Fig. 2. Estimated demand curves in the phase with food.

DIERGERICHT ONTWERPEN
Wat willen de dieren zelf?

B. Beerda & I.C. de Jong

Kader van dit rapport

Dit rapport is één van de producten van het onderzoeksproject Diergericht Ketenontwerp (DKO). DKO is een van de onderdelen van het LNV-onderzoeksprogramma Nieuwe Veehouderijsystemen.

Het programma Nieuwe Veehouderijsystemen
In dit programma (1999-2003) wordt gewerkt aan systeeminnovatie in de veehouderij. De aansturing en uitvoering vindt grotendeels plaats in samenwerkingsverbanden tussen onderzoeksgroepen en belanghebbenden (stakeholders) uit de veehouderijketen en betrokken maatschappelijke organisaties.

Het project Diergericht ketenontwerp
DKO (2001-2003) heeft als doelstelling om een dierhouderij te ontwerpen waarin het welzijn van dieren gewaarborgd is. Uitgaande van de behoeften van de dieren is een programma van eisen opgesteld. Vanuit die eisen kan dan ontworpen worden. Oplossingen hoeven daarbij in eerste instantie niet 'mooi' of 'natuurlijk' of publieksvriendelijk te zijn. Tevreden dieren is het streven. Vervolgens wordt het dierenwelzijnsgerichte resultaat geëvalueerd op kansen en bedreigingen vanuit de invalshoeken economie, milieu en voedselveiligheid. De ontvlechting van het dierbelang en andere wenselijke zaken helpt het maatschappelijke debat in het vinden van de balans tussen diergebruik (voedselproductie) en het respecteren van dierbelangen.

De DKO-activiteiten zijn grotendeels uitgevoerd bij de Wageningen-UR organisaties ID-Lelystad, IMAG en LEI, met procesondersteuning vanuit het bestuurscentrum. De Nederlandse Vereniging tot Bescherming van Dieren is opgetreden als 'trekkende stakeholder'. Andere bij het project betrokken keten- en maatschappelijke organisaties zijn LTO, NAJK, SKOVAR, PVE, Nutreco, IPG en Dumeco Breeding.

De belangrijkste resultaten zijn vastgelegd in een serie rapporten met de volgende titels
1. DIERGERICHT ONTWERPEN: 50 jaar varkenshouderij in Nederland [IMAG-2003-04]
2. DIERGERICHT ONTWERPEN: Behoeften van vleesvarkens [IMAG-2003-05]
3. DIERGERICHT ONTWERPEN: Methodisch in plaats van intuïtief naar een ontwerp voor een diervriendelijk houderijsysteem [IMAG-2003-06]
4. DIERGERICHT ONTWERPEN: Van programma van eisen naar voorbeeldontwerp voor een welzijnsvriendelijke vleesvarkenshouderij [IMAG-2003-07]
5. DIERGERICHT ONTWERPEN: Verbetering van de aansluiting tussen dier en omgeving door fokken op welzijn? [Dossier fokken op welzijn, ID-Lelystad, ID03/3556]
6. DIERGERICHT ONTWERPEN: Wat willen de dieren zelf? [ID-Lelystad, ID03/3561]
7. DIERGERICHT ONTWERPEN: Consumentenwensen rond dierenwelzijn [LEI/ID-Lelystad, ID03/3557]
8. DIERGERICHT ONTWERPEN: Relaties van welzijneisen met milieu, economie en voedselveiligheid [IMAG/ID-Lelystad IMAG-2003-08]

Daarnaast is de informatie samengevat te vinden in de toegankelijke brochure *Welzwijn in de toekomst. Over varkenswensen voor varkensstallen* [Wageningen-UR, ISBN 90 6754 677 1]

Informatie over het project DKO vindt u op www.vsys.nl/DKO of bij Marijke de Jong (Dierenbescherming, Marijke.de.Jong@dierenbescherming.nl) of Karel de Greef (ID-Lelystad, Karel.deGreef@wur.nl). Op www.vsys.nl/DKO staan de producten ook als download.
Informatie over het programma Nieuwe Veehouderijsystemen kunt u aantreffen op www.vsys.nl of bij de programmaleider Sierk Spoelstra (Sierk.Spoelstra@wur.nl).

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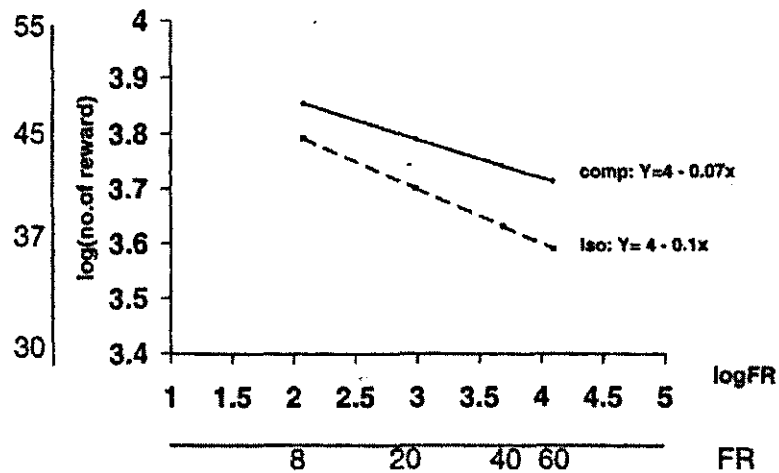
DIERGERICHT ONTWERPEN

Wat willen de dieren zelf?

Fig. 2. Estimated demand curves in the phase with food.

The assessment of motivation in chickens and pigs

B. Beerda and I.C. de Jong

Nederlandse samenvatting

Het meten van motivaties om specifieke gedragingen uit te voeren draagt bij aan de beoordeling van dierenwelzijn. Dierexperimenteel onderzoek op basis van operante conditionering technieken, waaronder de 'consumer-demand' methode, en keuze testen richten zich op het meten van motivatie en geven inzicht in hoe aspecten van de leefomgeving door dieren worden ervaren en welke waarde ze hechten aan het kunnen uitvoeren van gedrag. Net als andere onderzoeksmethoden hebben operante conditionering technieken en keuze testen haken en ogen met betrekking tot de interpretatie van de bevindingen. Er zijn de nodige factoren beschreven die onderzoeksresultaten, ongewenst, kunnen beinvloeden, en hier kan rekening mee worden gehouden bij het ontwerp van experimentele designs. De motivaties van dieren zijn niet constant, en worden bijvoorbeeld direct beinvloedt door de omgeving waaronder ze worden gemeten. Dit compliceert de interpretatie van de metingen, en liefst worden verschillende onderzoeksaanpakken of kennisbronnen gecombineerd om tot een uitspraak te komen over het welzijn van dieren. Operante conditionering studies en keuze testen geven dus niet automatisch uitsluitsel bij welzijnsvragen, maar kunnen substantieel bijdragen aan de beantwoording ervan.

Er zijn de nodige operante conditionering studies en keuze testen gedaan met kippen en varkens, maar het zijn met name de kennisleemtes en onbeantwoorde vragen die opvallen. Deels doordat studies vaak moeilijk te vergelijken blijken, waardoor het nauwelijks mogelijk is om motivaties die in verschillende studies zijn onderzocht te rangschikken naar importantie. Uit het beschikbare onderzoek komt naar voren dat voor kippen onder meer substraat, zitstokken en, op bepaalde tijdstippen, nestboxen belangrijk zijn. Behoefte aan ruimte lijkt afhankelijk van het type gedragspatroon dat de dieren tonen. De interactie tussen de waardering van omgevingsfactoren en het gedrag dat de dieren uitvoeren, is eveneens terug te vinden bij varkens. Een comfortabele bodembedekking is met name tijdens het rusten van belang. Varkensonderzoek toont verder dat voer, sociaal contact, warmte, licht, nestplaatsen en substraat enkele van de factoren zijn die voor de dieren van belang zijn. De voermotivatie is in het bijzonder sterk. In meer detail, tonen operante conditionering studies bijvoorbeeld aan dat met name de trilling tijdens transport aversief is voor varkens, zeker direct na een grote maaltijd, en dat takken als substraat interessant zijn.

Met de huidige kennis, is het op basis van operante conditionering studies en keuze testen alleen, slechts in zeer beperkte mate mogelijk motivaties te rangschikken naar algemene importantie voor het dier. Voor specifieke situaties geven de studies echter relevante inzichten in hoe omgevingsfactoren door dieren worden gewaardeerd. Samen met andere kennisbronnen, zoals het natuurlijke gedrag van de soort, dragen de resultaten van operante conditionering studies en keuze testen bij aan een objectieve evaluatie van dierenwelzijn gegeven specifieke houderijcondities, en nader onderzoek volgens deze methoden is gewenst.

Summary

The performance of natural behaviour benefits the well being of animals, but acclimatization / adaptation, genetic differences and differences with regards to external stimuli, e.g. resources and releasers, are factors that may prevent that the absence of natural behaviour automatically leads to poor welfare. Unless there is knowledge of the function of a specific behaviour, of the way it is regulated and of the behavioural and physiological consequences of withholding it, the precise consequences of the opportunity to perform specific (natural) behaviours on animal welfare remain speculative. The knowledge that is needed includes information on the animals' motivations to perform specific behaviours. Preference (choice) tests and operant methods have been widely used to study motivation and assess the way animals perceive aspects of their environment. Operant methods, in which the animal has to work for a resource, are combined with the consumer-demand approach used in economics to rank resources in terms of how important they are to the animal.

Operant and choice studies in chickens show that laying hens have a high demand for litter substrate, a nest box and a perch, whereas it has been suggested that the demand for space seems to be dependent on the motivation to perform certain behaviour patterns. Little work has been done on ranking different resources, e.g. litter, perches and a nest-box, and more research to rank behavioural priorities and priorities for different resources should be carried out. There are only a few studies measuring the preferences for resources in broiler (breeder) chickens and one should be careful when extrapolating findings in hens to broilers or broiler breeders. Measurements in laying hens were done in adult birds, whereas broilers often do not get older than 35 days. Moreover, due to selection broiler behaviour and physiology differs considerably from that in laying hens and the motivation for resources in broiler may differ from that in laying hens. Like in broilers, there is little information about the behavioural preferences and preference for resources in laying hens during rearing. As the rearing environment has an effect on the performance of hens when adult (e.g. in the development of feather pecking), this aspect also needs further research.

The inelasticity of the demand function for food shows that food is highly valued by pigs. For pigs, food, social contact and some sort of stimulus change rank in order of decreasing importance, but pigs clearly prefer variety (stimulus change) to monotony. Sows have a clear preference to use an appropriate farrowing site such as an earth floor, but uncertainty about the future availability of the nesting site, food and / or water will affect the pigs' choice of a farrowing site. The pigs' motivation to root may be closely associated with the investigation of new stimuli and, consequently, the motivation to root may be relatively low in a non-stimulating environment. Note, that under austere conditions rooting motivation may manifest as stereotypies and as such may not be recognized as rooting. Pigs are willing to work for thermal comfort and light, but not darkness (under conditions of continuous light). Light seems most important to them at the time of high activity, i.e. around feeding times. Piglets will express clear preferences for specific floor types, but the strength of their preference differs with, for example, their behavioural activities. The operant conditioning and choice studies provide detailed information on which aspects of ramps or transport are especially aversive to pigs, i.e. steepness and vibration, respectively, and which are preferred rooting substrates (e.g. branches). The differences in experimental design and presentation of the

results, e.g. measures of demand elasticity are rarely given, often prevent comparisons across studies. This means that the ranking of resources on the bases of their importance to pigs is possible only to some degree. Also, the motivational states in pigs are not fixed in time or over different situations and individual differences exist.

The studies with chickens and pigs illustrate difficulties in designing experiments that acutely measure an animal's motivation with regards to the resource(s) under study. Several authors stated that other motivations than the ones they were interested in might have biased their findings. Nevertheless, especially the studies in which several resources were investigated simultaneously provide valuable information on how animals are motivated and appraise their environment. There are many factors influencing the outcome of experiments using the consumer demand approach. Therefore, measurements of behavioural priorities are, preferably, combined with other behavioural and physiological measurements and knowledge on biological processes and functions. As a method the consumer demand approach, like preference tests and other methods, has its own disadvantages and is not the 'ideal' method to measure animal welfare. Nevertheless, operant methods, including the consumer demand approach, and choice tests are valuable tools for the determination of motivation for resources and assessment of animal welfare.

1.   Welfare from the animal's point of view

There are two main scientific approaches to the issue of animal welfare. One is based on the assumption that animal welfare is compromised when normal biological function is impaired. In this approach a variety of welfare indicators is measured to obtain a comprehensive view of the animal's biological state. The interpretation of such measures as to provide an overall welfare assessment is not straight-forward (Dawkins 1990, Mendl 2001). The second approach equates an animal's welfare with its subjective experiences. Animals may grow, reproduce and appear to be healthy, yet still have poor welfare if they experience subjective suffering such as prolonged frustration. Providing resources that allow captive animals to express their most preferred activities has been suggested as being an effective means of improving their welfare. Thwarting a motivation is seen as a means of causing psychological suffering and thus reducing welfare (Dawkins 1990, Gonyou 1994, Mendl 2001, Matthews and Ladewig 1994). Here, we focus on the second approach to the issue of animal welfare, i.e. how to measure motivation, preferences and appraisals.

There are many factors influencing the outcome of experiments using the consumer demand approach. Therefore, measurements of behavioural priorities are, preferably, combined with other behavioural and physiological measurements and knowledge on biological processes and functions. As a method the consumer demand approach, like preference tests and other methods, has its own disadvantages and is not the 'ideal' method to measure animal welfare. Nevertheless, many researchers stress the importance of the consumer demand approach and preference testing for determining motivation for resources and assessing animal welfare.

2.   Natural behaviour

Natural behaviour refers to behaviour that is shown by the members of a species in the habitat they have evolved in, and which is based on control mechanisms that have evolved to enable animals to successfully cope with their environment. Natural behaviour reflects the fact that individuals function in a way for which they were selected. It also reflects the fact that an animal's capacities are put to appropriate use, causing conscious experience (Gazzaniga 1998) and maintaining the integrity of the biological functioning of the animal. Natural behaviour often involves active engagement with the environment, creating a source of experience. It also suggests coping ability in the sense that such behaviour allows the animals to adapt to circumstances. It prevents the animals from getting bored (Hughes and Duncan 1988, Wemelsfelder 1993) and may fulfil specific behavioural needs (Wood-Gush and Vestergaard 1991, 1993). Frequencies of behaviours under different conditions, including natural conditions, have been compared to assess what animals value and determines their welfare. It has been assumed that those environmental stimuli with which free-ranging animals interact the most, or the behaviours that they perform the longest, are most valued by the animals. Animals are then assumed to suffer when they cannot perform the behaviour that they show 'in nature' (Thorpe 1965). This approach is based strongly on the model of instinctive behaviour such as it has been popularised by Lorenz (1963). The model maintains that the motivation to perform specific behaviour rises with the increasing time that it is not performed, until it may be released spontaneously. It follows that animals

suffer when the performance of behaviours is obstructed, for example by the absence of releasing stimuli. This model is too simple and Lorenz himself later speaks of slowly raising internal motivations and many other stimuli that may raise motivation until one of them releases the behaviour (Lorenz 1978). In the absence of specific stimuli the want to perform the associated behaviour may never occur. Farm animals have changed genetically compared to their wild ancestors and adapted to the conditions created by man. This means that the absence of behaviours seen under (semi) wild conditions is not necessarily indicative of stress. Whilst the keeping of wild jungle fowl in cages results in abnormal behaviour, injury and zero production (Tschanz 1978), this is not the case for domesticated hens. In a similar way, wild-caught mice will not breed under man-made conditions, but laboratory mice do (for a discussion see Beilharz and Zeeb 1981). Dawkins (1985) argues that acclimatization / adaptation; genetic differences and differences with regards to external stimuli, e.g. resources and releasers, are factors that may prevent that the absence of natural behaviour automatically means suffering. Unless there is knowledge of the function of a specific behaviour, of the way it is regulated and of the behavioural and physiological consequences of withholding it, the precise consequences of the opportunity to perform specific (natural) behaviours on animal welfare remain speculative (see Dawkins 1998). Behavioural needs and motivation are concepts that deal with such consequences.

3.   Behavioural needs

A need may be defined as a state, which if not attained causes suffering to an animal as indexed by, for example, disturbed behaviour, increased risk of pathology or marks consistent with stress (Jensen and Toates 1993). The various existing definitions of a behavioural needs portray that (1) they are caused mainly by internal factors, (2) its tendency to occur builds up with its non-performance and (3) its performance is rewarding in itself. The animal tends to perform the behaviour more or less regardless of the environment or the consequences. This may be a too simplistic view (Jensen and Toates 1993). Firstly, to dichotomise between external and internal factors seems unjustified. Satiated pigs may start eating when seeing other pigs eat (Hsia and Wood-Gush 1983). This shows how a typical 'internally regulated behaviour' is also influenced by external factors and that the regulation of motivation is situation specific. Nesting behaviour in sows has been linked to rises in prolactin and, as such, seems internally regulated. However, Jensen (1993) showed that the environment affects parts of the nesting behaviour differently. Sows in bare concrete pens performed 'normal' amounts of nesting activity, but only the first part of it, i.e. nosing, rooting and pawing. Also, sows may construct a second nest when the first is infested by ants (Jensen 1988). Thus, in different situations the behaviour is regulated differently by internal and external factors. Secondly, Jensen and Toates argue that there is no reason to assume that the need to perform behaviour is stronger when it is triggered by a time-dependent build up than by an immediate

external stimulus (e.g. a predator). Thirdly, behaviour per se is not always rewarding and may, for example, only function as a coping response. It is often unclear what effects motor activity may have on motivational systems and how this varies with environmental circumstances. Thus, Jensen and Toates argue against the approach of labelling only some behaviour as needs. The authors advocate a holistic approach to the causation and control of specific behaviours in order to establish its importance for the well being of animals. Behaviour is flexible and the foregoing suggests that it is inappropriate to strictly discriminate 'behavioural needs' from 'less important behaviours' as, for example, such a categorization may well differ with environmental circumstances. Instead of determining the behavioural needs of a species, and consider only these to be relevant to animal welfare, one may determine the strength of motivation to perform specific behaviours under given environmental circumstances. Motivations to perform specific behaviour will vary with, for example, breeds (i.e. domestication), individual animals, age, keeping conditions, but they will reflect what the animal considers to be important at a given point of time and situation. Behaviours that all individuals of a species typically are highly motivated to perform, especially if relatively independent of time and situation, are the ones that may be labelled as behavioural needs.

4.   Motivation and motivational models

The motivational state is a state of the central nervous system that determines the animal's tendency to engage in specific behaviour (In Jensen and Toates 1993). In Lorenz's model, action-specific energy builds up as a function of time. The model was later modified in that the dichotomy between actions of internal or external factors was removed (Lorenz 1978). It implies that (1) behaviour is released by a combination of internal and external factors, (2) when behaviour is performed, and after an initial period of positive feedback, it wanes, (3) the non-performance of a behaviour increases the motivation to express it. In the model of Wiepkema (1987), animals monitor the outer world (Istwert) and compare aspects of it with the desired state (Sollwert). Upon discrepancy, the animal takes action and may feel pleasure when its actions effectively reduce the discrepancy. Like the Lorenzian model homeostatic models (including that of Wiepkema) state that behaviour is released in reaction to the departure of some variable from a certain value and is stopped when this value is reached. Differences are that in Lorenz's model the actual motor act is a prerequisite for turning off the motivation whereas in homeostatic models changes in the environment may suffice (Jensen and Toates 1993). The model presented by Hughes and Duncan (1988) states that motivation is affected by internal factors and that the behavioural output is modulated by the perception of external stimuli. Both the appetitive and consummatory behaviour acts as a positive feedback on motivation, at least initially, and only the latter exerts a negative feedback. The behavioural consequences on the environment may lead to negative feedback. Hughes and Duncan's model emphasizes both the proprioceptive feedback from performing motor patterns (like the Lorenzian model) and the feedback of the behavioural consequences (like the homeostatic models).

In summary, there is good reason to assume that the performance of natural behaviour benefits the well-being of animals, but acclimatization / adaptation, genetic differences and differences with regards to external stimuli, e.g. resources and releasers, are factors that

may prevent that, for example, the absence of natural behaviour equates to suffering. Behaviours that are primarily induced by internal factors, that have a tendency to increasingly occur with its non-performance, and that are rewarding in itself may be labelled as behavioural needs. However, behaviour is flexible and it may be inappropriate to strictly discriminate behavioural needs from behaviours that seem to be less important for well-being as such a categorization may well vary with environmental circumstances. Unless there is knowledge of the function of a specific behaviour, of the way it is regulated and of the behavioural and physiological consequences of withholding it, the precise consequences of the opportunity to perform specific (natural) behaviours on animal welfare remain speculative. The knowledge that is needed includes information on the animals' motivations to perform specific behaviours. Motivations to perform specific behaviour will vary with, amongst other things, breeds, individual animals, age or keeping conditions, they are more fluid / dynamic than behavioural needs and reflect what the animal considers to be important at a given point of time and situation. It is recognized that both the proprioceptive feedback from performing motor patterns (i.e. behaviour) and the feedback of the behavioural consequences may be rewarding to animals and regulate their motivations.

It is important that appropriate and accurate methods to measure motivation are used and / or developed. Preference tests and operant methods have been widely used to study aspects of the environment to improve comfort of the animals or to determine the optimal feed composition for animals. Dawkins (1983) combined operant methods, in which the animal has to work for a resource, with the consumer-demand approach used in economics to rank resources in terms of how important they are to the animal. After the introduction of the consumer demand approach in ethological research concerning animal welfare this method has been developed, fine-tuned and recently more frequently used to measure motivation in farm animals. Below, the different methods to measure preferences and motivation are discussed briefly.

5. Preference testing, operant conditioning and aversion learning techniques

Instead of observing the animals' 'natural' behaviour, they can be made to chose between alternatives to assess which they prefer, i.e. preference (choice) tests, or they can be trained to work for rewarding commodities or avoid aversive experiences, i.e. operant conditioning. On the basis of our own human experiences, it may be assumed that the intensity with which behavioural strategies are performed are correlated with the animal's expectations about the intensities of their subjective experiences (for a discussion see Van Rooijen 1983). Preference tests and operant conditioning have been used to establish the way animals appraise different types of flooring (Hughes and Black 1973, Hughes 1976, Ponteaux et al. 1983, Irps 1983, Van Rooijen 1985), cage sizes (Dawkins 1981), temperatures and light levels (Richards 1976, Curtis 1983, Baldwin and Start 1985, Morrison and McMillan 1985), aspects of transport (Bailey et al. 1983) and other factors (Kilgour 1976, Beilharz and Zeeb 1981).

5.1   Preference testing

Preference tests may put environmental factors on a scale regarding the animals' expectations (Van Rooijen 1983). Note, that domestication has reduced the selectivity of preferences and domesticated animals may be viewed as relatively tolerant in many respects (Van Rooijen 1982).

Two choice tests or multi-choice tests
A two-choice or multi-choice test arena typically consists of two or more chambers bordered to a central chamber. It allows the animal to choose between two or more conditions, which are conducive to the same behaviour. It is recorded which chamber the animal chooses to aggregate with or to enter and the time in or near the chambers is used as an indicator of the motivation (e.g. Bradshaw 1992, François et al. 1998, Nicol 1986, Widowski et al. 1992, Widowski and Duncan 1996). This is one of the oldest methods to determine preferences in poultry. The first tests in laying hens were choice feeding tests (1932) to determine diet preferences (Duncan 1992).

When measuring preferences, some problems may arise when the following points are not taken into account. First, an animal's preference is affected by its previous experiences. Familiar environments will often be preferred over other environments (Dawkins 1976). Preferences may depend on the amount of effort that is required. For example, Hursh and Natelson (1981) found that rats prefer brain stimulation to food, but that this preference is reversed when the amount work that is needed to receive the two rewards is increased. Position preferences may confound the results of preference tests (Van Rooijen and Metz 1987). Repeated testing is one way for addressing this problem, but repeated testing may interact with the animal's motivation. Preference tests only give information about the relative properties of the choices given. This may be overcome to give as wide a range of choices as possible. Or, which is described in detail below for the consumer demand approach, to measure the strength of the preference. Another issue is the conflict between short-term preference and long-term welfare. A preference test gives information on the current feelings of the animal, which has to be balanced against the knowledge that is available on the long-term risks to welfare of a particular course of action (Duncan 1992). This problem can be overcome by giving an animal the opportunity to change its behaviour continuously over long periods (Dawkins 1990), since short-term choices may not reflect the preferred situation on the long term (Timberlake 1984).

Runway and Y-maze / T-maze tests
Variants to the two-choice test are the two-choice runway test and the Y-maze / T-maze test. In these tests the animal can chose between two compartments with different properties after it has been released from a start box. The frequencies of entering a different compartment, or the time being in or near a certain compartment are used as indicator of motivation (e.g. Millman and Duncan 2000, Petherick et al. 1990).
A runway test with only one goal box is also used to measure motivation. In a simple runway test, an animal is released from a start box after which it can go to a goal box or not. The time to reach the goal box is measured as indicator of motivation to reach the goal (e.g. Marin et al. 2001). A variant to this test is the runway test in which an obstacle is placed after

the animals are trained to reach a goal box containing a food reward. Speed of walking is used as indicator of the motivation of the animal (Bokkers and Koene 2002).

5.2   Operant conditioning and consumer demand

In an operant conditioning test the animal is trained to work for rewarding commodities or to avoid aversive experiences (for a description of aversion tests, see below). In poultry, key pecking is often used in operant conditioning tests (e.g. McAdie et al. 1993, Jarvis et al. 2002, Savory 1989, Savory et al. 1993), whereas pigs are often trained to press a panel with their nose (Arave 1996). The number of key pecks or presses to obtain the reward can be increased (e.g. on a fixed ratio (FR) schedule) to determine the motivation to work for the reward.

Dawkins (1983) recommends the consumer demand approach derived from human economics to assess the value of resources to captive animals.
Two measures of behavioural elasticity have been recommended:
1. elasticity of demand, i.e. the price of commodities or environmental resources is varied;
2. elasticity of income, i.e. the price for environmental resources is fixed but the animal's income, in terms of time or energy budgets, is varied.
With both techniques animals defend consumption of important resources, but not consumption of luxuries, so it is possible to rank resources in terms of their importance to the animal. The majority of studies in animal economics have used demand elasticity to compare the value of resources (Cooper and Mason 2001). The elasticity of a demand (e) of a resource or commodity is derived by plotting its 'consumption' against its 'price' and calculating the rate of decline in consumption per unit increase in cost (Dawkins 1990). The elasticity is mathematically equal to the absolute value of the typically negative slope of the plot of log consumption against log price. The function is expressed as $\log Y = b + e \log X$ (Lea 1978). An example of elasticity of demand of different commodities is represented in Fig. 2 (L.J. Pedersen et al. 2002a).
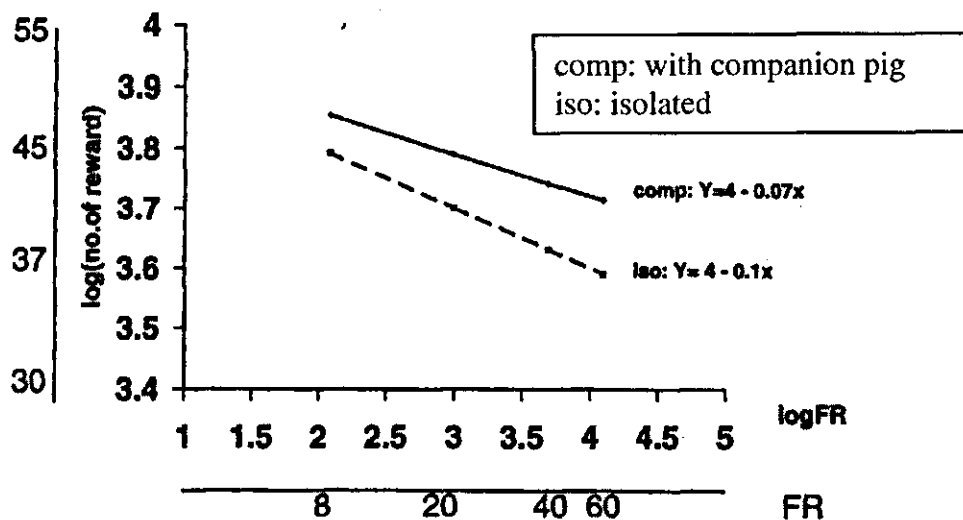
Fig. 2. Estimated demand curves in the phase with food.

Some use a cut-off of e = -1.0 to discriminate between inelastic necessities (0 < e < -1) and elastic luxuries (e > -1) whereas others have ranked these slopes into behavioural priorities (Cooper and Mason 2001). Dawkins suggested that food might serve as a standard for comparison as it is essential for survival, highly valued and typically has an elasticity coefficient close to zero. The elasticity coefficients are independent of the magnitude of the reinforcers (see for example Hursh and Natelson 1981), unlike the situation in studies of preference (Savory and Duncan 1982). In the latter study, the proportion of the day that chickens activated lighting was depended on reward duration. The intensity of the demand may be expressed as the elevation of the demand function above the origin (Hursh 1984). An increase of the intercept with the y-axis indicates that the animals are willing to work harder across the range of workloads. When different commodities are compared this is based upon functions of reward ratio, cost per operant, and amount of reward, i.e. prices. Difficulties arise with the fixing of the amount of rewards across different commodities. Units of different resources are not comparable, which makes the slope of the demand function the most useful measure, but if the same resource is investigated under different conditions the intensity of the demand function may be used. The area under the demand curve has been criticized as a parameter as it may overestimate the value of commodities that are consumed at a high rate at low costs as compared with resources that require little time for satisfaction (Dawkins 1990). Operant approaches have been widely used to measure preferences, as they allow automatic measurement of cost paid and consumption for deriving demand function. However, other learned response tasks have also been used to investigate demand, e.g. baths of water, squeezing trough narrow gaps or pushing open weighted doors (Cooper and Mason 2001).

Open versus closed economy

Dawkins (1988) lists several factors that may complicate, but not disqualify, the measurement of demand elasticity. The resources that are available to the animal outside of the experimental setting will direct its experimental responses (Hursh 1984) and demands for

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commodities may depend on the availability of substitutes (Lea and Roper 1977). To have the most realistic view of animal priorities one should test animals in closed rather than in open economies (Dawkins 1990, Ladewig et al. 2002, Mason et al. 1998). In open economies animals often have a relaxed attitude to resources they learn if they can get them elsewhere, which leads to misleading impressions of elastic demand. In an operant conditioning paradigm with rats (Ladewig et al. 2002), demand curves for drinking water had steeper slopes if water was available, especially 1 h before tests, outside of the test sessions (-1.09 versus –0.35). Open / closed economy effects may be especially important when reinforcers take a long time to consume or need to be provided several times a day (e.g. resting), and depend for example on the timing and duration that the commodity is available and the FR (for a discussion see Ladewig et al. 2002).

True costs
It is important that the imposed cost truly places a cost on consumption and that this is equivalent for each resource under consideration. For example, the animal may compensate for fewer visits by consuming more on each visit. Hens made fewer visits when narrowing a gap restricted the access to a nest, but their time spent with the nest site was little affected by cost on access (Cooper and Appleby 1995, 1997). It has also been shown that the interaction with a resource is more intense once the animals overcome higher costs on access and that the latencies to interact were shorter (Cooper and Mason 2000). Thus, animals may reorganize their behaviour in response to increasing costs, e.g. increase their interaction with the commodity, such that consumption remains fixed. This means that actual consumption and the number of times the price is paid need not co vary. Break points in studies with progressive ratio schedules, i.e. the FR level were animals stop responding, or in a broader sense reservation or maximum price is and alternative approach of demand curves (Cooper and Mason 2001). Maximum prices, including overcoming aversive barriers, may be especially appropriate for non-divisible resources like nest boxes or social contact (Cooper and Mason 2001). Cooper and Mason (2001) described how maximum prices (overcoming a weighted entry door), but not conventional consumer demand curves, discriminated between the different ways in which resources were valued by mink. The increase in entrance fee to enter seven resources (a bath, nest box, platform, empty compartment, cat toys and a novel object) resulted in an increased duration of visit. As a consequence, the total time spent with the resources did not change when the cost increased. Moreover, the mink spent a greater proportion of time in interaction with the resource as cost increased. Therefore, in the next experiment they adopted the approach of maximum price paid and abandoned the use of elasticity curves. In this experiment farmed mink paid higher prices for food and swimming water than for resources such as tunnels, water bowls, pet toys and empty compartments, which led the authors to the conclusion that the mink placed a higher value on food and swimming water than on other resources.

Compatibility of operant response and reinforcer: constraints of learning
The ease with which animals associate the operant task and the commodity may bias the measured value of the commodity, i.e. biological preparedness (Arave 1996, Chance 1988, Dawkins 1988). Motivation may then be biased by the compatibility of operant response and reinforcer. Breland and Breland (1966) found that with repetition of particular tasks the behaviour sometimes reverted into species-specific patterns. Pigs started to root and toss

the coins that they had to carry towards the moneybox banks that operated the feeding device and new animals had to be trained. Dawkins and Beardsley (1986) showed that hens did not work for litter when the operant was to peck a key but they do when they have to work for food. Thus, birds seem not to be very highly motivated to do a particular kind of behaviour when the operant task belongs to a different motivational system. The same problem was signalled in pigeons (Hemmes 1973). Mendl (1990) stresses that the effects of experience during development are likely to affect the rate of learning to work for a particular resource, the use of the resource and the elasticity of demand. Resources may be subdivided into three categories: (a) those for which all animals show rapid learning and have an inelastic demand, e.g. rooting for pigs; (b) those for which experienced animals have an inelastic demand but inexperienced animals may have a more elastic demand and show rapid learning, e.g. nest boxes for hens, and (c) those for which all animals, irrespective of experience, have an elastic demand. It can be suggested that denying access to category (a) is likely to cause considerable suffering in all individuals, denying access to category (b) is likely to cause considerable suffering only in individuals that have a certain amount of experience of the resource or stimulus, and denying access to (c) is likely to cause the least suffering.

Situation specificity

Mench and Stricklin (1990) and Sherwin and Nicol (1998) emphasize that it should be taken into account that in social groups, both the ability and the motivation of individual animals to acquire particular resources are likely to vary depending on the social context. Thus, one should be careful about the extension of results of testing individuals to social groups.

Repeated testing

Repeated testing may interact with the animal's motivation. Petherick et al. (1993) illustrated how hens' motivation for dustbathing increased with repeated exposure to sand, whereas the motivation for feed, after an initial increase, decreased with repeated reinforcement. Operant conditioning schedules may, thus, alter the underlying motivation as, for example, some level of satisfaction is achieved with subsequent rewards or animals become aroused in response to repeated small reinforcements (Day et al. 1996). The problem may be tackled by the use of second-order schedules of reinforcement. Pigs seem to have increased expectancies when operant responses for food are reinforced by a conditioned stimulus (noise) that is associated with food reward, and they show stronger operant responses when these are reinforced by the conditioned stimulus (Day et al. 1996). It is unclear if the reinforcing properties of the conditioned stimulus mean that the pigs have a mental image of the goal-object, i.e. food (declarative representation), or that it is associated with the reinforcement of operant behaviour at a lower level of consciousness (procedural representation, for a discussion see Day et al. 1996).

Interruption of behaviour

In test situations, the interruption of the reinforcements may devalue the rewards and instead of offering short periods of reinforcement, the animal may be given control over the length of reinforcement (Mason et al. 1998). However, in such models animals may increase the length of reinforcement as a compensation for increased prices (Sherwin and Nicol 1996, Cooper and Mason 2000). This indicates that animals may reorganize their behaviour rather

than increase their effort to obtain commodities (Sherwin and Nicol 1998). Nevertheless, in hens Matthews et al (1998) found similar demand curves for dustbathing when reinforcements were 150, 300 or 450 s of access. Jensen et al (2001) showed that interrupted social contact between familiar piglets induced increased expression of specific elements of agonistic behaviour, i.e. flank pushing and avoidance. Calves increasingly licked and sniffed each other when contact was interrupted. For some behaviours, such as perching or nesting in laying hens, the resource that enables the behaviour to be performed will only be meaningful if the hen is given full access to it until the behaviour is completed, i.e. if the animal can chose its own bout length (Mason et al. 1998, Olsson et al. 2002). As a consequence, methods to generate demand functions that require that the commodity can be bought on repeated occasions and in discrete quantities are not suitable. Olsson et al. (2002), therefore, adapted the so-called push-door method for these 'all-or-none' responses in laying hens. To gain access to the resource, the hen has to exert a certain force to push open the door. The cost of opening the door is varied by varying its resistance (see also Cooper and Mason 2000).

5.3   Aversion learning techniques

Aversion learning techniques have been used, for example, to compare sheep handling practices and components of transport of pigs with regards to animal suffering (Rushen 1996). The extent to which animals will try to avoid the feelings that it associates with specific events tells something about the degree of suffering that is involved. Using this approach, Rushen investigated the relative aversion that sheep felt towards certain handling procedures (in Rushen 1996). Sheep were treated in specific ways when they reached the end of a race: run through unhindered, restrained in a handling machine or subjected to simulated shearing (no wool was removed). The time it took the sheep to run down the race or how much time was needed to push it down the race was taken as the measure of aversiveness. The procedure was repeated 7 times. By the fourth trial it became clear that the sheep resisted the most when approaching simulated shearing whilst none needed to be pushed when they could run through unhindered. From the procedure follows that it works only when animals must have previous experience with the treatments and the findings may be influenced by their learning abilities. This would be problematic in the case of, for example, branding or castration. Furthermore, animals may associate specific places with aversive treatments and this means that treatments must be clearly separated in location. Natural responses of the animals, e.g. fear-induced freezing, may undermine the reliability of avoidance learning procedures. Rushen remarks that negative results may result from methodological problems instead of the treatment being non-aversive. Alternative techniques are forced choices (Rushen 1986) or procedures where avoidance responses interfere with obtaining food (Rutter and Duncan 1992).

6.   Motivation of chickens for resources

Most studies on preferences and motivation in chickens to work for resources have been carried out in laying hens. This is primarily caused by the fact that the battery housing of laying hens does not give the hen opportunities to perform natural behaviour. It has,

therefore, been argued that those activities and resources valued most highly by the hens should be provided in alternative caging or housing systems.

6.1. Motivation of laying hens for resources

6.1.1. Substrate types and substrate-related behaviours

Bubier (1996a) studied the preference of laying hens for certain substrates and the distribution of its time budget by different methods. First she used a multi-choice pen with a free access situation (thus, the hen did not have to pay a cost to enter one of the pens). The hen could chose between pens with the following resources: food and water, woodchips, grass or wheat seedlings, a perch, a nest box and a pen facing another pen with familiar hens. After the free access situation she imposed a cost on entering the pens (the hen had to squeeze trough two vertical dowels). Grass was the most favourite resource when no cost was imposed, but in the cost condition hens gave priority to the pen containing food and water. The amount of time spent in the woodchip pen remained similar under both conditions. The hens had a previous experience of food supplied in woodchips and when a cost was imposed they chose to peck and scratch in the woodchips after fulfilling their need for food and water.

Thereafter, Bubier (1996a) deprived the hens from all resources for 22.5 h and measured the time budget as indicator of behaviours with high priority. As compared to the situation where the hens had free access to all resources for 22.5 h there was no change in the time spent feeding and pecking and scratching in the woodchips. This suggests that the motivation of pecking and scratching is high as compared to feeding and that this motivation is constant under various conditions.

In another experiment, Bubier (1996b) compared time budgets of laying hens in an enriched condition and in an austere condition. The idea was that if the hens in the enriched pens chose to devote some time to new activities due to the presence of new objects they had to forgo time in performing other behaviours. It turned out that drinking, preening and social pecking was greater in duration in the austere condition. She concludes that these behaviours are relatively elastic and may be used to fill spare time. The time spent feeding did not change and the same was valid for pecking and scratching, indicating that these behaviours were relatively inelastic. In a second experiment Bubier (1996b) assessed the behavioural priorities of laying hens by comparing time budgets in a pen in which the food was supplied in woodchip substrate with an identical pen in which food was only available from a hopper. The amount of effort spent on feeding was the same under both conditions. Moreover, there was no difference in pecking and scratching although food was in one condition available from a hopper, which confirms the suggestion that hens attach a high value to pecking and scratching (Bubier 1996).

Matthews et al. (1995) studied the demand for different substrates by laying hens. Hens had to work for three different substrates (peat, sand or wood shavings), for a wired cage and for food. He showed that the demand for the three litter substrates was relatively inelastic and that the hens failed to work for the wire cage, suggesting that there was a high demand for access to litter. The value of the different litter substrates seemed to vary with the type of

activity performed. Wood shavings were less valued for dustbathing. All three substrates were similarly highly valued for pecking and scratching. The demand for food was relatively inelastic, as expected.

Gunnarsson et al. (2000) studied the demand for straw and feathers as substrate, for hens that have been reared on grass and earth mixed with sand. He studied the demand for feathers because early exposure to feathers has been suggested to have an association with the development of feather pecking behaviour. All hens worked to get access to straw and used it for pecking and scratching. Only one hen (out of six) used straw for dustbathing. Three out of six hens worked for feathers. For these hens, the elasticity of demand did not differ between straw and feathers. Hens used feathers as substrate for pecking and scratching. This study shows that even if a substrate does not support dustbathing, laying hens may have a very high demand for a litter substrate. This is in contrast to the findings of Matthews et al. (1998). They concluded that the elasticities for dustbathing were significantly lower as compared to the elasticities for all other behaviours in peat, suggesting that litter had more value as a dustbath than for other activities in laying hens.

Widowski and Duncan (2000) deprived hens of dustbathing and let them work (trough pushing a door) to enter peat moss as dustbathing substrate. Although hens tended to push more weight and made more attempts to open the door when they were deprived, they are not necessarily willing to work harder when they are in a state of deprivation than when they have recently dustbathed (as not all hens were willing to work harder when deprived). The results are difficult to interpret using a 'needs' model of motivation in which deprivation leads to a state of suffering. They are more consistent with an 'opportunity' model of motivation in which performance of the behaviour leads to a state of pleasure. This may also explain the results of Faure and Lagadic (1994). They found that hens were willing to withstand variable wind speeds to work for food, but that there was no difference in the demand for sand and wire floors if the hens had to withstand variable wind speeds. It should also be noted that visual stimuli seem to be important to trigger dustbathing behaviour. In studies were the substrate could not be seen it was concluded that dustbathing was not very highly motivated (e.g. Dawkins and Beardsly 1986, Petherick et al. 1990) whereas in studies where the dustbathing substrate could be observed it was concluded that dustbathing was important (e.g. Matthews et al. 1993).

The results of the previous experiments showed that hens have a high demand for a litter substrate, but that it is difficult to assess the level of demand for a particular behaviour. It is clear that hens attach a high value to pecking and scratching behaviour although this has also been suggested for dustbathing. The type of litter seems to be less important for pecking and scratching, but seems to be more important to perform dustbathing behaviour. This may have affected the results of Matthews et al. (1998), as they tested the hen's preferences to perform substrate-related behaviours in peat that is known to be a preferred substrate for dustbathing.

6.1.2. Access to next boxes

It has been shown that the demand for next boxes was high and inelastic during the pre-lay period (e.g. Cooper and Appleby 1994). Cooper and Appleby (1995) tested in more detail if previous experience of a nest site affected the hen's responses during testing. Narrowing the

door between the home pen and a pen with a nest site assessed the demand for nest searching behaviour. It turned out that the demand for a nest was independent of previous experience of a nest site. Moreover, there appeared to be some demand for nest searching behaviour even if a nest was present, because hens also returned to their home pen despite the narrow gaps between the pens. In a further experiment, Cooper and Appleby (1996) more precisely assessed the demand for a nest box in the separate time periods prior to and after oviposition. They found that hens were willing to pass a narrower gap before as compared to after oviposition. As the cost of entry increased, the time spent in the next box increased. Cooper and Appleby (1996) suggested that initially, when the hens performed investigative behaviour, it was not important to gain access to either the nest pen or the nest box it contained, but that when hens normally perform nesting behaviour, it was very important to gain access to the nest box. What remains to be investigated is to distinguish between the demand for resources to allow nest seeking behaviour and resources that allow nest building behaviour.

Laying hens are housed in a social environment that may have an effect on the motivation of the birds, as described in paragraph 2.4. Freire et al. (1997) studied the effect of social interaction on pre-laying motivation in hens. He studied the responses of hens that had to pass trough a pen that was either empty or contained another hen (higher or lower in social status or unfamiliar) in order to reach a nest site. His results suggested that hens were weakly motivated to reach the nest site during the searching phase when the hen had to pass an unfamiliar or dominant bird. However, the motivation to gain access to a nest site increased near the start of the sitting phase of pre-laying behaviour, as in that case the hens were more willing to pass an unfamiliar or dominant bird to reach the nest site.

The results of these experiments show that laying hens have a high demand for a nest site, even if they do not have experience with it. The motivation of the birds is very high near oviposition. There appeared also to be some demand for nest-searching behaviour but this needs further investigation.

6.1.3. Access to perches

Olsson and Keeling (2002) measured the hen's individual maximum performance in a push-door setting by measuring the maximum resistance overcome in order to get access to food when food-deprived. Thereafter, they measured the motivation of hens to gain access to a perch at night by measuring the actual motivation as percentage of the maximum capacity as defined earlier. All hens had experience with previous access to perches. They found that hens were willing to push trough heavier resistances to reach a perch as compared to reach a sham-perch. The maximum resistance to reach a perch was 75% of the door resistance to access food when the hens were food deprived, indicating a high motivation for perching. However, the opportunity to perch together with another hen did not have any effect on the motivation.

In conclusion, the motivation to reach a perch appears to be high.

6.1.4. Space

Hughes (1975) used a two-choice test to determine if hens preferred a spacious or a confined cage. Irrespective of time of the day or strain of bird the hens had a preference for the larger cage. Later, Nicol (1986) tested the preference of hens for four cages differing in size and shape. She measured the preference in free access conditions, by scoring the time the birds were in the cages. She also found that hens had a preference for the largest cage; however, substantial amounts of time were spent in the other cages. Subsequently she tested the hens' preferences for a cage in a situation in which the hens had to work to enter the cage (they had to pass two vertical dowelling rods). Results suggested that there might be a monitoring component to the hens' behaviour but that the hens may also continue to visit small cages to perform particular behaviour patterns, like nest building behaviour.

However, the studies of Nicol (1986) and Hughes (1975) were performed on individual hens, whereas the social context may play an important role in the preference of birds. Therefore, Faure (1994) measured the preference for space in groups of four hens. In an operant conditioning apparatus hens could peck a key to enlarge or reduce the cage area. The results of this experiment showed that, when tested in groups and for a long period, hens show variable patterns of space use. This confirms the suggestions of Nicol (1986) that hens may visit small cages to perform particular behaviour patterns. However, it should be noted that in the study of Faure (1994) in most groups only one hen did most of the key pecks. This shows that when testing groups to include social context in the preference of laying hens, one (dominant?) hen may indeed determine the preference of a group of hens.

Thus, the preference for a spacious or a more confined cage seems to be dependent on the motivation to perform a particular behaviour pattern.

6.1.5. Social preference

Bradshaw (1992) determined the social preference of hens in a multi-choice test arena in which different familiar hens, unfamiliar hens and an empty cage were present. Hens chose to aggregate with familiar conspecifics rather than unfamiliar conspecifics, but the time to aggregate with unfamiliar conspecifics significantly increased over the day.

6.1.6. Light

The preference of hens to incandescent or fluorescent lighting was tested in a two-choice test. In contrast to the expectation that hens found

fluorescent light aversive, hens were more motivated to be in the pen with fluorescent lighting (120 Hz) than in the pen with incandescent lighting (Widowski et al. 1992). In addition, laying hens did not have a preference for extreme high-frequency (20 000-60 000 Hz) versus low-frequency fluorescent light (120 Hz) (Widowski and Duncan 1996). It is supposed that birds are able to detect a flicker rate of 120 Hz but not the extremely high flicker rate of 20 000-60 000 Hz.

Thus, in contrast to the expectation that hens find fluorescent light aversive, this cannot be found for 120 Hz fluorescent lighting.

6.1.7 Aversiveness for vibration

Using the operant conditioning paradigm the aversion for resources can be determined. Rutter and Randall (1993) measured aversion of laying hens to two levels of vibration. They found that vibration at 1 Hz was aversive but that vibration of 0.5 Hz was not aversive for the birds.

6.2. Motivation of broiler (breeder) chickens for resources

It appears that only a few studies on motivation or preferences for resources have been carried out in broilers and broiler breeders.

Shields et al. (2002) determined preference for different dustbathing substrates for broilers in a two-choice test. Preference was determined by measuring the time spent dustbathing in a particular substrate. Broilers could chose between pine wood shavings, rice hulls, construction grade sand and a recycled paper product. The results showed that sand was attractive and a potent dustbathing stimulus for broilers.

Abeysinghe et al. (2001) used two-choice chambers to study the aversion of broilers for vibrational and thermal transport stressors, to improve broiler welfare during transport. Birds that were fasted overnight had to make their choice for a compartment containing feed and a vibrational or thermal stressor. It turned out that broilers avoided vibration but there was no main effect of the thermal treatment.

Bokkers and Koene (2002) used a runway with obstacles to determine if the motivation for a food reward is influenced by gender of the broiler and type of feed it received before. They found that gender did have an effect as male broilers always were faster in the runway as compared to females.

Estevez et al. (2002) determined the preference of broilers for different types of perches (i.e. perches with different temperatures and different heights). They measured the number of broilers perching on a certain type of perch at different ages. A strong preference for high perches (15 cm) and cool perches was found.

Zulkifli and Khatijah (1998) measured the preference of broilers for wire or plastic mesh flooring when the broilers had free access to both types of floor. They found that broilers had a preference for wire floors over plastic mesh floors.

Davis et al. (1999) tested the preference for broilers for different intensities of incandescent light at different ages. They used a multi-choice test with four compartments, illuminated with different intensities, and measured the behaviour of the birds. They found that young broilers

(2 weeks of age) had a preference for the brightest environment (200 lux) whereas older broilers (6 weeks of age) had a preference for the dimmest (6 lux) environment.

Millman and Duncan (2000) used a Y-maze test to examine mate preferences by broiler breeder females. In this test the females could chose between models and tethered live males of a laying strain and broiler breeder strain. They did not find a preference for a particular breed, suggesting that male morphology is not a basis for female choices.

Savory et al. (1993) used an operant conditioning test to determine feeding motivation in broiler breeders fed at different restriction levels. Broiler breeders had to peck a disk to receive a food reward. Birds were placed on a progressive ratio schedule to determine their feeding motivation. The motivation to eat increased with different level of restriction, which led them to the conclusion that this operant test could be used as measurement of hunger in broiler breeders.

Brake (1993) tested the preference of broiler breeder hens for different colours (brown, black, green and grey) of AstroTurf nest pads. Hens had a free choice between traditional brown nest pads and one of the other colours. He found that hens significantly preferred grey to brown, but no difference between the other colours and brown was found.

In conclusion, only a few studies on preferences of broilers or broiler breeder chickens have been carried out and no general conclusions can be drawn from this. E.g., only one study on substrate preferences for dustbathing in broilers was found. Moreover, there is a lack of studies that determine the strength of preference for resources in broilers and broiler breeders.

6.3. Summarizing conclusions on findings in chickens

Most studies on preferences and motivation in chickens to work for resources have been carried out in laying hens. Studies on motivation in hens focused on substrate for dustbathing and foraging behaviour. It has been shown that hens have a high demand for litter substrate, but that it is difficult to assess the level of demand for a particular behaviour like dustbathing or foraging. It is clear that hens attach a high value to foraging behaviour and that the type of substrate seems to be less important for this behaviour as compared to dustbathing. When assessing the motivation for a substrate for dustbathing the visual stimuli seem to be important in triggering the motivation and the substrate for dustbathing must be visible to the hen. Moreover, previous experience of the hen with substrate types affects the demand for a particular substrate.

Hens show a high demand for a nest box in the pre-laying period. The demand for a nest box seems to be independent of previous experience of the hen with a nest box. Moreover, there appears to be some demand for nest searching behaviour, but this needs further research. Hens are also highly motivated to reach a perch.

The preference for a spacious or more confined cage seems to depend on the motivation to perform a particular behaviour. Hens do not always choose for a spacious cage and will spent some time in a more confined cage. In an experiment where a group of hens could choose for different sizes of cages it has been shown that one hen may determine the preference of the whole group of hens, i.e. that one hen per group performed the operant response.

Some single experiments have been performed on social preference, light preference and the aversiveness of vibration. One interesting outcome was that hens do not prefer incandescent light over 120 Hz fluorescent light, in contrast to the expectations beforehand.
In broilers and broiler breeders some single experiments on preferences (e.g. for a dustbathing substrate, a type of floor and a type of perch) have been carried out, but experiments measuring the strength of preferences are lacking. One interesting outcome was that the preference of broilers for different intensities of incandescent light differed with the age of the birds. Young broilers (2 weeks of age) had a preference for a bright environment (200 lux) whereas broilers of 6 weeks of age had a preference for a dim environment (6 lux).

It has been shown that laying hens have a high demand for litter substrate, a nest box and a perch, whereas it has been suggested that the demand for space seems to be dependent on the motivation to perform certain behaviour patterns. However, little work has been done on ranking different resources, e.g. litter, perches and a nest-box, except by Bubier (1996). In her study the demand for food and substrate to perform pecking and scratching was high as compared to the demand for other resources. However, more research to rank behavioural priorities and priorities for different resources should be carried out. There is a need for more information for the proper development of alternative housing systems and the provision of resources in enriched cages for laying hens.
Results of the studies in chickens also stress that there are many factors influencing the outcome of the measurements in studies using the consumer demand approach. It is therefore sometimes argued that measurements of behavioural priorities should be combined with other behavioural and physiological measurements and understanding of biological processes and functions to identify appropriate environments for animals (Matthews and Gregory 2002). Thus, although many researchers stress the importance of the consumer demand approach to determine motivation for resources to assess animal welfare, this method has its own disadvantages that point out that we still do not have the 'ideal' method to measure animal welfare.
It seems that there are only a few studies measuring the preferences for resources in broiler (breeder) chickens. The results of these preference studies are mentioned in paragraph 6.2, but no studies using the consumer demand approach to rank different resources were found. One should be careful when extrapolating findings in hens to broilers or broiler breeders. Measurements in laying hens were done in adult birds, whereas broilers often do not get older than 35 days. Moreover, due to selection probably broiler behaviour and physiology differs considerably from that in laying hens, which suggests that motivation for resources in broiler may differ from that in laying hens. Although the housing conditions of broilers are usually better as compared to layers (as they are housed on litter floors) it may still be useful to determine the strength of preference of broiler chickens or broiler breeders for resources in their environment, and rank the behavioural priorities so that broiler (breeder) welfare can be improved.
As stated above, measurements in laying hens are predominantly performed in adult birds. This means that there is little information about the behavioural preferences and preference for resources in laying hens during rearing. As the rearing environment has an effect on the performance of hens when adult (e.g. in the development of feather pecking), this aspect also needs further research.

7. Findings on motivation, preference and appraisal in pigs

7.1 Feeding

Feeding patterns

Musial et al. (1999) studied 4 Munich Minipigs of 6-9 months of age. Two females and 2 castrated males were housed as pairs of the same sex. The animals were conditioned to operate feeders and a computer recorded their feeding, drinking and defecation. Fifty % of the daily energy intake occurred during the 11 h dark cycle and there was not a clear circadian rhythm in feeding behaviour. Though, most feeding bouts occurred between 08:00 – 12:00 and 19:00-24:00. Meal size was not correlated with the postprandial interval with the next meal and only moderately with the pre-prandial inter-meal interval. Feeding facilitated defecation. Bigelow and Houpt (1988) studied 6 female Yorkshire pigs from 3 weeks until 6 months of age. The animals were trained to operate panel switches at a fixed ration of 10 to obtain food (5-10 g) and water (30-45 ml). In time the daily feed intake increased nearly threefold. Eating bout frequency decreased from 14 to 7 per day. Bout sizes increased primarily by an increased rate of eating. Of the water intake 75% was closely associated with eating and 68% was drank during the 12 h light period.

In these studies the pigs did not show a strong preference for eating / drinking on fixed periods of the day. The preferred meal frequencies may be about 7 a day with higher markedly high frequencies (around 14) in the young. Drinking is typically done around a meal. The importance of such preferences for the pigs is unclear. For example, in the study by Špinka et al. (1998) pigs frequently chose to willingly feed in a crate where they were confined for 240 min, instead of 30 min, without having access to water.

Feeding motivation

Lawrence et al. (1988) used an operant conditioning procedure to demonstrate that feed restricted boars are highly motivated to obtain food. Feeding motivation, as measured by operant conditioning, may be reduced in the immediate postprandial period, both in growing pigs (Day et al. 1996) and food restricted sows (Robert et al. 1997). Lawrence et al. (1988) showed that a restricted meal (0.6 x the ad lib intake) did not affect feeding motivation, and that meals of 0.8 x the ad lib intake decreased motivation at 1h after the meal, but not at 5 h. The intake of food and water seems highly rewarding to pigs, but may be reduced when self-stimulation of the lateral hypothalamic region is possible. In 15 min test sessions pigs may initially show response rates (panel presses) in the range of 70-90 per minute to obtain electric stimulation of the lateral hypothalamus (Baldwin and Parrott 1979). If there was operant access to food and water, self-stimulation tended to occur together with feeding and drinking.

Multiparous pregnant sows (n = 15) received consecutively (during 3-week periods) a low fibre diet, a high-fibre diet based on sugar beet-pulp and a high-fibre diet based on wheat bran (Ramonet et al. 2000). All diets provided the same energy supply and animals were fed restrictively. On the 16th day of each 3-week period, at 4.5 and 23 h after the last meal, animals could operate a switch for a reward (8 g of standard food). The authors applied a

progressive ratio schedule and at the end of the 45 min sessions the sows typically had to turn the switch about 46 times to obtain a reward. The number of rewards obtained ranged from 7 –32 (on average 19). The type of diet or the interval since that last meal did not affect the operant responses of the sows (Ramonet et al. 2000). Pigs may dislike food with high levels of crude fibre (10-15%: Kennelly and Aherne 1980) or high water content (Day et al. 1996). But in the design by Ramonet et al. (2000), different type of diets did not influence the pig's motivation for food.

Pedersen et al. (2002a) used a model in which female pigs pressed a panel for food (26 g) or straw (500 g, 3 min access) rewards. Food sessions lasted 80 min per day and no food was provided outside the sessions. Sessions for straw lasted 45 min and again no straw was provided outside the sessions. FR levels run from 8 to 60, and 2 to 15 for food and straw, respectively. The pigs were tested alone and in the presence of a neighbouring companion (castrate littermate). The number of rewards was on average in the range between 35 and 50 for food and between 10 and 25 for straw. Demand functions for food had steeper slopes (-0.11) when animals were alone than in the presence of a companion (-0.07), indicating that food was valued more in the presence of a conspecific. Since the intensity of the demand curves were unchanged, seemingly, the higher FR was perceived as reduced food availability resulting in increased competitiveness. The slope of the demand function for straw was not affected by the social context, but the intensity (intercept with the y-axis) was higher in the presence of a companion than when alone. Also, the time that the animals interacted with the straw was relatively long in the presence of a companion. Thus, with increasing FR the animals reorganized their behaviour and increased the interaction with the reward. At low FR the animals obtained a surplus of straw and engaged in play behaviour. The slope of the demand function for straw was similar to that found for straw presented in a rack, i.e. –0.56, but steeper than for 30 min access to a straw bedded area, i.e. -0.14 (Ladewig and Matthews 1996).

The inelasticity of the demand function for food shows that food is important to pigs. The study by Pedersen et al. (2002a) illustrates how the pigs' motivation for food is, to some degree, situation specific. In general, pigs express a strong motivation to obtain food, which may be reduced only in the immediate postprandial period. The period of the day and moderate differences in the type of diet seem to have little influence on the pigs feeding motivation.

7.2   Heat

Swiergiel and Ingram (1987) tested 6-8 week old male Large White pigs. It is assumed that at this age the animals have fully developed thermoregulatory mechanisms, whereas sexual maturity is 3-5 months ahead. The animals were trained, on a continuous reinforcement schedule, to press a lever that switched on heaters (infra-red lamps) for 6 seconds. Ambient temperature was 15 °C. Lever-presses during reinforcement were not effective, as to prevent sporadic bursts of working followed by prolonged pauses. The numbers of reinforcements in 30 min were about 55 (n=7) and 103 (n=6) at 1 and 22 h after the last meal, respectively. At ambient temperatures of 25°C, instead of 15°C, these numbers were 3 (n=6) and 12 (n=6).

The demand for heat may be linked to body temperature, which on its turn is linked to meals (Ingram and Legge 1970). Thus, pigs may show body temperature rhythms when starved, but not when fed ad lib (Ingram and Mount 1973). In the study by Ingram et al (1975) 4 out of 6 pigs showed highest heat demands just before their daily meal when body temperature may be low. Ingram et al. (1975) concluded that the demand for heat, such as it is determined by operant conditioning, varies over a 24 hour period, but that the time of peak demand is not consistent among pigs.

Thus, behavioural studies show that in the laboratory pigs are willing to work for heat at temperatures below 25 °C. Under semi-wild conditions groups of Large White pigs, aged between 8 and 17 weeks, may begin to shelter and huddle together in a hut at ambient temperatures of 5°C or lower (Ingram and Legge 1970). Other factors that increased the time that the pigs stayed inside the hut were rain, especially in combination with cold, and darkness. The time in the hut increased when the animals were fed ad lib. This suggests that the drive for food played a role in overcoming thermal discomfort and going outside. Animals tended to spend most time in areas of lowest air movement, but stayed near the food troughs, and thus exposed themselves to thermal discomfort, when food was ad lib available. Air movements where pigs lay down were never greater than 147 cm /s and on average only 74 cm / s. Pigs will perform operant responses to turn off a fan when ambient temperatures are below 30°C. The duration of the reinforcement has less effect on the response rate than when infra red heat is used as a reinforcer and this suggests that in addition to heat loss, high air movement has other aversive components (Baldwin and Ingram 1968).

It has been calculated that heat loss doubles when, at 15°C, air movement increases from 10 to 100 cm / s (Hatfield 1950). Single pigs have increasing oxygen consumption with decreasing ambient temperatures, with oxygen consumption at 10°C being twice that of 25°C (Baldwin and Ingram 1967) unless they can huddle together (Holmes and Mount 1967). However, when pigs can operate an infrared heater their oxygen consumption remains constant within the range of 25°C to 10°C (Baldwin and Ingram 1967). However, the control of metabolic rate, at different temperatures, via operant conditioning is readily disrupted by means of applying a FR of 9 or more, or decreasing the intensity of the heat that is delivered (In Ingram et al. 1975).

In conclusion, pigs are willing to work for thermal comfort, but the importance of heat is influenced by factors like food availability and daily rhythms.

7.3   Illumination

The illumination preferences of pigs have been studied by Baldwin and Start (1985). Large White male and female pigs of 8-12 weeks were tested individually in a pen of 2.4 x 1.2 m. By means of interrupting an infrared beam the animals could activate lighting. After acclimatization to the test pen, the animals (n=10) were kept in the dark for 4 days. During this time it was recorded how often the beam was interrupted (chance level). Next, the infrared beam switch was activated and its operation resulted in 40 seconds lighting, with additional interruptions during these 40 seconds being ineffective. These conditions were installed for 10 days after which the initial 4-day period was repeated. Chance levels were 42

min of light per 24 hours. During the 10-day test period the animals obtained 1.5-2 h per 24 hours. Over de last 4 days of the study, when the infrared beam switch was not active, the levels decline down to the pre-test chance levels. There was a clear circadian rhythm in the amount of light obtained. Pigs mainly worked for light between 08:00 and 21:00 with peaks around 09:00-10:00 and, especially 15:00-18:00. Feeding times were around 09:00 and 16:30. In an identical experimental design it was investigated if pigs (n=4) were willing to work for darkness in a situation of continuous light. This proofed not to be the case, and substantiates that light, and not merely the stimulus change that goes with it, is rewarding to pigs. In a preference test, pigs (n = 12) could operate two infrared beam switches: one to turn the lights on and one to turn them off again. Six pigs were tested with bright light (110 lux) and six pigs 10 with dim light (10 lux). The first group kept the lights on for 54% of the time with relatively little variation across the day. The latter group, kept the lights on for on for a mean 63% of the time, again without a clear circadian rhythm. There were no clear changes over the 5 test days suggesting that novelty did not play a major role.

In the situation that pigs have to work for light they will show daily rhythms in obtaining it, possibly, with peak levels around the time of feeding. The rhythm may reflect daily variation in activity rather than in the preference for light, as pigs that control illumination without having to work continuously do not install a clear rhythm in light regime. Pigs may prefer about 12 h light per 24 h with longer light periods at the lower light intensities. It seems that sows are not willing to work for darkness under conditions of continuous illumination.

7.4   Ammonia

Long-term exposure to ammonia (10-100 ppm) causes health problems in pigs (in Jones et al. 1998). Jones et al. (1998) assessed the motivation of pigs to avoid ammonia gas. They tested six Duroc x Landrace gilts in active operant conditioning experiments and 12 Duroc x Landrace uncastrated boars in passive avoidance operant conditioning experiments. The studies started after the animals reached 6 weeks of age. The pigs were trained to root an operant manipulandum for 14 g food rewards. A light bulb signalled the availability of food. During active operant conditioning sessions, together with food rewards ammonia gas passed through one of the two operant manipulandum for 2 s, achieving maximum concentrations of 100 ppm. The sessions took place some 18 h after the pigs' last meal and included reinforcement by a fixed-interval independent schedule of 30 s. Initially, more roots were made on the control than on the ammonia manipulandum, but in time this difference disappeared. During passive operant conditioning sessions, rooting responses were reinforced on a variable-interval schedule of 30 s. Fresh air or ammonia (achieving peak concentrations of 40 or 100 ppm) was released for 15 seconds along with food reinforcements. Significantly fewer roots were made when 100 ppm ammonia was released in comparison to when 40 ppm ammonia or fresh air was released. These differences increased in time. Nevertheless, the pigs performed a high number of rooting responses even if this achieved ammonia concentrations of 100 ppm. The results indicate that pigs readily learn to tolerate acute exposures to ammonia when they are motivated to feed. In an other study by Jones et al. (1996), in which the pigs could choose between different compartments, the animals tolerated ammonia concentrations of 40 ppm in order to obtain warmth and companionship, but typically would intermittently (typically after about 40 min)

leave the compartment for fresh air. It seems that pigs will avoid prolonged exposure to ammonia concentrations as low as 40 ppm (Jones et al. 1996), and background levels may be more important to them than peak levels (Jones et al. 1998).

7.5   Floor and ramp design

Flooring

Marx and Schuster (1980) presented 6 groups of 8 piglets the choice between two of six different floor types. The piglets' behaviour was recorded by time-laps photography for several weeks. There were clear preferences for types of floors. Concrete plane of cleavage, perforated plate floors and one type of plastic plane of cleavage were preferred, especially for lying, When different floor types seemed to differ only minimally the piglets place preference seem to be determined by social factors. In a second similar study, Marx and Schuster (1982) found that the piglets again strongly avoided wire mesh, and had little liking for cast iron grid. A specific type of plastic plane was the preferred type of floor, followed by concrete plane of cleavage and perforated plate floor. In a final study, Marx and Schuster (1986) piglets were observed for preferences between the previously favoured plastic-coated wire mesh floor and the cast-iron grid, under different conditions of space availability (0.23, 0.30 or 0.45 m^2 per animal) and with or without straw in a feed rack. For lying, space availability seemed the least important, if not too small (i.e. 0.23 m^2 for the more grown piglets), whereas floor type was the determining factor. During activity the type of flooring seemed less important to the piglets than straw. Groups of 4 weaning piglets were placed for 1 h in pens with different floor types per quadrant: expanded metal, plastic-coated expanded metal, fibreglass slats and moulded plastics. The floor on which the piglets stood or lay was recorded at 1 min intervals, both at 18°C and 27°C. There were no significant differences for the time spent standing on the different floors, but the pigs spent much more time on the plastic-coated expanded metal floors than on 3 other floors. Lying times were longer at 27°C than at 18°C. The pigs spent 47% of their time (either standing or lying) on the plastic-coated expanded metal floors. The authors noted that the pigs preferred one quadrant, regardless of the floor type, that was farthest from the floor but from which the piglets could best observe the departure / return of the experimenter (standing incidence was typically high in this quadrant). From later work Farmer and Christison (1982) concluded that weanling pigs take from 2 to 10 h to establish long-term preference for a floor type, and that floor preference is not correlated with heat loss to the floor (Farmer and Christison 1982). Together, the results show that piglets express clear preferences for specific floor types, but that the strength of their preference differs with, for example, their behavioural activities.

Rasmussen et al. (2002) observed the behaviour of group housed sows (10 groups of 11-15 animals kept on deep litter) to establish what motivated the sows to visit individual, concrete floored, feeding stalls outside the feeding periods. Exploration seemed to play a role, as visits were more frequent in the first period of stall use. The number of visits were linked to temperature and the sows probably used the concrete floors to cool themselves. On occasions the feeding area was used as a refuge for social interactions.

Ramp design

Phillips et al. (1988) studied pigs of 7-8 weeks of age (about 16 kg) in a preference testing apparatus that consisted of a central holding pen (1 m^2) at floor level with 4 ramps leading to platforms (0.55 m^2 at 0.75 m high). Piglets were tested as a group and ramp preferences were measured on the basis of their use by the animals. The steeper slopes, within the range of 20-32°, were used less often by the piglets. Slopes below 20° may further increase ramp use, but its implementation seems to be impractical. Piglets preferred ramps with angle-iron cleats spaced every 0.1 m or less, compared to those space every 0.2 or 0.3 m. The piglets preferred ramps that had solid or open wire mesh sidewalls over those enclosed by a railing. Ramps with widths of 0.71 m were not preferred over those that were 0.51 m width. Different levels of illumination (from < 5 up to 1200 lux) did not affect the pigs' behaviour significantly. There was a trend towards the avoidance of the dark and very bright ramps. Staircases composed of small steps, but not those with relatively large steps, were used as readily as a ramp with a similar slope. Ramps with a slope of 20-24 °, with cleats cross-laid every 0.05-0.1 m may be used for loading young pigs in trucks or in two-level housing systems. Of the ramp design factors tested, slope and cleat spacing were the most influential on the pigs' behaviour.

7.6   Sites for farrowing

Sows are known to perform relatively high levels of locomotion on the day before farrowing (Jensen 1986). Haskell et al. (1997) investigated the sows' motivation to gain access to space, assumingly for the performance of locomotion. Six multiparous sows were kept in a 6.5 x 7 m test arena including a 2 x 2 m home pen and studied from 4 days before farrowing until farrowing. The lifting of a lever on a progressive ratio (increment of one with a reset per observation day) enabled the animals to move from the small home pen, where they had access to water and food, into the test arena, or back. The animals were observed from 09:00 until 17:00, unless they seemed about to farrow and observations proceeded into the night. During the night the animals were restricted to the home pen. The mean number of lever lifts ranged around 5 or 17 per day on days 4-2 or day 1 before farrowing, respectively (Haskell et al. 1997). Also, the sows showed increased locomotion during the day before farrowing, but this was not expressed in the test arena. Levels of locomotion were relatively low compared to that of an earlier group of sows that had free access to the test arena. The results show that prior to farrowing the sows are increasingly restless, but seem not to be especially motivated to gain extra space for the purpose of locomotory behaviour.

Hutson and Haskell (1990) measured the motivation of sows to utilize an earth floor for farrowing. Six individually housed sows in concrete floored pens had free access to an earth

floored pen for 8 h per day. The number of visits to the earth floor increased with approaching farrowing date and about 8 h before farrowing the sows excavated an earth nest. In a second experiment the sows had to lift a lever to gain access to the earth floor. A progressive reinforcement schedule was used with the FR increasing with one per reinforcement. Three out of 6 sows dug an earth nest and only one farrowed in the nest. The authors hypothesize that the animals may have experienced uncertainty about the future availability of the nesting site, as they were required to visit the concreted floored pen for water and food. In a later study they substantiated that feeder and drinker locations affect the pigs' choice of farrowing site (Haskell and Hutson 1994).

7.7   Rooting material

Sows living under semi-natural conditions may spend 40-60% of their active time exploring and seeking food, and spend 10-20% of their active time rooting (in Studnitz and Jensen 2002). Rooting seems to be important to pigs as, for example, individuals without prior experience start rooting the moment they are put on grass or soil (Studnitz 2002). Possibly, a pig's motivation to root accumulates when rooting is prevented. For example, cows show increased walking, trotting and explorative behaviour with decreasing amounts of exercise, suggesting a build up of motivation with the time of tethering (Loberg and Lidfors 2002). Studnitz and Jensen (2002) investigated if sows show rebound behaviour, i.e. build up motivation, in response to the deprivation of rooting material. Landrace x Yorkshire gilts, which were normally kept on 30 cm of sterile peat, were withheld rooting material for 0 up to 32 h and subsequently observed for their behaviour upon return in the earth pen (Studnitz and Jensen 2002). Deprivation of rooting for more than 24 h made the gilts root longer (4.2 compared to 2.0 min / h) during the light hours of the first 24 h after returning. With repeated testing the effect dissipated. In time, the pigs may have lost interest in the earth pen. A declining interest in earth over time has been reported by Appleby and Wood-Gush (1988). This could indicate that the motivation to root is closely associated with investigating new stimuli. It seems that in pigs the motivation for rooting may accumulate to some degree when its performance is prevented, but, possibly, not in the situation that they have learned to expect rooting material after short periods of deprivation (Studnitz and Jensen 2002). In the design of Studnitz and Jensen (2002) the movement of the barren pen to the earth pen and back may have aroused the pigs and affected their behaviour. Pigs prefer variety to monotony as, for example, Stolba and Wood-Gush (1980) showed that pigs living in a barren environment are more motivated to leave their pen and explore new area than those living in an enriched environment (in Studnitz and Jensen 2002). Another example is the preference of young pigs (5-6 weeks) for unfamiliar over familiar objects (Wood-Gush and Vestergaard 1991). In the experiment by Studnitz and Jensen (2002)

Testing the motivation for one resource at a time may overestimate its value as animals are left with little alternatives. Therefore, Pedersen et al. (2002b) measured the pig's motivation to work for different rooting materials relative to that of long straw. At different FR, the animals could either work for long straw or one of the alternative materials, i.e. chopped straw, fir branches, peat or again long straw. The animals worked in a closed economy

situation for 45 min per day. The cross points between the demand curves of long straw and other treatments were compared (cross points lower than that of long straw against long straw indicating preference). The pigs preferred peat and especially branches to straw.

7.8   Comparison of the motivation for food, social contact and stimulus change

Matthews and Ladewig (1994) tested castrated male pigs for their willingness to work for food, contact with a familiar partner animal and stimulus change. Demand curves were calculated from the findings on different fixed ratio schedules: FR = 1, 2, 5, 10, 15 20 and 30. The animals (n=8) had been raised as a group on straw. During the study they were kept individually in pens of 170 x 60 x 80 cm. The social reward consisted of the opening (for 15 s) of a door that uncovered a 40 x 75 cm opening, with vertical bars every 13 cm, to the individual cage of a familiar animal. Outside of the test sessions the animals had 10 min of daily contact with their partner. The animals were tested also when no neighbouring pig was present. Food rewards were 27 g of pelleted diet. In order to obtain rewards the animals had to press (more than 1 Newton) 9 cm diameter nose-plates. Operation of the panels was accompanied by auditory signals. Animals were exposed to ascending and descending reinforcement schedules. The press plate for food remained 6 s inactive after a reward had been delivered in order to prevent accumulation of food at low FR schedules. Test sessions were terminated after 100 min (excl. reinforcement delivery times). Typically, the animals worked for social contact or door opening during the first 20 min of the tests only. Major responses for food occurred during the first 40-50 min. At high FR, 10-20 min eating periods later on in the session were common. Food intake (which was restricted to the test situation) was similar to that of ad libitum fed animals. The mean elasticity coefficients for food and social contact and door opening were 0.02 and 0.49 and 0.63, respectively. The order of exposure to the different reinforcers did not seem to influence the results. The results show that for castrated male pigs food, social contact and ' door opening' (some sort of stimulus change) rank in order of decreasing importance.

7.9   Pigs' appraisal of various management procedures and events

Transport
Pigs were placed in a pen of 1.5 x 1.5 m that vibrated and generated noise similar to that of a car (Bailey et al. 1983, Stephens et al. 1985). The animals were first trained to stop the machine by means of approaching the pen-side that contained a switch. Next, the animals had to operate the switch in order to stop vibration and noise for 30 s. After 1-4 sessions, which lasted 30 min each, the machine was off for about 80% of the time, indicating the aversiveness of the vibration and noise. It was investigated if the speed of vibration, the duration of the test, the interval between last meal and testing (30 min versus 16 h) and sedative drugs (azaperone) affected the pigs' behaviour. Increased speed resulted in more positive reinforcements and these occurred more in the latter 20 min of the tests. When the animals were fed ad lib (not when given meals of 2% of their body weight), short meal-test intervals resulted in more positive reinforcements. The latter occurred less when sedative drugs were given. Pigs that turned off the vibrator would also work to turn off the noise.

However, naïve animals did not learn to switch off the noise and this suggests that the vibration during transport is more aversive than the noise. The results show that the intake of large meals before transport and long lasting bumpy rides add to the aversiveness of transport.

Short-term confinement

Špinka et al (1998) assessed the preference of gilts for two different periods of confinement, including water deprivation. Twelve gilts, which were housed in large straw-bedded pens, were trained to enter two types of crates for feeding (twice a day). After feeding the animals were confined for 30 min in the one type of crate and 240 min in the other. Eight gilts chose the short confinement side more often, two, the long confinement side more often and two, each side an equal number of times. The visits to the long-term confinement crates may have been errors in the learning tasks or may have resulted from the pigs' motivation to explore or monitor the environment. Pigs clearly prefer a dry floor pen to a wet floor (Hutson et al. 1993), but they may visit a wet floored pen markedly more often than usual when, overnight, they have been prevented from entering the wet pen. Possibly, the one gilt with the preference for long-term confinement did not like to return quickly to her home pen for social reasons. In general, gilts chose the long confinement side on occasion and it seems that even though most pigs will prefer short periods of confinement they may not find confinement for as long as 240 min very aversive.

Self-expression of an anxiety state in response to different events

The drug-discriminative paradigm has been used to evaluate how pigs perceive management procedures. First, the pigs were learned to discriminate PTZ (pentylenetetrazole: known to induce anxiety in man) from saline treatments, as indicated by the ratio of presses for food rewards on two different levers (Carey et al. 1992). Next, Carey and Fry (1995) showed that conditioned pigs expressed, by means of pressing the 'PTZ-lever', a subsequent state of anxiety in response to specific environmental stimuli. In short (Carey and Fry 1995), male pigs of the Large White breed (8 weeks of age) were learned to alternating press two levers for food rewards (FR20). Next, they were learned to press only one of the levers when PTZ was administered via a jugular catheter, whilst both levers had to be operated when saline was administered. In the presence of stimuli or immediately after an event the pigs were tested with both levers set to reward. Three out of 4 pigs showed a preference for the PTZ lever when the usual wire mesh floor of the test box was replaced with a smooth wooden board. Two out of 3 pigs expressed anxiety when a small rubber ball was introduced into their food bowl. Reducing the temperature from its normal range around 21°C to 5°C was associated with anxiety in 2 out of 4 pigs. Changes in the colour or intensity, i.e. lowering, of the lighting had no effects, possibly reflecting that pigs rarely use visual cues in their search for food. Vocalizations of a restrained pig or barking dog, but not neutral noise of the same intensity, interrupted operant responding (way beyond the play back time). In response to the barks one animal, which did resume responding, showed a preference for the PTZ lever. Only one of the 3 animals tested showed anxiety responses when tested after 20 min of transport. Following the encounter with two intruder male prepubertal pigs, which resulted in behaviours like circling, and shoulder to shoulder pressing, 2 out 4 pigs showed anxiety responses. Odours of oestrous sow urine induced anxiety in two out of 4 pigs; secretions of the preputial gland of a boar induced anxiety in 1 out of 3; smells of a fresh pig

carcass induced anxiety in 2 out of 4. The results identify a number of events that seem to induce anxiety in pigs, though alternative interpretations of the findings exist. Noteworthy, are the clear individual differences in the perception of the different events, indicating that what may be aversive and stressful to one pig may not be automatically so for others.

7.10   Summarizing conclusions on findings in pigs

The inelasticity of the demand function for food shows that food is highly valued by pigs. Pigs express a strong motivation to obtain food, and this motivation may be reduced only in the immediate postprandial period. To some degree, motivations for feeding may be influenced by factors such as social context (Pedersen et al. 2002a). Pigs are willing to work for thermal comfort, and the importance of heat is influenced by factors like food availability and daily rhythms. Pigs that have to work for light will show daily rhythms in obtaining it. The rhythm may reflect daily variation in activity rather than in the preference for light. Pigs that control illumination without having to work continuously do not install a clear rhythm in illumination. Pigs may prefer about 12 h light per 24 h with longer light periods at the lower light intensities, but the importance of such regimes is unclear. Pigs value darkness, under conditions of continuous light minimally. There are indications that pigs will avoid prolonged exposure to ammonia concentrations as low as 40 ppm (Jones et al. 1996), and that background levels seem to be more important to them than short-lasting peak concentrations, which are readily tolerated (Jones et al. 1998).

Piglets will express clear preferences for specific floor types, but the strength of their preference differs with, for example, their behavioural activities. Sows will visit areas with concrete floors, when they can stay in deep litters, for reasons of explorations, cooling themselves or to escape social interactions (Rasmussen et al. 2002). Ramps with a slope of 20-24 °, with cleats cross-laid every 0.05-0.1 m may be used for loading young pigs in trucks or in two-level housing systems.

Prior to farrowing the sows are increasingly restless, but they may not be strongly motivated to gain extra space for the purpose of performing locomotory behaviour. Other motivation such as for example exploration may predominate. Sows have a clear preference to use an appropriate farrowing site such as an earth floor, but uncertainty about the future availability of the nesting site, food and / or water will affect the pigs' choice of a farrowing site. It seems that in pigs the motivation for rooting may accumulate to some degree when its performance is prevented, but not in the situation that they have learned to expect rooting material after short periods of deprivation (Studnitz and Jensen 2002). Also, the motivation to root may be closely associated with the investigation of new stimuli and, consequently, the motivation to root may be relatively low in a non-stimulating environment. In non-stimulating environments pigs will redirect rooting behaviour towards penmates (e.g. McKinnon 1989, Olsen 2001).

With regards to rooting substrates, pigs prefer peat and especially branches over straw (Pedersen et al. 2002b).

For pigs, food, social contact and 'door opening' (some sort of stimulus change) rank in order of decreasing importance (Matthews and Ladewig 1994). Pigs prefer variety (stimulus change) to monotony as, for example, Stolba and Wood-Gush (1980) showed that more than pigs living in an enriched environment, those living in an barren environment want to leave their pen and explore new area (in Studnitz and Jensen 2002).

Findings on simulated transport show that the intake of large meals before transport and long lasting bumpy rides add to the aversiveness of transport (Bailey et al. 1983, Stephens et al. 1985). The noise that accompanies transport is less aversive to pigs than the vibration. Most pigs will prefer short periods of confinement over long ones, but they may not find confinement for as long as 240 min very aversive (Špinka et al.1998). Other motivations, such as for example exploration, may overcome the aversion against short-term confinement. Experiments on self-expression of anxiety identify a number of events that seem to be induce anxiety in pigs (Carey and Fry 1995). The interpretation of such studies is not straight-forward and there seem to be clear individual differences in the perception of the different events, indicating that what may be aversive and stressful to one pig may not be automatically so for others.

The studies with pigs such as they were reviewed here, illustrate the difficulty in designing experiments that acutely measure a pig's motivation with regards to the resource(s) under study. Several authors stated that other motivations than the ones they were interested in may have biased their findings. Nevertheless, especially the studies in which several resources were investigated simultaneously, provide valuable information on how pigs are motivated and appraise their environment. The differences in experimental design and presentation of the results, e.g. measures of demand elasticity are rarely given, often prevent comparisons across studies. It is clear that motivational states in pigs are not fixed in time or over different situations and individual differences exist. This means that there is no easy way to label resources with regards to their value for pigs as this will depend, for example, on individual preferences and specific situations, i.e. the availability of other resources. However, he pigs strong motivation for feeding, which is consistently found across studies, is just one of the examples that show how studies on motivation help in assessing the way pigs feel about their environment.

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