

SELECTION FOR BEHAVIOUR IN POULTRY

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INTRODUCTION

Genetic selection for behavioural traits has been carried out traditionally in many domestic animal species before scientific information on the inheritance of traits was available. In some cases the behaviour was the primary purpose for domestication. It is assumed that Japanese quail (*Coturnix japonica*) has been kept and selected for its song prior to selection for egg and meat production. The crow of roosters was also subject to selection in the past, and some breeds with extended length and frequency of crows are still kept and selected by fancy breeders. First studies using quantitative genetic analysis have been carried out on broodiness in domestic chickens by Saeki (1957). In the 1960's the social and sexual behaviour was subject to heritability analysis and selection experiments (Guhl *et al.*, 1960; Craig *et al.*, 1965; Siegel, 1965). In the 1970's and later the welfare discussions raised the questions on adaptability of the animals to intensive husbandry conditions and the behavioural needs of the birds in response to their genetic background. Fear related behaviour, such as tonic immobility, open-field activity, has been studied as a central mechanism to cope with different environmental conditions and unfamiliar stimuli (Jones *et al.*, 1982). The restriction of physical space, lack of litter material and nest boxes in conventional cages has stimulated genetic studies on the locomotor activity, including pre-laying restlessness (Jeziarski and Bessei, 1978; Heil, *et al.*, 1990), and dustbathing behaviour (Gerken, 1983).

With the development of loose house systems using large group sizes problems of feather pecking and cannibalism have increased, and measures are sought to control the so-called vicious behaviours. Since management measures (except beak trimming) have failed to effectively control the problems caused by feather pecking and cannibalism so far genetic selection has been put forward as a potential means to improve the situation.

Fear-related behaviour and adaptability has also to be mentioned in this context. This behavioural complex is dealt with elsewhere in this conference. The following contribution will focus on social behaviour, locomotor activity, dustbathing, and special attention will be paid to feather pecking and cannibalism.

SOCIAL BEHAVIOUR

Systematic selection for high and low social dominance has been carried out by Guhl *et al.* (1960) and Craig *et al.* (1965). The estimated heritability for social dominance reported in these experiments varied from .00 to .43. Birds selected for high social dominance ability were not only more aggressive in pair contests, but also when kept in groups. The difference in aggression and social dominance may explain a part of the genotype x environment interaction which has been reported for production traits: Egg production of the high and low dominance strains was similar when the birds were kept in individual cages, but low social dominance birds performed better in multiple bird cages (Biswas and Craig, 1970). The interrelationship

of social behaviour and housing system was also demonstrated in a selection experiment where sub-lines of two White Leghorn strains were selected under cage and deep litter systems for high egg output for five generations (Bessei *et al.*, 1984). While the general level of aggression was low when the lines were observed in their selection environment, significantly more aggressive interactions were found when the cage selected lines were kept in larger groups in deep litter compartments. It has been speculated that selection of hens for egg production in individual cages may lead to loss of social mechanisms to avoid aggression.

The results show that the interrelationships between social dominance, aggression and performance are complicated by genotype-environment interaction and by the correlation of social behaviour with other characteristics such as early maturity and body weight. Selection for both, increased egg production and high social dominance resulted in earlier maturity (Lowry and Abplanalp, 1970) and higher body weight (Tindell and Craig, 1959). Earlier maturing birds have larger wattles and combs, which enables them to dominate the later maturing companions. Thus, the relationships between social rank and egg production are more pronounced at the beginning of the laying period. "Social inertia" can maintain this relationships in some strains even when the later maturing birds have reached the same physiological status as the early maturing birds (Guhl, 1968). In some cases, however, the social dominance order changes totally after the onset of lay (Craig *et al.*, 1975). There is generally a positive correlation between social rank and body weight within strains (Siegel and Siegel, 1963). This correlation cannot be found among lines differing in body weight and social dominance (Craig and Toth, 1969).

A method to characterise the social competence in birds is the social reinstatement test. In this test the distance that the birds run on a treadmill in order to maintain close contact with a group of conspecifics is recorded. Using this method a quail line was subject to a bi-directional selection programme (Faure and Mills, 1998). It was first expected that the high social reinstatement line would easier adapt to commercial husbandry conditions, e.g. high stocking density and large groups. But it was found that the tendency for social reinstatement was only expressed when the birds were separated from their conspecifics. Since the high social reinstatement lines showed more non-aggressive pecks (Francois *et al.*, 2000) and feather pecking (Bilcik and Bessei, 1993) than the low social reinstatement line it was suggested that the latter would adapt more easily to conventional husbandry systems.

In summary, considerable knowledge on the genetic background of social dominance and aggression and their interrelationships with production and husbandry conditions have been collected in the past. This knowledge has not been applied in commercial breeding programmes, probably because deep litter systems with large groups have been replaced by cages with 4 to 6 birds with a stable rank order and low level of social interactions. Problems will arise when the egg production will return to non-cage systems with large groups.

LOCOMOTOR ACTIVITY

The wild ancestors of the domestic fowl and domestic chickens kept under wild life conditions spend a considerable proportion of their time budget in locomotor activities (Savory *et al.*, 1978). Even under intensive cage systems the hens spend about 20 percent of their time walking (Bessei, 1983). It has been hypothesised that the amount spend moving of hens is genetically fixed, and the birds may suffer when they are kept under conditions where locomotion is physically restricted. This raised the question whether the spontaneous

locomotor activity can be modified by genetic selection. Consequently the locomotor activity of pedigreed hens of two White Leghorn strains was measured in shuttle boxes (Jeziarski and Bessei, 1978). There were significant differences in activity between the two White Leghorn strains, and on the basis of paternal half sib information the heritability was .18. There was a positive genetic correlation between body weight and activity ($r_g = .31$). This is in contrast to the general finding that heavier birds are less active. Genetic studies on locomotor activity in different lines of Japanese quail (*Coturnix japonica*) have been carried out by Saleh and Bessei (1980). Locomotor activity was measured in males and females of a light laboratory strain and of a commercial broiler strain. The heritability estimates for locomotor activity were .17 for the light and .04 for the heavy strain. The genetic correlation between activity and body weight were negative in the light strain ($r = -.30$) and positive in the heavy strain (.31). The studies of locomotor activity in chickens and quail show that there is considerable genetic variation for this trait which could be used for genetic selection. Although heavier lines of chickens are generally less active than lighter ones, the genetic correlation estimated within lines in both, chickens and quails, reveal that the opposite relationship holds true in some cases. A special case of locomotor activity in laying hens is the pre-laying restlessness. This behaviour was first described by Wood-Gush and Gilbert (1969). In caged layers this behaviour is thought to be a sign of frustration caused by the impossibility to find a nest. Differences between lines in the incidence of pre-laying unrest has been reported by Wood-Gush (1972). Heil *et al.* (1990) compared the pre-laying behaviour of 4 White Leghorn lines over three generations. Both the genetic and phenotypic variation of these behaviours varied largely and heritability values of .12 and .09 were obtained for the duration of pre-laying activity and the number of escape movements respectively. The results showed the possibility to control the pre-laying restlessness by genetic selection. Whether the selection for reduced pre-laying restlessness would alleviate stress or – in contrast – remove a behavioural means to cope with the pre-laying situation has still to be elucidated.

DUST BATHING

Dust bathing in laying hens has been considered as a typical example of a genetically fixed and invariable behaviour following the Lorenzian theory (Vestergaard, 1980). Since standard battery cages do not provide the substrate for the birds to perform dust bathing it was assumed that the hens might suffer under these conditions. Gerken (1983; 1991) selected two lines of Japanese quail for high and low frequencies of dust tossing behaviour over 17 generations. After 3 generations the lines diverged significantly (7.9; 13.6 and 16.2 dust tosses for the low, control and high dustbathing lines respectively). Although the selection was based only on the behaviour of males these differences were also expressed in the females. The heritability estimate for the selection trait was .28, and the realised heritabilities .18 and .38 in the high and low dustbathing lines respectively. The selection programme not only modified the frequency of the selected trait but also all the related characteristics of dustbathing behaviour, such as total time spent dustbathing, the latency to start and the intensity of dustbathing as well as vacuum dustbathing shown on a wire floor. The genetic correlation between dustbathing, egg production, fertility and body weight were generally low. The results showed clearly that dustbathing is highly variable within lines of Japanese quail and can be modified by genetic selection. This may also hold through for the domestic fowl.

FEATHER PECKING AND CANNIBALISM

Description of feather pecking and cannibalism. The genetic selection depends on reliable definition of the selection trait. This is particularly important for observed behavioural traits where generally accepted and standardised methods of measurement and dimensions do not exist. The main problem in the present case is that pecking activities occur in different situations, e.g. feeding, preening, exploring, aggression, and it is difficult in many cases to identify the motivation of the observed pecking activity. It is now generally accepted that pecking of the feathers or at skin, which causes deterioration of the feather cover and skin regions has a motivation on his own, and must not be confounded with other pecking activities. There are various types of feather pecking (for detailed description see Keeling, 1995; Savory, 1995; Kjaer and Vestergaard, 1999). At present there is a certain agreement among scientists that at least two categories, which are clearly distinct in intensity, have to be recorded separately: gentle pecks and severe feather pecks, the latter being identical with vigorous feather pulling. Gentle feather pecking is mainly directed to the tips of feathers. It may damage the structure of the barbs but does not cause feather loss. Little if any avoidance behaviour is observed by the target bird in this case. In contrast to this, severe feather pecking or vigorous feather pulling is carried out with lower frequency but with high intensity. It usually leads to the removal of feathers which may be eaten by the feather pulling bird. The attacked bird may show avoidance behaviour. But in some cases pulling is tolerated even if feathers are removed. The same is true for cannibalistic pecking at wounds and bleeding body area. This has led the attention to the target hen, and it has been demonstrated that the tendency of the individual bird to be pecked has to be considered as well. There is a certain transition from gentle feather pecking to severe feather pecking or vigorous pulling and cannibalistic pecking: It has been observed that severe pecking and vigorous feather pulling occurs after a series of gentle pecks. The deterioration of the feather structure by gentle pecking seems to encourage further feather pecking activity (McAdie and Keeling, 1999). Transition from severe feather pecking/vigorous feather pulling to cannibalistic pecking is likely to occur when feather pulling causes wounds at the follicles. The sequence from gentle feather pecking to severe feather pecking/vigorous pulling and cannibalistic pecking, however, is not compulsory. There is severe pecking and pulling even without prior gentle pecking, and cannibalism has been observed even in birds with intact feathers.

Heritability of feather pecking and cannibalism. Differences among breeds and hybrid lines for feather pecking behaviour and/or feather damages have been found since in numerous studies (Löfliger *et al.*, 1982; Ambrosen and Petersen, 1997; Herremans *et al.*, 1988). Bessei (1984a) observed pullets of Rhode Island Red, Sussex and their reciprocal crosses in intermingled groups and found that the frequency of feather peckers and feather pecking activity was higher in the Rhode Island Red as compared to Sussex, and the reciprocal crosses being intermediary. This indicated the presence of additive genetic variation. Heritability as estimated on the basis of full and half sib components in a mixed model was .07 for feather pecking. No estimate was obtained for the trait being-pecked because of negative variance components. When the pullets were classified as feather peckers and being pecked and binomial heritability was estimated within lines and crosses (Robertson and Lerner, 1949), the values varied between zero and .10 for pecking and from zero to .11 for being pecked. A similarly low binomial heritability of .09 was found for feather pecking behaviour in a White

Leghorn line by Cuthbertson (1980). The heritability coefficient was considerably higher (.56), when families which showed no feather pecking were discarded from the analysis. When the heritability of feather pecking behaviour in pullets of a tinted layer strain was estimated on the basis of half sib information the coefficients for feather pecking and being pecked were .20 and .25 respectively (Bessei, 1984b). Kjaer and Sorensen (1997) estimated the heritability of feather pecking behaviour using the sire component and animal model at different ages. The heritability coefficients were low to moderate (.06 and .14) at 6 and 38 weeks respectively and higher (.35 to .38) at 69 weeks of age. For the trait being pecked the heritability coefficient was .15 at 6 weeks of age. No estimate was obtained at later age. Craig and Muir (1993) kept sire families in 6 bird cages and recorded the number of days without beak-inflicted injuries (1 cm² of area that was bleeding or showed hard scab) as selection criterion. The groups were scored daily from 16 to 40 weeks of age. The heritability estimates increased from .05 to .17 when the number of 6 bird cages increased from 1 to 3. Because of the high standard error of the estimate none of the coefficients significantly differed from zero. As an alternative to the visual observation of feather pecking in penned or caged groups of hens a method was developed to measure pecking of a bunch of feathers automatically (Bessei, 1984b). A heritability of .18 was estimated for this trait using a half sib analysis of adult tinted layers. The genetic correlation between pecking at the bunch of feathers and visual observations of feather pecking activity of the same birds before the onset of lay was close to zero (-.04). A refined method for the automatic measurement of pecking at a bunch of feathers which allows gentle pecks and vigorous pulls to be recorded separately has since been developed. Using this technique, a Rhode Island red line was tested and two divergent sub-lines showing high or low rates of vigorous feather pulling were built (Bessei *et al.*, 1997). The offspring of both sub-lines were raised in deep litter systems and their feather pecking behaviour was observed visually from 21 to 26 weeks of age, before their responses to the feather bunch were later recorded in individual cages. These birds differed significantly in their feather pulling behaviour and the phenotypic rank correlation, using group means, were .82 in the high and .61 in the low feather pulling sub-lines (Bessei, 1995). However, the differences between the sub-lines disappeared in later generations when the birds were raised in intermingled groups from one day of age (Bessei, unpublished). As feather damages in multibird cages are mainly caused by feather pecking, the feather scores can be used as an indirect measure for feather pecking activities. The heritabilities of feather conditions of a Rhode Island (RIR) and Sussex line and their reciprocal crosses as estimated on the basis of sire and dam components ranged from .22 and .54 (Damme and Pirchner, 1984). Craig and Muir (1989) in a similar experiment with full sib groups of White Leghorn hens in cages estimated the heritability of feather condition of .37. Kjaer and Sorensen (1997) received an heritability estimate of .22 (sire component) for the plumage condition in White Leghorns kept in intermingled groups at high density in aviaries. Grashorn and Flock (1987) studied the heritability of various White Leghorn and brown layer crossbred lines. The average heritability of three White Leghorn lines was .37 and .87 for the sire and dam components respectively. In the brown layer strains the heritability based on the sire component was .22. It was also noticed that the heritability was very low at the beginning of the laying period, obviously for lack of variability at this age.

In conclusion there is obviously evidence for additive genetic variation for both, feather pecking behaviour and damages caused by "beak inflicted" activities. The heritability coefficients of the behavioural traits seem to be lower than those of the damages. The question

whether the behaviour or the damages be used for selection against the problems are still to be debated. With regard to the higher heritability estimate and the easier method of taking records the latter is considered more suitable for selection procedures. It has, however, be taken into account that feather and skin damages are may not only caused by pecking activities, but feather loss, accidents and abrasion. Special tests for feather pecking that measure pecking of feather dummies in individually caged hens are criticised for not representing the environmental (social) conditions of practical poultry husbandry.

Realised heritabilities. The highly variable results of heritability estimates do not allow reliable predictions on the opportunity of selection against the undesirable behaviours. Therefore a few short term experiments have been carried out to verify the potential effect of genetic selection for feather pecking. Bessei (1995) reported about two experiments using Rhode Island Reds (RIR) and Sussex as founder lines which had been split into high and low feather peckers by visual observation during the rearing period and their offspring. The realised heritabilities in the RIR were .32 and 1.04 in the first and second experiment respectively. The realised heritabilities in the Sussex were negative in the first and .09 in the second experiment. After two generations of divergent selection on visually observed feather pecking in a White Leghorn line, the high and low feather pecking sub-lines significantly diverged in the selection trait (Kjaer, 1999). The results were confirmed in the 3rd generation (Kjaer *et al.*, 2001). Craig and Muir (1993) selected White Leghorn hens for days without beak inflicted injuries in multibird cages. The realised heritability based on sire family selection over two generations was .65. The short time selection experiments confirm the results of the heritability estimates within lines and demonstrate the possibility for genetic selection to reduce the incidence of feather pecking and injuries caused by pecking activity. With regard to the inclusion of feather pecking or beak inflicted injuries in the selection index of commercial breeding programmes the genetic correlation of the behavioural traits with performance results are important.

Genetic correlation between feather pecking and performance traits. Kjaer and Sorensen (1997) found a negative genetic correlation between feather pecking and body weight of hens at 52 weeks of age. A similar result was reported by Bessei (1984b). The genetic correlation between feather pecking rates and body weight in pullets at 2 days, 8 and 20 weeks varied from .20 to .66. Since poor feather conditions were represented by high feather scores, the interrelationship between feather pecking was negative as in the former case. It may be speculated that selection for lower body weight may result - or be the reason - for higher incidence of feather pecking. This assumption, however, has not been confirmed in the selection for high and low feather pecking where the low feather pecking line showed reduced body weight after four generation of selection (Kjaer *et al.*, 2001). Comparisons of body weight and mortality due to cannibalism among different pure lines and hybrid strains did not show a tendency of heavier breeds suffering less from cannibalism (Anonymous, 1996). As to the correlation between feather pecking and egg production it has been assumed that selection for egg output may result in higher tendency of feather pecking. This assumption fitted with the finding of Bessei (1995) who found a genetic correlation of .30 for egg mass and pecking at a bunch of feathers.

CONCLUSION

Commercial layer lines have been selected in cages for many generations, where the expression of behaviours was restricted. The genetic variation of the behaviour was of little economic importance under these conditions. Genetic experiments were focussed on potential welfare problems connected with behaviours which cannot be displayed or which are disturbed under cage conditions. With the return of husbandry systems for laying hens from conventional cages to floor or aviary systems the behaviour is becoming more important not only with regard to welfare but also to economical aspects. The social reaction of hens to large groups not only determines the level of aggression, but also influence the productivity of a flock. Nesting behaviour was not important in cages, and the genetic tendency to lay the eggs in a nest may have declined. This behaviour may be re-instated by direct selection so as to reduce the number of floor eggs. The most important problem for both, economic and welfare aspects is the risk of feather pecking and cannibalism. Though there is a certain genetic basis for these behaviours, the best methods for genetic improvement has still to be developed.

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