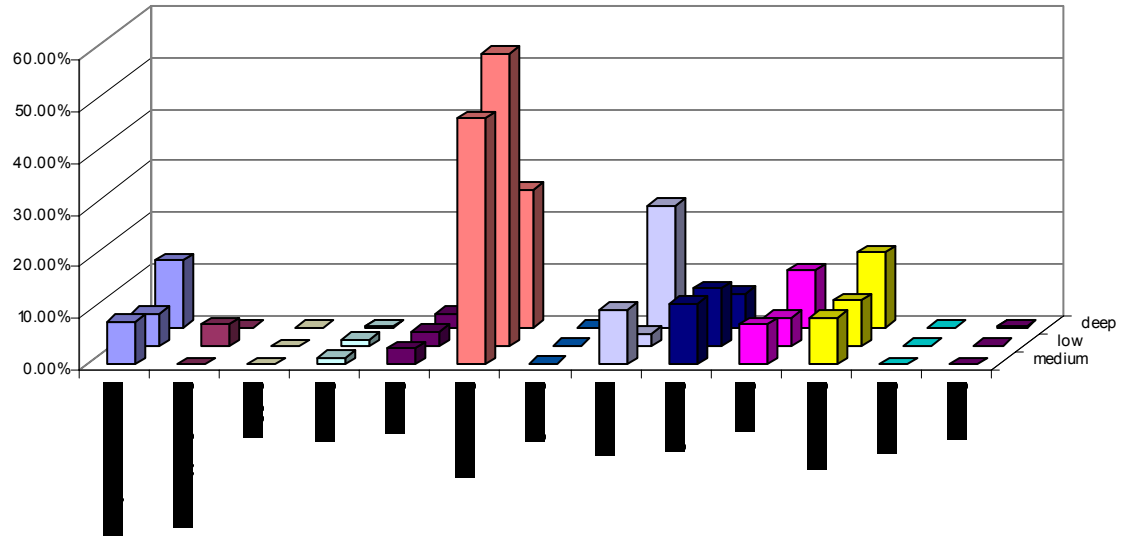
oberer Wert in der Zelle: Regressionskoeffizient (r); unterer Wert: probability level (P)
r und P -Werte nur angegeben, wenn signifikant

6.4 zusätzliche Grafiken

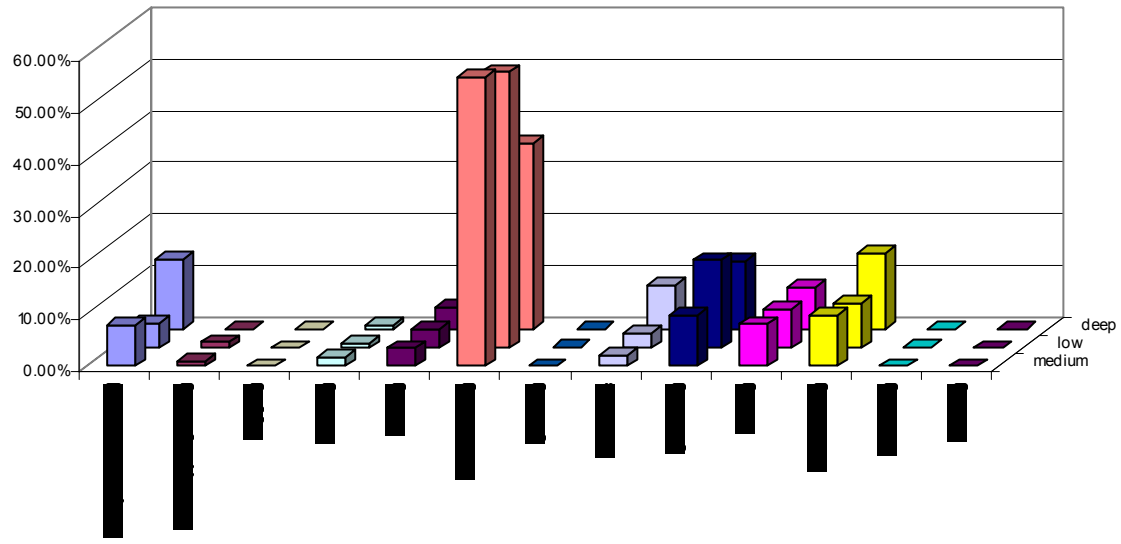
Figur 1a: Prozentanteile der Verhaltensweisen in Video 1



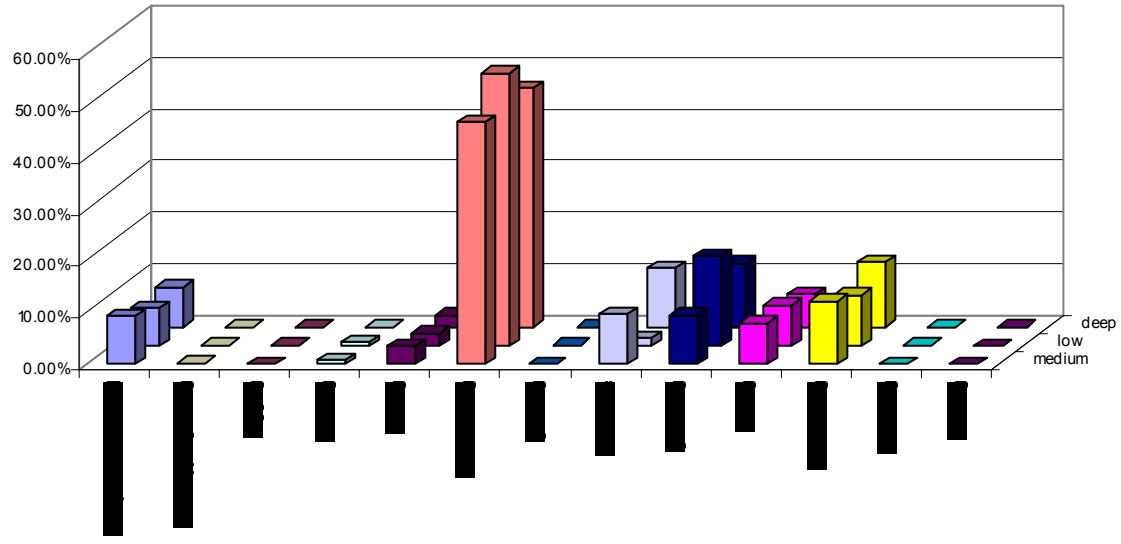
Figur 1b: Prozentanteile der Verhaltensweisen in Video 2



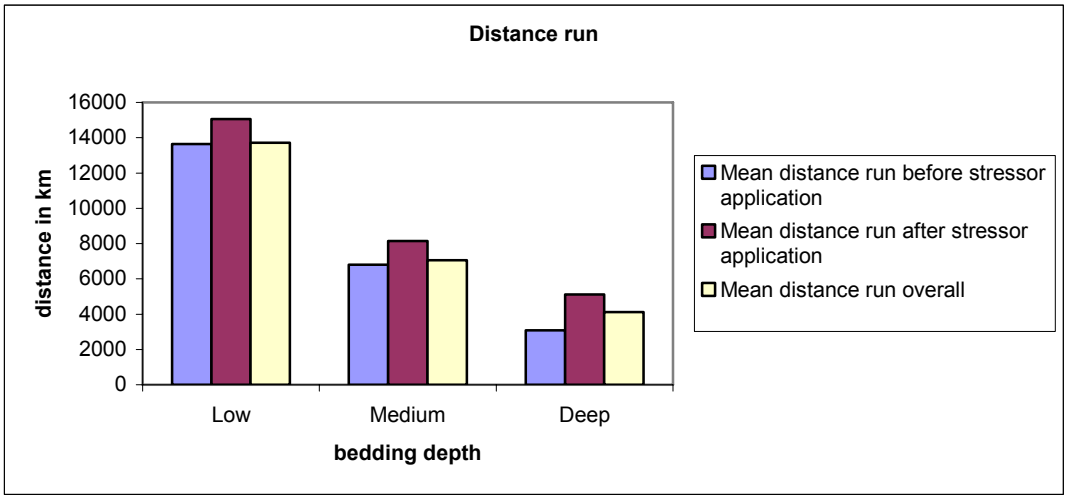
Figur 1c: Prozentanteile der Verhaltensweisen im Stressvideo



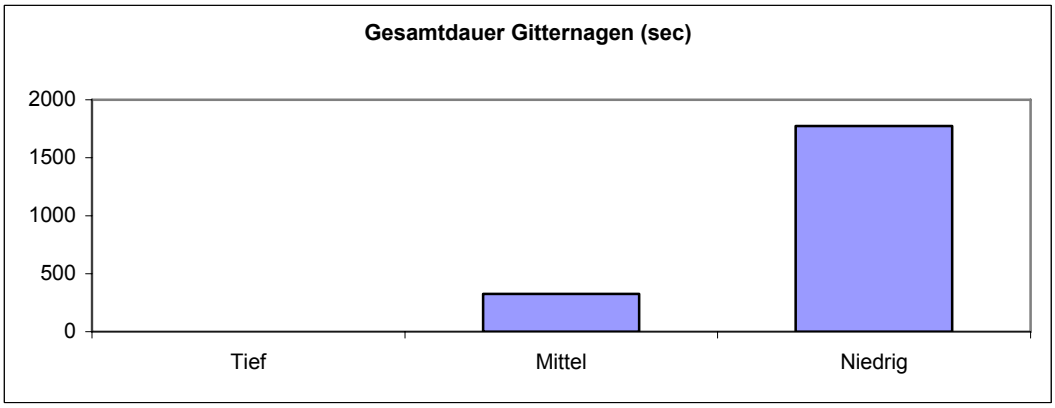
Figur 1d: Prozentanteile der Verhaltensweisen in Video 3



Figur 2: Laufleistung als berechnete Distanz in m

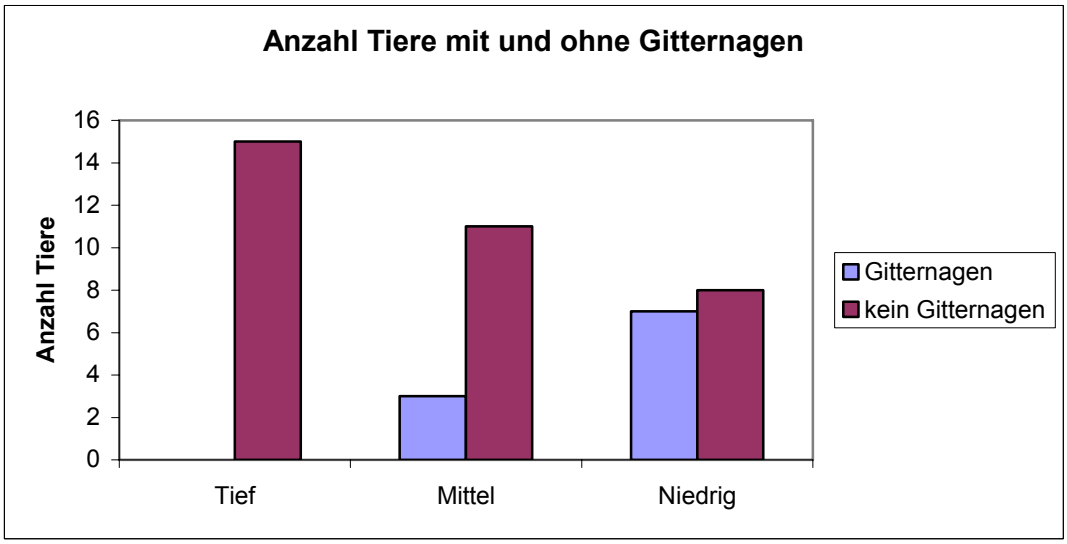


Figur 3: Gesamtdauer Gitternagen in den einzelnen Tiefen



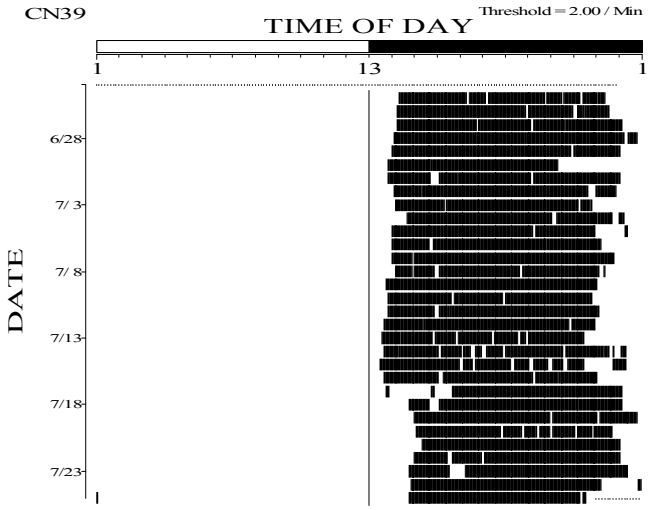
Kruskal Wallis: χ^2=9.599, DF=2, P=0.008

Figur 4: Anzahl Tiere pro Gruppe, Gitternager im Vergleich zu nicht Gitternager

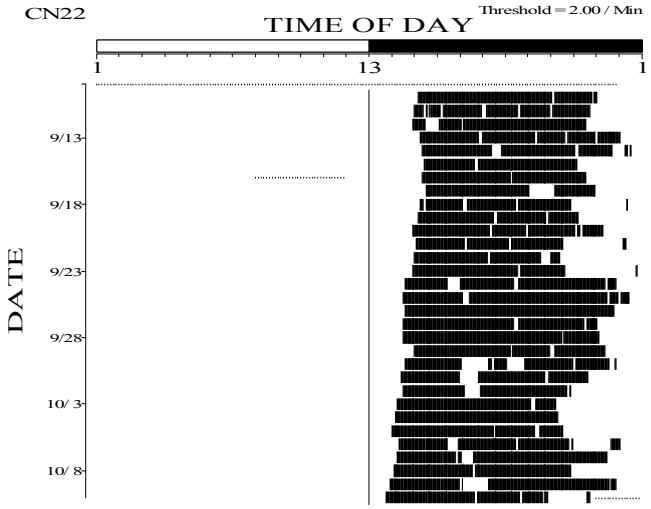


Fisher's Exact Test: n=44, P=0.0059

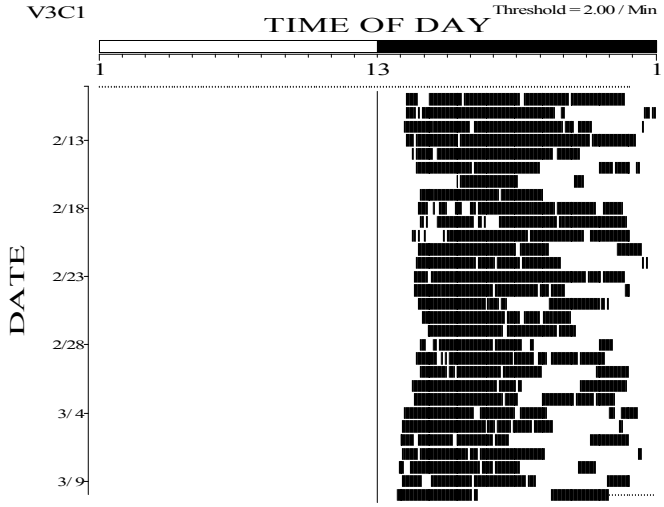
Figur 5: Ausschnitt aus je einem Actogramm der kleinen Gruppe (Einstreutiefe = 10 cm) von jedem Durchgang



Actogramm Tier Nr. 525 Durchgang 1

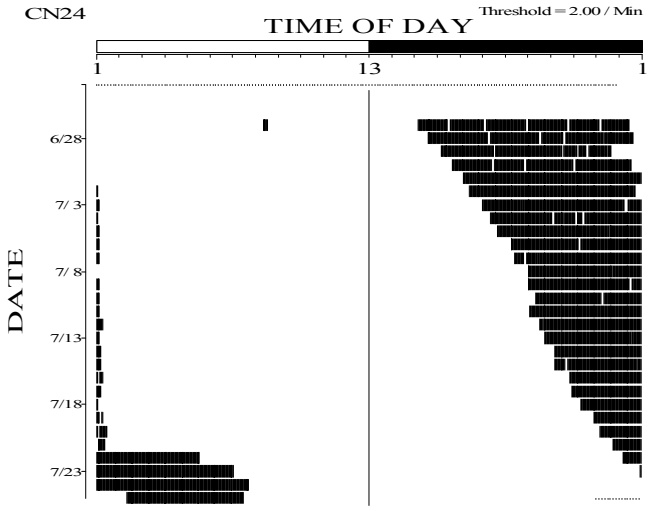


Actrogramm Tier Nr. 700 Durchgang 2

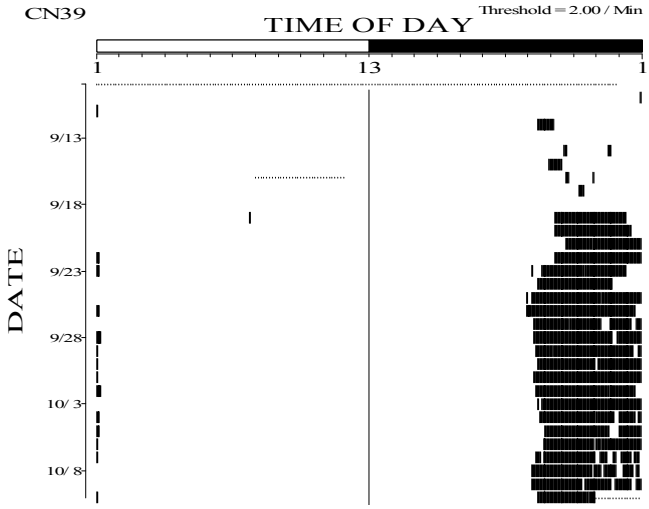


Actogramm Tier Nr. 726 Durchgang 3

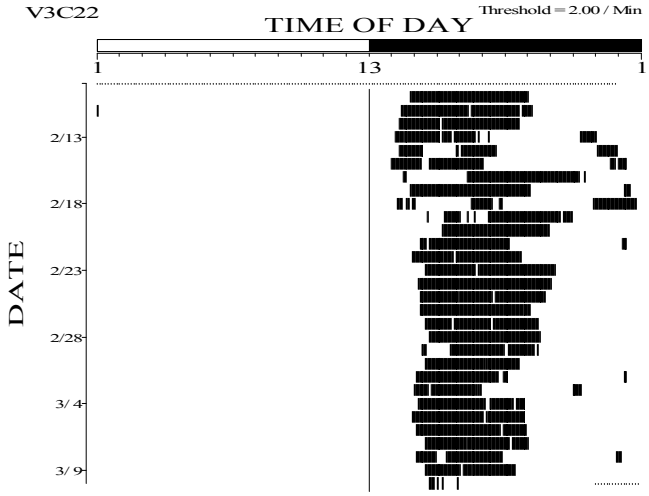
Figur 6: Ausschnitt aus je einem Actogramm der mittleren Gruppe (Einstreutiefe = 40 cm) von jedem Durchgang



Actogramm Tier Nr. 523 Durchgang 1

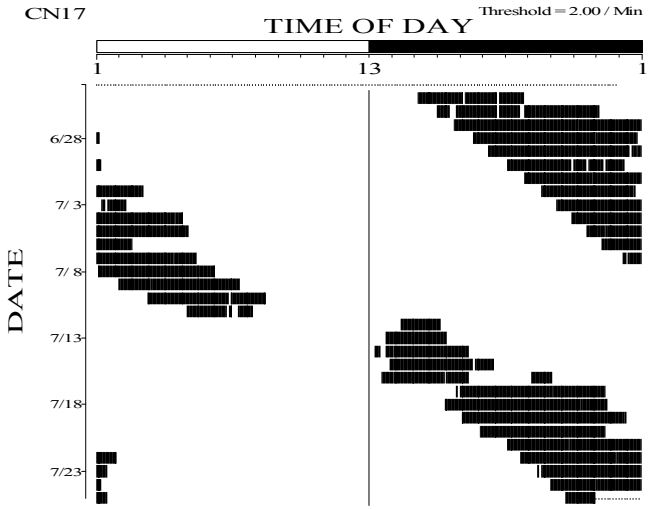


Actogramm Tier Nr. 701 Durchgang 2

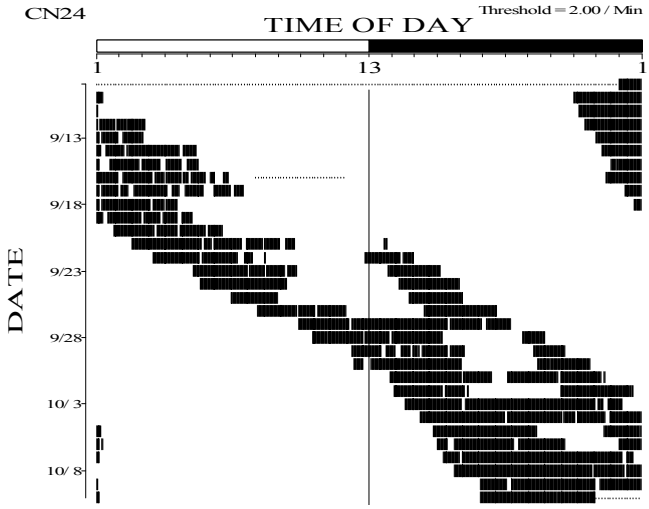


Actogramm Tier Nr. 725 Durchgang 3

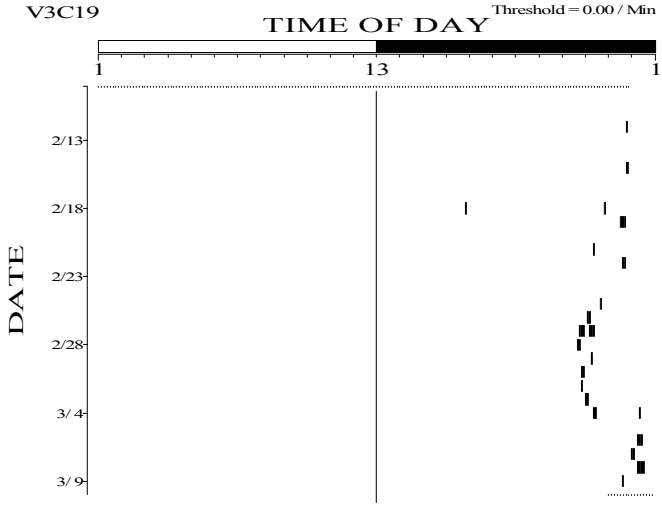
Figur 7: Ausschnitt aus je einem Actogramm der tiefen Gruppe (Einstreutiefe = 80 cm) von jedem Durchgang



Actogramm Tier Nr. 521 Durchgang 1

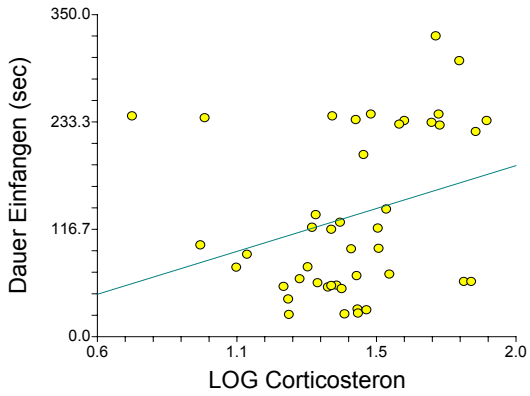


Actogramm Tier Nr. 680 Durchgang 2

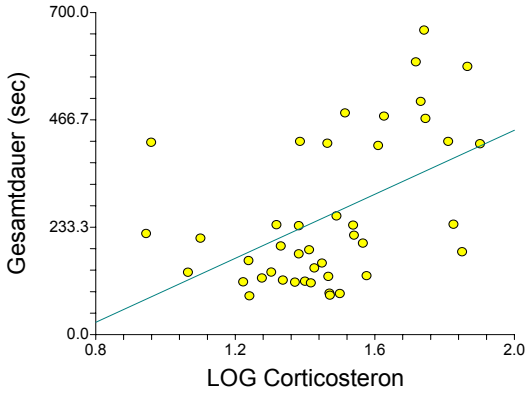


Actogramm Tier Nr. 737 Durchgang 3

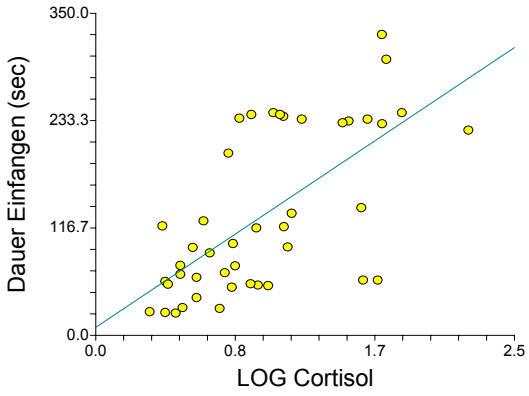
Figur 8 a : Korrelation von Corticosteron mit der Dauer des Einfangens der Hamster



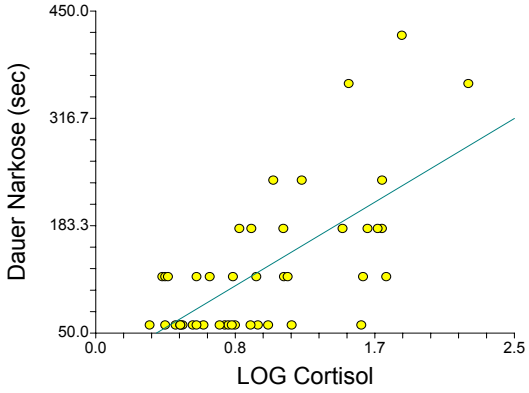
Figur 8 b : Korrelation von Corticosteron mit der Gesamtdauer der Störung bis zur Betäubung



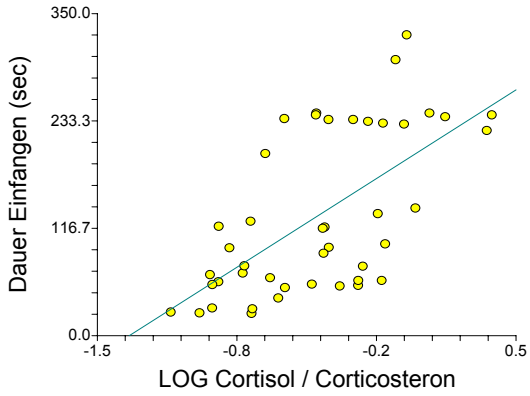
Figur 8 c : Korrelation von Cortisol mit der Dauer des Einfangens der Hamster



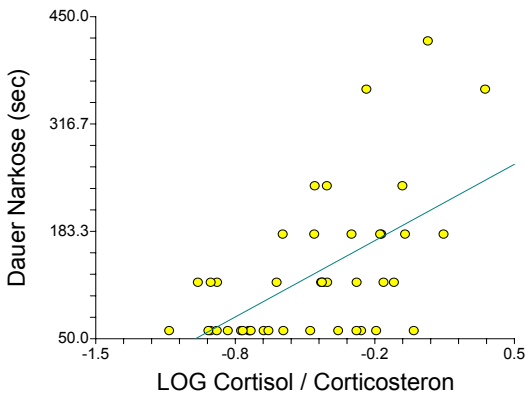
Figur 8 d : Korrelation von Cortisol mit der Dauer der Narkose



Figur 8 e : Korrelation der Cortisol / Corticosteron Ratio mit der Dauer des Einfangens der Hamster



Figur 8 f : Korrelation der Cortisol / Corticosteron Ratio mit der Dauer der Narkose



6.5 Abbildungen

Abb. 1: Anordnung der Käfige im Raum

Abb. 2: tiefer Käfig (80 cm Einstreu)

Abb. 3: mittlerer Käfig (40 cm Einstreu)

Abb. 4: niedriger Käfig (10 cm Einstreu)

Abb. 5: Einsatz aus Plexiglas, um die zwei grösseren Käfigtiefen zu erreichen

Abb. 6: Einstreuhaufen eines Hamsters, der sich einen Gang angelegt hat

Abb. 7: schlafender Hamster in seiner Nestkammer, Gänge sind zu erkennen

Abb. 8: Hamster in seiner Nestkammer

6.6 Danksagungen

Viele Personen haben mitgewirkt, dass dieses Projekt einen erfolgreichen Abschluss gefunden hat. Einige möchte ich namentlich erwähnen, obwohl ich mir bewusst bin, dass ich nicht alle werde nennen können, die irgendetwas zum Gelingen des Projektes beigetragen haben!

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Prof. **Rolf Gattermann** für seine Weitergabe an Erfahrung. Der Besuch bei seinen Hamstern in Halle/D hat uns einen guten Einblick in die Arbeit mit Goldhamstern verschafft und war überaus interessant und instruktiv.

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und natürlich meiner Familie, insbesondere meinem Verlobten **André Zbinden**, der toleriert hat, dass manchmal auch Arbeit zu Hause nach „Feierabend“ erledigt wurde. Sie alle haben mich immer unterstützt und reges Interesse an meiner Arbeit gezeigt.

allen anderen, die dieses Projekt in irgendeiner Art und Weise unterstützt haben, sei es durch Sammeln von Haushaltspapierröhren, Hilfe in der statistischen Auswertung oder durch moralische Unterstützung!